Fact Sheet

Issue: 5 Volume: 1 Year: 2015

WCWC Walkerton Clean Water Centre
An agency of the Government of Ontario
CWAE Centre de Walkerton pour l'assainissement de l'eau
Un organisme du gouvernement de l'Ontario

Selection of a Baffling Factor for CT Calculations

Key Words: Baffling factor, Effective contact time, Detention time, Concentration, CT Calculations

Disinfection and the CT Concept

In order to claim disinfection credits, water treatment plants (WTPs) must have sufficient disinfectant concentration (C, mg/L) and contact time (T, minutes), at a given pH and temperature. The product of C and T is called CT and can be used to measure the level of disinfection in a WTP.

$$CT = \text{Disinfectant Conc. (C)} \times \text{Contact Time (T)}$$

CT values can be found in the Procedure for Disinfection of Drinking Water in Ontario, published by Ministry of the Environment and Climate Change (MOECC, 2006). Disinfectants include free chlorine, chloramine, ozone or chlorine dioxide and their residual concentrations are typically measured after the contact chamber.

Short-circuiting and Baffling Factor Use

Contact time refers to the amount of time that a disinfectant is in contact with water. Sometimes, water might bypass the normal flow path through a contact chamber and reach the chamber outlet in less time than the normal hydraulic detention time due to dead zones, known as short-circuiting (Figure 1). In cases like this, the actual contact time is less than the calculated detention time. Typically, baffles are used to avoid short-circuiting, to guide water flow and to lengthen water path. A baffling factor (BF) indicates the proportion of dead space, plug flow (water moves as a plug such as in a pipeline) and mixed flow in a contact chamber.

In order to understand BF, it is important to know hydraulic detention time and effective contact time. Hydraulic detention time (HDT, min) is the ratio of the contact chamber volume (V, m^3) to the water flow rate (Q, m^3/min) or in equation form, HDT=V/Q. Whereas, effective contact time (T_{10}) is the length of time during which 10% of the water passes through the disinfection contact chamber, which can be used as a conservative value. The use of T_{10} ensures that 90% of the water has a longer contact time than the T_{10}. The BF is the ratio of effective contact time (T_{10}) to hydraulic detention time (HDT). A lower BF shows a higher degree of short-circuiting or a higher percentage of dead space in the contact chamber (Figure 1).

The product of BF and HDT provides the effective contact time (T_{10}) in CT calculations.

$$CT = C \times T_{10} = C \times HDT \times BF$$

Why is a Baffling Factor Important?

Accurate BF allows the correct inactivation values to be calculated and allows optimized disinfection performance to be maintained. If an actual BF is higher than the estimated BF, a WTP can save on disinfection chemical and reduce disinfection by-product formation. If an actual BF is lower than the estimated BF, the disinfection requirements might not be met.

How is a Baffling Factor Selected or Estimated?

If a WTP does not have an accurate BF, the BF is conservatively estimated as per Table 1 (for examples, see Figures 1-3) or as per the manufacturer's recommendation. This greatly reduces the calculated CT value. Figure 1 shows dead zones without intra-basin baffles, whereas Figure 2 and 3 show average and superior baffling conditions, respectively.

Additional baffles increases the BF and reduces the percentage of dead space. BF can also increase with increasing the length to width ratio and with other modifications. A higher BF will enable the disinfectant to be distributed throughout a greater portion of the contact chamber. If a contact basin has plug flow, there will be no dead zone, resulting in a BF of 1. Although plug flow is an ideal condition, it is not realistic in WTP conditions.

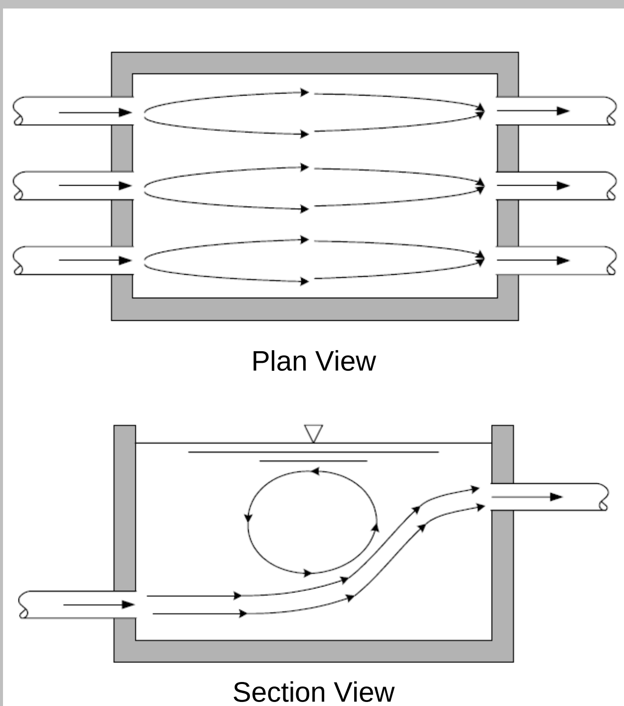

Figure 1: Example of poor baffling conditions of a rectangular clearwell (obtained from US EPA, 2003)

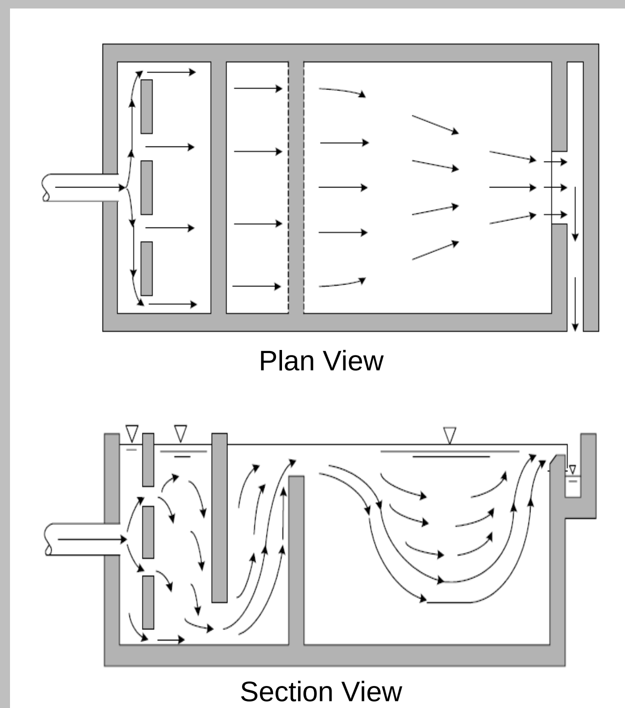

Figure 2: Example of average baffling conditions of a rectangular clearwell (obtained from US EPA, 2003)

WTPs can conduct a tracer test to characterize the amount of mixing throughout the contact chamber and can determine an accurate BF. In a tracer test, (ANSI/NSF Standards 60/61 certified or food grade) tracers such as fluoride, chloride, barium or sodium can be injected at the inlet and measured at the outlet. Either the pulse input method (all at once) or step input method (continuous addition) can be used with different flow rates. Teefy (1996) specifies the protocol to conduct a tracer test. Two and three dimensional computational flow dynamics (CFD) modeling can also be used to estimate a BF (Templeton *et al.*, 2006). CFD modeling can provide a reasonable estimate of a BF during the preconstruction phase, to assess different baffle layouts, or during the post-construction phase, but it is less accurate than a tracer test (Templeton *et al.*, 2006).

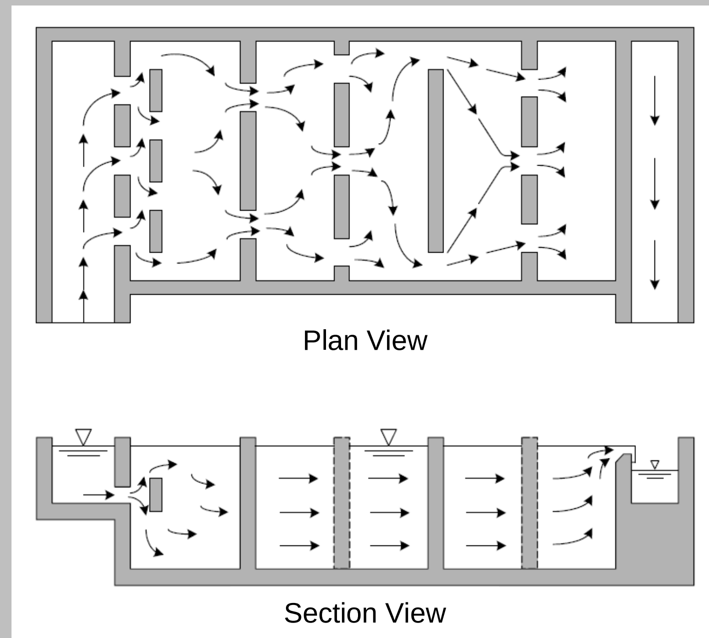

Figure 3: Example of superior baffling conditions of a rectangular clearwell (obtained from US EPA, 2003)

Table 1. Typical baffling conditions (MOECC, 2006)

Baffling Condition	T_{10}/HDT Ratio	Baffling Description
Unbaffled (mixed flow) Separate inlet/outlet	0.1	No baffles, agitated basin, very low length to width ratio, high inlet and outlet flow velocities
Poor	0.3	Single or multiple unbaffled inlets and outlets, no intra-basin baffles
Average	0.5	Baffled inlet or outlet with some intra-basin baffles
Superior	0.7	Perforated inlet baffle, serpentine or perforated intra-basin baffles, outlet weir or perforated launders
Perfect (Plug Flow)	1.0	Very high length to width ratio (pipeline flow)

Example:

The clearwell of a surface water treatment plant targets 0.5 log *Giardia* inactivation at 5^0C and pH-7.5 using minimum free chlorine level of 1.0 mg/L. Hydraulic detention time of a clearwell is 55 minutes. The WTP has a similar configuration to the clearwell shown in Figure 3 and the BF is assumed to be 0.6. As per the Procedure for Disinfection of Drinking Water in Ontario (2006), the CT requirement is 30 mg-min/L for 0.5 log *Giardia* inactivation.

The calculated CT value for the clearwell is 33 mg-min/L:

$CT = C \times HDT \times BF$

$CT = 1\ mg/L \times 55\ min \times 0.6$

$CT = 33\ mg\text{-}min/L$

Since the calculated CT value is higher than the CT value required by the Procedure for Disinfection of Drinking Water in Ontario (2006), the plant is deemed to be in compliance with its regulatory requirements. Subsequently, the WTP conducted a tracer test of clearwell to validate its BF.

Case A) The measured BF is 0.7 as per the tracer test. If all other parameters/conditions remain the same, a higher CT value (38.5 mg-min/L) will be provided than required and further optimization will be possible.

The measured CT value for Case A is 38.5 mg-min/L:

$CT = C \times HDT \times BF$

$CT = 1\ mg/L \times 55\ min \times 0.7$

$CT = 38.5\ mg\text{-}min/L$

Case B) The measured BF is 0.5 as per the tracer test. If all other parameters/conditions remain the same, a lower CT value (27.5 mg-min/L) will be provided than required and therefore 0.5 log inactivation of *Giardia* might not be achieved.

The measured CT value for Case B is 27.5 mg-min/L:

$CT = C \times HDT \times BF$

$CT = 1\ mg/L \times 55\ min \times 0.5$

$CT = 27.5\ mg\text{-}min/L$

In conclusion, baffling factors can have an impact on CT requirements for sufficient inactivation of pathogens, as shown in Case A and Case B.

Reference

MOECC (2006) Procedure for Disinfection of Drinking Water in Ontario. Second revision June 2006 PBIS 4448e01.

Teefy, S. (1996) Tracer studies in water treatment facilities: A protocol and case studies AWWA research Foundation, ISBN-0-89867-857-9.

Templeton, M.R. Hofmann, R. and Andrews, R.C. (2006) Case study comparisons of computational fluid dynamics(CFD) modeling versus tracer testing for determining clearwell residence times in drinking water treatment *J. Environ. Eng. Sci.,* 5:529-536

US EPA (2003) EPA Guidance Manual LT1ESWTR Disinfection Profiling and Benchmarking.

Related Training Courses

WCWC may offer courses related to this topic. Please browse our course descriptions to learn more about related training: www.wcwc.ca/registration

For More Information

For further information and resources on drinking water research and water operator training programs, please visit our website: www.wcwc.ca

Walkerton Clean Water Centre
20 Ontario Road, P.O. Box 160
Walkerton, ON, N0G 2V0
519-881-2003 or toll-free 866-515-0550