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Guidelines for Obtaining Approval of Membranes to Meet Particulate and Microbiological Removal Requirements for Surface Water Treatment

Division: DDAGW
Number: ENG-05-001
Category: Engineering - Policy
Status: Final
Issued: September 16, 2003

This document was developed in consultation with Ohio Section AWWA - Technology Committee for purposes of providing technical guidance to members of the regulated community to comply with Ohio Administrative Code Rule 3745-81-73. This guidance is not intended to create any new requirement but is merely a suggested approach to complying with OAC Rule 3745-81-73. Nothing herein should be interpreted as precluding other strategies to complying with those requirements.

I. PURPOSE

To establish a recommended standard protocol for obtaining approval of a specific membrane system to meet particulate and microbiological (*Giardia lamblia*, *Cryptosporidium parvum*, bacteria, and if proposed, viruses) removal requirements for surface water treatment.

It is intended that the successful application of these guidelines will result in the design of a treatment system that will provide drinking water meeting or exceeding the requirements of surface water treatment at reasonable cost. It must be recognized that additional treatment may be required to address other water quality issues such as disinfection, viruses, disinfection byproduct formation, organics removal, hardness, taste and odor, color, or other contaminants that might be present.

Log removal credit for *Giardia lamblia* and *Cryptosporidium parvum* for a specific membrane module will be based on the data from challenge tests indicating the log removal capability of the specific membrane module. The challenge test may be conducted by the manufacturer or a third party (preferred). This guideline also presents a recommended protocol to gather site specific information related to full scale plant design, reliability, and O & M issues.

Deviations from this protocol may be accepted based on the justification submitted.

II. BACKGROUND AND OBJECTIVES

Ohio Administrative Code (OAC) Rule 3745-81-73 requires public water systems that use a surface water source, or a groundwater source under the direct influence of surface water, to provide conventional filtration, direct filtration, slow sand filtration or other filtration technology for the removal of pathogenic microorganisms. Membrane technology is a process that may be used to satisfy the filtration requirements of the OAC.

It is not expected that membrane treatment will satisfy all requirements for the treatment of surface water. The total treatment scheme must be evaluated; consideration must be

given to pretreatment and post treatment processes.

Membranes may be used to achieve treatment objectives other than particulate and microbiological removal. These objectives must be addressed in the protocol. In any case, membrane treatment must satisfy the requirements of OAC Rule 3745-81-73.

The objective of this guideline is to promote consistency throughout the State of Ohio in administering provisions of the Ohio Administrative Code in regard to the use of membranes for compliance with surface water treatment requirements.

III. OTHER APPLICABLE GUIDANCE

ASTM Standard D6908-03 Standard Practice for Integrity Testing of Water Filtration Membrane Systems, ASTM, Unpublished.

Guidance Manual for Compliance with the Filtration and Disinfection Requirements for Public Water Systems Using Surface Water Sources, U.S. EPA, Contract No. 68-01-6989, March, 1991.

Guidance Manual for Membrane Filtration, USEPA (In Progress.)

Long Term 2 Enhanced Surface Water Treatment Rule, USEPA. (Anticipated proposal summer 2003.)

Low-Pressure Membrane Filtration For Pathogen Removal: Application, Implementation, and Regulatory Issues, USEPA, 815-C-01-001, April 2001.

Membrane Treatment Handbook, AWWA.

Recommended Standards for Water Works, The Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, 1997, (also referred to as Ten States Standards).

Water Quality and Treatment, A Handbook of Community Water Supplies, 5th Edition, (AWWA), 1999.

Water Treatment Membrane Processes, American Water Works Association Research Foundation, Lyonnaise des Eaux and Water Research Commission of South Africa, J. Mallevalle, P.E. Odendaal, and M.R. Wiesner (Editors), 1996.

IV. POLICY

In consultation with Ohio Section AWWA - Technology Committee, the DDAGW recommends the following procedures be used to determine the acceptability of membranes for treatment of surface waters at water treatment plants.

V. PROCEDURE

1.1 Operating parameters to be evaluated should include:

Cold and warm temperature flux, percent recovery, backwash frequency, backwash duration, backwash method, clean-in-place (CIP) method and frequency, transmembrane pressure, pretreatment, and post treatment.

- 1.2 Where a new membrane process is proposed for an existing water treatment plant, a membrane pilot scale unit should utilize the water following any existing processes that will precede the membrane units in the proposed design. When a new membrane treatment plant is proposed, all pretreatment processes will need to be included in the pilot test.

Where rerating of existing membranes or utilization of a different membrane is proposed, the isolation of full-scale membrane units at an existing WTP operated for comparison with all or some of the remaining membrane units is the preferred method. An alternative is the use of a pilot-scale membrane unit for comparison with the full-scale membrane units of the existing WTP.

- 1.3 Additional requirements that should be met prior to performing a demonstration study using a full scale WTP are:

- 1.3.1 The WTP should be under the responsible charge of a properly certified operator.

- 1.3.2 The WTP should have appropriate redundancies for all essential processes and associated equipment.

- 1.3.3 All equipment should be maintained in good condition.

- 1.4 It is strongly recommended that the Division of Surface Water be contacted as early as possible to determine options for disposal of waste streams from both the pilot and the full scale plant. The following are examples of disposal options that may be approvable:

- 1.4.1 Direct discharge to a stream. An NPDES permit is required based on wastestream characterization, receiving stream low flow discharge, and protection of water quality standards. Water quality standards may include Total Dissolved Solids (less than approximately 2000 mg/l), mercury, and bacteria. Best available technology for disinfection of viruses and cysts may be required.

- 1.4.2 Discharge to a Publicly Owned Treatment Works (POTW). If the discharge is to an approved pretreatment program POTW (a list of approved pretreatment program POTW's are available at: http://www.epa.state.oh.us/dsw/pretreatment/approve_program_listing1.html or contact Ohio EPA Division of Surface Water), the local POTW should be contacted for any possible limits or specific pre-treatment needed. If the discharge is to any POTW other than a Ohio EPA approved pretreatment program POTW, then the industry will either be covered by Ohio EPA's permit-by-rule requirements (OAC Rule 3745-36-06) if it is a non-significant industrial user or submit an indirect discharge application to Ohio EPA for possible pretreatment limits (OAC Chapter 3745-03) if it is a significant industrial user (OAC Rule 3745-36-02(U)).

- 1.5 Since this is an emerging technology, it is highly recommended that at least one person be an engineer who has been involved in conducting and interpreting previous membrane filtration studies, at least one of which is comparable to the proposed study. (See footnote ¹)
- 2.0 Application for Log Removal Credit
- 2.1 A request for specific log removal credit for *Giardia lamblia*, *Cryptosporidium parvum* and viruses must be submitted for review and approval by the agency to comply with OAC Rule 3745-81-73(C). The submittal should include supporting performance data from challenge studies conforming to the requirements of the Long Term 2 Enhanced Surface Water Treatment Rule (or latest draft) and the USEPA *Membrane Filtration Guidance Manual EPA 815-D-03-008 June 2003 Proposal Draft*. The challenge test results must be verifiable. Log removal credits will be granted in accordance with Section 4.0. This request must also include a description of all proposed integrity testing procedures for the full scale system, and calculations to justify the requested log removal credits.
- 2.2 In order to receive the requested log removal credits, an integrity testing program consistent with the requirements of Long Term 2 Enhanced Surface Water Treatment Rule (or latest draft) and the USEPA *Membrane Filtration Guidance Manual EPA 815-D-03-008 June 2003 Proposal Draft* for the proposed plant should be submitted for approval. Direct integrity testing (e.g. pressure decay, vacuum hold, bubble point, sonic, etc.) should be performed at least daily for each rack, and monthly for each individual membrane module. Integrity monitoring should also include continuous indirect integrity testing such as particle counting.
- 3.0 Demonstration Study
- 3.1 Demonstration Criteria

The purpose of the demonstration study is to assess the performance and reliability of the membrane system during the critical conditions, to determine operating parameters, to assess the fouling potential, and to determine the necessary cleaning procedures for receiving approval for the process from OEPA. Prior to the performance of the demonstration study, a plan must be submitted and approved in compliance with OAC Rules 3745-81-73(C) and 3745-91-02(C). The plan should include:

- 3.1.1 Results from analysis of raw water quality data for at least the previous 12-month period, if available. Variations in raw water quality will need to be addressed.
- 3.1.2 Statement of objectives and conclusions from an evaluation of the raw water quality identifying time periods when the critical conditions are likely to occur. Critical conditions include, but may not be limited to high turbidity,

¹ Once a particular membrane and configuration is selected for testing, care should be taken to protect the owner from extreme price fluctuations. The following items should be considered; Obtain firm equipment and membrane prices prior to testing the membrane, Ensure price caps are provided for eventual replacement of membranes; Ensure that the membrane to be piloted will be available for the foreseeable future. Obtain performance guarantees based on seasonal water quality and demands. Also consider piloting more than one membrane.

low temperature, and presence of algae .

- 3.1.3 Schematic drawings and detailed descriptions of the facilities to be used. Differences between the pilot configuration and the proposed full scale WTP should be clearly noted, and discussed. The need for additional testing of a modified design will be reviewed on a case by case basis.
- 3.1.4 Mode(s) of operation to be tested. For example: flux, transmembrane pressure, pretreatment, etc..
- 3.1.5 Time schedules for each mode of operation. The schedule should address the relationship between the modes of operation and the critical conditions identified in 3.1.2 and should encompass all of the periods of critical conditions identified.
- 3.1.6 Sampling locations to be monitored, including pretreatment and post treatment processes, when required. It is expected that most post treatment processes may be tested on the bench scale.
- 3.1.7 Parameters to be monitored at each sampling location.
- 3.1.8 Frequency of monitoring for each parameter.
- 3.1.9 Description of on-line and bench analytical equipment to be used for monitoring each parameter.
- 3.1.10 Quality assurance/quality control procedures to be used. All parameters for which Ohio EPA laboratory certification is available should be conducted in an Ohio EPA certified laboratory.
- 3.1.11 Description of analyses to be used for evaluating the data collected.
- 3.1.12 Additional data collection for treatment objectives beyond particulate and microbiological removal requirements for surface water treatment. The data collection for pretreatment and post treatment are site specific and should be included in the plan.
- 3.1.13 Proposed plant capacity ratings

The generally recognized relationship between membrane flux and water temperature suggests that plant capacity will be higher in the warmer months than in the colder months. The nature of membranes is such that economic benefits may be realized by pursuing a dual plant capacity rating based on seasonal water temperature and system demand.

A single plant capacity rating will be based on meeting the annual maximum day at the limiting flux, typically the coldest water temperature. In many cases this will result in significantly more membrane area being installed.

If applicant proposes a dual plant capacity rating, data must be collected to show that maximum day demands will be met for each period. Data may

include manufacturer’s temperature versus flux curves, system demand curves and data collected during the pilot testing periods. Data analysis must address the impact of membrane feed water turbidity and temperature on flux.

- 3.2 A pilot scale demonstration study should be conducted for at least 2000 hours. The selection of the test period(s) is to be based on analysis of raw water quality data as indicated in Item 3.1.2 The test should include the time periods likely to encounter critical conditions.

Examples of acceptable testing schedules are:

One year, 5 days per week, 8 hours per day
 One test period starting in late winter and ending in early fall
 Continuous operation of the pilot unit is recommended. However, only periods of time when monitoring is being conducted at the required frequencies should apply towards the minimum recommended 2000 hours.

Testing requirements may be reduced where at least one year of acceptable operational data are submitted from a WTP which uses membranes similar to the proposed membranes, treats feed water of similar quality and under similar operating conditions. Data from previous studies conforming to these guidelines will be considered.

Similarity of feed water quality parameters which may affect the operation of the membrane should be statistically demonstrated. Such parameters may include: turbidity, total organic carbon, algae, calcium, magnesium, total hardness, total alkalinity, pH and temperature.

The testing may not be required if the operational data submitted are for a feed water of similar quality, the same membrane, and the same operating conditions.

- 3.3 The following data should be collected for the demonstration study. Data collection for control unit sampling locations should only apply to upgrading existing membrane plants.

3.3.1 Turbidity

<u>Turbidity Requirements</u>	<u>Frequency</u>
Raw Water	daily ²
Piloted Membrane Feed water	every 4 hours
Control Membrane Feed water	every 4 hours
Piloted Membrane Permeate	every 4 hours ³
Control Membrane Permeate	every 4 hours ³

² Raw Water, at least daily, more frequent when raw water turbidity is expected to be changing based on historical data.

³ OEPA recommend continuous testing for permeate. Continuous turbidity analyzers shall be standardized in accordance with Ohio EPA guidance.

3.3.2 Other parameters

<u>Parameters</u>	<u>Frequency</u>
Water temperature	Daily
Flow rates	Every 4 hours
Backwash method, duration, frequency	(As performed)
Membrane feed and permeate pressures	Every 4 hours
Direct integrity testing and results	Daily

Additional data may be needed for treatment objectives beyond particulate and microbiological removal requirements for surface water treatment.

3.4 Data analysis should be performed for the pilot membrane and control membrane, if used, and should consist of, at least:

3.4.1 Turbidity

3.4.1.1 Raw water, membrane feed, and permeate for both pilot and control membranes:

Maximum, average, minimum and standard deviation.

Graphical representation versus time, and trend analysis.

3.4.1.2 Pilot membrane and control membrane permeates:

Percent of time turbidity exceeds 0.3 NTU

Note: It should be recognized that a well operated membrane system should be capable of achieving turbidity values significantly below 0.3 NTU.

3.4.2 Other data

Pilot and control membrane results of the following:

Pretreatment

Post treatment

Flow rates - graphical representation versus time, and trend analysis

Membrane flux - graphical representation versus time, and trend analysis

Percent recovery - graphical representation versus time, and trend analysis

Backwash method, duration, frequency

Transmembrane pressure - graphical representation versus time, and trend analysis

Direct and indirect integrity testing and results

3.4.3 Membrane Maintenance Recommendations

The demonstration study data and other relevant data should be evaluated and a recommendation made regarding cleaning frequency and procedures to optimize membrane performance and longevity.

4.0 APPROVAL CRITERIA

Membranes are eligible for log removal credits up to the level documented by the challenge tests results submitted. Log removal credits will be granted up to the requirements of the OAC rules in effect at the time the approval of the demonstration study. Documented log removal capabilities in excess of current requirements are eligible for log removal credits to satisfy future requirements. Where the log removal credit granted is equal to the total inactivation/removal requirement, additional inactivation is not required.

4.1 Piloted membranes should be tested the entire period specified. If the membrane to be used in the full scale water treatment plant is different from the piloted membrane, additional testing may be required. Changes should be described and potential impacts should be discussed to determine if additional testing is needed.

4.2 A report shall be submitted in which the data collected, results of the data analysis, and the conclusions and recommendations are presented and clearly summarized.

The results of the data analysis should be presented in an acceptable format. Data should also be submitted in an agreed on electronic format. The report should also include all other data collected during start up prior to each test period.

For each operation mode performed during the demonstration study, the pertinent parameters (raw water source, chemical type and dose, pH, etc.) should be clearly defined and presented in the report.

4.3 Permeate turbidity from a pilot membrane should:

4.3.1 Be less than 0.3 NTU in at least 95 percent of the samples during the test period.

4.3.2 Be less than 1 NTU in all samples during the test period.

4.4 Integrity Testing

The integrity testing program submitted in accordance with Section 2.2 for the full scale plant must be capable of verifying the log removal credits granted. Any changes in the integrity testing program during full scale operations must be reviewed and approved by the agency. Unapproved changes in integrity testing may reduce or void log removal credits.

5.0 Conflict Resolution

Conflicts in interpretation of whether the Demonstration Study has met the Approval Criteria will be resolved following the procedures as specified in the document, "Action Plan", Drinking Water Plan Review Work Group Final Report, draft July 15, 2003.

VI. HISTORY

The Division of Drinking and Ground Waters first issued this policy on September 16, 2003.