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Guidelines for Obtaining Approval of Membranes to Meet Treatment Requirements for Ground Water Treatment

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This document was developed in consultation with the Technology Committee of the Ohio Section of the American Water Works Association for purposes of providing technical guidance to members of the regulated community to comply with the Ohio Revised Code (ORC) and Ohio Administrative Code (OAC). This guidance is not intended to create any new requirement but is merely a suggested approach. Nothing herein should be interpreted as precluding other ways/strategies to complying with those requirements.

I. PURPOSE:

To establish standard protocols for obtaining approval of a membrane process to meet regulatory requirements and other treatment objectives for ground water. Approval for membranes used to treat ground waters under the influence of surface water must follow the guidelines 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 ground water treatment at reasonable cost. Membrane treatment of ground water may address a variety of water quality problems such as arsenic, radionuclides, hardness, total dissolved solids, taste and odor, color, disinfection byproducts formation, organics removal, or other contaminants that might be present.

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

If deviations from this protocol are considered, a meeting with the Central Office Engineering Group is highly recommended.

II. BACKGROUND AND OBJECTIVES:

The OAC requires public water systems that use a ground water source to meet the water quality standards for inorganic contaminants, organic contaminants, radiological contaminants, and corrosion control (OAC rules 3745-81-11, 3745-81-12, 3745-81-15, 3745-81-80, respectively). Water systems may need to use treatment processes to meet those standards. Membrane technology is a process that may be used to satisfy the

requirements of the OAC and other treatment objectives such as softening. It is not expected that membrane treatment will satisfy all requirements for treatment of ground water. The total treatment scheme must be evaluated; consideration must be given to pretreatment and post treatment processes, (i.e., including blending, corrosion control and stability.)

The objective of this guideline is to achieve consistency throughout the State of Ohio in administering provisions of the OAC in regard to the use of membranes for compliance with ground water treatment requirements and provide guidelines for other unregulated objectives.

III. OTHER APPLICABLE GUIDANCE:

Recommended Standards for Water Works 2003 Edition, Great Lakes - Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers, (also referred to as "Ten States Standards").

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

Guidance Manual for Membrane Filtration, USEPA (In Progress)

AWWA Manual of Water Supply Practices (M46): Reverse Osmosis and Nanofiltration, AWWA, 1999.

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

IV. POLICY:

In consultation with Ohio Section AWWA – Technology Committee, the Division of Drinking and Ground Waters (DDAGW) recommends the following procedures be used to determine the acceptability of membranes for treatment of ground water at water treatment plants (WTPs).

V. PROCEDURE:

1.1 A demonstration study (as described in Section 2.0) should be performed prior to implementation of membrane treatment ; a proof test (as described in Section 3.0) should also be performed prior to making modifications to an existing membrane treatment facility.

1.1.1 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 and/or proposed processes that will precede the membrane units in the proposed design to help ensure the validity of testing results. When a new membrane treatment plant is proposed, all pretreatment processes will need to be included in the demonstration study.

1.1.2 Where utilization of a different membrane model at an existing membrane plant 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. The test should follow the requirements of the proof test listed in Section 3.0.

1.1.3 In the event the pilot scale demonstration study is used to establish the membrane performance criteria requirements needed to design the treatment facility, and a different membrane model than that which was tested is proposed to be installed in the full scale plant, a 700 hour proof test is recommended. This proof test is designed to verify that the operational performance requirements of the new membrane model meet or exceed the design criteria.

The following table summarizes the suggested minimum testing:

Suggested Minimum Testing		
Scenario	Demonstration Study (Refer to Section 2.0)	Proof Test (Refer to Section 3.0)
New Membrane Facility	**X**	
Modification of an Existing Membrane Process		**X**
Change of Membrane Model		**X**

1.2 Operational conditions to be evaluated should include:

Permeate flux, percent recovery, backwash frequency, backwash duration, backwash method, CIP method, frequency, flux recovery, transmembrane pressure, pretreatment, and post treatment.

1.3 If a new membrane is being tested in an existing membrane plant, and the membrane process is needed to comply with the maximum contaminant level (MCL) of a

contaminant, the permeate from the membrane being tested should be discharged to waste. If the membrane process is only used for treatment of aesthetic contaminants which are not subject to MCL requirements, the permeate may be discharged to service.

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. A National Pollutant Discharge Elimination System (NPDES) permit is required based on waste stream characterization, receiving stream low flow discharge, and protection of water quality standards.

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_listing11.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 water system 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 Rules 3745-03) if it is a "significant industrial user" (OAC Rule 3745-36-02(U)).

1.5 It is highly recommended that 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, be involved in the demonstration study or proof test. (See foot note [1])

2.0 Demonstration Study

2.1 Demonstration Criteria

The purpose of the demonstration study is to assess the performance and reliability

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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; piloting more than one membrane is recommended.

of the membrane process 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 Ohio EPA. Prior to the performance of the demonstration study, a plan containing he following information should be submitted and approved.

2.1.1 A description of the existing or proposed wells or wellfields and existing treatment facilities. Reliable raw water quality analyses for all parameters with MCLs, iron, manganese, calcium hardness, magnesium hardness, total alkalinity, and pH should be provided. Existing raw water and finished water quality data will be considered. Additional sampling may be required for gaps in data or data that may not represent existing conditions. Varying water quality in the source water for the pilot system should to be addressed. Results of a silt density index test (ASTM standard D4189-95) should also be provided for each existing well and the proposed source for the pilot test.

2.1.2 Statement of objectives and conclusions from an evaluation of the raw water quality, identifying critical water quality issues to be evaluated during the study.

2.1.3 Analysis of the raw water quality to determine scalants or foulants likely to affect membrane performance (e.g. via computer simulation). Based on this analysis, pretreatment methods and goals should be provided.

2.1.4 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.

2.1.5 Target ranges for all finished water quality parameters, including stability and corrosion.

2.1.6 Mode(s) of operation to be tested.

2.1.7 Time schedules for each mode of operation in relation to the critical water quality issues to be evaluated (Item 2.1.2).

2.1.8 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.

2.1.9 Contaminants and other water quality indicators to be monitored at each sampling location.

2.1.10 Frequency of monitoring for each contaminant and water quality indicator.

2.1.11 Description of on-line and bench analytical equipment to be used for monitoring each parameter.

2.1.12 Quality assurance/quality control procedures to be used. All parameters for which Ohio EPA laboratory certification is available shall be conducted in an Ohio EPA certified laboratory.

2.1.13 A target for the level of reduction of specific flux that will trigger a clean in place operation.

2.2 The demonstration study should be performed to assess the performance and fouling potential of the membrane selected for the study. The demonstration pilot study should last a minimum of 2000 operational hours. The operational hours do not need to be continuous.

The collection of primary and secondary contaminant removal data should coincide with operating conditions proposed for the full scale plant. The membrane pilot system should operate continuously for at least 200 hours at the operating conditions proposed, during which time the two sampling events for primary and secondary parameters should be performed. (Note: It is recommended that the 200 hour data collection test period begin after a minimum “settling-in period” of 200 operational hours to allow for the operation of new membranes to stabilize.)

2.3 The demonstration study plan should include a target for the reduction of specific flux. If the target reduction of specific flux is reached, a clean in place operation should be performed and flux recovery shall be measured. At this time, if the fouling potential has been adequately determined, the test may be terminated. Alternately, the membrane should be cleaned and evaluated for flux recovery at the bench scale. If a change of operating conditions is warranted, additional testing may be required.

Note: A laboratory analysis of the membrane following the operational test to determine the nature of any scalants or foulants which have caused flux reductions may be helpful in determining the types of pretreatment and effective cleaning procedures needed during operation.

2.4 Based on submitted raw water quality, any contaminant at concentrations at or above 80% of the MCL or secondary maximum contaminant level (SMCL) for the finished water should be monitored at the frequency in the following table. Additional data should be collected at the frequency in the table.

Where the two measured permeate concentrations for either a primary or secondary contaminant are significantly different from one another, and the differences cannot be explained by changes in feed water quality or operational parameters, a third sample should be taken for that parameter. Two monitoring results are considered significantly different when the higher of the two results is at least two times greater

than the lower value and the higher value exceeds the primary or secondary MCL. Data collection for control unit sampling locations only applies for upgrading existing membrane plants.

Note: Parameters not included in the table that may cause fouling of the membrane should also be monitored.

	Raw Water	Control Membrane Influent	Piloted Membrane Influent	Control Membrane Permeate	Piloted Membrane Permeate
Primary Contaminants	2	2	2	2	2
Secondary Contaminants	2	2	2	2	2

	Raw Water	Control Membrane Influent	Piloted Membrane Influent	Control Membrane Permeate	Piloted Membrane Permeate
Alkalinity, Total	8	8	8	8	8
Calcium Hardness	8	8	8	8	8
Magnesium Hardness	8	8	8	8	8
pH	8	8	8	8	8
Total Hardness	8	8	8	8	8
Total Coliform	2	2	2	2	2
Conductivity	8	8	8	8	8

Other Data: Pretreatment
Post treatment
Membrane flux
Flow rates
Percent water recovery
Backwash method, duration, frequency (if applicable)
Transmembrane pressure
Chemicals added and doses
Cleaning in place method and frequency
Additional data may be needed for certain specific treatment objectives

2.5 Post Treatment

2.5.1 If post-treatment processes are necessary for stabilization of the membrane

permeate or blended water, they should be tested at the bench scale to verify the finished water quality goals presented in the demonstration study plan. Examples of such post-treatment processes include chemical pH adjustment, blending of permeate with non-membrane treated water, and air stripping. The applicant should bench scale test these processes and analyze the resulting finished water for total alkalinity, calcium hardness, magnesium hardness, pH, total hardness, and any other key parameter presented in the demonstration study plan related to finished water stability, and quality. The bench scale testing of post-treatment processes should be performed a minimum of two times during the data collection period.

2.5.1 Piloting or bench scale treatment of bypass streams or blended streams may be required to ensure that relevant finished water MCLs are met.

2.6 Data analysis should consist of at least:

2.6.1 Primary contaminants, secondary contaminants and additional data:

Maximum, average, and minimum for each operating condition for each sample point.

2.6.2 Other data

Pilot and/or control membrane results for each operating condition of the following:

Pretreatment
Post treatment
Membrane flux - graphical representation vs. time and trend analysis
Flow rates - graphical representation vs. time and trend analysis
Percent water recovery - graphical representation vs. time and trend analysis
Backwash method, duration, frequency (if applicable)
Transmembrane pressure - graphical representation vs. time and trend analysis
Direct and indirect integrity testing and results (if applicable)
Cleaning in place method and frequency
Additional data may be needed for certain specific treatment objectives

2.6.3 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.

3.0 Proof Test

In lieu of a demonstration pilot study, the applicant may perform a proof test (see Section 1.1.3) to verify the performance of a new membrane model with existing design criteria. The purpose of the proof test is to verify that the operational performance requirements of the new membrane meet or exceed the design criteria. Prior to the performance of the proof test, a proof test plan should be submitted and approved. The plan should include:

3.0.1 Target ranges for all finished water quality parameters, including stability and corrosion.

3.0.2 Mode(s) of operation to be tested.

3.0.3 Time schedules for each mode of operation in relation to the critical water quality issues to be evaluated.

3.0.4 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.

3.0.5 Parameters to be monitored at each sampling location.

3.0.6 Frequency of monitoring for each parameter.

3.0.7 Description of on-line and bench analytical equipment to be used for monitoring each parameter.

3.0.8 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 Proof Test Data requirements

The proof test should last a minimum of 700 operational hours. The operational hours do not need to be continuous.

The collection of primary and secondary contaminant data should coincide with operating conditions proposed for the full scale plant. The proof test should be operated under these conditions continuously for at least 200 hours during which time the two sampling events for primary and secondary parameters are performed. (Note: It is recommended that the 200 hour data collection period begin after a “settling-in period” to allow for the operation of new membranes to stabilize. This period should last a minimum of 200 operational hours.)

The following data should be collected for the proof test. Based on submitted raw water quality, any contaminant at concentrations at or above 80% of the MCL or SMCL for the finished water should be monitored at the frequency on the attached table. Additional data should be collected at the frequency in the table below.

PROOF TEST DATA

	Raw Water	**Control Membrane Influent**	**Piloted Membrane Influent**	**Control Membrane Permeate**	**Piloted Membrane Permeate**
Primary Contaminants	2	2	2	2	2
Secondary Contaminants	2	2	2	2	2

Additional Data	**Raw Water**	**Control Membrane Influent**	**Piloted Membrane Influent**	**Control Membrane Permeate**	**Piloted Membrane Permeate**
Alkalinity, Total	4	4	4	4	4
Calcium Hardness	4	4	4	4	4
Magnesium Hardness	4	4	4	4	4
pH	4	4	4	4	4
Total Hardness	4	4	4	4	4
Total Coliform	2	2	2	2	2
Conductivity	4	4	4	4	4

Other Data: Pretreatment
Post treatment
Membrane flux
Flow rates
Percent water recovery
Backwash method, duration, frequency (if applicable)
Transmembrane pressure
Chemicals added and doses
Cleaning in place method and frequency
Additional data may be needed for certain specific treatment objectives

4.0 Approval Criteria

4.1 OAC rule 3745-91-06 requires that supporting information for plans submitted for approval include the basis for design and other relevant information that may not be fully evident from the plan drawings and specifications. The results of demonstration

studies and proof tests will provide part of the basis for design for membrane treatment systems and would not likely be evident from plan drawings and specifications. Therefore, for each demonstration study or proof test, a report should 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 to ensure the information is usable. The Ohio EPA prefers that data submitted also be provided in an agreed on electronic format. The report should also include all other data collected during start up. For each operation mode performed during the demonstration study, the pertinent parameters (raw water source, all chemicals used and dosages pH, etc.) should be clearly defined and presented in the report. Any changes from the accepted protocol should be discussed and justified.

4.2 The piloted membrane should demonstrate its capability to meet the objectives of the pilot study.

4.3 Primary and secondary contaminants for all required samples for finished water shall be less than their respective MCLs or SMCLs (for iron and manganese).

5.0 Conflict Resolution

Conflicts in interpretation of whether a proposed pilot study or proof test has met the approval criteria will be resolved according to the procedures specified in the document, Drinking Water Plan Review Work Group Final Report, November, 2003.

HISTORY:

The Division of Drinking and Ground Waters first proposed this policy on February 2, 2001 and issued it on November 28, 2005.