TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

PTR SECTION STAFF GUIDANCE

SELECTION OF BAFFLING FACTORS AND OPERATING CONDITIONS FOR "T10" CALCULATIONS

Rules Affected: 30 TAC §290.42(c)(1); §290.42(d)(1); and §290.110(b)(1)

Background:

TCEQ regulations require utilities which use surface water sources, such as spring water, surface water and ground water under the influence of surface water (GUI), to achieve a 2.0-log removal of *Cryptosporidium parvuum*, a 3.0-log removal/inactivation of *Giardia lamblia*, and a 4.0-log removal/inactivation of viruses. Physical removal is achieved by coagulation, sedimentation, and/or filtration processes while inactivation is achieved through disinfection processes.

In order to determine the inactivation level achieved, it is necessary to calculate the "Concentration-Time", or "CT", for the disinfection process. While it is possible to directly measure the disinfectant concentration, "C", the contact time, "T", must be derived. The theoretical detention time, ($T_{theoretical}$) depends on the volume of a basin and the rate that water flows through it. However, the actual contact time depends on these two factors and the hydraulic characteristics of the basin.

In order to compensate for the fact that individual drops of water do not always remain in the basin for exactly the same amount of time, the contact time used in CT calculations is T10, which is the time it takes for 10% of the water to pass through the basin. In basins with hydraulic conditions that cause water to move in a "plug-flow" fashion, T10 is about the same as the theoretical detention time. However, in basins that have a lot of short-circuiting, T10 can be much less than the theoretical detention time. The term "baffling factor" is used to describe the degree of short-circuiting that occurs within a basin. The relationship between the baffling factor and T10 is defined by the following relationship:

$$T_{10} = \textit{Baffling factor} \ x \ T_{theoretical}$$

$$= \textit{Baffling factor} \ x \ \textit{Basin Volume / Flow Rate}$$

The purpose of this document is to describe the method that TCEQ staff will use to determine the value of the baffling factor, basin volume, and flow rate for the equation above in the absence of empirical data.

Guidance:

Baffling Factor

Preferably, the baffling factor for a particular disinfection zone is determined by conducting a tracer study and collecting empirical data. However, the baffling factor for a particular basin can also be estimated based the configuration of the basin and the degree of short-circuiting expected. In basins where significant short-circuiting occurs, low baffling factors are expected while in well-baffled basins where there is less chance of short-circuiting, higher factors are expected. In the absence of empirical (tracer study) data, the baffling factors shown in Table 1 may be used. It should be noted that these suggested baffling factors may need to be adjusted based on site-specific conditions. For example, it may be appropriate to assign two unbaffled basins that operate in series a baffling factor of 0.3 instead of 0.2 if they both fill from the top and discharge from the bottom.

Table 1: Suggested Baffling Factors for Various Basin Configurations

Basin Description	Examples	Baffling Factor
Single chamber with a mechanical mixer	Mechanical rapid mix basin Single-stage flocculator in its own basin	0.1
Tank with a single submerged inlet or a single submerged outlet and no intra-basin baffles	Typical clearwell	0.1
Two unbaffled basins in series	Two-stage rapid mix with mechanical mixers	0.2
Three unbaffled basins in series		0.3
Tank with a 2.0 ft air gap between the inlet and the water surface	Clearwell with an internal or external riser that discharges above the maximum water level	0.3
Tank with 1 – 2 baffles[1,2]	Clearwell with a baffled inlet and one baffle wall Sedimentation basin with an external flocculator, perforated inlet channel and straight-edge weir Flocculators and sedimentation basins in a single basin with no intra-basin baffles in the sedimentation basin Slurry-recirculation and sludge blanket clarifiers	0.3
Tank with a length: width ratio above 10:1	Short, narrow, and shallow flow channel	0.3
Walker Claricone® Clarifier		0.42

Table 1: Suggested Baffling Factors for Various Basin Configurations

Basin Description	Examples	Baffling Factor
Tank with 3 – 4 baffles[1,2]	Clearwell with baffled inlet and three internal baffle walls Three-stage flocculators with a perforated inlet channel, two internal baffling walls, and outlet baffling Typical flocculator/sed basin with multi-stage flocculator, an intra-basin baffle in the sedimentation basin, and settled water launderers.	0.5
Tank with a length: width ratio above 20:1	Long, narrow, and shallow flow channels	0.5
Tank with a length: width ratio above 50:1	Extremely long, narrow, and shallow flow channels	0.7
Filters (including inlet gullet, water above media, media bed, and plenum)		0.7
Trident®, Pacer II®, and Actiflow®		0.7
Other package plant technologies	Aquarius®, Tri-Mite®, etc	case-by-case
Piping	Typical piping Narrow, shallow flow channels with a length: width ratio above 100:1	1.0

Notes: *(1)* Assumes that:

- inlet baffles are used to dissipate the hydraulic energy of the water entering the basin, and
- intrabasin baffles are distributed fairly uniformly across the length and width of the basin in a manner that will maximize the length: width ratio of the flow path and achieve a uniform flow pattern across the entire basin.

(2) Baffles can include:

- an inlet diffusion plate,
- a perforated inlet header,
- a perforated inlet or outlet trough,
- perforated walls in a cross-flow or radial flow basin,
- solid walls in a basin with serpentine flow,
- weirs or launderers that span the entire width of the basin, or
- any similar device that is designed to dissipate the energy of the water entering or leaving a basin.

Basin Volume

In order to assure that the disinfection requirements will be met under all operating conditions, the TCEQ staff will base their T_{10} calculations on the minimum volume that will be available in the basin. It is a relatively simple matter to determine the minimum water volume in a basin where the water level remains fairly constant. This is typically the case in rapid mix, flocculation, and sedimentation, and clarification basins. It is also the case in many basins that have effluent weirs.

However, certain assumptions must be made when determining the minimum volume of a basin where the water level changes. These types of basins include clearwells and other basins where the outlet is located at the bottom of the basin instead of the top. In the absence of historical site-specific data, the TCEQ staff will use the following assumptions when establishing the minimum water level in variable-level basins.

- The minimum operating level in transfer wells and pump sumps will be based on the elevation of the low level pump cut-off switch.
- The minimum operating level in most clearwells will be based on:
  - 50% of the nominal tank capacity when the plant meets the TCEQ's minimum total storage capacity requirements **OR**
  - 30% of the nominal tank capacity when the plant fails to meet the TCEQ's minimum total storage capacity requirements.
- A minimum operating level greater than 80% of the nominal clearwell capacity will not be approved in order to reduce the incentive to operate the plant for short, intermittent cycles. This mode of operation frequently results in poorer particle removal in the clarification and filtration processes and thereby compromises the ability of the plant to remove *Cryptosporidium*.

Flow Rate

To assure that the disinfection requirements will be met under all operating conditions, the TCEQ staff will base their T_{10} calculations on the maximum anticipated flow rate through the basin.

Since the flow rate through an individual basin depends on the total flow rate through the plant and the number of parallel treatment units in the plant, the TCEQ staff member will make the following assumptions:

- The total flow rate through the plant will usually be based on the greater of the following two values;
  - the historical maximum daily raw water flow rate reported by the plant, **OR**
  - the rated capacity of the water treatment plant. (see Endnote 1)
- The flow rate through an individual basin will usually be based on one of the following values:
  - the percentage of the total plant flow that passes through the basin, **OR**
  - the design capacity of the particular treatment unit.

  If the plant has parallel treatment trains, the TCEQ will usually assume a proportional flow distribution to each of the parallel basins. For example, if there are four identical clarifiers that are operating in parallel, the TCEQ will assume that each clarifier is treating 25% of the total flow through the plant.

The TCEQ is aware that flow is not always distributed evenly amongst all of the treatment trains and that these assumptions do not reflect the conditions that exist under most actual operating conditions. However, the impact of the assumptions will be eliminated by the macros that are incorporated into the

Surface Water Monthly Operating Report (SWMOR) spreadsheet.

While the influent flow rate and the effluent flow rate will always be identical in fixed-level basins, this is not the case for variable-level basins. In variable-level basins, the water level rises when the influent flow rate exceeds the effluent flow rate and the water level falls when the opposite conditions exist. On the other hand, by assuming that the variable level basin is operating at a minimum water level, we establish a condition where the overall influent and effluent flow rates will be equal.

For example, assume that the raw water pumps have a capacity of 1,000 gpm but the service pumps have a capacity of 5,000 gpm. Although the service pumps are capable of discharging 5 times as much water as the raw water pumps produce, they will only be operating 1/5 of the time when the water level reaches a minimum. Otherwise, the water level would not be at a minimum; if they were operating more than 20% of the time, the water level would continue to fall and if they were operating less than 20% of the time, the water level in the clearwell would rise.

Endnotes:

1) As implied in the preceding flow rate discussion, the flow rate used in the CT Study approval letter may be different from the "approved" capacity of the plant.
2) The CT Study approval letter DOES set the minimum inactivation levels that must be met by a treatment plant and establish the flow rate and T10 time that should be used as a reference when completing the SWMOR.
3) The CT Study approval letter **DOES NOT**:
   - ☐ approve an exception to any of the TCEQ design requirements,
   - ☐ approve the construction of new facilities,
   - ☐ approve any Alternative Capacity Requirements, or
   - ☐ change the TCEQ-approved rated plant capacity,

   unless the letter explicitly and specifically addresses the issue.

Finalized and Approved by:

Ada Lichaa 7/29/13

Ada Lichaa, Plan and Technical Review Section Manager 07/26/2013

If no formal expiration date has been established for this staff guidance, it will remain in effect until superseded or canceled.

Revision History

Date	Action	Action by
4/1/2004	Approved	Buck Henderson
11/29/2012	Revised	Cindy Haynie
12/12/2012	Revised	Joel Klumpp
07/26/2013	Approved	Ada Lichaa