Chlorine Contact Time Calculations

Steps to solving a math problem:

a. Read the problem and write down what is “given”.
b. Determine what is being requested with the correct units.
c. Cross out anything “given” that has nothing to do with solving the problem.
d. Select the appropriate formulas & factors.
e. Write down the formula in vertical format.
f. Plug in the “given” numbers into the formula.
g. Make sure units on both sides of the equation match.
h. Convert all units to the same form using conversion factors in vertical format to cancel out like units in the numerator & denominator.
i. Solve the problem.

Equations:

$$Total\ detention\ time = \frac{Lowest\ operating\ volume}{Peak\ flow}$$

The operating volume should be taken during peak hour demand but the lowest operating volume may be substituted with Safe Drinking Water Branch’s approval.

$$Contact\ time = Total\ detention\ time \times Baffling\ factor$$

$$CT\ calc = Residual\ chlorine\ concentration \times Contact\ time$$

$$Inactivation\ Ratio = \frac{CTcalc}{CTreq}$$

$$4log\ virus\ inactivation\ check: Inactivation\ ratio \times 4\ \geq 4 \rightarrow OK!$$

$$4log\ virus\ inactivation\ check: Inactivation\ ratio \times 4\ < 4 \rightarrow Rework\ Calculated\ Parameters$$

Table 3-2 – Baffling Factors

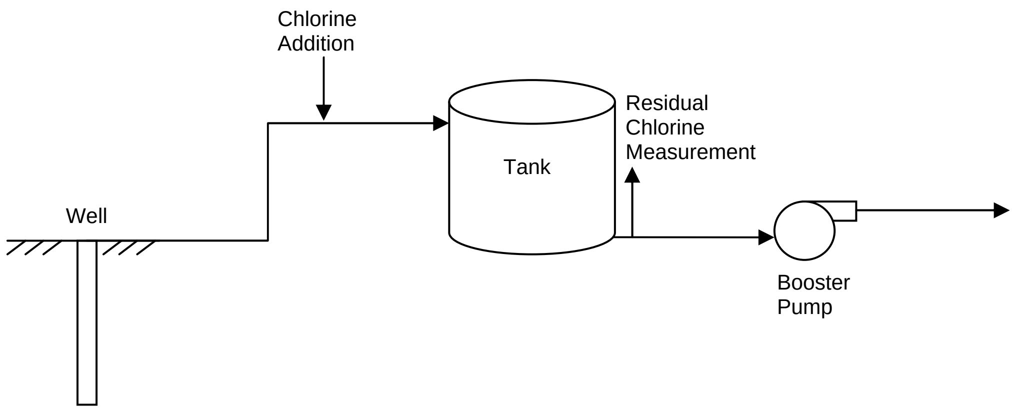
Factor	Description
0.1	None, agitated basis, very low length to width ratio, high inlet and outlet flow velocities. Enclosed circular or rectangular tank with single inlet and outlet line. Enclosed circular or rectangular tank with inlet on top and outlet on the bottom, either directly below or on the same side as the inlet line.
0.3	Single or multiple unbaffled inlets and outlets, no intra-basin baffles. Enclosed circular or rectangular tank with inlet on top and outlet on the bottom on the opposite wall.
0.5	Baffled inlet or outlet with some intra-basin baffles.
0.7	Perforated inlet baffle, serpentine or perforated intra-basin baffles, outlet weir or perforated launders.
1	Very high length to width ratio (pipeline flow), perforated inlet, outlet, and intra-basin baffles.

Table B-2 – CTreq values for 4-log virus inactivation of viruses by free chlorine in mg/L•min

Temperature (°C)	**pH**	
	6-9	**10**
0.5	12	90
5	8	60
10	6	45
15	4	30
20	3	22
25	2	15

1. Is the water system providing 4log virus inactivation using 12.5% sodium hypochlorite?

GIVEN



Well capacity = 100 gpm
Residual chlorine concentration = 0.1 mg/L free chlorine, measured at the outlet of the tank
Tank's total capacity = 50,000 gallons
Tank's lowest operating volume = 25,000 gallons
Booster pump capacity = 250 gpm
Tank has no baffles with a separate inlet and outlet. The inlet is located at the top of the tank and the outlet is located at the bottom of the tank on the opposite wall.
pH = 7.5
Temperature = 20°C

FIND If the water system is providing 4-log virus inactivation.

NOT RELEVANT
- The well capacity has no bearing on the peak flow of the water system.
- Using the tank's total capacity will increase the results and not cover the most conservative situation when the tank is at its lowest operating volume.

SOLUTION

From Table 3-2, Baffling factor = 0.3.
From Table B-2, CT req = 3 $\frac{mg}{L} \cdot min$
Peak Flow = 250 gpm

$$Total\ detention\ time = \frac{Lowest\ Operating\ Volume}{Peak\ flow}$$

$$Total\ detention\ time = \frac{25{,}000\ gallons}{250\ \frac{gal}{min}}$$

$$Total\ detention\ time = 100\ min$$

$$Contact\ time = Total\ detention\ time \times Baffling\ factor$$

$$Contact\ time = 100\ min \times\ 0.3$$

$$Contact\ time = 30\ min$$

$$CTcalc = Residual\ chlorine\ concentration \times Contact\ time$$

$$CT\ calc = 0.1\ \frac{mg}{L}\ \times 30\ min$$

$$CT\ calc = 3\ \frac{mg}{L} \cdot min$$

$$Inactivation\ ratio = \frac{CT\ calc}{CT\ req}$$

$$Inactivation\ ratio = \frac{3\ \frac{mg}{L}\ \cdot min}{3\ \frac{mg}{L}\ \cdot min}$$

$$Inactivation\ ratio = 1$$

$$4log\ virus\ inactivation\ check = Inactivation\ ratio \times 4$$

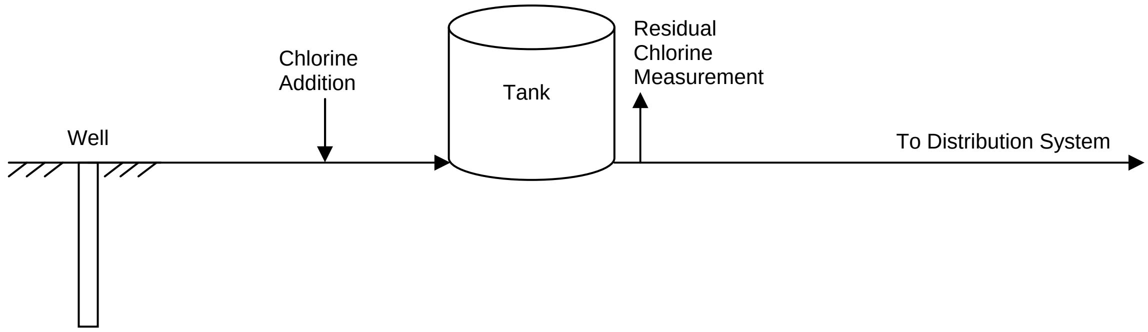
$$4log\ virus\ inactivation\ check = 1 \times 4$$

$$4log\ virus\ inactivation\ check = 4$$

$4log\ virus\ inactivation\ check\ \geq 4, therefore, 4log\ virus\ inactivation\ is\ achieved!$ Answer: YES

2. Is the water system providing 4log virus inactivation using 12.5% sodium hypochlorite?

GIVEN



Well capacity = 600 gpm
Residual chlorine concentration = 0.1 mg/L free chlorine, measured at the outlet of the tank
Tank's total capacity = 600,000 gallons
Tank's lowest operating volume = 200,000 gallons
Peak hour flow = 1,200 gpm
Tank has no baffles with a separate inlet and outlet with high inlet and outlet flow velocities.
pH = 6.8
Temperature = 25°C

FIND If the water system is providing 4-log virus inactivation.

NOT RELEVANT
- The well capacity has no bearing on the peak flow of the water system.
- Using the tank's total capacity will increase the results and not cover the most conservative situation when the tank is at its lowest operating volume.

SOLUTION

From Table 3-2, Baffling factor = 0.1
From Table B-2, CT req = 2 $\frac{mg}{L} \cdot min$
Peak flow = 1,200 gpm

$$Total\ detention\ time = \frac{Lowest\ Operating\ Volume}{Peak\ flow}$$

$$Total\ detention\ time = \frac{200{,}000\ gallons}{1{,}200\ \frac{gal}{min}}$$

$$Total\ detention\ time = 166.67\ min$$

$$Contact\ time = Total\ detention\ time \times Baffling\ factor$$

$$Contact\ time = 166.67\ min \times\ 0.1$$

$$Contact\ time = 16.67\ min$$

$$CTcalc = Residual\ chlorine\ concentration \times Contact\ time$$

$$CT\ calc = 0.1\ \frac{mg}{L} \times 16.67\ min$$

$$CT\ calc = 1.67\ \frac{mg}{L} \cdot min$$

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$$Inactivation\ ratio = \frac{CT\ calc}{CT\ req}$$

$$Inactivation\ ratio = \frac{1.67\ \frac{mg}{L} \cdot min}{2\ \frac{mg}{L} \cdot min}$$

$$Inactivation\ ratio = 0.84$$

Round to 1 decimal place.

$$Inactivation\ ratio = 0.8$$

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$$4log\ virus\ inactivation\ check = Inactivation\ ratio \times 4$$

$$4log\ virus\ inactivation\ check = 0.8 \times 4$$

$$4log\ virus\ inactivation\ check = 3.6$$

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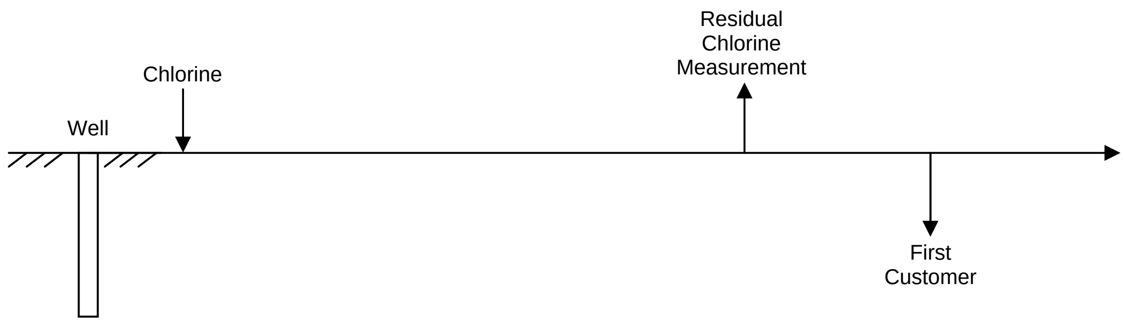
$$4log\ virus\ inactivation\ check\ < 4, therefore, 4log\ virus\ inactivation\ is\ \boldsymbol{not}\ achieved!$$

Answer: NO

3. Is the water system providing 4log virus inactivation using 12.5% sodium hypochlorite?

GIVEN



Well capacity = 200 gpm
Residual chlorine concentration = 0.1 mg/L free chlorine, measured before the first customer
Pipeline has a diameter of 12 inches and a length of 1,000 feet between the chlorine injection point and the first customer.
Peak hour flow = 200 gpm
pH = 6.6
Temperature = 20°C

FIND If the water system is providing 4-log virus inactivation.

NOT RELEVANT - The well capacity has no bearing on the peak flow of the water system.

SOLUTION

From Table 3-2, Baffling factor = 1
From Table B-2, CT req = 3 $\frac{mg}{L} \cdot min$
Peak flow = 200 gpm
$12\ inches = 1\ foot$
$1 ft^3 = 7.48\ gallons$

$$Cross\ sectional\ area\ of\ the\ pipe = \left(\frac{\pi}{4}\right) \times (Diameter^2)$$

$$Cross\ sectional\ area\ of\ the\ pipe = \left(\frac{\pi}{4}\right) \times (1\ foot^2)$$

$$Cross\ sectional\ area\ of\ the\ pipe = 0.785\ ft^2$$

$$Lowest\ Operating\ Volume = Cross\ sectional\ area\ of\ the\ pipe \times Length$$

$$Lowest\ Operating\ Volume = 0.785\ ft^2 \times 1{,}000\ feet \times 7.48\ \frac{gallons}{ft^3}$$

$$Lowest\ Operating\ Volume = 5{,}871.8\ gallons$$

$$Total\ detention\ time = \frac{Lowest\ Operating\ Volume}{Peak\ flow}$$

$$Total\ detention\ time = \frac{5{,}871.8\ gallons}{200\ \frac{gal}{min}}$$

$$Total\ detention\ time = 29.36\ min$$

$$Contact\ time = Total\ detention\ time \times Baffling\ factor$$

$$Contact\ time = 29.36\ min \times\ 1$$

$$Contact\ time = 29.36\ min$$

$$CTcalc = Residual\ chlorine\ concentration \times Contact\ time$$

$$CT\ calc = 0.1\ \frac{mg}{L} \times 29.36\ min$$

$$CT\ calc = 2.94\ \frac{mg}{L} \cdot min$$

$$Inactivation\ ratio = \frac{CT\ calc}{CT\ req}$$

$$Inactivation\ ratio = \frac{2.94\ \frac{mg}{L}\ \cdot min}{3\ \frac{mg}{L}\ \cdot min}$$

$$Inactivation\ ratio = 0.98$$

Round to one decimal place

$$Inactivation\ ratio = 1.0$$

$$4log\ virus\ inactivation\ check = Inactivation\ ratio \times 4$$

$$4log\ virus\ inactivation\ check = 1.0 \times 4$$

$$4log\ virus\ inactivation\ check = 4.0$$

$$4log\ virus\ inactivation\ check\ = 4, therefore, 4log\ virus\ inactivation\ is\ achieved!$$

Answer: YES