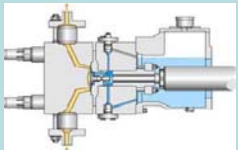
CHEMICAL APPLICATIONS AND CHEMICAL FEED PUMPS



Gary Byrd, Training Specialist

Hawai'i Rural Water Association

Need for Chemicals

A wide variety of chemicals are used in the water treatment system for the production of a safe and palatable drinking water supply.

Chemical Applications

- Algae Control
- Clarification
- Water Softening
- Taste & Odor Control
- Corrosion/Scaling Control
- Disinfection
- Fluoridation

Chemical Applications

- Algae Control
  - Copper Sulfate – $CuSO_4 \cdot 5\ H_2O$
    - 99% - $CuSO_4$

Chemical Applications

- Clarification
  - Coagulants
    - Aluminum Sulfate (Alum) – $Al_2(SO_4)_3 \cdot 14\ H_2O$
      - 47-50% - $Al_2(SO_4)_3$
      - Acidic
    - Ferric Chloride – $FeCl_3 \cdot 6\ H_2O$
      - 59-61% - $FeCl_3$
      - Acidic
    - Ferric Sulfate – $Fe_2(SO_4)_3 \cdot 9\ H_2O$
      - 90-94% - $Fe_2(SO_4)_3$
      - Acidic
      - Staining
    - Ferrous Sulfate – $FeSO_4 \cdot 7\ H_2O$
      - 55% – $FeSO_4$
      - Cakes Dry

Chemical Applications

- Coagulant Aids
  - Polymers
    - Cationic Polymers
      - Positively Charged (+)
    - Anionic Polymers
      - Negatively Charged (-)
    - Nonionic Polymers
      - Neutral

Chemical Applications

- Water Softening
  - Calcium Oxide - CaO
    - Quicklime
    - 75-99% - CaO
  - Sodium Carbonate – Na_2CO_3
    - Soda Ash
    - 99.4% - Na_2CO_3

Chemical Applications

- Taste & Odor Control
  - Activated Carbon – C
    - Insoluble
  - Potassium Permanganate – $KMnO_4$
    - 100%
    - Very Soluble

Chemical Applications

- Corrosion/Scaling Control
  - Calcium Hydroxide – $Ca(OH)_2$
    - Hydrated Lime
    - 75-99% - CaO
    - Basic
  - Sodium Hydroxide – NaOH
    - Caustic Soda
    - 98.9% - NaOH
    - Very Basic

Chemical Applications

- Disinfection
  - Sodium Hypochlorite – NaOCl
    - 12-15% - Cl_2
    - Solution/Bleach
    - Generated On Site
  - Calcium Hypochlorite – $Ca(OCl)_2 \cdot 4\ H_2O$
    - 65-70% - Cl_2
    - Powder/HTH
  - Chlorine – Cl_2
    - 99.8% - Cl_2
    - Gas/Liquid
  - Chlorine Dioxide – ClO_2
    - 26.3% - Cl_2
    - Generated On Site

Chemical Applications

- Fluoridation
  - Sodium Silicofluoride – Na_2SiF_6
    - 59.8% - F
    - Powder
  - Sodium Fluoride – NaF
    - 43.6% - F
    - Powder or Crystal
  - Fluosilicic Acid – H_2SiF_6
    - 23.8% - F
    - Solution

Chemical Feed Points Throughout A Water Treatment System

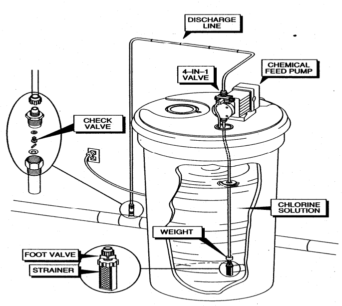
Chemical Feed Pumps

- **Positive Displacement Pumps**
  - **Diaphragm Pumps**
  - **Piston Pumps**
  - **Peristaltic Pumps**
  - **Rotary Style Pumps**
- **Gas Regulator Equipment**
- **Volumetric**
- **Gravimetric**

POSITIVE DISPLACEMENT PUMPS

- Precise volume at a precise time
- Usually a Diaphragm Pump
- Operated electrically or mechanically
- Foot valve and screen on suction, and 4-in-1 valve on discharge to prevent backsiphonage of chemical.

CHEMICAL FEED PUMP ARRANGEMENTS



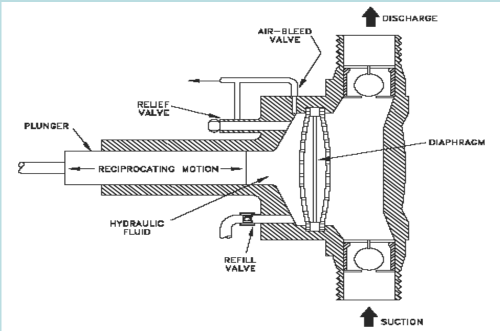
Single feed system

Dual Feed System

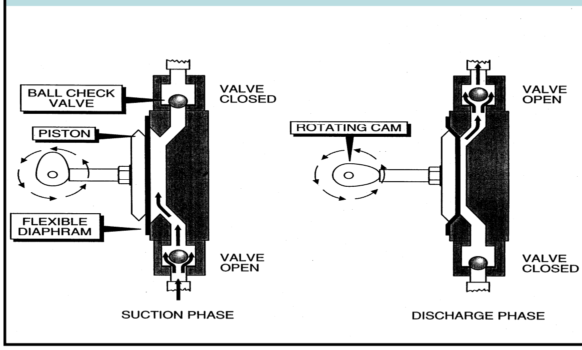
Diaphragm Pumps

- Chemical Pumps
- Sludge Pumps
- Diaphragm pumping system
- Operated electrically or pnuematically
- Adjust the % and speed of each stroke
- Foot valve and screen on suction
- 4-in-1 valve system to prevent backsiphonage of chemical.

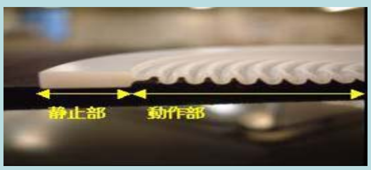
Diaphragm Pumps

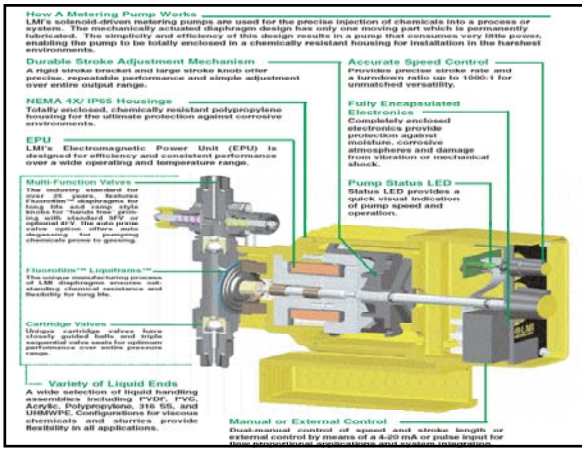


Diaphragm Pumps



Synthetic Diaphragm



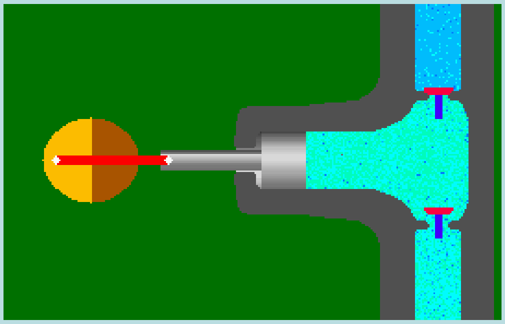


Pump Rebuild Kits

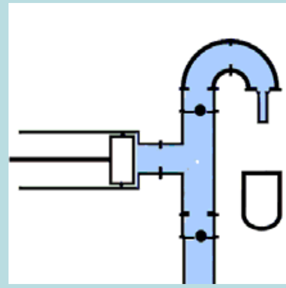
Reciprocating/Piston Pumps

- Chemical Pumps
- “Mud Pump”
- Precise volume with each stroke
- Operated electrically or mechanically
- Adjust length and frequency of each stroke
- Foot valve and screen on suction
- 2 valve system to prevent backsiphonage of chemical.

Reciprocating/Piston Pumps



Piston Pumps



Reciprocating/Piston Pumps

Diaphragm/Reciprocating Pumps

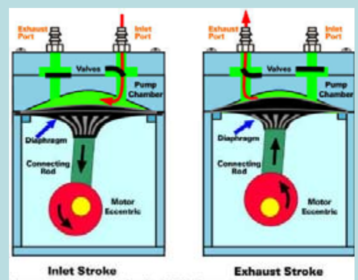
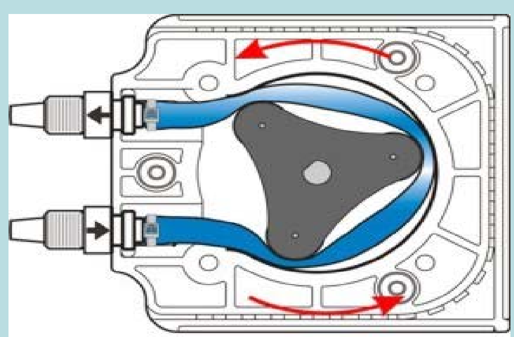


Figure 1 Operation of a liquid diaphragm pump.

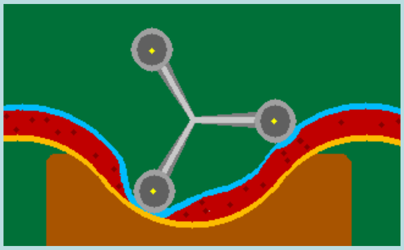
Peristaltic Pumps

- Chemical feed applications
- Sampling machines
- Low maintenance
- Tubes ware out
- Change tubes according to manufacturers recommendations

Peristaltic Pumps



Peristaltic Pumps

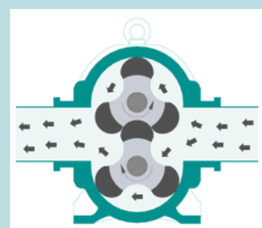


Peristaltic Pumps

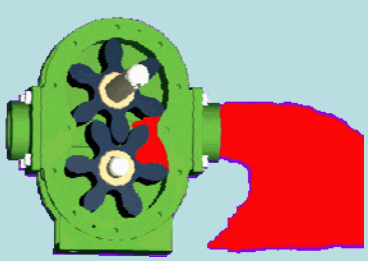
Rotary Style Pumps

- Chemical Pumps
- Tight Clearances
- Rotary Lube
- Rotary Gear
- Adjustable Speeds
- Blowers
- Sludge Pumps

Rotary Lube Pumps



Rotary Gear Pumps



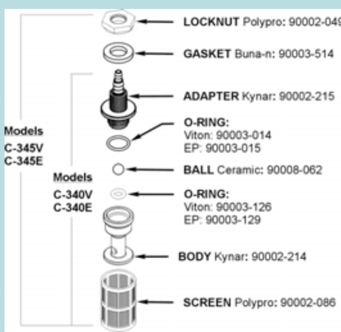
Chemical Feed Pump Accessories

- **Chemical Mixers**
- **Chemical Solution Tanks**
- **Foot Valves**
- **Injector/Ejector**
- **4-in-1 Valves**
- **Calibration Equipment**
- **Flow Sensors**
- **Rebuild Kits**

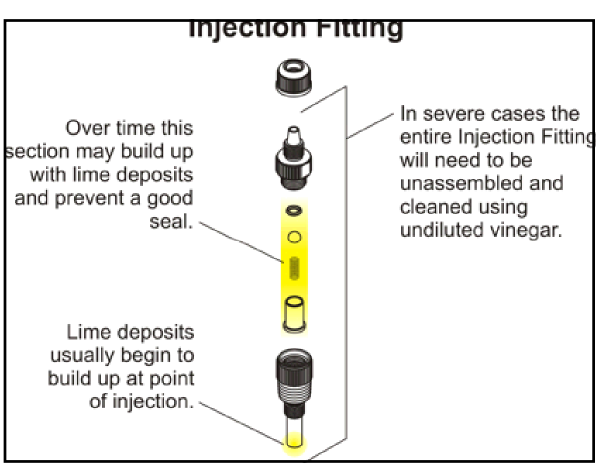
Chemical Mixers

Chemical Solution Tanks

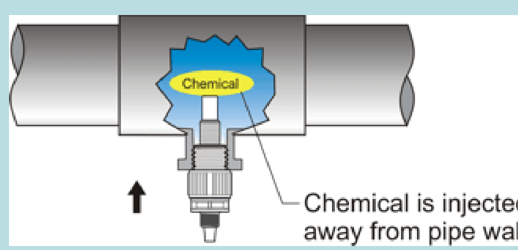
Foot Valve Unit with Strainer

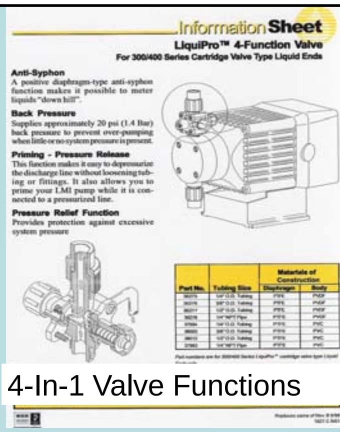


Injector/Ejector



Injection Point





4-In-1 Valve Functions

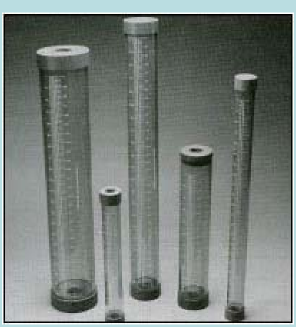
4-in-1 Valves

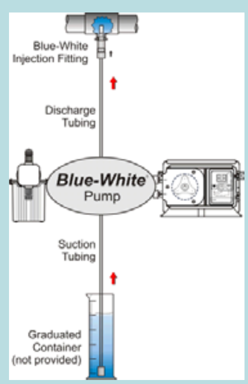
4 in 1 Valve

Chemical Pump Calibration

- **Calibration Cylinders are installed on suction side of pump**
- **Fill cylinder to the top mark then close the valve from the chemical tank**
- **Switch on chemical feed pump and draw down the chemical in the cylinder for 30 seconds**
- **Switch the pump off**
- **The reading on the left side of the cylinder is in GPH**

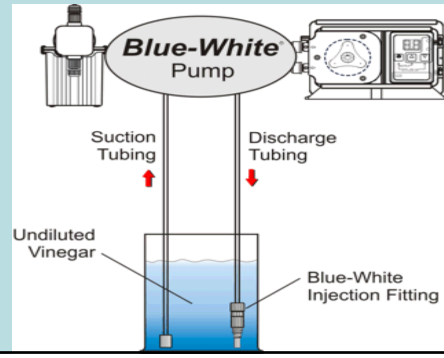
Calibration Cylinders



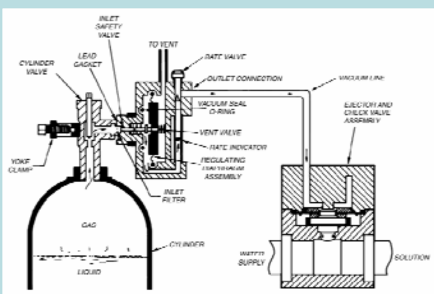


Flow Control Sensor

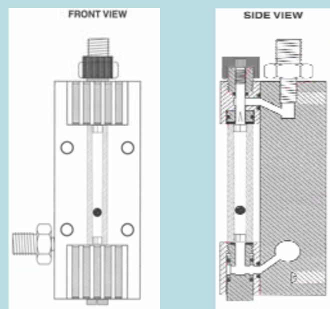
Chemical Pump Cleaning



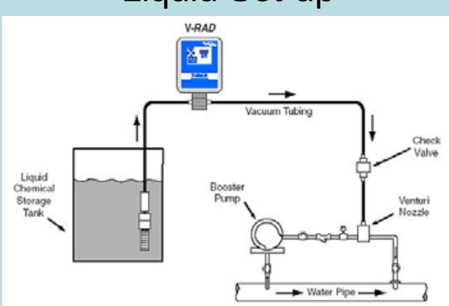
Gas Chemical Feed System



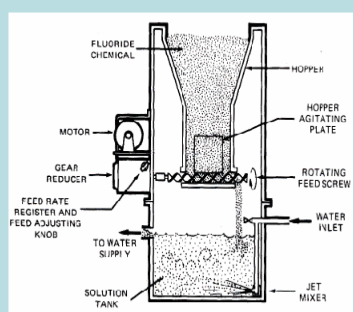
Rotameter - Rate of Gas Flow



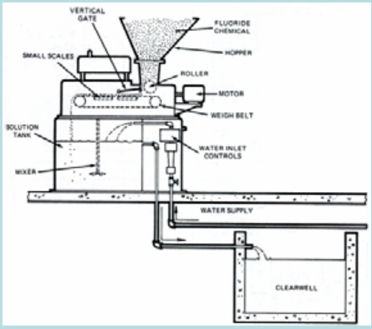
Booster Pump System
Liquid Set-up



Volumetric Chemical Feeder
Dry Feed System



Gravimetric Chemical Feeder Dry Feed System



Dry Chemical Feeder

Chemical Feed Rate Calculations Example 1

In a solution feed system, if the desired feed rate is 3 gph and the chemical feeder has a maximum feed rate of 15 gph, the feeder would be set at:

$$\text{Scale Setting, \%} = \frac{(\text{Desired Feed Rate, gph})(100\%)}{\text{Maximum Feed Rate, gph}}$$

$$= \frac{(3\text{ gph})(100\%)}{15\text{ gph}}$$

= 20% of full setting

Chemical Feed Rate Calculations Problem 1

In a solution feed system, if the desired feed rate is 15 gph and the chemical feeder has a maximum feed rate of 20 gph, the feeder would be set at:

$$\text{Scale Setting, \%} = \frac{(\text{Desired Feed Rate, gph})(100\%)}{\text{Maximum Feed Rate, gph}}$$

$$= \frac{(15\text{ gph})(100\%)}{20\text{ gph}}$$

= 75% of full setting

Chemical Feed Rate Calculations Problem 2

In a solution feed system, if the desired feed rate is 1.5 gph and the chemical feeder has a maximum feed rate of 10 gph, the feeder would be set at:

$$\text{Scale Setting, \%} = \frac{(\text{Desired Feed Rate, gph})(100\%)}{\text{Maximum Feed Rate, gph}}$$

$$= \frac{(1.5\text{ gph})(100\%)}{10\text{ gph}}$$

= 15% of full setting

$$\text{68\% chemical} = \frac{15\%}{0.68}$$

= 22%

Chemical Feed Pump Calibration Example 1

A chemical feeder draws a liquid from a one-liter (1,000 mL) graduated cylinder for 30 seconds. At the end of 30 seconds, the graduated cylinder has 400 mL remaining. What is the chemical feed rate in milliliters per minute and in gallons per minute (gpm)?

1. Determine volume of chemical fed in milliliters.

Chemical Fed, mL = Starting level, mL – Final level, mL

= 1,000 mL – 400 mL

= 600 mL

Chemical Feed Pump Calibration Example 1

A chemical feeder draws a liquid from a one-liter (1,000 mL) graduated cylinder for 30 seconds. At the end of 30 seconds, the graduated cylinder has 400 mL remaining. What is the chemical feed rate in milliliters per minute and in gallons per minute (gpm)?

2. Determine chemical feed rate, mL/min

Chemical Feed Rate, mL/min = Chemical Fed, mL / Feed Time, min

= (600 mL)(60 sec/min) / 30 sec

= 1,200 mL/min

Chemical Feed Pump Calibration Example 1

A chemical feeder draws a liquid from a one-liter (1,000 mL) graduated cylinder for 30 seconds. At the end of 30 seconds, the graduated cylinder has 400 mL remaining. What is the chemical feed rate in milliliters per minute and in gallons per minute (gpm)?

3. Determine chemical feed rate, gpm

Chemical Feed Rate, gpm = Chemical Fed, mL/min / 3,785 mL/gal

= (1,200 mL/min) / 3,785 mL/gal

= 0.32 gpm

65% chemical = 0.32 gpm / 0.65

= 0.49 gpm

Chemical Feed Pump Calibration Problem 1

A chemical feeder draws a liquid from a one-liter (1,000 mL) graduated cylinder for 15 seconds. At the end of 15 seconds, the graduated cylinder has 600 mL remaining. What is the chemical feed rate in milliliters per minute and in gallons per minute (gpm)?

1. Determine volume of chemical fed in milliliters.

Chemical Fed, mL = Starting level, mL – Final level, mL

= 1,000 mL – 600 mL

= 400 mL

Chemical Feed Pump Calibration Problem 1

A chemical feeder draws a liquid from a one-liter (1,000 mL) graduated cylinder for 15 seconds. At the end of 15 seconds, the graduated cylinder has 600 mL remaining. What is the chemical feed rate in milliliters per minute and in gallons per minute (gpm)?

2. Determine chemical feed rate, mL/min

Chemical Feed Rate, mL/min = Chemical Fed, mL / Feed Time, min

= (400 mL)(60 sec/min) / 15 sec

= 1,600 mL/min

Chemical Feed Pump Calibration Problem 1

A chemical feeder draws a liquid from a one-liter (1,000 mL) graduated cylinder for 15 seconds. At the end of 15 seconds, the graduated cylinder has 600 mL remaining. What is the chemical feed rate in milliliters per minute and in gallons per minute (gpm)?

3. Determine chemical feed rate, gpm

Chemical Feed Rate, gpm = Chemical Fed, mL/min / 3,785 mL/gal

= (1,600 mL/min) / 3,785 mL/gal

= 0.42 gpm

45% chemical = 0.42 gpm / 0.45

= 0.94 gpm

Chemical Feed Pump Calibration Example 2

A chemical feeder draws a liquid from a one-liter (1,000 mL) graduated cylinder for 60 seconds. At the end of 60 seconds, the graduated cylinder has 250 mL remaining. What is the chemical feed rate in milliliters per minute and in gallons per minute (gpm)?

1. Determine volume of chemical fed in milliliters.

Chemical Fed, mL = Starting level, mL – Final level, mL

= 1,000 mL – 250 mL

= 750 mL

Chemical Feed Pump Calibration Problem 2

A chemical feeder draws a liquid from a one-liter (1,000 mL) graduated cylinder for 60 seconds. At the end of 60 seconds, the graduated cylinder has 250 mL remaining. What is the chemical feed rate in milliliters per minute and in gallons per minute (gpm)?

2. Determine chemical feed rate, mL/min

Chemical Feed Rate, mL/min = Chemical Fed, mL / Feed Time, min

= (750 mL) / 60 sec

= 750 mL/min

Chemical Feed Pump Calibration Problem 2

A chemical feeder draws a liquid from a one-liter (1,000 mL) graduated cylinder for 60 seconds. At the end of 60 seconds, the graduated cylinder has 250 mL remaining. What is the chemical feed rate in milliliters per minute and in gallons per minute (gpm)?

3. Determine chemical feed rate, gpm

Chemical Feed Rate, gpm = Chemical Fed, mL/min / 3,785 mL/gal

= (750 mL/min) / 3,785 mL/gal

= 0.2 gpm

55% chemical = 0.2 gpm / 0.55

= 0.36 gpm

Gas Feed Rates Example 1

A well has a capacity of 2,800 gallons per minute (gpm) and operates 9 hours and 15 minutes. The water has a chlorine demand of 1.5 mg/L. **How many pounds per day** would the **rotameter** have to be set in order to have a 1.7 mg/L chlorine residual?

Flow, MG/Day = 2,800 gpm X 1440 min/Day / 1,000,000 gal/MG

= 4.032 MG/Day

Dose, ppm = Demand + Residual

= 1.5 ppm + 1.7 ppm

= 3.2 ppm

Lbs/Day = Flow, MG/Day X 8.34 Lbs/ppm·MG X dose, ppm

= 4.032 MG/Day X 8.34 Lbs/ppm·MG X 3.2 ppm

= 108 Lbs/Day

Gas Feed Rates Problem 1

A well has a capacity of 1,500 gallons per minute (gpm) and operates 19 hours and 30 minutes. The water has a chlorine demand of 3.5 mg/L. **How many pounds per day** would the **rotameter** have to be set in order to have a 0.7 mg/L chlorine residual?

Flow, MG/Day = 1,500 gpm X 1440 min/Day / 1,000,000 gal/MG

= 2.16 MG/Day

Dose, ppm = Demand + Residual

= 3.5 ppm + 0.7 ppm

= 4.2 ppm

Lbs/Day = Flow, MG/Day X 8.34 Lbs/ppm·MG X dose, ppm

= 2.16 MG/Day X 8.34 Lbs/ppm·MG X 4.2 ppm

= 76 Lbs/Day

Gas Feed Rates Problem 2

A well has a capacity of 50 gallons per minute (gpm) and operates 19 hours and 30 minutes. The water has a chlorine demand of 1.3 mg/L. **How many pounds per day** would the **rotameter** have to be set in order to have a 0.2 mg/L chlorine residual?

Flow, MG/Day = 50 gpm X 1440 min/Day / 1,000,000 gal/MG

= 0.072 MG/Day

Dose, ppm = Demand + Residual

= 1.3 ppm + 0.2 ppm

= 1.5 ppm

Lbs/Day = Flow, MG/Day X 8.34 Lbs/ppm·MG X dose, ppm

= 0.072 MG/Day X 8.34 Lbs/ppm·MG X 1.5 ppm

= 1 Lbs/Day

Gas Feed Rates Example 2

Your well is operating at 3.0 MGD and the chlorine **rotameter** is set on 65 pounds per day. **What is the chlorine residual of the water** if the chlorine demand is 1.8 mg/L?

Dose, ppm = Lbs/Day / MG/Day X 8.34 Lbs/ppm·MG

= 65 Lbs/Day / 3.0 MGD X 8.34 Lbs/ppm·MG

= 2.6 ppm

Residual, ppm = Dose, ppm – Demand, ppm

= 2.6 ppm – 1.8 ppm

= 0.8 ppm

Gas Feed Rates Problem 3

Your well is operating at 0.12 MGD and the chlorine **rotameter** is set on 8 pounds per day. **What is the chlorine residual of the water** if the chlorine demand is 5.8 mg/L?

Dose, ppm = Lbs/Day ÷ (MG/Day X 8.34 Lbs/ppm·MG)

= 8 Lbs/Day ÷ (0.12 MGD X 8.34 Lbs/ppm·MG)

= 8.0 ppm

Residual, ppm = Dose, ppm – Demand, ppm

= 8.0 ppm – 5.8 ppm

= 2.2 ppm

Gas Feed Rates Problem 4

Your well is operating at 0.7 MGD and the chlorine **rotameter** is set on 4.5 pounds per day. **What is the chlorine residual of the water** if the chlorine demand is 0.5 mg/L?

Dose, ppm = Lbs/Day ÷ (MG/Day X 8.34 Lbs/ppm·MG)

= 4.5 Lbs/Day ÷ (0.7 MGD X 8.34 Lbs/ppm·MG)

= 0.77 ppm

Residual, ppm = Dose, ppm – Demand, ppm

= 0.77 ppm – 0.5 ppm

= 0.27 ppm

Disinfection Feed Rate Example 1

The chlorinator at your well breaks down and you must feed a Sodium Hypochlorite solution containing 10% chlorine as a temporary measure. Four mg/L is the dose being added to 1.5 million gallons pumped in 20 hours. **How many gallons of the sodium hypochlorite** (10% chlorine) **solution** will be required?

NaOCl, gal = MG/Day X 8.34 Lbs X ppm

= 1.5 MG X 8.34 Lbs/MG·ppm X 4.0 ppm ÷ 8.34 Lbs/gal

= 6.0 gals

10% Cl_2 = gals ÷ %

= 6.0 gals ÷ 0.10

= 60 gals

Disinfection Feed Rate Example 2

How many gallons of sodium hypochlorite (5% available chlorine) have to be added to 400 gallons of water to produce a 100 mg/L chlorine solution?

NaOCl, gal = MG/Day X 8.34 Lbs X ppm

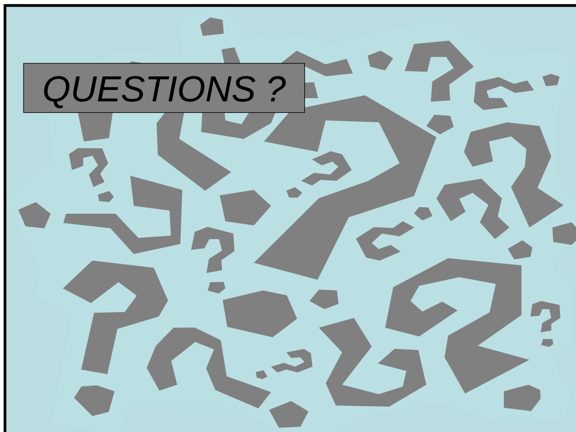
= 0.0004 MG X 8.34 Lbs/MG·ppm X 100.0 ppm ÷ 8.34 Lbs/gal

= 0.04 gals

5% Cl_2 = gals ÷ %

= 0.04 gals ÷ 0.05

= 0.8 gals



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