# Basic Math
# For
# Utility Operators

# Table of Contents

# Rules and Tools

## Tools

The following are the tools you need to use to solve math problems.

- Scientific Calculator – we recommend the Texas Instrument TI30Xa.
- Pencil
- Paper
- ABC&C2EP Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams.

When you take the certification exam pencil, paper and ABC&C2EP Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams will be provided for you.

You will need to bring a calculator, preferably two, one for a backup.

## Organizing

One major step that will help you solve almost any math problem is to organize your work. Organization involves using these tools:

- Pencil;
- Paper;
- ABC&C2EP Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams.

To organize your work follow these steps.

1. Reread the question and make sure you know what you are being asked to do.
2. Find the formula and write it down. (Using your pencil, paper and the ABC&C2EP Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams.)
3. Make a table of data.
4. Plug the data into the formula.
5. Do the math.

You are not ready to use the calculator and do the fifth step until the first four steps are complete.

## Order of Operations

Solving problems correctly requires performing any math operations in the correct order. The order of operations is as follows.

1. Exponents and Roots

An exponent is a quantity representing the power to which a given number or expression is to be raised, usually expressed as a raised symbol beside the number or expression.

2. Multiplication – X or ( ) or •

3. Division – — or ÷

4. Addition – +

5. Subtraction – -

# Exponents

An exponent is the number of times a number (referred to as the base) is to be multiplied by itself. For example, in the expression $3^2$ (read as three squared). The exponent as also referred to as the power. In this case, the expression could be read as three to the second power.

$$3^2 = 3 \times 3 = 9$$


On the Texas Instruments TI30Xa calculator, a number can be squared by entering the number to squared, and then hitting the “square” button.

Two (2) is not the only exponent. For exponents or powers other than 2, the exponential button is provided. On the TI30Xa, the exponential button looks like this.


Example: Raise the diameter of a pipe to the 2.63 power. The pipe diameter is 0.5 feet.

To do so with the TI30Xa, enter 0.5, hit the “exponential” button, enter 2.63, hit the “equals” button. In this case 0.5 to the 2.63 power equals 0.161544104.

The square root of a number is a value that, when multiplied by itself, gives the number. To find the square root of a number, you will use this button on your TI30Xa calculator. For example to find the square root of a number, enter the number, then hit the square root button.


Example: What is the square root of 100?

Enter 100, hit the square root button, and the answer is 10. 10 is the square root of 100.

# Squaring Numbers

Square the following numbers.

1. 37 squared = _____.

2. 24 squared = _____.

3. 56 squared = _____.

4. 39 squared = _____.

5. 42 squared = _____.

6. 87 squared = _____.

7. 59 squared = _____.

8. 45 squared = _____.

9. 20 squared = _____.

10. 13 squared = _____.

11. 18 squared = _____.

12. 15 squared = _____.

13. 100 squared = _____.

14. 104 squared = _____.

15. 110 squared = _____.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 1,369 | 2. 576 | 3. 3,136 | 4. 1,521 | 5. 1,764 |
| 6. 7,569 | 7. 3,481 | 8. 2,025 | 9. 400 | 10. 169 |
| 11. 324 | 12. 225 | 13. 10,000 | 14. 10,816 | 15. 12,100 |

# Square Roots

Find the square roots for the following numbers.

1. The square root of 10,000 is _____.

2. The square root of 1,024 is _____.

3. The square root of 9,801 is _____.

4. The square root of 25,600 is _____.

5. The square root of 625 is _____.

6. The square root of 1,369 is _____.

7. The square root of 4,761 is _____.

8. The square root of 1,936 is _____.

9. The square root of 484 is _____.

10. The square root of 289 is _____.

11. The square root of 361 is _____.

12. The square root of 144 is _____.

13. The square root of 40,000 is _____.

14. The square root of 15,376 is _____.

15. The square root of 13,456 is _____.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 100 | 2. 32 | 3. 99 | 4. 160 | 5. 25 |
| 6. 37 | 7. 69 | 8. 44 | 9. 22 | 10. 17 |
| 11. 19 | 12. 12 | 13. 200 | 14. 124 | 15. 116 |

# Exponents Other Than Squaring

Answer the following questions.

1. Find 37 to the fourth power.

2. Raise 24 to the sixth power.

3. What is 56 to the 0.54 power?

4. Determine 39 to the 2.63 power.

5. Calculate 42 to the third power.

6. Find 87 to the fourth power.

7. Raise 59 to the 0.5 power.

8. What is 45 to the 1.12 power?

9. Determine 20 to the 2.1 power.

10. Calculate 13 to the third power.

11. Find 18 to the third power.

12. Raise 15 to the 0.75 power.

13. What is 100 to the 2.22 power?

14. Determine 104 to the 1.25 power.

15. Calculate 110 to the 1.1 power.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 1,874,161 | 2. 191,102,976 | 3. 8.7906 | 4. 15,293.2545 | 5. 74,088 |
| 6. 57,289,761 | 7. 7.6811 | 8. 71.0555 | 9. 539.7131 | 10. 2,197 |
| 11. 5,832 | 12. 7.6219 | 13. 27,542.287 | 14. 332.1174 | 15. 176.0078 |

# The Metric System of Measurements

The metric system was established in France in 1799 as a way to standardize measurements. The modern metric system is now widely used throughout the world and is called the International System of Units (SI).[1] The units of measure in the metric are system are:

Gram = Weight

Meter = Length

Liter = Capacity

Multiples and submultiples of these units are used for larger of smaller weights, lengths and capacities.

| Multiples | Submultiples |
|---|---|
| Weight - Grams | |
| Dekagram (dag) = 10 Grams (g) | Decigram = 1/10$^{th}$ of a Gram (g) |
| Hectogram (hg) = 100 Grams (g) | Centigram = 1/100$^{th}$ of a Gram (g) |
| Kilogram (kg) = 1,000 grams (g) | Milligram = 1/1000$^{th}$ of a Gram (g) |
| Capacity - Liters | |
| Dekaliters (daL) = 10 Liters | Deciliter = 1/10$^{th}$ of a Liter (L) |
| Hectoliters (hL) = 100 Liters | Centiliter = 1/100$^{th}$ of a Liter (L) |
| Kiloliters (kL) = 1,000 liters | Milliliters = 1/1000$^{th}$ of a Liter (L) |

## Metric Conversion Factors

These conversion factors can be used to convert from one multiple or submultiple in the metric system. Only the practical conversion factors are listed here.

1 Liter (L) = 1,000 milliliters (mL)

[1] http://www.sciencemadesimple.com/metric_system.html

1 Kilogram (Kg) = 1,000 grams (g)

1 Gram (g) = 1,000 milligrams (mg)

***Practice Problems***

1. A volume of 650 milliliters is equivalent to how many liters?

2. Convert a mass of 3,500 milligrams to its equivalent mass in grams.

3. 3.785 Liters is equivalent to _____ milliliters.

4. 3.5 grams is equivalent to _____ milligram.

5. 4,897 grams is equivalent to _____ kilograms.

6. 1,100 milligrams is equivalent to _____ grams.

7. An operator weighed out 11.1 grams of potassium permanganate in order to prepare one Liter of a 1 percent solution. How many milligrams of potassium permanganate were weighed out?

8. A forty-eight percent liquid alum solution has a concentration of 2.417 kilograms of alum per gallon. How many grams of alum are contained in one gallon of liquid alum?

9. Fifty percent ferric sulfate is used as the primary coagulant at a water treatment plant. One gallons of the ferric sulfate solution contains is 2.747 kg of ferric sulfate. Calculate the grams of ferric sulfate in a gallon of solution.

10. One liter of solution is equivalent to how many milliliters of solution?

11. Sixty percent ferric sulfate is used as the primary coagulant at Eastside's water treatment plant. The ferric sulfate concentration in a solution is 3.623 kg per gallon. How many milligrams of ferric sulfate are contained in one gallon of solution?

12. One gallon is equivalent to 3.785 Liters. One gallon is equivalent to how many milliliters?

13. One pound is equivalent to 0.454 kg. One pound is equivalent to _____ mg.

14. How many milligrams of caustic soda are contained in one gallon of 25 percent solution if there are 1,214 grams of caustic soda in one gallon of solution?

15. 2.16 kg is equivalent to _____ mg.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 0.65 Liters. | 2. 3.5 g | 3. 3,785 mL. | 4. 3,500 mg | 5. 4.897 Kg |
| 6. 1.1 grams | 7. 11,100 mg | 8. 2,417 g | 9. 2,747 g | 10. 1,000 mL |
| 11. 3,623 mg | 12. 3,785 mL | 13. 454,000 mg | 14. 1,214,000 mg | 15. 2,160,000 mg |

# Metric – US Customary Unit Conversions

These conversion factors are provided for converting select metric and US Customary units.

1 gallon = 3.79 liters

1 pound = 0.454 kilograms

## Converting Volumes Measures

Gallons are converted to the equivalent volume in Liters by multiplying by the conversions factor.

**Example 1: Convert a volume of 5 gallons to its equivalent volume in Liters.**

5 gal X 3.79 = 18.95 L

**Example 2: Convert 18.95 Liters to its equivalent volume in gallons.**

18.95 L ÷ 3.79 = 5 gal

***Practice Problems***

1. Convert a volume of 7.5 gallons to its equivalent volume in Liters.

2. A volume of 6.25 gallons is equivalent to _____ L.

3. 0.75 gallons is equivalent to _____ L.

4. Twenty gallons is equal to _____ L.

5. 1.25 gallons is equivalent to _____ L.

6. Convert a volume of 7.5 Liters to its equivalent volume in gallons.

7. A volume of 6.25 Liters is equivalent to _____ gallons.

8. 0.75 Liters is equivalent to _____ gallons.

9. Twenty Liters is equal to _____ gallons.

10. 1.25 Liters is equivalent to _____ gallons.

11. One gallon is equivalent to _____ ml.

12. Convert 0.5 gallons to its equivalent volume in milliliters.

13. Convert 1.25 gallons to milliliters.

14. What is the equivalent volume in milliliters for 0.25 gallons?

15. 0.37 gallons is equivalent to _____ mL.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 28.425 L | 2. 23.688 L | 3. 2.843 L | 4. 75.8 L | 5. 4.738 L |
| 6. 1.979 gal | 7. 1.649 gal | 8. 1.979 gal | 9. 5.277 gal | 10. 0.33 gal |
| 11. 3,790 mL | 12. 1,895 mL | 13. 4,738 mL | 14. 948 mL | 15. 1,402 mL |

# Common Conversions

## Converting Weight Measures

**Example 1: Ten pounds is equivalent to _____ kg.**

10 lb X 0.454 = 4.54 kg

**Example 2: 4.54 kg is equivalent to _____ lb.**

4.54 kg ÷ 0.454 = 10 lb

***Practice Problems***

1. Convert 3.5 pounds to its equivalent weight in kilograms.

2. 4.75 pounds is equivalent to _____ kilograms.

3. 1.25 pounds is equivalent to _____ kilograms

4. 0.5 pounds is equivalent to _____ kilograms.

5. 1.65 pounds is equivalent to _____ kilograms.

6. Convert 3.5 kilograms to its equivalent weight in pounds.

7. 4.75 kilograms is equivalent to _____ pounds.

8. 1.25 kilograms is equivalent to _____ pounds

9. 0.5 kilograms is equivalent to _____ pounds.

10. 1.65 kilograms is equivalent to _____ pounds.

11. One gallon of 50 percent caustic contains 6.31 pounds of caustic soda. How many milligrams of caustic soda are contained in one gallon of the 50 percent solution?

12. Twenty percent sodium permanganate solution has a concentration of 1.926 pounds of sodium permanganate per gallon. Determine how many milligrams of sodium permanganate are contained in one gallon of the solution.

13. Forty-eight percent liquid alum has a concentration of 5.26 pounds per gallon. How many milligrams of alum are contained in a gallon of 48 percent liquid alum?

14. One gallon of 35 percent hydrogen peroxide contains 3.283 pounds of peroxide. Calculate how many milligrams pf peroxide are contained in one gallon of 35 percent peroxide.

15. One gallon of 25 percent caustic soda solution contains 2.68 pounds of sodium hydroxide. How many milligrams of sodium hydroxide are contained in one gallon of 25 percent caustic soda?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 1.589 kg | 2. 2.157 kg | 3. 0.568 kg | 4. 0.227 kg | 5. 0.749 kg |
| 6. 7.71 lb | 7. 10.463 lb | 8. 2.753 lb | 9. 1.101 lb | 10. 3.634 lbs |
| 11. 2,864,740 mg | 12. 874,404 mg | 13. 2,388,040 mg | 14. 1,481,402 mg | 15. 1,216,720 mg |

# Time Conversions

You will be required to make conversions between various time measurements during operations, and on the certification exams. There are no conversion factors or formulas provided. However, these conversion factors should be memorized.

1 minute = 60 sec

1 hour = 60 minutes

1 day = 24 hours

1 day = 1,440 minutes

Example 1: During a drop test to measure the hydraulic loading rate on a filter, the water level over the filter dropped six inches in 106 seconds. What was the time required for the water to drop six inches in minutes?

106 sec ÷ 60 = 1.766666666666 or 1.767 min

Example 2: Water was flushed from a water main for 37 minutes. Calculate the time used to flush the water main in hours.

37 min ÷ 60 = 0.61666666666 or 0.617 hrs

Example 3: A water plant was operated for 18 hours. Convert the 18 hours to days.

18 hours ÷ 24 = 0.75 days

Example 4: Water flows at a rate of 250 gal/min. What is the flow rate in gallons per day?

250 gal/min X 1,440 = 360,000 gal/day

### *Practice Problems*

1. 1.6 minutes is equivalent to _____ seconds.

2. 3.4 hours is equivalent to _____ min.

3. Convert 21 hours to days.

4. 0.75 days is equivalent to _____ minutes.

5. Three hundred seconds is equivalent to _____ minutes.

6. 2.5 days equals _____ hours.

7. A filter operates 124 hours between backwashes. How many days between backwashes does the filter operate?

8. During a drop test to measure the hydraulic loading rate on a filter, the water level over the filter dropped six inches in 108 seconds. What was the time required for the water to drop six inches in minutes?

9. Water was flushed from a water main for 42 minutes. Calculate the time used to flush the water main in hours.

10. A chemical is fed at a rate of 0.136 gallons per minute. What is the feed rate in gallons per hour?

11. A basin has a detention time of 480 minutes. What is its detention time in hours?

12. A flocculator has a detention time of 0.75 hours. What is its detention time in minutes?

13. Determine the detention time in seconds for a flash mix if its detention time is 0.15 minutes.

14. 17 hours is equivalent to how many days?

15. Lime is fed at a rate of 0.15 pounds per minute. What is the lime feed rate in pounds per day?

### *Answers*

| | | | | |
|---|---|---|---|---|
| 1. 96 sec | 2. 204 min | 3. 0.875 days | 4. 1,080 min | 5. 5 minutes |
| 6. 60 hours | 7. 5.17 days | 8. 1.8 min | 9. 0.7 hrs | 10. 8.16 gal/hr |
| 11. 8 hours | 12. 45 min | 13. 9 sec | 14. 0.71 days | 15. 216 lb/day |

# Temperature Conversions

There are two temperature scales used in the United States, the Fahrenheit scale (°F), and the Celsius scale, also called the Centigrade scale (°C). The Centigrade scale is most commonly used for monitoring and reporting purposes.

An operator can convert from one temperature scale to another using these formulas.

***Centigrade to Fahrenheit***

$$\text{Degrees Fahrenheit} = (°C)(1.8) + 32°$$

***Fahrenheit to Centigrade***

$$\text{Degrees Centigrade} = \frac{(°F - 32°)}{1.8}$$

## Converting Temperature in Degrees Centigrade to Fahrenheit

This formula is provided for converting temperature in degrees Centigrade to degrees Fahrenheit.

$$\text{Degrees Fahrenheit} = (°C)(1.8) + 32°$$

Example: Convert 20°C to its equivalent in degrees Fahrenheit.

**Write down the formula.**

$$\text{Degrees Fahrenheit} = (°C)(1.8) + 32°$$

**Make a table of data.**

$$°C = 20°C$$

**Plug the data into the formula.**

$$\text{Degrees Fahrenheit} = (20°C)(1.8) + 32°$$

**Do the multiplication.**

$$\text{Degrees Fahrenheit} = 36°C + 32°$$

**Do the addition.**

$$\text{Degrees Fahrenheit} = 68°C$$

### *Practice Problems*

1. A raw water sample has a temperature of 15°C. What is its equivalent temperature in degrees Fahrenheit?

2. Convert 28°C to degrees Fahrenheit.

3. What is the raw water temperature in degrees Fahrenheit if the temperature is 12°C.

4. Determine the temperature in degrees Fahrenheit if the temperature is 5°C.

5. The finished water temperature is 4°C. What is the temperature in degrees Fahrenheit?

6. A raw water sample has a temperature of 0°C. What is its equivalent temperature in degrees Fahrenheit?

7. Convert 32°C to degrees Fahrenheit.

8. What is the raw water temperature in degrees Fahrenheit if the temperature is 100°C.

9. Determine the temperature in degrees Fahrenheit if the temperature is 44°C.

10. The finished water temperature is 39°C. What is the temperature in degrees Fahrenheit?

11. A raw water sample has a temperature of 52°C. What is its equivalent temperature in degrees Fahrenheit?

12. Convert 61°C to degrees Fahrenheit.

13. What is the raw water temperature in degrees Fahrenheit if the temperature is 71°C.

14. Determine the temperature in degrees Fahrenheit if the temperature is 25°C.

15. The finished water temperature is 21°C. What is the temperature in degrees Fahrenheit?

### *Answers*

| | | | | |
|---|---|---|---|---|
| 1. 59°F | 2. 82.4°F | 3. 53.6°F | 4. 41°F | 5. 39.2°F |
| 6. 32°F | 7. 89.6°F | 8. 212°F | 9. 111.2°F | 10. 102.2°F |
| 11. 125.6°F | 12. 141.8°F | 13. 159.8°F | 14. 77°F | 15. 69.8°F |

# Converting Temperature in Degrees Fahrenheit to Centigrade

This formula is provided for converting temperature in degrees Centigrade to degrees Fahrenheit.

$$\text{Degrees Centigrade} = \frac{(°F - 32°)}{1.8}$$

Example: Convert 212°F to its equivalent in degrees Centigrade.

**Write down the formula.**

$$\text{Degrees Centigrade} = \frac{(°F - 32°)}{1.8}$$

**Make a table of data.**

$$°F = 212°F$$

**Plug the data into the formula.**

$$\text{Degrees Centigrade} = \frac{(212° - 32°)}{1.8}$$

**Do the subtraction.**

$$\text{Degrees Centigrade} = \frac{(180°)}{1.8}$$

**Do the division.**

$$\text{Degrees Centigrade} = 100°C$$

***Practice Problems***

1. A raw water sample has a temperature of 68°F. What is its equivalent temperature in degrees Centigrade?

2. Convert 45°F to degrees Centigrade.

3. What is the raw water temperature in degrees Centigrade if the temperature is 37°F.

4. Determine the temperature in degrees Centigrade if the temperature is 59°F.

5. The finished water temperature is 63°F. What is the temperature in degrees Centigrade?

6. A raw water sample has a temperature of 74°F. What is its equivalent temperature in degrees Centigrade?

7. Convert 110°F to degrees Centigrade.

8. What is the raw water temperature in degrees Centigrade if the temperature is 100°F.

9. Determine the temperature in degrees Centigrade if the temperature is 50°F.

10. The finished water temperature is 40°F. What is the temperature in degrees Centigrade?

11. A raw water sample has a temperature of 150°F. What is its equivalent temperature in degrees Centigrade?

12. Convert 32°F to degrees Centigrade.

13. What is the raw water temperature in degrees Centigrade if the temperature is 38°F.

14. Determine the temperature in degrees Centigrade if the temperature is 35°F.

15. The finished water temperature is 99°F. What is the temperature in degrees Centigrade?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 20°C | 2. 7.2°C | 3. 2.8°C | 4. 15°C | 5. 17.2°C |
| 6. 23.3°C | 7. 43.3°C | 8. 37.8°C | 9. 10°C | 10. 4.4°C |
| 11. 65.6°C | 12. 0°C | 13. 3.3°C | 14. 1.7°C | 15. 37.2°C |

# Rearranging Formulas

When required to rearrange a formula in order to solve a problem, this is the simplest approach to doing that.

Example 1: During Thursday's operations, a total of 2.5 MG of water were treated. The operator fed 196 pounds of hydrated lime. The lime has a commercial purity of 85 percent. Calculate the lime dose in milligrams per liter.

The formula you will have to use for this problem is as follows.

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}{\text{Purity, \% expressed as a decimal.}}$$

**Write down the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}{\text{Purity, \% expressed as a decimal.}}$$

**Make a table of data.**

Feed Rate, lbs/day = 196 lbs

Capacity, MGD = 2.5 MG

Purity, % as a decimal = 85% ÷ 100% = 0.85

**Plug the data into the formula.**

$$196\ \text{lbs} = \frac{(\text{Dosage, mg/L})\,(2.5\ \text{MG})\,(8.34\ \text{lbs/gal})}{0.85}$$

**Multiply the numbers above the line.**

$$196\ \text{lbs} = \frac{(\text{Dosage, mg/L})\,(20.85)}{0.85}$$

**Divide the number above the line by the number below the line.**

$$196\ \text{lbs} = (\text{Dosage, mg/L})\,(24.5294)$$

**Divide each side of the equal sign by 24.5294.**

$$\frac{196}{24.5294} = \frac{(\text{Dosage, mg/L})\,(24.5294)}{24.5294}$$

$$7.9904 \text{ mg/L} = \text{Dosage, mg/L}$$

Example 2: An operator fed 58 pounds of sodium fluorosilicate while treating 3.75 MG of water. The sodium fluorosilicate has a commercial purity of 98.5 percent. The available fluoride ion concentration in the sodium fluorosilicate is 60.7 percent. What was the fluoride dose in milligrams per liter?

**Write down the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})\,(\text{Capacity, MGD})\,(8.34 \text{ lbs/gal})}{\left(\begin{array}{c}\text{Available Fluoride Ion, \%}\\ \text{expressed as a decimal}\end{array}\right)\left(\begin{array}{c}\text{Purity, \%}\\ \text{expressed as a decimal}\end{array}\right)}$$

**Make a table of data.**

Feed Rate, lbs/day = 58 lbs

Capacity, MGD = 3.75 MG

Available Fluoride Ion, % = 60.7% ÷ 100% = 0.607

Purity, % expressed as a decimal = 98.5% ÷ 100% = 0.985

**Plug the data into the formula.**

$$58 \text{ lbs} = \frac{(\text{Dosage, mg/L})\,(3.75 \text{ MG})\,(8.34 \text{ lbs/gal})}{(0.607)\,(0.985)}$$

**Multiply the numbers above the line.**

$$58 = \frac{(\text{Dosage, mg/L})\,(31.275)}{(0.607)\,(0.985)}$$

**Multiply the numbers below the line.**

$$58 = \frac{(\text{Dosage, mg/L})\,(31.275)}{0.5978}$$

**Divide the number above the line by the number below the line.**

$$58 = (\text{Dosage, mg/L})\,(52.3168)$$

**Divide each side of the equal sign by 52.3168.**

$$\frac{58}{52.3168} = \frac{(\text{Dosage, mg/L})\,(52.3168)}{52.3168}$$

$$1.1086 = \text{Dosage, mg/L}$$

### *Practice Problems*

1. An operator fed 20 gallons of saturated sodium fluoride solution while treating 360,000 gallons of water. Determine the fluoride dose in milligrams per liter.

2. A chemical feed pump is set on 30% stroke. The maximum output for the pump is 1150 mL/min. What is the flow rate in milliliters per minute delivered by the pump with this setting?

3. A circle has a circumference of 377 feet. What is the diameter of the circle?

4. The alkalinity in a water sample is 80 mg/L as $CaCO_3$. The normality of the acid used is 0.02N. The volume of the titrant used was 4 mL. What was the sample volume in milliliters?

5. The average of a set of terms is 27. The number of terms in the set is 6. What is the sum of all the terms?

6. Water flows through a sedimentation basin at a rate of 1,980,000 gal/day. The surface loading rate for the basin is 550 gpd/$ft^2$. What is the surface are of the basin in square feet?

7. The detention time for a flash mix basin is 24 seconds. Water flows through the basin at a rate of 4 $ft^3$/sec. What is the volume of the basin in cubic feet?

8. While calibrating a dry feeder, it was determine that, at a setting of 50 percent, the feeder would deliver 250 pounds of hydrated lime per day. The sample used to determine the feed rate at 50 percent was collected over three minutes. How many grams of hydrated lime were collected while taking this sample?

9. An operator fed 72.2 pounds of sodium fluorosilicate while treating 5.75 MG of water. The sodium fluorosilicate has an available fluoride concentration of 60.7 percent. It has a commercial purity of 98.5 percent. What was the fluoride dose in milligrams per liter?

10. The backwash rise rate for a filter is 30 in/min. Calculate the backwash rate in gallons per minute per square foot.

11. The weir overflow rate is 6,944 gpd/ft. The flow rate through the basin is 1,250,000 gpd. What is the length of the weir in feet?

12. An AC motor consumes 154,000 watts. The voltage is 440 volts. The amperage is 200 amps. What is the power factor?

13. The filtration rate is 3.5 gpd/$ft^2$. Water flow through the filter at a rate of 1500 gpm. What is the area of the filter bed in square feet?

14. Fifty percent liquid alum is fed at a dose of 20 mg/L. Water is treated at a rate of 2.75 MGD. It is fed at a rate of 213 mL/min. What is the alum concentration in milligrams per milliliter?

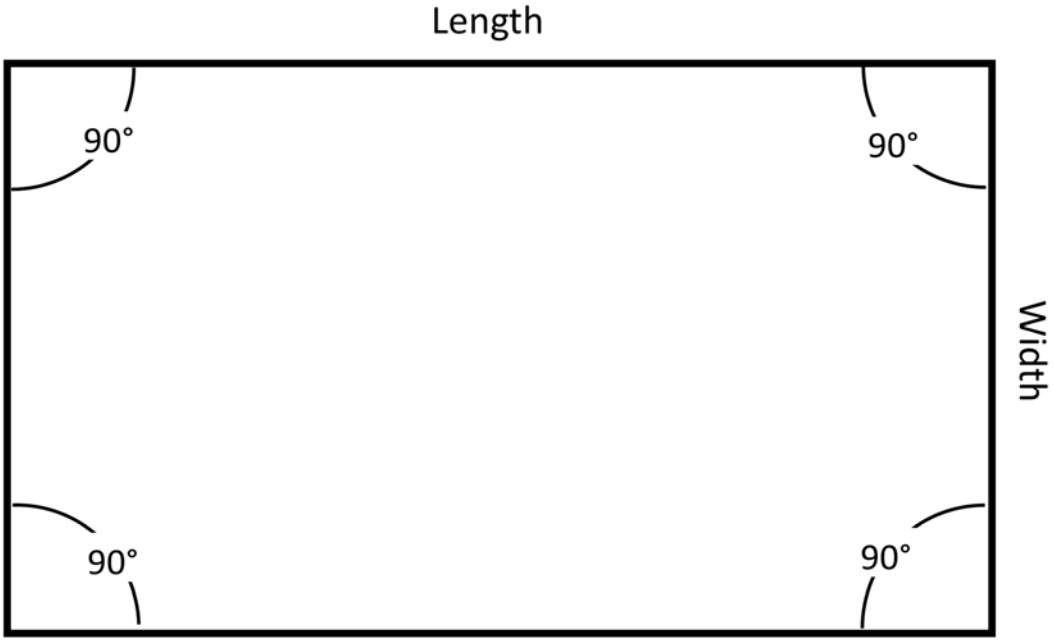
15. The CT value is 244. The time is 72 minutes. What is the chlorine dose in milligrams per liter?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 1.0 mg/L | 2. 345 mL/min | 3. 120 ft | 4. 50 mL | 5. 162 |
| 6. 3,600 $ft^2$ | 7. 96 $ft^3$ | 8. 236 grams | 9. 0.90 mg/L | 10. 18.7 $gpm/ft^2$ |
| 11. 180 ft | 12. 1.75 | 13. 429 $ft^2$ | 14. 679 mg/mL | 15. 3.4 mg/L |

# Rectangles




A rectangle is a four-sided (quadrilateral) plane figure, each corner forms a right (90°).

- All of the angles inside a rectangle are right angles.
- The rectangle is generally considered the most frequently occurring shape in the world.
- A square is technically a type of rectangle.

For certification purposes, the most important characteristic is the area of a rectangle. This formula is provided in the ABC & $C_2$EP Formula/Conversions Table for Water Treatment, Distribution, & Laboratory Exams for calculating the area of a rectangle.

$$\text{Area of Rectangle} = (\text{Length})\,(\text{Width})$$

Another useful formula is for calculating the periphery of the rectangle.

$$\text{Periphery} = (2\ \text{X}\ \text{Length}) + (2\ \text{X}\ \text{Width})$$

# Area

The area of a plane figure refers to the number of square units the figure covers or contains.

This formula is provided in the ABC & $C_2$EP Formula/Conversions Table for Water Treatment, Distribution, & Laboratory Exams for calculating the area of a rectangle.

$$\text{Area of Rectangle} = (\text{Length})\,(\text{Width})$$

Example: Determine the area in square feet for a rectangle which is 75 feet long and 30 feet wide.

**Write down the formula.**

$$\text{Area} = (\text{Length})\,(\text{Width})$$

**Make a table of data.**

$$\text{Length, ft} = 75 \text{ ft}$$

$$\text{Width, ft} = 30 \text{ ft}$$

**Plug the data into the formula.**

$$\text{Area} = (75 \text{ ft})\,(30 \text{ ft})$$

**Do the arithmetic.**

$$\text{Area,} = 2{,}250 \text{ ft}^2$$

***Practice Problem***

Round your answers to the nearest square foot (whole numbers).

1. What is the area in square feet ($ft^2$) for a rectangle which is 65 feet long and 20 feet wide?

2. A rectangle is 62 feet long and 16.5 feet wide. Calculate the area of the rectangle in square feet.

3. Determine the area in square feet for a rectangle which is 50 feet long and 17 feet wide.

4. A rectangle is 80 feet long and 20 feet wide. Determine the area of the rectangle in square feet.

5. A rectangular basin is 46 feet long, 15 feet wide, and 16 feet deep. Calculate the surface area of the basin in square feet.

6. What is the area in square feet ($ft^2$) for a rectangle which is 72 feet long and 23 feet wide?

7. A rectangle is 110 feet long and 25 feet wide. Calculate the area of the rectangle in square feet.

8. Determine the area in square feet for a rectangle which is 52 feet long and 18 feet wide.

9 A rectangle is 86 feet long and 21 feet wide. Determine the area of the rectangle in square feet.

10. A rectangular basin is 101 feet long, 26 feet wide and 16 feet deep. Calculate the surface area of the basin in square feet.

11. What is the area in square feet ($ft^2$) for a rectangle which is 84 feet long and 21 feet wide?

12. A rectangle is 35 feet long and 15 feet wide. Calculate the area of the rectangle in square feet.

13. Determine the area in square feet for a rectangle which is 96 feet long and 19 feet wide.

14. A rectangle is 120 feet long and 30 feet wide. Determine the area of the rectangle in square feet.

15. A rectangular basin is 105 feet long, 32 feet wide and 16 feet deep. Calculate the surface area of the basin in square feet.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 1,300 $ft^2$ | 2. 1,023 $ft^2$ | 3. 850 $ft^2$ | 4. 1,600 $ft^2$ | 5. 690 $ft^2$ |
| 6. 1,656 $ft^2$ | 7. 2,750 $ft^2$ | 8. 936 $ft^2$ | 9. 1,806 $ft^2$ | 10. 2,626 $ft^2$ |
| 11. 1,764 $ft^2$ | 12. 525 $ft^2$ | 13. 1,824 $ft^2$ | 14. 3,600 $ft^2$ | 15. 3,360 $ft^2$ |

# Circles

A **circle** is a simple closed shape in Euclidean geometry. It is the set of all points in a plane that are at a given distance from a given point, the centre; equivalently it is the curve traced out by a point that moves so that its distance from a given point is constant. The distance between any of the points and the centre is called the radius.

## Circumference of a Circle

The ABC&C2EP Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams formula sheet provides this formula for calculating the circumference of a circle.

$$\text{Circumference of Circle} = (\pi)\,(\text{Diameter})$$

Example 1: An alum day tank has a diameter of 48 inches. What is the circumference of the tank in inches?

**Write down the formula.**

$$\text{Circumference of Circle} = (\pi)\,(\text{Diameter})$$

**Make a table of data.**

$$\pi = 3.14159$$

$$\text{Diameter} = 48 \text{ in}$$

**Plug the data into the formula.**

$$\text{Circumference of Circle} = (3.14159)\,(48 \text{ in})$$

**Do the multiplication.**

$$\text{Circumference of Circle} = 54.79632 \text{ or } 55 \text{ in}$$

Example 2: A standpipe is 22 feet in diameter and 100 feet deep.. What is the circumference of the standpipe in feet?

**Write down the formula.**

$$\text{Circumference of Circle} = (\pi)\,(\text{Diameter})$$

**Make a table of data.**

$$\pi = 3.14159$$

Diameter = 22 ft

**Plug the data into the formula.**

$$\text{Circumference of Circle} = (3.14159)\,(22\text{ ft})$$

**Do the multiplication.**

$$\text{Circumference of Circle} = 69.11498 \text{ or } 69\text{ ft}$$

### *Practice Problems*

1. What is the circumference of a storage tank in feet if the tank is 45 feet in diameter?

2. Determine the circumference of a cylindrical tank in feet if the diameter of the tank is 32 feet.

3. A bleach bulk tank is 96 inches in diameter. Calculate the circumference of the tank in inches.

4. Calculate the circumference in feet for a day tank which is 72 inches in diameter.

5. An above ground clearwell is 62 feet in diameter. It has a height of 36 feet. Determine the circumference of the clearwell in feet.

6. What is the circumference of a storage tank in feet if the tank is 48.5 feet in diameter?

7. Determine the circumference of a cylindrical tank in feet if the diameter of the tank is 12 feet.

8. A bleach bulk tank is 36 inches in diameter. Calculate the circumference of the tank in inches.

9. Calculate the circumference in feet for a day tank which is 42 inches in diameter.

10. An above ground clearwell is 52 feet in diameter. It has a height of 30 feet. Determine the circumference of the clearwell in feet.

11. What is the circumference of a storage tank in feet if the tank is 25 feet in diameter?

12. Determine the circumference of a cylindrical tank in feet if the diameter of the tank is 60 feet.

13. A caustic soda bulk tank is 56 inches in diameter. Calculate the circumference of the tank in inches.

14. Calculate the circumference in feet for a day tank which is 32 inches in diameter.

15. An above ground clearwell is 34 feet in diameter. It has a height of 46 feet. Determine the circumference of the clearwell in feet.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 141 ft | 2. 101 ft | 3. 302 in | 4. 19 ft | 5. 195 ft |
| 6. 152 ft | 7. 38 ft | 8. 113 in | 9. 11 ft | 10. 163 ft |
| 11. 79 ft | 12. 188 ft | 13. 176 in | 14. 8.4 ft | 15. 107 ft |

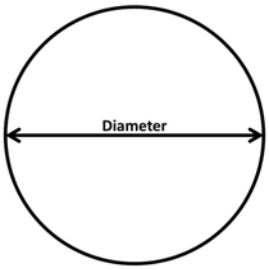
# Area of a Circle

The area of a circle in square feet ($ft^2$) can be calculated using either of these formulas.

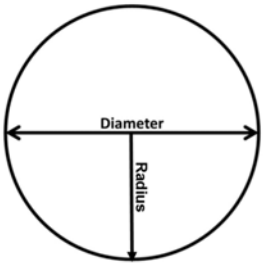
$$\text{Area} = (.785)\,(\text{Diameter})^2$$

$$\text{Area} = (\pi)\,(\text{Radius})^2$$

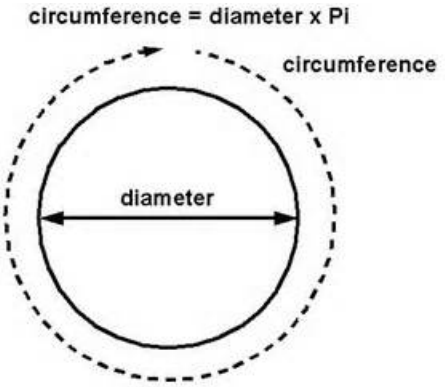
***Terminology***




Diameter - a straight line passing from side to side through the center of a body or figure, especially a circle or sphere.




Radius - a straight line from the center to the circumference of a circle or sphere.




Circumference - the enclosing boundary of a curved geometric figure, especially a circle.

Example 1: A circular basin has a diameter of 80 feet. Determine the surface area of the basin in square feet ($ft^2$).

**Write down the formula.**

$$\text{Area} = (.785)\,(\text{Diameter})^2$$

**Make a table of data.**

Diameter ft = 80 feet

**Plug the data into the formula.**

$$\text{Area}, = (.785)\,(80\ \text{ft})^2$$

**Square the diameter.**

$$\text{Area} = (.785)\,(6{,}400\ \text{ft}^2)$$

**Do the multiplication.**

$$\text{Area} = 5{,}024\ \text{ft}^2$$

Example 2: A circular basin has a radius of 40 feet. Determine the surface area of the basin in square feet ($ft^2$).

**Write down the formula.**

$$\text{Area} = (\pi)\,(\text{Radius})^2$$

**Make a table of data.**

Radius = 40 feet

$\pi$ = 3.14159

**Plug the data into the formula.**

$$\text{Area} = (3.14159)\,(40\ \text{ft})^2$$

**Square the radius.**

$$\text{Area} = (3.14159)\,(1{,}600\ \text{ft}^2)$$

**Do the multiplication.**

$$\text{Area} = 5{,}026.544 \text{ or } 5{,}027 \text{ ft}^2$$

***Practice Problems***

1. A circular basin is 100 feet in diameter and 20 feet deep. Calculate the surface area of the basin in square feet ($ft^2$).

2. What is the surface area in square feet for a circular basin with a diameter of 60 feet?

3. A circular concrete pad is 35 feet in diameter. Determine the surface area of the pad in square feet ($ft^2$)

4. A circular sedimentation basin is 65 feet in diameter. It has an average depth of 12 feet. What is the surface of the basin in square feet?

5. Calculate the area in square feet ($ft^2$) for a circle which is 40 feet in diameter.

6. Determine the area of a circle in square feet if the circle is 36 feet in diameter.

7. What is the area in square feet for a circle which is 24 feet in diameter?

8. A treatment plant has four circular clarifiers, each of which has a radius of 37.5 feet and has an average depth of 12 feet. One of the basins is out of service for maintenance. What is the surface area in square feet for each basin?

9. Determine the surface area in square feet for a circular basin which has a radius of 42 feet.

10. A circular basin is 72 feet in diameter. Calculate the surface area of the basin in square feet ($ft^2$).

11. Determine the area in square feet ($ft^2$) for a circle which is 8 feet in diameter.

12. A circular clear well is 63 feet in diameter with a depth of 18 feet. What is the surface area of the clearwell in square feet?

13. A circle has a radius of 6 feet. Determine the area of the circle in square feet ($ft^2$).

14. Calculate the area in square feet ($ft^2$) for a circle with a diameter of 28 feet.

15. Determine the area in square feet for a circle with a radius of 45 feet.

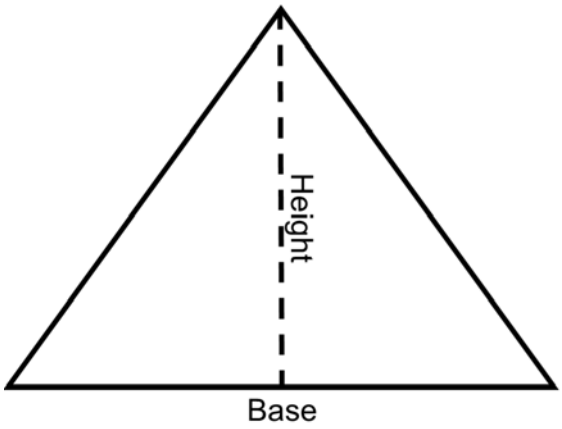
***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 7,850 $ft^2$ | 2. 2,826 $ft^2$ | 3. 962 $ft^2$ | 4. 3,317 $ft^2$ | 5. 1,256 $ft^2$ |
| 6. 1,017 $ft^2$ | 7. 452 $ft^2$ | 8. 4,418 $ft^2$ | 9. 5,542 $ft^2$ | 10. 4,069 $ft^2$ |
| 11. 50 $ft^2$ | 12. 3,116 $ft^2$ | 13. 113 $ft^2$ | 14. 615 $ft^2$ | 15. 6,362 $ft^2$ |

# Triangles

## Area of a Triangle




This formula can be used to calculate the area of a triangle.

$$\text{Area} = \frac{(\text{Base})(\text{Height})}{2}$$

Example: A triangle has a base of 20 feet and a height of 12 feet.

What is the area of the triangle in square feet?

**Write down the formula.**

$$\text{Area} = \frac{(\text{Base})(\text{Height})}{2}$$

**Make a table of data.**

Base = 20 feet

Height=12 feet

**Plug the data into the formula.**

$$\text{Area} = \frac{(20\text{ ft})(12\text{ ft})}{2}$$

**Multiply the numbers above the line.**

$$\text{Area} = \frac{240\ \text{ft}^2}{2}$$

**Divide the number above the line by the numbers below the line.**

$$\text{Area} = 120\ \text{ft}^2$$

### *Practice problems*

1. What is the area in square feet for a triangle with a base of 11 feet and a height of five feet?

2. Determine the area in square feet for a triangle which has a base of 17 feet and a height of ten feet.

3. Calculate the area in square feet for a triangle with a base of 25 feet and a height of nine feet.

4. A triangle has a base of 23 feet and a height of 13 feet. Determine the area of the triangle in square feet.

5. Given the following data, calculate the area of a triangle in square feet.

Base=30 ft

Height=15 ft

6. What is the area in square feet for a triangle with a base of 16 feet and a height of 18 feet?

7. Determine the area in square feet for a triangle which has a base of 14 feet and a height of 12 feet.

8. Calculate the area in square feet for a triangle with a base of 32 feet and a height of 16 feet.

9. A triangle has a base of 49 feet and a height of 19 feet. Determine the area of the triangle in square feet.

10. Given the following data, calculate the area of a triangle in square feet.

Base=51 ft

Height=14 ft

11. What is the area in square feet for a triangle with a base of 13 feet and a height of three feet?

12. Determine the area in square feet for a triangle which has a base of 54 feet and a height of 11 feet.

13. Calculate the area in square feet for a triangle with a base of 41 feet and a height of 15 feet.

14. A triangle has a base of 50 feet and a height of 17 feet. Determine the area of the triangle in square feet.

15. Given the following data, calculate the area of a triangle in square feet.

Base=62 ft

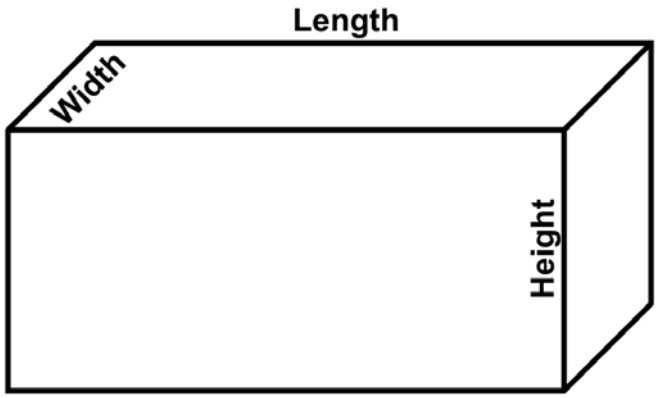
Height=21 ft

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 27.5 $ft^2$ | 2. 85.0 $ft^2$ | 3. 112.5 $ft^2$ | 4. 149.5 $ft^2$ | 5. 225.0 $ft^2$ |
| 6. 144.0 $ft^2$ | 7. 84.0 $ft^2$ | 8. 256.0 $ft^2$ | 9. 465.5 $ft^2$ | 10. 357.0 $ft^2$ |
| 11. 19.5 $ft^2$ | 12. 297.0 $ft^2$ | 13. 307.5 $ft^2$ | 14. 425.0 $ft^2$ | 15. 651.0 $ft^2$ |

# Rectangular Tanks and Basins




## Volume, $ft^3$ - Rectangular Tanks

This formula can be used to calculate the volume of a rectangular tank in cubic feet.

$$\text{Volume} = (\text{Length})\,(\text{WIdth})\,(\text{Depth})$$

Example 1: A rectangular basin is 110 feet long, 26 feet wide and 14 feet deep. What is the volume of the basin in cubic feet?

**Write down the formula.**

$$\text{Volume} = (\text{Length})\,(\text{WIdth})\,(\text{Depth})$$

**Make a table of data.**

Length, ft=110 ft

Width, ft=26 ft

Depth, ft=14 ft

**Plug the data into the formula.**

$$\text{Volume} = (110\text{ ft})\,(26\text{ ft})\,(14\text{ ft})$$

**Do the arithmetic.**

$$\text{Volume} = 40{,}040 \text{ ft}^3$$

Example 2: Twenty percent soda ash solution is fed from a day tank which is 48 inches long, 36 inches wide and has a liquid depth of 39 inches. How many cubic feet of soda ash solution are contained in the day tanks?

**Write down the formula.**

$$\text{Volume} = (\text{Length})\,(\text{WIdth})\,(\text{Depth})$$

**Make a table of data.**

Length, ft=48 in÷12in/ft=4 ft

Width, ft=36 in÷12in/ft=3 ft

Depth, ft=39 in÷12in/ft=3.25 ft

**Plug the data in to the formula.**

$$\text{Volume} = (4 \text{ ft})\,(3 \text{ ft})\,(3.25 \text{ ft})$$

**Do the arithmetic.**

$$\text{Volume} = 39 \text{ ft}^3$$

***Practice Problems***

1. A flash mix basin is 5 feet long, 5 feet wide and 8 feet deep. What is the volume of the flash mix in cubic feet?

2. The clearwell at a water plant is 50 feet long, 40 feet wide and 16 feet deep. Determine the volume of the clearwell in cubic feet.

3. The flocculates at a water treatment plant are 40 feet long, 15 feet wide and 14 feet deep. What is the volume of each flocculator in cubic feet?

4. A water treatment plant has four sedimentation basins, each of which is 150 feet long, 32 feet wide and 17 feet deep. Determine the volume of one of the sedimentation basins in cubic feet.

5. An operator uses a rectangle tank to mix and feed a 25 percent soda ash solution. The tank is 39 inches long, 24 inches wide, and has a liquid depth of 32 inches. Calculate the volume of liquid, in cubic feet contained in the tank.

6. Sludge is pumped to a drying bed. The drying bed is 36 feet long, 15 feet wide. The sludge is 15 inches deep. How many cubic feet of sludge were pumped onto the bed?

7. A basin is 75 feet long, 30 feet wide and 12 feet deep. What is the volume of the basin in cubic feet?

8. A flash mix basin is 4.5 feet long, 4.5 feet wide and 4.5 feet deep. Determine the volume of the flash mix in cubic feet.

9. A water treatment plant has four sedimentation basins, each of which is 102 feet long and 26 feet wide. The average depth of the clarifier is 12.5 feet. Calculate the total volume of the sedimentation basins in cubic feet.

10. A clearwell is 72 feet long, 56 feet wide and 16 feet deep. What is the volume of the clearwell in cubic feet?

11. At a water treatment plant there are four flocculation basins, each of which is 80 feet long, 14 feet wide, and 15 feet deep. Determine the total volume of the flocculators in cubic feet.

12. Liquid alum is fed form a day tank which is 42 inches long, and 42 inches wide. At the beginning of the day's operations the depth of the liquid alum was 62 inches. At the end of the day's operations the liquid alum depth was 24 inches. Calculate the volume of liquid alum fed in cubic feet.

13. A chemical mixing tank is 39 inches wide and 36 inches long, with a depth of 42 inches. While preparing a chemical solution the tank was filled with water to a depth of 30 inches. How many cubic feet of water were placed into the tank?

14. A chemical day tank is 36 inches long, 36 inches wide and 24 inches deep. What is the volume of the day tank in cubic feet?

15. A chemical bulk tank is 96 inches long, 84 inches wide and has a maximum liquid depth of 86 inches. The liquid depth in the tank is 60 inches. How many cubic feet of liquid are contained in the tank?

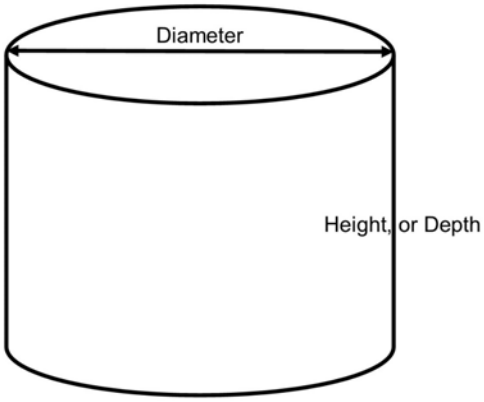
***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 200 $ft^3$ | 2. 32,000 $ft^3$ | 3. 8,400 $ft^3$ | 4. 81,600 $ft^3$ | 5. 17 $ft^3$ |
| 6. 675 $ft^3$ | 7. 27,000 $ft^3$ | 8. 91 $ft^3$ | 9. 132,600 $ft^3$ | 10. 64,512 $ft^3$ |
| 11. 67,200 $ft^3$ | 12. 39 $ft^3$ | 13. 24 $ft^3$ | 14. 18 $ft^3$ | 15. 280 $ft^3$ |

# Cylinders

## Volume, $ft^3$ - Right Circular Cylinders




This formula can be used to calculate the volume, in cubic feet, for a right circular cylinder standing on end.

$$\text{Volume} = (0.785)(\text{Diameter}^2)(\text{Height})$$

$$\text{Volume} = (\pi)(\text{Radius}^2)(\text{Height})$$

Example 1: A circular clarifier has a diameter of 42 feet, and an average depth of 12 ft. Calculate the volume of the clarifier in cubic feet ($ft^3$).

**Write down the formula.**

$$\text{Volume} = (0.785)(\text{Diameter}^2)(\text{Height})$$

**Make a table of data.**

Diameter, ft = 42 ft

Height, ft = 12 ft

**Plug the data into the formula.**

$$\text{Volume} = (0.785)\,(42\text{ ft})^2\,(12\text{ ft})$$

**Square the diameter.**

$$\text{Volume} = (0.785)\,(1{,}764\text{ ft}^2)\,(12\text{ ft})$$

**Do the multiplication.**

$$\text{Volume, ft}^3 = 16{,}616.88 \text{ or } 16{,}617\text{ ft}^3$$

Example 2: A liquid alum day tank has a diameter of 30 inches. The depth of the liquid alum in the day tank is 54 inches. Determine the liquid alum volume in cubic feet.

**Write down the formula.**

$$\text{Volume} = (0.785)\,(\text{Diameter})^2\,(\text{Height})$$

**Make a table of data**

Diameter, ft = 30 in ÷ 12in/ft = 2.5 ft

Height, ft = 54 in ÷ 12 in/ft = 4.5 ft

**Plug the data into the formula.**

$$\text{Volume,} = (0.785)\,(2.5\text{ ft})^2\,(4.5\text{ ft})$$

**Square the diameter.**

$$\text{Volume} = (0.785)\,(6.25\text{ ft}^2)\,(4.5\text{ ft})$$

**Do the multiplication.**

$$\text{Volume,} = 22.078125 \text{ or } 22.1\text{ ft}^3$$

Example 3: A liquid alum day tank has a radius of 15 inches. The depth of the liquid alum in the day tank is 54 inches. Determine the liquid alum volume in cubic feet.

Write down the formula.

$$\text{Volume} = (\pi)\,(\text{Radius}^2)\,(\text{Height})$$

**Make a table of data**

π = 3.14159

Radius, ft = 15 in ÷ 12in/ft = 1.25 ft

Height, ft = 54 in ÷ 12 in/ft = 4.5 ft

**Plug the data into the formula.**

$$\text{Volume} = (3.14159)\,(1.25\text{ ft})^2\,(4.5\text{ft})$$

**Square the radius.**

$$\text{Volume} = (3.14159)\,(1.5625\text{ ft}^2)\,(4.5\text{ft})$$

**Do the multiplication.**

$$\text{Volume} = 22.08930446875 \text{ or } 22.1\text{ft}^3$$

***Practice Problems***

1. A standpipe has a diameter of 22 feet and an overflow elevation of 110 feet. When full, how many cubic feet of water will the standpipe hold?

2. A circular clarifier has a diameter of 60 feet, and an average depth of 14 feet. What is the volume of the clarifier in cubic feet?

3. Bleach is stored in a cylindrical bulk tank with a diameter of 12 feet and a maximum depth of 18 feet when full. Determine the volume of bleach in cubic feet when the tank is full.

4. The clearwell at a water treatment plant is 75 feet in diameter and has a depth of 16 feet. How many cubic feet of water will the clearwell hold when full?

5. A ground level storage tank has a diameter of 50 feet. The depth of the water in the tank is 36 feet. Determine the volume of the water contained in the tank in cubic feet.

6. A clarifier is 47 feet in diameter with an average depth of 12 feet. What is the volume of the clarifier in cubic feet?

7. Determine the volume in cubic feet for a cylinder which is 4.5 feet in diameter and is 7 feet tall.

8. A bulk tank is 15 feet in diameter. It has a maximum liquid depth of 24 feet. The depth of the liquid in the tank is 17 feet. Calculate the volume of the liquid in cubic feet.

9. A liquid sodium permanganate day tank has a diameter of 42 inches and a height of 60 inches. The depth of the liquid in the tank is 39 inches. Determine the volume of the liquid sodium permanganate in cubic feet.

10. Liquid caustic is fed from a day tank which is 30 inches in diameter. The depth of the liquid caustic is 43 inches. How many cubic feet of liquid caustic are contained in the day tank?

11. Liquid ferric sulfate is stored in a bulk tank which has a diameter of 102 inches, and a maximum liquid depth of 228 inches. The depth of the liquid ferric sulfate in the tank is 144 inches. What is the volume of the liquid ferric sulfate in cubic feet?

12. Bleach is stored in a bulk tank which is 86 inches in diameter. It is fed from two day tanks which are 32 inches in diameter. Before filling the day tanks the depth of the bleach in the bulk tank was 79 inches. After filling the day tanks, the depth of the bleach in the bulk tank was 53 inches. How many cubic feet of bleach were used to fill the day tank?

13. A cylinder is 84 inches in diameter and 120 inches tall. Determine the volume of the cylinder in cubic feet?

14. At the beginning of Tuesday's operations the depth of the corrosion inhibitor solution in a day tank was 51 inches. At the end of that day's operations the corrosion inhibitor depth was 22 inches. Calculate the volume of corrosion fed in cubic feet if the day tank is 36 inches in diameter.

15. During Thursday's operations the liquid soda ash level in a day tank dropped 45 inches. The day tank is 24 inches in diameter. How many cubic feet of liquid soda ash were fed?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 41,793 $ft^3$ | 2. 39,564 $ft^3$ | 3. 2,035 $ft^3$ | 4. 70,650 $ft^3$ | 5. 70,650 $ft^3$ |
| 6. 20,809 $ft^3$ | 7. 111 $ft^3$ | 8. 3,003 $ft^3$ | 9. 31 $ft^3$ | 10. 18 $ft^3$ |
| 11. 681 $ft^3$ | 12. 87 $ft^3$ | 13. 385 $ft^3$ | 14. 17 $ft^3$ | 15. 12 $ft^3$ |

# Lateral Area

Lateral surfaces are the surfaces on the sides of a solid object. It is also known as lateral face or lateral side. A cylinder has one lateral side which is curved around the surface.

These formulas can be used to determine the lateral area of a cylinder.

$$\text{Lateral Area of a Cylnder} = (\pi)\,(\text{Diameter})\,(\text{Height})$$

$$\text{Lateral Area of a Cylnder} = (\pi)\,(2)\,(\text{Radius})\,(\text{Height})$$

Example 1: Determine the lateral area in square feet for a cylinder that is 30 feet in diameter, and has a height of 20 feet.

**Write down the formula.**

$$\text{Lateral Area of a Cylnder} = (\pi)\,(\text{Diameter})\,(\text{Height})$$

**Make a table of data.**

$\pi$ = 3.14159

Diameter = 30 ft

Height = 20 ft

**Plug the data into the formula.**

$$\text{Lateral Area of a Cylnder} = (3.14159)\,(30\text{ ft})\,(20\text{ ft})$$

**Do the multiplication.**

$$\text{Lateral Area of a Cylnder} = 1{,}884.954 \text{ or } 1{,}885\text{ ft}^2$$

Example 2: Determine the lateral area in square feet for a cylinder that has a radius of 15 feet, and has a height of 20 feet.

**Write down the formula.**

$$\text{Lateral Area of a Cylnder} = (\pi)\,(2)\,(\text{Radius})\,(\text{Height})$$

**Make a table of data.**

$\pi$ = 3.14159

Radius = 15 ft

Height = 20 ft

**Plug the data into the formula.**

$$\text{Lateral Area of a Cylnder} = (\pi)\,(2)\,(15\text{ ft})\,(20\text{ ft})$$

**Do the multiplication.**

$$\text{Lateral Area of a Cylnder} = 1{,}884.954 \text{ or } 1{,}885\text{ ft}^2$$

***Practice Problems***

1. A cylinder has a radius of 3 feet. It has a height of 10 feet. What is the lateral area of the cylinder in square feet?

2. Determine the lateral area in square feet for a cylinder with a diameter of 50 feet, and a height of 40 feet.

3. Calculate the lateral area in square feet for a cylinder that has a radius of 4 feet, and a height of 6 feet.

4. A liquid alum bulk tank has a radius of 5 feet and a height of 8 feet. What is the lateral area of the bulk tank in square feet?

5. What is the lateral area in square feet for a cylindrical tank with a diameter of 10 feet and a height of 9 feet.

6. A cylinder has a radius of 4 feet. It has a height of 7 feet. What is the lateral area of the cylinder in square feet?

7. Determine the lateral area in square feet for a cylinder with a diameter of 20 feet, and a height of 22 feet.

8. Calculate the lateral area in square feet for a cylinder that has a radius of 12 feet, and a height of 20 feet.

9. A water storage tank has a radius of 22 feet and a height of 80 feet. What is the lateral area of the storage tank in square feet?

10. What is the lateral area in square feet for a cylindrical tank with a diameter of 6 feet and a height of 4 feet.

11. A cylinder has a radius of 2 feet. It has a height of 3 feet. What is the lateral area of the cylinder in square feet?

12. Determine the lateral area in square feet for a cylinder with a diameter of 10 feet, and a height of 2 feet.

13. Calculate the lateral area in square feet for a cylinder that has a radius of 15 feet, and a height of 12 feet.

14. A sodium hypochlorite bulk tank has a radius of 14 feet and a height of 32 feet. What is the lateral area of the bulk tank in square feet?

5. What is the lateral area in square feet for a cylindrical tank with a diameter of 90 feet and a height of 45 feet.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 188 $ft^2$ | 2. 6,283 $ft^2$ | 3. 151 $ft^2$ | 4. 251 $ft^2$ | 5. 283 $ft^2$ |
| 6. 176 $ft^2$ | 7. 1,382 $ft^2$ | 8. 1,508 $ft^2$ | 9. 11,058 $ft^2$ | 10. 75 $ft^2$ |
| 11. 38 $ft^2$ | 12. 63 $ft^2$ | 13. 1,131 $ft^2$ | 14. 2,815 $ft^2$ | 15. 12,723 $ft^2$ |

# Total Exterior Surface Area

The ABC & $C_2$EP Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams provides this formula for calculating the total exterior surface area of a cylinder.

$$\text{Area of a Cylinder} = [\text{Surface Area of End \#1}] + [\text{Surface Area of End \#2}] = [(\pi)\,(\text{Diameter})\,(\text{Height})]$$

Example: Determine the total surface area of a cylinder in square feet if its radius of is 5 feet, and its height is 8 feet.

***Step One: Determine the area of End #1.***

**Write down the formula.**

$$\text{Area of a Circle} = (.785)\,(\text{Diameter}^2)$$

**Make a table of data.**

$$\text{Diameter} = 10 \text{ ft}$$

**Plug the data into the formula.**

$$\text{Area of a Circle} = (.785)\,(10 \text{ ft})^2$$

**Do the multiplication.**

$$\text{Area of a Circle} = 78.5 \text{ ft}^2$$

***Step Two: Determine the area of End #2.***

**Write down the formula.**

$$\text{Area of a Circle} = (.785)\,(\text{Diameter}^2)$$

**Make a table of data.**

$$\text{Diameter} = 10 \text{ ft}$$

**Plug the data into the formula.**

$$\text{Area of a Circle} = (.785)\,(10 \text{ ft})^2$$

**Do the multiplication.**

$$\text{Area of a Circle} = 78.5 \text{ ft}^2$$

***Step Three: Determine the total exterior surface area.***

**Write down the formula.**

$$\text{Area of a Cylinder} = [\text{Surface Area of End \#1}] + [\text{Surface Area of End \#2}] = [(\pi)\,(\text{Diameter})\,(\text{Height})]$$

**Make a table of data.**

Surface Area of End #1 = 78.5 $ft^2$

Surface Area of End #2 = 78.5 $ft^2$

$\pi$ = 3.14159

Diameter = 10 ft

Height = 8 feet

**Plug the data into the formula.**

$$\text{Area of a Cylinder} = \left[78.5\ ft^2\right] + \left[78.5\ ft^2\right] + \left[(3.14159)\,(10\ ft)\,(8\ ft)\right]$$

**Clear the third set of parentheses.**

$$\text{Area of a Cylinder} = \left[78.5\ ft^2\right] + \left[78.5\ ft^2\right] + \left[251.1327\ ft^2\right]$$

**Do the addition.**

$$\text{Area of a Cylinder} = 408.1327 \text{ or } 408\ ft^2$$

***Practice Problems***

1. A bulk tank has a diameter of 6 feet, and a height of 10 feet. What is the total exterior surface area of the bulk tank in square feet?

2. Determine the total exterior surface area of a cylinder if its diameter is 50 feet, and its height is 40 feet.

3. Calculate the total exterior surface area in square feet for a cylinder with a diameter of 8 feet and a height of 6 feet.

4. What is the total exterior surface area in square feet for a cylinder that is 5 feet in diameter and 8 feet deep?

5. A cylindrical tank has a diameter of 10 feet. The cylinder's depth is 9 feet. Determine the total exterior surface area in square feet for the cylinder.

6. A bulk tank has a diameter of 8 feet, and a height of 7 feet. What is the total exterior surface area of the bulk tank in square feet?

7. Determine the total exterior surface area of a cylinder if its diameter is 20 feet, and its height is 22 feet.

8. Calculate the total exterior surface area in square feet for a cylinder with a diameter of 24 feet and a height of 20 feet.

9. What is the total exterior surface area in square feet for a cylinder that is 44 feet in diameter and 80 feet deep?

10. A cylindrical tank has a diameter of 6 feet. The cylinder's depth is 4 feet. Determine the total exterior surface area in square feet for the cylinder.

11. A day tank has a diameter of 4 feet, and a height of 3 feet. What is the total exterior surface area of the day tank in square feet?

12. Determine the total exterior surface area of a cylinder if its diameter is 10 feet, and its height is 2 feet.

13. Calculate the total exterior surface area in square feet for a cylinder with a diameter of 30 feet and a height of 12 feet.

14. What is the total exterior surface area in square feet for a cylinder that is 28 feet in diameter and 32 feet deep?

15. A cylindrical tank has a diameter of 90 feet. The cylinder's depth is 45 feet. Determine the total exterior surface area in square feet for the cylinder.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 245 $ft^2$ | 2. 10,208 $ft^2$ | 3. 251 $ft^2$ | 4. 165 $ft^2$ | 5. 440 $ft^2$ |
| 6. 276 $ft^2$ | 7. 2,010 $ft^2$ | 8. 2,412 $ft^2$ | 9. 14,098 $ft^2$ | 10. 132 $ft^2$ |
| 11. 63 $ft^2$ | 12. 220 $ft^2$ | 13. 2,544 $ft^2$ | 14. 4,046 $ft^2$ | 15. 25,440 $ft^2$ |

# Cones

## Volume

The ABC & $C_2EP$ Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams provides this formula for calculating the volume of a cone.

$$\text{Volume} = (1/3)\,(.785)\,(\text{Diameter}^2)\,(\text{Height})$$

$$\text{Volume} = (1/3)\,(\pi)\,(\text{Radius}^2)\,(\text{Height})$$

Example 1: A cone has a diameter of 12 feet, and a height of 5 feet. What is the volume of the cone in cubic feet?

**Write down the formula.**

$$\text{Volume} = (1/3)\,(.785)\,(\text{Diameter}^2)\,(\text{Height})$$

**Make a table of data.**

Diameter = 12 feet

Height = 5 feet

**Plug the data into the formula.**

$$\text{Volume} = (1/3)\,(.785)\,(12\text{ ft})^2\,(5\text{ ft})$$

**Square the diameter.**

$$\text{Volume} = (1/3)\,(.785)\,(144\text{ ft}^2)\,(5\text{ ft})$$

**Divide 1 by 3.**

$$\text{Volume} = (0.3333)\,(.785)\,(144\text{ ft}^2)\,(5\text{ ft})$$

**Do the multiplication.**

$$\text{Volume} = 188.38116 \text{ or } 188\text{ ft}^3$$

Example 2: A cone has a radius of 4 feet. It has a height of 8 feet. Determine the volume of the cone in cubic feet.

**Write down the formula.**

$$\text{Volume} = (1/3)(\pi)(\text{Radius}^2)(\text{Height})$$

**Make a table of data.**

$\pi$ = 3.14159

Radius = 4 feet

Height = 4 feet

**Plug the data into the formula.**

$$\text{Volume} = (1/3)(3.14159)(4\text{ ft})^2(4\text{ ft})$$

**Square the radius.**

$$\text{Volume} = (1/3)(3.14159)(16\text{ ft}^2)(4\text{ ft})$$

**Divide 1 by 3.**

$$\text{Volume} = (0.3333)(3.14159)(16\text{ ft}^2)(4\text{ ft})$$

**Do the multiplication.**

$$\text{Volume} = 67.013884608 \text{ or } 67\text{ ft}^3$$

Practice Problems

1. A cone has a radius of 25 feet, and a depth of 11 feet. What is the volume of the cone in cubic feet?

2. Determine the volume in cubic feet for a cone that has a diameter of 10 feet, and a depth of 3 feet.

3. What is the volume of a cone in cubic feet if it has a radius of 3 feet, and a height of 4 feet?

4. Calculate the volume in cubic feet for a cone that has a diameter of 16 feet if its height is 12 feet.

5. What is the volume in cubic feet for a cone that has a radius of 7 feet and a height of 4 feet?

6. A cone has a radius of 4 feet, and a depth of 3 feet. What is the volume of the cone in cubic feet?

7. Determine the volume in cubic feet for a cone that has a diameter of 12 feet, and a depth of 6 feet.

8. What is the volume of a cone in cubic feet if it has a radius of 32 feet, and a height of 12 feet?

9. Calculate the volume in cubic feet for a cone that has a diameter of 6 feet if its height is 2 feet.

10. What is the volume in cubic feet for a cone that has a radius of 2 feet and a height of 3 feet?

11. A cone has a radius of 1.5 feet, and a depth of 2 feet. What is the volume of the cone in cubic feet?

12. Determine the volume in cubic feet for a cone that has a diameter of 4 feet, and a depth of 2 feet.

13. What is the volume of a cone in cubic feet if it has a radius of 6 feet, and a height of 3 feet?

14. Calculate the volume in cubic feet for a cone that has a diameter of 4 feet if its height is 3 feet.

15. What is the volume in cubic feet for a cone that has a radius of 4 feet and a height of 3 feet?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 7,199 $ft^3$ | 2. 78.5 $ft^3$ | 3. 38 $ft^3$ | 4. 804 $ft^3$ | 5. 205 $ft^3$ |
| 6. 50 $ft^3$ | 7. 226 $ft^3$ | 8. 12,868 $ft^3$ | 9. 19 $ft^3$ | 10. 13 $ft^3$ |
| 11. 5 $ft^3$ | 12. 8 $ft^3$ | 13. 113 $ft^3$ | 14. 13 $ft^3$ | 15. 50 $ft^3$ |

# Lateral Area

The ABC & $C_2EP$ Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams provides this formula for calculating the lateral area of a cone.

$$\text{Area of a Cone (lateral area)} = (\pi)\,(\text{Radius})\sqrt{\text{Radius}^2 + \text{Height}^2}$$

Example: A cone has a radius of 6 feet and a height of 5 feet. Determine the lateral area in square feet for the triangle.

**Write down the formula.**

$$\text{Area of a Cone (lateral area)} = (\pi)\,(\text{Radius})\sqrt{\text{Radius}^2 + \text{Height}^2}$$

**Make a table of data.**

$\pi$ = 3.14159

Radius = 6 feet

Height = 5 feet

**Plug the data into the formula.**

$$\text{Area of a Cone (lateral area)} = (3.14159)\,(6\text{ ft})\sqrt{(6\text{ ft})^2 + (5\text{ ft})^2}$$

**Square the numbers under the square root sign.**

$$\text{Area of a Cone (lateral area)} = (3.14159)\,(6\text{ ft})\sqrt{36\text{ ft}^2 + 25\text{ ft}^2}$$

**Add the numbers under the square root sign.**

$$\text{Area of a Cone (lateral area)} = (3.14159)\,(6\text{ ft})\sqrt{61\text{ ft}^2}$$

**Find the square root of the number.**

$$\text{Area of a Cone (lateral area)} = (3.14159)\,(6\text{ ft})\,7.8102\text{ ft}$$

**Do the multiplication.**

$$\text{Area of a Cone (lateral area)} = (3.14159)\,(6\text{ ft})\,7.8102\text{ ft}$$

### *Practice Problems*

1. A cone has a radius of 4 feet. It has a height of 8 feet. What is the lateral area of the cone in square feet?

2. What is the lateral area in square feet for a cone that has a radius of 8 feet and a height of 4 feet?

3. Determine the lateral area in square feet for a cone with a radius of 6 feet, and a height of 8 feet.

4. Calculate the lateral area in square feet for a cone if its radius is 10 feet, and its height is 7 feet.

5. A cone has a radius of 7 feet and a height of 6 feet. Determine its lateral area in square feet.

6. A cone has a radius of 45 feet. It has a height of 3 feet. What is the lateral area of the cone in square feet?

7. What is the lateral area in square feet for a cone that has a radius of 60 feet and a height of 2.5 feet?

8. Determine the lateral area in square feet for a cone with a radius of 3 feet, and a height of 2 feet.

9. Calculate the lateral area in square feet for a cone if its radius is 4 feet, and its height is 2 feet.

10. A cone has a radius of 5 feet and a height of 4 feet. Determine its lateral area in square feet.

11. A cone has a radius of 7 feet. It has a height of 4 feet. What is the lateral area of the cone in square feet?

12. What is the lateral area in square feet for a cone that has a radius of 5 feet and a height of 3 feet?

13. Determine the lateral area in square feet for a cone with a radius of 4 feet, and a height of 6 feet.

14. Calculate the lateral area in square feet for a cone if its radius is 5 feet, and its height is 8 feet.

15. A cone has a radius of 6 feet and a height of 6 feet. Determine its lateral area in square feet.

### *Answers*

| | | | | |
|---|---|---|---|---|
| 1. 112 $ft^2$ | 2. 225 $ft^2$ | 3. 188 $ft^2$ | 4. 383 $ft^2$ | 5. 203 $ft^2$ |
| 6. 6,376 $ft^2$ | 7. 11,320 $ft^2$ | 8. 34 $ft^2$ | 9. 56 $ft^2$ | 10. 101 $ft^2$ |
| 11. 177 $ft^2$ | 12. 92 $ft^2$ | 13. 91 $ft^2$ | 14. 148 $ft^2$ | 15. 160 $ft^2$ |

# Total Surface Area

The ABC & $C_2EP$ Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams provides this formula for calculating the total surface area of a cone.

$$\text{Area of a Cone (total surface area)} = (\pi)(\text{Radius})\left((\text{Radius} + \sqrt{\text{Radius}^2 + \text{Height}^2}\right)$$

Example: A cone has a radius of 5 feet, and a height if 6 feet. What is the total surface area in square feet for the cone?

**Write down the formula.**

$$\text{Area of a Cone (total surface area)} = (\pi)(\text{Radius})\left((\text{Radius} + \sqrt{\text{Radius}^2 + \text{Height}^2}\right)$$

**Make a table of data.**

$\pi$ = 3.14159

Radius = 5 ft

Height = 6 ft

**Plug the data into the formula.**

$$\text{Area of a Cone (total surface area)} = (3.14159)(5\text{ ft})\left(5\text{ ft} + \sqrt{(5\text{ ft})^2 + (6\text{ ft})^2}\right)$$

**Square the numbers under the square root sign.**

$$\text{Area of a Cone (total surface area)} = (3.14159)(5\text{ ft})\left(5\text{ ft} + \sqrt{25\text{ ft}^2 + 36\text{ ft}^2}\right)$$

**Add the numbers under the square root sign.**

$$\text{Area of a Cone (total surface area)} = (3.14159)(5\text{ ft})\left(5\text{ ft} + \sqrt{61\text{ ft}^2}\right)$$

**Find the square root of the number.**

$$\text{Area of a Cone (total surface area)} = (3.14159)(5\text{ ft})(5\text{ ft} + 7.8102\text{ ft})$$

**Add the numbers inside the parentheses.**

$$\text{Area of a Cone (total surface area)} = (3.14159)(5\text{ ft})(12.8102\text{ ft})$$

**Do the multiplication.**

$$\text{Area of a Cone (total surface area)} = 201.22198109 \text{ or } 201 \text{ ft}^2$$

***Practice Problems***

1. A cone has a radius of 4 feet. It has a height of 8 feet. What is the total surface area of the cone in square feet?

2. What is the total surface area in square feet for a cone that has a radius of 8 feet and a height of 4 feet?

3. Determine the total surface area in square feet for a cone with a radius of 6 feet, and a height of 8 feet.

4. Calculate the total surface area in square feet for a cone if its radius is 10 feet, and its height is 7 feet.

5. A cone has a radius of 7 feet and a height of 6 feet. Determine its total surface area in square feet.

6. A cone has a radius of 45 feet. It has a height of 3 feet. What is the total surface area of the cone in square feet?

7. What is the total surface area in square feet for a cone that has a radius of 60 feet and a height of 2.5 feet?

8. Determine the total surface area in square feet for a cone with a radius of 3 feet, and a height of 2 feet.

9. Calculate the total surface area in square feet for a cone if its radius is 4 feet, and its height is 2 feet.

10. A cone has a radius of 5 feet and a height of 4 feet. Determine its total surface area in square feet.

11. A cone has a radius of 7 feet. It has a height of 4 feet. What is the total surface area of the cone in square feet?

12. What is the total surface area in square feet for a cone that has a radius of 5 feet and a height of 3 feet?

13. Determine the total surface area in square feet for a cone with a radius of 4 feet, and a height of 6 feet.

14. Calculate the total surface area in square feet for a cone if its radius is 5 feet, and its height is 8 feet.

15. A cone has a radius of 6 feet and a height of 6 feet. Determine its total surface area in square feet.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 163 $ft^2$ | 2. 426 $ft^2$ | 3. 302 $ft^2$ | 4. 698 $ft^2$ | 5. 357 $ft^2$ |
| 6. 12,738 $ft^2$ | 7. 22,629 $ft^2$ | 8. 62 $ft^2$ | 9. 106 $ft^2$ | 10. 179 $ft^2$ |
| 11. 331 $ft^2$ | 12. 170 $ft^2$ | 13. 141 $ft^2$ | 14. 227 $ft^2$ | 15. 273 $ft^2$ |

# Average

This formula is provided for calculating the average, or arithmetic mean, for a number of measurements or terms.

$$\text{Average} = \frac{\text{Sum of All Terms}}{\text{Number of Terms}}$$

Example: During a drop test on a filter the water level was allowed to drop six inches. The water level was dropped three times. The time required for the water level over the filter to drop six inches was:

$$\text{Test}_1 = 96 \text{ sec}$$

$$\text{Test}_2 = 99 \text{ sec}$$

$$\text{Test}_3 = 95 \text{ sec}$$

What was the average time in seconds required for the water to drop six inches during the drop test?

**Write down the formula.**

$$\text{Average} = \frac{\text{Sum of All Terms}}{\text{Number of Terms}}$$

**Make a table of data.**

$$\text{Test}_1 = 96 \text{ sec}$$

$$\text{Test}_2 = 99 \text{ sec}$$

$$\text{Test}_3 = 95 \text{ sec}$$

$$\text{Number of terms} = 3$$

**Plug the data into the formula.**

$$\text{Average} = \frac{96 \text{ sec} + 99 \text{ sec} + 95 \text{ sec}}{3}$$

**Add the numbers above the line.**

$$\text{Average} = \frac{96 \text{ sec} + 99\,290 \text{ sec}}{3}$$

**Divide the number above the line by the number below the line.**

Average = 96.666666666666 or 97 sec

***Practice Problems***

1. During the month of March an operator sampled and monitored the raw water for total alkalinity a total of 7 times. The following results were obtained.

$Test_1$ = 110 mg/L as $CaCO_3$

$Test_2$ = 114 mg/L as $CaCO_3$

$Test_3$ = 107 mg/L as $CaCO_3$

$Test_4$ = 111 mg/L as $CaCO_3$

$Test_5$ = 99 mg/L as $CaCO_3$

$Test_6$ = 102 mg/L as $CaCO_3$

$Test_7$ = 110 mg/L as $CaCO_3$

What was the average total alkalinity concentration, in mg/L as $CaCO_3$, for the month.

2. During a drop test on a filter the water level was allowed to drop six inches. The water level was dropped three times. The time required for the water level over the filter to drop six inches was:

$Test_1$ = 126 sec

$Test_2$ = 132 sec

$Test_3$ = 128 sec

What was the average time in seconds required for the water to drop six inches during the drop test?

3. During the month of August the length of each filter run was as follows:

96 hours

98 hours

94 hours

106 hours

90 hours

84 hours

62 hours

90 hours

What was the average filter run in hours?

4. Last year an operator bought four shipments of bleach. The first shipment the bleach cost $0.82/gal. The cost for the subsequent bleach purchases were $0.79/gal, $0.85/gal and $0.81/gal, respectively. Calculate the average cost per gallon for the bleach.

5. While calibrating a lime feeder, an operator collected three samples of lime as it fell from the feeder, at a feeder setting of 100 percent. The samples were collected for three minutes. This process was repeated for each major feeder setting. The first sample collected had a mass of 497 grams. The second sample had a mass of 502 grams. The third sample had a mass of 512 grams. What was the average sample mass in grams.

6. An operator gathered the data required for preparing a calibration curve for a liquid alum feeder. At each major setting the operator pumped liquid alum out of a 500-mL graduated cylinder for three minutes. At a pump setting of 40 percent, the volume of the three samples were 475 mL, 480 mL and 470 mL, respectively. What was the average volume of the samples taken at this feeder setting?

7. During calendar year 2014 an operator purchased six shipments of liquid alum. The costs of the shipments were $1,890 for the first shipment. The subsequent shipments cost $1,920, $1,895, $1,900, $1,825, and $1,899. What was the average cost of a shipment of liquid alum?

8. During the previous week's operations, the amount of liquid caustic fed on each day of the week was a follows.

Monday = 225 gal

Tuesday = 232 gal

Wednesday = 222 gal

Thursday = 234 gal

Friday = 227 gal

Saturday = 230 gal

Sunday = 231 gal

What was the average liquid caustic feed rate in gallons per day during that week?

9. During the previous week, the water plant was operated for the following hours.

Monday = 14 hours

Tuesday = 16 hours

Wednesday = 18 hours

Thursday = 17 hours

Friday = 19 hours

Saturday = 12 hours

Sunday = 14 hours

Determine the average hours per day for plant operations during that week.

10. During the month of March an operator sampled and monitored the raw water for total alkalinity a total of 7 times. The following results were obtained.

$Test_1$ = 117 mg/L as $CaCO_3$

$Test_2$ = 114 mg/L as $CaCO_3$

$Test_3$ = 127 mg/L as $CaCO_3$

$Test_4$ = 121 mg/L as $CaCO_3$

$Test_5$ = 97 mg/L as $CaCO_3$

$Test_6$ = 132 mg/L as $CaCO_3$

$Test_7$ = 120 mg/L as $CaCO_3$

What was the average total alkalinity concentration, in mg/L as $CaCO_3$, for the month.

11. During a rise test on a filter the water level was allowed to drop six inches. The water level was allowed to rise three times. The time required for the water level over the filter to rise six inches was:

$Test_1$ = 12 sec

$Test_2$ = 14 sec

$Test_3$ = 13 sec

What was the average time in seconds required for the water to rise six inches during the rise test?

12. During the month of August the length of each filter run was as follows:

106 hours

108 hours

104 hours

106 hours

110 hours

114 hours

102 hours

What was the average filter run I hours?

13. Last year an operator bought four shipments of bleach. The first shipment the bleach cost $0.89/gal. The cost for the subsequent bleach purchases were $0.92/gal, $0.86/gal and $0.84/gal, respectively. Calculate the average cost per gallon for the bleach.

14. While calibrating a lime feeder, an operator collected three samples of lime as it fell from the feeder, at a feeder setting of 100 percent. The samples were collected for three minutes. This process was repeated for each major feeder setting. The first sample collected had a mass of 697 grams. The second sample had a mass of 702 grams. The third sample had a mass of 712 grams. What was the average sample mass in grams.

15. An operator gathered the data required for preparing a calibration curve for a liquid alum feeder. At each major setting the operator pumped liquid alum out of a 500-mL graduated cylinder for three minutes. At a pump setting of 40 percent, the volume of the three samples were 485 mL, 480 mL and 482 mL, respectively. What was the average volume of the samples taken at this feeder setting?

***Answers***

| | | | |
|---|---|---|---|
| 1. 108 mg/L as $CaCO_3$ | | 2. 129 sec | 3. 90 hours |
| 4. $0.82/gal | 5. 504 grams | 6. 475 mL | |
| 7. $1,888 | 8. 229 gal | 9. 16 hours | |
| 10. 118 mg/L as $CaCO_3$ | | 11. 13 sec | 12. 107 hours |
| 13. $0.88 | 14. 704 grams | 15. 482 mL | |

# Coagulation/Flocculation

Coagulation/flocculation math involves determining the detention time in seconds for flash mix basins, and the detention time in minutes for flocculation basins.

This formula is provided for determining the detention time.

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

## Detention Time, secs

Flash mix basins are designed to have a detention time of 30 seconds or less.

Example 1: The flash mix basin at a water treatment plant has a volume of 100 gallons. Water flows through the basin at a rate of 200 gallons per minute. Calculate the detention time in seconds for the basin.

**Write down the formula.**

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

**Make a table of data.**

Volume = 100 gal

Flow, gal/min = 200 gal/min ÷ 60 sec/min = 3.3333 gal/sec

**Plug the data into the formula.**

$$\text{Detention Time} = \frac{100 \text{ gal}}{3.3333 \text{ gal/sec}}$$

**Divide the number above the line by the number below the line.**

$$\text{Detention Time} = 30.0003 \text{ or } 30 \text{ sec}$$

Example 2. The flash mix basin at a water treatment plant is 4 feet long, 4 feet wide, and 8 feet deep. Water flows through the basin at a rate of 5.1 cubic feet per second. Calculate the detention time in seconds for the basin.

***Step One: Calculate the volume of the basin in cubic feet.***

**Write down the formula.**

$$\text{Volume} = (\text{Length})\,(\text{Width})\,(\text{Depth})$$

**Make a table of data.**

length, ft = 4 ft

width, ft = 4 ft

depth, ft = 8 ft

**Plug the data into the formula.**

$$\text{Volume} = (4\text{ ft})\,(4\text{ ft})\,(8\text{ ft})$$

**Do the multiplication.**

$$\text{Volume} = 128\text{ ft}^3$$

***Step Two: Calculate the detention time in seconds.***

**Write down the formula.**

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

**Make a table of data.**

Volume = 128 $\text{ft}^3$

Flow = 5.1 $\text{ft}^3$/sec

**Plug the data into the formula.**

$$\text{Detention Time} = \frac{128\text{ ft}^3}{5.1\,\text{ft}^3/\text{sec}}$$

**Divide the number above the line by the number below the line.**

$$\text{Detention Time} = 25.09803922 \text{ or } 25\text{ sec}$$

### *Practice Problems*

1. A flash mix basin at a water treatment plant has a volume of 100 gallons. Water flows through the basin at a rate of 4 gallons per second. Determine the detention time for the basin in seconds.

2. The flash mix basin at a water treatment plant has a volume of 250 gallons. Water is treated at a rate of 1,042 gallons per minute. What is the detention time in seconds for the basin?

3. Determine the detention time in seconds for a flash mix with a volume of 54 cubic feet if water is treated at a rate of 3,500,000 gal/day.

4. Calculate the detention time in seconds for a flash mix, which is 4 feet long, 4 feet wide, and 5 feet deep when water is treated at a rate of 4.3 $ft^3$/sec.

5. A flash mix basin at a water treatment plant is 5 feet long, 5 feet wide, and 7 feet deep. Water flows through the basin at a rate of 6,000,000 gallons per day. Determine the detention time for the basin in seconds.

6. The flash mix basin at a water treatment plant is 6 feet long, 4 feet wide, and 7 feet deep. Water is treated at a rate of 603 cubic feet per min. What is the detention time in seconds for the basin?

7. Determine the detention time in seconds for a flash mix basin which is 4.5 feet long, 3.5 feet wide, and 5 feet deep if water is treated at a rate of 2,000,000 gal/day.

8. Calculate the detention time in seconds for a flash mix basin which is 6 feet long, 4 feet wide, and 6 feet deep when water is treated at a rate of 4,700,000 gal/day.

9. A flash mix basin at a water treatment plant is 7 feet long, 7 feet wide, and 11 feet deep. Water flows through the basin at a rate of 13,500,000 gallons per day. Determine the detention time for the basin in seconds.

10. The flash mix basin at a water treatment plant is 6 feet long, 6 feet wide, and 9 feet deep. Water is treated at a rate of 15,500,000 gallons per day. What is the detention time in seconds for the basin?

11. Determine the detention time in seconds for a flash mix basin which is 6.25 feet long, 5.25 feet wide, and 8 feet deep if water is treated at a rate of 4,250,000 gal/day.

12. Calculate the detention time in seconds for a flash mix basin which is 6 feet long, 3 feet wide, and 2.5 feet deep when water is treated at a rate of 2,750,000 gal/day.

13. At Lavergne's water treatment plant there are two flash mix basins, each of which is 6 feet long, 6 feet wide, and 7.5 feet deep. Water is treated at a rate of 18,000,000 gallons per day. Calculate the detention time in seconds for the flash mix basins.

14. The water treatment plant at South Pittsburg has two flash mix basins. Each of the basins is 5 feet long, 5 feet wide, and 6 feet deep. Determine the detention time in seconds for the basins if water is treated at a rate of 32,000,000 gallons per day.

15. There are two flash mix basins at Woodbury's water treatment plant, each of which is 3 feet long, 3 feet wide, and 4.5 feet deep. Water is treated at a rate of 5,500,000 gallons per day.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 25 sec | 2. 14 sec | 3. 10 sec | 4. 19 sec | 5. 19 sec |
| 6. 17 sec | 7. 25 sec | 8. 20 sec | 9. 26 sec | 10. 14 sec |
| 11. 40 sec | 12. 11 sec | 13. 19 sec | 14. 6 sec | 15. 10 sec |

# Detention Time, Minutes

Flocculation basins are designed to have a detention time of at least 30 minutes, with 45 minutes being preferable.

Example 1: The flocculation basins at a water treatment plant have a volume of 74,760 gallons. Water flows through the basin at a rate of 1,780 gallons per minute. Calculate the detention time in minutes for the basin.

**Write down the formula.**

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

**Make a table of data.**

Volume = 74,760 gal

Flow, gal/min = 1,780 gal/min

**Plug the data into the formula.**

$$\text{Detention Time} = \frac{74{,}760 \text{ gal}}{1{,}780 \text{ gal/min}}$$

**Divide the number above the line by the number below the line.**

$$\text{Detention Time} = 42 \text{ min}$$

Example 2. The flocculation basins at a water treatment plant have a depth of 12 feet, a width of 12 ft, and a length of 81 feet. Water flows through the basins at a rate of 306 cubic feet per minute. Calculate the detention time in seconds for the basins.

***Step One: Calculate the volume of the basin in cubic feet.***

**Write down the formula.**

$$\text{Volume} = (\text{Length})\,(\text{Width})\,(\text{Depth})$$

**Make a table of data.**

length, ft = 81 ft

width, ft = 12 ft

depth, ft = 12 ft

**Plug the data into the formula.**

$$\text{Volume} = (81\,\text{ft})\,(12\text{ ft})\,(12\text{ ft})$$

**Do the multiplication.**

$$\text{Volume} = 11{,}664\text{ ft}^3$$

***Step Two: Calculate the detention time in minutes.***

**Write down the formula.**

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

**Make a table of data.**

$$\text{Volume} = 11{,}664\text{ ft}^3$$

$$\text{Flow} = 306\text{ ft}^3/\text{min}$$

**Plug the data into the formula.**

$$\text{Detention Time} = \frac{11{,}664\text{ ft}^3}{306\text{ ft}^3/\text{min}}$$

**Divide the number above the line by the number below the line.**

$$\text{Detention Time} = 38.11764706 \text{ or } 38\text{ min}$$

***Practice Problems***

1. A flocculation basin at a water treatment plant has a volume of 52,000 gallons. Water flows through the basin at a rate of 1,125 gallons per minute. Determine the detention time for the basin in minutes.

2. The flocculation basin at a water treatment plant has a volume of 25,000 gallons. Water is treated at a rate of 695 gallons per minutes. What is the detention time in minutes for the basin?

3. Determine the detention time in minutes for a flocculation basin with a volume of 2,005 cubic feet if water is treated at a rate of 44 cfm.

4. Calculate the detention time in minutes for a flocculator with a volume of 32,000 gallons when water is treated at a rate of 750,000 gal/day.

5. A flocculation basin at a water treatment plant is 60 feet long, 12 feet wide, and 14 feet deep. Water flows through the basin at a rate of 274 cfm. Determine the detention time for the basin in minutes.

6. There are two flocculation basins at a water treatment plant. The flocculation basins are 60 feet long, 15 feet wide, and 16 feet deep. Water is treated at a rate of 8,500,000 gallons per day. What is the detention time in minutes for the basins?

7. There are two flocculation basins at a water plant. Determine the detention time in minutes if a flocculation basin is 35 feet long, 13 feet wide, and 12 feet deep if water is treated at a rate of 255 cfm.

8. Calculate the detention time in minutes for two flocculation basins which are 58 feet long, 14 feet wide, and 12.5 feet deep when water is treated at a rate of 4,250,000 gal/day.

9. A water treatment plant has four flocculation basins, each of which is 50 feet long, 16 feet wide, and 16 feet deep. Water is treated at a rate of 13,175,000 gal/day. Determine the detention time in minutes for the flocculation basins.

10. There are four flocculation basins at a water treatment plant. Each basin is 50 feet long, 13 feet wide and 12 feet deep. Water is treated at a rate of 8,850,000 gal/day. Calculate the detention time in minutes for the basins.

11. A water treatment plant has two flocculation basins, each of which is 30 feet long, 12 feet wide, and 13 feet deep. Water is treated at a rate of 2,300,000 gal/day. Determine the detention time in minutes for the flocculation basins.

12. There are four flocculation basins at a water treatment plant. Each basin is 100 feet long, 13 feet wide and 14 feet deep. The basins are operated in parallel. Water is treated at a rate of 17,500,000 gal/day. Calculate the detention time in minutes for the basins.

13. At Jasper's water treatment plant there are four flocculation basins. One is out of service. The basins are 80 feet long, 12 feet wife, and 12 feet deep. Determine the detention time in minutes for the basins if water is treated at a rate of 9,750,000 gallons per day.

14. Each of the four flocculation basins at a water treatment plant are 75 feet long, 10 feet wide, and 11 feet deep. One of the basins is out of service for maintenance. Water is treated at a rate of 7,250,000 gallons per day. What is the detention time in minutes for the basins in service?

15. At Cookeville's water treatment plant there are four flocculation basins. Water is treated at a rate of 16,500,000 gallons per day. One of the basins is out of service for maintenance. Each basin is 90 feet long, 13 feet wide, and 14 feet deep. Calculate the detention time in minutes for the basins.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 46 mins | 2. 36 mins | 3. 46 mins | 4. 61 mins | 5. 37 mins |
| 6. 36 mins | 7. 43 mins. | 8. 51 mins | 9. 42 mins | 10. 38 mins |
| 11. 44 mins | 12. 45 mins | 13. 38 mins | 14. 37 mins | 15. 32 mins |

# Sedimentation

These are the sedimentation calculations you may be asked to perform on the certification exam.

- Detention Time, hours
- Weir Overflow Rate, gal/day/ft
- Surface Overflow (Surface Loading) Rate, gal/day/ft$^2$

## Detention Time, hrs

The detention time is hours for various types of sedimentation basis is:

Conventional Sedimentation – Turbidity Removal 4.0 hours

Conventional Sedimentation – Iron Removal 3.0 hours

Sedimentation Basins equipped with tube settlers 1.0 hours

This formula is provided for calculating detention time in hours.

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

Example 1: A sedimentation basin has a volume of 145,000 gallons. Water flows through the basin at a rate of 36,250 gallons per hour. What is the detention time in hours for the basin?

**Write down the formula.**

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

**Make a table of data.**

Volume, gal = 145,000 gal

Flow, gph = 36,250 gph

**Plug the data into the formula.**

$$\text{Detention time} = \frac{145{,}000 \text{ gal}}{36{,}250 \text{ gph}}$$

**Divide the numbers above the line by the number below the line.**

$$\text{Detention time, hr} = 4.0\ \text{hr}$$

Example 2: There are two sedimentation basins at a water treatment plant, each of which is 70 feet long, 25 feet wide, and 13 feet deep. Water is treated at a rate of 3.2 cubic feet per second. What is the detention time in hours for the basin?

***Step One: Determine the volume of each basin in cubic feet.***

**Write down the formula.**

$$\text{Volume} = (\text{Length})\,(\text{Width})\,(\text{Depth})$$

**Make a table of data.**

Length, ft = 70 ft

Width, ft = 25

Depth, ft = 13 ft

**Plug the data into the formula.**

$$\text{Volume} = (70\ \text{ft})\,(25\ \text{ft})\,(13\ \text{ft})$$

**Do the multiplication.**

$$\text{Volume} = 22{,}750\ \text{ft}^3$$

***Step Two: Determine the total sedimentation volume.***

$$22{,}750\ \text{ft}^3\ \text{X}\ 2\ \text{Basins} = 45{,}500\ \text{ft}^3$$

***Step Three: Calculate the detention time in hours.***

**Write down the formula.**

$$\text{Detention Time} = \frac{\text{Volume}}{\text{Flow}}$$

**Make a table of data.**

Volume = 45,500 $\text{ft}^3$

Flow = 3.2 $\text{ft}^3$/sec X 60 sec/min X 60 min/hr = 11,520 $\text{ft}^3$/hr

**Plug the data into the formula.**

$$\text{Detention time, hr} = \frac{45{,}500\ \text{ft}^3}{11{,}520\ \text{ft}^3/\text{hr}}$$

**Divide the numbers above the line by the number below the line.**

$$\text{Detention time, hr} = 3.949652778 \text{ or } 3.9\ \text{hr}$$

***Practice Problems***

1. A water plant has two sedimentation basins with a total volume of 52,807 $ft^3$. Water flows through the basins at a rate of 209 $ft^3$/min. What is the detention time in hours for the basins?

2. There are four sedimentation basins at a water plant, each of which is 100 ft. long, 25 feet wide and 14 feet deep. Water flows through the sedimentation basins at a rate of 6,750,000 gallons per day. Calculate the detention time in hours for the basins.

3. A plant has four sedimentation basins which are 120 feet long, 30 feet wide and 17 feet deep. Determine the detention time in hours for the sedimentation basins if water is flowing through the basins at a rate of 11.6 $ft^3$/sec.

4. What would the detention time in hours be for sedimentation basins with a total volume of 829,000 gallons if water is flowing through the basins at a rate of 3,000,000 gal/day?

5. A water plant has two sedimentation basins. Each sedimentation basin is 95 feet long, 25 feet wide, and 16 feet deep. Water is flowing through the basins at a rate of 3,250,000 gal/day. What is the detention time in hours for the basin?

6. Water flows through four sedimentation basins at a rate of 12,750,000 gal/day. Each basin is 140 feet long, 35 feet wide, and 17 feet deep. Calculate the detention time in hours for the basin.

7. The sedimentation basins at a water treatment plant are 150 feet long, 40 feet wide, and 16 feet deep. There are eight basins. Water flows through the basin at a rate of 35,500,000 gal/day. Determine the detention time in hours for the basins.

8. Water flows through four sedimentation basins which are 100 feet long, 25 feet wide, and 16 feet deep at a rate of 5,250,000 gal/day. What is the detention time in hours for the basins?

9. A water treatment plant has four sedimentation basins, each of which is 100 feet long, 25 feet wide and 16 feet deep. Water is treated at a rate of 16,750,000 gallons per day. What is the detention time in hours for the basins?

10. There are four sedimentation basins at a water treatment plant. Each basin is 97 feet in length, 24 feet in width, and 17 feet deep. Water is treated at a rate of 20,150,000 gallons per day. Calculate the detention time in hours for the sedimentation basins.

11. Each of the sedimentation basins at a water treatment plant is 95 feet long, 20 feet wide, and 17 feet deep. There are four sedimentation basins at the treatment plant. Water is treated at a rate of 11,250,000 gallons per day. Determine the detention time in hours for the basins.

12. There are two sedimentation basins at a water treatment plant. Each of the sedimentation basins is 60 feet long, 18 feet wide, and 14 feet deep. Water is treated at a rate of 6,570,000 gal/day. Calculate the detention time in hours for the remaining basins.

13. At Franklin water treatment plant there are four sedimentation basins, each of which is 120 feet in length, 30 feet in width, and 18 feet deep. One basin is out of service for cleaning. Water is treated at a rate of 12,540,000 gallons per day. What is the detention time in hours for the basins?

14. There are four sedimentation basins at Smyrna's water treatment plant. One of the basins has been taken out of service for cleaning. Each of the basins in 110 feet long, 26 feet wide, and 15 feet deep. Water is treated at a rate of 15,250,000 gallons per day. Determine the detention time in hours for basins.

15. Union City's water plant has four sedimentation basins, three of which are in service. Each basin is 98 feet long, 24 feet wide, and 16 feet deep. Calculate the detention time in hours for the operational basins, if water is treated at a rate of 17,500,000 gal/day.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 4.2 hrs | 2. 3.7 hrs | 3. 5.9 hrs | 4. 6.6 hrs | 5. 4.2 hrs |
| 6. 4.7 hrs | 7. 3.9 hrs | 8. 5.5 hrs | 9. 1.7 hrs | 10. 1.4 hrs |
| 11. 2.1 hrs | 12. 0.8 hrs | 13. 2.8 hrs | 14. 1.5 hrs | 15. 1.2 hrs |

# Surface Overflow Rate, gpd/ft$^2$

According to Tennessee's Design Criteria, the surface overflow rate shall be between 0.25 - 0.38 gpm/ft$^2$. for conventional sedimentation. That is equivalent to 547 gpd/ft$^2$.

This formula is provided for determining the surface overflow, or surface loading, rate.

$$\text{Surface Overflow Rate, gpd/ft}^2 = \frac{\text{Flow, gpd}}{\text{Area, ft}^2}$$

Example: A sedimentation basin has a surface area of 2,000 square feet. Water flows through the basin at a rate of 1,100,000 gallons per day. What is the surface loading rate in gallons per day per square foot for the basin?

**Write down the formula.**

$$\text{Surface Overflow Rate, gpd/ft}^2 = \frac{\text{Flow, gpd}}{\text{Area, ft}^2}$$

**Make a table of data.**

$$\text{Flow, gpd} = 1{,}100{,}000 \text{ gpd}$$

$$\text{Area, ft}^2 = 2{,}000 \text{ ft}^2$$

**Plug the data into the formula.**

$$\text{Surface Overflow Rate, gpd/ft}^2 = \frac{1{,}100{,}000 \text{ gpd}}{2{,}000 \text{ ft}^2}$$

**Cancel terms and multiply the numbers above the line.**

$$\text{Surface Overflow Rate, gpd/ft}^2 = 550 \text{ gpd/ft}^2$$

### *Practice Problems*

1. A sedimentation basin has a surface area of 1,400 square feet. Water flows through the basin at a rate of 650,000 gallons per day. What is the surface loading rate for the basin in gallons per day per square foot?

2. Determine the surface loading rate in gallons per day per square foot for a sedimentation basin with a surface area of 1,300 square feet if water flows through the basin at a rate of 600,000 gal/day.

3. The flow through a sedimentation basin is 500,000 gallons per day. The basin has a surface area of 1,200 square feet. Calculate the surface loading rate in gallons per day per square foot for the basin.

4. Calculate the surface loading rate in gallons per day per square foot for a sedimentation basin which is 110 feet long and 25 feet wide, if the flow through the basin is 1,500,000 gallons per day.

5. A sedimentation basin at a water plant is 100 feet long, 25 feet wide, and 12 feet deep. Water flows through the basin at a rate of 1,750,000 gallons per day. Calculate the surface loading rate in gallons per day per square foot of surface area.

6. Water flows through the sedimentation basins at a water plant at a rate of 1,250,000 gallons per day. Each of the sedimentation basins is 60 feet long, 30 feet wide, and 11 feet deep. There are two basins. What is the surface loading rate for the basins in gallons per day per square foot?

7. Determine the surface loading rate for a sedimentation basin which is 80 feet long, 20 feet wide, and 10 feet deep if water flows through the basin at a rate of 450,000 gallons per day.

8. There are four sedimentation basins at a water plant. Calculate the surface loading rate for a sedimentation basins, if each is 90 feet long, 25 feet wide, and 13 feet deep if water flows through the basins at a rate of 2,500,000 gallons per day.

9. A water treatment plant has two sedimentation basins, each of which is 110 feet in length, 30 feet in width, and 14 feet deep. Water is treated at a rate of 1,250,000 gallons per day. What is the surface loading rate for the basin in gallons per day per square foot of surface area?

10. The sedimentation basins at a water treatment plant are 120 feet long, 30 feet wide, and 14 feet deep. There are four sedimentation basins. Water is treated at a rate of 3,750,000 gallons per day. Determine the surface loading rate in gallons per day per square foot for the basins.

11. A water treatment plant has eight sedimentation basins. Determine the surface loading rate for the sedimentation basin if each is 105 feet long, 29 feet wide, and 13 feet deep if water is treated at a rate of 9,000,000 gallons per day.

12. Calculate the surface loading rate for a pair of sedimentation basin, each of which is 90 feet long, 24 feet wide, and 10 feet deep if water flows through the basins at a rate of 1,500,000 gallons per day.

13. A water treatment plant has six sedimentation basins, each of which is 100 feet in length, 25 feet in width, and 14 feet deep. Water is treated at a rate of 7,500,000 gallons per day. What is the surface loading rate for the basin in gallons per day per square foot of surface area?

14. The sedimentation basins at a water treatment plant are 90 feet long, 30 feet wide, and 11 feet deep. There are four sedimentation basins. Water is treated at a rate of 6,750,000 gallons per day. Determine the surface loading rate in gallons per day per square foot for the basins.

15. A water treatment plant has four sedimentation basins. The basins are 100 feet long, 30 feet wide, and 12 feet deep. One of the basins has been taken out of service for maintenance.

Calculate the surface loading rate in gallons per day per square foot if water is treated at a rate of 8,250,000 gallons per day.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 464 gpd/ft$^2$ | 2. 462 gpd/ft$^2$ | 3. 417 gpd/ft$^2$ | 4. 545 gpd/ft$^2$ | 5. 700 gpd/ft$^2$ |
| 6. 347 gpd/ft$^2$ | 7. 281 gpd/ft$^2$ | 8. 278 gpd/ft$^2$ | 9. 189 gpd/ft$^2$ | 10. 260 gpd/ft$^2$ |
| 11. 369 gpd/ft$^2$ | 12. 347 gpd/ft$^2$ | 13. 500 gpd/ft$^2$ | 14. 625 gpd/ft$^2$ | 15. 917 gpd/ft$^2$ |

# Weir Over Rate, gpd/ft

According to Tennessee's Design Criteria, an overflow weir should be installed which will establish the maximum water level desired on top of the filters. Adjustable V-notch weirs are preferred. Weir overflow rates shall be between 8 - 10 gpm/ft (11,520 – 14,400 gpd/ft) for raw water with low turbidity and 10 - 15 gpm/ft (14,400 – 21,600 gpd/ft) for raw water with high turbidity. It shall discharge with a free fall at a location where the discharge can be observed.

This formula is provided for calculating the weir overflow rate.

$$\text{Weir Overflow Rate, gpd/ft} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

Example: A sedimentation basin has a weir which is 87 feet long. Water flows through the basin at a rate of 1,000,000 gallons per day. What is the weir overflow rate in gallons per day per foot of weir for the basin?

**Write down the formula.**

$$\text{Weir Overflow Rate, gpd/ft} = \frac{\text{Flow, gpd}}{\text{Weir Length, ft}}$$

**Make a table of data.**

Flow, gpd = 1,000,000 gpd

Length of weir, ft = 87 ft

**Plug the data into the formula.**

$$\text{Weir Overflow Rate, gpd/ft} = \frac{1{,}000{,}000\ \text{gpd}}{87\ \text{ft}}$$

**Do the multiplication.**

$$\text{Weir Overflow Rate, gpd/ft} = 11{,}494.258\,735 \text{ or } 11{,}494\ \text{gpd/ft}$$

***Practice Problems***

1. The effluent weir on a sedimentation basin is 90 feet long. Water flows through the basin at a rate of 675,000 gallons per day. What is the weir overflow rate in gallons per day per foot of weir for the basin?

2. Calculate the weir overflow rate in gallons per day per foot of weir if the effluent weir is 50 feet long and water flows through the basin at a rate of 450,000 gallons per day.

3. Determine the weir overflow rate in gallons per day per foot of weir for a sedimentation basin if the effluent weir is 80 feet long, and water flows through the basin at a rate of 400,000 gallons per day.

4. What would the weir overflow rate in gallons per day per foot of weir be for a plant with four sedimentation basins, each with an effluent weir which is 90 feet long if water flows through the basin at a rate of 1,000,000 gallons per day?

5. The effluent weirs on the sedimentation basins are 100 feet in length. There are four sedimentation basins. Water flows through the basins at a rate of 3,750,000 gallons per day. What is the weir overflow rate in gallons per day per foot of weir?

6. A water treatment plant has two sedimentation basins. Each basin has an effluent weir which is 120 feet long. Water is treated at a rate of 3,500,000 gallons per day. Calculate the weir overflow rate for the basins in gallons per day per foot of weir.

7. There are four sedimentation basins at a water treatment plant. The effluent weir in each basin is 90 feet in length. Water is treated at a rate of 2,750,000 gallons per day. Determine the weir overflow rate in gallons per day per foot of weir.

8. The effluent weirs in the sedimentation basins at a water treatment plant are 110 feet long. There are four sedimentation basins. Water flows through the plant at a rate of 4,000,000 gallons per day. What is the weir overflow rate in gallons per day per foot of weir?

9. The effluent weirs on the sedimentation basins at a water treatment plant are 80 feet in length. There are eight sedimentation basins. Water flows through the plant at a rate of 9,750,000 gallons per day. What is the weir overflow rate in gallons per day per foot of weir?

10. A water treatment plant has six sedimentation basins. Each basin has an effluent weir, which is 90 feet long. Water is treated at a rate of 4,500,000 gallons per day. Calculate the weir overflow rate for the basins in gallons per day per foot of weir.

11. There are four sedimentation basins at a water treatment plant. The effluent weir in each basin is 80 feet in length. Water is treated at a rate of 2,500,000 gallons per day. Determine the weir overflow rate in gallons per day per foot of weir.

12. The effluent weirs in the sedimentation basins at a water treatment plant are 60 feet long. There are four sedimentation basins. Water flows through the plant at a rate of 1,800,000 gallons per day. What is the weir overflow rate in gallons per day per foot of weir?

13. There are four circular clarifiers at a water treatment plant. Each clarifier is 100 feet in diameter, with circular weirs. The diameter of the weirs is 97 feet. Water is treated at a rate of 5,750,000 gallons per day. Calculate the weir overflow rate in gallons per day per foot of weirs.

14. There are six circular clarifiers at a water treatment plant, each of which is 90 feet in diameter. Each has a circular weir, which is 87 feet in diameter. Water is treated at a rate of 6,250,000 gal/day. One is out of service for maintenance. What is the weir over flow rate on gallons per day per foot of weir of the basins?

15. At Lebanon's water treatment plant there are eight circular clarifiers. Each of the clarifiers is 95 feet in diameter. Each is equipped with a weir, which is 92 feet in diameter. Two of the

basins are out of service. Water is treated at a rate of 6,500,000 gal/day. Determine the weir overflow rate in gallons per day per foot of weir.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 7,500 gpd/ft | 2. 9,000 gpd/ft | 3. 5,000 gpd/ft | 4. 2,778 gpd/ft | 5. 9,375 gpd/ft |
| 6. 14,583 gpd/ft | 7. 7,639 gpd/ft | 8. 9,091 gpd/ft | 9. 15,234 gpd/ft | 10. 8,333 gpd/ft |
| 11. 7,813 gpd/ft | 12. 7,500 gpd/ft | 13. 4,720 gpd/ft | 14. 4,576 gpd/ft | 15. 3,750 gpd/ft |

# Filtration

## Filtration Rate or Backwash Rate, gal/min/ft$^2$

This formula is provided for calculating the flow rate or backwash rate in gallons per minute per square foot.

$$\text{Filter Flow Rate or Backwash Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter Area, ft}^2}$$

Example: A filter bed has an area of 375 square feet. Water flows through the filter at a rate of 1,050 gal/min. Calculate the filtration rate in gallons per minute per square foot.

**Write down the formula.**

$$\text{Filter Flow Rate or Backwash Rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Filter Area, ft}^2}$$

**Make a table of data.**

$$\text{Flow, gpm} = 1{,}050 \text{ gpm}$$

$$\text{Filter Area, ft}^2 = 375 \text{ ft}^2$$

**Plug the data into the formula.**

$$\text{Filter Flow Rate or Backwash Rate, gpm/ft}^2 = \frac{1{,}050 \text{ gpm}}{375 \text{ ft}^2}$$

**Divide the number above the line by the number below the line.**

$$\text{Filter Flow Rate or Backwash Rate, gpm/ft}^2 = 2.8 \text{ gal/min/ft}^2$$

***Practice Problems***

1. A filter bed has an area of 195 square feet. Water passes through the filter at a rate of 644 gal/min. What is the filtration rate in gallons per minute per square foot?

2. A filter bed has an area of 500 square feet. Water flows through the filter bed at a rate of 1,450 gallons per minute. Determine the filtration rate in gallons per minute per square foot.

3. There are 8 filters at a water treatment plant. Each filter has a bay which is 24 feet long and 15 feet wide. Each filter's sand bed has an area of 315 square feet. A drop test was performed on one of the filters. During the drop test water flowed through the filter at a rate of 788 gallons per minute. Determine the filtration rate in gallons per minute per square foot.

4. Water flows through a filter at a rate of 1,232 gal/min. The filter bed has an area of 560 square feet. What was the filtration rate in gallons per minute per square foot?

5. A hook gage test was run on a filter. The water level over the filter was allowed to drop six inches. The filter bed has an area of 300 square feet. Water flowed through the filter at a rate of 630 gal/min during the test. Determine the filtration rate in gallons per minute per square foot.

6. Using a hook gauge, an operator performed a drop test on a filter. The filter bed is 26 feet long and 20 feet wide. During the test water flowed through the filter at a rate of 1,144 gal/min. Calculate the filtration rate in gallons per minute per square foot.

7. An operator performed a drop test on filter, during which water flowed through the filter at a rate of 316 gal/min. The filter bed was 9 feet long and 9 feet wide. Determine the filtration rate in gallons per minute per square foot of filter surface.

8. There are 27 filters at a water treatment plant. Each of the filters has a bay which is 30 feet long and 20 feet wide. Each filter bed is 27 feet long and 20 feet wide. During a drop test of one of the filters the water level over the filter was allowed to drop six inches a total of three times. During the test, water flowed through the filter at 1,836 gallons per minute. What was the filtration rate in gallons per minute per square foot?

9. A hook gage test was run on a filter. The filter bay was 15 feet long and 10 feet wide. The filter bed was 12 feet long and 10 feet wide. During the test the flow rate through the filter was 492 gal/min. Determine the filtration rate in gallons per minute per square foot.

10. Use the following data gathered during a hook gage test to calculate the filtration rate in gallons per minute per square foot for a filter. The filter bed has an area of 594 $ft^2$. The flow rate through the filter during the test was 1,426 gal/min.

11. A hook gauge test was used to perform a drop test on a filter. During the test water flowed through the filter at a rate of 1,814 gal/min. The filter bed has a length of 29 feet, and a width of 21 feet. Determine the filtration rate in gallons per minute per square foot.

12. During a hook gage test on a filter, water flowed through the filter at a rate of 487 gal/min. the filter bed has an area of 168 square feet. What was the filtration rate in gallons per minute per square foot?

13. The filer bays at Sewanee's water treatment plant are 18 feet long and 15 feet wide. The filter beds are 16 feet long and 15 feet wide. A hook gage test was performed on one of the filters. During the hook gage test the water flowed through the filter at a rate of 864 gal/min. Calculate the filtration rate in gallons per minute per square root.

14. A drop test (hook gage) was performed on a filter three times. During each test water flowed through the filter at a rate of 749 gallons per minute. The filter bed was 18 feet long and 16 feet wide. Determine the filtration rate in gallons per minute per square foot.

15. A drop (hook gage) test was performed on a filter with a bay that was 19 feet long and 14 feet wide, and a bed, which was 16.5 feet long and 14 feet wide. During the test the water flow rate through the filter was 531 gal/min. What is the filtration rate in gallons per minute per square foot?

***Answers***

1. 3.3 gal/min/$ft^2$ 2. 2.9 gal/min/$ft^2$ 3. 2.5 gal/min/$ft^2$ 4. 2.2 gal/min/$ft^2$ 5. 2.1 gal/min/$ft^2$

6. 2.2 gal/min/$ft^2$ 7. 3.9 gal/min/$ft^2$ 8. 3.4 gal/min/$ft^2$ 9. 4.1 gal/min/$ft^2$ 10. 2.4 gal/min/$ft^2$

11. 3.0 gal/min/$ft^2$ 12. 2.9 gal/min/$ft^2$ 13. 3.6 gal/min/$ft^2$ 14. 2.6 gal/min/$ft^2$ 15. 2.3 gal/min/$ft^2$

# Backwash Rate

Example: A filter has had an area of 340 square feet. It is backwashed at a rate of 5,000 gallons per minute. What was the backwash rate in gallons per minute per square foot?

**Write down the formula.**

$$\text{Filter Backwash rate, gpm/ft}^2 = \frac{\text{Flow, gpm}}{\text{Area, ft}^2}$$

**Make a table of data.**

Flow, gpm= 5,000 gpm

Filter Area, $ft^2$= 340 $ft^2$

**Plug the data into the formula.**

$$\text{Filter Backwash rate, gpm/ft}^2 = \frac{5{,}000 \text{ gpm}}{340 \text{ ft}^2}$$

**Divide the numbers above the line by the numbers below the line.**

$$\text{Filter Backwash rate, gpm/ft}^2 = 14.705823529 \text{ or } 14.7 \text{ gpm/ft}^2$$

***Practice Problems***

1. Determine the backwash rate in gallons per minute per square foot if its surface area is 49 square feet and the backwash flow rate was 750 gpm.

2. What is the backwash rate in gallons per minute per square foot for filter with a surface area of 70 square feet if the backwash flow rate is 1,100 gpm.

3. A filter bed is 19 feet long and 15 feet wide. The flow rate during backwash is 3,750 gpm. Calculate the backwash rate in gallons per minute per square foot for this filter.

4. Calculate the backwash rate in gallons per minute per square foot for a filter with a bed that is 22 feet long and 18 feet wide. The flow rate through the filer during backwash in 4,500 gpm.

5. A filter bed is 23 feet long and 18 feet wide. During backwash water flows through the filter at a rate of 5,286 gpm. Determine the bacwash rate for the filer in gallons per minute per square foot.

6. The flow rate through a filer during backwash is 5,575 gpm. The filer bed is 26 feet long and 20 feet wide. What is the backwash rate for this filter in gallons per minute per square foot.

7. The filter beds at a water treatment plant are 25 feet long and 19 feet wide. During backwash water is pumped through the filers at a rate of 5,890 gpm. Determine this backwash rate in gallons per minute per square foot.

8. At a water treatment plant filters are backwash at a flow rate of 8,575 gpm. The filter beds are 28 feet long and 22 feet wide. What is the backwash rate in gallons per minute per square foot for the filters?

9. A water plant has six filters. The filter bays are 11 feet long and 8 feet wide. The filter beds are 8 feet long and 8 feet wide. When a filter is backwashed water is pumped through the filter at a rate of 900 gpm. Calculate the filter backwash rate in gallons per minute per square foot.

10. The filter bed at a water treatment plant are 11 feet long and 8 feet wide. There are two filters. During backwash water in pumped through the filter at a rate of 1,275 gpm. Determine the backwash rate in gallons per minute per square foot for the filters.

11. The flow rate through a filer during backwash is 2,000 gpm. The filer bed is 16 feet long and 12 feet wide. What is the backwash rate for this filter in gallons per minute per square foot.

12. The filter beds at a water treatment plant are 17 feet long and 12 feet wide. During backwash water is pumped through the filers at a rate of 3,000 gpm. Determine this backwash rate in gallons per minute per square foot.

13. At a water treatment plant filters are backwash at a flow rate of 4,550 gpm. The filter beds are 20 feet long and 16 feet wide. What is the backwash rate in gallons per minute per square foot for the filters?

14. A water plant has ten filters. The filter bays are 32 feet long and 23 feet wide. The filter beds are 28 feet long and 23 feet wide. When a filter is backwashed water is pumped through the filter at a rate of 9,600 gpm. Calculate the filter backwash rate in gallons per minute per square foot.

15. The filter bed at a water treatment plant are 30 feet long and 23 feet wide. There are twelve filters. During backwash water in pumped through the filter at a rate of 10,000 gpm. Determine the backwash rate in gallons per minute per square foot for the filters.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1.15.3 gpm/ft$^2$ | 2. 15.7 gpm/ft$^2$ | 3. 13.2 gpm/ft$^2$ | 4. 11.4 gpm/ft$^2$ | 5. 12.8 gpm/ft$^2$ |
| 6. 10.7 gpm/ft$^2$ | 7. 12.4 gpm/ft$^2$ | 8. 13.9 gpm/ft$^2$ | 9. 14.1 gpm/ft$^2$ | 10. 14.5 gpm/ft$^2$ |
| 11. 10.4 gpm/ft$^2$ | 12. 14.7 gpm/ft$^2$ | 13. 14.2 gpm/ft$^2$ | 14. 14.9 gpm/ft$^2$ | 15. 14.5 gpm/ft$^2$ |

# Filter Drop Test Velocity, ft/ min

This formula is provided for determining the filter drop test velocity in feet per minute.

$$\text{Filter Drop Velocity, ft/min} = \frac{\text{Water Drop, ft}}{\text{Time of Drop, min}}$$

Example: During a drop test it took 1.75 minutes for the water level over the filter to drop 6 inches. Determine the filter drop test velocity in feet per minute.

**Write down the formula.**

$$\text{Filter Drop Velocity, ft/min} = \frac{\text{Water Drop, ft}}{\text{Time of Drop, min}}$$

**Make a table of data**

Water Drop, ft= 6 in ÷ 12 in/ft= 0.5 ft

Time, min= 1.75 min

**Plug the data into the formula.**

$$\text{Filter Drop Velocity, ft/min} = \frac{0.5\text{ ft}}{1.75\text{ min}}$$

**Divide the numbers above the line by the number below the line.**

$$\text{Filter Drop Velocity, ft/min} = 0.28571428571 \text{ or } 0.29\text{ ft/min}$$

***Practice Problems***

1. During a drop test the water level over a filter dropped nine inches in 105 seconds. Determine the filter drop test velocity in feet per minute.

2. A drop test was performed on a filter. During the test it took 75 seconds for the water level over the filter to drop eight inches. Calculate the filter drop test velocity in feet per minute.

3. An operator performed a drop test on a filter. During the test the water level dropped seven inches in 120 seconds. What was the filter drop test velocity in feet per minute?

4. Determine the drop test velocity in feet per minute if the water level over the filter dropped six inches in 156 seconds during the test.

5. What is the filter drop test velocity in feet per minute if the water lever over a filter dropped six inches in 110 seconds?

6. During a drop test the water level over a filter dropped eight inches in 106 seconds. Determine the filter drop test velocity in feet per minute.

7. A drop test was performed on a filter. During the test it took 101 seconds for the water level over the filter to drop nine inches. Calculate the filter drop test velocity in feet per minute.

8. An operator performed a drop test on a filter. During the test the water level dropped seven inches in 94 seconds. What was the filter drop test velocity in feet per minute?

9. Determine the drop test velocity in feet per minute if the water level over the filter dropped six inches in 109 seconds during the test.

10. What is the filter drop test velocity in feet per minute if the water lever over a filter dropped six inches in 112 seconds?

11. During a drop test the water level over a filter dropped six inches in 124 seconds. Determine the filter drop test velocity in feet per minute.

12. A drop test was performed on a filter. During the test it took 132 seconds for the water level over the filter to drop six inches. Calculate the filter drop test velocity in feet per minute.

13. An operator performed a drop test on a filter. During the test the water level dropped six inches in 136 seconds. What was the filter drop test velocity in feet per minute?

14. Determine the drop test velocity in feet per minute if the water level over the filter dropped six inches in 98 seconds during the test.

15. What is the filter drop test velocity in feet per minute if the water lever over a filter dropped six inches in 147 seconds?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 0.43 ft/min | 2. 0.53 ft/min | 3. 0.29 ft/min | 4. 0.19 ft/min | 5. 0.27 ft/min |
| 6. 0.38 ft/min | 7. 0.45 ft/min | 8. 0.37 ft/min | 9. 0.28 ft/min | 10. 0.27 ft/min |
| 11. 0.24 ft/min | 12. 0.23 ft/min | 13. 0.22 ft/min | 14. 0.31 ft/min | 15. 0.20 ft/min |

# Filter Rise Rate, in/min

This formula is provided for determining the filter rise rate in inches per minute.

$$\text{Filter Backwash Rise Rate, in/min} = \frac{(\text{Backwash Rate, gal/min/ft}^2)\,(12\ \text{in/ft})}{7.48\ \text{gal/ft}^3}$$

Example: A filter is backwashed at a rate of 14.7pm/ft$^2$. What is the filter rise rate in inches per minute?

**Write down the formula.**

$$\text{Filter Backwash Rise Rate, in/min} = \frac{(\text{Backwash Rate, gal/min/ft}^2)\,(12\ \text{in/ft})}{7.48\ \text{gal/ft}^3}$$

**Make a table of data**

$$\text{Backwash Rate, gpm/ft}^2 = 14.7\ \text{gpm/ft}^2$$

**Plug the data into the formula.**

$$\text{Filter Backwash Rise Rate, in/min} = \frac{(14.7\ \text{gal/min/ft}^2)\,(12\ \text{in/ft})}{7.48\ \text{gal/ft}^3}$$

**Multiply the numbers above the line.**

$$\text{Filter Backwash Rise Rate, in/min} = \frac{176.4\ \text{in/min}}{7.48}$$

**Divide the numbers above the line by the numbers below the line.**

$$\text{Filter Backwash Rise Rate, in/min} = 23.5828877 \text{ or } 23.6\ \text{in/min}$$

***Practice problems***

1. A filter is backwashed at a rate of 15.3 gpm/ft$^2$. Determine the backwash rise rate in inches per minute during backwash.

2. What is the backwash rise rate in inches per minute for a filter that is backwashed at a rate of 15.7 gpm/ft$^2$.

3, Calculate the backwash rise rate in inches per minute for a filter that is backwashed at a rate of 13.2 gpm/ft$^2$

4. Determine the backwash rise rate in inches per minute if a filter is backwashed at a rate of 11.4 gpm/ft$^2$

5. A water plant has six filers. Each filter's bed is 23 feet in length, and 18 feet wide. The filters are backwashed at a rate of 5,200 gpm. The backwash rate for the filters is 12.5 gpm/ft$^2$. What is the rise rate in inches per minute during backwash?

6. The flow rate through a filter during backwash is 5,575 gpm. The filter bed id 26 feet long and 20 feet wide. Determine the rise rate in inches per minute for the filter.

7. A water plant has eight filers. The filter bays are 30 feet long and 19 feet wide. The filter beds are 25 feet long and 19 feet wide. During backwash water flows through the filter at a rate of 5,890 gpm. The filters are backwashed at a rate of 12.4 gpm/ft$^2$. What is the rise rate in inches per minute for these filters?

8. The flow rate through a filter during backwash is 8,575 gpm/ft$^2$. The filter bed is 28 feet in length, and 22 feet in width. Calculate the rise rate in inches per minute during backwash.

9. What is the rise rate in inches per minute for a filter with a bed that is 8 feet long and 8 feet wide, if the flow rate through he filter during backwash is 900 gpm/ft$^2$?

10. A water plant has four filters. The filter beds are 11 feet long and 8 feet wide. During backwash water is primped through the filter at a rate of 1,275 gpm/ft$^2$. What is the rise rate in inches per minute for the filter during backwash?

11. The flow rate through a filter during backwash is 2,000 gpm. The filter bed id 16 feet long and 12 feet wide. Determine the rise rate in inches per minute for the filter.

12. A water plant has six filers. The filter bays are 21 feet long and 12 feet wide. The filter beds are 17 feet long and 12 feet wide. During backwash water flows through the filter at a rate of 3,000 gpm. The filters are backwashed at a rate of 14.7 gpm/ft$^2$. What is the rise rate in inches per minute for these filters?

13. The flow rate through a filter during backwash is 4,550 gpm/ft$^2$. The filter bed is 20 feet in length, and 16 feet in width. Calculate the rise rate in inches per minute during backwash.

14. What is the rise rate in inches per minute for a filter with a bed that is 28 feet long and 23 feet wide, if the flow rate through he filter during backwash is 9,600 gpm/ft$^2$?

15. A water plant has ten filters. The filter beds are 30 feet long and 25 feet wide. During backwash water is primped through the filter at a rate of 10,000 gpm/ft$^2$. What is the rise rate in inches per minute for the filter during backwash?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 24.5 in/min | 2. 25.2 in/min | 3. 21.2 in/min | 4. 18.3 in/min | 5. 20.2 in/min |
| 6. 17.2 in/min | 7. 19.9 in/min | 8. 22.3 in/min | 9. 22.6 in/min | 10. 23.2 in/min |
| 11. 16.7 in/min | 12. 23.6 in/min | 13. 22.8 in/min | 14. 23.9 in/min | 15. 21.4 in/min |

# Drop Test

According to the TDEC – Division of Water Resources Regulation 0400-45-01-.17(12) these are the allowable filtration rates for various types of filters.

| Type of Filter | Allowable Rate, gal/min/ft$^2$ |
|---|---|
| Rapid Sand – Turbidity Removal | 2.0 gal/min/ft$^2$ |
| Rapid Sand – Iron Removal | 2.0 gal/min/ft$^2$ |
| High Rate – Turbidity Removal | 2.0 gal/min/ft$^2$ |
| High Rate – Iron Removal | 2.0 gal/min/ft$^2$ |

The test used to determine the filtration rate in gallons per minute per square foot is called the drop test. A hook gauge is used to measure the drop in feet over the filter during the test. The drop should be 0.5 ft (6 inches).

Example: A hook gauge test was performed on a filter. During the test, the water level was allowed to drop six inches a total of three times. The time required for the water to drop six inches was 87 seconds, 88 seconds, and 86 seconds, respectively. The filter bay is 25 feet long and 18 feet wide. The filter bed is 21 feet long and 18 feet wide. What is the filtration rate in gallons per minute per square foot?

## Gallons

***Find the volume of water flowing through the filter during the test in cubic feet.***

**Write down the formula.**

$$\text{Volume} = (\text{Length})\,(\text{Width})\,(\text{Height})$$

**Make a table of data.**

Length = 25 ft

Width = 18 ft

Height = 6 in ÷ 12 in/ft = 0.5 ft

**Plug the data into the formula.**

$$\text{Volume} = (25\text{ ft})(18\text{ ft})(0.5\text{ ft})$$

**Do the multiplication.**

$$\text{Volume} = 225\text{ ft}^3$$

***Find the volume of water flowing through the filter during the test in gallons, using the conversion factor.***

$$\text{Volume} = 225\text{ ft}^3\text{ X }7.48\text{ gal/ft}^3 = 1{,}683\text{ gal}$$

## Minutes

***Find the average time in seconds.***

**Write down the formula.**

$$\text{Average} = \frac{\text{Sum of All Terms}}{\text{Number of Terms}}$$

**Make a table of data.**

Time 1 = 87 sec

Time 2 = 88 sec

Time 3 = 86 sec

Number of Terms = 3

**Plug the data into the formula.**

$$\text{Average} = \frac{87\text{ sec} + 88\text{ sec} + 86\text{ sec}}{3}$$

**Add the numbers above the line.**

$$\text{Average} = \frac{261\text{ sec}}{3}$$

**Divide the number above the line by the number below the line.**

$$\text{Average} = 87\text{ sec}$$

**Convert the time in seconds to time in minutes.**

$$\text{Mintues} = 87\text{ sec} \div 60\text{ sec/min} = 1.45\text{ min}$$

## Square Feet

**Write down the formula.**

$$\text{Area} = (\text{Length})\,(\text{Width})$$

**Make a table of data.**

$$\text{Length} = 21 \text{ ft}$$

$$\text{Width} = 18 \text{ ft}$$

**Plug the data into the formula.**

$$\text{Area} = (21\,\text{ft})\,(18 \text{ ft})$$

**Do the multiplication.**

$$\text{Area} = 378\,\text{ft}^2$$

## Gal/Min

$$\frac{1{,}683 \text{ gal}}{1.45 \text{ min}} = 1{,}160.6896 \text{ gal/min}$$

## Gal/Min/Ft$^2$

$$\frac{1{,}160.6896 \text{ gal/min}}{378\,\text{ft}^2} = 3.070607407 \text{ or } 3.1\,\text{gal/min/ft}^2$$

***Practice Problems***

1. An operator performed a drop test on a filter during which the water level over the filter was allowed to drop six inches. The water was allowed to drop three times. The following data was gathered.

   Time for Test 1 = 106 seconds

   Time for Test 2 = 110 seconds

   Time for Test 3 = 105 seconds

   The filter bay is 18 feet wide and 13 feet long. The filter bed is 14 feet wide and 13 feet long. Calculate the filter rate in gallons per minute per square foot of filter.

2. During a hook gage test on a filter, the following data was collected.

   Time for Test 1 = 110 seconds

Time for Test 2 = 109 seconds

Time for Test 3 = 114 seconds

The filter's sand bed is 20 feet long and 15 feed wide. The filter bay is 15 feet long and 15 feet wide. What is the filtration rate in gallons per minute per square foot?

3. There are 8 filters at a water treatment plant. Each filter has a bay which is 12 feet long and 8 feet wide. Each filter's sand bed is 12 feet long and 8 feet wide. A drop test was performed three times on one of the filters. During each run, the water over the filter was allowed to drop six inches. Determine the filtration rate in gallons per minute per square foot given the following times.

Test 1 = 96 seconds

Test 2 = 98 seconds

Test 3 = 96 seconds

4. During a drop test, the water level over a filter was allowed to drop by six inches a total of three times. The times required for the water to drop were 121 seconds, 124 seconds, and 121 seconds. The filter bed is 28 feet long and 22 feet wide. The filter bay is 24 feet long and 22 feet wide. What was the filtration rate in gallons per minute per square foot of filter?

5. A drop test was run on a filter. The water level over the filter was allowed to drop six inches. The times required for the water level to drop were recorded as follows.

Test 1 = 101 seconds

Test 2 = 98 seconds

Test 3 = 103 seconds

The filter bay and was 21 feet long and 17 feet wide. The filtration bed was 18 feet long and 17 feet wide. Determine the filtration rate in gallons per minute per square foot.

6. These times were required for the water level over a filter to drop six inches during a hook gage test.

Test 1 = 115 seconds

Test 2 = 118 seconds

Test 3 = 120 seconds

The filter bay is 24 feet long and 16 feet wide. The filter bed is 20 feet long and 16 feet wide. Calculate the filtration rate in gallons per minute per square foot.

7. An operator performed a hook gage test on filter, during which the water level over the filter was allowed to drop 6 inches a total of three times. The filter bay was 15 feet long and 8 feet wide. The filter bed was 11 feet long and 8 feet wide. The times required for the water level

to drop by six inches were 87 seconds, 88 seconds and 84 seconds. Determine the filtration rate in gallons per minute per square foot of filter surface.

8. There are four filters at a water treatment plant. Each of the filters has a bay which is 9 feet long and 7 feet wide. Each filter bed is 7 feet long and 7 feet wide. During a hook gage test of one of the filters the water level over the filter was allowed to drop six inches a total of three times. The times required for the water level to drop were 124 seconds, 128 seconds, and 132 seconds. What was the filtration rate in gallons per minute per square foot?

9. A drop test was run on a filter and the following data was collected.

Time, Test 1 = 108 seconds

Time, Test 2 = 111 seconds

Time, Test 3 = 105 seconds

The filter bay was 13 feet long and 8 feet wide. The filter bed was 10 feet long and 8 feet wide. Determine the filtration rate in gallons per minute per square foot.

10. Use the following data gathered during a hook gage test to calculate the filtration rate in gallons per minute per square foot for a filter.

Filter Bay: Length = 30 feet Width = 20 feet

Filter Bed: Length = 25 feet Width = 20 feet

Water Drop = 6 inches

Times: Test 1 = 96 seconds

Test 2 = 98 seconds

Test 3 = 93 seconds

11. A drop test was performed on a filter. During the test the water level over the filter was allowed to drop three times. Use the following data to determine the filtration rate in gallons per minute per square foot for the filter.

Filter Bay Dimensions: Length = 17 feet Width = 10 feet

Filter Bed Dimensions: Length = 14 feet Width = 10 feet

Water Drop = 6 inches

Times: Test 1 = 128 seconds

Test 2 = 132 seconds

Test 3 = 130 seconds

12. The following data was gathered during a hook gage test on a filter.

Filter Bay Dimensions: Length = 22 feet Width = 15 feet

Filter Bed Dimensions: Length = 18 feet Width = 15 feet

Water Drop = 6 inches

Times: Test 1 = 76 seconds

Test 2 = 74 seconds

Test 3 = 78 seconds

What is the filtration rate in gal/min/ft$^2$?

13. The filer bays at Sewanee's water treatment plant are 15 feet long and 9 feet wide. The filter beds are 12 feet long and 9 feet wide. A hook gage test was performed on one of the filters. During the hook gage test the water was allowed to drop six inches a total of three times. During the first test it took 66 seconds for the water to drop six inches. During the second and third test, the time for the water to drop six inches were 68 seconds and 68 seconds. Calculate the filtration rate in gallons per minute per square root.

14. A drop test (hook gage) was performed on a filter three times. During each test the water over the filter was dropped six inches during the first test it took 71 seconds for the water to drop six inches, 76 seconds the second test, and 72 seconds in the third test. The filter bay was 27 feet long and 19 feet wide. The filter bed was 22 feet long and 19 feet wide. Determine the filtration rate in gallons per minute per square foot.

15. A drop (hook gage) test was performed on a filter with a bay that was 21 feet long and 14 feet wide, and a bed, which was 18 feet long and 14 feet wide. During the test the water over the filter was allowed to drop six inches. It took 69 seconds for the water to drop six inches the first time, 70 seconds the second time, and 67 seconds the third time. What is the filtration rate in gallons per minute per square foot?

***Answers***

1. 2.7 gal/minft$^2$ 2. 2.7 gal/min/ft$^2$ 3. 2.3 gal/min/ft$^2$

| | | |
|---|---|---|
| 4. 2.1 gal/min/ft$^2$ | 5. 2.6 gal/min/ft$^2$ | 6. 2.3 gal/min/ft$^2$ |
| 7. 3.5 gal/min/ft$^2$ | 8. 2.3 gal/min/ft$^2$ | 9. 2.7 gal/min/ft$^2$ |
| 10. 2.8 gal/min/ft$^2$ | 11. 2.1 gal/min/ft$^2$ | 12. 3.6 gal/min/ft$^2$ |
| 13. 4.2 gal/min/ft$^2$ | 14. 3.8 gal/min/ft$^2$ | 15. 3.8 gal/min/ft$^2$ |

# Rise Test

The “rise test” is used to determine the backwash rate in gallons per minute per square foot for a granular media filter.

The Design Criteria for Community Public Water Systems addresses backwash rates as follows.

4.2.1 Gravity Filters

k. Backwash - Provisions shall be made for washing filters as follows:

1. a rate to provide for a 50 percent expansion of the media is recommended; for a sand filter, a minimum rate of 18.75 gpm/ft$^2$ is required, consistent with water temperatures and specific gravity of the filter media;

Example: The filter bay on a granular media filter is 25 feet long, and 18 feet wide. The filter bed is 21 feet long and 18 feet wide. During a rise test on the filter the filter was partially backwashed three times. During each partial backwash the time required for the water to rise six inches was measured three times. The time for the first test was 13 seconds. The second time was 17 seconds, and the third was 15 seconds. Determine the filter backwash rate in gallons per minute per square foot.

## Gallons

***Find the volume of water flowing through the filter during the test in cubic feet.***

**Write down the formula.**

$$\text{Volume} = (\text{Length})\,(\text{Width})\,(\text{Height})$$

**Make a table of data.**

$$\text{Length} = 25 \text{ ft}$$

$$\text{Width} = 18 \text{ ft}$$

$$\text{Height} = 6 \text{ in} \div 12 \text{ in/ft} = 0.5 \text{ ft}$$

**Plug the data into the formula.**

$$\text{Volume} = (25 \text{ ft})\,(18 \text{ ft})\,(0.5 \text{ ft})$$

**Do the multiplication.**

$$\text{Volume} = 225 \text{ ft}^3$$

***Find the volume of water flowing through the filter during the test in gallons, using the conversion factor.***

$$\text{Volume} = 225 \text{ ft}^3 \text{ X } 7.48 \text{ gal/ft}^3 = 1{,}683 \text{ gal}$$

## Minutes

***Find the average time in seconds.***

**Write down the formula.**

$$\text{Average} = \frac{\text{Sum of All Terms}}{\text{Number of Terms}}$$

**Make a table of data.**

$\text{Time}_1 = 13 \text{ sec}$

$\text{Time}_2 = 17 \text{ sec}$

$\text{Time}_3 = 15 \text{ sec}$

$\text{Number of Terms} = 3$

**Plug the data into the formula.**

$$\text{Average} = \frac{13 \text{ sec} + 17 \text{ sec} + 15 \text{ sec}}{3}$$

**Add the numbers above the line.**

$$\text{Average} = \frac{45 \text{ sec}}{3}$$

**Divide the number above the line by the number below the line.**

$$\text{Average} = 15 \text{ sec}$$

***Convert the time in seconds to time in minutes.***

$$\text{Mintues} = 15 \text{ sec} \div 60 \text{ sec/min} = 0.25 \text{ min}$$

## Square Feet

**Write down the formula.**

$$\text{Area} = (\text{Length})\,(\text{Width})$$

**Make a table of data.**

$\text{Length} = 21 \text{ ft}$

$\text{Width} = 18 \text{ ft}$

**Plug the data into the formula.**

$$\text{Area} = (21\,\text{ft})\,(18\,\text{ft})$$

**Do the multiplication.**

$$\text{Area} = 378\,\text{ft}^2$$

## Gal/Min

$$\frac{1{,}683\,\text{gal}}{0.25\,\text{min}} = 6{,}732\,\text{gal/min}$$

## Gal/Min/Ft$^2$

$$\frac{6{,}732\,\text{gal/min}}{378\,\text{ft}^2} = 17.8095238095 \text{ or } 17.8\,\text{gal/min/ft}^2$$

***Practice Problems***

1. A rise test was performed on a filter with the following dimensions.

   Filter Bay Length = 18 ft  Filter Bay Width = 13 ft

   Filter Bed Length = 14 ft  Filter Bed Width = 13 ft

   The times required for the water to rise six inches during the test were: $Test_1$ – 12 sec; $Test_2$ – 15 sec; $Test_3$ – 12 sec. Determine the backwash rate in gallons per minute per square foot.

2. The filter bay on a granular media filter is 20 feet long, and 15 feet wide. The filter bed is 15 feet long and 15 feet wide. During a rise test on the filter the filter was partially backwashed three times. During each partial backwash the time required for the water to rise six inches was measured three times. The time for the first test was 17 seconds. The second time was 16 seconds, and the third was 15 seconds. Calculate the filter backwash rate in gallons per minute per square foot.

3. Given the following data, calculate the backwash rate in gallons per minute per square foot for the filter.

   Filter Bay Length = 12 ft  Filter Bay Width = 8 ft

   Filter Bed Length = 12 ft  Filter Bed Width = 8 ft

   Time Required for the Water to Rise Six Inches

   $Time_1$ = 20 sec  $Time_2$ = 18 sec  $Time_3$ = 21 sec

4. An operator performed a rise test in order to determine the backwash rate for a filter. During the test, the time required for the water over the filter to rise six inches was measured three times. The results were: $Test_1$ – 19 sec; $Test_2$ – 21 sec; $Test_3$ – 18 sec. The filter bay is 28

feet long and 22 feet wide. The filter bed is 24 feet long and 22 feet wide. What was the backwash rate in gallons per minute per square foot?

5. A filter bay is 21 feet long and 17 feet wide. The filter bed is 18 feet long and 17 feet wide. 4. An operator performed a rise test in order to determine the backwash rate for a filter. During the test, the time required for the water over the filter to rise six inches was measured three times. The results were: $Test_1$ – 16 sec; $Test_2$ – 15 sec; $Test_3$ – 18 sec. Determine the backwash rate in gallons per minute per square foot.

6. A rise test was performed on a filter with the following dimensions.

Filter Bay Length = 24 ft  Filter Bay Width = 16 ft

Filter Bed Length = 20 ft  Filter Bed Width = 16 ft

The times required for the water to rise six inches during the test were: $Test_1$ – 17 sec; $Test_2$ – 15 sec; $Test_3$ – 19 sec. Determine the backwash rate in gallons per minute per square foot.

7. The filter bay on a granular media filter is 15 feet long, and 8 feet wide. The filter bed is 11 feet long and 8 feet wide. During a rise test on the filter the filter was partially backwashed three times. During each partial backwash the time required for the water to rise six inches was measured three times. The time for the first test was 14 seconds. The second time was 13 seconds, and the third was 16 seconds. Calculate the filter backwash rate in gallons per minute per square foot.

8. Given the following data, calculate the backwash rate in gallons per minute per square foot for the filter.

Filter Bay Length = 9 ft  Filter Bay Width = 7 ft

Filter Bed Length = 7 ft  Filter Bed Width = 7 ft

Time Required for the Water to Rise Six Inches

$Time_1$ = 16 sec  $Time_2$ = 15 sec  $Time_3$ = 18 sec

9. An operator performed a rise test in order to determine the backwash rate for a filter. During the test, the time required for the water over the filter to rise six inches was measured three times. The results were: $Test_1$ – 17 sec; $Test_2$ – 16 sec; $Test_3$ – 19 sec. The filter bay is 13 feet long and 8 feet wide. The filter bed is 10 feet long and 8 feet wide. What was the backwash rate in gallons per minute per square foot?

10. A filter bay is 30 feet long and 20 feet wide. The filter bed is 25 feet long and 20 feet wide. An operator performed a rise test in order to determine the backwash rate for a filter. During the test, the time required for the water over the filter to rise six inches was measured three times. The results were: $Test_1$ – 13 sec; $Test_2$ – 16 sec; $Test_3$ – 12 sec. Determine the backwash rate in gallons per minute per square foot.

11. A rise test was performed on a filter with the following dimensions.

Filter Bay Length = 17 ft  Filter Bay Width = 10 ft

Filter Bed Length = 14 ft  Filter Bed Width = 10 ft

The times required for the water to rise six inches during the test were: $Test_1$ – 12 sec; $Test_2$ – 11 sec; $Test_3$ – 12 sec. Determine the backwash rate in gallons per minute per square foot.

12. The filter bay on a granular media filter is 22 feet long, and 15 feet wide. The filter bed is 18 feet long and 15 feet wide. During a rise test on the filter the filter was partially backwashed three times. During each partial backwash the time required for the water to rise six inches was measured three times. The time for the first test was 24 seconds. The second time was 23 seconds, and the third was 25 seconds. Calculate the filter backwash rate in gallons per minute per square foot.

13. Given the following data, calculate the backwash rate in gallons per minute per square foot for the filter.

Filter Bay Length = 15 ft  Filter Bay Width = 9 ft

Filter Bed Length = 12 ft  Filter Bed Width = 9 ft

Time Required for the Water to Rise Six Inches

$Time_1$ = 20 sec  $Time_2$ = 21 sec  $Time_3$ = 18 sec

14. An operator performed a rise test in order to determine the backwash rate for a filter. During the test, the time required for the water over the filter to rise six inches was measured three times. The results were: $Test_1$ – 28 sec; $Test_2$ – 27 sec; $Test_3$ – 29 sec. The filter bay is 27 feet long and 19 feet wide. The filter bed is 22 feet long and 19 feet wide. What was the backwash rate in gallons per minute per square foot?

15. A filter bay is 21 feet long and 14 feet wide. The filter bed is 18 feet long and 14 feet wide. An operator performed a rise test in order to determine the backwash rate for a filter. During the test, the time required for the water over the filter to rise six inches was measured three times. The results were: $Test_1$ – 14 sec; $Test_2$ – 16 sec; $Test_3$ – 13 sec. Determine the backwash rate in gallons per minute per square foot.

***Answers***

| | | | |
|---|---|---|---|
| 1. 22.2 gal/min/ft$^2$ | 2. 18.7 gal/min/ft$^2$ | 3. 11.4 gal/min/ft$^2$ | 4. 13.5 gal/min/ft$^2$ |
| 5. 16.0 gal/min/ft$^2$ | 6. 15.8 gal/min/ft$^2$ | 7. 21.3 gal/min/ft$^2$ | 8. 17.7 gal/min/ft$^2$ |
| 9. 16.8 gal/min/ft$^2$ | 10. 19.7 gal/min/ft$^2$ | 11. 23.4 gal/min/ft$^2$ | 12. 11.4 gal/min/ft$^2$ |
| 13. 14.3 gal/min/ft$^2$ | 14. 9.8 gal/min/ft$^2$ | 15. 18.3 gal/min/ft$^2$ | |

# Properties of Liquid Chemicals

Most treatment plant operators have switched from feeding dry chemicals to liquid, for convenience, safety, and less handling.

Liquid chemicals have a number of important characteristics, some for safety, some for operations.

Liquid chemical characteristics important for security include:

- Specific Gravity;
- pH;
- Color or appearance; and,
- Odor.

Important characteristics for operations include:

- Specific Gravity;
- Specific Weight or Density, lbs/gal; and,
- Concentration.

Concentrations for liquid treatment chemicals can be expressed as:

- Percent;
- Active Ingredient, lbs/gal; and,
- Active Ingredient, mg/mL.

# Specific Gravity

Specific gravity is the ratio of the specific weight (density) of the solution to the specific weight (density) of a standard. The most common standard is to water, with a specific weight (density) of 8.34 lbs/gal. Specific gravity can be determined by using a hydrometer, or a balance and graduated cylinder. It can also be determined mathematically, using this formula.

$$\text{Specific Gravity} = \frac{\text{Specific Weight of Substance, lbs/gal}}{\text{Specific Weight of Water, lbs/gal}}$$

Example: A ten percent soda ash solution has a density of 9.22 lbs/gal. What is the specific gravity of the solution?

**Write down the formula.**

$$\text{Specific Gravity} = \frac{\text{Specific Weight of Substance, lbs/gal}}{\text{Specific Weight of Water, lbs/gal}}$$

**Make a table of data.**

Specific Weight of Substance(Density), lbs/gal = 9.22 lbs/gal

Specific Weight of Water (Density), lbs/gal = 8.34 lbs/gal

**Plug the data into the formula.**

$$\text{Specific Gravity} = \frac{9.22\ \text{lb/gal}}{8.34\ \text{lb/gal}}$$

**Divide the number above the line by the number below the line.**

$$\text{Specific Gravity} = 1.10551558752 \text{ or } 1.11$$

***Practice Problems***

1. Determine the specific gravity of a 20 percent caustic soda solution if the density of the solution is 10.15 lbs/gal.

2. What is the specific gravity of a 43 percent ferric chloride solution if its density is 12.00 lbs/gal?

3. The density of a 50 percent ferric sulfate solution is 12.40 lbs/gal. Calculate the specific gravity of the solution.

4. Determine the specific gravity of a 60 percent ferric sulfate solution with a density of 13.4 lbs/gal.

5. Calculate the specific gravity of a 48 percent liquid alum solution with a density of 10.96 lbs/gal.

6. Determine the specific gravity of a 50 percent caustic soda solution if the density of the solution is 12.7 lbs/gal.

7. What is the specific gravity of a 38 percent ferric chloride solution if its density is 11.50 lbs/gal?

8. The density of a 50 percent hydrogen peroxide solution is 9.80 lbs/gal. Calculate the specific gravity of the solution.

9. Determine the specific gravity of a 20 percent sodium permanganate solution with a density of 9.65 lbs/gal.

10. Calculate the specific gravity of a 12.5 bleach (sodium hypochlorite) solution with a density of 10.18 lbs/gal.

11. Determine the specific gravity of an 8 percent hydrogen peroxide solution if the density of the solution is 8.80 lbs/gal.

12. What is the specific gravity of a 30 percent soda ash solution if its density is 11.05 lbs/gal?

13. The density of a 50 percent ferric sulfate solution is 11.90 lbs/gal. Calculate the specific gravity of the solution.

14. Determine the specific gravity of a 60 percent ferric sulfate solution with a density of 13.1 lbs/gal.

15. Calculate the specific gravity of a 20 percent sodium permanganate solution with a density of 9.63 lbs/gal.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 1.22 | 2. 1.44 | 3. 1.49 | 4. 1.61 | 5. 1.31 |
| 6. 1.52 | 7. 1.38 | 8. 1.18 | 9. 1.16 | 10. 1.22 |
| 11. 1.06 | 12. 1.32 | 13. 1.43 | 14. 1.57 | 15. 1.15 |

# Specific Weight (Density), lbs/gal

Specific weight, or density, is the weight or mass of a substance per unit volume. It can be calculated using its specific gravity.

$$\text{Density, lbs/gal} = (\text{Specific Gravity})(8.34\ \text{lbs/gal})$$

Example: A 35 percent liquid ferrous chloride solution has a specific gravity of 1.396. What is the density of the ferrous chloride solution in pounds per gallon (lbs/gal)?

**Write down the formula.**

$$\text{Density, lbs/gal} = (\text{Specific Gravity})(8.34\ \text{lbs/gal})$$

**Make a table of data.**

Specific Gravity = 1.396

**Plug the data into the formula.**

$$\text{Density, lbs/gal} = (1.396)(8.34\ \text{lbs/gal})$$

**Do the multiplication.**

$$\text{Density, lbs/gal} = 11.64264 \text{ or } 11.64\ \text{lbs/gal}$$

### *Practice Problems*

1. Fifty percent liquid ferric sulfate has a specific gravity of 1.46. Calculate the density of the solution in pounds per gallon (lbs/gal).

2. DelPAC 2020 has a specific gravity of 1.23. Determine the density of the chemical solution in pounds per gallon (lbs/gal).

3. A 40 percent polyaluminum chloride solution has a specific gravity of 1.32. What is the density of the solution in pounds per gallon (lbs/gal)?

4. The operators at a water treatment plant use EC-300 HB as the primary coagulant. The EC-300 HB solution has a specific gravity of 1.15. What is the density of the solution in pounds per gallon (lbs/gal)?

5. Twenty percent sodium permanganate is used to oxidize disinfection byproduct precursors at Clarksville's water treatment plant. The 20 percent sodium permanganate has a specific gravity of 1.16. Determine the density of the sodium permanganate solution in pounds per gallon (lbs/gal).

6. The specific gravity of 35 percent hydrogen peroxide is 1.13. Calculate the density of the hydrogen peroxide solution in pounds per gallon (lbs/gal).

7. Determine the density of 40 percent liquid caustic in pounds per gallon if the specific gravity of the caustic soda solution is 1.43.

8. A 48 percent liquid alum solution has a specific gravity of 1.33. What is the density of the liquid alum in pounds per gallon (lbs/gal)?

9. Twenty-five percent liquid ferrous sulfate has a specific gravity of 1.31. Calculate the density of the solution in pounds per gallon (lbs/gal).

10. Liquid citric acid, 50 percent, has a specific gravity of 1.24. Determine the density of the citric acid solution in pounds per gallon (lbs/gal).

11. A 25 liquid caustic solution has a specific gravity of 1.29. What is the density of the solution in pounds per gallon (lbs/gal)?

12. The operators at a water treatment plant use SternPAC 70 as the primary coagulant. The SternPAC 70 solution has a specific gravity of 1.225. What is the density of the solution in pounds per gallon (lbs/gal)?

13. Fifty percent sulfuric acid is used to lower the pH at Clarksville's water treatment plant before the addition of hydrogen peroxide. The 50 percent sulfuric acid has a specific gravity of 1.41. Determine the density of the sulfuric acid solution in pounds per gallon (lbs/gal).

14. The specific gravity of 25 percent fluorosilicic acid is 1.234. Calculate the density of the fluorosilicic acid solution in pounds per gallon (lbs/gal).

15. Determine the density of 20 percent liquid caustic in pounds per gallon if the specific gravity of the caustic soda solution is 1.226.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 12.18 lbs/gal | 2. 10.26 lbs/gal | 3. 11.01 lbs/gal | 4. 9.59 lbs/gal | 5. 9.67 lbs/gal |
| 6. 9.42 lbs/gal | 7. 11.93 lbs/gal | 8. 11.09 lbs/gal | 9. 10.93 lbs/gal | 10. 10.34 lbs/gal |
| 11. 10.76 lbs/gal | 12. 10.22 lbs/gal | 13. 11.76 lbs/gal | 14. 10.29 lbs/gal | 15. 10.22 lbs/gal |

# Concentration, lbs/gal from Density and Concentration in Percent.

You can use this formula for determining the concentration of a chemical in pounds per gallon in a solution. It is not provided on the formula sheet.

$$\text{Concentration, lbs/gal} = \text{Specific Weight, lbs/gal X Concentration, \% expressed as a decimal}$$

Example: Sixty percent ferric sulfate has a specific weight (density) of 13.51 lbs/gal. What is the ferric sulfate concentration in pounds per gallon?

**Write down the formula.**

$$\text{Concentration, lbs/gal} = \text{Specific Weight, lbs/gal X Concentration, \% expressed as a decimal}$$

**Make a table of data.**

Specific Weight, lbs/gal = 13.51 lbs/gal

Concentration, % = 60% ÷ 100% = 0.60

**Plug the data into the formula.**

$$\text{Concentration, lbs/gal} = 13.51 \text{ lbs/gal X } 0.60$$

**Do the multiplication.**

$$\text{Concentration, lbs/gal} = 8.106 \text{ or } 8.1 \text{ lbs/gal}$$

***Practice Problems***

1. Ninety-eight percent sulfuric acid has a specific weight of 15.38 pounds per gallon. Calculate the sulfuric acid concentration in pounds per gallon.

2. Thirty-five percent hydrogen peroxide has a specific weight of 9.42 lbs/gal. What is the hydrogen peroxide concentration in pounds per gallon?

3. Forty percent liquid caustic has a specific weight of 12.01 lbs/gal. Determine the caustic soda concentration in pounds per gallon.

4. Twenty-five percent liquid caustic has a specific weight of 10.84 lbs/gal. What is the caustic soda concentration in pounds per gallon?

5. What is the aluminum chloride concentration in pounds per gallon for 29 percent liquid aluminum chloride if the 29 percent solution has a specific weight of 10.76 lbs/gal?

6. Forty-five percent liquid sodium aluminate has a specific weight of 13.1 pounds per gallon. Calculate the sodium aluminate concentration in pounds per gallon.

7. Thirty percent Cal-Flo (liquid Lime) has a specific weight of 9.93 lbs/gal. What is the lime concentration in pounds per gallon?

8. SIxty percent liquid ferric sulfate has a specific weight of 13.1 lbs/gal. Determine the ferric sulfate concentration in pounds per gallon.

9. Thirty-eight percent liquid ferric chloride has a specific weight of 11.51 lbs/gal. What is the ferric chloride concentration in pounds per gallon?

10. What is the ferric chloride concentration in pounds per gallon for 43 percent liquid ferric chloride if the 43 percent solution has a specific weight of 12.34 lbs/gal?

11. Fifty percent liquid ferric sulfate has a specific weight of 12.34 pounds per gallon. Calculate the ferric sulfate concentration in pounds per gallon.

12. Twenty percent liquid sodium permanganate has a specific weight of 9.76 lbs/gal. What is the sodium permanganate concentration in pounds per gallon?

13. Fifty percent liquid hydrogen peroxide has a specific weight of 9.92 lbs/gal. Determine the hydrogen peroxide concentration in pounds per gallon.

14. Fifty percent liquid caustic has a specific weight of 12.76 lbs/gal. What is the caustic soda concentration in pounds per gallon?

15. What is the alum concentration in pounds per gallon for 48.5 percent liquid alum if the 48.5 percent solution has a specific weight of 11.22 lbs/gal?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 15.07 lb/gal | 2. 3.3 lb/gal | 3. 4.8 lb/gallon | 4. 2.71 lb/gal | 5. 3.12 lb/gal |
| 6. 5.90 lb/gal | 7. 3.0 lb/gal | 8. 7.86 lb/gal | 9. 4.37 lb/gal | 10. 5.31 lb/gal |
| 11. 6.17 lb/gal | 12. 1.95 lb/gal | 13. 4.96 lb/gal | 14. 6.38 lb/gal | 15. 5.44 lb/gal |

# Converting Concentration in Pounds per Gallon to Milligrams per Milliliter

Example: Sixty percent ferric sulfate contains 8.1 pounds of ferric sulfate per gallon. What is the ferric sulfate concentration in milligrams per milliliter?

**Step One: Convert lbs/gal to kilograms per gallon, using the conversion factor provided.**

$$\frac{8.1\,\text{lbs}}{\text{gal}} \text{ X } 0.454\ \text{kg/lbs} = 3.6774\ \text{kg/gal}$$

**Step Two: Convert kilograms per gallon (kg/gal) to grams/gal.**

$$\frac{0.36774\ \text{kg}}{\text{gal}} \text{ X } 1{,}000\ \text{g/kg} = 3{,}677.4\ \text{g/gal}$$

**Step Three: Convert g/gal to milligrams per gallon (mg/gal).**

$$\frac{3{,}677.4\ \text{g}}{\text{gal}} \text{ X } 1{,}000\ \text{mg/g} = 3{,}677{,}400\ \text{mg/gal}$$

**Step Four: Convert gallons to liters using the conversion factor in the formula sheets.**

$$\frac{3{,}677{,}400\ \text{mg}}{\text{gal}} \text{ X } 3.79\ \text{L/gal} = \frac{3{,}677{,}400\ \text{mg}}{3.79\ \text{L}}$$

**Step Five: Convert liters to milliliters.**

$$\frac{3{,}677{,}400\ \text{mg}}{3.79\ \text{L}} \text{ X } 1{,}000\ \text{mL/L} = \frac{3{,}677{,}400\ \text{mg}}{3{,}790\ \text{mL}}$$

**Step Six: Divide the concentration in milligrams by the volume in milliliters.**

$$\frac{3{,}677{,}400\ \text{mg}}{3{,}790\ \text{mL}} = 970.2902375 \text{ or } 970\ \text{mg/mL}$$

***Practice Problems***

1. 48.5 percent liquid alum has an alum concentration of 5.44 lbs/gal. What is the alum concentration in milligrams per milliliter?

2. What is the caustic soda concentration in pounds per gallon for 50 percent liquid caustic? The caustic soda concentration in 50 percent liquid caustic is 6.38 lbs/gal.

3. Twenty percent sodium permanganate solution has a sodium permanganate concentration of 1.95 lbs/gal. Determine the sodium permanganate concentration in milligrams per milliliter.

4. Fifty percent hydrogen peroxide contains 4.96 lbs of peroxide per gallon. Calculate the hydrogen peroxide concentration in milligrams per liter.

5. Determine the ferric sulfate concentration in milligrams per milliliter for 50 percent liquid ferric sulfate if the ferric sulfate concentration in the solution is 6.17 lbs/gal.

6. Forty-three percent liquid ferric chloride has a ferric chloride concentration of 5.31 lbs/gal. What is the ferric chloride concentration in milligrams per milliliter?

7. What is the ferric chloride concentration in milligrams per milliliter for 38 percent liquid ferric chloride? The ferric chloride concentration in 38 percent liquid ferric chloride is 4.37 lbs/gal.

8. Sixty percent liquid ferric sulfate has a ferric sulfate concentration of 7.86 lbs/gal. Determine the ferric sulfate concentration in milligrams per milliliter.

9. Thirty percent Cal-Flo (liquid lime) contains 2.98 lbs of lime per gallon. Calculate the lime concentration in milligrams per liter.

10. Determine the sodium aluminate concentration in milligrams per milliliter for 45 percent liquid sodium aluminate if the sodium aluminate concentration in the solution is 5.88 lbs/gal.

11. Twenty-nine percent liquid aluminum chloride has an aluminum chloride concentration of 3.12 lbs/gal. What is the aluminum chloride concentration in milligrams per milliliter?

12. What is the caustic soda concentration in pounds per gallon for 25 percent liquid caustic? The caustic soda concentration in 25 percent liquid caustic is 2.71 lbs/gal.

13. Forty percent liquid caustic has a caustic soda concentration of 4.8 lbs/gal. Determine the caustic soda concentration in milligrams per milliliter.

14. Thirty-five percent hydrogen peroxide contains 3.3 lbs of hydrogen peroxide per gallon. Calculate the hydrogen peroxide concentration in milligrams per liter.

15. Determine the sulfuric acid concentration in milligrams per milliliter for 98 percent sulfuric acid if the sulfuric acid concentration in the solution is 15.07 lbs/gal.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 652 mg/mL | 2. 764 mg/mL | 3. 234 mg/mL | 4. 594 mg/mL | 5. 739 mg/mL |
| 6. 636 mg/mL | 7. 523 mg/mL | 8. 941 mg/mL | 9. 357 mg/mL | 10. 704 mg/mL |
| 11. 374 mg/mL | 12. 325 mg/mL | 13. 575 mg/mL | 14. 395 mg/mL | 15. 1,805 mg/mL |

# Liquid Chemical Feed Rates

There are at least three ways to determine the required liquid chemical feed rate:

Feed Rate, ml/min;

Feed Rate, gal/day – from concentration in pounds per gal (lbs/gal), and;

Feed Rate, gal/day – from specific gravity and concentration in percent.

## Liquid Feeder Setting, ml/min

This formula can be used to determine the rate, in milliliters per minute, at which a chemical must be fed.

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{(\text{Flow, MGD})\,(\text{Dose, mg/L})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/MG})}{(\text{Liquid, mg/mL})\,(24\ \text{hr/day})\,(60\ \text{min/hr})}$$

An operator feeds liquid alum. The 50% liquid alum has a concentration of 5.61 lbs/gal or 673 mg/ml. Raw water is treated at a rate of 1.584 MGD. The jar test indicates that a dose of 15 mg/l alum is the best dose to use. Calculate the required liquid alum feed rate in milliliters per minute (ml/min).

**Write down the formula.**

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{(\text{Flow, MGD})\,(\text{Dose, mg/L})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/MG})}{(\text{Liquid, mg/mL})\,(24\ \text{hr/day})\,(60\ \text{min/hr})}$$

**Make a table of data.**

Dose, mg/l = 15 mg/l

Flow, MGD = 1.584 MGD

Concentration, mg/ml = 673 mg/ml

**Plug the data into the formula.**

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{(1{,}584\ \text{MGD})\,(15\ \text{mg/L})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/MG})}{(673\ \text{mg/mL})\,(24\ \text{hr/day})\,(60\ \text{min/hr})}$$

**Multiply the numbers above the line.**

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{89{,}931{,}600}{(673\ \text{mg/mL})\,(24\ \text{hr/day})\,(60\ \text{min/hr})}$$

**Multiply the numbers below the line.**

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{89{,}931{,}600}{969{,}120 \text{ mL/min}}$$

**Divide the number above the line by the number below the line.**

$$\text{Chemical Feed Pump Setting, mL/min} = 92.79717682 \text{ or } 93 \text{ mL/min}$$

***Practice Problems***

1. An operator uses 50% liquid caustic to adjust the pH of the filtered water. The caustic soda dose required is 8 mg/l. The 50% liquid caustic has a concentration of 764 mg/mL. Water is treated at a rate of 2.376 MGD. Determine the required feed rate in milliliter per minute (ml/min).

2. A 50% liquid ferric sulfate solution is used to provide a dose of 5 mg/l in the raw water. Raw water is treated at a rate of 4.032 MGD. The 50% liquid ferric sulfate has a concentration of 724 mg/mL. Calculate the required chemical feed rate in milliliters per minute (ml/min).

3. Liquid alum is fed at a dose of 20 mg/l while treating raw water at a rate of 6.48 MGD. Liquid alum (50%) is used in the coagulation/flocculation process. The liquid alum has concentration of 664 mg/mL.. What is the required feed rate in milliliters per minute (ml/min)?

4. An operator uses 25% liquid caustic soda in treating the water. The 25% liquid caustic has a concentration of 320 mg/ml. The caustic soda dose is 6 mg/l. What would the required feed rate be in ml/min if raw water is treated at a rate of 1.30 MGD?

5. An operator uses a saturated sodium fluoride solution to fluoridate water. Water is treated at a rate of 1.10 MGD. What would the required feed rate be in milliliters per minute (ml/min) if the fluoride dose is 1.0 mg/l? A saturated sodium fluoride solution has a fluoride concentration of 18 mg/ml.

6. A 50% caustic soda solution has a concentration of 768 mg/ml. Caustic soda is fed at a dose of 10 mg/l while treating water at a rate of 3.60 MGD. Determine the required feed rate in milliliters per minute (ml/min).

7. Ferric sulfate is fed at a dose of 11 mg/l while treating water at a rate of 3.024 MGD. A 50% ferric sulfate solution with a concentration of 739 mg/ml is used to treat the water. Calculate the feed rate (ml/min) required to provide the desired dose.

8. What would the required feed rate in ml/min be for a 25% caustic soda solution (concentration = 320 mg/ml) if water is treated at a rate of 1.872 MGD and the caustic soda dose is 12 mg/l?

9. Liquid alum is used in the coagulation/flocculation process at a water treatment plant. The liquid alum (50%) has a concentration of 673 mg/ml. An alum dose of 25 mg/l is used to treat raw water. Raw water is treated at a rate of 1,500 gal/min. Calculate the required liquid alum feed rate in milliliters per minute (ml/min).

10. Sodium fluoride is used to fluoridate the filtered water at a treatment plant. A saturated sodium fluoride solution has a fluoride concentration of 18 mg/ml. Water is treated at a rate of 200 gal/min. Determine the required feed rate in ml/min if the fluoride dose is to be 0.9 mg/l.

11. A saturated sodium fluoride solution will be used to fluoridate water at a dose of 1.1 mg/l. The saturated sodium fluoride solution has a concentration of 18 mg/l. Water is treated at a rate of 175 gal/min. What is the required feed rate in milliliters per minute (ml/min)?

12. A 50% ferric sulfate solution is used in the coagulation/flocculation process at a water treatment plant. The 50% ferric sulfate solution has a specific gravity of 1.46. Raw water is treated at a rate of 10 MGD. The ferric sulfate dose is 8 mg/l. Determine the required feed rate in milliliters per minute (ml/min).

13. Fluorosilicic acid is used to fluoridate the filtered water at a treatment plant. Twenty-three percent fluorosilicic acid solution has a specific gravity of 1.21. Water is treated at a rate of 5.40 MGD. Determine the required feed rate in ml/min if the fluoride dose is to be 1.0 mg/l.

14. A soda ash solution will be used to adjust the pH and alkalinity of the finished water. The soda ash dose is to be 15 mg/l. The soda ash solution has a specific gravity of 1.16. Water is treated at a rate of 2.52 MGD. What is the required feed rate in milliliters per minute (ml/min)?

15. A 60% ferric sulfate solution is used in the coagulation/flocculation process at a water treatment plant. The ferric sulfate solution has a specific gravity of 1.383. Raw water is treated at a rate of 10,080,000 gallons per day. The ferric sulfate dose is 18 mg/l. Determine the required feed rate in milliliters per minute (ml/min).

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 65 mL/min | 2. 73 mL/min | 3. 513 mL/min | 4. 64 mL/min | 5. 161 mL/min |
| 6. 123 mL/min | 7. 118 mL/min | 8. 185 mL/min | 9. 211 mL/min | 10. 38 mL/min |
| 11. 40 mL/min | 12. 288 mL/min | 13. 64 mL/min | 14. 571 mL/min | 15. 575 mL/min |

# Liquid Feeder Setting, gal/day – from Concentration, lbs/gal

You can use this formula for calculating the required feed rate in gallons per day when the concentration of the chemical in pounds per gallon is given.

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})}{\text{Concentration, lbs/gal}}$$

Example: An operator feeds 48 percent liquid alum as a primary coagulant. The desired alum dose is 25 mg/L. Water is treated at a rate of 2.75 MGD. Forty-eight percent liquid alum has an alum concentration of 5.32 lbs/gal. What is the required feed rate in gallons per day?

**Write down the formula.**

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})\,(8.34\ \text{lbs/gal})}{\text{Concentration, lbs/gal}}$$

**Make a table of data.**

Dose, mg/L = 25 mg/L

Flow, MGD = 2.75 MGD

Concentration, lbs/gal = 5.32 lbs/gal

**Plug the data into the formula.**

$$\text{Feeder Setting, gal/day} = \frac{(25\ \text{mg/L})\,(2.75\ \text{MGD})\,(8.34\ \text{lbs/gal})}{5.32\ \text{lbs/gal}}$$

**Cancel terms and multiply the numbers above the line.**

$$\text{Feeder Setting, gal/day} = \frac{573.375\ \text{gal/day}}{5.32}$$

**Divide the number above the line by the number below the line.**

$$\text{Feeder Setting, gal/day} = 107.777255639 \text{ or } 108\ \text{gal/day}$$

***Practice Problems***

1. Fifty percent liquid ferric sulfate is used as the primary coagulant. Water is treated at a rate of 8.5 MGD. The ferric sulfate concentration in the solution is 6.0 lbs/gal. Determine the feed rate in gallons per day that is required to feed a dose of 16 mg/L.

2. Fifty percent hydrogen peroxide is fed at a dose of 0.8 mg/L while treating water at a rate of 2.5 MGD. The hydrogen peroxide concentration is 4.96 lbs/gal. What is the required feed rate in gallons per day?

3. Forty percent liquid caustic is fed at a dose of 6 mg/L. Water is treated at a rate 8.5 MGD. Each gallon of 40 percent liquid caustic contains 4.77 pounds of caustic soda. Calculate the feed rate in gallons per day required to achieve this dose.

4. Liquid sodium permanganate is fed to oxidize disinfection byproduct precursors in the raw water. The liquid sodium permanganate has a concentration of 20 percent, or 1.94 lbs/gal. The desired sodium permanganate dose is 1.5 mg/L. Raw water is treated at a rate of 4.45 MGD. Determine the feed rate in gallons per day that is required to deliver the desired dose.

5. Sixty percent liquid ferric sulfate is used as the primary coagulant. Water is treated at a rate of 9.25 MGD. The ferric sulfate concentration in the solution is 7.96 lbs/gal. Determine the feed rate in gallons per day that is required to feed a dose of 18 mg/L.

6. Cal-Flo is used to adjust the pH and alkalinity in the finished water. Cal-Flo is 30 percent hydrated lime. Each gallon of Cal-Flo contains 2.93 pounds of hydrated lime. The desired lime dose is 10 mg/L. Water is treated at a rate of 12.36 MGD. What is the required feed rate in gallons per day?

7. Twenty-five percent liquid caustic is fed at a dose of 6 mg/L. Water is treated at a rate 2.5 MGD. Each gallon of 25 percent liquid caustic contains 2.7 pounds of caustic soda. Calculate the feed rate in gallons per day required to achieve this dose.

8. Liquid sodium permanganate is fed to oxidize disinfection byproduct precursors in the raw water. The liquid sodium permanganate has a concentration of 20 percent, or 1.95 lbs/gal. The desired sodium permanganate dose is 1.2 mg/L. Raw water is treated at a rate of 9.37 MGD. Determine the feed rate in gallons per day that is required to deliver the desired dose.

9. An operator feeds a 20 percent soda ash solution. Each gallon of the soda ash solution contains 2.02 pounds of soda ash. Water is treated at a rate of 3.27 MGD. What feed rate in gallons per day is needed to deliver a dose of 12 mg/L?

10. Sixty percent liquid ferric sulfate is used as the primary coagulant. Water is treated at a rate of 3.65 MGD. The ferric sulfate concentration in the solution is 8.06 lbs/gal. Determine the feed rate in gallons per day that is required to feed a dose of 20 mg/L.

11. An operator feeds 48 percent liquid alum as a primary coagulant. The desired alum dose is 14 mg/L. Water is treated at a rate of 5.95 MGD. Forty-eight percent liquid alum has an alum concentration of 5.28 lbs/gal. What is the required feed rate in gallons per day?

12. Fifty percent liquid ferric sulfate is used as the primary coagulant. Water is treated at a rate of 4.75 MGD. The ferric sulfate concentration in the solution is 6.05 lbs/gal. Determine the feed rate in gallons per day that is required to feed a dose of 12 mg/L.

13. Ninety-eight percent sulfuric acid is fed to adjust the pH in the raw water. Raw water is treated at a rate of 25.75 MGD. Each gallon of 98 percent sulfuric acid contains 15.07 pounds of sulfuric acid. Calculate the feed rate, in gallons per day, necessary to deliver a sulfuric acid dose of 3 mg/L.

14. Fifty percent liquid caustic is fed at a dose of 12 mg/L. Water is treated at a rate 10 MGD. Each gallon of 50 percent liquid caustic contains 6.34 pounds of caustic soda. Calculate the feed rate in gallons per day required to achieve this dose.

15. Cal-Flo is used to adjust the pH and alkalinity in the finished water. Each gallon of Cal-Flo contains 2.93 pounds of hydrated lime. The desired lime dose is 10 mg/L. Water is treated at a rate of 12.36 MGD. What is the required feed rate in gallons per day?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 189 gal/day | 2. 3.4 gal/day | 3. 71 gal/day | 4. 29 gal/day | 5. 175 gal/day |
| 6. 25 gal/day | 7. 47 gal/day | 8. 48 gal/day | 9. 162 gal/day | 10. 76 gal/day |
| 11. 131 gal/day | 12. 79 gal/day | 13. 43 gal/day | 14. 158 gal/day | 15. 352 gal/day |

# Liquid Feeder Setting, gal/day – from Specific Gravity and Concentration, %

You can use this formula for calculating the required feed rate in gallons per day when the concentration of the chemical in percent and the specific gravity are given.

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})}{(\text{Concentration, \%, expressed as a decimal})\,(\text{Specific Gravity})}$$

Example: An operator feeds 30 percent liquid lime (Cal-Flo)to adjust the pH and alkalinity in the water. The desired lime dose is 7 mg/L. Water is treated at a rate of 10.25 MGD. Liquid lime (Cal-Flo) has a specific gravity of 1.18. What is the required feed rate in gallons per day?

**Write down the formula.**

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/L})\,(\text{Flow, MGD})}{(\text{Concentration, \%, expressed as a decimal})\,(\text{Specific Gravity})}$$

**Make a table of data.**

Dose, mg/L = 7 mg/L

Flow, MGD = 10.25 MGD

Concentration, % = 30% ÷ 100% = 0.30

Specific Gravity = 1.18

**Plug the data into the formula.**

$$\text{Feeder Setting, gal/day} = \frac{(7\text{ mg/L})\,(10.25\text{ MGD})}{(0.30)\,(1.18)}$$

**Cancel terms and multiply the numbers above the line.**

$$\text{Feeder Setting, gal/day} = \frac{71.75\text{ gal/day}}{(0.30)\,(1.18)}$$

**Multiply the numbers below the line.**

$$\text{Feeder Setting, gal/day} = \frac{71.75\text{ gal/day}}{0.354}$$

**Divide the number above the line by the number below the line.**

$$\text{Feeder Setting, gal/day} = 202.683615819 \text{ or } 203\text{ gal/day}$$

### *Practice Problems*

1. Fifty percent liquid ferric sulfate is used as the primary coagulant. Water is treated at a rate of 8.5 MGD. The fifty percent ferric sulfate has a specific gravity of 1.44. Determine the feed rate in gallons per day that is required to feed a dose of 16 mg/L.

2. Fifty percent hydrogen peroxide is fed at a dose of 0.8 mg/L while treating water at a rate of 2.5 MGD. The hydrogen peroxide has a specific gravity of 1.19. What is the required feed rate in gallons per day?

3. Forty percent liquid caustic is fed at a dose of 6 mg/L. Water is treated at a rate 8.5 MGD. The specific gravity of the liquid caustic solution is 1.43. Calculate the feed rate in gallons per day required to achieve this dose.

4. Liquid sodium permanganate is fed to oxidize disinfection byproduct precursors in the raw water. The liquid sodium permanganate has a specific gravity of 1.16. The desired sodium permanganate dose is 1.5 mg/L. Raw water is treated at a rate of 4.45 MGD. Determine the feed rate in gallons per day that is required to deliver the desired dose.

5. Sixty percent liquid ferric sulfate is used as the primary coagulant. Water is treated at a rate of 9.25 MGD. The specific gravity of the ferric sulfate concentration is 1.59. Determine the feed rate in gallons per day that is required to feed a dose of 18 mg/L.

6. Cal-Flo is used to adjust the pH and alkalinity in the finished water. Cal-Flo is 30 percent hydrated lime. The specific gravity of the Cal-Flo is 1.19. The desired lime dose is 10 mg/L. Water is treated at a rate of 12.36 MGD. What is the required feed rate in gallons per day?

7. Twenty-five percent liquid caustic is fed at a dose of 6 mg/L. Water is treated at a rate 2.5 MGD. Twenty-five percent liquid caustic has a specific gravity of 1.29. Calculate the feed rate in gallons per day required to achieve this dose.

8. Liquid sodium permanganate is fed to oxidize disinfection byproduct precursors in the raw water. The liquid sodium permanganate has a specific gravity of 1.17. The desired sodium permanganate dose is 1.2 mg/L. Raw water is treated at a rate of 9.37 MGD. Determine the feed rate in gallons per day that is required to deliver the desired dose.

9. An operator feeds a 20 percent soda ash solution. The specific gravity of the soda ash solution is 1.214. Water is treated at a rate of 3.27 MGD. What feed rate in gallons per day is needed to deliver a dose of 12 mg/L?

10. Sixty percent liquid ferric sulfate is used as the primary coagulant. Water is treated at a rate of 3.65 MGD. The ferric sulfate has a specific gravity of 1.61. Determine the feed rate in gallons per day that is required to feed a dose of 20 mg/L.

11. An operator feeds 48 percent liquid alum as a primary coagulant. The desired alum dose is 14 mg/L. Water is treated at a rate of 5.95 MGD. Forty-eight percent liquid alum has a specific gravity of 1.32. What is the required feed rate in gallons per day?

12. Fifty percent liquid ferric sulfate is used as the primary coagulant. Water is treated at a rate of 4.75 MGD. The ferric sulfate solution has a specific gravity of 1.45. Determine the feed rate in gallons per day that is required to feed a dose of 12 mg/L.

13. Ninety-eight percent sulfuric acid is fed to adjust the pH in the raw water. Raw water is treated at a rate of 25.75 MGD. The sulfuric acid solution has a specific gravity of 1.844. Calculate the feed rate, in gallons per day, necessary to deliver a sulfuric acid dose of 3 mg/L.

14. Fifty percent liquid caustic is fed at a dose of 12 mg/L. Water is treated at a rate 10 MGD. The specific gravity of the 50 percent liquid caustic is 1.52. Calculate the feed rate in gallons per day required to achieve this dose.

15. Cal-Flo is used to adjust the pH and alkalinity in the finished water. Cal-Flo has a hydrated lime concentration of 30 percent, and a specific gravity of 1.17. The desired lime dose is 10 mg/L. Water is treated at a rate of 12.36 MGD. What is the required feed rate in gallons per day?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 189 gal/day | 2. 3.4 gal/day | 3. 71 gal/day | 4. 29 gal/day | 5. 175 gal/day |
| 6. 25 gal/day | 7. 47 gal/day | 8. 48 gal/day | 9. 162 gal/day | 10. 76 gal/day |
| 11. 131 gal/day | 12. 79 gal/day | 13. 43 gal/day | 14. 158 gal/day | 15. 352 gal/day |

# Preparing Batches Treatment Chemical Solutions

## Preparing a Solution of Known Strength

This formula can be used to calculate the pounds of chemical required to make a solution of known strength if the volume of water to be used is known.

$$\text{Required Pounds, lbs} = \frac{\left[\text{Water Volume, gal X 8.34 lbs/gal}\right] \text{ X Desired Strength, \%}}{\text{100\% - Desired Strength, \%}}$$

Example: An operator wants to prepare a 10 percent soda ash solution using 250 gallons of water. How many pounds of soda ash are needed to make the solution?

**Write down the formula.**

$$\text{Required Pounds, lbs} = \frac{\left[\text{Water Volume, gal X 8.34 lbs/gal}\right] \text{ X Desired Strength, \%}}{\text{100\% - Desired Strength, \%}}$$

**Make a table of data.**

Volume of Water, gal = 250 gal

Desired Strength, % = 10%

**Plug the data into the formula.**

$$\text{Required Pounds, lbs} = \frac{\left[\text{250 gal X 8.34 lbs/gal}\right] \text{ X 10 \%}}{\text{100\% - 10\%}}$$

**Do the math inside the brackets.**

$$\text{Required Pounds, lbs} = \frac{\text{2,085 lbs X 10 \%}}{\text{100\% - 10\%}}$$

**Multiply the numbers above the line.**

$$\text{Required Pounds, lbs} = \frac{\text{20,850 lbs}}{\text{100 - 10}}$$

**Multiply the numbers below the line.**

$$\text{Required Pounds, lbs} = \frac{\text{20,850 lbs}}{\text{90}}$$

**Divide the number above the line by the number below the line.**

$$\text{Required Pounds, lbs} = 231.6666666667 \text{ or } 232 \text{ lbs}$$

### *Practice Problems*

1. An operator wants to make a 5 percent soda ash solution for adjusting the pH of the finished water. The operator will use 75 gallons of water to make the solution. How many pounds of soda ash will be needed?

2. At Beaver Creek Utility District the operator uses a three percent potassium permanganate solution for oxidizing iron and manganese in the raw water. The operator added 55 gallons of water to the potassium permanganate day tank. How many pounds of potassium permanganate must be added to the water to make a three percent solution?

3. The operator at the Spencer water treatment plant uses a 15 percent sodium hexametaphosphate solution for corrosion control. The operator added 65 gallons of water to the day tank. Determine how many pounds of sodium hexametaphosphate the operator will need to make the 15 percent solution.

4. Calculate the number of pounds of ferric chloride that must be added to 85 gallons of water in order to make a 25 percent ferric chloride solution.

5. At Dover's water treatment plant the operator uses a 9 percent soda ash solution for adjusting the pH and alkalinity of the raw water. The operator will use 165 gallons of water to prepare the solution. Determine how many pounds of soda ash are needed to make the solution.

6. Monterey's water plant operator uses a three percent potassium permanganate solution for taste and odor control in the raw water. The operator will use 45 gallons of water to make the solution. Calculate the number of pounds of potassium permanganate needed to make the three percent solution.

7. An operator wants to make a 7.5 percent soda ash solution for adjusting the pH of the finished water. The operator will use 75 gallons of water to make the solution. How many pounds of soda ash will be needed?

8. At the city of Bell's water treatment plant, the operator uses a 3 percent potassium permanganate solution for oxidizing iron and manganese in the raw water. The operator added 95 gallons of water to the potassium permanganate day tank. How many pounds of potassium permanganate must be added to the water to make a 3 percent solution?

9. The operator at the Humboldt Utilities' water treatment plant uses an 10 percent sodium hexametaphosphate solution for corrosion control. The operator added 70 gallons of water to the day tank. Determine how many pounds of sodium hexametaphosphate the operator will need to make the 10 percent solution.

10. Calculate the number of pounds of ferric sulfate that must be added to 145 gallons of water in order to make a 32 percent ferric chloride solution.

11. At Cleveland's water treatment plant the operator uses a 7 percent soda ash solution for adjusting the pH and alkalinity of the raw water. The operator will use 225 gallons of water to

prepare the solution. Determine how many pounds of soda ash are needed to make the solution.

12. McMinnville's water plant operator uses a three percent potassium permanganate solution for taste and odor control in the raw water. The operator will use 345 gallons of water to make the solution. Calculate the number of pounds of potassium permanganate needed to make the three percent solution.

13. An operator wants to make a 10 percent soda ash solution for adjusting the pH of the finished water. The operator will use 50 gallons of water to make the solution. How many pounds of soda ash will be needed?

14. At Beaver Creek Utility District the operator uses a 3 percent potassium permanganate solution for oxidizing iron and manganese in the raw water. The operator added 35 gallons of water to the potassium permanganate day tank. How many pounds of potassium permanganate must e added to the water to make a 3 percent solution?

15. The operator at Monterey's water plant uses an 10 percent sodium hexametaphosphate solution for corrosion control. The operator added 60 gallons of water to the day tank. Determine how many pounds of sodium hexametaphosphate the operator will need to make the 10 percent solution.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 32.9 lbs | 2. 14.2 lbs | 3. 95.7 lbs | 4. 236.3 lbs | 5. 136.1 lbs |
| 6. 11.6 lbs | 7. 50.7 lbs | 8. 24.5 lbs | 9. 64.9 lbs | 10. 569.1 lbs |
| 11. 141.2 lbs | 12. 88.9 lbs | 13. 46.3 lbs | 14. 9.0 lbs | 15. 55.6 lbs |

# Water Required, Gallons

This formula can be used to determine the volume of water in gallons needed to make a solution of predetermined strength.

$$\text{Water Volume, gal} = \frac{\text{Chemical, lb (100\% - Desired Concentration, \%)}}{\text{8.34 lb/gal X Desired Concentration, \%}}$$

Example: An operator wants to prepare an eight percent soda ash solution using one 50-lb bag of soda ash. How many gallons of water are needed?

**Write down the formula.**

$$\text{Water Volume, gal} = \frac{\text{Chemical, lb (100\% - Desired Concentration, \%)}}{\text{8.34 lb/gal X Desired Concentration, \%}}$$

**Make a table of data.**

Chemical, lb = 50 lb

Desired Concentration, % = 8%.

**Plug the data into the formula.**

$$\text{Water Volume, gal} = \frac{\text{50 lb (100\% - 8 \%)}}{\text{8.34 lb/gal X 8 \%}}$$

**Cancel terms and do the math inside the parentheses.**

$$\text{Water Volume, gal} = \frac{\text{50 (92)}}{\text{8.34 gal X 8}}$$

**Multiply the numbers above the line.**

$$\text{Water Volume, gal} = \frac{\text{4,600}}{\text{8.34 gal X 8}}$$

**Multiply the numbers below the line.**

$$\text{Water Volume, gal} = \frac{\text{4,600}}{\text{66.72 gal}}$$

**Divide the number above the line by the number below the line.**

$$\text{Water Volume, gal} = 68.9448441247 \text{ or } 68.9 \text{ lb}$$

### *Practice Problems*

1. An operator wants to make up a three percent potassium permanganate solution using one pail of potassium permanganate. A pail of potassium permanganate contains 55 pounds. Calculate the volume of water (on gallons) needed to prepare the three percent solution.

2. How many gallons of water are needed to prepare a ten percent soda ash solution, using one 50-lb bag of soda ash?

3. Calculate the volume of water in gallons required to make a 5 percent solution of sodium bicarbonate if two 50-lb bags of sodium bicarbonate will be used.

4. A utility purchases sodium hexametaphosphate an 50-lb pails. An operator wants to prepare an eight percent solution using three pails. Determine how many gallons of water must be used to prepare the eight percent solution.

5. The operators at Bloomingdale Utility District want to prepare a 15 percent copper sulfate solution to treat their raw water holding pond. They will use two 100-lb bags of copper sulfate to prepare the solution. Calculate the volume of water (in gallons) needed to prepare the copper sulfate solution.

6. A utility purchases a dry corrosion inhibitor in 50-lb bags. The operators want to use three bags of the corrosion inhibitor to prepare a 12 percent solution. How many gallons of water are needed to prepare the solution?

7. An operator wants to make up a three percent potassium permanganate solution using one bucket of potassium permanganate. A pail of potassium permanganate contains 110 pounds. Calculate the volume of water (on gallons) needed to prepare the three percent solution.

8. How many gallons of water are needed to prepare a six percent soda ash solution, using one 50-lb bag of soda ash?

9. Calculate the volume of water in gallons required to make a thirteen percent solution of sodium bicarbonate if three 100-lb bags of sodium bicarbonate will be used.

10. A utility purchases sodium carbonate in 50-lb bags. An operator wants to prepare an nine percent solution using three bags. Determine how many gallons of water must be used to prepare the nine percent solution.

11. The operators at Livingston Utility District want to prepare a 20 percent copper sulfate solution to treat their raw water holding pond. They will use four 100-lb bags of copper sulfate to prepare the solution. Calculate the volume of water (in gallons) needed to prepare the copper sulfate solution.

12. A utility purchases a dry chemical in 100-lb bags. The operators want to use two bags of the corrosion inhibitor to prepare a 16 percent solution. How many gallons of water are needed to prepare the solution?

13. An operator wants to make up a three percent potassium permanganate solution using three buckets of potassium permanganate. A bucket of potassium permanganate contains 55 pounds. Calculate the volume of water (on gallons) needed to prepare the three percent solution.

14. How many gallons of water are needed to prepare a thirteen percent soda ash solution, using four 50-lb bag of soda ash?

15. Calculate the volume of water in gallons required to make a 7 percent solution of sodium bicarbonate if three 50-lb bags of sodium bicarbonate will be used.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 213 gal | 2. 54 gal | 3. 228 gal | 4. 207 gal | 5. 136 gal |
| 6. 132 gal | 7. 426 gal | 8. 94 gal | 9. 241 gal | 10. 182 gal |
| 11. 192 gal | 12. 126 gal | 13. 640 gal | 14. 160 gal | 15. 239 gal |

# Solution Preparation - Whole Container

This formula can be used to calculate the volume of water (on gallons) required to prepare a solution of predetermined strength on concentration when a whole container of chemical must be used.

$$\text{Water Volume, gal} = \frac{\text{Chemical, lbs (100\% - Desired Concentration, \%)}}{\text{8.34 lbs/gal X Desired Concentration, \%}}$$

Example: An operator wants to prepare an eight percent soda ash solution using one 50-lb bag of soda ash. How many gallons of water are needed?

Write down the formula.

$$\text{Water Volume, gal} = \frac{\text{Chemical, lbs (100\% - Desired Concentration, \%)}}{\text{8.34 lbs/gal X Desired Concentration, \%}}$$

Make a table of data.

Chemical, lbs = 50 lbs

Desired Concentration, % = 8%

Plug the data into the formula.

$$\text{Water Volume, gal} = \frac{\text{50 lbs (100\% - 8\%)}}{\text{8.34 lbs/gal X 8\%}}$$

Cancel terms.

$$\text{Water Volume, gal} = \frac{\text{50 (100 - 8)}}{\text{8.34 gal X 8}}$$

Subtract the number inside the parentheses.

$$\text{Water Volume, gal} = \frac{\text{50 (92)}}{\text{8.34 gal X 8}}$$

Multiply the numbers above the line.

$$\text{Water Volume, gal} = \frac{\text{4,600}}{\text{8.34 gal X 8}}$$

Multiply the numbers below the line.

$$\text{Water Volume, gal} = \frac{\text{4,600}}{\text{66.72 gal}}$$

Divide the numbers above the line by the numbers below the line.

$$\text{Water Volume, gal} = 68.9448441247 \text{ or } 69 \text{ gal}$$

Practice Problems

Round your answers to the nearest gallon (whole number).

1. An operator wants to make up a three percent potassium permanganate solution using one pail of potassium permanganate. A pail of potassium permanganate contains 55 pounds. Calculate the volume of water (on gallons) needed to prepare the three percent solution.

2. How many gallons of water are needed to prepare a ten percent soda ash solution, using one 50-lb bag of soda ash?

3. Calculate the volume of water in gallons required to make a 5 percent solution of sodium bicarbonate if two 50-lb bags of sodium bicarbonate will be used.

4. A utility purchases sodium hexametaphosphate in 50-lb pails. An operator wants to prepare an eight percent solution using three pails. Determine how many gallons of water must be used to prepare the eight percent solution.

5. The operators at Bloomingdale Utility District want to prepare a 15 percent copper sulfate solution to treat their raw water holding pond. They will use two 100-lb bags of copper sulfate to prepare the solution. Calculate the volume of water (in gallons) needed to prepare the copper sulfate solution.

6. A utility purchases a dry corrosion inhibitor in 50-lb bags. The operators want to use three bags of the corrosion inhibitor to prepare a 12 percent solution. How many gallons of water are needed to prepare the solution?

7. An operator wants to make up a three percent potassium permanganate solution using one pail of potassium permanganate. A pail of potassium permanganate contains 100 pounds. Calculate the volume of water (on gallons) needed to prepare the three percent solution.

8. How many gallons of water are needed to prepare a six percent soda ash solution, using one 50-lb bag of soda ash?

9. Calculate the volume of water in gallons required to make a thirteen percent solution of sodium bicarbonate if three 100-lb bags of sodium bicarbonate will be used.

10. A utility purchases sodium carbonate in 50-lb bags. An operator wants to prepare a ten percent solution using two bags. Determine how many gallons of water must be used to prepare the ten percent solution.

11. The operators at Livingston Utility District want to prepare a 20 percent copper sulfate solution to treat their raw water holding pond. They will use four 100-lb bags of copper sulfate to prepare the solution. Calculate the volume of water (in gallons) needed to prepare the copper sulfate solution.

12. A utility purchases a dry chemical in 100-lb bags. The operators want to use two bags of the corrosion inhibitor to prepare a 16 percent solution. How many gallons of water are needed to prepare the solution?

13. An operator wants to make up a three percent potassium permanganate solution using three buckets of potassium permanganate. A bucket of potassium permanganate contains 110 pounds. Calculate the volume of water (on gallons) needed to prepare the three percent solution.

14. How many gallons of water are needed to prepare a thirteen percent soda ash solution, using four 50-lb bag of soda ash?

15. Calculate the volume of water in gallons required to make a 7 percent solution of sodium bicarbonate if three 50-lb bags of sodium bicarbonate will be used.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 213 gal | 2. 54 gal | 3. 228 gal | 4. 207 gal | 5. 136 gal |
| 6. 132 gal | 7. 388 gal | 8. 94 gal | 9. 241 gal | 10. 108 gal |
| 11. 192 gal | 12. 126 gal | 13. 1,279 gal | 14. 160 gal | 15. 239 gal |

# Solution Preparation - Whole Container

This formula can be used to calculate the volume of water (on gallons) required to prepare a solution of predetermined strength on concentration when a whole container of chemical must be used.

$$\text{Water Volume, gal} = \frac{\text{Chemical, lbs (100\% - Desired Concentration, \%)}}{\text{8.34 lbs/gal X Desired Concentration, \%}}$$

Example: An operator wants to prepare an eight percent soda ash solution using one 50-lb bag of soda ash. How many gallons of water are needed?

**Write down the formula.**

$$\text{Water Volume, gal} = \frac{\text{Chemical, lbs (100\% - Desired Concentration, \%)}}{\text{8.34 lbs/gal X Desired Concentration, \%}}$$

**Make a table of data.**

Chemical, lbs = 50 lbs

Desired Concentration, % = 8%

**Plug the data into the formula.**

$$\text{Water Volume, gal} = \frac{\text{50 lbs (100\% - 8\%)}}{\text{8.34 lbs/gal X 8\%}}$$

**Cancel terms and subtract the number inside the parentheses.**

$$\text{Water Volume, gal} = \frac{\text{50 (92)}}{\text{8.34 gal X 8}}$$

**Multiply the numbers above the line.**

$$\text{Water Volume, gal} = \frac{\text{4,600}}{\text{8.34 gal X 8}}$$

**Multiply the numbers below the line.**

$$\text{Water Volume, gal} = \frac{\text{4,600}}{\text{66.72 gal}}$$

**Divide the numbers above the line by the numbers below the line.**

$$\text{Water Volume, gal} = 68.9448441247 \text{ or } 69 \text{ gal}$$

***Practice Problems***

1. An operator wants to make up a three percent potassium permanganate solution using one pail of potassium permanganate. A pail of potassium permanganate contains 55 pounds. Calculate the volume of water (on gallons) needed to prepare the three percent solution.

2. How many gallons of water are needed to prepare a ten percent soda ash solution, using one 50-lb bag of soda ash?

3. Calculate the volume of water in gallons required to make a 5 percent solution of sodium bicarbonate if two 50-lb bags of sodium bicarbonate will be used.

4. A utility purchases sodium hexametaphosphate in 50-lb pails. An operator wants to prepare an eight percent solution using three pails. Determine how many gallons of water must be used to prepare the eight percent solution.

5. The operators at Bloomingdale Utility District want to prepare a 15 percent copper sulfate solution to treat their raw water holding pond. They will use two 100-lb bags of copper sulfate to prepare the solution. Calculate the volume of water (in gallons) needed to prepare the copper sulfate solution.

6. A utility purchases a dry corrosion inhibitor in 50-lb bags. The operators want to use three bags of the corrosion inhibitor to prepare a 12 percent solution. How many gallons of water are needed to prepare the solution?

7. An operator wants to make up a three percent potassium permanganate solution using one pail of potassium permanganate. A pail of potassium permanganate contains 100 pounds. Calculate the volume of water (on gallons) needed to prepare the three percent solution.

8. How many gallons of water are needed to prepare a six percent soda ash solution, using one 50-lb bag of soda ash?

9. Calculate the volume of water in gallons required to make a thirteen percent solution of sodium bicarbonate if three 100-lb bags of sodium bicarbonate will be used.

10. A utility purchases sodium carbonate in 50-lb bags. An operator wants to prepare a ten percent solution using two bags. Determine how many gallons of water must be used to prepare the ten percent solution.

11. The operators at Livingston Utility District want to prepare a 20 percent copper sulfate solution to treat their raw water holding pond. They will use four 100-lb bags of copper sulfate to prepare the solution. Calculate the volume of water (in gallons) needed to prepare the copper sulfate solution.

12. A utility purchases a dry chemical in 100-lb bags. The operators want to use two bags of the corrosion inhibitor to prepare a 16 percent solution. How many gallons of water are needed to prepare the solution?

13. An operator wants to make up a three percent potassium permanganate solution using three buckets of potassium permanganate. A bucket of potassium permanganate contains 110

pounds. Calculate the volume of water (on gallons) needed to prepare the three percent solution.

14. How many gallons of water are needed to prepare a thirteen percent soda ash solution, using four 50-lb bag of soda ash?

15. Calculate the volume of water in gallons required to make a 7 percent solution of sodium bicarbonate if three 50-lb bags of sodium bicarbonate will be used.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 213 gal | 2. 54 gal | 3. 228 gal | 4. 207 gal | 5. 136 gal |
| 6. 132 gal | 7. 388 gal | 8. 94 gal | 9. 241 gal | 10. 108 gal |
| 11. 192 gal | 12. 126 gal | 13. 1,279 gal | 14. 160 gal | 15. 239 gal |

# Inches of Water Required

These formulas can be used to calculate the amount of water in inches which must be added to a mixing tank to prepare a solution of desired strength or concentration.

**Cylindrical Tanks**

$$\text{Depth, in} = \frac{\text{Volume, gal X } 231\,\text{in}^3/\text{gal}}{(0.785)\,(\text{Diameter, in})^2}$$

**Rectangular Tanks**

$$\text{Depth, in} = \frac{\text{Volume, gal X } 231\,\text{in}^3/\text{gal}}{(\text{Length, in})\,(\text{Width, in})}$$

Example 1: The operators of Rockwood's water treatment plant want to make a three percent potassium permanganate solution by adding 55 pounds of KMn04 to 213 gallons of water. The solution will be prepared in a mixing tank which is 36 inches in diameter. How many inches of water must be added to the tank in order to add the 213 gallons?

**Write down the formula**

$$\text{Depth, in} = \frac{\text{Volume, gal X } 231\,\text{in}^3/\text{gal}}{(0.785)\,(\text{Diameter, in})^2}$$

**Make a table of data**

Volume, gal = 213 gal

Diameter, in = 36 in

**Plug the data into the formula.**

$$\text{Depth, in} = \frac{213\text{ gal X } 231\,\text{in}^3/\text{gal}}{(0.785)\,(36\,\text{in})^2}$$

**Square the tank diameter**

$$\text{Depth, in} = \frac{213\text{ gal X } 231\,\text{in}^3/\text{gal}}{(0.785)\,(1{,}296\,\text{in}^2)}$$

**Cancel terms and multiply the numbers above the line.**

$$\text{Depth, in} = \frac{49{,}203\ \text{in}^3}{(0.785)\,(1{,}296\ \text{in}^2)}$$

**Multiply the numbers below the line.**

$$\text{Depth, in} = \frac{49{,}203\ \text{in}^3}{1{,}017.36\ \text{in}^2}$$

**Divide the numbers above the line by the number below the line.**

$$\text{Depth, in} = 48.36341118 \text{ or } 48.4\ \text{in}$$

Example 2: An operator wants to use 121 gallons of water to prepare a 13 percent soda ash solution. The solution will be made up in a mixing tank which is 42 inches long, 36 inches wide, and 36 inches deep. How many inches of water must be added to the tank in order to make up the solution?

**Write down the formula.**

$$\text{Depth, in} = \frac{\text{Volume, gal X } 231\ \text{in}^3/\text{gal}}{(\text{Length, in})\,(\text{Width, in})}$$

**Make a table of data.**

Volume, gal = 121 gal

Length, in = 42 in

Width, in = 36 in

**Plug in the data into the formula.**

$$\text{Depth, in} = \frac{121\ \text{gal X } 231\ \text{in}^3/\text{gal}}{(42\ \text{in})\,(36\ \text{in})}$$

**Cancel terms and multiply the numbers above the line.**

$$\text{Depth, in} = \frac{27{,}951\ \text{in}^3}{(42\ \text{in})\,(36\ \text{in})}$$

**Multiply the numbers below the line.**

$$\text{Depth, in} = \frac{27{,}951\ \text{in}^3}{1{,}512\ \text{in}^2}$$

**Divide the number above the line by numbers below the line.**

$$\text{Depth, in} = 18.486111111 \text{ or } 18.5 \text{ in}$$

***Practice Problems***

1. In order to make up a batch of 3 percent potassium permanganate solution, 300 gallons of water must be added to a mixing tank which is 42 inches in diameter. How many inches of water must be added to the table?

2. 250 gallons of water is to be added to a mixing tank which is 40 inches in diameter. Calculate the inches of water which must be added to the tank.

3. To prepare a batch of sodium bicarbonate solution 175 gallons of water are needed. The solution will be mixed in a tank with a diameter of 38 inches. Determine how many inches of water must be added to the tank.

4. How many inches of water must be added to a mixing tank which is 40 inches in diameter if an operator wants to add 200 gallons to the tank?

5. An operator wants to prepare a ten percent sodium carbonate solution using 225 gallons of water. The solution will be prepared in a mixing tank which is 40 inches in diameter. Determine how many inches of water are to be added to the tank to prepare the desired solution.

6. The operators at Clinton's water treatment plant makes up a three percent potassium permanganate solution using 100 pounds of potassium permanganate and 388 gallons of water. They mix up the solution in a tank which is 48 inches in diameter. Calculate the number of inches of water required to add the 388 gallons to the mixing tank.

7. A mixing tank is 30 inches in diameter. Operators want to add 75 gallons of water to the tank. How many inches of water must be added to the tank?

8. In order to add 200 gallons of water to a tank which is 41 inches in diameter, how many inches of water must be added to the tank?

9. Determine how many inches of water must be added to a mixing tank which is 44 inches in diameter if 250 gallons of water are needed.

10. A seven percent soda ash solution is used at Hallsdale-Powell's water treatment plant to adjust pH and alkalinity. To make up the solution 50 pounds of soda ash are added to 80 gallons of water. The solution is made up in a mixing tank which is 34 inches in diameter. Calculate how many inches of water must be added to the tank to make up the solution.

11. Three percent potassium permanganate solution is made up in a mixing tank which is 50 inches in diameter. Three hundred and fifty gallons of water will be used to make up the solution. Determine how many inches of water must be added to the tank to make up the solution.

12. Calculate the number of inches of water which must be added to a mixing tank with a diameter of 28 inches in order to add 100 gallons to the tank.

13. Adding 125 gallons to a mixing tank with a diameter of 32 inches requires how many inches of water to be added to the tank?

14. An operator wants to add 120 gallons to a mixing tank which is 35 inches in diameter. Determine how many inches of water must be added to the tank.

15. A mixing tank is 40 inches in diameter. An operator wants to add 213 gallons of water to the tank. How many inches of water must be added to the tank?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 50.0 inches | 2. 46.0 inches | 3. 35.7 inches | 4. 36.8 inches | 5. 41.4 inches |
| 6. 49.6 inches | 7. 24.5 inches | 8. 35.0 inches | 9. 38.0 inches | 10. 20.4 inches |
| 11. 41.2 inches | 12. 37.5 inches | 13. 35.9 inches | 14. 28.8 inches | 15. 39.2 inches |

# Facility Disinfection

Newly installed, or repaired water treatment and storage facilities must be disinfected according to TDEC – Division of Water Sources Resources regulation 0400-45-01-.17(8).

| Facility | Standard | Chlorine Dose |
|---|---|---|
| Water Mains | AWWA Standard C-651 – 14 or Approved SOP | • 25 mg/L<br>• 100 mg/L (Slug Method)<br>• 300 mg/L (Emergency) |
| Storage tanks and clearwells | AWWA C-652 - 11 | • Method 1 – sufficient to produce a residual of at least 10 mg/L after holding time.<br>• Method 2 – 200 mg/L solution<br>• Method 3 – 50 mg/L in five percent of the tank volume. |
| Water Plants | AWWA C-653 – 03 | Various |
| Wells | AWWA C-654 | Various |

# Water Main Disinfection - HTH

Example: A newly installed section of 10-inch water main is 950 long. It is to be disinfected using a chlorine dose of 25 mg/L. HTH will be the source of chlorine. HTH has an available chlorine concentration of 65%. How many pounds of HTH will be needed to disinfect the water main?

**Write down the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

**Make a table of data.**

Dosage, mg/L = 25 mg/L

Capacity, MGD = ? MGD

Purity = 65% ÷ 100% = 0.65

***Find the volume in million gallons (MG).***

**Write down the formula.**

$$\text{Volume} = (.785)\,(\text{Diameter}^2)\,(\text{Height})$$

**Make a table of data.**

Diameter = 10 in ÷ 12 in/ft = 0.8333 ft

Height = 950 ft

**Plug the data into the formula.**

$$\text{Volume} = (.785)\,(0.8333\ \text{ft})^2\ (950\ \text{ft})$$

**Square the diameter.**

$$\text{Volume} = (.785)\,(0.6943\ \text{ft}^2)\,(950\ \text{ft})$$

**Do the multiplication.**

$$\text{Volume} = 517.774225 \text{ or } 517.7742\ \text{ft}^3$$

**Find the volume in gallons using the conversion factor.**

$$\text{Volume} = 517.7742\ \text{ft}^3\ \text{X}\ 7.48\ \text{gal/ft}^3 = 3{,}872.951016 \text{ or } 3{,}873\ \text{gal}$$

**Find the volume in MG (million gallons).**

$$\text{Volume} = \frac{3{,}873 \text{ gal}}{1{,}000{,}000} = 0.003873 \text{ MG}$$

***Go back to the original formula.***

**Write down the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})\,(\text{Capacity, MGD})\,(8.34 \text{ lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

**Make a table of data.**

Dosage, mg/L = 25 mg/L

Capacity, MGD = 0.003873 MG

Purity = 65% ÷ 100% = 0.65

**Plug the data into the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(25 \text{ mg/L})\,(0.003873 \text{ MG})\,(8.34 \text{ lbs/gal})}{0.65}$$

**Multiply the numbers above the line.**

$$\text{Feed Rate, lbs/day} = \frac{0.8075 \text{ lbs}}{0.65}$$

**Divide the number above the line by the number below the line.**

$$\text{Feed Rate, lbs/day} = 1.243076923 \text{ or } 1.24 \text{ lbs}$$

***Practice Problems***

1. A newly-installed section of 12-inch water main is 1,200 feet long. How many pounds of HTH (65% available chlorine) are needed to disinfect the main if the chlorine dose is to be 25 mg/L?

2. Determine how many pounds of HTH (65% available chlorine) are needed to disinfect 1,100 feet of 6-inch water main if the chlorine dose is to be 25 mg/.

3. Calculate the pounds of HTH (65% available chlorine) needed to disinfect 1,900 feet of 20-inch water main using a chlorine dose of 25 mg/L.

4. How many pounds of HTH (65% available chlorine) are needed to disinfect 875 feet of 8-inch water main if the chlorine dose is to be 25 mg/L?

5. How many pounds of HTH (65% available chlorine) are required to disinfect 679 feet of 4-inch water pipe if the chlorine dose is to be 25 mg/L?

6. A newly-installed section of 6-inch water main is 1,400 feet in length. It is to be disinfected using HTH (65% available chlorine). The chlorine dose will be 25 mg/L. Calculate how many pounds of HTH will be needed.

7. A 1,250-foot section of 8-inch water main has just be installed. It is to be disinfected using a chlorine dose of 25 mg/L. Determine how many pounds of HTH (65% available chlorine) will be required to disinfect the new section of water main.

8. Seventeen hundred and fifty (1,750) feet of 10-inch water main has just been installed. Calculate how many pounds of HTH (65% available chlorine) will be required to disinfect the main if the chlorine dose is 25 mg/L.

9. A new section of 12-inch water main is to be disinfected using a chlorine dose of 25 mg/L. The section of water main is 1,800 feet long. Determine how many pounds of HTH (65% available chlorine) are needed to disinfect the water main.

10. How many pounds of HTH (65% available chlorine) are needed to disinfect 2,000 feet of 14-inch water pipe using a chlorine dose of 25 mg/L?

11. A newly-installed section of 10-inch water main is 1,650 feet long. It has a volume of 0.0066 MG. How many pounds of HTH (65% available chlorine) are needed to disinfect the main if the chlorine dose is to be 25 mg/L?

12. Determine how many pounds of HTH (65% available chlorine) are needed to disinfect 1,700 feet of 8-inch water main if the chlorine dose is to be 25 mg/L.

13. Calculate the pounds of HTH (65% available chlorine) needed to disinfect 1,375 feet of 6-inch water main using a chlorine dose of 25 mg/L.

14. How many pounds of HTH (65% available chlorine) are needed to disinfect 1,080 feet of 6-inch water main if the chlorine dose is to be 25 mg/L?

15. How many pounds of HTH (65% available chlorine) are required to disinfect 1,240 feet of 8-inch water pipe if the chlorine dose is to be 25 mg/L?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 2.3 lbs | 2. 0.5 lbs | 3. 9.9 lbs | 4. 0.7 lbs | 5. 0.1 lbs |
| 6. 0.7 lbs | 7. 1.0 lbs | 8. 2.3 lbs | 9. 3.4 lbs | 10. 5.1 lbs |
| 11. 2.2 lbs | 12. 1.4 lbs | 13. 0.6 lbs | 14. 0.5 lbs | 15. 1.0 lbs |

# Tank Chlorination Method 1 - HTH

This formula is provided for use when HTH is used as the source of chlorine for disinfecting water storage tanks. Unless the problem states otherwise, the chemical purity of HTH is 65 percent available chlorine.

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34\text{lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

Example: A newly constructed water treatment tank is to be disinfected using a chlorine dose of 12 mg/L. The tank has a diameter of 35 feet, and a height of 45 feet. HTH is to be used as the source of chlorine for disinfecting the storage tank. HTH has an available chlorine concentration of 65 percent. Determine how many pounds of HTH will be needed to disinfect the tank.

***Step One: Find the volume of the tank in cubic feet.***

**Write down the formula.**

$$\text{Volume} = (.785)\,(\text{Diameter}^2)\,(\text{Height})$$

**Make a table of data.**

Diameter = 35 ft

Height = 45 ft

**Plug the data into the formula.**

$$\text{Volume} = (.785)\,(35\text{ ft})^2\,(45\text{ ft})$$

**Square the diameter.**

$$\text{Volume} = (0.785)\,(1{,}225\text{ ft}^2)\,(45\text{ ft})$$

**Do the multiplication.**

$$\text{Volume} = 43{,}273.125\text{ ft}^3$$

***StepTwo: Find the volume of the tank in gallons using the conversion factor.***

$$\text{Volume} = 43{,}273.125\text{ ft}^3\ \text{ X }\ 7.48 = 323{,}682.975\text{ gal}$$

***StepThree: Convert the volume gallons to Million Gallons (MG).***

$$\text{Volume} = \frac{323{,}682.975}{1{,}000{,}000} = 0.323682975 \text{ or } 0.3236\text{ MG}$$

***Step Four: Determine the pounds of HTH required to disinfect the tank.***

**Write down the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34\text{lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

**Make a table of data.**

Dosage, mg/L = 12 mg/L

Capacity, MG = 0.3236 MG

Purity, % expressed as a decimal = 65% ÷ 100% = 0.65

**Plug the data into the formula.**

$$\text{Feed Rate , lbs/day} = \frac{(12\text{ mg/L})(0.3236\text{ MG})(8.34\text{lbs/gal})}{(0.65)}$$

**Multiply the numbers above the line.**

$$\text{Feed Rate, lbs/day} = \frac{32.385888\text{ lbs}}{(0.65)}$$

**Do the division.**

$$\text{Feed Rate, lbs/day} = 49.8244430769 \text{ or } 50\text{ lbs}$$

***Practice Problems***

1. How many pounds of HTH (65% available chlorine) are required to disinfect a storage tank if the chlorine dose is to be 15 mg/L? The tank is 45 feet in diameter and has a height of 40 feet.

2. A standpipe with a diameter of 22 feet and a height 110 feet is to be disinfected using a chlorine dose of 15 mg/L. Calculate the number of pounds of HTH needed to disinfect the tank? HTH is 65% available chlorine.

3. Determine how many pounds of HTH (65% available chlorine) would be required to disinfect a storage tank if the chlorine dose is 15 mg/L. The tank has a diameter of 40 feet. It has a height of 65 feet.

4. Calculate the number of pounds of HTH (65% available chlorine) required to disinfect a storage tank using a chlorine dose of 15 mg/L. The tank has a height of 35 feet, and a diameter of 30 feet.

5. A stand pipe is 25 feet in diameter. It has a height of 56 feet. It is to be disinfected using a chlorine dose of 15 mg/L. How many pounds of HTH (65% available chlorine) are needed to disinfect the standpipe?

6. How many pounds of HTH (65% available chlorine) are needed to disinfect a ground-level storage tank which is 18 feet in diameter and has a depth of 45 feet, if the chlorine dose is to be 15 mg/L?

7. Determine how many pounds of HTH (65% available chlorine) are needed to disinfect a standpipe using a chlorine dose of 15 mg/L. The standpipe has a diameter of 40 feet. The maximum water depth for the tank is 60 feet.

8. A ground-level storage tank is 75 feet in diameter. It has a depth of 20 feet. Calculate the number of pounds of HTH (65% available chlorine) required to disinfect the tank using a chlorine dose of 15 mg/L.

9. Calculate the number of pounds of HTH (65% available chlorine) required to disinfect a storage tank using a chlorine dose of 15 mg/L if the tank has a diameter of 25 feet and a height of 85 feet.

10. A standpipe has a depth of 90 feet. It is to be disinfected using a chlorine dose of 15 mg/L. How many pounds of HTH (65% available chlorine) are needed to disinfect the standpipe if its diameter is 21 feet.

11. A storage tank is 30 feet in diameter and has a depth of 25 feet. How many pounds of HTH (65% available chlorine) are needed to disinfect the tank if the chlorine dose is to be 15 mg/L?

12. A groundlevel storage tank is to be disinfected using HTH. The chlorine dose will be 15 mg/L. The tank has a diameter of 28 feet. It has a depth of 54 feet. How many pounds of HTH (65% available chlorine) will be needed to disinfect the tank?

13. A standpipe has a depth of 80 feet. It is to be disinfected using a chlorine dose of 15 mg/L. How many pounds of HTH (65% available chlorine) are needed to disinfect the standpipe if its diameter is 20 feet.

14. A storage tank is 56 feet in diameter and has a depth of 65 feet. How many pounds of HTH (65% available chlorine) are needed to disinfect the tank if the chlorine dose is to be 15 mg/L?

15. A groundlevel storage tank is to be disinfected using HTH. The chlorine dose will be 15 mg/L. The tank has a diameter of 45 feet. It has a depth of 35 feet. How many pounds of HTH (65% available chlorine) will be needed to disinfect the tank?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 92 lbs | 2. 60 lbs | 3. 118 lbs | 4. 42 lbs | 5. 40 lbs |
| 6. 16 lbs | 7. 108 lbs | 8. 127 lbs | 9. 60 lbs | 10. 45 lbs |
| 11. 25 lbs | 12. 48 lbs | 13. 36 lbs | 14. 230 lbs | 15. 80 lbs |

# Storage Tank Chlorination Method 2 - HTH

This method consists of brushing or spraying all parts of the tank that would come into contact with treated water with a solution containing 200 mg/L available chlorine. The solution is to remain on the tank walls and floor for at least 30 minutes. After this time, the tank is to be filled to its overflow level with potable water.

The 200 mg/L solution can be prepared using either HTH or bleach. The pounds of HTH needed to prepare the solution can be determined using this formula.

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})(\text{Capacity, MG})(8.34\ \text{lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

Example: A newly-constructed storage tank is to be disinfected using tank disinfected method 2. One thousand gallons of the 200 mg/L available chlorine solution will be needed. How many pounds of HTH (65% available chlorine) will be needed to make the solution?

**Write down the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})(\text{Capacity, MG})(8.34\ \text{lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

**Make a table of data.**

$$\text{Dosage, mg/L} = 200\ \text{mg/L}$$

$$\text{Volume, MG} = 1{,}000\ \text{gal} \div 1{,}000{,}000\ \text{gal/MG} = 0.001\text{MG}$$

$$\text{\% available HTH} = 65\% \div 100\% = 0.65$$

**Plug the data into the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(200\ \text{mg/L})(0.001\text{MG})(8.34\ \text{lbs/gal})}{0.65}$$

**Multiply the numbers above the line.**

$$\text{Feed Rate, lbs/day} = \frac{1.668\ \text{lbs}}{0.65}$$

**Do the division.**

$$\text{Feed Rate, lbs/day} = 2.566153846 \text{ or } 2.6\ \text{lbs}$$

***Practice Problems***

1. A newly-constructed water storage tank will be disinfected, using chlorination method 2, before being placed into service. The operator will need 3,050 gallons of 200 mg/L available chlorine solution to coat the tank interior. How many pounds of HTH (65% available chlorine) will be needed to prepare the solution?

2. Before being placed into service, a water storage tank will be disinfected using tank chlorination method 2. In this method, all tank services that will come into contact with potable water are to be coated with a chlorine solution with an available chlorine concentration of 200 mg/L. Determine how many pounds of HTH will be required to make 1,370 gallons of the 200 mg/L available chlorine solution. The HTH has an available chlorine concentration of 65%.

3. A standpipe was taken out of service for inspection. Before being placed back into service the tank will be disinfected using tank chlorination method 2, in which all the tank's surfaces which will come into contact with the potable water are to be coated with a chlorine solution with a concentration of 200 mg/L available chlorine. Calculate the number of pounds of HTH required to prepare 2,980 gallons of the solution. HTH has a strength of 65% available chlorine.

4. A water storage tank is to be disinfected by spraying the interior with a chlorine solution with a strength of 200 mg/L available chlorine. How many pounds of HTH (65% available chlorine) will be needed to make 1,450 gallons of solution with an available chlorine concentration of 200 mg/L?

5. How many pounds of HTH (65% available chlorine) are needed to make 2,840 gallons of chlorine solution with a strength of 200 mg/L available chlorine to be used to disinfect a groundlevel storage tank using chlorination method 2.

6. An elevated storage tank is to be disinfected using tank chlorination method 2. In this tank disinfection method all interior surfaces that will come into contact with the potable water are coated with a chlorine solution containing 200 mg/L available chlorine. It will take 1,500 gallons of the chlorine solution to coat the tank interior. Calculate the pounds of HTH (65% available chlorine) needed to make the solution.

7. A newly-constructed water storage tank will be disinfected, using chlorination method 2, before being placed into service. The operator will need 4,050 gallons of 200 mg/L available chlorine solution to coat the tank interior. How many pounds of HTH (65% available chlorine) will be needed to prepare the solution?

8. Before being placed into service, a water storage tank will be disinfected using tank chlorination method 2. In this method, all tank services that will come into contact with potable water are to be coated with a chlorine solution with an available chlorine concentration of 200 mg/L. Determine how many pounds of HTH will be required to make 1,170 gallons of the 200 mg/L available chlorine solution. The HTH has an available chlorine concentration of 65%.

9. A standpipe was taken out of service for inspection. Before being placed back into service the tank will be disinfected using tank chlorination method 2, in which all the tank's surfaces which will come into contact with the potable water are to be coated with a chlorine solution with a concentration of 200 mg/L available chlorine. Calculate the number of pounds of HTH required to prepare 4,000 gallons of the solution. HTH has a strength of 65% available chlorine.

10. A water storage tank is to be disinfected by spraying the interior with a chlorine solution with a strength of 200 mg/L available chlorine. How many pounds of HTH (65% available chlorine) will be needed to make 2,000 gallons of solution with an available chlorine concentration of 200 mg/L?

11. How many pounds of HTH (65% available chlorine) are needed to make 2,600 gallons of chlorine solution with a strength of 200 mg/L available chlorine to be used to disinfect a groundlevel storage tank using chlorination method 2.

12. An elevated storage tank is to be disinfected using tank chlorination method 2. In this tank disinfection method all interior surfaces that will come into contact with the potable water are coated with a chlorine solution containing 200 mg/L available chlorine. It will take 4,500 gallons of the chlorine solution to coat the tank interior. Calculate the pounds of HTH (65% available chlorine) needed to make the solution.

13. Before being placed into service, a water storage tank will be disinfected using tank chlorination method 2. In this method, all tank services that will come into contact with potable water are to be coated with a chlorine solution with an available chlorine concentration of 200 mg/L. Determine how many pounds of HTH will be required to make 1,750 gallons of the 200 mg/L available chlorine solution. The HTH has an available chlorine concentration of 65%.

14. A standpipe was taken out of service for inspection. Before being placed back into service the tank will be disinfected using tank chlorination method 2, in which all the tank's surfaces which will come into contact with the potable water are to be coated with a chlorine solution with a concentration of 200 mg/L available chlorine. Calculate the number of pounds of HTH required to prepare 3,000 gallons of the solution. HTH has a strength of 65% available chlorine.

15. A water storage tank is to be disinfected by spraying the interior with a chlorine solution with a strength of 200 mg/L available chlorine. How many pounds of HTH (65% available chlorine) will be needed to make 1,650 gallons of solution with an available chlorine concentration of 200 mg/L?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 7.8 lbs | 2. 3.5 lbs | 3. 7.6 lbs | 4. 3.7 lbs | 5. 7.3 lbs |
| 6. 3.8 lbs | 7. 10.4 lbs | 8. 3.0 lbs | 9. 10.3 lbs | 10. 5.1 lbs |
| 11. 6.7 lbs | 12. 11.5 lbs | 13. 4.5 lbs | 14. 7.7 lbs | 15. 4.2 lbs |

# Tank Chlorination Method 3 - HTH

Tank chlorination method 3 uses the same formulas as method 1. There are two differences. The chlorine dose will be 50 mg/L, and only five percent of the tank's volume is to be used in the calculation. Five percent (5%) of the tank's volume can be calculated by multiplying the tank's volume by 0.05.

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34\text{lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

Example: A water storage tank has just been inspected and cleaned. The tank has a volume of 0.65 MG. Before being put back into service, it is to disinfected using tank chlorination method 3. The chlorine dose is to be 50 mg/L. How many pounds of HTH (65% available chlorine) are needed to disinfect the storage tank?

**Write down the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})(\text{Capacity, MGD})(8.34\text{lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

**Make a table of data.**

Dosage, mg/L = 50 mg/L

Capacity, MG = 0.65 MG X 0.05 = 0.0325 MG

Purity, % expressed as a decimal = 65%/100% = 0.65

**Plug the data into the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(50\text{ mg/L})(0.0325\text{ MG})(8.34\text{lbs/gal})}{0.65}$$

**Multiply the numbers above the line.**

$$\text{Feed Rate, lbs/day} = \frac{13.5525\text{ lbs}}{0.65}$$

**Do the division.**

$$\text{Feed Rate, lbs/day} = 20.85 \text{ or } 21\text{lbs}$$

***Practice Problems***

1. A newly-constructed water storage tank is to be disinfected using tank chlorination method 3. After cleaning, the tank will be initially filled to 5% of its volume with water containing a chlorine residual of 50 mg/L. How many pounds of HTH (65% available chlorine) will be required to disinfect the tank if its total volume is 0.48 MG?

2. A storage tank with a volume of 0.31 MG is to be disinfected using tank chlorination method 3. The tank will initially be filled to five percent of its volume with water containing a chlorine residual of 50 mg/L. Calculate the number of pounds of HTH (65% available chlorine) needed to disinfect the tank.

3. A standpipe with a volume of 0.61 MG has been cleaned and inspected. Before being placed back into to service it is to be disinfected using tank chlorination method 3. In this method, the tank will be initially filled to five percent of its total volume with water containing 50 mg/L free chlorine residual. Determine how many pounds HTH (65% available chlorine) will be needed to disinfect the tank.

4. How many pounds of HTH (65% available chlorine) will be needed to disinfect a 0.185 MG groundlevel storage tank using tank chlorination method 3? Tank chlorination method 3 requires that 5 percent of the tank's volume be filled with water containing a free chlorine residual of 50 mg/L.

5. A newly-constructed water storage tank is to be disinfected using tank chlorination method 3. After cleaning, the tank will be initially filled to 5% of its volume with water containing a chlorine residual of 50 mg/L. How many pounds of HTH (65% available chlorine) will be required to disinfect the tank if its total volume is 205,000 gallons?

6. A storage tank with a volume of 856,000 gallons is to be disinfected using tank chlorination method 3. The tank will initially be filled to five percent of its volume with water containing a chlorine residual of 50 mg/L. Calculate the number of pounds of HTH (65% available chlorine) needed to disinfect the tank.

7. A standpipe with a volume of 564,000 gallons has been cleaned and inspected. Before being placed back into to service it is to be disinfected using tank chlorination method 3. In this method, the tank will be initially filled to five percent of its total volume with water containing 50 mg/L free chlorine residual. Determine how many pounds of HTH (65% available chlorine) will be needed to disinfect the tank.

8. How many pounds of HTH (65% available chlorine) will be needed to disinfect a 660,000-gallon groundlevel storage tank using tank chlorination method 3? Tank chlorination method 3 requires that 5 percent of the tank's volume be filled with water containing a free chlorine residual of 50 mg/L.

9. A newly-constructed water storage tank is to be disinfected using tank chlorination method 3. After cleaning, the tank will be initially filled to 5% of its volume with water containing a chlorine residual of 50 mg/L. How many pounds of HTH (65% available chlorine) will be required to disinfect the tank if the tank has a diameter of 25 feet and a height of 85 feet?

10. A storage tank with a diameter of 21 feet and a height of 90 feet is to be disinfected using tank chlorination method 3. The tank will initially be filled to five percent of its volume with water containing a chlorine residual of 50 mg/L. Calculate the number of pounds of HTH (65% available chlorine) needed to disinfect the tank.

11. A groundlevel storage tank with a diameter of 30 feet and a depth of 25 feet has been cleaned and inspected. Before being placed back into to service it is to be disinfected using tank chlorination method 3. In this method, the tank will be initially filled to five percent of its total volume with water containing 50 mg/L free chlorine residual. Determine how many pounds of HTH (65% available chlorine) will be needed to disinfect the tank.

12. How many pounds of HTH (65% available chlorine) will be needed to disinfect a groundlevel storage tank using tank chlorination method 3? Tank chlorination method 3 requires that 5 percent of the tank's volume be filled with water containing a free chlorine residual of 50 mg/L. The tank has a diameter of 28 feet and a height of 54 feet.

13. A storage tank with a diameter of 20 feet and a height of 80 feet is to be disinfected using tank chlorination method 3. The tank will initially be filled to five percent of its volume with water containing a chlorine residual of 50 mg/L. Calculate the number of pounds of HTH (65% available chlorine) needed to disinfect the tank.

14. A groundlevel storage tank with a diameter of 56 feet and a depth of 65 feet has been cleaned and inspected. Before being placed back into to service it is to be disinfected using tank chlorination method 3. In this method, the tank will be initially filled to five percent of its total volume with water containing 50 mg/L free chlorine residual. Determine how many pounds of HTH (65% available chlorine) will be needed to disinfect the tank.

15. How many pounds of HTH (65% available chlorine) will be needed to disinfect a groundlevel storage tank using tank chlorination method 3? Tank chlorination method 3 requires that 5 percent of the tank's volume be filled with water containing a free chlorine residual of 50 mg/L. The tank has a diameter of 45 feet and a height of 35 feet.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 15 lbs | 2. 10 lbs | 3. 20 lbs | 4. 6 lbs | 5. 7 lbs |
| 6. 27 lbs | 7. 18 lbs | 8. 21 lbs | 9. 10 lbs | 10. 7 lbs |
| 11. 4 lbs | 12. 8 lbs | 13. 6 lbs | 14. 38 lbs | 15. 13 lbs |

# Fluoridation

## Sodium Fluoride Solution Feed Rate – gal/min

This formula is used to calculate the saturated sodium fluoride feed rate in gallons per minute (gal/min).

$$\text{Feed Rate, gal/min (Fluoride Saturator)} = \frac{\text{(Plant Capacity, gpm) (Dosage, mg/L)}}{\text{18,000 mg/L}}$$

Example: A fluoride saturator is used to feed sodium fluoride. The desired fluoride dose is 1.0 mg/L. Water is treated at a rate of 300 gal/min. Calculate the sodium fluoride solution feed rate in gallons per minute.

**Write down the formula.**

$$\text{Feed Rate, gal/min} = \frac{\text{(Plant Capacity, gpm) (Dosage, mg/L)}}{\text{18,000 mg/L}}$$

**Make a table of data**

Dose, mg/L = 1.0 mg/L

Plant Capacity, gpm = 300 gpm

**Plug the data into the formula.**

$$\text{Feed Rate, gal/min} = \frac{\text{(300 gpm) (1.0 mg/L)}}{\text{18,000 mg/L}}$$

**Cancel terms and multiply the numbers above the line.**

$$\text{Feed Rate, gal/min} = \frac{\text{300 gpm}}{\text{18,000}}$$

**Divide the number above the line by the number below the line.**

$$\text{Feed Rate, gal/min} = 0.016666666666 \text{ or } 0.0167 \text{ gal/min}$$

***Practice Problems***

1. Saturated sodium fluoride is fed at a rate required to produce a fluoride dose of 1.1 mg/L. Water is treated at a rate of 750 gal/min. What is the saturated sodium fluoride solution feed rate in gallons per minute?

2. Water is treated at a rate of 125 gal/min. Determine the saturated sodium fluoride solution feed rate, in gallons per minute, required to produce a fluoride dose of 1.0 mg/L.

3. An operator wants to feed fluoride at a dose of 0.9 mg/L using a sodium fluoride saturator. Water is treated at a rate of 225 gal/min. Calculate the saturated sodium fluoride solution feed rate in gallons per minute needed to produce the desired dose.

4. The desired fluoride dose is 1.1 mg/L. What is the required saturated sodium fluoride solution feed rate in gallons per minute if water is treated at a rate of 300 gal/min?

5. Saturated sodium fluoride solution is fed at such a rate as to produce a fluoride dose of 1.0 mg/L. Water is treated at a rate of 800 gal/min. Calculate the required solution feed rate in gallons per minutes.

6. Saturated sodium fluoride is fed at a rate required to produce a fluoride dose of 0.9 mg/L. Water is treated at a rate of 900 gal/min. What is the saturated sodium fluoride solution feed rate in gallons per minute?

7. Water is treated at a rate of 275 gal/min. Determine the saturated sodium fluoride solution feed rate, in gallons per minute, required to produce a fluoride dose of 1.0 mg/L.

8. An operator wants to feed fluoride at a dose of 1.1 mg/L using a sodium fluoride saturator. Water is treated at a rate of 320 gal/min. Calculate the saturated sodium fluoride solution feed rate in gallons per minute needed to produce the desired dose.

9. The desired fluoride dose is 1.0 mg/L. What is the required saturated sodium fluoride solution feed rate in gallons per minute if water is treated at a rate of 350 gal/min?

10. Saturated sodium fluoride solution is fed at such a rate as to produce a fluoride dose of 0.9 mg/L. Water is treated at a rate of 245 gal/min. Calculate the required solution feed rate in gallons per minutes.

11. Saturated sodium fluoride is fed at a rate required to produce a fluoride dose of 1.0 mg/L. Water is treated at a rate of 550 gal/min. What is the saturated sodium fluoride solution feed rate in gallons per minute?

12. Water is treated at a rate of 675 gal/min. Determine the saturated sodium fluoride solution feed rate, in gallons per minute, required to produce a fluoride dose of 0.7 mg/L.

13. An operator wants to feed fluoride at a dose of 0.8 mg/L using a sodium fluoride saturator. Water is treated at a rate of 400 gal/min. Calculate the saturated sodium fluoride solution feed rate in gallons per minute needed to produce the desired dose.

14. The desired fluoride dose is 0.6 mg/L. What is the required saturated sodium fluoride solution feed rate in gallons per minute if water is treated at a rate of 425 gal/min?

15. Saturated sodium fluoride solution is fed at such a rate as to produce a fluoride dose of 0.5 mg/L. Water is treated at a rate of 775 gal/min. Calculate the required solution feed rate in gallons per minutes.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 0.0458 gpm | 2. 0.0069 gpm | 3. 0.0113 gpm | 4. 0.0183 gpm | 5. 0.0444 gpm |
| 6. 0.0450 gpm | 7. 0.0153 gpm | 8. 0.0196 gpm | 9. 0.0194 gpm | 10. 0.0123 gpm |
| 11. 0.0306 gpm | 12. 0.0263 gpm | 13. 0.0178 gpm | 14. 0.0142 gpm | 15. 0.0215 gpm |

# Sodium Fluorosilicate Feed Rate, lb/day

This formula is used to calculate the sodium fluorosilicate feed rate in pounds per day.

$$\text{Feed Rate, lbs/day (Fluoride)} = \frac{\text{(Dosage, mg/L) (Capacity, MGD) (8.34 lbs/gal)}}{\left(\begin{array}{c}\text{Available Fluoride Ion, \%}\\ \text{expressed as a decimal}\end{array}\right)\text{(Purity, \% expressed as a decimal)}}$$

Example: An operator fed fluoride at a dose 1.0 mg/L using sodium fluorosilicate. Sodium fluorosilicate has an available fluoride ion concentration of 60.7 percent, and a purity of 98.5 percent. Water is treated at a rate of 1.75 MGD. Determine the sodium fluorosilicate feed rate in pounds per day.

**Write down the formula.**

$$\text{Feed Rate, lbs/day (Fluoride)} = \frac{\text{(Dosage, mg/L) (Capacity, MGD) (8.34 lbs/gal)}}{\left(\begin{array}{c}\text{Available Fluoride Ion, \%}\\ \text{expressed as a decimal}\end{array}\right)\text{(Purity, \% expressed as a decimal)}}$$

**Make a table of data**

Dose, mg/L=1.0 mg/L

Flow, MGD=1.75 MGD

AFI = 60.7% ÷ 100% = 0.607

Purity = 98.5% ÷ 100% = 0.985

**Plug the data into the formula.**

$$\text{Feed Rate, lbs/day (Fluoride)} = \frac{\text{(1.0 mg/L) (1.75 MGD) (8.34 lbs/gal)}}{\text{(0.607) (0.985)}}$$

**Cancel terms and multiply the numbers above the line.**

$$\text{Feed Rate, lbs/day (Fluoride)} = \frac{\text{14.595 lbs/day}}{\text{(0.607) (0.985)}}$$

**Multiply the numbers below the line.**

$$\text{Feed Rate, lbs/day (Fluoride)} = \frac{\text{14.595 lbs/day}}{0.597895}$$

**Divide the number above the line by the number below the line.**

$$\text{Feed Rate, lbs/day (Fluoride)} = 24.4106406643 \text{ or } 24.4 \text{ lbs/day}$$

1. Fluoride is fed at a dose of 1.1 mg/L. Water is treated at a rate of 2.25 MGD. What is the sodium fluorosilicate feed rate in pounds per day? Sodium fluorosilicate has a commercial purity of 98.5 percent, and an available fluoride ion concentration of 60.7 percent.
2. Sodium fluorosilicate is used to feed a fluoride dose of 1.0 mg/L. Sodium fluorosilicate has a commercial purity of 98.5 percent. It has an available fluoride concentration of 60.7 percent. Calculate the sodium fluorosilicate feed rate in pounds per day if water is treated at a rate of 5.5 MGD.
3. Water is fluoridated using sodium silicafluoride. Sodium fluorosilicate has a commercial purity of 98.5 percent. It has an available fluoride concentration of 60.7 percent. Water is treated at a rate of 7.5 MGD. Determine the sodium fluorosilicate feed rate in pounds per day if the fluoride dose is 0.9 mg./L
4. Calculate the sodium fluorosilicate feed rate in pounds per day if the fluoride dose is to be 1.1 mg/L, and the flow is 1.25 MGD. Sodium fluorosilicate has a commercial purity of 98.5 percent. It has an available fluoride concentration of 60.7 percent.
5. Water is treated at a rate of 2.75 MGD. The desired fluoride dose is 1.1 mg/L. Sodium fluorosilicate is used to fluoridate the water. What is the sodium fluorosilicate feed rate in pounds per day? Sodium fluorosilicate has a commercial purity of 98.5 percent, and an available fluoride ion concentration of 60.7 percent.
6. Fluoride is fed at a dose of 0.9 mg/L. Water is treated at a rate of 3,750,000 gal/day. What is the sodium fluorosilicate feed rate in pounds per day? Sodium fluorosilicate has an commercial purity of 98.5 percent, and an available fluoride ion concentration of 60.7 percent.
7. Sodium fluorosilicate is used to feed a fluoride dose of 1.0 mg/L. Sodium fluorosilicate has a commercial purity of 98.5 percent. It has an available fluoride concentration of 60.7 percent. Calculate the sodium fluorosilicate feed rate in pounds per day if water is treated at a rate of 10,000,000 gal/day.
8. Water is fluoridated using sodium silicafluoride. Water is treated at a rate of 475,000 gal/day. Determine the sodium fluorosilicate feed rate in pounds per day if the fluoride dose is 1.1 mg./L. Sodium fluorosilicate has a commercial purity of 98.5 percent, and an available fluoride ion concentration of 60.7 percent.
9. Calculate the sodium fluorosilicate feed rate in pounds per day if the fluoride dose is to be 1.1 mg/L, and the flow is 1,750,000 gal/day. Sodium fluorosilicate has a commercial purity of 98.5 percent, and an available fluoride ion concentration of 60.7 percent.
10. Water is treated at a rate of 2,450,000 gal/day. The desired fluoride dose is 0.9 mg/L. Sodium fluorosilicate is used to fluoridate the water. Sodium fluorosilicate has a commercial purity of 98.5 percent, and an available fluoride ion concentration of 60.7 percent. What is the sodium fluorosilicate feed rate in pounds per day?
11. The fluoride dose is to be 1.0 mg/L. Water is treated at a rate of 12,750,000 gal/day. Sodium fluorosilicate is used to treat the water. Determine the sodium fluorosilicate feed rate in pounds per day. Sodium fluorosilicate has an commercial purity of 98.5 percent, and an available fluoride ion concentration of 60.7 percent.
12. An operator feeds sodium fluorosilicate to produce a fluoride concentration of 1.0 mg/L. The natural fluoride concentration in the raw water is 0.3 mg/L. Sodium fluorosilicate has a commercial purity of 98.5 percent. It has an available fluoride concentration of 60.7 percent. Water is treated at a rate of 1.475 MGD. What is the sodium fluorosilicate feed rate in pounds per day?

13. The natural fluoride concentration in the raw water is 0.3 mg/L. Sodium fluorosilicate is fed at a rate to produce a fluoride concentration of 1.1 mg/L in the finished water. Water is treated at a rate of 2.75 MGD. Determine the required sodium fluorosilicate feed rate in pounds per day. Sodium fluorosilicate has a commercial purity of 98.5 percent. It has an available fluoride concentration of 60.7 percent.
14. Water is treated at a rate of 3,750,000 gal/day. The desired fluoride concentration in the finished water is 1.0 mg/L. The fluoride concentration in the raw water is 0.4 mg/L. What is the sodium fluorosilicate feed rate in pounds per day required to deliver the desired dose? Sodium fluorosilicate has a commercial purity of 98.5 percent. It has an available fluoride concentration of 60.7 percent.
15. The natural fluoride concentration in the raw water is 0.5 mg/L. The desired fluoride concentration in the finished water is 1.0 mg/L. Water is treated at a rate of 8,750,000 gal/day. Determine the sodium fluorosilicate feed rate in pounds per day needed to deliver the desired fluoride dose. Sodium fluorosilicate has a commercial purity of 98.5 percent. It has an available fluoride concentration of 60.7 percent.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 34.5 lb/day | 2. 76.7 lb/day | 3. 94.2 lb/day | 4. 19.2 lb/day | 5. 42.2 lb/day |
| 6. 47.1 lb/day | 7. 139.5 lb/day | 8. 7.3 lb/day | 9. 26.9 lb/day | 10. 30.8 lb/day |
| 11. 177.8 lb/day | 12. 14.4 lb/day | 13. 30.7 lb/day | 14. 31.4 lb/day | 15. 61.0 lb/day |

# Fluorosilicic Acid Feed Rate-lb/day

This formula can be used to calculate the fluorosilicic acid feed rate in pounds per day.

$$\text{Feed Rate, lbs/day (Fluoride)} = \frac{\text{(Dosage, mg/L) (Capacity, MGD) (8.34 lbs/gal)}}{\left(\begin{array}{c}\text{Available Fluoride Ion, \%}\\ \text{expressed as a decimal}\end{array}\right)\text{(Purity, \% expressed as a decimal)}}$$

Example: Fluorosilicic acid is used to fluoridate the finished water. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent. Water is treated at a rate of 1.75 MGD. The desired fluoride dose is 1.0 mg/L. Calculate the required fluorosilicic acid feed rate in pounds per day.

**Write down the formula.**

$$\text{Feed Rate, lbs/day (Fluoride)} = \frac{\text{(Dosage, mg/L) (Capacity, MGD) (8.34 lbs/gal)}}{\left(\begin{array}{c}\text{Available Fluoride Ion, \%}\\ \text{expressed as a decimal}\end{array}\right)\text{(Purity, \% expressed as a decimal)}}$$

**Make a table of data**

Dose, mg/L=1.0

Flow, MGD=1.75 MGD

AFI = 79.2% ÷ 100% = 0.792

Purity = 23% ÷ 100% = 0.230

**Plug the data into the formula.**

$$\text{Feed Rate, lbs/day (Fluoride)} = \frac{\text{(1.0 mg/L) (1.75 MGD) (8.34 lbs/gal)}}{\text{(0.792) (0.23)}}$$

**Cancel terms and multiply the numbers above the line.**

$$\text{Feed Rate, lbs/day (Fluoride)} = \frac{\text{14.595 lbs/day}}{\text{(0.792) (0.23)}}$$

**Multiply the numbers below the line.**

$$\text{Feed Rate, lbs/day (Fluoride)} = \frac{\text{14.595 lbs/day}}{0.18216}$$

**Divide the number above the line by the number below the line.**

$$\text{Feed Rate, lbs/day (Fluoride)} = 80.1086777539 \text{ or } 80.1 \text{ lbs/day}$$

***Practice Problems***

1. Finished water is fluoridated using fluorosilicic acid. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent. The fluoride dose is 1.1 mg/L. Water is treated at a rate of 2.25 MGD. Determine the fluorosilicic acid feed rate in pounds per day.
2. What is the fluorosilicic acid feed rate in pounds per day if water is treated at a rate of 5.6 MGD and the fluoride dose is 1.0 mg/L? Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent.
3. Fluorosilicic acid is used to fluoridate the finished water. Water is treated at a rate of 7.5 MGD. The fluoride dose is 0.9 mg/L. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent. Calculate the fluorosilicic acid feed rate in pounds per day required to deliver the desired dosage.
4. Calculate the required fluorosilicic acid feed rate in pounds per day if the fluoride dose is 1.1 mg/L and water is treated at a rate of 1.25 MGD. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent.
5. Fluorosilicic acid is used to fluoridate finished water at Woodbury's water treatment plant. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent. On Tuesday the fluoride dose was 1.0 mg/L. Water was treated at a rate of 2.75 MGD. What was the fluorosilicic acid feed rate in pounds per day?
6. Finished water is fluoridated using fluorosilicic acid. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent. The fluoride dose is 0.9 mg/L. Water is treated at a rate of 3.75 MGD. Determine the fluorosilicic acid feed rate in pounds per day.
7. What is the fluorosilicic acid feed rate in pounds per day if water is treated at a rate of 10.0 MGD and the fluoride dose is 1.0 mg/L? Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent.
8. Fluorosilicic acid is used to fluoridate the finished water. Water is treated at a rate of 0.475 MGD. The fluoride dose is 1.1 mg/L. Calculate the fluorosilicic acid feed rate in pounds per day required to deliver the desired dosage. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent.
9. Calculate the required fluorosilicic acid feed rate in pounds per day if the fluoride dose is 1.0 mg/L and water is treated at a rate of 1.75 MGD. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent.
10. Fluorosilicic acid is used to fluoridate finished water at Clinton's water treatment plant. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent. On Tuesday the fluoride dose was 0.9 mg/L. Water was treated at a rate of 2.45 MGD. What was the fluorosilicic acid feed rate in pounds per day?
11. Finished water is fluoridated using fluorosilicic acid. The fluoride dose is 1.0 mg/L. Water is treated at a rate of 12,750,000 gal/day. Determine the fluorosilicic acid feed rate in pounds per day. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent.
12. The natural fluoride concentration in the raw water is 0.3 mg/L. The desired fluoride concentration in the finished water is 1.0 mg/L. Fluorosilicic acid is used to treat the water. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion

concentration of 79.2 percent. Water is treated at a rate of 1,475,000 gal/day. Calculate the fluorosilicic acid feed rate in pounds per day.

13. Water is treated at a rate of 2,750,000 gal/day. The fluoride concentration in the raw water is 0.2 mg/L. The desired fluoride concentration in the finished water is 1.0 mg/L. Fluorosilicic acid is used to fluoridate the water. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent. Determine required fluorosilicic acid feed rate in pounds per day.
14. The raw water at Kingsport has a natural fluoride concentration of 0.4 mg/L. Fluorosilicic acid is fed to provide a fluoride concentration in the finished water of 1.0 mg/L. Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent. Water is treated at a rate of 3.75 MGD. Calculate the fluorosilicic acid feed rate in pounds per day needed to provide the desired fluoride concentration.
15. The desired fluoride concentration in the finished water is 1.0 mg/L. The fluoride concentration in the raw water is 0.5 mg/L. Fluorosilicic acid is used to fluoridate the water. Water is treated at a rate of 8,750,000 gallons per day. What is the fluorosilicic acid feed rate in pounds per day required to provide the desired finished water fluoride concentration? Fluorosilicic acid has a commercial purity of 23 percent, and an available fluoride ion concentration of 79.2 percent.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 113.3 lbs/day | 2. 256.4 lbs/day | 3. 309.0 lbs/day | 4. 63.0 lbs/day | 5. 125.9 lbs/day |
| 6. 154.5 lbs/day | 7. 457.8 lbs/day | 8. 23.9 lbs/day | 9. 80.1 lbs/day | 10. 101.0 lbs/day |
| 11. 583.7 lbs/day | 12. 47.3 lbs/day | 13. 100.7 lbs/day | 14. 103.0 lbs/day | 15. 200.3 lbs/day |

# Calculated Dosage for Sodium Fluoride

When using sodium fluoride, the calculated fluoride dose in milligrams per liter can be calculated if you rearrange this formula. Rearranging is done to isolate the information you want to determine. In this case, it is the calculated dosage.

$$\text{Feed Rate, gal/min} = \frac{(\text{Plant Capacity, gpm})\,(\text{Dosage, mg/L})}{18{,}000\ \text{mg/L}}$$

Example: The sodium fluoride solution feed rate is 0.0458 gpm. Water is treated at a rate of 750 gpm. What is the fluoride dose in mg/L?

***Rearrange the formula.***

**Multiply each side by 18,000 mg/L.**

$$(18{,}000\ \text{mg/L})\,(\text{Feed Rate, gal/min}) = \frac{(\text{Plant Capacity, gpm})\,(\text{Dosage, mg/L})\,(18{,}000\ \text{mg/L})}{18{,}000\ \text{mg/L}}$$

**On the right side of the equal sign, divide by 18,000 mg/L.**

$$(18{,}000\ \text{mg/L})\ (\text{Feed Rate, gal/min}) = (\text{Plant Capacity, gpm})\ (\text{Dosage, mg/L})$$

**Divide each side by the plant capacity in gpm to finish the rearrangement..**

$$\frac{(18{,}000\ \text{mg/L})\,(\text{Feed Rate, gal/min})}{\text{Plant Capcaity, gpm}} = \frac{(\text{Plant Capacity, gpm})\,(\text{Dosage, mg/L})}{\text{Plant Capacity, gpm}}$$

$$\frac{(18{,}000\ \text{mg/L})\,(\text{Feed Rate, gal/min})}{\text{Plant Capcaity, gpm}} = \text{Dosage, mg/L}$$

***Solve the problem.***

**Write down the rearranged formula.**

$$\frac{(18{,}000\ \text{mg/L})\,(\text{Feed Rate, gal/min})}{\text{Plant Capcaity, gpm}} = \text{Dosage, mg/L}$$

**Make a table of data.**

Feed Rate, gpm = 0.0458 gpm

Plant Capacity, gpm = 750 gpm

**Plug the data into the rearranged formula.**

$$\frac{(18{,}000\ \text{mg/L})\,(0.0458\ \text{gal/min})}{750\ \ \text{gpm}} = \text{Dosage, mg/L}$$

**Multiply the numbers above the line.**

$$\frac{824.4\ \text{mg/L}}{750} = \text{Dosage, mg/L}$$

**Divide the number above the line by the number below the line.**

$$1.0992 \text{ or } 1.1\,\text{mg/L} = \text{Dosage, mg/L}$$

### *Practice Problems – Sodium Fluoride Saturator*

1. Determine the fluoride dose in milligrams per liter if water is treated at a rate of 300 gal/min, and saturated sodium fluoride solution is fed at a rate of 0.015 gal/min.
2. Water is treated at a rate of 250 gal/min. Saturated sodium fluoride solution is fed at a rate of 0.0153 gal/min. Calculate the fluoride dose in milligrams per liter.
3. An operator feeds sodium fluoride from a saturator at a rate of 0.0222 gpm. Water is treated at a rate of 400 gpm. What is the fluoride dose in milligrams per liter?
4. An operator feeds saturated sodium fluoride at a rate of 0.0267 gpm while treating water at a rate of 600 gpm. Determine the fluoride dose in milligrams per liter.
5. What is the fluoride dose in milligrams per liter if saturated sodium fluoride solution is fed at a rate of 0.01 gal/min while water is treated at a rate of 200 gal/min?
6. Determine the fluoride dose in milligrams per liter if water is treated at a rate of 800 gal/min, and saturated sodium fluoride solution is fed at a rate of 0.0311 gal/min.
7. Water is treated at a rate of 350 gal/min. Saturated sodium fluoride solution is fed at a rate of 0.0156 gal/min. Calculate the fluoride dose in milligrams per liter.
8. An operator feeds sodium fluoride from a saturator at a rate of 0.0238 gpm. Water is treated at a rate of 475 gpm. What is the fluoride dose in milligrams per liter?
9. An operator feeds saturated sodium fluoride at a rate of 0.0413 gpm while treating water at a rate of 675 gpm. Determine the fluoride dose in milligrams per liter.
10. What is the fluoride dose in milligrams per liter if saturated sodium fluoride solution is fed at a rate of 0.0125 gal/min while water is treated at a rate of 225 gal/min?
11. Determine the fluoride dose in milligrams per liter if water is treated at a rate of 325 gal/min, and saturated sodium fluoride solution is fed at a rate of 0.0126 gal/min.
12. Water is treated at a rate of 275 gal/min. Saturated sodium fluoride solution is fed at a rate of 0.0122 gal/min. Calculate the fluoride dose in milligrams per liter.
13. An operator feeds sodium fluoride from a saturator at a rate of 0.048 gpm. Water is treated at a rate of 960 gpm. What is the fluoride dose in milligrams per liter?
14. An operator feeds saturated sodium fluoride at a rate of 0.0306 gpm while treating water at a rate of 550 gpm. Determine the fluoride dose in milligrams per liter.

15. What is the fluoride dose in milligrams per liter if saturated sodium fluoride solution is fed at a rate of 0.0322 gal/min while water is treated at a rate of 725 gal/min?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 0.9 mg/L | 2. 1.1 mg/L | 3. 1.0 mg/L | 4. 0.8 mg/L | 5. 0.9 mg/L |
| 6. 0.7 mg/L | 7. 0.8 mg/L | 8. 0.9 mg/L | 9. 1.1 mg/L | 10. 1.0 mg/L |
| 11. 0.7 mg/L | 12. 0.8 mg/L | 13. 0.9 mg/L | 14. 1.0 mg/L | 15. 0.8 mg/L |

# Calculated Dosage for Sodium Fluorosilcate and Fluorosilicic Acid

To find the calculated fluoride dose you will have to rearrange the equation.

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mgL})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}{\left(\begin{array}{c}\text{Available Fluoride Ion, \%}\\ \text{expressed as a decimal}\end{array}\right)\left(\begin{array}{c}\text{Purity, \%}\\ \text{expressed as a decimal}\end{array}\right)}$$

**Multiply the right side of the equation by the available fluoride ion concentration and purity as decimals.**

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mgL})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})\,(\text{AFI, \%})\,(\text{Purity, \%})}{(\text{AFI, \%})\,(\text{Purity, \%})}$$

**Cancel the available fluoride ion concentration and purity as decimals on the right side.**

$$\text{Feed Rate, lbs/day} = (\text{Dosage, mgL})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})$$

**Multiply the left side by the available fluoride ion concentration and purity as decimals.**

$$(\text{AFI, \%})\,(\text{Purity, \%})\,(\text{Feed Rate, lbs/day}) = (\text{Dosage, mgL})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})$$

**Divide the right side by capacity and 8.34 lbs/gal.**

$$(\text{AFI, \%})\,(\text{Purity, \%})\,(\text{Feed Rate, lbs/day}) = \frac{(\text{Dosage, mgL})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}{(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}$$

$$(\text{AFI, \%})\,(\text{Purity, \%})\,(\text{Feed Rate, lbs/day}) = \text{Dosage, mg/L}$$

**Divide the left side of the equation by capacity and 8.34 lbs/gal.**

$$\frac{(\text{AFI, \%})\,(\text{Purity, \%})\,(\text{Feed Rate, lbs/day})}{(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})} = \text{Dosage, mg/L}$$

Now you have the formula you need.

Example: On Tuesday an operator fed 492 pounds of fluorosilicic acid. 10.75 MG of water were treated that day. The fluorosilicic acid fed was 23% fluorosilicic acid, and had a commercial purity of 79.2%. What was the fluoride dose in milligrams per liter?

***Step One: Rearrange the formula.***

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mgL})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}{\left(\begin{array}{c}\text{Available Fluoride Ion, \%}\\ \text{expressed as a decimal}\end{array}\right)\left(\begin{array}{c}\text{Purity, \%}\\ \text{expressed as a decimal}\end{array}\right)}$$

**Multiply the right side of the equation by the available fluoride ion concentration and purity as decimals.**

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mgL})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})\,(\text{AFI, \%})\,(\text{Purity, \%})}{(\text{AFI, \%})\,(\text{Purity, \%})}$$

**Cancel the available fluoride ion concentration and purity as decimals on the right side.**

$$\text{Feed Rate, lbs/day} = (\text{Dosage, mgL})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})$$

**Multiply the left side by the available fluoride ion concentration and purity as decimals.**

$$(\text{AFI, \%})\,(\text{Purity, \%})\,(\text{Feed Rate, lbs/day}) = (\text{Dosage, mgL})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})$$

**Divide the right side by capacity and 8.34 lbs/gal.**

$$(\text{AFI, \%})\,(\text{Purity, \%})\,(\text{Feed Rate, lbs/day}) = \frac{(\text{Dosage, mgL})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}{(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}$$

$$(\text{AFI, \%})\,(\text{Purity, \%})\,(\text{Feed Rate, lbs/day}) = \text{Dosage, mg/L}$$

**Divide the left side of the equation by capacity and 8.34 lbs/gal.**

$$\frac{\left(\begin{array}{c}\text{Available Fluoride Ion, \%}\\ \text{expressed as a decimal}\end{array}\right)\left(\begin{array}{c}\text{Purity, \%}\\ \text{expressed as a decimal}\end{array}\right)(\text{Feed Rate, lbs/day})}{(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})} = \text{Dosage, mg/L}$$

***Step Two: Determine the calculated fluoride dose in milligrams per liter.***

**Write down the formula.**

$$\frac{\left(\begin{array}{c}\text{Available Fluoride Ion, \%}\\ \text{expressed as a decimal}\end{array}\right)\left(\begin{array}{c}\text{Purity, \%}\\ \text{expressed as a decimal}\end{array}\right)(\text{Feed Rate, lbs/day})}{(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})} = \text{Dosage, mg/L}$$

**Make a table of data.**

Available Fluoride Ion, % = 23% ÷ 100% = 0.23

Purity, % = 79.2% ÷ 100% = 0.792

Feed Rate, lbs/day = 492 lbs/day

Capacity, MGD = 10.75 MGD

**Plug the data into the formula.**

$$\frac{(0.23)\,(0.792)\,(492\,\text{lbs/day})}{(10.75\,\text{MGD})\,(8.34\,\text{lbs/gal})} = \text{Dosage, mg/L}$$

**Multiply the numbers above the line.**

$$\frac{89.6227}{(10.75\,\text{MGD})\,(8.34\,\text{lbs/gal})} = \text{Dosage, mg/L}$$

**Multiply the numbers below the line.**

$$\frac{89.6227}{89.655} = \text{Dosage, mg/L}$$

**Divide the number above the line by the number below the line.**

$$0.99963973 \text{ or } 1.0\,\text{mg/L} = \text{Dosage, mg/L}$$

### *Practice Problems*

1. While treating a flow of 2.75 MGD, an operator fed 42.2 pounds of sodium fluorosilicate. The sodium fluorosilcate has an available fluoride ion concentration of 60.7% and a purity of 98.5%. What was the fluoride dose in milligrams per liter (mg/l)?
2. During the previous 24-hour period water was treated at a rate of 4,500,000 gal/day. fluorosilicic acid was fed at a rate of 206 lbs/day. The available fluoride ion concentration of the fluorosilicic acid is 23%. The commercial purity of the acid is 79.2%. Calculate the fluoride dose in milligrams per liter (mg/l).
3. On Tuesday, fluorosilicic acid was fed at a rate of 525.4 lbs/day. Water was treated at a rate of 12,750,000 gal/day. What was the fluoride dose in milligrams per liter (mg/l)? The available fluoride ion concentration of the fluorosilicic acid is 23%. The commercial purity of the acid is 79.2%.
4. Calculate the fluoride dose in mg/l if sodium fluorosilicate is fed at a rate of 95.2 pounds per day (lbs/day) and the flow was 9.75 MGD. The sodium fluorosilcate has an available fluoride ion concentration of 60.7% and a purity of 98.5%.
5. While treating a flow of 750,000 gal/day, an operator fed 10.5 pounds of sodium fluorosilicate. The sodium fluorosilcate has an available fluoride ion concentration of 60.7% and a purity of 98.5%. What was the calculated fluoride dose in milligrams per liter (mg/l)?
6. During the previous 24-hour period water was treated at a rate of 575,000 gal/day. Fluorosilicic acid was fed at a rate of 29 lbs/day. Calculate the fluoride dose in milligrams per liter (mg/l). The available fluoride ion concentration of the fluorosilicic acid is 23%. The commercial purity of the acid is 79.2%.
7. On Friday, 137.4 pounds of fluorosilicic acid were fed. Water was treated at a rate of 2,500,000 gal/day. The available fluoride ion concentration of the fluorosilicic acid is 23%.

The commercial purity of the acid is 79.2%. What was the calculated fluoride dose in milligrams per liter (mg/l)?

8. 15.7 pounds of sodium fluorosilicate were fed while treating a flow of 1,250,000 gal/day. The sodium fluorosilcate has an available fluoride ion concentration of 60.7% and a purity of 98.5%. Determine the calculated fluoride dose in milligrams per liter (mg/l).

9. While treating a flow of 8,650,000 gal/day, an operator fed 120.7 pounds of sodium fluorosilicate. What was the fluoride dose in milligrams per liter (mg/l)? The sodium fluorosilcate has an available fluoride ion concentration of 60.7% and a purity of 98.5%.

10. During the previous 24-hour period water was treated at a rate of 5,730,000 gal/day. 262.3 pounds of fluorosilicic acid were used to treat the water. The available fluoride ion concentration of the fluorosilicic acid is 23%. The commercial purity of the acid is 79.2%. Calculate the fluoride dose in milligrams per liter (mg/l).

11. On Tuesday, 188.9 pounds of fluorosilicic acid was used to treat 3,750,000 gallons of water. The available fluoride ion concentration of the fluorosilicic acid is 23%. The commercial purity of the acid is 79.2%. What was the fluoride dose in milligrams per liter (mg/l)?

12. Calculate the fluoride dose in milligrams per liter if 62.8 pounds of sodium silicofluoride is used to treat 4,500,000 gallons of water. The sodium fluorosilcate has an available fluoride ion concentration of 60.7% and a purity of 98.5%.

13. On Wednesday, 123.5 pounds of sodium fluorosilicate were used to treat 12,650,000 gallons of water. The sodium fluorosilcate has an available fluoride ion concentration of 60.7% and a purity of 98.5%. The raw water has a natural fluoride concentration of 0.3 mg/L. What was the calculated fluoride does in milligrams per liter (mg/L)?

14. During Friday's operation, 432.7 pounds of fluorosilicic acid were used to treat a flow of 15,750,000 gal/day. The available fluoride ion concentration of the fluorosilicic acid is 23%. The commercial purity of the acid is 79.2%. The natural fluoride concentration in the raw water was 0.5 mg/L. Determine the calculated fluoride does in milligrams per liter (mg/L).

15. 283.9 pounds of fluorosilicic acid were used to treat 7,750,000 gallons of water. The available fluoride ion concentration of the fluorosilicic acid is 23%. The commercial purity of the acid is 79.2%. What is the calculated fluoride does in milligrams per liter?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 1.1 mg/l | 2. 1.0 mg/l | 3. 0.9 mg/l | 4. 0.7 mg/l | 5. 1.0 mg/l |
| 6. 1.1 mg/l | 7. 1.2 mg/l | 8. 0.9 mg/l | 9. 1.0 mg/l | 10. 1.0 mg/l |
| 11. 1.1 mg/l | 12. 1.0 mg/l | 13. 0.7 mg/l | 14. 0.6 mg/L | 15. 0.8 mg/L |

# Flows

Flow is defined as the action or fact of moving along in a steady, continuous stream. It is calculated from the cross-sectional area of the pipe or channel through which water is flowing, and the velocity of the water, usually expressed in cubic feet per second.

This is the typical formula provided for calculating flow.

$$Q = AV$$

Where “Q” is quantity or flow, “A” is the cross-sectional area, and “V” is the velocity.

These formulas are provided on the ABC & C2EP Formula/Conversion Table for Water Treatment, Distribution and Laboratory Exams for calculating flow.

$$\text{Flow Rate, cfs} = (\text{Area, ft}^2)\,(\text{Velocity, ft/sec})$$

$$Q = AV \textit{ units must be compatible}.$$

When the flow is through a pipe, the cross sectional area is calculated using this formula.

$$\text{Area} = (.785)\,(\text{Diameter}^2)$$

When the flow is through a channel, the cross sectional area is calculated using this formula.

$$\text{Area} = (\text{Length})\,(\text{Width})$$

## Flow Through a Pipe

**Example 1**: Water flows through a 6-inch pipe at a velocity of 3.5 feet per second. What is the flow rate in cubic feet per second?

***Find the cross-sectional area of the pipe.***

**Write down the formula.**

$$\text{Area} = (.785)\,(\text{Diameter}^2)$$

**Make a table of data.**

$$\text{Diameter} = 6 \text{ in} \div 12 \text{ in/ft} = 0.5 \text{ ft}$$

**Plug the data into the formula.**

$$\text{Area} = (.785)(0.5\text{ ft})^2$$

**Square the diameter.**

$$\text{Area} = (.785)(0.25\text{ ft}^2)$$

**Do the multiplication.**

$$\text{Area} = 0.19625\text{ ft}^2$$

***Calculate the flow rate through the pipe.***

**Write down the formula.**

$$\text{Flow Rate, cfs} = (\text{Area, ft}^2)(\text{Velocity, ft/sec})$$

**Make a table of data.**

$$\text{Area} = 0.19625\text{ ft}^2$$

$$\text{Velocity} = 3.5\text{ ft/sec}$$

**Plug the data into the formula.**

$$\text{Flow Rate, cfs} = (0.19625\text{ ft}^2)(3.5\text{ ft/sec})$$

**Do the multiplication.**

$$\text{Flow Rate, cfs} = 0.686875 \text{ or } 0.69\text{ ft}^3/\text{sec}$$

**Example 2**: Water flows through a 15-inch water pipe at a velocity of 112 feet per minute. What is the flow rate through the pipe in gallons per minute?

***Find the cross-sectional area for the pipe.***

**Write down the formula.**

$$\text{Area} = (.785)(\text{Diameter}^2)$$

**Make a table of data.**

$$\text{Diameter} = 15\text{ in} \div 12\text{ in/ft} = 1.25\text{ ft}$$

**Plug the data into the formula.**

$$\text{Area} = (.785)(1.25\text{ ft})^2$$

**Square the diameter.**

$$\text{Area} = (.785)(1.5625 \text{ ft})^2$$

**Do the multiplication.**

$$\text{Area} = 1.2265625 \text{ ft}^2$$

***Calculate the flow in cubic feet per minute.***

**Write down the formula.**

$$Q = AV$$

**Make a table of data.**

$$A = 1.2265625 \text{ ft}^2$$

$$V = 112 \text{ ft/min}$$

**Plug the data into the formula.**

$$Q = (1.2265625 \text{ ft}^2)(112 \text{ ft/min})$$

**Do the multiplication.**

$$Q = 137.375 \text{ ft}^3/\text{min}$$

***Convert the flow to gallons per minute using the conversion factor.***

$$Q = 137.375 \text{ ft}^3/\text{min} \text{ X } 7.48 \text{ gal/ft}^3 = 1{,}027.565 \text{ or } 1{,}028 \text{ gal/min}$$

**Example 3**: Water flows through a 14-inch water pipe at a velocity of 76 feet per minute. What is the flow rate through the pipe in gallons per minute??

***Find the cross-sectional area for the pipe.***

**Write down the formula.**

$$\text{Area} = (.785)(\text{Diameter}^2)$$

**Make a table of data.**

$$\text{Diameter} = 14 \text{ in} \div 12 \text{ in/ft} = 1.1666 \text{ ft}$$

**Plug the data into the formula.**

$$\text{Area} = (.785)(1.1666 \text{ ft})^2$$

**Square the diameter.**

$$\text{Area} = (.785)(1.3609 \text{ ft})^2$$

**Do the multiplication.**

$$\text{Area} = 1.0683 \text{ ft}^2$$

***Calculate the flow in gallons per minute.***

**Write down the formula.**

$$Q = AV$$

**Make a table of data.**

$$A = 1.0683 \text{ ft}^2$$

$$V = 76 \text{ ft/min}$$

**Plug the data into the formula.**

$$Q = (1.0683 \text{ ft}^2)(76 \text{ ft/min})$$

**Do the multiplication.**

$$Q = 81.1908 \text{ ft}^3/\text{min}$$

***Convert the flow to gallons per minute using the conversion factor.***

$$Q = 81.1908 \text{ ft}^3/\text{min} \text{ X } 7.48 \text{ gal/ft}^3 = 607.307184 \text{ or } 607 \text{ gal/min}$$

***Practice Problems***

1. Water flows through a 6-inch water main at a velocity of 5 ft/sec. Determine the flow rate through the water main in cubic feet per second.
2. Water is flowing at a velocity of 2.75 feet per second through a 12-inch water main. Determine the flow rate through the water main in cubic feet per minute.
3. A water main is eight inches in diameter. The velocity of the flow through the main is 1.5 ft/sec. What is the flow in gallons per minute?

4. What is the flow rate through a 21-inch water main in gallons per day if the flow velocity is 3.25 ft/sec?

5. The velocity of the flow through a 12-inch water main is 2.5 ft/sec. Determine the flow through the water main in gallons per minute.

6. Water flows through a 14-inch water main at a velocity of 4.5 ft/sec. Determine the flow rate through the water main in cubic feet per second.

7. Water is flowing at a velocity of 3.5 feet per second through a 48-inch water main. Determine the flow rate through the water main in cubic feet per minute.

8. A water main is 24 inches in diameter. The velocity of the flow through the main is 3.4 ft/sec. What is the flow in gallons per minute?

9. What is the flow rate through a 16-inch water pipe in gallons per day if the flow velocity is 2.25 ft/sec?

10. The velocity of the flow through a 4-inch water pipe is 5 ft/sec. Determine the flow through the water main in gallons per minute.

11. Water flows through a 6-inch water main at a velocity of 3.75 ft/sec. Determine the flow rate through the water main in cubic feet per second.

12. Water is flowing at a velocity of 4.25 feet per second through an 8-inch water main. Determine the flow rate through the water main in cubic feet per minute.

13. A water main is ten inches in diameter. The velocity of the flow through the main is 6.5 ft/sec. What is the flow in gallons per minute?

14. What is the flow rate through a 12-inch water main in gallons per day if the flow velocity is 3.7 ft/sec?

15. The velocity of the flow through a 6-inch water main is 4 ft/sec. Determine the flow through the water main in gallons per minute.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 0.98 cfs | 2. 130 cfm | 3. 235 gpm | 4. 5,049,454 gpd | 5. 881 gpm |
| 6. 4.8 cfs | 7. 2,638 gpm | 8. 4,791 gpm | 9. 2,029,294 gpd | 10. 196 gpm |
| 11. 0.74 cfs | 12. 89 cfm | 13. 1,590 gpm | 14. 1,877,097 gpd | 15. 352 gpm |

# Flow Through a Channel

Example: Water is flowing through a channel at a velocity of 2.5 feet per second. The channel is 36 inches wide and 24 inches deep. The depth of the flow though the channel is 18 inches. Calculate the flow rate in cubic feet per second.

***Find the cross-sectional area of the flow in the channel.***

**Write down the formula.**

$$\text{Area} = (\text{Length})\,(\text{Width})$$

**Make a table of data.**

$$\text{Length} = 36 \text{ in} \div 12 \text{ in/ft} = 3 \text{ ft}$$

$$\text{Width} = 18 \text{ in} \div 12 \text{ in/ft} = 1.5 \text{ ft}$$

**Plug the data into the formula.**

$$\text{Area} = (3 \text{ ft})\,(1.5 \text{ ft})$$

**Do the multiplication.**

$$\text{Area} = 4.5 \text{ ft}^2$$

***Calculate the flow in cubic feet per second.***

**Write down the formula.**

$$\text{Flow Rate, cfs} = (\text{Area, ft}^2)\,(\text{Velocity, ft/sec})$$

**Make a table of data.**

$$\text{Area} = 4.5 \text{ ft}^2$$

$$\text{Velocity} = 2.5 \text{ ft/sec}$$

**Plug the data into the formula.**

$$\text{Flow Rate, cfs} = (4.5 \text{ ft}^2)\,(2.5 \text{ ft/sec})$$

**Do the multiplication.**

$$\text{Flow Rate, cfs} = 11.25 \text{ ft}^3/\text{sec}$$

***Practice Problems***

1. Water is flowing through a channel at a velocity of 3.5 feet per second. The channel is 32 inches wide and 30 inches deep. The depth of the flow though the channel is 16 inches. Calculate the flow rate in cubic feet per second.

2. A channel is 20 inches wide and 22 inches deep. Water is flowing through the channel at a velocity of 2.75 ft/sec. The depth of the water in the channel is 14 inches. Determine the flow in gallons per minute through the channel.

3. A channel is 48 inches wide and 36 inches deep. Water flows through the channel at a depth of 18 inches and a velocity of 1.5 ft/sec. What is the flow through the channel in gallons per day?

4. Water is flowing through a channel that is 20 inches wide and 24 inches deep. The depth of the flow is 14 inches. Determine the flow rate in cubic feet per second if the velocity of the flow is 3.25 ft/sec.

5. Determine the flow rate in gallons per minute through a channel that is 30 inches wide and 30 inches deep. The depth of the flow is 21 inches. The velocity of the flow is 2.5 ft/sec.

6. Water is flowing through a channel at a velocity of 4.5 feet per second. The channel is 34 inches wide and 28 inches deep. The depth of the flow though the channel is 20 inches. Calculate the flow rate in cubic feet per second.

7. A channel is 48 inches wide and 32 inches deep. Water is flowing through the channel at a velocity of 3.5 ft/sec. The depth of the water in the channel is 26 inches. Determine the flow in gallons per minute through the channel.

8. A channel is 24 inches wide and 24 inches deep. Water flows through the channel at a depth of 17 inches and a velocity of 3.4 ft/sec. What is the flow through the channel in gallons per day?

9. Water is flowing through a channel that is 22 inches wide and 16 inches deep. The depth of the flow is 10 inches. Determine the flow rate in cubic feet per second if the velocity of the flow is 2.25 ft/sec.

10. Determine the flow rate in gallons per minute through a channel that is 44 inches wide and 32 inches deep. The depth of the flow is 28 inches. The velocity of the flow is 5 ft/sec.

11. Water is flowing through a channel at a velocity of 3.75 feet per second. The channel is 20 inches wide and 18 inches deep. The depth of the flow though the channel is 12 inches. Calculate the flow rate in cubic feet per second.

12. A channel is 28 inches wide and 22 inches deep. Water is flowing through the channel at a velocity of 4.25 ft/sec. The depth of the water in the channel is 14 inches. Determine the flow in gallons per minute through the channel.

13. A channel is 12 inches wide and 12 inches deep. Water flows through the channel at a depth of 3 inches and a velocity of 6.5 ft/sec. What is the flow through the channel in gallons per day?

14. Water is flowing through a channel that is 12 inches wide and 10 inches deep. The depth of the flow is 4 inches. Determine the flow rate in cubic feet per second if the velocity of the flow is 3.7 ft/sec.

15. Determine the flow rate in gallons per minute through a channel that is 10 inches wide and 10 inches deep. The depth of the flow is 2 inches. The velocity of the flow is 4 ft/sec.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 12.4 cfs | 2. 2,400 gal/min | 3. 5,816,448 gpd | 4. 6.3 cfs | 5. 4,909 gpm |
| 6. 21.3 cfs | 7. 13,664 gpm | 8. 6,225,754 gpd | 9. 3.4 cfs | 10. 49,199 gpm |
| 11. 43 cfs | 12. 5,192 gpm | 13. 1,050,192 gpd | 14.1.2 cfs | 15. 249 gpm |

# Pressure

Pressure is defined as the force or thrust exerted over a surface divided by its area. It is usually expressed in pounds per square inch.

Pressure can also be expressed in feet of head. Head is the difference in elevation between two points in a system, expressed in feet.

These conversion factors are provided in the ABC & $C_2$EP Formula/Conversion Table for Water Treatment, Distribution, & Laboratory Exams.

- 1 foot of water = 0.433 psi
- 1 pounds per square inch = 2.31 feet of water

## Converting Pressure in PSI to Feet of Head

**Example 1:** The reading on a pressure gauge is 35 psi. Determine the pressure in feet of head.

***Multiply the pressure in psi by the conversion factor.***

35 psi X 2.31 feet of water = 80.85 or 81 feet

***Practice Problems***

1. A pressure gauge is attached to the hose nozzle on a fire hydrant. The pressure reading on the gauge is 85 psi. What is the pressure in feet of head?
2. Convert 25 psi to its equivalent pressure in feet of head.
3. The pressure at a hose bibb on a house is 76 psi. Determine the pressure in feet of head.
4. The pressure in a water main is 113 psi. What is the pressure in feet of head?
5. The pressure at the bottom of a standpipe is 32 psi. What is the depth of the water in the standpipe?
6. A pressure gauge reads 47 psi. Calculate the pressure in feet of head.
7. 51 psi is equivalent to how many feet of head?
8. A pressure gauge on a fire hydrant reads 69 psi. What is the pressure at the hydrant in feet of head?
9. A groundlevel storage tank is located on a hill. At the bottom of the hill, the pressure in the main supplied by the tank is 73 psi. What is the difference in elevation between the main and the water level in the tank?
10. Eighty-six psi is equivalent to how many feet of head?

11. Convert 92 psi to the equivalent pressure in feet of head?

12. The pressure at the bottom of a lake is 125 psi. What is the depth of the lake in feet?

13. The pressure in a water main at the bottom of a ridge is 225 psi. A storage tank on the side of the ridge serves the water main. What is the difference in elevation in feet between the water main and the water level in the tank?

14. The water pressure in a water main is 63 psi. Determine the equivalent pressure in ffeet of head.

15. Fifty-eight psi is equivalent to how many feet of head?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 196 ft | 2. 58 ft | 3. 176 ft | 4. 261 ft | 5. 74 ft |
| 6. 109 ft | 7. 118 ft | 8. 159 ft | 9. 169 ft | 10. 199 ft |
| 11. 213 ft | 12. 289 ft | 13. 520 ft | 14. 146 ft | 15. 114 ft |

# Converting Pressure in Feet of Head to PSI

Example: A pressure of 45 feet of head is equivalent to a pressure of how many psi?

Multiply the pressure in feet of head by the conversion factor.

45 ft X 0.433 psi = 19.485 or 19 psi

Practice Problems

1. The difference between the water level in a storage tank and the service line to a house is 42 feet. What is the pressure in the service line in psi?
2. Sixty-four feet of head is equivalent to what pressure in psi?
3. A water tank is located on a hill side. The difference in elevation between the water level in the tank and the main at the bottom of the hill is 600 feet. Determine the pressure in psi in the water main.
4. Determine the pressure in psi if the pressure in a main is 75 feet of head.
5. Convert 140 feet of head to its equivalent pressure in psi.
6. A reservoir is 140 feet deep. What is the pressure, in psi, at the bottom of the reservoir?
7. A standpipe has a depth of 99 feet. Calculate the pressure on the floor of the tank in psi.
8. What is the pressure in pounds per square inch if the pressure is 92 feet of head?
9. Convert a pressure of 38 feet to its equivalent pressure in psi.
10. The difference in elevation between a fire hydrant and the water level in the storage tank which serves it is 21 feet. What is the pressure in psi at the fire hydrant?
11. A pressure of 47 feet of head is equivalent to how many psi?
12. The pressure in a water main is 68 feet of head. Convert the pressure to its equivalent in psi.
13. What is the pressure in psi if the pressure is 73 feet of head?
14. Eighty-nine feet of head is equivalent to what pressure in psi?
15. 154 feet of head is equivalent to _____ psi.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 18 psi | 2. 28 psi | 3. 260 psi | 4. 32 psi | 5. 61 psi |
| 6. 43 psi | 7. 34 psi | 8. 40 psi | 9. 16 psi | 10. 9 psi |
| 11. 20 psi | 12. 29 psi | 13. 32 psi | 14. 39 psi | 15. 67 psi |

# Parts per Million and Percent

You will need to use the conversion factor provided in the formula booklet to change parts per million (or milligrams per Liter, mg/L) to percent, and percent to parts per million.

$$1\% = 10{,}000 \text{ mg/L}$$

To convert “percent” to “parts per million” (mg/L), you must multiply the concentration in percent by the conversion factor, 10,000 mg/L.

Example: Liquid alum has a concentration of 48.5%. What is the alum concentration in mg/L?

$$\text{mg/L} = 48.5\% \text{ X } 10{,}000 \text{ mg/L} = 485{,}000 \text{ mg/L}$$

To convert parts per million” (mg/L) to “percent” (%), you must divide the concentration in parts per million by the conversion factor, 10,000 mg/L.

Example: A solution has a concentration of 75,000 mg/L. What is the alum concentration in percent?

$$\% = \frac{75{,}000 \text{ mg/L}}{10{,}000 \text{ mg/L}} = 7.5\%$$

***Practice Problems***

1. What is the caustic soda concentration in milligrams per liter if the caustic soda concentration in the solution is 25%.
2. The concentration of a compound in a solution is 125,000 mg/L. What is its concentration in percent?
3. Calculate the sodium permanganate concentration in milligrams per liter if the sodium permanganate concentration in the solution is 20%.
4. The soda ash concentration in a batch of solution is 50,000 mg/L. What is the soda ash concentration in percent?
5. The caustic soda concentration in a solution is 400,000 mg/L. Determine the caustic soda concentration in percent.
6. What is the potassium permanganate concentration in milligrams per liter if the potassium permanganate concentration in the solution is 3%.
7. The concentration of a compound in a solution is 25,000 mg/L. What is its concentration in percent?

8. Calculate the sodium hypochlorite concentration in milligrams per liter if the sodium hypochlorite concentration in the solution is 15%.

9. The soda ash concentration in a batch of solution is 150,000 mg/L. What is the soda ash concentration in percent?

10. The caustic soda concentration in a solution is 250,000 mg/L. Determine the caustic soda concentration in percent.

11. What is the ferric sulfate concentration in milligrams per liter if the ferric sulfate concentration in the solution is 55%.

12. The concentration of a compound in a solution is 2,500 mg/L. What is its concentration in percent?

13. Calculate the hydrogen peroxide concentration in milligrams per liter if the sodium permanganate concentration in the solution is 33%.

14. The soda ash concentration in a batch of solution is 175,000 mg/L. What is the soda ash concentration in percent?

15. The caustic soda concentration in a solution is 325,000 mg/L. Determine the caustic soda concentration in percent.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 250,000 mg/L | 2. 12.5% | 3. 200,000 mg/L | 4. 5% | 5. 40% |
| 6. 30,000 mg/L | 7. 2.5% | 8. 150,000 mg/L | 9. 15% | 10. 25% |
| 11. 550,000 mg/L | 12. 0.25% | 13. 330,000 mg/L | 14. 17.5% | 15. 32.5% |

# Pounds Calculations

This formula is provided calculate feed rate in pounds per day.

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

If the purity of the chemical is not given, assume the purity to be 100 percent.

Example 1: Dry alum is fed at a dose of 23 mg/L. Raw water is treated at a rate of 2.75 MGD. What is the alum feed rate in pounds per day (lb/day).

**Write down the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

**Make a table of data.**

Dose, mg/L = 23 mg/L

Flow, MGD = 2.75 MGD

Purity, % = 100% ÷ 100% = 1.0

**Plug the data into the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(23\ \text{mg/L})\,(2.75, \text{MGD})\,(8.34\ \text{lbs/gal})}{1.0}$$

**Cancel terms and multiply the numbers above the line.**

$$\text{Feed Rate, lbs/day} = \frac{527.505\ \text{lbs/day}}{1.0}$$

**Divide the number above the line by the number below the line.**

$$\text{Feed Rate, lb/day} = 527.505 \text{ or } 528\ \text{lb/day}$$

Example 2: Hydrated lime is fed to adjust the pH and alkalinity of the finished water. The hydrated lime has a commercial purity of 90 percent. Water is treated at a rate of 6.75 MGD. The lime dose is 11 mg/L. Calculate the lime feed rate in pounds per day.

**Write down the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(\text{Dosage, mg/L})\,(\text{Capacity, MGD})\,(8.34\ \text{lbs/gal})}{\text{Purity, \% expressed as a decimal}}$$

**Make a table of data.**

Dose, mg/L = 11 mg/L

Capacity, MGD = 6.75 MGD

Purity, % = 90% ÷ 100% = 0.90

**Plug the data into the formula.**

$$\text{Feed Rate, lbs/day} = \frac{(11\,\text{mg/L})\,(6.75\,\text{MGD})\,(8.34\ \text{lbs/gal})}{0.90}$$

**Cancel terms and multiply the numbers above the line.**

$$\text{Feed Rate, lbs/day} = \frac{619.245\ \text{lbs/day}}{0.90}$$

**Do the multiplication.**

$$\text{Feed Rate, lb/day} = 688.05 \text{ or } 688\ \text{lb/day}$$

***Practice Problems***

1. Alum is fed at a dose of 20 mg/L. The volume of raw water treated was 3.75 MG. How many pounds of alum were fed?
2. An alum dose of 15 mg/L was used to treat 5.75 MG of raw water. Calculate the pounds of alum fed.
3. During the previous 24-hours a total of 14.5 MG of raw water were treated using a ferric chloride dose of 6 mg/L. Determine the pounds of ferric chloride which were fed.
4. The zinc orthophosphate dose was 1.5 mg/L. A total of 2,750,000 gallons of water were treated. How many pounds of zinc orthophosphate were fed?
5. Calculate the pounds of sodium hexametaphosphate were fed if the dose was 1.8 mg/L and the volume of water fed was 6,750,000 gallons.

6. Lime with a commercial purity of 85% is used to adjust the pH and alkalinity of the water. The lime dose is 8 mg/L. How many pounds of lime would be fed if 3.75 MG of water were treated?

7. A powdered activated carbon dose of 25 mg/L was used to treat 4.75 MG of raw water. How many pounds of powdered activated carbon were fed if the powdered activated carbon had a commercial purity of 88%.

8. Between 8:00 am on Tuesday and 8:00 am on Wednesday, 5,865,000 gallons of water were treated using hydrated lime. The lime dose was 10 mg/L. The commercial purity of the hydrated lime was 80%. Determine how many pounds of hydrated lime were fed.

9. During the previous 24-hour period a total of 8,750,000 gallons of water were treated. One of the chemicals used to treat the water was fed at a dose of 12 mg/L. The chemical has a commercial purity of 95%. Calculate how many pounds of the chemical were fed.

10. An operator uses ferric sulfate as the primary coagulant. The dose is 10 mg/L. The commercial purity of the ferric sulfate is 90%. During Monday's operations 13,890,000 gallons of raw water were treated. How many pounds of ferric sulfate were fed?

11. The alum dose was 18 mg/L. Raw water was treated at a rate of 3.85 MGD. What was the alum feed rate in pounds per day (lbs / day)?

12. Caustic soda is used to adjust the pH of the filtered water at a treatment plant. Water is treated at a rate of 8.37 MGD. The caustic soda dose is 7 mg/L. Calculate the caustic soda feed rate in pounds per day (lbs/day).

13. Raw water is treated at a rate of 6.75 MGD. Potassium permanganate is fed at a dose of 1.1 mg/L. Determine the potassium permanganate feed rate in pounds per day.

14. Alum is used as the primary coagulant at a water treatment plant. The alum dose is 22 mg/L. What would the alum feed rate be in pounds per day (lbs/day) if raw water is treated at a rate of 2.65 MGD?

15. Potassium permanganate is used to oxidize iron and manganese in the raw water. Raw water is treated at a rate of 0.75 MGD. What would the potassium permanganate feed rate be in pounds per day if the dose is 1.2 mg/L?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 625.5 lb/day | 2. 719.3 lb/day | 3. 726.0 lb/day | 4. 34.4 lb/day | 5. 101.3 lb/day |
| 6. 294.4 lb/day | 7. 1,125.4 lb/day | 8. 611.4 lb/day | 9. 922.0 lb/day | 10. 1,287.1 lb/day |
| 11. 578.0 lb/day | 12. 488.6 lb/day | 13. 61.9 lb/day | 14. 486.2 lb/day | 15. 7.5 lb/day |

# Percent (%)

The concentration in percent can be determined using this formula, if the specific weight (density) of the solution (lbs/gal) and concentration of the chemical (lbs/gal) is known.

$$\text{Percent, \%} = \frac{\text{Part}}{\text{Whole}} \text{ X } 100\%$$

Example: A batch of liquid caustic solution has a density of 12.015 lbs/gal. The caustic soda concentration in the solution is 4.81 lbs/gal. What is the concentration of the caustic soda solution in percent (%)?

**Write down the formula.**

$$\text{Percent, \%} = \frac{\text{Part}}{\text{Whole}} \text{ X } 100\%$$

**Make a table of data.**

Part = 4.81 lbs/gal

Whole = 12.015 lbs/gal

**Plug the data into the formula.**

$$\text{Percent, \%} = \frac{4.81 \text{ lbs/gal}}{12.015 \text{ lbs/gal}} \text{ X } 100\%$$

**Do the division.**

$$\text{Percent, \%} = 0.40033291718 \text{ X } 100\%$$

**Do the multiplication.**

$$\text{Percent, \%} = 40.033291718 \text{ or } 40.0\%$$

***Practice problems.***

1. The hydrogen peroxide used at a water treatment plant has a density of 10.00 lbs/gal and a hydrogen peroxide concentration of 5.00 lbs/gal. What is the hydrogen peroxide concentration in percent (%)?
2. A batch of aluminum chlorohydrate solution has an aluminum chlorohydrate concentration of 5.63 lbs/gal. The density of the solution is 11.26 lbs/gal. Calculate the aluminum chlorohydrate concentration in percent (%).

3. The ferric sulfate solution used at Newport's water treatment plant has a density of 13.01 lbs/gal. The ferric sulfate concentration in the solution is 8.59 lbs/gal. Determine the ferric sulfate concentration of the solution in percent (%).

4. At Big Creek Utility District's water plant, a sodium permanganate solution (concentration = 4.54 lbs/gal) is used to oxidize iron, manganese, and organics in the raw water. Calculate the sodium permanganate concentration in percent (%) if the solution has a density of 11.34 lbs/gal.

5. A batch of bleach has a density of 10.01 lbs/gal, and an available chlorine concentration of 1.25 lbs/gal. What is the available chlorine concentration in percent (%) for the bleach?

6. At Jackson's water treatment plant liquid caustic is used to adjust the pH of the finished water. The liquid caustic has a density of 10.23 lbs/gal. It has a caustic soda concentration of 2.05 lbs/gal. Determine the caustic soda concentration in percent (%).

7. At Lexington, hydrogen peroxide is used to control algae in the basin. The hydrogen peroxide has a density of 9.44 lbs/gal. Each gallon contains 3.30 pounds of hydrogen peroxide. Calculate the hydrogen peroxide concentration in percent (%).

8. The sodium permanganate solution used at a treatment plant has a density of 11.51 lbs/gal and a sodium permanganate concentration of 4.83 lbs/gal. Calculate the sodium permanganate concentration in percent (%).

9. The operator's at Cleveland's water treatment plant use an aluminum chlorohydrate solution as the coagulant. The aluminum chlorohydrate solution density is 10.26 lbs/gal. The aluminum chlorohydrate concentration is 3.59 lbs/gal. What is the aluminum chlorohydrate concentration in percent (%)?

10. Determine the caustic soda concentration in percent for a liquid caustic soda solution with a density of 12.82 pounds per gallon, and a caustic soda concentration of 6.41 lbs/gal.

11. A batch of liquid alum has a density of 11.05 lbs/gal. The alum concentration is 5.31 lbs/gal. Calculate the alum concentration in percent (%).

12. The ferric sulfate solution used at Franklin's water treatment plant has a density of 12.09 lbs/gal. It has a ferric sulfate concentration of 5.68 lbs/gal. What is the ferric sulfate concentration in percent (%)?

13. A batch of sodium permanganate solution has a density of 9.59 lbs/gal, and a sodium permanganate concentration of 1.87 lbs/gal. What is the sodium permanganate concentration in percent (%)?

14. At Eastside Utility District's water plant, the operators use liquid caustic with a density of 10.69 lbs/gal to adjust the pH in the finished water. The caustic soda concentration in the solution has a concentration of 2.67 lbs/gal. Determine the caustic soda concentration in percent (%).

15. Calculate the alum concentration in percent for a batch of liquid alum which has a density of 11.07 lbs/gal and an alum concentration of 5.34 lbs/gal.

***Answers.***

| | | | | |
|---|---|---|---|---|
| 1. 50.0 % | 2. 50.0 % | 3. 66.0 % | 4. 40.0 % | 5. 12.5 % |
| 6. 20.0 % | 7. 35.0 % | 8. 42.0 % | 9. 35.0 % | 10. 50.0 % |
| 11. 48.1 % | 12. 47.0 % | 13. 19.5 % | 14. 25.0 % | 15. 48.2 % |

# Gallons/Capita/Day

ABC provides this formula for calculating Gallons/Capita/Day.

$$\text{Gallons/Capita/Day} = \frac{\text{Volume of Water Produced, gpd}}{\text{Population}}$$

Example: The town of Pottersville has a population of 1,350. On a typical day the water treatment plant produces 275,000 gallons of water. Calculate the water consumed in gallons per capita per day.

**Write down the formula.**

$$\text{Gallons/Capita/Day} = \frac{\text{Volume of Water Produced, gpd}}{\text{Population}}$$

**Make a table of data.**

Volume of Water Produced, gpd = 275,000 gpd

Population = 1,350

**Plug the data into the formula.**

$$\text{Gallons/Capita/Day} = \frac{275{,}000 \text{ gpd}}{1{,}350}$$

**Divide the number above the line by the number below the line.**

$$\text{Gallons/Capita/Day} = 203.7037037 \text{ of } 204 \text{ gpd/Capita}$$

***Practice Problems***

1. The town of Hollow Rock has a population of 75,250. On a typical day the water treatment plant production rate is 12,650,000 gallons per day. Calculate the water production rate in gallons per capita per day.

2. Determine the production rate in gallons per capita per day if the population is 12,000, and water is produced at a rate of 1,375,000 gpd.

3. Calculate the production rate in gallons per capita per day for a system that serves 18,560 people if the system produces water at a rate of 2,235,000 gpd.

4. What is the water production rate in gallons per capita per day if the water production rate is 456,725 gpd, and the population served is 2,650?

5. Water is produced at a rate of 25,125,000 gpd. The population served is 182,457. What is the water production rate in gallons per capita per day?

6. The town of Bruceton has a population of 26,175. On a typical day the water treatment plant production rate is 3,456,170 gallons per day. Calculate the water production rate in gallons per capita per day.

7. Determine the production rate in gallons per capita per day if the population is 13,275, and water is produced at a rate of 1,345,678 gpd.

8. Calculate the production rate in gallons per capita per day for a system that serves 25,347 people if the system produces water at a rate of 4,256,700 gpd.

9. What is the water production rate in gallons per capita per day if the water production rate is 6,389,000 gpd, and the population served is 36,750?

10. Water is produced at a rate of 5,123,425 gpd. The population served is 41,350. What is the water production rate in gallons per capita per day?

11. The town of Jackson has a population of 60,150. On a typical day the water treatment plant production rate is 7,345,000 gallons per day. Calculate the water production rate in gallons per capita per day.

12. Determine the production rate in gallons per capita per day if the population is 72,540, and water is produced at a rate of 8,345,000 gpd.

13. Calculate the production rate in gallons per capita per day for a system that serves 97,123 people if the system produces water at a rate of 9,345,670 gpd.

14. What is the water production rate in gallons per capita per day if the water production rate is 10,324,000 gpd, and the population served is 99,165?

15. Water is produced at a rate of 14,375,000 gpd. The population served is 125,120. What is the water production rate in gallons per capita per day?

***Answers***

1. 168 gpd/capita 2. 115 gpd/capita 3. 120 gpd/capita 4. 172 gpd/capita 5. 138 gpd/capita

6. 132 gpd/capita 7. 101 gpd/capita 8. 168 gpd/capita 9. 174 gpd/capita 10. 124 gpd/capita

11. 122 gpd/capita 12. 115 gpd/capita 13. 96 gpd/capita 14. 104 gpd/capita 15. 115 gpd/capita

# Liquid Chemical Feed Rates

## Liquid Feeder Setting, ml/min

This formula can be used to determine the rate, in milliliters per minute, at which a chemical must be fed.

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{(\text{Flow, MGD})\,(\text{Dose, mg/L})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/MG})}{(\text{Liquid, mg/mL})\,(24\ \text{hr/day})\,(60\ \text{min/hr})}$$

An operator feeds liquid alum. The 50% liquid alum has a concentration of 5.61 lbs/gal or 673 mg/ml. Raw water is treated at a rate of 1.584 MGD. The jar test indicates that a dose of 15 mg/l alum is the best dose to use. Calculate the required liquid alum feed rate in milliliters per minute (ml/min).

**Write down the formula.**

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{(\text{Flow, MGD})\,(\text{Dose, mg/L})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/MG})}{(\text{Liquid, mg/mL})\,(24\ \text{hr/day})\,(60\ \text{min/hr})}$$

**Make a table of data.**

Dose, mg/l = 15 mg/l

Flow, MGD = 1.584 MGD

Concentration, mg/ml = 673 mg/ml

**Plug the data into the formula.**

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{(1{,}584\ \text{MGD})\,(15\ \text{mg/L})\,(3.785\ \text{L/gal})\,(1{,}000{,}000\ \text{gal/MG})}{(673\ \text{mg/mL})\,(24\ \text{hr/day})\,(60\ \text{min/hr})}$$

**Multiply the numbers above the line.**

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{89{,}931{,}600}{(673\ \text{mg/mL})\,(24\ \text{hr/day})\,(60\ \text{min/hr})}$$

**Multiply the numbers below the line.**

$$\text{Chemical Feed Pump Setting, mL/min} = \frac{89{,}931{,}600}{969{,}120\ \text{mL/min}}$$

**Divide the number above the line by the number below the line.**

Chemical Feed Pump Setting, mL/min = 92.79717682 or 93 mL/min

### *Practice Problems*

1. An operator uses 50% liquid caustic to adjust the pH of the filtered water. The caustic soda dose required is 8 mg/l. The 50% liquid caustic has a concentration of 764 mg/mL. Water is treated at a rate of 2.376 MGD. Determine the required feed rate in milliliter per minute (ml/min).
2. A 50% liquid ferric sulfate solution is used to provide a dose of 5 mg/l in the raw water. Raw water is treated at a rate of 4.032 MGD. The 50% liquid ferric sulfate has a concentration of 724 mg/mL. Calculate the required chemical feed rate in milliliters per minute (ml/min).
3. Liquid alum is fed at a dose of 20 mg/l while treating raw water at a rate of 6.48 MGD. Liquid alum (50%) is used in the coagulation/flocculation process. The liquid alum has concentration of 664 mg/mL.. What is the required feed rate in milliliters per minute (ml/min)?
4. An operator uses 25% liquid caustic soda in treating the water. The 25% liquid caustic has a concentration of 320 mg/ml. The caustic soda dose is 6 mg/l. What would the required feed rate be in ml/min if raw water is treated at a rate of 1.30 MGD?
5. An operator uses a saturated sodium fluoride solution to fluoridate water. Water is treated at a rate of 1.10 MGD. What would the required feed rate be in milliliters per minute (ml/min) if the fluoride dose is 1.0 mg/l? A saturated sodium fluoride solution has a fluoride concentration of 18 mg/ml.
6. A 50% caustic soda solution has a concentration of 768 mg/ml. Caustic soda is fed at a dose of 10 mg/l while treating water at a rate of 3.60 MGD. Determine the required feed rate in milliliters per minute (ml/min).
7. Ferric sulfate is fed at a dose of 11 mg/l while treating water at a rate of 3.024 MGD. A 50% ferric sulfate solution with a concentration of 739 mg/ml is used to treat the water. Calculate the feed rate (ml/min) required to provide the desired dose.
8. What would the required feed rate in ml/min be for a 25% caustic soda solution (concentration = 320 mg/ml) if water is treated at a rate of 1.872 MGD and the caustic soda dose is 12 mg/l?
9. Liquid alum is used in the coagulation/flocculation process at a water treatment plant. The liquid alum (50%) has a concentration of 673 mg/ml. An alum dose of 25 mg/l is used to treat raw water. Raw water is treated at a rate of 1,500 gal/min. Calculate the required liquid alum feed rate in milliliters per minute (ml/min).
10. Sodium fluoride is used to fluoridate the filtered water at a treatment plant. A saturated sodium fluoride solution has a fluoride concentration of 18 mg/ml. Water is treated at a rate of 200 gal/min. Determine the required feed rate in ml/min if the fluoride dose is to be 0.9 mg/l.
11. A saturated sodium fluoride solution will be used to fluoridate water at a dose of 1.1 mg/l. The saturated sodium fluoride solution has a concentration of 18 mg/l. Water is treated at a rate of 175 gal/min. What is the required feed rate in milliliters per minute (ml/min)?

12. A 50% ferric sulfate solution is used in the coagulation/flocculation process at a water treatment plant. The 50% ferric sulfate solution has a specific gravity of 1.46. Raw water is treated at a rate of 10 MGD. The ferric sulfate dose is 8 mg/l. Determine the required feed rate in milliliters per minute (ml/min).

13. Fluorosilicic acid is used to fluoridate the filtered water at a treatment plant. Twenty-three percent fluorosilicic acid solution has a specific gravity of 1.21. Water is treated at a rate of 5.40 MGD. Determine the required feed rate in ml/min if the fluoride dose is to be 1.0 mg/l.

14. A soda ash solution will be used to adjust the pH and alkalinity of the finished water. The soda ash dose is to be 15 mg/l. The soda ash solution has a specific gravity of 1.16. Water is treated at a rate of 2.52 MGD. What is the required feed rate in milliliters per minute (ml/min)?

15. A 60% ferric sulfate solution is used in the coagulation/flocculation process at a water treatment plant. The ferric sulfate solution has a specific gravity of 1.383. Raw water is treated at a rate of 10,080,000 gallons per day. The ferric sulfate dose is 18 mg/l. Determine the required feed rate in milliliters per minute (ml/min).

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 65 mL/min | 2. 73 mL/min | 3. 513 mL/min | 4. 64 mL/min | 5. 161 mL/min |
| 6. 123 mL/min | 7. 118 mL/min | 8. 185 mL/min | 9. 211 mL/min | 10. 38 mL/min |
| 11. 40 mL/min | 12. 288 mL/min | 13. 64 mL/min | 14. 571 mL/min | 15. 575 mL/min |

# Liquid Feeder Setting, gal/day

This formula can be used to calculate the feed rate required to deliver a desired dose when the concentration in pounds per gallon is known.

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/L})(\text{Flow, MGD})(8.34\ \text{lbs/gal})}{\text{Concentration, lbs/gal}}$$

Example: An operator uses a 15 percent soda ash solution to adjust the pH and alkalinity in the raw water. The soda ash solution has a concentration of 1.451 pounds of soda ash per gallon. Raw water is treated at a rate of 2.5 MGD. Calculate the required feed rate in gallons per day if the soda ash dose is to be 12 mg/L..

**Write down the formula.**

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/L})(\text{Flow, MGD})(8.34\ \text{lbs/gal})}{\text{Concentration, lbs/gal}}$$

**Make a table of data.**

Dose, mg/L = 12 mg/L

Flow, MGD = 2.5 MGD

Concentration, lbs/gal = 1.451 lbs/gal

**Plug the data into the formula.**

$$\text{Feeder Setting, gal/day} = \frac{(12\ \text{mg/L})(2.5\ \text{MGD})(8.34\ \text{lbs/gal})}{1.451\ \text{lbs/gal}}$$

**Cancel terms and multiply the numbers above the line.**

$$\text{Feeder Setting, gal/day} = \frac{250.2\ \text{gal/day}}{1.451}$$

**Divide the number above the line by the number below the line.**

$$\text{Feeder Setting, gal/day} = 172.432805 \text{ or } 172.4\ \text{gal/day}$$

***Practice Problems***

1. An operator uses a 50 percent ferric sulfate solution as the coagulant. Each gallon of 50 percent ferric sulfate solution contains 6.17 pounds of ferric sulfate. Raw water is treated at a rate of 6.75 MGD. Determine the liquid feeder setting in gallons per day (gal/day) if the ferric sulfate dose is to be 10 milligrams per liter (mg/L).

2. A 3 percent potassium permanganate solution is used to oxidize iron, manganese and organics in the raw water. The potassium permanganate dose is to be 0.7 mg/L. Raw water is treated at a rate of 2.3 MGD. Calculate the liquid feeder setting if each gallon of 3 percent potassium permanganate solution contains 0.25 pounds of potassium permanganate.

3. A 20 percent caustic soda solution is used at Beaver Creek Utility District's treatment plant. Each gallon of 20 percent caustic contains 2.05 pounds of caustic soda. Water is treated at a rate of 4,250,000 gal/day. The caustic soda dose used is 8 mg/L. What is the liquid feeder setting in gallons per day required to deliver this dose?

4. Fifty percent liquid alum is used in the coagulation/flocculation process. Each gallon of 50% liquid alum contains 5.6 pounds of alum. Raw water is treated at a rate of 3,650,000 gallons per day. Alum is fed at a dose of 25 mg/L. Determine the liquid feeder setting (gal/day) required to produce the desired dose.

5. Water is treated at a rate of 2,100 gallons per minute. Sodium hexametaphosphate is fed at a dose of 1.3 milligrams per liter (mg/L). An 8 percent sodium hexametaphosphate solution contains 0.7 pounds of sodium hexametaphosphate. What liquid feeder setting in gallons per day is required to produce the desired dose?

6. Determine the required feed rate in gallons per day for 20 percent sodium permanganate with a concentration of 1.93 lbs/gal if it is fed at a dose of 0.8 mg/L while treating raw water at a rate of 7.75 MGD.

7. An operator uses 48 percent liquid alum as the coagulant. Each gallon of 48 percent liquid alum 5.38 pounds of alum. Raw water is treated at a rate of 1.75 MGD. Determine the liquid feeder setting in gallons per day (gal/day) if the alum dose is to be 22 milligrams per liter (mg/L).

8. Fifty percent hydrogen peroxide is used to organics in the raw water. The hydrogen peroxide dose is to be 0.5 mg/L. Raw water is treated at a rate of 10.5 MGD. Calculate the liquid feeder setting if each gallon of 50 percent hydrogen peroxide contains 4.94 pounds of hydrogen peroxide.

9. A 50 percent caustic soda solution is used at Big Creek Utility District's treatment plant. Each gallon of 50 percent caustic contains 6.31 pounds of caustic soda. Water is treated at a rate of 5,250,000 gal/day. The caustic soda dose used is 6 mg/L. What is the liquid feeder setting in gallons per day required to deliver this dose?

10. Sixty percent ferric sulfate is used in the coagulation/flocculation process. Each gallon of 60% liquid alum contains 6.924 pounds of ferric sulfate. Raw water is treated at a rate of 13,650,000 gallons per day. Ferric sulfate is fed at a dose of 15 mg/L. Determine the liquid feeder setting (gal/day) required to produce the desired dose.

11. Water is treated at a rate of 6,100 gallons per minute. Thirty-five percent hydrogen peroxide is fed at a dose of 1.3 milligrams per liter (mg/L). Each gallon of the hydrogen peroxide solution contains 3.283 pounds of hydrogen peroxide. What liquid feeder setting in gallons per day is required to produce the desired dose?

12. Determine the required feed rate in gallons per day for 93 percent sulfuric acid with a concentration of 14.16 lbs/gal if it is fed at a dose of 3.0 mg/L while treating raw water at a rate of 3.75 MGD.

13. A 25 percent caustic soda solution is used at Selmer's treatment plant. Each gallon of 25 percent caustic contains 2.64 pounds of caustic soda. Water is treated at a rate of 4.5 MGD. The caustic soda dose used is 12 mg/L. What is the liquid feeder setting in gallons per day required to deliver this dose?

14. Thirty percent soda ash solution is used to provide alkalinity for the coagulation/flocculation process. Each gallon of 30 percent soda ash contains 3.32 pounds of soda. Raw water is treated at a rate of 8,650,000 gallons per day. Soda ash is fed at a dose of 15 mg/L. Determine the liquid feeder setting (gal/day) required to produce the desired dose.

15. Water is treated at a rate of 1,400 gallons per minute. Twenty-five percent soda ash solution is used to feed soda ash at a dose of 13 milligrams per liter (mg/L). Each gallon of the 25 percent soda ash solution contains 2.65 pounds of soda ash. What liquid feeder setting in gallons per day is required to produce the desired dose?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 91.2 gal/day | 2. 53.7 gal/day | 3. 138.3 gal/day | 4. 135.9 gal/day | 5. 46.8 gal/day |
| 6. 26.8 gal/day | 7. 59.7 gal/day | 8. 8.9 gal/day | 9. 41.6 gal/day | 10. 246.6 gal/day |
| 11. 29.0 gal/day | 12. 6.6 gal/day | 13. 170.6 gal/day | 14. 325.9 gal/day | 15. 82.5 gal/day |

# Liquid Feeder Setting, gal/day

This formula can be used to determine the feed rate in gallons per day if the specific gravity of the treatment chemical solution is known.

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/L})(\text{Flow, MGD})}{(\text{Concentration, \% expressed as a decimal})(\text{Specific Gravity})}$$

Example: An operator uses 50% liquid caustic solution to adjust the pH of the finished water. Caustic soda is fed at a dose of 10 mg/L while treating a flow of 5.65 MGD. What would the required feed rate be in gallons per day (gal/day) if 50% liquid caustic has a specific gravity of 1.5372?

**Write down the formula.**

$$\text{Feeder Setting, gal/day} = \frac{(\text{Dose, mg/L})(\text{Flow, MGD})}{(\text{Concentration, \% expressed as a decimal})(\text{Specific Gravity})}$$

**Make a table of data.**

Chemical dose, mg/L = 10 mg/L

Flow, MGD = 5.65 MGD

% available = 50% ÷ 100% = 0.50

Specific gravity = 1.5372

**Plug the data into the formula.**

$$\text{Feeder Setting, gal/day} = \frac{(10\,\text{mg/L})(5.65\,\text{MGD})}{(0.50)(1.5372)}$$

**Cancel terms and multiply the numbers below the line.**

$$\text{Feeder Setting, gal/day} = \frac{56.50\,\text{gal/day}}{0.7686}$$

**Divide the number above the line by the number below the line.**

$$\text{Feeder Setting, gal/day} = 73.5102784283 \text{ or } 73.5\,\text{gal/day}$$

***Practice Problems***

1. At Three-Way Utility District water is treated at a rate of 1.75 MGD. A 20 percent liquid caustic solution is used to adjust the pH and alkalinity in the raw water. The caustic soda dose is to be 10 mg/L. Twenty percent liquid caustic has a specific gravity of 1.2263. Determine the liquid caustic feed rate in gallons per day required to deliver the desired dose.

2. The operators at Beaver Creek Utility District use a 50 percent ferric sulfate solution as the coagulant. A 50 percent ferric sulfate solution has a specific gravity of 1.48. Calculate the liquid ferric sulfate solution feed rate, in gallons per day, required to deliver a ferric sulfate dose of 20 mg/L. Water is treated at a rate of 2.5 MGD.

3. An operator feeds an 8 percent sodium hexametaphosphate solution as part of the systems corrosion control program. An 8 percent sodium hexametaphosphate solution has a specific gravity of 1.048. The operator wants to feed sodium hexametaphosphate at a dose of 1.7 mg/L. Water is treated at a rate of 6.75 MGD. What is the sodium hexametaphosphate solution feed rate in gallons per day required to deliver the desired dose?

4. An operator uses liquid alum (48%) as the coagulant. A 48 percent liquid caustic solution has a specific gravity of 1.326. Raw water is treated at a rate of 10.63 MGD. The desired alum dose is 22 mg/L. determine the liquid alum feed rate in gallons per day required to deliver the desired alum dose.

5. Calculate the 3 percent potassium permanganate solution feed rate in gallons per day required to treat a flow of 2.5 MGD with a potassium permanganate dose of 2.1 mg/L if 3 percent potassium permanganate solution has a specific gravity of 1.011.

6. At Three-Way Utility District water is treated at a rate of 1.75 MGD. A 20 percent liquid caustic solution is used to adjust the pH and alkalinity in the raw water. Twenty percent liquid caustic has a specific gravity of 1.2263. The caustic soda dose is 7 mg/L. Determine the liquid caustic feed rate in gallons per day required to deliver the desired dose.

7. Fifty percent liquid alum is used as the coagulant at a water treatment plant. Fifty percent liquid alum has a specific gravity of 1.343. Raw water is treated at a rate of 8.75 MGD using an alum dose of 30 mg/L. What is the feeder setting in gallons per day required to produce the desired dose?

8. An operator uses a four percent potassium permanganate solution to treat raw water. The potassium permanganate solution has a specific gravity of 1.023. A 0.6 mg/L potassium permanganate dose is used to treat a flow of 5.69 MGD. Calculate the liquid feeder setting (gal/day) required to produce the desired dose.

9. At Eastside Utility District 50% caustic soda is used to treat the water. A 50% caustic soda solution has a specific gravity of 1.54. Water is treated at a rate of 4,500,000 gallons per day (gal/day). Determine the liquid feeder setting in gallons per day needed to produce a dose of 5 milligrams per liter (mg/L).

10. At a water treatment plant a 34 percent ferric sulfate solution is used in the coagulation and flocculation process. The ferric sulfate solution has a specific gravity of 1.30. Raw water is treated at a rate of 7,500,000 gallons per day. What is the feeder setting (gal/day) required to produce a dose of 12 mg/L?

11. Water is treated at a rate of 3,500 gal/min using a ferric sulfate dose of 15 mg/L. A 47 percent ferric sulfate solution with a specific gravity of 1.45 is used. Calculate the liquid feeder setting (gal/day) needed to produce the desired dose.

12. A 6 percent sodium hexametaphosphate solution is used in a utility's corrosion control program. A 6 percent sodium hexametaphosphate solution has a specific gravity of 1.031. The desired sodium hexametaphosphate dose is 1.6 milligrams per liter. Determine the liquid feeder setting in gallons per day needed to produce the desired dose if raw water is treated at a rate of 0.864 MGD.

13. At a water treatment plant a 30 percent liquid caustic is used in the coagulation and flocculation process. The liquid caustic has a specific gravity of 1.318. Raw water is treated at a rate of 2,750,000 gallons per day. What is the feeder setting (gal/day) required to produce a dose of 12 mg/L?

14. Water is treated at a rate of 8,500 gal/min using a soda ash dose of 15 mg/L. A 25 percent soda ash solution with a specific gravity of 1.269 is used. Calculate the liquid feeder setting (gal/day) needed to produce the desired dose.

15. Twenty percent liquid caustic is used in a utility's corrosion control program. A 20 percent caustic soda has a specific gravity of 1.21. The desired caustic soda dose is 12 milligrams per liter. Determine the liquid feeder setting in gallons per day needed to produce the desired dose if raw water is treated at a rate of 2.864 MGD.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 71.4 gal/day | 2. 67.6 gal/day | 3. 136.9 gal/day | 4. 367.4 gal/day | 5. 173.1 gal/day |
| 6. 49.9 gal/day | 7. 390.9 gal/day | 8. 83.4 gal/day | 9. 29.2 gal/day | 10. 203.6 gal/day |
| 11. 110.9 gal/day | 12. 22.3 gal/day | 13. 83.5 gal/day | 14. 578.7 gal/day | 15. 142.0 gal/day |

# Hypochlorite Strength, %

This formula is provided for calculating the strength (available chlorine concentration) in percent, when preparing a solution to substitute for chlorine.

$$\text{Hypochlorite Strength, \%} = \frac{\text{Chlorine Required, lbs}}{(\text{Hypochlorite Solution Needed, gal})\,(8.34\ \text{lbs/gal})}\ \text{X}\,100\%$$

Example: An operator wants to prepare 75 gallons of hypochlorite to substitute for 50 pounds of chlorine. What solution strength in percent is required?

**Write down the formula.**

$$\text{Hypochlorite Strength, \%} = \frac{\text{Chlorine Required, lbs}}{(\text{Hypochlorite Solution Needed, gal})\,(8.34\ \text{lbs/gal})}\ \text{X}\,100\%$$

**Make a table of data.**

Chlorine Required, lbs = 50 lbs

Hypochlorite Solution Needed, gal = 75 gal

**Plug the data into the formula.**

$$\text{Hypochlorite Strength, \%} = \frac{50\ \text{lbs}}{(75\ \text{gal})\,(8.34\ \text{lbs/gal})}\ \text{X}\,100\%$$

**Multiply the numbers below the line.**

$$\text{Hypochlorite Strength, \%} = \frac{50\ \text{lbs}}{625.5\ \text{lbs/gal}}\ \text{X}\,100\%$$

**Divide the number above the line by the number below the line.**

$$\text{Hypochlorite Strength, \%} = 0.799360512\ \text{X}\,100\%$$

**Do the multiplication.**

$$\text{Hypochlorite Strength, \%} = 7.99360512 \text{ or } 8.0\%$$

***Practice Problems***

1. In the event of an emergency, an operator will prepare a batch of hypochlorite solution. The planned volume of hypochlorite solution is 100 gallons. The operator normally feeds 25 pounds of chlorine per day. What would the hypochlorite strength, in percent, need to be?

2. An operator needs to prepare 50 gallons of hypochlorite solution to feed in an emergency. The solution will need to replace 32 pounds of chlorine. What hypochlorite strength in percent is needed?

3. A shipment of chlorine has been delayed. Normally 41 pounds of chlorine are fed in a day. The operator at the water plant wants to prepare 125 gallons of hypochlorite solution to feed while waiting on the chlorine. Determine the hypochlorite strength needed to substitute for the chlorine.

4. Normally, 53 pounds of chlorine are fed in a day. To substitute for the chlorine, an operator wants to prepare 100 gallons of hypochlorite solution. Calculate the required hypochlorite solution strength in percent available chlorine.

5. What strength, in percent, hypochlorite solution is required if 80 gallons of hypochlorite solution is required to substitute for 29 pounds of chlorine?

6. In the event of an emergency, an operator will prepare a batch of hypochlorite solution. The planned volume of hypochlorite solution is 185 gallons. The operator normally feeds 48 pounds of chlorine per day. What would the hypochlorite strength, in percent, need to be?

7. An operator needs to prepare 110 gallons of hypochlorite solution to feed in an emergency. The solution will need to replace 75 pounds of chlorine. What hypochlorite strength in percent is needed?

8. A shipment of chlorine has been delayed. Normally 34 pounds of chlorine are fed in a day. The operator at the water plant wants to prepare 96 gallons of hypochlorite solution to feed while waiting on the chlorine. Determine the hypochlorite strength needed to substitute for the chlorine.

9. Normally, 28 pounds of chlorine are fed in a day. To substitute for the chlorine, an operator wants to prepare 90 gallons of hypochlorite solution. Calculate the required hypochlorite solution strength in percent available chlorine.

10. What strength, in percent, hypochlorite solution is required if 68 gallons of hypochlorite solution is required to substitute for 19 pounds of chlorine?

11. In the event of an emergency, an operator will prepare a batch of hypochlorite solution. The planned volume of hypochlorite solution is 77 gallons. The operator normally feeds 22 pounds of chlorine per day. What would the hypochlorite strength, in percent, need to be?

12. An operator needs to prepare 38 gallons of hypochlorite solution to feed in an emergency. The solution will need to replace 20 pounds of chlorine. What hypochlorite strength in percent is needed?

13. A shipment of chlorine has been delayed. Normally 27 pounds of chlorine are fed in a day. The operator at the water plant wants to prepare 45 gallons of hypochlorite solution to feed while waiting on the chlorine. Determine the hypochlorite strength needed to substitute for the chlorine.

14. Normally, 37 pounds of chlorine are fed in a day. To substitute for the chlorine, an operator wants to prepare 75 gallons of hypochlorite solution. Calculate the required hypochlorite solution strength in percent available chlorine.

15. What strength, in percent, hypochlorite solution is required if 60 gallons of hypochlorite solution is required to substitute for 43 pounds of chlorine?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 3.0% | 2. 7.7% | 3. 3.9% | 4. 6.4% | 5. 4.3% |
| 6. 3.1% | 7. 8.2% | 8. 4.2% | 9. 3.7% | 10. 3.4% |
| 11. 3.4% | 12. 6.3% | 13. 7.2% | 14. 5.9% | 15. 8.6% |

# Chlorine Dose, Demand and Residual

The **chlorine dosage** is the amount of chlorine added to the water.

$$\text{Chlorine Dose, mg/L} = \text{Chlorine Demand, mg/L} + \text{Total Chlorine Residual, mg/L}$$

When chlorine is mixed with water in the chlorinator, this reaction occurs.

$$\underset{Cl_2}{\text{Chlorine}} + \underset{H_2O}{\text{Water}} \rightarrow \underset{HOCl}{\text{Hypochlorous Acid}} + \underset{OCl^-}{\text{Hypochlorite Ion}} + \underset{HCl}{\text{Hydrochloric Acid}}$$

When bleach is added to water, this reaction occurs.

$$\underset{NaOCl}{\text{Bleach}} + \underset{H_2O}{\text{Water}} \rightarrow \underset{HOCl}{\text{Hypochlorous Acid}} + \underset{OCl^-}{\text{Hypochlorite Ion}} + \underset{HCl}{\text{Hydrochloric Acid}}$$

**Chlorine demand** - The amount of chlorine used up or consumed by bacteria, algae, organic compounds and some inorganic substances like iron and manganese. Chlorine demand is time dependent since many of the reactions are not instantaneous and need time to be carried to completion. Normally expressed as ppm (mg/l).

$$\text{Chlorine Demand, mg/L} = \text{Chlorine Dose, mg/L} - \text{Chlorine Residual, mg/L}$$

**Chlorine residual** is the amount of chlorine remaining in the water at the time of measurement.

**Total chlorine residual** is the sum of free and combined residual chlorine

$$\text{Total Chlorine Residual, mg/L} = \text{Combined Chlorine Residual, mg/L} + \text{Free Chlorine Residual, mg/L}$$

**Combined chlorine residual** is composed of chloramines that can kill bacteria and oxidize organic matter

$$\text{Combined Chlorine Residual, mg/L} = \text{Total Chlorine Residual, mg/L} - \text{Free Chlorine Residual, mg/L}$$

Free chlorine residual is unreacted chlorine. It is made up of hypochlorous acid, hypochlorite ion, and chlorine gas.

Mathematically it is the difference between the total chlorine residual and the combined chlorine residual.

$$\text{Free Chlorine Residual, mg/L} = \text{Total Chlorine Residual, mg/L} - \text{Combined Chlorine Residual, mg/L}$$

**Available chlorine** is the concentration of chlorine in any of its oxidized forms that is available for disinfection or other oxidizing reactions.

# Chlorine Dose, mg/L

Example: What is the chlorine dose in milligrams per liter if the chlorine residual is 2.8 mg/L, and the chlorine demand is 0.7 mg/L?

**Write down the formula.**

$$\text{Chlorine Dose, mg/L} = \text{Chlorine Demand, mg/L} + \text{Chlorine Residual, mg/L}$$

**Make a table of data.**

Chlorine Demand, mg/L = 0.7 mg/L

Chlorine Residual, mg/L = 2.8 mg/L

**Plug the data into the formula.**

$$\text{Chlorine Dose, mg/L} = 0.7\ \text{mg/L} + 2.8\ \text{mg/L}$$

**Do the addition.**

$$\text{Chlorine Dose, mg/L} = 3.5\ \text{mg/L}$$

***Practice Problems***

1. What is the chlorine dose in milligrams per liter if the chlorine residual is 3.8 mg/L, and the chlorine demand is 2.7 mg/L?
2. The chlorine residual in a water sample is 3.1 mg/L. The chlorine demand in the water is 4.5 mg/L. Determine the chlorine dose in milligrams per liter.
3. Calculate the chlorine dose in milligrams per liter if the chlorine residual is 1.4 mg/L and the chlorine demand is 4.2 mg/L.
4. Determine the chlorine dose in milligrams per liter if the chlorine demand is 5.1 mg/L and the chlorine residual is 1.8 mg/L.
5. The chlorine demand is 0.5 mg/L. The chlorine residual is 1.1 mg/L. What is the chlorine dose in milligrams per liter?
6. What is the chlorine dose in milligrams per liter if the chlorine residual is 2.8 mg/L, and the chlorine demand is 4.7 mg/L?
7. The chlorine residual in a water sample is 1.1 mg/L. The chlorine demand in the water is 4.9 mg/L. Determine the chlorine dose in milligrams per liter.
8. Calculate the chlorine dose in milligrams per liter if the chlorine residual is 3.2 mg/L and the chlorine demand is 5.7 mg/L.
9. Determine the chlorine dose in milligrams per liter if the chlorine demand is 9.2 mg/L and the chlorine residual is 2.8 mg/L.

10. The chlorine demand is 0.7 mg/L. The chlorine residual is 1.9 mg/L. What is the chlorine dose in milligrams per liter?

11. What is the chlorine dose in milligrams per liter if the chlorine residual is 2.7 mg/L, and the chlorine demand is 6.7 mg/L?

12. The chlorine residual in a water sample is 2.1 mg/L. The chlorine demand in the water is 7.8 mg/L. Determine the chlorine dose in milligrams per liter.

13. Calculate the chlorine dose in milligrams per liter if the chlorine residual is 3.1 mg/L and the chlorine demand is 5.5 mg/L.

14. Determine the chlorine dose in milligrams per liter if the chlorine demand is 7.4 mg/L and the chlorine residual is 2.8 mg/L.

15. The chlorine demand is 1.5 mg/L. The chlorine residual is 2.1 mg/L. What is the chlorine dose in milligrams per liter?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 6.5 mg/L | 2. 7.6 mg/L | 3. 5.6 mg/L | 4. 6.9 mg/L | 5. 1.6 mg/L |
| 6. 7.5 mg/L | 7. 6.0 mg/L | 8. 8.9 mg/L | 9. 12.0 mg/L | 10. 2.6 mg/L |
| 11. 9.4 mg/L | 12. 9.9 mg/L | 13. 8.6 mg/L | 14. 10.2 mg/L | 15. 3.6 mg/L |

# Chlorine Demand

Example: The chlorine dose is 6.2 mg/L. The chlorine residual is 3.2 mg/L. What is the chlorine demand in milligrams per milliliter?

**Write down the formula.**

$$\text{Chlorine Demand, mg/L} = \text{Chlorine Dose, mg/L} - \text{Chlorine Residual, mg/L}$$

**Make a table of data.**

Chlorine Dose, mg/L = 6.2 mg/L

Chlorine Residual, mg/L = 3.2 mg/L

**Plug the data into the formula.**

$$\text{Chlorine Demand, mg/L} = 6.2\ \text{mg/L} - 3.2\ \text{mg/L}$$

**Do the subtraction.**

$$\text{Chlorine Demand, mg/L} = 3.0\ \text{mg/L}$$

***Practice Problems***

1. The chlorine dose is 7.2 mg/L. The chlorine residual is 2.2 mg/L. What is the chlorine demand in milligrams per milliliter?
2. The chlorine residual in a water sample is 1.1 mg/L. The chlorine dose was 2.7 mg/L. Determine the chlorine demand in milligrams per liter.
3. Determine the chlorine demand if the chlorine dose was 5.6 mg/L and the chlorine residual is 3.2 mg/L.
4. Calculate the chlorine demand if the chlorine dose was 4.8 mg/L and the chlorine residual is 1.4 mg/L.
5. Chlorine is fed at a dose of 3.5 mg/L. The chlorine residual is 2.3 mg/L. Determine the chlorine demand in milligrams per liter.
6. The chlorine dose is 8.4 mg/L. The chlorine residual is 1.2 mg/L. What is the chlorine demand in milligrams per milliliter?
7. The chlorine residual in a water sample is 3.1 mg/L. The chlorine dose was 7.7 mg/L. Determine the chlorine demand in milligrams per liter.
8. Determine the chlorine demand if the chlorine dose was 4.7 mg/L and the chlorine residual is 2.2 mg/L.
9. Calculate the chlorine demand if the chlorine dose was 5.3 mg/L and the chlorine residual is 2.4 mg/L.

10. Chlorine is fed at a dose of 5.6 mg/L. The chlorine residual is 2.1 mg/L. Determine the chlorine demand in milligrams per liter.
11. The chlorine dose is 6.5 mg/L. The chlorine residual is 2.8 mg/L. What is the chlorine demand in milligrams per milliliter?
12. The chlorine residual in a water sample is 1.4 mg/L. The chlorine dose was 5.1 mg/L. Determine the chlorine demand in milligrams per liter.
13. Determine the chlorine demand if the chlorine dose was 6.9 mg/L and the chlorine residual is 3.4 mg/L.
14. Calculate the chlorine demand if the chlorine dose was 4.4 mg/L and the chlorine residual is 1.6 mg/L.
15. Chlorine is fed at a dose of 2.8 mg/L. The chlorine residual is 2.0 mg/L. Determine the chlorine demand in milligrams per liter.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 5.0 mg/L | 2. 1.6 mg/L | 3. 2.4 mg/L | 4. 3.4 mg/L | 5. 1.2 mg/L |
| 6. 7.2 mg/L | 7. 4.6 mg/L | 8. 2.5 mg/L | 9. 2.9 mg/L | 10. 3.5 mg/L |
| 11. 3.7 mg/L | 12. 3.7 mg/L | 13. 3.5 mg/L | 14. 2.8 mg/L | 15. 0.8 mg/L |

# Chlorine Residuals

Example 1: What is the total chlorine residual if the free chlorine residual is 2.3 mg/L and the combined chlorine residual is 1.1 mg/L?

**Write down the formula.**

$$\text{Total Chlorine Residual, mg/L} = \text{Combined Chlorine Residual, mg/L} + \text{Free Chlorine Residual, mg/L}$$

**Make a table of data.**

Combined Chlorine Residual, mg/L = 1.1 mg/L

Free Chlorine Residual, mg/L = 2.3 mg/L

**Plug the data into the formula.**

$$\text{Total Chlorine Residual, mg/L} = 1.1\,\text{mg/L} + 2.3\,\text{mg/L}$$

**Do the addition.**

$$\text{Total Chlorine Residual, mg/L} = 3.4\,\text{mg/L}$$

Example 2: What is the free chlorine residual if the total chlorine residual is 2.8 mg/L and the combined chlorine residual is 0.3 mg/L?

**Write down the formula.**

$$\text{Free Chlorine Residual, mg/L} = \text{Total Chlorine Residual, mg/L} - \text{Combined Chlorine Residual, mg/L}$$

**Make a table of data.**

Total Chlorine Residual, mg/L = 2.8 mg/L

Combined Chlorine Residual, mg/L = 0.3 mg/L

**Plug the data into the formula.**

$$\text{Free Chlorine Residual, mg/L} = 2.8\,\text{mg/L} - 0.3\,\text{mg/L}$$

**Do the subtraction.**

$$\text{Free Chlorine Residual, mg/L} = 2.5\,\text{mg/L}$$

Example 3: The free chlorine residual in a water sample is 3.1 mg/L. The total chlorine residual in the same sample is 6.4 mg/L. What is the combined chlorine residual concentration in the sample?

**Write down the formula.**

$$\text{Combined Chlorine Residual, mg/L} = \text{Total Chlorine Residual, mg/L} - \text{Free Chlorine Residual, mg/L}$$

**Make a table of data.**

Total Chlorine Residual, mg/L = 6.4 mg/L

Free Chlorine Residual, mg/L = 3.1 mg/L

**Plug the data into the formula.**

$$\text{Combined Chlorine Residual, mg/L} = 6.4\ \text{mg/L} - 3.1\ \text{mg/L}$$

**Do the subtraction.**

$$\text{Combined Chlorine Residual, mg/L} = 3.3\ \text{mg/L}$$

### *Practice Problems*

1. What is the total chlorine residual if the free chlorine residual is 1.3 mg/L and the combined chlorine residual is 2.1 mg/L?
2. What is the free chlorine residual if the total chlorine residual is 3.8 mg/L and the combined chlorine residual is 0.9 mg/L?
3. Determine the combined chlorine residual in milligrams per liter if the free chlorine residual is 0.6 mg/L and the total chlorine residual is 2.4 mg/L.
4. Calculate the total chorine residual if the free chlorine residual is 1.6 mg/L and the combined chlorine residual is 2.4 mg/L.
5. A water sample was analyzed for its free and total chlorine residuals. The free chlorine residual was 2.7 mg/L. The total chlorine residual was 5.6 mg/L. Determine the combined chlorine residual for the sample.
6. What is the total chlorine residual if the free chlorine residual is 2.3 mg/L and the combined chlorine residual is 1.1 mg/L?
7. What is the free chlorine residual if the total chlorine residual is 6.8 mg/L and the combined chlorine residual is 4.9 mg/L?
8. Determine the combined chlorine residual in milligrams per liter if the free chlorine residual is 1.6 mg/L and the total chlorine residual is 2.9 mg/L.
9. Calculate the total chorine residual if the free chlorine residual is 2.2 mg/L and the combined chlorine residual is 5.4 mg/L.

10. A water sample was analyzed for its free and total chlorine residuals. The free chlorine residual was 1.7 mg/L. The total chlorine residual was 4.9 mg/L. Determine the combined chlorine residual for the sample.

11. What is the total chlorine residual if the free chlorine residual is 3.8 mg/L and the combined chlorine residual is 5.1 mg/L?

12. What is the free chlorine residual if the total chlorine residual is 5.7 mg/L and the combined chlorine residual is 3.1 mg/L?

13. Determine the combined chlorine residual in milligrams per liter if the free chlorine residual is 1.6 mg/L and the total chlorine residual is 7.4 mg/L.

14. Calculate the total chorine residual if the free chlorine residual is 2.7 mg/L and the combined chlorine residual is 1.4 mg/L.

15. A water sample was analyzed for its free and total chlorine residuals. The free chlorine residual was 2.4 mg/L. The total chlorine residual was 6.6 mg/L. Determine the combined chlorine residual for the sample.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 3.4 mg/L | 2. 2.9 mg/L | 3. 1.8 mg/L | 4. 4.0 mg/L | 5. 2.9 mg/L |
| 6. 3.4 mg/L | 7. 1.9 mg/L | 8. 1.3 mg/L | 9. 7.6 mg/L | 10. 3.2 mg/L |
| 11. 8.9 mg/L | 12. 2.6 mg/L | 13. 5.8 mg/L | 14. 4.1 mg/L | 15. 4.2 mg/L |

# Pumps and Motors

## Pumping Rate

Example: One of two high service pumps runs for 6 hours. During that time the water level in the clearwell dropped 7 feet. The clearwell is 30 feet long, 30 feet wide and 17 feet deep. Calculate the pump rate in gallons per minute.

***Step One: Determine the volume of water pumped from the clearwell.***

**Volume, ft3**

**Write down the formula.**

$$\text{Volume} = (\text{Length})(\text{Width})\,(\text{Depth})$$

**Make a table of data.**

Length = 30 ft

Width = 30 ft

Depth = 7 ft

**Plug the data into the formula.**

$$\text{Volume} = (30\text{ ft})(30\text{ ft})\,(7\text{ ft})$$

**Do the multiplication.**

$$\text{Volume} = 6{,}300\text{ ft}^3$$

***Step Two: Convert the volume to gallons.***

$$\text{Gallons} = 6{,}300\text{ ft}^3 \text{ X } 7.48\text{ gal/ft}^3 = 47{,}127\text{ gallons}$$

***Step Three: Determine the time in minutes.***

$$\text{Time, min} = 6\text{ hours X } 60\text{ min/hr} = 360\text{ min}$$

***Step Four: Determine the pump rate in gallons per minute.***

**Write down the formula.**

$$\text{Pump Rate, gal/min} = \frac{\text{Volume, gal}}{\text{Time, min}}$$

**Make a table of data.**

Volume, gal = 47,127 gal

Time, min = 360 min

**Plug the data into the formula.**

$$\text{Pump Rate, gal/min} = \frac{47{,}127\ \text{gal}}{360\ \text{min}}$$

**Divide the number above the line by the number below the line.**

$$\text{Pump Rate, gal/min} = 130.908333333 \text{ or } 131\ \text{gal/min}$$

***Practice Problems***

1. One of two high service pumps runs for 5 hours. During that time the water level in the clearwell dropped 8 feet. The clearwell is 45 feet long, 35 feet wide and 16 feet deep. Calculate the pump rate in gallons per minute.
2. A standpipe is 20 feet in diameter and has a maximum water depth of 80 feet. It took 8 hours and 30 minutes to fill the tank using its booster pump. Calculate the flow rate for the pump in gallons per minute.
3. The two high service pumps at a water plant pump operated for 3 hours and 8 minutes. During this time, the water level in the clearwell dropped 6 feet 3 inches. The clearwell is 31 feet long, 21 feet wide and 12 feet deep. Determine the flow rate in gallons per minute for each of the pumps.
4. An above ground clearwell is 85 feet in diameter, and 18 feet deep. Water enters the tank at a rate of 2,500 gpm. The high service pumps ran for 4 hours and 32 minutes. The water level in the tank dropped 5 feet during that time. There are three high service pumps, each with the same pumping capacity.. What is the pumping rate in gallons per minute for each high service pump?
5. The water level in the clearwell dropped 6.5 feet in 6 hours. The clearwell is 60 feet in diameter and 28 feet deep. The plant is producing water at a rate of 2.5 MGD. What is the discharge rate for the high service pumps in gallons per minute?
6. One of two high service pumps runs for 8 hours and 27 minutes. During that time the water level in the clearwell dropped 7 feet 9 inches. The clearwell is 40 feet long, 36 feet wide and 18 feet deep. Calculate the pump rate in gallons per minute.
7. A standpipe is 18 feet in diameter and has a maximum water depth of 40 feet. It took 4 hours and 36 minutes to fill the tank using its booster pump. Calculate the flow rate for the pump in gallons per minute.
8. The two high service pumps at a water plant pump operated for 4 hours and 8 minutes. During this time, the water level in the clearwell dropped 5 feet 10 inches. The clearwell is

35 feet long, 21 feet wide and 12 feet deep. Determine the flow rate in gallons per minute for each of the pumps.

9. An above ground clearwell is 80 feet in diameter, and 19 feet deep. Water enters the tank at a rate of 2,200 gpm. The high service pumps ran for 5 hours and 42 minutes. The water level in the tank dropped 7 feet during that time. There are three high service pumps, each with the same pumping capacity.. What is the pumping rate in gallons per minute for each high service pump?

10. The water level in the clearwell dropped 8.5 feet in 9 hours. The clearwell is 63 feet in diameter and 28 feet deep. The plant is producing water at a rate of 2.75 MGD. What is the discharge rate for the high service pumps in gallons per minute?

11. One of two high service pumps runs for 3 hours. During that time the water level in the clearwell dropped 6 feet. The clearwell is 45 feet long, 35 feet wide and 16 feet deep. Calculate the pump rate in gallons per minute.

12. A standpipe is 21 feet in diameter and has a maximum water depth of 88 feet. It took 6 hours and 31 minutes to fill the tank using its booster pump. Calculate the flow rate for the pump in gallons per minute.

13. The two high service pumps at a water plant pump operated for 4 hours and 12 minutes. During this time, the water level in the clearwell dropped 6 feet 11 inches. The clearwell is 33 feet long, 20 feet wide and 12 feet deep. Determine the flow rate in gallons per minute for each of the pumps.

14. An above ground clearwell is 65 feet in diameter, and 18 feet deep. Water enters the tank at a rate of 1,500 gpm. The high service pumps ran for 3 hours and 52 minutes. The water level in the tank dropped 7 feet during that time. There are three high service pumps, each with the same pumping capacity. What is the pumping rate in gallons per minute for each high service pump?

15. The water level in the clearwell dropped 4.5 feet in 4 hours. The clearwell is 64 feet in diameter and 28 feet deep. The plant is producing water at a rate of 2.75 MGD. What is the discharge rate for the high service pumps in gallons per minute?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 314 gpm | 2. 368 gpm | 3. 81 gpm | 4. 1,069 gpm | 5. 2,018 gpm |
| 6. 165 gpm | 7. 276 gpm | 8. 115 gpm | 9. 990 gpm | 10. 2,276 gpm |
| 11. 393 gpm | 12. 583 gpm | 13. 136 gpm | 14. 750 gpm | 15. 2,361 gpm |

# Water Horsepower

Water horsepower is:

- that portion of the power supplied to a pump that actually used to move water;
- the amount of work needed to move a flow of water against a specified head;
- the amount of power required to lift water.

ABC provides this formula for calculating water horsepower.

$$\text{Horsepower, Water (whp)} = \frac{\text{(Flow, gpm) (Head, ft)}}{3{,}960}$$

Sample Problem: Water is pumped at a rate of 100 gallons per minute against a total head of 75 feet.

**Write down the formula.**

$$\text{Horsepower, Water (whp)} = \frac{\text{(Flow, gpm) (Head, ft)}}{3{,}960}$$

**Make a table of data.**

$$\text{Flow, gpm} = 100 \text{ gpm}$$

$$\text{Head, ft} = 75 \text{ ft}$$

**Plug the data into the formula.**

$$\text{Horsepower, Water (whp)} = \frac{\text{(100 gpm) (75 ft)}}{3{,}960}$$

**Multiply the numbers above the line.**

$$\text{Horsepower, Water (whp)} = \frac{7{,}500}{3{,}960}$$

**Divide the number above the line by the number below the line.**

$$\text{Horsepower, Water (whp)} = 1.893939393939 \text{ or } 1.9 \text{ whp}$$

### *Practice Problems*

1. Calculate the water horsepower required for a pump to deliver 400 gallons per minute against a total head of 275 feet.
2. Determine the water horsepower required to pump 275 gal/min against a total head of 195 feet.
3. A pump delivers a flow of 1,200 gal/min. The total head is 970 feet. What is the water horsepower?
4. Calculate the water horsepower required for a pump to deliver 520 gallons per minute against a total head of 310 feet.
5. Determine the water horsepower required to pump 1,750 gal/min against a total head of 1,050 feet.
6. A pump delivers a flow of 225 gal/min. The total head is 610 feet. What is the water horsepower?
7. Calculate the water horsepower required for a pump to deliver 650 gallons per minute against a total head of 175 feet.
8. Determine the water horsepower required to pump 1,875 gal/min against a total head of 775 feet.
9. A pump delivers a flow of 3.000 gal/min. The total head is 575 feet. What is the water horsepower?
10. A pump has an efficiency of 90 %. The motor has an efficiency of 93 %. The pump delivers water at a rate of 2,520 gallons per minute against a total head of 875 feet. What is the water horsepower for this pump?
11. The motor on a pump has an efficiency of 92 %. The pump has an efficiency of 86 %. The pump delivers water at a rate of 1,620 gallons per minute against a total head of 1,100 feet. What is the water horsepower for this pump?
12. What would the water horsepower required to move a flow of 670 gal/min against a total head of 1,275 feet be if the motor efficiency is 90 % and the pump efficiency is 90%?
13. A pump has an efficiency of 90 %. The motor has an efficiency of 93 %. The pump delivers water at a rate of 2,500 gallons per minute against a total head of 870 feet. What is the water horsepower for this pump?
14. The motor on a pump has an efficiency of 92 %. The pump has an efficiency of 86 %. The pump delivers water at a rate of 3,960 gallons per minute against a total head of 642 feet. What is the water horsepower for this pump?
15. What would the water horsepower required to move a flow of 3,750 gal/min against a total head of 437 feet be if the motor efficiency is 90 % and the pump efficiency is 90%?

### *Answers*

| | | | | |
|---|---|---|---|---|
| 1. 28 whp | 2. 14 whp | 3. 294 whp | 4. 41 whp | 5. 464 whp |
| 6. 35 whp | 7. 29 whp | 8. 367 whp | 9. 436 whp | 10. 557 whp |
| 11. 450 whp | 12. 119 whp | 13. 549 whp | 14. 642 whp | 15. 414 whp |

# Brake Horsepower

Brake horsepower is the power supplied to a pump by a motor.

This formula is provided by ABC for calculating brake horsepower.

$$\text{Horsepower, Brake (bhp)} = \frac{\text{(Flow, gpm) (Head, ft)}}{\text{(3,960) (Pump Efficiency, \% expressed as a decimal)}}$$

Sample Problem: A booster pump delivers water at a rate of 820 gal./min. against a total head of 165 feet. The pump has an efficiency of 87% and the motor has an efficiency of 90%. What is the brake horsepower for this pump?

**Write down the formula.**

$$\text{Horsepower, Brake (bhp)} = \frac{\text{(Flow, gpm) (Head, ft)}}{\text{(3,960) (Pump Efficiency, \% expressed as a decimal)}}$$

**Make a table of data.**

Flow, gpm = 820 gpm

Head, ft = 165 ft

Pump Efficiency, % = 87% ÷ 100% = 0.87

**Plug the data into the formula.**

$$\text{Horsepower, Brake (bhp)} = \frac{\text{(820 gpm) (165 ft)}}{\text{(3,960) (0.87)}}$$

**Multiply the numbers above the line.**

$$\text{Horsepower, Brake (bhp)} = \frac{135{,}300}{\text{(3,960) (0.87)}}$$

**Multiply the numbers below the line.**

$$\text{Horsepower, Brake (bhp)} = \frac{135{,}300}{3{,}445.2}$$

**Divide the number above the line by the number below the line.**

$$\text{Horsepower, Brake (bhp)} = 39.272030651 \text{ or } 39 \text{ bhp}$$

***Practice Problems***

1. Calculate the brake horsepower required for a pump to deliver 500 gallons per minute against a total head of 220 feet, the pump efficiency is 85 %, and the motor efficiency is 92 %.

2. Determine the brake horsepower required to pump 670 gal/min against a total head of 1,175 feet, the pump has an efficiency of 85 %, and the motor efficiency is 89 %.

3. A pump delivers a flow of 500 gal/min. The total head is 430 feet. The pump has an efficiency of 87 %. The motor efficiency is 87 %.What is the brake horsepower?

4. Calculate the brake horsepower required for a pump to deliver 600 gallons per minute against a total head of 975 feet if the pump has an efficiency of 84 %, and the motor efficiency is 92 %.

5. Determine the brake horsepower required to pump 600 gal/min against a total head of 1,050 feet if the pump has an efficiency of 83 %, and the motor efficiency is 87 %.

6. A pump delivers a flow of 450 gal/min. The total head is 220 feet. The pump has an efficiency of 86 %. The motor efficiency is 93 %.What is the brake horsepower?

7. Calculate the brake horsepower required for a pump to deliver 620 gallons per minute against a total head of 842 feet if the motor efficiency is 89 %, and the pump has an efficiency of 81 %.

8. Determine the brake horsepower required to pump 400 gal/min against a total head of 270 feet, if the pump has an efficiency of 87 %, and the motor efficiency is 94 %.

9. A pump delivers a flow of 850 gal/min. The total head is 900 feet. The pump has an efficiency of 81 %. The motor efficiency is 85 %.What is the brake horsepower?

10. A pump has an efficiency of 88 %. The motor has an efficiency of 88 %. The pump delivers water at a rate of 270 gallons per minute against a total head of 225 feet. What is the brake horsepower for this pump?

11. The motor on a pump has an efficiency of 90 %. The pump has an efficiency of 86 %. The pump delivers water at a rate of 370 gallons per minute against a total head of 410 feet. What is the brake horsepower for this pump?

12. What would the brake horsepower required to move a flow of 525 gal/min against a total head of 437 feet be if the motor efficiency is 83 % and the pump efficiency is 83 %? 10. A pump has an efficiency of 88 %. The motor has an efficiency of 88 %. The pump delivers water at a rate of 270 gallons per minute against a total head of 225 feet. What is the brake horsepower for this pump?

13. A pump has an efficiency of 70 %. The motor has an efficiency of 89 %. The pump delivers water at a rate of 250 gallons per minute against a total head of 350 feet. What is the brake horsepower for this pump?

14. The motor on a pump has an efficiency of 90 %. The pump has an efficiency of 86 %. The pump delivers water at a rate of 470 gallons per minute against a total head of 325 feet. What is the brake horsepower for this pump?

15. What would the brake horsepower required to move a flow of 620 gal/min against a total head of 450 feet be if the motor efficiency is 83 % and the pump efficiency is 79 %?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 33 bhp | 2. 234 bhp | 3. 62 bhp | 4. 176 bhp | 5. 192 bhp |
| 6. 29 bhp | 7. 163 bhp | 8. 31 bhp | 9. 239 bhp | 10. 17 bhp |
| 11. 45 bhp | 12. 70 bhp | 13. 95 bhp | 14. 43 bhp | 15. 89 bhp |

# Motor Horsepower

Motor horsepower is defined as the horsepower which is equivalent to the electric power (watts) supplied to the motor.

ABC provides this formula for solving motor horsepower problems.

$$\text{Horsepower, Motor (mhp)} = \frac{\text{(Flow, gpm) (Head, ft)}}{(3{,}960)\left[\begin{array}{c}\text{Pump Efficiency, \%}\\ \text{expressed as a decimal}\end{array}\right]\left[\begin{array}{c}\text{Motor Efficiency, \%}\\ \text{expressed as a decimal}\end{array}\right]}$$

Sample Problem: A booster pump delivers water at a rate of 875 gal./min. against a total head of 265 feet. The pump has an efficiency of 89% and the motor has an efficiency of 91%. What is motor horsepower?

**Write down the formula.**

$$\text{Horsepower, Motor (mhp)} = \frac{\text{(Flow, gpm) (Head, ft)}}{(3{,}960)\left[\begin{array}{c}\text{Pump Efficiency, \%}\\ \text{expressed as a decimal}\end{array}\right]\left[\begin{array}{c}\text{Motor Efficiency, \%}\\ \text{expressed as a decimal}\end{array}\right]}$$

**Make a table of data.**

Flow, gpm = 875 gpm

Head, ft = 265 ft

Pump Efficiency, % = 89% ÷ 100% = 0.89

Motor Efficiency, % = 91% ÷ 100% = 0.91

**Plug the data into the formula.**

$$\text{Horsepower, Motor (mhp)} = \frac{\text{(875 gpm) (265 ft)}}{(3{,}960)\,(0.89)\,(0.91)}$$

Multiply the numbers above the line.

$$\text{Horsepower, Motor (mhp)} = \frac{231{,}875}{(3{,}960)\,(0.89)\,(0.91)}$$

**Multiply the numbers below the line.**

$$\text{Horsepower, Motor (mhp)} = \frac{231{,}875}{3{,}207.204}$$

**Divide the number above the line by the number below the line.**

$$\text{Horsepower, Motor (mhp)} = 72.2981762307 \text{ or } 72 \text{ mhp}$$

***Practice Problems***

1. Calculate the motor horsepower required for a pump to deliver 450 gallons per minute against a total head of 175 feet, the pump efficiency is 85 %, and the motor efficiency is 92 %.
2. Determine the motor horsepower required to pump 625 gal/min against a total head of 1,150 feet, the pump has an efficiency of 85 %, and the motor efficiency is 89 %.
3. A pump delivers a flow of 500 gal/min. The total head is 625 feet. The pump has an efficiency of 87 %. The motor efficiency is 87 %.What is the motor horsepower?
4. Calculate the motor horsepower required for a pump to deliver 575 gallons per minute against a total head of 1,025 feet if the pump has an efficiency of 84 %, and the motor efficiency is 92 %.
5. Determine the motor horsepower required to pump 620 gal/min against a total head of 1,100 feet if the pump has an efficiency of 83 %, and the motor efficiency is 87 %.
6. A pump delivers a flow of 475 gal/min. The total head is 200 feet. The pump has an efficiency of 86 %. The motor efficiency is 93 %.What is the motor horsepower?
7. Calculate the motor horsepower required for a pump to deliver 1,250 gallons per minute against a total head of 950 feet if the motor efficiency is 89 %, and the pump has an efficiency of 81 %.
8. Determine the motor horsepower required to pump 875 gal/min against a total head of 225 feet, if the pump has an efficiency of 87 %, and the motor efficiency is 94 %.
9. A pump delivers a flow of 750 gal/min. The total head is 1,050 feet. The pump has an efficiency of 81 %. The motor efficiency is 85 %.What is the motor horsepower?
10. A pump has an efficiency of 88 %. The motor has an efficiency of 88 %. The pump delivers motor at a rate of 500 gallons per minute against a total head of 650 feet. What is the motor horsepower for this pump?
11. The motor on a pump has an efficiency of 90 %. The pump has an efficiency of 86 %. The pump delivers motor at a rate of 450 gallons per minute against a total head of 300 feet. What is the motor horsepower for this pump?
12. What would the motor horsepower required to move a flow of 675 gal/min against a total head of 525 feet be if the motor efficiency is 83 % and the pump efficiency is 83 %?
13. A pump has an efficiency of 88 %. The motor has an efficiency of 88 %. The pump delivers motor at a rate of 575 gallons per minute against a total head of 700 feet. What is the motor horsepower for this pump?
14. The motor on a pump has an efficiency of 90 %. The pump has an efficiency of 86 %. The pump delivers motor at a rate of 475 gallons per minute against a total head of 325 feet. What is the motor horsepower for this pump?
15. What would the motor horsepower required to move a flow of 1,650 gal/min against a total head of 400 feet be if the motor efficiency is 83 % and the pump efficiency is 83 %?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 25 mhp | 2. 240 mhp | 3. 104 mhp | 4. 193 mhp | 5. 239 mhp |
| 6. 30 mhp | 7. 416 mhp | 8. 61 mhp | 9. 289 mhp | 10. 106 mhp |
| 11. 44 mhp | 12. 130 mhp | 13. 131 mhp | 14. 50 mhp | 15. 242 mhp |

# Wire-to-Water Efficiency - 1

There are two formula provided by ABC for calculating wire-to-water efficiency.

$$\text{Wire - to - Water Efficiency, \%} = \frac{\text{Water Horsepower, whp}}{\text{Pump Input, hp or Motor hp}} \text{ X } 100\%$$

$$\text{Wire - to - Water Efficiency, \%} = \frac{\text{(Flow, gpm) (Total Dynamic Head, ft) (0.746 kW/hp)}}{\text{(3,960) (Electrical Demand, kilowatts)}} \text{ X } 100\%$$

Example 1: Determine the wire-to-water efficiency for a motor and pump if the power supplied to the motor is 189 HP and the pump output is 156 HP.

**Write down the formula.**

$$\text{Wire - to - Water Efficiency, \%} = \frac{\text{Water Horsepower, whp}}{\text{Pump Input, hp or Motor hp}} \text{ X } 100\%$$

**Make a table of data.**

Water Horsepower, whp = 156 hp

Motor Horsepower, mhp = 189 hp

**Plug the data into the formula.**

$$\text{Wire - to - Water Efficiency, \%} = \frac{156 \text{ hp}}{189 \text{ hp}} \text{ X } 100\%$$

**Divide the number above the line by the number below the line.**

$$\text{Wire - to - Water Efficiency, \%} = 0.825396825 \text{ X } 100\%$$

**Do the multiplication.**

$$\text{Wire - to - Water Efficiency, \%} = 82.5396825 \text{ or } 83\%$$

***Practice Problems***

1. Determine the percent efficiency if 101 HP are supplied to a motor and the output is 89 HP.
2. Calculate the percent efficiency for a pump and motor if the power supplied is 100 HP and the power output is 75 HP.

3. What would the percent efficiency for a motor and pump be if the HP output is 35 HP and HP supplied is 47 HP?

4. 49 horsepower are supplied to a pump and motor. The output of the pump and motor is 37 HP. Determine the percent efficiency of the pump and motor.

5. What would the percent efficiency for a pump and motor be if 57 horsepower are supplied to the motor and the power output of the pump is 42 horsepower?

6. The power supplied to a motor is 87 HP. The power output for the pump is 69 HP. Calculate the percent efficiency for the pump and motor.

7. Calculate the percent efficiency for a pump and motor if 96 HP are supplied to the motor and the pump output is 83 HP.

8. Determine the percent efficiency for a motor and pump if the power supplied to the motor is 177 HP and the pump output is 156 HP.

9. The power supplied to a motor and pump is 210 horsepower. The output for the pump and motor is 179 horsepower. What is the percent efficiency for the pump and motor?

10. The power supplied to a pump and motor is 50 HP. The power output for the pump and motor is 42 HP. Determine the % overall efficiency for the pump and motor.

11. What would the wire-to-water efficiency be for a motor and pump if 93 horsepower are supplied to the motor and the pump output is 76 horsepower?

12. The power output for a pump is 25 horsepower. The power supplied to the motor is 31 horsepower. Calculate the wire-to-water efficiency for the pump and motor.

13. Determine the efficiency in percent for a motor and pump if the motor horsepower is 97 HP and the pump output is 78 water horsepower.

14. Calculate the wire-to-water efficiency in percent for a pump and motor if the input to the motor is 77 motor horsepower, and the output for the pump is 56 HP.

15. The largest finished water pump at a water treatment plant has a power input of 279 HP. The power output for the pump is 212 HP. What is the wire-to-water efficiency in percent for the finished water pump?

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 88% | 2. 75% | 3. 74% | 4. 76% | 5. 74% |
| 6. 79% | 7. 86% | 8. 88% | 9. 85% | 10. 84% |
| 11. 82% | 12. 81% | 13. 80% | 14. 73% | 15. 76% |

# Wire-to-Water Efficiency – 2

ABC also provides this formula for determining wire-to-water efficiency in percent.

$$\text{Wire - to - Water Efficiency, \%} = \frac{(\text{Flow, gpm})\,(\text{Total Dynamic Head, ft})\,(0.746\ \text{kW/hp})}{(3{,}960)\,(\text{Electrical Demand, kilowatts})}\ \text{X}\ 100\%$$

Example: A pump delivers a flow of 1,200 gallons per minute against a total dynamic head of 432 feet. The electrical demand for the pump is 107 kilowatts. Calculate the wire-to-water efficiency in percent.

**Write down the formula.**

$$\text{Wire - to - Water Efficiency, \%} = \frac{(\text{Flow, gpm})\,(\text{Total Dynamic Head, ft})\,(0.746\ \text{kW/hp})}{(3{,}960)\,(\text{Electrical Demand, kilowatts})}\ \text{X}\ 100\%$$

**Make a table of data.**

Flow, gpm = 1,200 gpm

Total Dynamic Head, ft = 432 ft

Electrical Demand, kilowatts = 107 kilowatts

**Plug the data into the formula.**

$$\text{Wire - to - Water Efficiency, \%} = \frac{(1{,}200\ \text{gpm})\,(432\ \text{ft})\,(0.746\ \text{kW/hp})}{(3{,}960)\,(107\ \text{kilowatts})}\ \text{X}\ 100\%$$

**Multiply the numbers above the line.**

$$\text{Wire - to - Water Efficiency, \%} = \frac{386{,}726.4}{(3{,}960)\,(107\ \text{kilowatts})}\ \text{X}\ 100\%$$

**Multiply the numbers below the line.**

$$\text{Wire - to - Water Efficiency, \%} = \frac{386{,}726.4}{423{,}720}\ \text{X}\ 100\%$$

**Divide the number above the line by the number below the line.**

$$\text{Wire - to - Water Efficiency, \%} = 0.916932880\,2\ \text{X}\ 100\%$$

**Do the multiplication.**

$$\text{Wire - to - Water Efficiency, \%} = 91.69328802\ \text{or}\ 92\%$$

Practice Problems

1. A pump delivers a flow of 750 gallons per minute against a total dynamic head of 354 feet. The electrical demand for the pump is 58 kilowatts. Calculate the wire-to-water efficiency in percent.

2. What is the wire-to-water efficiency, in percent, for a pump that delivers 450 gallons per minute, against a total dynamic head of 175 feet? The electrical demand for the pump is 26 kilowatts.

3. Determine the wire-to-water efficiency for a pump which delivers a flow of 225 gallons per minute, against a total dynamic head of 200 feet, if the electrical demand is 9 kilowatts.

4. A pump consumes 225 kilowatts of electricity while pumping a flow of 1,200 gallons per minute against a total dynamic head of 875 feet. Calculate the wire-to-water efficiency for the pump.

5. A high service pump delivers a flow of 650 gallons per minute while pumping against a total dynamic head of 176 feet. When operating, the electrical demand for the pump is 24 kilowatts. Determine the wire-to-water efficiency for the pump.

6. A pump delivers a flow of 175 gallons per minute against a total dynamic head of 145 feet. The electrical demand for the pump is 6 kilowatts. Calculate the wire-to-water efficiency in percent.

7. What is the wire-to-water efficiency, in percent, for a pump that delivers 560 gallons per minute, against a total dynamic head of 389 feet? The electrical demand for the pump is 48 kilowatts.

8. Determine the wire-to-water efficiency for a pump which delivers a flow of 2,360 gallons per minute, against a total dynamic head of 459 feet, if the electrical demand is 220 kilowatts.

9. A pump consumes 228 kilowatts of electricity while pumping a flow of 1,000 gallons per minute against a total dynamic head of 1,100 feet. Calculate the wire-to-water efficiency for the pump.

10. A high service pump delivers a flow of 1,250 gallons per minute while pumping against a total dynamic head of 674 feet. When operating, the electrical demand for the pump is 187 kilowatts. Determine the wire-to-water efficiency for the pump.

11. A pump delivers a flow of 3,750 gallons per minute against a total dynamic head of 569 feet. The electrical demand for the pump is 470 kilowatts. Calculate the wire-to-water efficiency in percent.

12. What is the wire-to-water efficiency, in percent, for a pump that delivers 825 gallons per minute, against a total dynamic head of 730 feet? The electrical demand for the pump is 119 kilowatts.

13. Determine the wire-to-water efficiency for a pump which delivers a flow of 675 gallons per minute, against a total dynamic head of 823 feet, if the electrical demand is 113 kilowatts.

14. A pump consumes 187 kilowatts of electricity while pumping a flow of 960 gallons per minute against a total dynamic head of 925 feet. Calculate the wire-to-water efficiency for the pump.

15. A high service pump delivers a flow of 1,500 gallons per minute while pumping against a total dynamic head of 675 feet. When operating, the electrical demand for the pump is 208 kilowatts. Determine the wire-to-water efficiency for the pump.

***Answers***

| | | | | |
|---|---|---|---|---|
| 1. 86% | 2. 57% | 3. 94% | 4. 88% | 5. 90% |
| 6. 80% | 7. 85% | 8. 93% | 9. 91% | 10. 85% |
| 11. 86% | 12. 95% | 13. 93% | 14. 89% | 15. 92% |

# The Training Station

Tennessee Association of Utility Districts