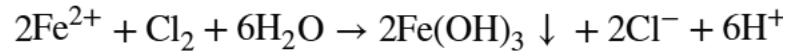


## Chlorine Disinfection: Dose, Demand, and Residual. Handout 1

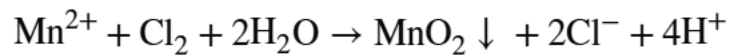
You can use the following stoichiometric relationships as a reference to complete selected problems in this worksheet.

### Stoichiometric Relationships

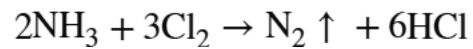
- **Iron (Fe):** 0.64 mg of chlorine is required to oxidize 1.0 mg of ferrous iron



- **Manganese (Mn):** 1.29 mg of chlorine is required to oxidize 1.0 mg of manganese



- **Ammonia (NH<sub>3</sub>):** 7.6 mg of chlorine is required to completely oxidize 1.0 mg of ammonia-nitrogen to nitrogen gas



**Part 1:** Estimate the resulting free residual after accounting for reducing compound demand.

1. Estimate the total chlorine demand for a groundwater source that has 0.3 mg/L of iron (Fe)

2. A groundwater has an iron (Fe) concentration of 0.2 mg/L and a manganese (Mn) concentration of 0.01 mg/L. Estimate the resulting free residual if a dose of 1.2 mg/L chlorine is applied.

3. A surface water source has an ammonia concentration of 0.15 mg/L. Estimate the residual free chlorine remaining if a dose of 1.7 mg/L chlorine is applied.

**Part 2:** Calculate the gas chlorine feed rate or dose for the following disinfection scenarios.

1. A plant has a flow of 2.4 MGD and needs to apply a dose of 2.7 mg/L gas chlorine. Determine the chlorinator setting in lbs/day.

2. A plant has a gas chlorine feed rate of 17 lbs per day and a plant flow of 1.0 MGD. What is the dose for this plant?

3. A surface water plant has a flow of 3 MGD and needs to achieve a free chlorine residual of 1.0 mg/L. What should be the chlorine gas feed rate in pounds per day if the ammonia concentration is 0.02 mg/L?

4. A groundwater system has a plant flow of 0.9 MGD and needs to achieve a free chlorine residual of 1.0 mg/L. What should be the chlorine gas feed rate in pounds per day if the iron concentration is 0.2 mg/L and the manganese concentration is 0.04 mg/L?

**Chlorine Disinfection. Feed rates for sodium hypochlorite. Handout 2.**

$$\text{Feed rate (gpd)} = \frac{\text{Flow (MGD)} \times \text{Conc (mg/L)} \times 8.34 \text{ lbs/gal}}{\% \text{strength} \times \text{s.g.} \times 8.34 \text{ lbs/gal}}$$

1. A groundwater system has a flow of 1.4 MGD and needs a dose of 1.3 mg/L chlorine. What should be the feed rate of 12.5% sodium hypochlorite in GPD? (assume s.g. = 1.2)

2. A groundwater system produces a flow of 800 gallons per minute. The desired free residual is 1.2 mg/L. What should be the feed rate of 12.5% sodium hypochlorite in GPD if the iron concentration is 0.25 mg/L and the manganese concentration is 0.015 mg/L? (assume s.g. = 1.2)

3. A sodium hypochlorite feed pump is rated for 0.5 GPH. Estimate the output of this pump in GPD if the stroke and speed are both set at 70%.

4. A water system with a flow of 750 gpm purchased a sodium hypochlorite feed pump rated at 1 GPH. This system aims to feed the correct amount of chlorine to achieve a dosage of 2 mg/L. The sodium hypochlorite strength is 12.5% and has a s.g. of 1.2. The

operators have connected the chemical feed pump and have set the speed at 89%. Estimate the stroke setting as a percent needed to achieve the correct feed rate in GPD.

5. A water utility has a flow of 1.6 MGD and wants to deliver a dose that results in a 1.2 mg/L free residual. The water source includes 0.05 mg/L of manganese and 0.01 mg/L of ammonia. 5.25% sodium hypochlorite will be fed with a chemical feed pump and has a s.g. of 1.08. If the following feed pump ratings were your only options, which one would you select for this application, and why? (show your work).

- a. Chemical feed pump rated at 2.5 GPH
- b. Chemical feed pump rated at 1.6 GPH
- c. Chemical feed pump rated at 0.75 GPH

### **Chlorine Disinfection CT Compliance – Handout 3**

1. A plant has a flow of 2.2 MGD and a disinfection clear well with a volume of 100,000 gallons. The clear well has superior baffling with a BF = 0.7. If the free residual in the water exiting the clear well is 1.5 mg/L, what CT has been achieved?

2. Water has a temperature of 5 degrees Celsius, a pH of 6.5, and a final free chlorine residual of 1.6 mg/L. If the plant flow is 1 MGD and the clear well has a volume of 100,000 gallons with a BF of 0.7, what is the Log treatment that was achieved by disinfection alone? (show your work).

3. Water in a surface water treatment plant has a temperature of 10 degrees Celsius, a pH of 7.5, and a free chlorine residual of 1.2 mg/L (at the end of the chlorine contact basin). This plant has a flow of 2 MGD and is credited with a 2.5-log removal credit toward 3-log Giardia compliance. What is the minimum chlorine contact time required to achieve 1-log inactivation toward 3-log Giardia compliance? (Bonus question: What would be the minimum required volume (in gallons) of the clear well if the baffling factor was 0.5?)

4. Flow from a groundwater well is chlorinated with sodium hypochlorite to achieve a free residual of 0.9 mg/L. The water temperature is 10 degrees Celsius, and the pH is 7.0. Water flows from the well at a rate of 700 GPM through an 8-inch water main. From the disinfection point, water flows through 1,000 feet of water main to reach the first connection. Has this system achieved 4 Log treatment for viruses?

**Chlorine Disinfection: Emergency or repair-based disinfection. Handout 4.**

1. A well has a 10-inch casing and a water column height of 300 feet. How many gallons of 12.5% bleach should be added to the casing to achieve a dose of 100 mg/L?

2. A distribution system crew needs to disinfect a newly installed 1,000-foot-long section of 12-inch water main with a dose of 25 mg/L. 1-inch tablets of calcium hypochlorite (HTH) will be used. Each tablet has a strength of 68% and weighs 5 grams, which is equivalent to 0.011 lbs. Estimate the minimum number of tablets needed.

3. A storage tank has been drained for repairs and needs to be disinfected before refilling. The interior of the tank will be sprayed with a 200 mg/L solution of sodium hypochlorite. How many gallons of 12.5% sodium hypochlorite will be needed to make 5 gallons of 200 mg/L solution? (There are 3.785 liters in a gallon.)