

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

PTR SECTION STAFF GUIDANCE

MEETING TREATMENT TECHNIQUE REQUIREMENTS FOR *CRYPTOSPORIDIUM*, *GIARDIA* AND VIRUSES

Rules Affected: Title 30 Texas Administrative Code (30 TAC) §290.42(c)(1); §290.42(d)(1); and §290.111

Background:

40 Code of Federal Regulations (40 CFR) Part 141, Subpart H, also known as the Surface Water Treatment Rule (SWTR), adopted by the United States Environmental Protection Agency (US EPA) in 1989, applies to all public water systems using surface water, ground water under the influence of surface water (GUIs), or other water sources classified at surface water, e.g. harvested rainwater. The SWTR set filtration and disinfection requirements to provide control of microbiological contaminants by physical removal, (determined by measuring turbidity) and inactivation (verified by measuring the amount of disinfectant in the water).

In 1998, the US EPA promulgated the Interim Enhanced SWTR (IESWTR) for systems serving at least 10,000 people and the Long Term 1 Enhanced SWTR (LT1ESWTR) for systems serving less than 10,000 people to add requirements for the removal of *Cryptosporidium* (*Crypto*). The compliance dates for the additional treatment technique requirements of the IESWTR and LT1ESWTR were January 1, 2002 and January 1, 2005, respectively.¹

Compliance with the SWTRs and the effectiveness of the overall treatment process can be evaluated based on the percentage of pathogenic organisms that are removed or inactivated by a treatment plant. The adequacy of the disinfection protocol is evaluated using Concentration Time (CT) Studies. The SWTR defines CT as the residual disinfectant concentration(s) in mg/L multiplied by the contact time(s) of the disinfection in minutes. The actual CT value is then compared to the CT required to achieve the desired level of pathogen inactivation.

The CT-study approval letter establishes performance standards for the disinfection process at each plant that treats surface water or GUI sources. Based on the treatment processes for physical removal at the plant, the disinfection process is required to achieve a minimum number of log inactivation of *Giardia lamblia* cysts (*Giardia*) and viruses.

For most systems in Texas, the following total inactivation and/or removal is required:

Table 1: Pathogen Treatment Required for Surface Water Bin 1 Systems

| <i>Crypto</i> | <i>Giardia</i> | Virus |
|----------------------|-----------------------|--------------|
| 2.0-log | 3.0-log | 4.0-log |

Bin 1 plants with conventional treatment methods (coagulation, flocculation, sedimentation and granular media filtration) will receive 2.0-log removal for *Crypto*, 2.5-log removal of *Giardia* and 2.0-log removal of viruses. Therefore, the plant will be required to achieve an additional 0.5-log inactivation of *Giardia* and 2.0-log inactivation of viruses. Systems with elevated levels of source water *Crypto*, determined through LT2 source water sampling, must achieve higher levels of *Crypto* treatment, depending on their results.

Long Term 2 Enhanced Surface Water Treatment Rule:

More recently, in 2006, the Long Term 2 Enhanced SWTR (LT2) further expanded the treatment requirements. LT2 required PWSs to test their source water for *Crypto*, *Escherichia coli* (*E. coli*), and turbidity. Source water testing was required for plants treating surface water, GUI, harvested rainwater, or wastewater effluent. Sampling start times were staggered, depended on the population size being served, or were determined by the largest population size in a combined distribution system including wholesale purchasers. As previously stated, systems that treat surface water or GUI are required to minimally provide 2.0-log removal for *Crypto*, 3.0-log removal for *Giardia*, and 4.0-log removal for viruses by their pathogen removal and disinfection processes. Based on the number of *Crypto* found in the plant’s source water, LT2 source water testing results may result in an increase in the level of *Crypto* removal required by a plant.

Bin Categories:

Once LT2 source water testing is finished, a Bin category is calculated and assigned using enumerated sampling results. The table below defines the Bin categories and shows the pathogen treatment required for specific average *Crypto* levels in the source water.

Table 2: Pathogen Treatment Requirements based on Bin Classification

| Average <i>Cryptosporidium</i> Level in Source Water | Bin Classification | <i>Cryptosporidium</i> | <i>Giardia</i> | Virus |
|---|---------------------------|-------------------------------|-----------------------|--------------|
| <i>Cryptosporidium</i> < 0.075 oocysts/L | Bin 1 | 2.0-log | 3.0-log | 4.0-log |
| 0.075 oocysts/L ≤ <i>Cryptosporidium</i> < 1.0 oocysts/L | Bin 2 | 4.0-log | 3.0-log | 4.0-log |
| 1.0 oocysts/L ≤ <i>Cryptosporidium</i> < 3.0 oocysts/L | Bin 3 | 5.0-log | 3.0-log | 4.0-log |
| <i>Cryptosporidium</i> ≥ 3.0 oocysts/L | Bin 4 | 5.5-log | 3.0-log | 4.0-log |

Bin 1 systems calculated to have an average of less than 0.075 oocysts/Liter(L) of *Crypto* are required to provide the minimum amount of treatment, including 2.0-log removal of *Crypto*, 3.0 log-removal for *Giardia*, and 4.0-log removal for viruses by the

water treatment plant(s). Systems with higher levels of *Crypto* in their source water are classified as Bin 2 or higher, depending on the 12 to 24-month running average of *Crypto* oocysts/L found. Calculated Bin 2 systems have an average of greater than or equal to 0.075 oocysts/L of *Crypto* but less than 1.0 oocysts/L. Bin 2 systems are required to provide 4.0-log removal/inactivation of *Crypto*. Bin 3 systems have an average of greater than or equal to 1.0 oocysts/L, but less than 3.0 oocysts/L. Bin 3 systems must provide a minimum inactivation/removal of 5.0-log of *Crypto*. Lastly, A PWS demonstrating their source water has *Crypto* levels greater than or equal to 3.0 oocysts/L must provide 5.5-log *Crypto* inactivation/ removal.

Pathogen Treatment Required vs. Provided:

Surface Water Treatment Plants must provide at least the amount of pathogen treatment required by their Bin classification.

Pathogen Treatment Provided ≥ Pathogen Treatment Required

The pathogen treatment is achieved through the sum of removal and inactivation treatment provided for the specific pathogens.

Pathogen Treatment Provided = Removal + Inactivation

Removal is typically provided through filtration while inactivation is achieved with disinfection using chemical disinfectants or ultraviolet light. Systems have many choices for providing both removal and inactivation for their water sources, but must achieve pathogen treatment using a combination of physical removal and inactivation. For systems assigned a Bin 1 or Bin 2 classification, please see the section *Water Treatment Plant Removal Credit*.

Systems which have been assigned a Bin 3 or Bin 4 classification, must achieve 1.0-log removal /inactivation of *Cryptosporidium* by using one or a combination of the following:

- Bag filters;
- Cartridge filters;
- Membranes;
- Chlorine dioxide;
- Ozone;
- Ultraviolet light.

Water Treatment Plant Removal Credit:

Pathogen Treatment Provided = Removal + Inactivation

The amount of pathogen removal is based on the treatment processes employed by the water treatment plant. Removal credit is calculated by the TCEQ based on the treatment processes used at the plant, provided that these treatment processes meet TCEQ design and operational requirements. If a plant meets the combined filter effluent turbidity requirements, the following credits will be granted:

- Coagulation, flocculation, and granular media filtration: The TCEQ will grant 2.5-log removal of *Cryptosporidium*, 2.0-log removal of *Giardia*, and a 1.0-log removal of viruses.
- Coagulation, flocculation, clarification, and granular media filtration: The TCEQ will grant 3.0-log removal of *Cryptosporidium*, 2.5-log removal of *Giardia*, and a 2.0-log removal of viruses.
- Bag, cartridge or membrane filters: The TCEQ will grant removal of *Cryptosporidium*, *Giardia*, and virus on an individual basis.

For additional information and tables on pathogen removal credits, please see the technology options below.

Conventional Filtration: Conventional filters are those that use granular media to provide filtration. Direct filtration is the use of conventional filters without the use of a clarifier or sedimentation basin. Plants without continuous coagulation will not be given pathogen log removal credit. A plant using continuous coagulation and flocculation and providing direct filtration will be granted 2.5-log removal for *Crypto*, 2.0-log removal for *Giardia lamblia* and 1.0-log removal for viruses by physical removal provided that the turbidity of the filtered water meets the turbidity and other requirements of 30 TAC 290.111(e). If a treatment plant uses coagulation, flocculation, and clarification, the plant will receive 3.0-log removal for *Crypto*, 2.5-log removal for *Giardia*, and 2.0-log virus removal.

A plant which has optimized their conventional filtration process by achieving an individual filter turbidity of 0.15 Nephelometric Turbidity Units (NTU) or less at each filter for at least 95% of the measurements recorded during a month, and has no individual filter producing water with turbidity above 0.3 NTU in any two consecutive 15-minute readings, may be granted an additional 1.0-log removal of *Crypto* and *Giardia*. A plant which has optimized their conventional filtration process by achieving a combined filter turbidity of 0.15 NTU or less for at least 95% of the measurements recorded during the month may be granted an additional 0.5-log removal of *Giardia* and *Crypto* even if the plant doesn't meet the performance standards needed to get a full 1.0-log of additional credit. A plant may claim **only one** of these two credits during any given month.

Table 3: Pathogen Removal Credits for Conventional Filters¹

| Treatment Provided | <i>Crypto</i> | <i>Giardia</i> | Virus |
|---|----------------------|----------------------|----------------------|
| No Coagulation and Conventional Filters | 0.0-log ² | 0.0-log ² | 0.0-log ² |
| Coagulation, Flocculation, and Conventional Filters | 2.5-log | 2.0-log | 1.0-log |
| Coagulation, Flocculation Clarification, and Conventional Filters | 3.0-log | 2.5-log | 2.0-log |
| Coagulation, Flocculation, Clarification, and Optimized Combined Filter Effluent for Conventional Filters | 3.5-log | 3.0-log | 2.0-log |
| Coagulation, Flocculation, | 4.0-log | 3.5-log | 2.0-log |

| Treatment Provided | <i>Crypto</i> | <i>Giardia</i> | Virus |
|--|---------------|----------------|-------|
| Clarification, and Optimized Individual Filter Effluent for Conventional Filters | | | |

¹ Filters in which water passes through a porous granular media (such as sand or anthracite), and which utilize depth filtration processes. These include Pressure Media Filters and Gravity Media Filters.

² Conventional filtration without coagulation is not eligible to receive Log Removal Credit for *Crypto*, *Giardia* or Viruses.

Bag or Cartridge Filtration: Surface water treatment facilities using bag or cartridge filtration will be required to provide results from a Challenge test (Challenge test or C-test) before they can receive *Crypto* credit. The Challenge test results show the TCEQ what level of pathogen removal a specific make and model of bag or cartridge filter can achieve. Currently, virus removal has not been demonstrated using a bag or cartridge filter. Plants using bag or cartridge filtration will be granted removal for *Crypto* and *Giardia* based on Challenge test results. Removal of viruses can be granted to the process if coagulation, flocculation and potentially clarification is provided. For approved challenge study results please see the [TCEQ's Membrane Challenge Studies webpage](#). For further information on Bag or Cartridge filter operation, please refer to the Staff Guidance Document named *Monitoring, Operating, and Reporting Requirements for Bag and Cartridge Filters*.

Table 4: Pathogen Removal Credits for Bag/Cartridge Filters¹

| Pretreatment Provided | <i>Crypto</i> | <i>Giardia</i> | Virus |
|--|--|--|---------|
| No Coagulation | NA | NA | 0.0-log |
| Coagulation and Flocculation | NA | NA | 1.0-log |
| Coagulation, Flocculation, and Clarification | 0.5-log | 0.5-log | 2.0-log |
| Single Bag or Cartridge Credit | LRV _{C-test} ² minus 1.0-log | LRV _{C-test} ² minus 1.0-log | NA |
| Two-Stage Bag or Cartridge Credit | LRV _{2-stage C-test} ² minus 0.5-log | LRV _{2-stage C-test} ² minus 0.5-log | NA |

NA-Not Applicable

¹ Bag filters are typically constructed of a non-rigid, fabric filtration media housed in a pressure vessel in which the direction of flow is from the inside of the bag to the outside. Cartridge filters are usually constructed as rigid or semi-rigid, self-supporting filter elements housed in pressure vessels, in which flow is from the outside of the cartridge to the inside.

² Log Removal Value (LRV) is assigned based on the results of Challenge Testing conducted according to the criteria established by 40 Code of Federal Regulations (CFR) §141.79 and the Executive Director. For challenge studies conducted on individual cartridge or bag assemblies, the log removal credit for parasites is based on the challenge study results minus a 1.0-log safety factor. For challenge studies conducted on two cartridge or bag assemblies operated in series, the log removal credit for parasites is based on the challenge study results minus a 0.5-log safety factor.

Micro-filtration (MF)/Ultra-filtration (UF) Membranes: Water treatment facilities using MF or UF membrane filters are required to provide results from a Log Removal Value Challenge test (LRV_{C-test}), and a Log Removal Value Direct Integrity Test (LRV_{DIT}) to receive removal credit for *Crypto* and *Giardia*. The lower result between both tests will be used to determine the level of removal granted. Each plant must have customized DIT parameters approved by the TCEQ. The challenge test results show the TCEQ what level of pathogen removal a specific make and model of membrane filter can achieve. Currently, no MF or UF membrane filters have provided a challenge study showing the removal of virus and current direct integrity methods do not provide a method for testing for virus; therefore, removal cannot be given for viruses without pretreatment. Removal of viruses can be granted to the process if coagulation, flocculation and potentially clarification is provided. For approved challenge study results please see the [TCEQ's Membrane Challenge Studies webpage](#).

Table 5: Pathogen Removal Credits for MF/UF Membranes

| Pretreatment Provided* | <i>Crypto</i> | <i>Giardia</i> | Virus |
|--|---|---|--------------------|
| No Coagulation | Lower result of LRV_{C-test} , or LRV_{DIT}^1 | Lower result of LRV_{C-test} or LRV_{DIT}^1 | 0.0-log^2 |
| Coagulation and Flocculation | Lower result of LRV_{C-test} or LRV_{DIT}^1 | Lower result of LRV_{C-test} or LRV_{DIT}^1 | 1.0-log^2 |
| Coagulation, Flocculation, and Clarification | $0.5 +$ Lower result of LRV_{C-test} or LRV_{DIT}^1 | $0.5 +$ Lower result of LRV_{C-test} or LRV_{DIT}^1 | 2.0-log^2 |

*Coagulant must be fed on a continuous basis.

¹ Log Removal Value (LRV) is assigned, based on the results of Challenge Testing (C-test) and Direct Integrity Testing (DIT), using the lower of both results. A C-Test is one performed by a third party. A DIT is a test done on-site by the plant and is site-specific; the parameters show if the test is successful.

² Additional LRV will be added to this number, based on the results of a TCEQ acceptable C-Test results and DIT method, using the lower of the two results.

Please note: Challenge and DIT testing must be conducted according to the criteria established by 40 Code of Federal Regulations (CFR) §141.79 and the Executive Director.

Reverse Osmosis and Nanofiltration (NF) Membranes: Until spiral wound system DITs and challenge studies become commercially available to satisfy federal and state regulatory requirements, the TCEQ will be unable to give pathogen removal credit for RO membrane systems. If a DIT method and challenge studies become available, credit will be considered on a case-by-case basis. For further information on Reverse Osmosis Membranes, please refer to the Staff Guidance Document named *Removal Credit for Reverse Osmosis Membranes*.

Other Removal Options: Bin 2 or higher systems calculated to have greater than 0.075 oocysts/L of *Cryptosporidium* in their source water require additional pathogen treatment. Additional removal is available on an individual basis depending on the plant

or system. The plants can use the filtration methods described above or any of the pathogen treatment options shown in Table 6.

To receive additional *Cryptosporidium* credits, options include:

Table 6: Pathogen Removal Credits for Other Treatments allowed by the EPA*

| Treatment Provided | <i>Crypto</i> Removal Credit |
|---|--|
| Watershed Control Program | 0.5-log |
| Alternative Source/Intake Management | Based on <i>Crypto</i> level in new source |
| Pre-sedimentation Basin with Continuous Coagulation | 0.5-log |
| Two-stage Lime Softening | 0.5-log |
| Bank Filtration | Based on design of the filter, and distance from source |
| Demonstration of Performance | Based on demonstrated <i>Crypto</i> treatment |
| Second Stage Conventional Filtration | 0.5-log |
| Slow Sand Filters | Primary filter=3.0-log; Secondary filter=2.5-log ¹ |

*For a complete list of Microbial Toolbox Options and requirements, please see 40 CFR §141.715.

¹ Secondary Slow Sand Filters are given 2.5-log pathogen removal credits in addition to the primary filter log removal credit.

Water Treatment Plant Inactivation Credit:

Pathogen Treatment Provided = Removal + Inactivation

Typically the amount of removal is a fixed number based on the unique combination of treatment processes used at the plant. The amount of pathogen inactivation is based on how well the disinfectant(s) used at the plant inactivate pathogens. The amount of inactivation is based on which disinfectant is used, how much disinfectant is used, how long the water is in contact with the disinfectant, and can be based on pH, temperature, and water clarity. Drinking water disinfectants that can achieve inactivation include:

- chlorine,
- chloramines,
- chlorine dioxide,
- ozone, and
- ultraviolet light.

More information about inactivation can be found in the TCEQ's RG-211 *Monthly Testing and Reporting at Surface Water Treatment Plants*.

Examples of TCEQ Approved Log Removal Credits and Requirements

The three examples below demonstrate multiple plants and Bin categories containing different methods of pathogen treatment removal barriers and their associated log removal credits.

Pathogen Treatment Provided = Removal + Inactivation

Example 1: Bin 1 Classified Plant with Conventional Treatment

| Individual Barriers* | Cryptosporidium | Giardia | Virus |
|--|------------------------|------------------------|------------------------|
| Coagulation, Flocculation and Clarification with Conventional Gravity Filters | 3.0-log ^{1,2} | 2.5-log ^{1,2} | 2.0-log _{1,2} |
| Total Removal Provided | 3.0-log | 2.5-log | 2.0-log |
| Total Treatment Required for Bin 1 | 2.0-log | 3.0-log | 4.0-log |
| Total Inactivation Needed | 0.0-log | 0.5-log | 2.0-log |

*Coagulant must be fed on a continuous basis.

¹ Maximum allowed removal by 30 TAC §290.111(d)(1).

² Maximum allowed removal in Footnote C of 30 TAC §290.111(c)(3)(B).

Example 2: Bin 2 Classified Plant with Conventional Treatment

| Individual Barriers* | Cryptosporidium | Giardia | Virus |
|--|------------------------|----------------------------|------------------------|
| Coagulation, Flocculation and Clarification with Conventional Gravity Filters | 3.0-log ^{1,2} | 2.5-log ^{1,2} | 2.0-log ^{1,2} |
| Gravity Filters with Optimized CFE and IFE | (+1.0) ³ | (+1.0) ³ | 0.0-log |
| Total Removal Provided | 4.0-log | 3.5-log | 2.0-log |
| Total Treatment Required for Bin 2 | 4.0-log | 3.0-log | 4.0-log |
| Total Inactivation Needed | 0.0-log | 0.0-log⁴ | 2.0-log |

*Coagulant must be fed on a continuous basis.

¹ Maximum allowed removal by 30 TAC §290.111(d)(1).

² Maximum allowed removal in Footnote C of 30 TAC §290.111(c)(3)(B).

³ Maximum allowed removal by 30 TAC §290.111(g)(1).

⁴ Minimum required *Giardia* removal per 290.111 (d)(1). Some regulatory relief may be provided, in situations where facilities meet the *Giardia* treatment requirements with removal, but do not meet the 0.5-log *Giardia* inactivation requirements.

Example 3: Bin 2 Classified Plant with Membrane Treatment

| Individual Barriers* | <i>Cryptosporidium</i> | <i>Giardia</i> | <i>Virus</i> |
|--|-------------------------------|-----------------------|---------------------|
| Coagulation, Flocculation and Clarification | 0.5 ¹ | 0.5 ¹ | 2.0 ¹ |
| MF Membranes | 4.0 ² | 4.0 ² | 0.0 ² |
| RO Membranes | 0 | 0 | 0 |
| Total Removal Provided | 4.5-log | 4.5-log | 2.0-log |
| Total Treatment Required for Bin 2 | 4.0-log | 3.0-log | 4.0-log |
| Total Inactivation Needed | 0.0-log | 0.0-log | 2.0-log |

*Coagulant must be fed on a continuous basis.

¹ Maximum allowed removal by 30 TAC §290.111(d)(1).

² – EXAMPLE ONLY - Based on lower log removal of Challenge Test or Direct Integrity Test (DIT).

Bibliography:

1-SWTR *Fact Sheet*, EPA Region 8, January 2011.

The USEPA Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Systems (March 1991 Edition)

RG-211 Monthly Testing and Reporting at Surface Water Treatment Plants (Revised May 2013)

Finalized and Approved by:

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

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