TCEQ REGULATORY GUIDANCE
Water Supply Division
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Public Water System: Meeting Treatment Technique Requirements for Cryptosporidium, Giardia and Viruses

Title 40 of the US Code of Federal Regulations (40 CFR) Part 141, Subpart H, also known as the Surface Water Treatment Rule (SWTR), was adopted by the Environmental Protection Agency (EPA) in 1989. The SWTR established filtration and disinfection requirements to provide control of microbiological contaminants by physical removal and inactivation. The SWTR applies to all public water systems (PWSs) using surface water, ground water under the direct influence of surface water (GUI), or other water sources classified as surface water (e.g., harvested rainwater). In 1998, the EPA initiated the Interim Enhanced SWTR (IESWTR) for systems serving at least 10,000 people, and the Long Term 1 Enhanced SWTR (LT1) for systems serving less than 10,000 people. These rules added requirements for the removal of *Crypto*.

More recently, the 2006 Long Term 2 Enhanced SWTR (LT2) further expanded the treatment requirements for all systems. LT2 requires a PWS to test applicable source water for *Crypto*, *E. coli*, and turbidity. Sampling start times were established in Title 30 of the Texas Administrative Code (30 TAC) 290.111(b)(4). Once LT2 source water testing is finished, a Bin category is calculated and assigned to the PWS based on the enumerated sampling results of *crypto*. Surface Water Treatment Plants must provide at least the amount of pathogen treatment required by their Bin classification.

Treatment Technique Requirements

Bin classification

Compliance with the SWTR is evaluated based on the percentage of pathogenic organisms that are removed or inactivated by a treatment plant. Table 1 below defines Bin categories and indicates the pathogen treatment required based on the average *Crypto* level(s) in a plant's source water.

Table 1: Bin Classification and Pathogen treatment Required

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

Bin 1 PWSs have a calculated average of less than 0.075 oocysts/Liter (L) of *Crypto*, and these plants are required to provide the minimum amount of treatment:

- 2.0-log (99%) removal/inactivation of *Crypto*,
- 3.0-log (99.9%) removal/inactivation for *Giardia*, and
- 4.0-log (99.99%) removal/inactivation for viruses.

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,* in addition to the 3.0-log *Giardia* and 4.0-log virus removal.

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 removal/inactivation of 5.0-log of Crypto*,* in addition to the 3.0-log *Giardia* and 4.0-log virus removal.

Lastly, a Bin 4 PWS demonstrating their source water has Crypto levels greater than or equal to 3.0 oocysts/L must provide:

- 5.5-log Crypto removal/inactivation*,* in addition to the 3.0-log *Giardia* and 4.0-log virus removal.

Pathogen treatment – provided vs. required

Surface Water Treatment Plants must provide <u>at least</u> the amount of *pathogen treatment required* by their Bin classification. *Pathogen treatment provided* is the

sum of removal treatments and inactivation treatments provided for the specific pathogens.

Pathogen Treatment Provided = Removal + Inactivation

Removal is typically achieved through filtration while inactivation is achieved with 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 *Crypto* by using one or a combination of the following:

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

Water Treatment Plant Removal Credit

The amount of pathogen removal is based on the removal 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:

Table 2: Removal Credits based on Conventional Treatment Process

Removal Treatment Process	***Cryptosporidium***	***Giardia***	***Virus***
Continuous coagulation, flocculation, and granular media filtration	2.5-log	2.0-log	1.0-log
Continuous coagulation, flocculation, clarification, and granular media filtration	3.0-log	2.5-log	2.0-log

Bag, cartridge or membrane filters: The TCEQ will grant removal of *Crypto*, *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 such as sand or anthracite to provide filtration, and which utilize depth filtration

processes. These include Pressure Media Filters and Gravity Media Filters. 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 coagulation and flocculation that provides direct filtration will be granted the following log removal credits by physical removal provided that the turbidity of the filtered water meets the turbidity and other requirements of 30 TAC 290.111(e):

Crypto	***Giardia***	**Virus**
2.5-log	2.0-log	1.0-log

If a treatment plant uses coagulation, flocculation, and clarification, the plant will receive the following log removal credits:

Crypto	***Giardia***	**Virus**
3.0-log	2.5-log	2.0-log

An additional 1.0-log removal of *Crypto* and *Giardia* may be granted to 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.

An additional 0.5-log removal of *Crypto* and *Giardia* may be granted to 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, 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 the two additional log removal credits during any given month.

Table 3: Pathogen Removal Credits for Conventional Filters

Treatment Provided	***Crypto***	***Giardia***	**Virus**
Conventional Filters Only	0.0-log	0.0-log	0.0-log
Continuous Coagulation, Flocculation, and Conventional Filters	2.5-log	2.0-log	1.0-log
Continuous Coagulation, Flocculation Clarification, and Conventional Filters	3.0-log	2.5-log	2.0-log
Continuous Coagulation, Flocculation, Clarification, and Optimized Combined Filter Effluent for Conventional Filters	3.5-log	3.0-log	2.0-log

Treatment Provided	***Crypto***	***Giardia***	**Virus**
Continuous Coagulation, Flocculation, Clarification, and Optimized Individual Filter Effluent for Conventional Filters	4.0-log	3.5-log	2.0-log

Bag or Cartridge Filtration: Surface water treatment facilities using bag or cartridge filtration will be evaluated on an individual basis. 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. Plants employing these methods are required to provide results from a Challenge test (C-test) before they can receive *Crypto* credit. The C-test results demonstrate to the TCEQ the level of pathogen removal that a specific make and model of a 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 C-test results. Removal of viruses can be granted to the process if coagulation, flocculation and potentially clarification are provided.

For approved C-test results, please see the TCEQ's Membrane Challenge Studies webpage at <https://www.tceq.texas.gov/drinkingwater/trot/membrane-challenge-studies>.

Table 4: Pathogen Removal Credits for Bag/Cartridge Filters

Pretreatment Provided	***Crypto***	***Giardia***	**Virus**
No Coagulation	NA	NA	0.0-log
Continuous Coagulation and Flocculation	NA	NA	1.0-log
Continuous Coagulation, Flocculation, and Clarification	0.5-log	0.5-log	2.0-log
Single Bag or Cartridge Credit	$LRV_{(C\text{-}test)}$[1] minus 1.0-log	$LRV_{(C\text{-}test)}$[1] minus 1.0-log	NA
Two-Stage Bag or Cartridge Credit	$LRV_{(2\text{-}stage\ C\text{-}test)}$[1] minus 0.5-log	$LRV_{(2\text{-}stage\ C\text{-}test)}$[1] minus 0.5-log	NA

[1]Log Removal Value (LRV) is assigned based on the results of C-testing conducted according to the criteria established by 40 CFR 141.79 and the Executive Director. For C-tests conducted on individual cartridge or bag assemblies, the log removal credit for parasites is based on the C-test results minus a 1.0-log safety factor. For C-testing conducted on two cartridge or bag assemblies operated in series, the log removal credit for parasites is based on the C-test 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 C-test ($LRV_{C\text{-}test}$), 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 C-test results demonstrate to the TCEQ the level of pathogen removal that a specific make and model of membrane filter can achieve. Currently, no MF or UF membrane filters have provided a C-test 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 a process if coagulation, flocculation and potentially clarification are provided. For approved C-test results, please see the TCEQ's Membrane Challenge Studies webpage at <https://www.tceq.texas.gov/drinkingwater/trot/membrane-challenge-studies>.

Table 5: Pathogen Removal Credits for MF/UF Membranres

Pretreatment Provided	***Crypto***	***Giardia***	**Virus**
No Coagulation	Lower result of $LRV_{C\text{-}test}$, or LRV_{DIT}[1]	Lower result of $LRV_{C\text{-}test}$ or LRV_{DIT}[1]	0.0-log[2]
Continuous Coagulation and Flocculation	Lower result of $LRV_{C\text{-}test}$ or LRV_{DIT}[1]	Lower result of $LRV_{C\text{-}test}$ or LRV_{DIT}[1]	1.0-log[2]
Continuous Coagulation, Flocculation, and Clarification	0.5 + Lower result of $LRV_{C\text{-}test}$ or LRV_{DIT}[1]	0.5 + Lower result of $LRV_{C\text{-}test}$ or LRV_{DIT}[1]	2.0-log[2]

[1] LRV is assigned based on the results of C-testing 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 CFR 141.79 and the Executive Director.

Reverse Osmosis (RO) 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 and Nanofiltration Membranes* at <https://www.tceq.texas.gov/drinkingwater/trot/exception>.

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

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

To receive additional *Crypto* credits, options include:

*Table 6: Pathogen Removal Credits for Other Treatment Allowed by the EPA**

Treatment Provided	***Crypto Removal Credit***
Watershed Control Program	0.5-log
Alternative Source/Intake Management	Based on *Crypto* 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 C*rypto* 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:

Whereas the amount of pathogen removal is a fixed number based on the combination of removal treatment processes used at a plant, the amount of pathogen inactivation is based on how well a plant's unique disinfectant treatment protocol inactivates pathogens. Drinking water disinfectants that can achieve inactivation include:

- Chlorine;
- Chloramines;
- Chlorine dioxide;
- Ozone; and
- Ultraviolet light.

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. The log removal value of a plant's disinfection protocol is evaluated using site-specific Concentration Time (CT)

Studies. The SWTR defines CT as the residual disinfectant concentration(s) in milligrams per liter (mg/L) multiplied by the contact time(s) of the disinfection in minutes. The actual CT value of a plant 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 a plant, the disinfection process is required to achieve a minimum number of log inactivation of *Crypto*, *Giardia* and viruses. More information about inactivation can be found in the TCEQ's RG-211 Monthly Testing and Reporting at Surface Water Treatment Plants at <https://www.tceq.texas.gov/publications/rg/rg-211>.

Treatment Provided ≥ Treatment Required

Surface Water Treatment Plants must provide at least the amount of pathogen treatment required by their Bin classification. For most systems in Texas, total pathogen treatment required is as follows:

Crypto	***Giardia***	**Virus**
2.0-log	3.0-log	4.0-log

A Bin 1 plant with conventional treatment methods (continuous coagulation, flocculation, sedimentation and granular media filtration) will receive the following removal credits:

Crypto	***Giardia***	**Virus**
2.0-log	2.5-log	2.0-log

Pathogen Treatment Provided = Removal + Inactivation

Therefore, a Bin 1 plant will be required to provide an additional 0.5-log inactivation of *Giardia* and 2.0-log inactivation of viruses. The three examples below demonstrate multiple plants and Bin categories containing different methods of pathogen treatment removal barriers and their associated log removal credits.

Examples of TCEQ Approved Log Removal Credits and Requirements

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**

Individual Barriers*	***Cryptosporidium***	***Giardia***	***Virus***
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-log[4]**	**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 30 TAC 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*	***Cryptosporidium***	***Giardia***	***Virus***
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**

Individual Barriers*	***Cryptosporidium***	***Giardia***	***Virus***
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 C-test or DIT.