3745-81-68 **Microbial toolbox options for meeting Cryptosporidium treatment requirements.**

(A) Water systems shall obtain plan approval by the director for each microbial toolbox option prior to receiving treatment credit for the toolbox option. Systems receive the treatment credits listed in the following table by meeting the conditions for microbial toolbox options described in paragraphs (B) to (N) of this rule. Systems shall apply these treatment credits to meet the treatment required by paragraph (E) of rule 3745-81-67 of the Administrative Code. The following table summarizes options in the microbial toolbox:

MICROBIAL TOOLBOX SUMMARY TABLE: OPTIONS, TREATMENT CREDITS AND CRITERIA	
Toolbox Option	Cryptosporidium treatment credit with design and implementation criteria
Source Protection and Management Toolbox Options	
(1) Watershed control program...	0.5-log credit for director-approved program comprising required elements, annual program status report to director, and regular watershed survey. Specific criteria are in paragraph (B) of this rule.
(2) Alternative source/intake management...	No prescribed credit. Systems may conduct simultaneous monitoring for treatment bin classification at alternative intake locations or under alternative intake management strategies. Specific criteria are in paragraph (C) of this rule.

MICROBIAL TOOLBOX SUMMARY TABLE: OPTIONS, TREATMENT CREDITS AND CRITERIA	
Toolbox Option	Cryptosporidium treatment credit with design and implementation criteria
Pre Filtration Toolbox Options	
(3) Presedimentation basin with coagulation...	0.5-log credit during any month that presedimentation basins achieve a monthly mean reduction of 0.5-log or greater in turbidity or alternative director-approved performance criteria. To be eligible, basins shall be operated continuously with coagulant addition and all plant flow shall pass through basins. Specific criteria are in paragraph (D) of this rule.
(4) Two-stage lime softening...	0.5-log credit for two-stage softening where chemical additional and hardness precipitation occur in both stages. All plant flow shall pass through both stages. Single-stage softening is credited as equivalent to conventional treatment. Specific criteria are in paragraph (E) of this rule.
(5) Bank filtration...	0.5-log credit for 25-foot setback; 1.0-log credit for 50-foot setback; aquifer shall be unconsolidated sand containing at least 10 per cent fines; average turbidity in wells shall be less than 1 NTU. Systems using wells followed by filtration when conducting source water monitoring shall sample the well to determine bin classification and are not eligible for additional credit. Specific criteria are in paragraph (F) of this rule.

MICROBIAL TOOLBOX SUMMARY TABLE: OPTIONS, TREATMENT CREDITS AND CRITERIA	
Toolbox Option	Cryptosporidium treatment credit with design and implementation criteria
Treatment Performance Toolbox Options	
(6) Combined filter performance...	0.5-log credit for combined filter effluent turbidity less than or equal to 0.15 NTU in at least 95 per cent of measurements each month. Specific criteria are in paragraph (G) of this rule.
(7) Individual filter performance…	0.5-log credit (in addition to 0.5-log combined filter performance credit) if individual filter effluent turbidity is less than or equal to 0.15 NTU in at least 95 per cent of samples each month in each filter and is never greater than 0.3 NTU in two consecutive measurements in any filter. Specific criteria are in paragraph (H) of this rule.
(8) Demonstration of performance…	Credit awarded to unit process or treatment train based on a demonstration to the director with a director-accepted protocol. Specific criteria are in paragraph (I) of this rule.
Additional Filtration Toolbox Options	
(9) Bag or cartridge filters (individual filters)…	Up to 2-log credit based on the removal efficiency demonstrated during challenge testing with a 1.0-log factor of safety. Specific criteria are in paragraph (J) of this rule.
(10) Bag or cartridge filters (in series)...	Up to 2.5-log credit based on the removal efficiency demonstrated during challenge testing with a 0.5-log factor of safety. Specific criteria in paragraph (J) of this rule.
(11) Membrane filtration...	Log credit equivalent to removal efficiency demonstrated in challenge test for device if supported by direct integrity testing. Specific criteria are in paragraph (K) of this rule.
(12) Second stage filtration...	0.5-log credit for second separate granular media filtration stage if treatment train includes coagulation prior to first filter. Specific criteria are in paragraph (L) of this rule.
(13) Slow sand filters....	2.5-log credit as a secondary filtration step; 3.0-log credit as a primary filtration process. No prior chlorination for either option. Specific criteria are in paragraph (M) of this rule.

MICROBIAL TOOLBOX SUMMARY TABLE: OPTIONS, TREATMENT CREDITS AND CRITERIA	
Toolbox Option	Cryptosporidium treatment credit with design and implementation criteria
Inactivation Toolbox Options	
(14) Chlorine dioxide...	Log credit based on measured CT in relation to CT table. Specific criteria in paragraph (N)(2) of this rule.
(15) Ozone...	Log credit based on measured CT in relation to CT table. Specific criteria in paragraph (N)(2) of this rule.
(16) UV...	Log credit based on validated UV dose in relation to UV dose table; reactor validation testing required to establish UV dose and associated operating conditions. Specific criteria in paragraph (N)(4) of this rule.

(B) Watershed control program.

Systems received 0.5-log Cryptosporidium treatment credit for implementing a watershed control program that meets the requirements of this paragraph.

(1) Systems that intend to apply for the watershed control program credit shall notify the director of this intent no later than two years prior to the treatment compliance date applicable to the system in paragraph (F) of rule 3745-81-67 of the Administrative Code.

(2) Systems shall submit to the director a proposed watershed control plan no later than one year before the applicable treatment compliance date in paragraph (F) of rule 3745-81-67 of the Administrative Code. The director shall approve the watershed control plan for the system to receive watershed control program treatment credit. The watershed control plan shall include the following elements:

(a) Identification of an area of influence outside of which the likelihood of Cryptosporidium or fecal contamination affecting the treatment plant intake is not significant as approved by the director. This is the area to be evaluated in future watershed surveys in accordance with paragraph (B)(4)(b) of this rule. The area of influence shall include, at a minimum:

(i) For systems using inland streams, reservoirs, and lakes, the drinking water source protection area with primary focus on the corridor management zone and any additional areas within the watershed that have been

specifically identified by the public water system or the director as possible sources of Cryptosporidium.

(ii) For systems using the Ohio River, the zone of critical concern.

(iii) For systems using Lake Erie, the potential influence zone, where this zone has been delineated.

(b) Identification of both potential and actual sources of Cryptosporidium contamination and an assessment of the relative impact of these sources on the system's source water quality.

(c) An analysis of the effectiveness and feasibility of control measures that could reduce Cryptosporidium loading from sources of contamination to the system's source water.

(d) A statement of goals and specific actions the system will undertake to reduce source water Cryptosporidium levels. The plan shall explain how the actions are expected to contribute to specific goals, identify watershed partners and their roles, identify resource requirements and commitments, and include a schedule for plan implementation with deadlines for completing specific actions identified in the plan.

(3) Systems with existing watershed control programs (i.e., programs in place on January 5, 2006) are eligible to seek this credit. Their watershed control plans shall meet the criteria in paragraph (B)(2) of this rule and shall specify ongoing and future actions that will reduce source water Cryptosporidium levels.

(4) Systems shall complete the following actions to maintain the 0.5-log credit.

(a) Submit an annual watershed control program status report to the director. The annual watershed control program status report shall describe the system's implementation of the approved plan and assess the adequacy of the plan to meet its goals. It shall explain how the system is addressing any shortcomings in plan implementation, including those previously identified by the director or as the result of the watershed survey conducted under paragraph (B)(4)(b) of this rule. It shall also describe any significant changes that have occurred in the watershed since the last watershed sanitary survey. If a system determines during implementation that making a significant change to its approved watershed control program is necessary, the system shall notify the director prior to making any such changes. If any change is

likely to reduce the level of source water protection, the system shall also list in its notification the actions the system will take to mitigate this effect.

(b) Undergo a watershed sanitary survey every three years for community water systems and every five years for non-community water systems and submit the survey report to the director. The survey shall be conducted according to Ohio environmental protection agency guidelines and by persons acceptable to the director.

(i) The watershed sanitary survey shall meet the following criteria: encompass the region identified in the director-approved watershed control plan as the area of influence; assess the implementation of actions to reduce source water Cryptosporidium levels; and identify any significant new sources of Cryptosporidium.

(ii) If the director determines that significant changes may have occurred in the watershed since the previous watershed sanitary survey, systems shall undergo another watershed sanitary survey by a date the director requires, which may be earlier than the regular date in paragraph (B)(4)(b) of this rule.

(c) The system shall make the watershed control plan, annual status reports, and watershed sanitary survey reports available to the public upon request. These documents shall be in a plain language style and include criteria by which to evaluate the success of the program in achieving plan goals. The director may accept systems to withhold from the public portions of the annual status report, watershed control plan, and watershed sanitary survey based on water supply security considerations.

(5) If the director determines that a system is not carrying out the approved watershed control plan, or if conditions change from those approved, the watershed control plan may no longer be approvable. An approvable plan must be submitted to maintain the watershed control program treatment credit.

(C) Alternative source.

(1) A system may conduct source water monitoring that reflects a different intake location (either in the same source or for an alternate source) or a different procedure for the timing or level of withdrawal from the source (alternative source monitoring). If the director approves, a system may determine its bin classification in accordance with paragraphs (A) to (D) of rule 3745-81-67 of the Administrative Code based on

the alternative source monitoring results.

(2) If systems conduct alternative source monitoring in accordance with paragraph (C)(1) of this rule, systems shall also monitor their current plant intake concurrently as described in paragraphs (A) to (H) of rule 3745-81-65 of the Administrative Code.

(3) Alternative source monitoring under paragraph (C)(1) of this rule shall meet the requirements for source monitoring to determine bin classification, as described in rule 3745-81-65, paragraphs (H) to (J) of rule 3745-81-27, rule 3745-89-11, and paragraph (A) of rule 3745-81-66 of the Administrative Code. Systems shall report the alternative source monitoring results to the director, along with supporting information documenting the operating conditions under which the samples were collected.

(4) If a system determines its bin classification in accordance with paragraphs (A) to (D) of rule 3745-81-67 of the Administrative Code using alternative source monitoring results that reflect a different intake location or a different procedure for managing the timing or level of withdrawal from the source, the system shall relocate the intake or permanently adopt the withdrawal procedure, as applicable, no later than the applicable treatment compliance date in paragraph (F) of rule 3745-81-67 of the Administrative Code.

(D) Presedimentation.

Systems receive 0.5-log Cryptosporidium treatment credit for a presedimentation basin during any month the process meets the criteria in this paragraph.

(1) The presedimentation basin shall be in continuous operation and shall treat the entire plant flow taken from a surface water source.

(2) The system shall continuously add a coagulant to the presedimentation basin.

(3) The presedimentation basin shall achieve the performance criteria in paragraph (D)(3)(a) or (D)(3)(b) of this rule.

(a) Demonstrates at least 0.5-log mean reduction of influent turbidity. This reduction shall be determined using daily turbidity measurements in the presedimentation process influent and effluent and shall be calculated as follows:

$\log_{10}$ (monthly mean of daily influent turbidity) - $\log_{10}$ (monthly mean of

daily effluent turbidity).

The daily turbidity measurements shall be taken under normal operating conditions for that day. Presedimentation operations shall not be altered for the sole purpose of influencing sample results.

(b) Complies with director-approved performance criteria that demonstrate at least 0.5-log mean removal of micron sized particulate material through the presedimentation process.

(E) Two-stage lime softening.

Systems receive an additional 0.5-log Cryptosporidium treatment credit for a two-stage lime softening plant if chemical addition and hardness precipitation occur in two separate and sequential softening stages prior to filtration. Both softening stages shall treat the entire plant flow taken from a surface water source.

(F) Bank filtration.

Systems receive Cryptosporidium treatment credit for bank filtration that serves as pretreatment to a filtration plant by meeting the criteria in this paragraph. Systems using bank filtration when they begin source water monitoring in accordance with paragraph (A) of rule 3745-81-65 of the Administrative Code shall collect samples as described in paragraph (J)(4) of rule 3745-81-65 of the Administrative Code and are not eligible for this credit.

(1) Wells with a ground water flow path of at least twenty-five feet receive 0.5-log treatment credit; wells with a ground water flow path of at least fifty feet receive 1.0-log treatment credit. The ground water flow path shall be determined as specified in paragraph (F)(4) of this rule.

(2) Only wells in granular aquifers are eligible for treatment credit. Granular aquifers are those comprised of sand, clay, silt, rock fragments, pebbles or larger particles, and minor cement. A system shall characterize the aquifer at the well site to determine aquifer properties. Systems shall extract a core from the aquifer and demonstrate that in at least ninety per cent of the core length, grains less than 1.0 millimeters in diameter constitute at least ten per cent of the core material.

(3) Only horizontal and vertical wells are eligible for treatment credit.

(4) For vertical wells, the ground water flow path is the measured distance from the edge of the surface water body under high flow conditions (determined by the one hundred

year floodplain elevation boundary or by the floodway, as defined in Federal emergency management agency flood hazard maps) to the well screen. For horizontal wells, the ground water flow path is the measured distance from the bed of the river under normal flow conditions to the closest horizontal well lateral screen.

(5) Systems shall monitor each wellhead for turbidity at least once within the first and last hours of bank filtration operation and at least every four hours in between. If monthly average turbidity levels, based on daily maximum values in the well, exceed one NTU, the system shall report this result to the director and conduct an assessment within thirty days to determine the cause of the high turbidity levels in the well. If the director determines that microbial removal has been compromised, the bank filtration credit may no longer be approvable. To maintain the bank filtration treatment credit, the system shall implement corrective actions to remediate the problem and submit approvable plans.

(6) Springs and infiltration galleries are not eligible for treatment credit under paragraph (F) of this rule, but are eligible for credit under paragraph (I) of this rule.

(7) Bank filtration demonstration of performance. The director may approve Cryptosporidium treatment credit for bank filtration based on a demonstration of performance study that meets the criteria in this paragraph. This treatment credit may be greater than 1.0-log and may be awarded to bank filtration that does not meet the criteria in paragraphs (F)(1) to (F)(5) of this rule.

(a) The study shall follow a protocol acceptable to the director and shall involve the collection of data on the removal of Cryptosporidium or a surrogate for Cryptosporidium and related hydrogeologic and water quality parameters during the full range of operating conditions.

(b) The study shall include sampling both from the production well(s) and from monitoring wells that are screened and located along the shortest flow path between the surface water source and the production well(s).

(G) Combined filter performance.

Systems using conventional filtration treatment or direct filtration treatment receive an additional 0.5-log Cryptosporidium treatment credit during any month the system meets the criteria in this paragraph. Combined filter effluent (CFE) turbidity shall be less than or equal to 0.15 NTU in at least ninety-five per cent of the measurements. Turbidity shall be measured as described in paragraph (C)(3) of rule 3745-81-27 and paragraph (A) of rule 3745-81-74 of the Administrative Code.

(H) Individual filter performance.

Systems using conventional filtration treatment or direct filtration treatment receive 0.5-log Cryptosporidium treatment credit, which can be in addition to the 0.5-log credit under paragraph (G) of this rule, during any month the system meets the criteria in this paragraph. Compliance with these criteria shall be based on individual filter turbidity monitoring as described in paragraphs (B) and (C) of rule 3745-81-74 of the Administrative Code, as applicable.

(1) The filtered water turbidity for each individual filter shall be less than or equal to 0.15 NTU in at least ninety-five per cent of the measurements recorded each month.

(2) No individual filter may have a measured turbidity greater than 0.3 NTU in two consecutive measurements taken fifteen minutes apart.

(3) Any system that has received treatment credit for individual filter performance and fails to meet the requirements of paragraph (H)(1) or (H)(2) of this rule during any month does not receive a treatment technique violation under paragraph (E)(4) of rule 3745-81-67 of the Administrative Code if the director determines the following:

(a) The failure was due to unusual and short-term circumstances that could not reasonably be prevented through optimizing treatment plant design, operation, and maintenance.

(b) The system has experienced no more than two such failures in any calendar year.

(I) Demonstration of performance.

The director may approve Cryptosporidium treatment credit for drinking water treatment processes based on a demonstration of performance study that meets the criteria in this paragraph. This treatment credit may be greater than or less than the prescribed treatment credits in paragraph (E) of rule 3745-81-67 of the Administrative Code or paragraphs (D) to (N) of this rule and may be awarded to treatment processes that do not meet the criteria for the prescribed credits.

(1) Systems cannot receive the prescribed treatment credit for any toolbox option in paragraphs (D) to (N) of this rule if that toolbox option is included in a demonstration of performance study for which treatment credit is awarded under this paragraph.

(2) The demonstration of performance study shall follow a protocol acceptable to the director and shall demonstrate the level of Cryptosporidium reduction the treatment process will achieve under the full range of expected operating conditions for the system.

(3) Approval by the director shall be in writing and may include monitoring and treatment performance criteria that the system shall demonstrate and report on an ongoing basis to remain eligible for the treatment credit. The director may designate such criteria where necessary to verify that the conditions under which the demonstration of performance credit was approved are maintained during routine operation.

(J) Bag and cartridge filters.

Systems receive Cryptosporidium treatment credit of up to 2.0-log for individual bag or cartridge filters and up to 2.5-log for bag or cartridge filters operated in series by meeting the criteria in paragraphs (J)(1) to (J)(10) of this rule. To be eligible for this credit, systems shall report the results of challenge testing that meets the requirements of paragraphs (J)(2) to (J)(9) of this rule to the director. The filters shall treat the entire plant flow taken from a surface water source.

(1) The Cryptosporidium treatment credit awarded to bag or cartridge filters shall be based on the removal efficiency demonstrated during challenge testing that is conducted according to the criteria in paragraphs (J)(2) to (J)(9) of this rule. A factor of safety equal to 1-log for individual bag or cartridge filters and 0.5-log for bag or cartridge filters in series shall be applied to challenge testing results to determine removal credit. Systems may use results from challenge testing conducted prior to January 5, 2006 if the prior testing was consistent with the criteria specified in paragraphs (J)(2) to (J)(9) of this rule.

(2) Challenge testing shall be performed on full-scale bag or cartridge filters, and the associated filter housing or pressure vessel, that are identical in material and construction to the filters and housings the system will use for removal of Cryptosporidium. Bag or cartridge filters shall be challenge tested in the same configuration that the system will use, either as individual filters or as a series configuration of filters.

(3) Challenge testing shall be conducted using Cryptosporidium or a surrogate that is removed no more efficiently than Cryptosporidium. The microorganism or surrogate used during challenge testing is referred to as the challenge particulate. The

concentration of the challenge particulate shall be determined using a method capable of discretely quantifying the specific microorganism or surrogate used in the test; gross measurements such as turbidity may not be used.

(4) The maximum feed water concentration that can be used during a challenge test shall be based on the detection limit of the challenge particulate in the filtrate (i.e., filtrate detection limit) and shall be calculated using the following equation:

Maximum Feed Concentration = $1 \times 10^{4} \times$ (filtrate detection limit)

(5) Challenge testing shall be conducted at the maximum design flow rate for the filter as specified by the manufacturer.

(6) Each filter evaluated shall be tested for the duration sufficient to reach one hundred per cent of the terminal pressure drop, which establishes the maximum pressure drop under which the filter may be used to comply with the requirements in paragraph (E) of rule 3745-81-67 of the Administrative Code.

(7) Removal efficiency of a filter shall be determined from the results of the challenge test and expressed in terms of log removal values using the following equation:

$LRV = LOG_{10}(Cf) - LOG_{10}(Cp)$

Where: LRV = log removal value demonstrated during challenge testing; Cf = the feed concentration measured during the challenge test; and Cp = the filtrate concentration measured during the challenge test. In applying this equation, the same units shall be used for the feed and filtrate concentrations. If the challenge particulate is not detected in the filtrate, then the term Cp shall be set equal to the detection limit.

(8) Each filter tested shall be challenged with the challenge particulate during three periods over the filtration cycle: within two hours of start-up of a new filter; when the pressure drop is between forty-five and fifty-five per cent of the terminal pressure drop; and at the end of the cycle after the pressure drop has reached one hundred per cent of the terminal pressure drop. An LRV shall be calculated for each of these challenge periods for each filter tested. The LRV for the filter (LRVfilter) shall be assigned the value of the minimum LRV observed during the three challenge periods for that filter.

(9) If fewer than twenty filters are tested, the overall removal efficiency for the filter product line shall be set equal to the lowest LRVfilter among the filters tested. If

twenty or more filters are tested, the overall removal efficiency for the filter product line shall be set equal to the tenth percentile of the set of LRVfilter values for the various filters tested. The percentile is defined by (i/(n+1)) where "i" is the rank of "n" individual data points ordered lowest to highest. If necessary, the tenth percentile may be calculated using linear interpolation.

(10) If a previously tested filter is modified in a manner that could change the removal efficiency of the filter product line, challenge testing to demonstrate the removal efficiency of the modified filter shall be conducted and submitted to the director.

(K) Membrane filtration.

(1) Systems receive Cryptosporidium treatment credit for membrane filtration that meets the criteria of this paragraph. Membrane cartridge filters that meet the definition of membrane filtration in rule 3745-81-01 of the Administrative Code are eligible for this credit. The level of treatment credit a system receives is equal to the lower of the values determined under paragraph (K)(1)(a) and (K)(1)(b) of this rule. The U.S. EPA "Membrane Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule" (November 2005), shall be used as a guide in the technical review of plans submitted for approval of membrane facilities. Approval of plans for membrane facilities may be conditioned upon requirements that may be necessary or desirable to ensure that the system being constructed, or of which the proposed project is a part, will be able to meet generally accepted standards for the design, equipping and operation of membrane facilities. Systems shall keep daily operational logs used to determine monthly compliance with the direct and indirect integrity testing requirements. The operational logs must be signed by an operator of record and kept on a form acceptable to the director. Operational logs must be made available for review upon request.

(a) The removal efficiency demonstrated during challenge testing conducted under the conditions in paragraph (K)(2) of this rule.

(b) The maximum removal efficiency that can be verified through direct integrity testing used with the membrane filtration process under the conditions in paragraph (K)(3) of this rule.

(2) Challenge testing.

The membrane used by the system shall undergo challenge testing to evaluate removal efficiency, and the system shall report the results of challenge testing to the director. Challenge testing shall be conducted according to the criteria in paragraphs

(K)(2)(a) to (K)(2)(g) of this rule. Systems may use data from challenge testing conducted prior to January 5, 2006 if the prior testing was consistent with the criteria in paragraphs (K)(2)(a) to (K)(2)(g) of this rule.

(a) Challenge testing shall be conducted on either a full-scale membrane module, identical in material and construction to the membrane modules used in the system's treatment facility, or a smaller-scale membrane module, identical in material and similar in construction to the full-scale module. A module is defined as the smallest component of a membrane unit in which a specific membrane surface area is housed in a device with a filtrate outlet structure.

(b) Challenge testing shall be conducted using Cryptosporidium oocysts or a surrogate that is removed no more efficiently than Cryptosporidium oocysts. The organism or surrogate used during challenge testing is referred to as the challenge particulate. The concentration of the challenge particulate, in both the feed and filtrate water, shall be determined using a method capable of discretely quantifying the specific challenge particulate used in the test; gross measurements such as turbidity may not be used.

(c) The maximum feed water concentration that can be used during a challenge test is based on the detection limit of the challenge particulate in the filtrate and shall be determined according to the following equation:

$$\text{Maximum Feed Concentration} = 3.16 \times 10^{6} \times (\text{Filtrate Detection Limit})$$

(d) Challenge testing shall be conducted under representative hydraulic conditions at the maximum design flux and maximum design process recovery specified by the manufacturer for the membrane module. Flux is defined as the throughput of a pressure driven membrane process expressed as flow per unit of membrane area. Recovery is defined as the volumetric per cent of feed water that is converted to filtrate over the course of an operating cycle uninterrupted by events such as chemical cleaning or a solids removal process (e.g., backwashing).

(e) Removal efficiency of a membrane module shall be calculated from the challenge test results and expressed as a log removal value according to the following equation:

$$LRV = LOG_{10}(Cf) - LOG_{10}(Cp)$$

Where:

LRV = log removal value demonstrated during the challenge test; Cf = the feed concentration measured during the challenge test; and Cp = the filtrate concentration measured during the challenge test.

Equivalent units shall be used for the feed and filtrate concentrations. If the challenge particulate is not detected in the filtrate, the term Cp is set equal to the detection limit for the purpose of calculating the LRV. An LRV shall be calculated for each membrane module evaluated during the challenge test.

(f) The removal efficiency of a membrane filtration process demonstrated during challenge testing shall be expressed as a log removal value ($LRV_{C\text{-}Test}$). If fewer than twenty modules are tested, then $LRV_{C\text{-}Test}$ is equal to the lowest of the representative LRVs among the modules tested. If twenty or more modules are tested, then $LRV_{C\text{-}Test}$ is equal to the tenth percentile of the representative LRVs among the modules tested. The percentile is defined by (i/(n+1)) where "i" is the rank of "n" individual data points ordered lowest to highest. If necessary, the tenth percentile may be calculated using linear interpolation.

(g) The challenge test shall establish a quality control release value (QCRV) for a non-destructive performance test that demonstrates the Cryptosporidium removal capability of the membrane filtration module. This performance test shall be applied to each production membrane module used by the system that was not directly challenge tested in order to verify Cryptosporidium removal capability. Production modules that do not meet the established QCRV are not eligible for the treatment credit demonstrated during the challenge test.

(h) If a previously tested membrane is modified in a manner that could change the removal efficiency of the membrane or the applicability of the non-destructive performance test and associated QCRV, additional challenge testing to demonstrate the removal efficiency of, and determine a new QCRV for, the modified membrane shall be conducted and submitted to the director.

(3) Direct integrity testing.

Systems shall conduct direct integrity testing in a manner that demonstrates a removal efficiency equal to or greater than the removal credit awarded to the

membrane filtration process and meets the requirements described in paragraphs (K)(3)(a) to (K)(3)(f) of this rule. A direct integrity test is defined as a physical test applied to a membrane unit in order to identify and isolate integrity breaches (e.g., one or more leaks that could result in contamination of the filtrate).

(a) The direct integrity test shall be independently applied to each membrane unit in service. A membrane unit is defined as a group of membrane modules that share common valving that allows the unit to be isolated from the rest of the system for the purpose of integrity testing or other maintenance.

(b) The direct integrity method shall have a resolution of three micrometers or less, where resolution is defined as the size of the smallest integrity breach that contributes to a response from the direct integrity test.

(c) The direct integrity test shall have the sensitivity sufficient to verify the log treatment credit approved by the director for the membrane filtration process, where sensitivity is defined as the maximum log removal value that can be reliably verified by a direct integrity test. Sensitivity shall be determined using the approach in either paragraph (K)(3)(c)(i) or (K)(3)(c)(ii) of this rule as applicable to the type of direct integrity test the system uses.

(i) For direct integrity tests that use an applied pressure or vacuum, the direct integrity test sensitivity shall be calculated according to the following equation:

$$LRV_{DIT} = LOG_{10} (Q_p /(VCF \times Q_{breach}))$$

Where:

LRV_{DIT} = the sensitivity of the direct integrity test; Qp = total design filtrate flow from the membrane unit; Q_{breach} = flow of water from an integrity breach associated with the smallest integrity test response that can be reliably measured; and VCF = volumetric concentration factor. The volumetric concentration factor is the ratio of the suspended solids concentration on the high pressure side of the membrane relative to that in the feed water.

(ii) For direct integrity tests that use a particulate or molecular marker, the direct integrity test sensitivity shall be calculated according to

the following equation:

$LRV_{DIT} = LOG_{10}(C_f) - LOG_{10}(C_p)$

Where:

LRV_{DIT} = the sensitivity of the direct integrity test; Cf = the typical feed concentration of the marker used in the test; and Cp = the filtrate concentration of the marker from an integral membrane unit.

(d) Systems shall establish a control limit within the sensitivity limits of the direct integrity test that is indicative of an integral membrane unit capable of meeting the removal credit approved by the director.

(e) If the result of a direct integrity test exceeds the control limit established under paragraph (K)(3)(d) of this rule, the system shall remove the membrane unit from service. Systems shall conduct a direct integrity test to verify any repairs, and may return the membrane unit to service only if the direct integrity test is within the established control limit.

(f) Systems shall conduct direct integrity testing on each membrane unit at a frequency of not less than once each day that the membrane unit is in operation. The director may approve less frequent testing, based on demonstrated process reliability, the use of multiple barriers effective for Cryptosporidium, or reliable process safeguards.

(4) Indirect integrity monitoring.

Systems shall conduct continuous indirect integrity monitoring on each membrane unit according to the criteria in paragraphs (K)(4)(a) to (K)(4)(f) of this rule. Indirect integrity monitoring is defined as monitoring some aspect of filtrate water quality that is indicative of the removal of particulate matter. A system that implements continuous direct integrity testing of membrane units in accordance with the criteria in paragraphs (K)(3)(a) to (K)(3)(f) of this rule is not subject to the requirements for continuous indirect integrity monitoring. Systems shall submit a monthly report to the director summarizing all continuous indirect integrity monitoring results triggering direct integrity testing and the corrective action that was taken in each case.

(a) Unless the director approves an alternative parameter, continuous indirect integrity monitoring shall include continuous filtrate turbidity monitoring.

(b) Continuous monitoring shall be conducted at a frequency of no less than once every fifteen minutes.

(c) Continuous monitoring shall be separately conducted on each membrane unit.

(d) If indirect integrity monitoring includes turbidity and if the filtrate turbidity readings are above 0.15 NTU for a period greater than fifteen minutes (i.e., two consecutive fifteen-minute readings above 0.15 NTU), direct integrity testing shall immediately be performed on the associated membrane unit as specified in paragraphs (K)(3)(a) to (K)(3)(f) of this rule.

(e) The public water system shall validate the continuous measurement for accuracy on a regular basis using a protocol acceptable to the director.

(f) If indirect integrity monitoring includes a director-approved alternative parameter and if the alternative parameter exceeds a director-approved control limit for a period greater than fifteen minutes, direct integrity testing shall immediately be performed on the associated membrane units as specified in paragraphs (K)(3)(a) to (K)(3)(f) of this rule.

(L) Second stage filtration.

Systems receive 0.5-log Cryptosporidium treatment credit for a separate second stage of filtration that consists of sand, dual media, GAC, or other fine grain media following granular media filtration if the director approves. To be eligible for this credit, the first stage of filtration shall be preceded by a coagulation step and both filtration stages shall treat the entire plant flow taken from a surface water source. A cap, such as GAC, on a single stage of filtration is not eligible for this credit. The director shall approve the treatment credit based on an assessment of the design characteristics of the filtration process.

(M) Slow sand filtration (as secondary filter).

Systems are eligible to receive 2.5-log Cryptosporidium treatment credit for a slow sand filtration process that follows a separate stage of filtration if both filtration stages treat entire plant flow taken from a surface water source and no disinfectant residual is present in the influent water to the slow sand filtration process. The director shall approve the treatment credit based on an assessment of the design characteristics of the filtration process. This paragraph does not apply to treatment credit awarded to slow sand filtration

used as a primary filtration process.

(N) Inactivation toolbox components.

(1) Calculation of CT values.

(a) CT is the product of the disinfectant contact time ("T", in minutes) and disinfectant concentration ("C", in milligrams per liter). Systems with treatment credit for chlorine dioxide or ozone under paragraphs (N)(2) or (N)(3) of this rule shall calculate CT at least once each day, with both "C" and "T" measured during peak hourly flow as specified in rules 3745-81-27 and 3745-81-72 of the Administrative Code.

(b) Systems with several disinfection segments in sequence may calculate CT for each segment, where a disinfection segment is defined as a treatment unit process with a measurable disinfectant residual level and a liquid volume. Under this approach, systems shall add the Cryptosporidium CT values in each segment to determine the total CT for the treatment plant.

(2) CT values for chlorine dioxide and ozone.

(a) Systems receive the Cryptosporidium treatment credit listed in this table by meeting the corresponding chlorine dioxide CT value for the applicable water temperature, as described in paragraph (N)(1) of this rule.

CT Values (MG-MIN/L) for Cryptosporidium Inactivation by Chlorine Dioxide [1]

Log credit	Water Temperature, °C										
	<=0.5	1	2	3	5	7	10	15	20	25	30
(i) 0.25 ...	159	153	140	128	107	90	69	45	29	19	12
(ii) 0.50 ...	319	305	279	256	214	180	138	89	58	38	24
(iii) 1.0...	637	610	558	511	429	360	277	179	116	75	49
(iv) 1.5...	956	915	838	767	643	539	415	268	174	113	73
(v) 2.0...	1275	1220	1117	1023	858	719	553	357	232	150	98
(vi) 2.5...	1594	1525	1396	1278	1072	899	691	447	289	188	122
(vii) 3.0 ...	1912	1830	1675	1534	1286	1079	830	536	347	226	147

1 Systems may use this equation to determine log credit between the indicated values: Log credit = (0.001506 x $(1.09116)^{Temp}$) x CT.

(b) Systems receive the Cryptosporidium treatment credit listed in this table by meeting the corresponding ozone CT values for the applicable water temperature, as described in paragraph (N)(1) of this rule.

CT Values (MG-MIN/L) for Cryptosporidium Inactivation by Ozone [1]

Log credit	Water Temperature, °C										
	<=0.5	1	2	3	5	7	10	15	20	25	30
(i) 0.25 ...	6.0	5.8	5.2	4.8	4.0	3.3	2.5	1.6	1.0	0.6	0.39
(ii) 0.50 ...	12	12	10	9.5	7.9	6.5	4.9	3.1	2.0	1.2	0.78
(iii) 1.0...	24	23	21	19	16	13	9.9	6.2	3.9	2.5	1.6
(iv) 1.5...	36	35	31	29	24	20	15	9.3	5.9	3.7	2.4
(v) 2.0...	48	46	42	38	32	26	20	12	7.8	4.9	3.1
(vi) 2.5…	60	58	52	48	40	33	25	16	9.8	6.2	3.9
(vii) 3.0 ...	72	69	63	57	47	39	30	19	12	7.4	4.7

1 Systems may use this equation to determine log credit between the indicated values: Log credit = (0.0397 x $(1.09757)^{Temp}$) x CT.

(3) Site-specific study.

The director may approve alternative chlorine dioxide or ozone CT values to those listed in paragraph (N)(2) of this rule on a site-specific basis. The director shall base this approval on a site-specific study a system conducts that follows a protocol acceptable to the director.

(4) Ultraviolet light. Systems receive Cryptosporidium, Giardia lamblia, and virus treatment credits for ultraviolet (UV) light reactors by achieving the corresponding UV dose values shown in paragraph (N)(4)(a) of this rule. Systems shall validate and monitor UV reactors as described in paragraphs (N)(4)(b) and (N)(4)(c) of this rule to demonstrate that they are achieving a particular UV dose value for treatment credit. The U.S. EPA "Ultraviolet Disinfection Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule" (November 2006), shall be used as a guide in the technical review of plans submitted for approval of UV facilities. Approval of plans for UV facilities may be conditioned upon requirements that may be necessary or desirable to ensure that the system being constructed, or of which the proposed project is a part, will be able to meet generally accepted standards for the design, equipping and operation of UV facilities. Systems shall keep daily operational logs used to determine monthly

compliance with the percentage of water treated under validated conditions. The operational logs must be signed by an operator of record and kept on a form acceptable to the director. Operational logs must be made available for review upon request.

(a) UV dose table.

The treatment credits listed in this table are for UV light at a wavelength of two hundred fifty-four nanometers as produced by a low pressure mercury vapor lamp. To receive treatment credit for other lamp types, systems shall demonstrate an equivalent germicidal dose through reactor validation testing, as described in paragraph (N)(4)(b) of this rule. The UV dose values in this table are applicable only to post-filter applications of UV.

UV Dose Table for Cryptosporidium, Giardia lamblia, and Virus Inactivation Credit

Log credit	Cryptosporidium UV dose (mJ/cm^2)	Giardia lamblia UV dose (mJ/cm^2)	Virus UV dose (mJ/cm^2)
(i) 0.5 …	1.6	1.5	39
(ii) 1.0 ...	2.5	2.1	58
(iii) 1.5 ...	3.9	3.0	79
(iv) 2.0 ...	5.8	5.2	100
(v) 2.5 ...	8.5	7.7	121
(vi) 3.0 ...	12	11	143
(vii) 3.5 ...	15	15	163
(viii) 4.0 ...	22	22	186

(b) Reactor validation testing.

Systems shall use UV reactors that have undergone validation testing to determine the operating conditions under which the reactor delivers the UV dose required in paragraph (N)(4)(a) of this rule (i.e., validated operating conditions). These operating conditions shall include flow rate, UV intensity as measured by a UV sensor, and UV lamp status.

(i) When determining validated operating conditions, systems shall account for the following factors: UV absorbance of the water; lamp fouling and aging; measurement uncertainty of on-line sensors; UV dose distributions arising from the velocity profiles through the reactor; failure of UV lamps or other critical system components; and inlet and outlet piping or channel configurations of the UV reactor.

(ii) Validation testing shall include the following: Full scale testing of a reactor that conforms uniformly to the UV reactors used by the system and inactivation of a test microorganism whose dose response characteristics have been quantified with a low pressure mercury vapor lamp.

(iii) The director may approve an alternative approach to validation testing.

(c) Reactor monitoring.

(i) Systems shall monitor their UV reactors to determine if the reactors are operating within validated conditions, as determined under paragraph (N)(4)(b) of this rule. This monitoring shall include UV intensity as measured by a UV sensor, flow rate, lamp status, and other parameters the director designates based on UV reactor operation. Systems shall verify the calibration of UV sensors and shall recalibrate sensors at least monthly in accordance with a protocol the director accepts. The following parameters shall be monitored and recorded at the frequencies indicated in the table below for each UV reactor:

Parameter	Recording Frequency	Required conditions for obtaining disinfection credit.
Off-specification alarm	At least every 5 minutes	Recording shall continue until the alarm condition has been corrected.
UV Intensity	At least every 4 hours	The UV intensity shall be greater than or equal to the validated set point.

UVT (required only if necessary for the dose monitoring strategy (e.g., calculated dose approach))	At least every 4 hours	The UVT shall be greater than or equal to the minimum UVT validated.
Validated Dose	At least every 4 hours	The validated dose shall be greater than or equal to the D_{req}.
Lamp Status	At least every 4 hours	Lamps shall be energized if water is flowing through the UV reactor.
Flow Rate	At least every 4 hours	The flow rate shall be less than or equal to the maximum flow tested in validation.
Production Volume	Off-specification events and monthly total	The production volume shall be recorded so the off-specification compliance calculation can be completed.
Calibration of UV Sensors	At least monthly	Calibration shall be conducted in accordance with a protocol acceptable to the director.
Calibration of On-line UVT Analyzer (required only if necessary for the dose monitoring strategy (e.g., calculated dose approach)	Weekly	Calibration must be conducted in accordance with a protocol acceptable to the director.

(ii) To receive treatment credit for UV light, systems shall treat at least ninety-five per cent of the water delivered to the public during each month by UV reactors operating within validated conditions for the required UV dose, as described in paragraphs (N)(4)(a) and (N)(4)(b) of this rule. Systems shall demonstrate compliance with this condition by the monitoring required under paragraph (N)(4)(c)(i) of this rule.

[This rule references the U.S. EPA "Membrane Guidance Manual for the Final Long Term 2 Enhanced Surface Water Treatment Rule," issued November 2005. This document is available from the "U.S. EPA Office of Ground Water and Drinking Water, Ariel Rios Building, 1200 Pennsylvania Ave, NW, Washington, DC 20460-0003, (202) 564-3750". A copy may also be obtained from www.epa.gov/safewater/disinfection/lt2/compliance.html.]

[This rule references the U.S. EPA "Ultraviolet Disinfection Guidance Manual for Final Long Term 2 Enhanced Surface Water Treatment Rule," issued November 2006. This document is available from the "U.S. EPA Office of Ground Water and Drinking Water, Ariel Rios Building, 1200 Pennsylvania Ave, NW, Washington, DC 20460-0003, (202) 564-3750". A copy may also be obtained from www.epa.gov/safewater/disinfection/lt2/compliance.html.]

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