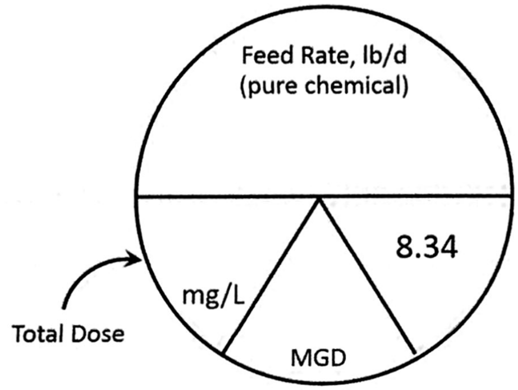
Chlorine Disinfection Math

$Dose = Demand + Residual$	
$$Feed\ Rate, ppd = \frac{(Dose, \frac{mg}{L})(Flow, mgd)(8.34)}{\%\ Available}$$	

1. The chlorine dose at the well head is 2 mg/L. If the residual measured at the far end of the distribution system was 0.2 mg/L, what was the demand?
2. Experience has shown that the chlorine demand in July averages 1.8 mg/L across the distribution system. If the desired residual at the first tap is 0.6 mg/L, what dose is required at the treatment plant?
3. The chlorine dose at the beginning of the chlorine contact chamber was 5.2 mg/L. The measured total chlorine result at the end of the chlorine contact chamber was 0.5 mg/L. What was the demand?
4. A well is disinfected using chlorine gas. The well produces 1.2 mgd of water on average. If the desired dose is 2.2 mg/L, where should the chlorinator be set in pounds per day?
5. How much chlorine gas is needed each day to treat 8.5 mgd of flow when the average demand is 3.5 mg/L and a residual of 0.5 mg/L is required at the first tap.
6. A drinking water system has two wells. The first well produces 600 gpm and the second produces 825 gpm. The operator needs to maintain a minimum chlorine residual of 0.2

mg/L at the far end of the distribution system. Experience has shown that a chlorine dose of 1.8 mg/L is sufficient. Where should the chlorinator feed rate be set?

7. A water treatment plant consumes four 150 lb chlorine cylinders each week. If the average daily flow is 3 mgd, what is the average chlorine dose?
8. A well produces an average of 1800 gpm. Chlorine is added at a dose of 5.1 mg/L. A full, 150 lb chlorine cylinder was just connected to the chlorinator. There are five other full chorine cylinders in reserve. How many days until the system runs out of chlorine?
9. A water system disinfects with 15% sodium hypochlorite solution. The average flow rate is 3.5 mgd and the dose is 4 mg/L. How many pounds per day of sodium hypochlorite solution will be needed?
10. A water plant disinfects with a sodium hypochlorite solution that contains 5.25% available chlorine. If the flow rate is 600 gpm, how many gallons of sodium hypochlorite solution will be needed each day at a dose of 4.5 mg/L?
11. From experience, the operator knows that the chlorine demand will be about 1.2 mg/L in the clearwell. She would like to maintain a total chlorine residual of 3.0 mg/L for disinfection. If the plant is treating 800 gpm and is using HTH tablets for disinfection (70% available chlorine), how many pounds of HTH tablets will be needed each day?
12. A water tank must be taken out of service for cleaning and maintenance. The tank will be shock chlorinated with a dose of 300 mg/L of chlorine before placing it back into service. The tank is 25 feet high and 30 feet in diameter. How many pounds of HTH tables (68% available chlorine) will be needed to disinfect the tank?
13. Sodium hypochlorite is delivered as a 5.25% solution. It must be diluted prior to use. The day tank holds 700 gallons and the desired chlorine concentration in the day tank is

250 mg/L. How much of the concentrated sodium hypochlorite solution should be added to the day tank?

14. How many gallons of 8% sodium hypochlorite solution are needed to disinfect a well that is 300 feet deep and 2.5 feet in diameter? The drawdown water level is 225 feet below grade and the desired dose is 500 mg/L.
15. An operator is collecting samples for free chlorine residual in the field. To check the proper function of their hand-held chlorine analyzer, they decide to analyze a certified standard. This will also check the freshness of their reagents and their laboratory technique. The stock standard solution has a concentration of 300 mg/L, but the test can only read concentrations up to 2 mg/L. The operator needs a working standard concentration of 1.5 mg/L. Looking around in the truck, they find a 250 mL volumetric flask. How much stock solution should be added to the flask and diluted to achieve the target concentration?
16. How many gallons of water can be treated with 100 pounds of 65% HTH to a dosage of 2.55 mg/L?
17. An operator added 165 pounds of 25% ferric chloride to a treatment flow of 10.5 mgd. What was the corresponding dosage?

1. DOSE = DEMAND + RESIDUAL

$2\ mg/L$ = DEMAND + $0.2\ mg/L$

$2 - 0.2$ = DEMAND + $0.2 - 0.2$

$1.8\ mg/L$ = DEMAND

2. DOSE = DEMAND + RESIDUAL

DOSE = $1.8\ mg/L + 0.6\ mg/L$

DOSE = $2.4\ mg/L$

3. DOSE = DEMAND + RESIDUAL

$5.2\ mg/L$ = DEMAND + $0.5\ mg/L$

$5.2 - 0.5$ = DEMAND + $0.5 - 0.5$

$4.7\ mg/L$ = DEMAND

4. $\text{feed rate, lb/d} = \frac{(mg/L)(mgd)(8.34)}{\%}$

$\text{feed rate, lb/d} = \frac{(2.2\ mg/L)(1.2\ mgd)(8.34)}{1}$

feed rate, lb/d = 22

5. $\text{feed rate, lb/d} = \frac{(mg/L)(mgd)(8.34)}{\%}$

feed rate, lb/d = $(3.5\ mg/L + 0.5\ mg/L)(8.5\ mgd)(8.34)$

feed rate, lb/d = 283.56

6. The feed rate formula only works if flow is in MGD. Add the flows together and convert.

$600\ gpm + 825\ gpm = 1425\ gpm$

$$\frac{1425\ gal}{min} \Big| \frac{1440\ min}{1\ day} \Big| \frac{1\ MG}{1000000\ gal} \Big| = 2.052\ mgd$$

$$\text{feed rate, lb/d} = \frac{(mg/L)(MGD)(8.34)}{\%\ avail}$$

$$\text{feed rate, lb/d} = \frac{(1.8\ mg/L + 0.2\ mg/L)(2.052\ mgd)(8.34)}{1}$$

$$\text{feed rate, lb/d} = \frac{(2\ mg/L)(2.052\ mgd)(8.34)}{1}$$

$$\text{feed rate, lb/d} = 34.2$$

conversion factor

* side note: to convert mg/L + flow → lb/d

$$\frac{1\ mg}{L} \Big| \frac{3.785\ L}{1\ gal} \Big| \frac{1000000\ gal}{1\ day} \Big| \frac{1\ g}{1000\ mg} \Big| \frac{1\ kg}{1000\ g} \Big| \frac{2.204\ lb}{1\ kg} \Big| = 8.34 \ \frac{mil\ gal}{day}$$

7. $4 \times 150 \text{ lbs} = 600 \frac{\text{lbs}}{\text{week}} \left| \frac{1 \text{ week}}{7 \text{ days}} \right| = 85.7 \text{ lb/d}$

$$\text{feed rate, lb/d} = \frac{(\text{mg/L})(\text{mgd})(8.34)}{\text{\% avail}}$$

$$85.7 \text{ lb/d} = \frac{(\text{mg/L})(3 \text{ mgd})(8.34)}{1}$$

$$85.7 \text{ lb/d} = (\text{mg/L})(25.02)$$

* divide both sides by 25.02

$$3.43 = \text{mg/L}$$

8. A) convert flow to mgd
B) find lb/d needed
c) estimate days of supply

$$\frac{1800 \text{ gal}}{\text{min}} \left| \frac{1440 \text{ min}}{1 \text{ day}} \right| \frac{1 \text{ MG}}{1000000 \text{ gal}} \Big| = 2.592 \text{ mgd}$$

$$\text{feed rate, lb/d} = \frac{(\text{mg/L})(\text{mgd})(8.34)}{\%}$$

$$\text{feed rate, lb/d} = \frac{(5.1 \text{ mg/L})(2.592 \text{ mgd})(8.34)}{1}$$

$$\text{feed rate, lb/d} = 110.24$$

8. cont. 5 + 1 cylinders

$(6)(150 \text{ lbs}) = 900 \text{ lbs available}$

$$\frac{900 \text{ lbs avail}}{} \left| \frac{1 \text{ day}}{110.24 \text{ lb}} \right| = 8.16 \text{ days}$$

(110.24 lb: needed)

9. $\text{feed rate, lb/d} = \frac{(\text{mg/L})(\text{mgd})(8.34)}{\% \text{ avail}}$

$\text{feed rate, lb/d} = \frac{(4 \text{ mg/L})(3.5 \text{ mgd})(8.34)}{0.15}$

$\text{feed rate, lb/d} = \frac{116.76}{0.15}$ — top # is lbs of chlorine needed

$\text{feed rate, lb/d} = 778.4$ — how much total chemical needed

10. $$\frac{600 \text{ gal}}{\text{min}} \left| \frac{1440 \text{ min}}{1 \text{ day}} \right| \frac{1 \text{ MG}}{1000000 \text{ gal}} \Bigg| = 0.864 \text{ mgd}$$

next page

10. feed rate, lb/d = $\frac{(mg/L)(mgd)(8.34)}{\% \text{ avail}}$

feed rate, lb/d = $\frac{(4.5\ mg/L)(0.864\ mgd)(8.34)}{0.0525}$

feed rate, lb/d = 617.64

convert to gallons

$\frac{617.64\ lbs}{} \Big| \frac{1\ gallon}{8.34\ lbs} \Big|$ = 74 gallons

11. $\frac{800\ gal}{min} \Big| \frac{1440\ min}{1\ day} \Big| \frac{1\ MG}{1000000\ gal} \Big|$ = 1.152 mgd

feed rate, lb/d = $\frac{(mg/L)(mgd)(8.34)}{\% \text{ avail}}$

feed rate, lb/d = $\frac{(1.2\ mg/L + 3.0\ mg/L)(1.152\ mgd)(8.34)}{0.7}$

feed rate, lb/d = $\frac{(4.2\ mg/L)(1.152\ mgd)(8.34)}{0.7}$

feed rate, lb/d = 57.64

12. Start by finding the volume of the tank in million gallons.

(A) Volume = (0.785)(diameter)^2(height)
Volume = (0.785)(30 ft)(30 ft)(25 ft)
Volume = 17662.5 cu ft

(B) $\frac{17662.5 \text{ cu ft}}{} \Big| \frac{7.48 \text{ gal}}{1 \text{ cu ft}} \Big| \frac{1 \text{ MG}}{1000000 \text{ gal}} = 0.132$ mil gal.

(C) feed rate, lb/d = $\frac{(\text{mg/L})(\text{MG})(8.34)}{\%}$

feed rate, lb/d = $\frac{(300 \text{ mg/L})(0.132 \text{ MG})(8.34)}{0.68}$

feed rate, lb/d = 485.7

13. Dilutions – use the normality equations

(Concentration 1)(Volume 1) = (Concentration 2)(Vol 2)
(5.25%)(Volume 1) = (250 mg/L)(700 gal)

convert to mg/L $5.25\% \Big| \frac{10000 \text{ mg/L}}{1\%} = 52500$ mg/L cont.

13. (Conc. 1)(Vol 1) = (Conc 2)(Vol 2)

(52,500 mg/L)(Vol 1) = (250 mg/L)(700 gal)

(52,500 mg/L)(Vol 1) = 175000 mg/L·gal

then, divide both sides by 52,500

$$Vol\,1 = \frac{175000\ mg/L \cdot gal}{52500\ mg/L}$$

Vol 1 = 3.33 gal

Operator should add 3.33 gallons of delivered hypochlorite solution to the day tank and fill to the 700 gallon mark with make-up water.

14. First – find the volume of WATER

Vol = (0.785)(diameter)^2(height)

Vol = (0.785)(2.5 ft)(2.5 ft)(300 − 225 ft)

Vol = 367.96 cu ft

call it 368 cu ft and convert to gal

$$368\ cu\ ft \times \frac{7.48\ gal}{1\ cu\ ft} = 2752.64\ gal$$

14. (cont.) $\frac{8\%}{} \left| \frac{10000 \text{ mg/L}}{1\%} \right| = 80000 \text{ mg/L}$

$(\text{Volume } 1)(\text{Conc. } 1) = (\text{Volume } 2)(\text{Conc. } 2)$

$(\text{Volume } 1)(80000 \text{ mg/L}) = (2752.64 \text{ gal})(500 \text{ mg/L})$

$(\text{Volume } 1)(80000 \text{ mg/L}) = 1376320 \text{ gal} \cdot \text{mg/L}$

$(\text{Volume } 1) = \frac{1376320 \text{ gal} \cdot \text{mg/L}}{80000 \text{ mg/L}}$

Volume 1 = 17.2 gallons

15. $(\text{Vol } 1)(\text{Conc } 1) = (\text{Vol } 2)(\text{Conc } 2)$

$(\text{Vol } 1)(300 \text{ mg/L}) = (1250 \text{ mL})(1.5 \text{ mg/L})$

$(\text{Vol } 1)(300 \text{ mg/L}) = 375 \text{ mL} \cdot \text{mg/L}$

$\text{Vol } 1 = \frac{375 \text{ mL} \cdot \text{mg/L}}{300 \text{ mg/L}}$

Vol 1 = 1.25 mL

16. feed rate, lb/d = $\frac{(\text{mg/L})(\text{mgd})(8.34)}{\%}$

$100 \text{ lbs} = \frac{(2.25 \text{ mg/L})(\text{mgd})(8.34)}{0.65}$

$100 \text{ lbs} = (28.869)(\text{mgd})$

$\frac{100}{28.869} = \text{mgd}$

$3.46 = \text{mgd}$

* asked for gallons

so 3,463,923 gal

17. feed rate, lb/d = $\frac{(\text{mg/L})(\text{mgd})(8.34)}{\%}$

$165 \text{ lbs} = \frac{(\text{mg/L})(10.5 \text{ mgd})(8.34)}{0.25}$

$165 \text{ lbs} = (\text{mg/L})(350.28)$

$0.47 = \text{mg/L}$