Drinking Water Tech Tips for Surveyors:
Chlorine Contact Time for Small Water Systems

This Tech Tip is a field guide to help surveyors understand the concept of chlorine contact time. It is written to provide information and should not be used for design purposes. Washington state drinking water rules (WAC 246-290-451) establish minimum chlorine contact times for water sources requiring disinfection. If your water system is required to disinfect and meet chlorine contact time, you must have a professional engineer prepare and submit a project report for review and approval by the Department of Health.

> **CT measures the effectiveness of a disinfection process.**
>
> CT = *Concentration of free chlorine* ($C_{mg/L}$) *X contact time* ($T_{Minutes}$)
>
> Free chlorine = *Concentration measured in milligrams per liter (mg/L)*

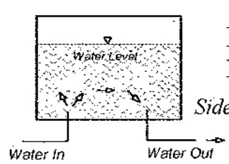
To inactivate viruses and bacteria, the minimum disinfection contact time measured before the first customer should be six milligrams per minute per liter (6 mg-min/L). This value is called "Chlorine Contact Time" or CT. To calculate CT, multiply the free chlorine residual concentration (C) times the contact time (T). To get the required CT value of 6, adjust the free chlorine residual concentration or the contact time.

For example, if water enters the system with a free chlorine residual of 0.5 mg/L and the chlorine is in contact with the water for 10 minutes before it reaches the first customer, the CT would be 5 (0.5 mg/L x 10 min = 5 mg-min/L). In this case you would increase the chlorine residual to 0.6 to have a CT of 6 (0.6 mg/L x 10 min = 6 mg-min/L).

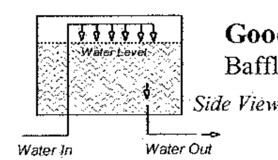
The circulation effectiveness or "baffling efficiency" of a tank is used to determine chlorine contact time. If the water used to calculate disinfection contact time moves through a storage tank, pressure tank, or pipes too quickly, the situation is called "short-circuiting." Some vessels provide better circulation than others. Water systems often add baffles to lengthen the path water travels before it leaves the vessel. For purposes of this tech tip, DOH used a rating system of zero to 100 percent to estimate the baffling efficiency of various storage and pressure tanks. For example, pipes have a baffling efficiency of 100 percent and bladder-type pressure tanks have a baffling efficiency of zero.

In summary, to calculate CT you must know: 1) the sum of the CTs for each water system component, from the point where chlorine is added to the point where it is measured before the first customer, 2) the volume and baffling efficiency of each component, 3) the peak flow through each component, and 4) the free chlorine residual measured downstream of all the components and upstream of the first customer. See the example calculation on Page 2.

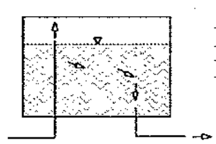
Estimated Baffling Efficiencies for Various Storage and Pressure Tanks



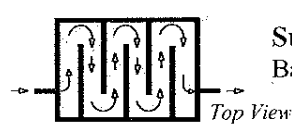
Poor Circulation
Baffling Efficiency = 5-10%



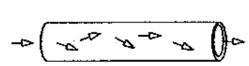
Good Circulation
Baffling Efficiency = 30-50%



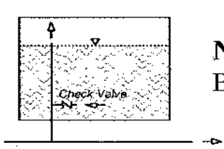
Poor Circulation
Baffling Efficiency = 10%



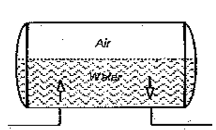
Superior Circulation
Baffling Efficiency = 70%



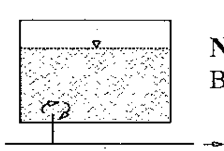
Perfect Circulation
Baffling Efficiency = 100%
Plug flow through a length of pipe



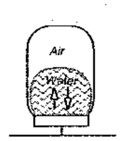
No Circulation
Baffling Efficiency = 0%



Poor Circulation
Baffling Efficiency = 10%
Hydropneumatic Tank



No Circulation
Baffling Efficiency = 0%



No Circulation
Baffling Efficiency = 0%
Bladder-Type Pressure Tank

Washington State Department of
Health
Division of Environmental Health
Office of Drinking Water

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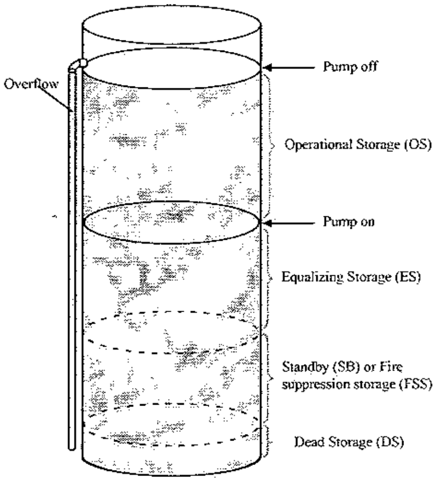
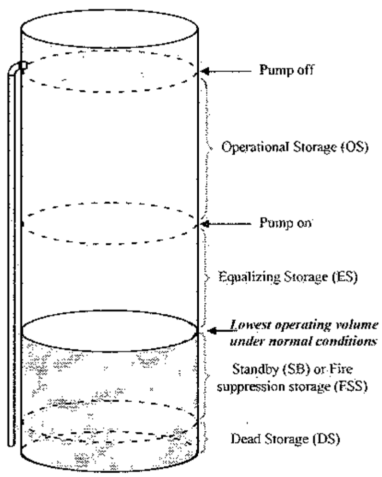




When calculating **Contact Time**, use the lowest volume of water in the tank under peak flow conditions: DS + (SB or FSS)

Diameter	Volume of Water per 10 Feet of Pipe
1 inch	0.41 gallons
1 1/2 inch	0.92 gallons
2 inch	1.64 gallons
3 inch	3.69 gallons
4 inch	6.53 gallons
6 inch	14.8 gallons
8 inch	26.2 gallons
12 inch	59 gallons

CT Calculation

Volume of water:
(Must be available at all times during non-emergency conditions):

Pipe $\text{Volume}_{\text{Gallons}} = \textit{Length}_{\textit{Feet}} \times \pi \times (\textit{Diameter}_{\textit{Inches}} / 2)^2 \times (7.48_{\textit{Gal/Cu.ft.}} / 144_{\textit{sq. in./sq. ft.}})$

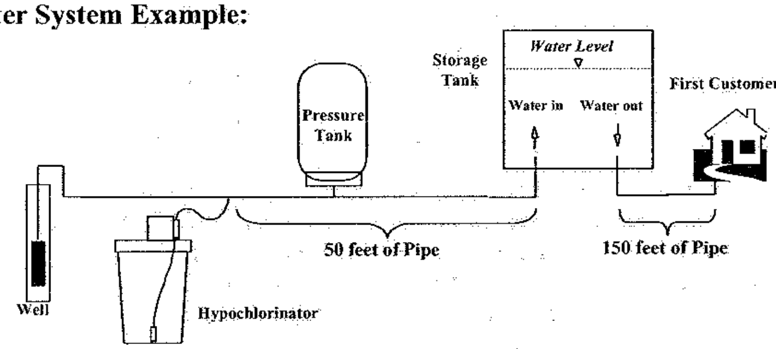
Storage $\text{Volume}_{\text{Gallons}} = \textit{Baffling Efficiency}_{\%} \times (\textit{Fire Suppression Storage}_{\textit{Gallons}} + \textit{Dead Storage}_{\textit{Gallons}})$ ***or***

Storage $\text{Volume}_{\text{Gallons}} = \textit{Baffling Efficiency}_{\%} \times (\textit{Standby Storage}_{\textit{Gallons}} + \textit{Dead Storage}_{\textit{Gallons}})$

Time it takes to move a volume of water to the first customer:

$\text{Time(T)}_{\text{Minutes}} = \textit{Total Volume}_{\textit{Gallons}} / \textit{Peak Flow Rate}_{\textit{Gallons per Minute}}$

Water System Example:



Storage Tank
Baffling Efficiency = 10% (*estimated rating*)
Total Storage Tank Volume = 30,000 gallons
Standby Storage Volume = 10,000 gallon
Dead Storage Volume = 1,000 gallons

Pipe
50 ft. of 3-inch diameter pipe
150 ft. of 3- inch diameter pipe
3.69 gallons per 10 ft

Pump Capacity
50 gallons/minute (GPM)

Peak Flow
160 gallons/minute (GPM)

Required Free Chlorine Residual based on this example:

Pipe Volume $= 50\textit{ ft.} \times \pi \times (3\textit{ inches}/2)^2 \times (7.48\textit{ gallons per cu. ft.} / 144\textit{ sq. in. per sq. ft.})$
$= 18$ *Gallons*

Storage Volume $= 10\% \times (10{,}000\textit{ gallons} + 1{,}000\textit{ gallons})$
$= 1{,}100$ *gallons*

Pipe Volume $= 150\textit{ ft.} \times \pi \times (3\textit{ inches}/2)^2 \times (7.48\textit{ gallons per cu. ft.} / 144\textit{ sq. in. per sq. ft.})$
$= 55$ *gallons*

Time(T) $= (18\textit{ gallons} / 50\textit{ GPM}) + (1{,}100\textit{ gallons} / 160\textit{ GPM}) + (55\textit{ gallons} / 160\textit{ GPM})$
$= 0.4\textit{ Minutes} + 6.9\textit{ Minutes} + 0.3\textit{ Minutes}$
≈ 7.6 *Minutes*

$CT_{\text{required}} = 6\textit{ mg-min/L}$

Required Free Chlorine Residual (C) $= 6\textit{ mg-min/L} / 7.6\textit{ minutes} = 0.8\textit{ mg/L}$

For this example, the free chlorine residual at the first service connection must be at least 0.8 mg/L to adequately inactivate bacteria and viruses.