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File PWS 2430001/CO
CN 600129316
RN 101611275

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

August 27, 2007

Ms. Susan Crawford, P.E.
Camp Dresser & McKee Inc.
8140 Walnut Hill Lane, Suite 1000
Dallas, Texas

Subject: Second HF Membrane Wastewater Reuse Pilot Study Report Protocol for the Treatment of Wastewater Effluent from the River Road WWTP
City of Wichita Falls – PWS ID #2430001
Wichita County, Texas

Dear Ms. Crawford:

The City of Wichita Falls (City) previously piloted Zenon's ZeeWeed® 500B and 1000 hollow-fiber (HF) ultrafiltration (UF) membranes for treating the wastewater effluent from the City's River Road Wastewater Treatment Plant (WWTP) in 2001. The City had requested that the Texas Commission on Environmental Quality (TCEQ) grant an exception to use one of these HF UF membrane treatment processes and be able to use this filtrate as a raw water source for the Jasper and Cypress Surface Water Treatment Plant's (SWTP) where additional water treatment will be received prior to distributed as potable water. In the TCEQ's letters dated July 31, 2002, January 7, 2004, and September 22, 2004, we granted an exception for the use of the Zenon ZeeWeed® 500B or 1000 HF UF membrane and the associated piloted treatment scheme for the proposed reclaim of wastewater effluent and use as a raw water source for the City's Jasper and Cypress SWTPs with specific design and operating conditions. Your letter dated October 11, 2005, requested that the TCEQ grant the same exceptions for the Pall and Siemens Memcor membranes. In the TCEQ's letter dated September 12, 2006, we stated we were unable to complete our review of the Siemens Memcor pilot study and that the Pall pilot study was unacceptable.

We have completed our review of the proposed second HF membrane pilot study protocol received on April 24, 2007. It is our understanding that the City now wishes to pilot the Pall Microza® USV 6203 HF microfiltration (MF) and the Siemens Memcor 4S10V HF MF membranes in accordance with the TCEQ's accepted pilot study protocol. In addition, Zenon wishes to pilot their HF UF membranes again. It is noted that several changes have been made to Zenon's membranes since the original pilot study and they would no longer be able to provide the membrane modules originally piloted. It was also noted that the City saw the need for denitrification of the WWTP's effluent prior to the membranes as a result of the previous pilot study. If this treatment process has been installed, then the feed water quality would be different from that piloted in 2001. Based on our review, we find that the submitted HF membrane pilot study protocol is **generally acceptable if amended to include:**

1. The log removal value verified by each membrane vendors direct integrity test (DIT) as calculated using the EPA's Membrane Filtration Guidance Manual – EPA 815-R-06-009, November 2005. Each DIT should be conducted at test pressures that result in a resolution of 3.0-microns to ensure removal of *Cryptosporidium* oocysts and *Giardia lamblia* cysts.

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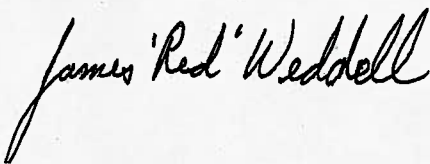
August 27, 2007

2. The pilot study's effluent must be returned to the WWTP (discharging through and air gap) and disposed of in accordance with the City's TCEQ permit.
3. At least twice during the pilot study, the raw water in the Jasper SWTP's terminal raw water basin must be tested for total coliform, viruses, nitrates, nitrites, ammonia and any other chemical constituent in the City's WWTP effluent and Jasper SWTP's source waters that exceed the maximum containment levels specified in 30 TAC Chapter 290, Subchapter F. These analyses will establish baseline data for the raw water prior to blending with the proposed HF membrane filtration facility's effluent.

This pilot study shall be conducted for **at least 50 continuous days** as previously agreed to by the TCEQ Public Drinking Water Section staff. Stage 1 will be conducted for a period of approximately 10 days to verify the coagulant dosage, Stage 2 for at least 30 days and Stage 3 for at least 10 days. It is agreed that all three vendors have collected data in the past to satisfy Stage 1 piloting.

If you have any questions or comments concerning this letter, or if we may be of further assistance, please contact me at the letterhead address or by telephone at (325) 481-8056.

Sincerely,



James "Red" Weddell, P.E.
Technical Review & Oversight Team
Public Drinking Water Section (MC 155)
Water Supply Division

JSW/av

Enclosures: Review of Pilot Study Protocols for Membrane Filtration
 Review of Pilot Study Reports for Membrane Filtration

cc: TCEQ Abilene Regional Office – R3
 Ms. Marlo Wanielista Berg, P.E., Team Leader, Technical Review & Oversight Team (MC 155)
 Mr. John Schildwachter, Team Leader, Source Water Protection Team (MC 155)
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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

PDW PROGRAM STAFF GUIDANCE

Guidance Title: REVIEW OF PILOT STUDY REPORTS FOR MEMBRANE FILTRATION

Rules Affected: Title 30 TAC §290.42(g), §290.104, §290.105, §290.110(b)(1) and §290.111(b)(2)

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This PDW Program Staff Guidance revises and replaces the previous PDW Program Staff Guidance titled, Review of Pilot Study Reports for Membrane Filtration that had an effective date of March 1, 2001. The earlier document expires upon the effective date of this document.

Background

Systems using surface water or groundwater under the influence of surface water must achieve at least a 2.0-log (99%) removal of *Cryptosporidium parvum* oocysts, a 3.0-log (99.9%) removal or inactivation of *Giardia lamblia* cysts, and a 4.0-log (99.99%) removal or inactivation of viruses. Water treatment plants achieve these treatment technique requirements through a combination of physical and chemical barriers.

These treatment techniques are generally achieved at water treatment plants that incorporate coagulation, flocculation, clarification, granular media filtration and disinfection. However, Title 30 TAC §290.42(g) of the Texas Commission on Environmental Quality (TCEQ) rules allows systems to utilize innovative or alternate treatment systems to achieve the treatment technique requirements.

When these innovative or alternate treatment systems are proposed, the rules require a licensed professional engineer to provide pilot test data or data collected at similar full-scale operations demonstrating that the proposed treatment systems will produce water that meets the requirements of Title 30 TAC Chapter 290, Subchapter F, Drinking Water Standards Governing Water Quality and Reporting Requirements for Public Water Systems.

One emerging alternative treatment system that is becoming a cost-effective treatment for many surface water and ground water under the influence of surface water systems is membrane filtration. Membrane filtration units can be installed in lieu of granular media filters at most water treatment plants and, in some cases, can be used in lieu of complete conventional treatment. Normally, these will be of the hollow-fiber (HF) microfiltration (MF) ultrafiltration (UF) types. However, in some cases nanofiltration (NF) and reverse osmosis (RO) membranes are used. While all four types of membranes achieve particulate and microorganism removal, NF and RO membranes can also remove undesirable chemical constituents and may be used for achieving compliance with state and federal drinking water standards. As membrane filtration has become economically feasible, the TCEQ staff have been receiving an increased number of proposals to pilot and install different types of membrane filtration units.

Purpose of this PDW Program Staff Guidance

This PDW Program Staff Guidance is intended to facilitate consistent and timely reviews of pilot study reports submitted on membrane filtration units by the TCEQ staff and develop a written response for each submittal stating whether the pilot study was acceptable or unacceptable. The pilot study report and the TCEQ's written response will be used by the design engineers to develop the required engineering plans and specifications for the proposed membrane installation. Please note that if NF or RO membranes are being proposed to only remove undesirable chemical constituents, a large portion of this document will not apply.

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Pilot Study Report

A pilot study report contains the results of the pilot study and recommendations for the full-scale design criteria. The purpose of a pilot study report is to provide the TCEQ staff with the results and conclusions of the pilot study, and to facilitate acceptance of the recommendations for the full-scale water treatment plant design. When reviewing a pilot study report, the TCEQ staff must be aware of and consider the following.

- I.** Acceptance of pilot study data or the proposed full-scale design criteria is not approval for construction of any membrane units for treatment of water for a public water system. Construction of the membrane water treatment facilities may not begin until the TCEQ staff has reviewed and approved the site-specific final engineering plans and specifications for modifications to an existing or a new full-scale water treatment plant.
- II.** Unless a site-specific request for an exception was received and granted by TCEQ staff, a pilot study must be conducted and data collected for a period of at least 90 days. At least 30 days must be conducted under the proposed full-scale pretreatment scheme and membrane flux rate, TMP, backwash parameters and chemical clean-in-place (CIP) procedures. The 30-day simulated full-scale run must be followed by a CIP procedure and at least another tens of operation under the same full-scale operating conditions.
- III.** The pilot study report must be prepared by the systems's professional engineer, licensed by the Texas Board of Professional Engineers, and accompanied by a cover letter that is signed, sealed and dated.
- VI.** The TCEQ staff that is reviewing a pilot study report may request a meeting with a responsible official of the public water system or their professional engineer prior to accepting the pilot study report or the proposed design criteria.
- V.** Each membrane unit tested must be of the same design and contain fibers of the same length and type as will be specified in the full-scale water treatment plant.
- VI.** As the TCEQ's design capacity and flow reporting requirements are in English Units, the flow rates must be reported in gallons per minute (gpm) or million gallons per day (MGD) and flux rates in gallons per square foot per day (gfd) to facilitate the review process.
- VII.** Pilot studies are normally conducted in three stages. However, each stage may contain more than one phase of testing. The TCEQ requires pilot studies to be conducted for a period of at least 90 days unless a written exception to this requirement was requested and granted. A CIP procedure and direct integrity test must have been conducted prior to beginning each of these three stages of testing.
 - A.** The Stage 1 test period should establish site-specific and full-scale pretreatment operating parameters for each tested membrane unit in regards to pretreatment requirements, specific flux rate, backwash frequency, backwash duration, backwash flow rate, and CIP procedures.

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A selected set of optimized conditions developed under the Stage 1 testing are used to conduct the Stage 2 and 3 testing. If NF or RO membranes are being used in an integrated membrane system to treat only a portion of the water, a blending ratio must be established to achieve compliance with the drinking water standards. Be aware that the Stage 1 test period data may indicate that modifications to the accepted pilot study protocol were required for one or all membrane test units.

- B.** After the Stage 1 test period, a chemical CIP and direct integrity test must be conducted on each membrane test unit before beginning the second stage of testing. The Stage 2 test period must be for a minimum of **30 days** under each membrane unit's selected set of full-scale operating conditions and verify the conclusions reached from data collected during the Stage 1 test period. For any unscheduled downtime greater than 24 hours, documentation must be included indicating that the TCEQ was contacted to see if the Stage 2 test period needed to be restarted.

All membranes are operated under parameters that consist either of a constant flux rate with a varying transmembrane pressure (TMP) or a constant TMP with a varying flux rate. When a membrane is in operation it continues to have an increase in the fouling that the backwash/backflush/reverse flow cycles do not remove. Once the varying parameter degrades to the manufactures recommended set point, a CIP procedure must be conducted to remove the fouling and restore the operating flux rate and TMP to an acceptable level. If the flux rate or TMP for a membrane unit reached unacceptable levels before the end of the 30-day test period, the engineer or system may have chosen to start a membrane unit's Stage 2 test period over under different simulated full-scale operating conditions. However, they may have chosen to conduct a CIP and direct integrity test and complete the 30-day test period under the same operating conditions. In this case, the CIP duration is less than 30 days and the time out of service must be taken into consideration when calculating the TCEQ's approved net capacity because of the decrease in frequency of CIP procedures.

Please note that Norit uses a chemical cleaning process for their membranes that consists of a series of "chemical enhanced backwash (CEB)" procedures using an acidic solution mixed in with the chlorinated filtrate backwash procedures approximately ever 18 to 20 backwashes in lieu of a single CIP procedures conducted ever 30 days or so. The CEB procedures are approximately 10 to 15 minutes in duration. Also, depending on the feed water quality, other membrane vendors will sometimes use similar procedures conducted at frequencies from once per day to once per week that they refer to as "enhanced filtrate maintenance," "mini CIP" or "chemical soaks" to extend the frequency between their normal CIP procedures. All of these procedures result in time out of production for the membrane units and must be taken into account when calculating the TCEQ's approved net capacity for a specific membrane unit. However, single CIP procedures conducted at a frequency of 30 days, or greater, that results in offline periods of less than four hours per month, do not significantly affect the average daily net production.

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- C. The Stage 3 test period must have included a CIP and direct integrity test followed by operating a minimum of ten days at the simulated full-scale operating conditions selected for the Stage 2 testing. This is used to establish the % loss of original specific flux, temperature adjusted to 20° C, and determine if any irreversible membrane fouling of each membrane unit has occurred. If the % loss of original specific flux for a specific membrane unit or % of irreversible membrane fouling is determined to be excessive, the selected full-scale operating conditions may result in the TCEQ's approved design capacity being less than is required or desired by the system. A rapid increase in irreversible fouling can result in degradation of net production and premature replacement of membrane units in a full-scale membrane installation. Under these conditions the reviewing TCEQ staff should include comments in the pilot study review letter stating that the pilot study indicates that the simulated full-scale operating conditions for the specific membrane unit indicates rapid fouling at the selected operating conditions and the potential for rapid degradation of the net production and a short membrane life. Also, the TCEQ's accepted net production for an individual membrane unit may need to be reduced. The designing engineer must address these concerns in the engineering plans and specifications submitted for the full-scale design.
- D. The TCEQ staff must evaluate the data from the three stages of testing to determine if the pilot study was acceptable for the TCEQ to review engineering plans and specifications for a proposed full-scale membrane installation and issue a TCEQ approved net capacity rating for a full-scale membrane filtration installation. The operating parameters during the Stage 2 testing are used to determine the total time a membrane unit would actually be in filtrate production, time in backwash/backflush/reverse flow cycles, and any other production limiting events during a 30-day period. This data is used to calculate the TCEQ's accepted net capacity rating at 20° C. However, the data from the Stage 1 and 3 testing must also be reviewed to determine what, if any, raw water conditions or tested operating parameters will need to be addressed in the site-specific engineering design and specifications.

If the consulting engineer and public water system has already selected one of the piloted membranes, only the pilot study data for the selected membrane will need to be submitted, reviewed and responded to in writing. The TCEQ staff's written response to the submitted pilot study report will be used by TCEQ staff to review the full-scale engineering design and specifications.

VIII. The pilot study report must contain the following background information.

- A. A copy of a TCEQ accepted pilot study protocol, if any. If the prior acceptance of a site-specific pilot study protocol from the TCEQ staff was not received, the pilot study report must indicate that the study was conducted in accordance with a pilot study protocol and include a copy of the pilot study guidelines. (See PDW Program Staff Guidance: Review of Pilot Study Protocols for Membrane Filtration)

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B. General information about the site where the pilot study was conducted.

1. The name of the public water system and water treatment plant(s) involved in the pilot study.
2. The Public Water System I.D. number.
3. The name of the raw water source or sources proposed for treatment by membrane filtration and the water rights allocation.
4. A USGS 7.5-minute quadrangle map showing the location of the intake structure(s) used during the pilot study. If the location of the intake for the pilot study differs from that of the existing water treatment plant, or that of the proposed full-scale membrane water treatment plant, both locations must also be shown on the map.
5. A schematic of the pilot plant that shows chemical feed points, pretreatment facilities, pilot equipment, flow meters, and monitoring points.

C. The pilot study report must contain the following information for each membrane module that was evaluated.

1. Membrane manufacturer's name;
2. Type of membrane (MF, UF, NF, RO);
3. Documentation that the piloted membrane unit conformed to American National Sanitation Institute/National Sanitation Foundation (ANSI/NSF) Standard 61 and has been certified by a testing organization accredited by ANSI;
4. Material the membrane fiber is constructed of;
5. Length of membrane fiber;
6. Surface area of the feed water side of the membrane module/element;
7. Flow direction (inside out or outside in)
8. Nominal and maximum pore sizes;
9. Oxidant resistance;
10. Water temperature operating range;
11. Feed water turbidity operating limit;
12. Method of operation (dead-end or crossflow);
13. Maximum recommended instantaneous filtrate flux rate;
14. Maximum allowable TMP;
15. The required direct integrity test pressure to detect a defect as small as 3.0 microns (see the most recent draft or adopted version of the ASTM document titled, Standard Practice for integrity Testing of Water Filtration Membrane Systems);
16. Concentration factor (CF), defined as a measure of the increase in concentration of the contaminant that could occur on the high pressure side of the membrane relative to the raw water;
17. Flow from the smallest breach (3.0 microns), at the maximum recommended instantaneous filtrate flux rate, that can be detected by the direct integrity test; and,

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18. Log removal value (LRV) as defined in EPA guidance (Also, see PDW Program Staff Guidance titled, Membrane Filtration Terms Defined).
- IX. A pilot study report must provide the following CIP (and any other chemical cleaning procedures such as "mini CIP," CEB and chemical soaking procedures) data for each membrane module that will be considered for the full-scale water treatment plant.
 - A. All chemicals used and their concentrations;
 - B. Documentation that all chemicals used conformed to ANSI/NSF Standard 60 and have been certified by a testing organization accredited by ANSI;
 - C. Flow rate;
 - D. Duration (time offline);
 - E. Quantity of filtrate water used;
 - F. Disinfectant residual (if applicable);
 - G. pH of the chemical solution;
 - H. Temperature of the chemical solution;
 - I. Procedure;
 - J. Disposal method of chemical waste; and,
 - K. The expected chemical cleaning frequency for the full-scale membrane water treatment plant.
 - X. The TCEQ requires continuous/indirect integrity monitoring of the filtrate water of each manufacturer's membrane test unit. For removal credit of particulates and microorganisms, this may be accomplished by continuous on-line particle counters and monitors or Hach FilterTrak (FT660) laser turbidimeters (for individual membrane rack/tank filtrate/permeate only). Any other method must have received the TCEQ staff's acceptance prior to beginning the pilot study.
 - XI. The pilot study report must include a list of the analytical methods and equipment used during the pilot study and describe the calibration procedures and frequency for the analytical equipment and flow meters.

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- A. Some acceptable analytical procedures, calibration procedures, frequency, and accuracy of measurement requirements are found in Title 30 TAC §290.46(s), §290.110(d), §290.111(d) and §290.119.
 - B. If ozone was used, residuals must have been measured and reported to a minimum accuracy of ± 0.02 milligrams per liter using the Indigo Method as specified in Standard Methods, 20th Edition, 4500-O₃B.
 - C. Benchtop particle counters/monitors must have been calibrated as specified in the EPA/NSF Equipment Verification Testing (ETV) Plan: Membrane Filtration for the Removal of Microbiological and Particulate Contaminants, Chapter 13.0, Section 13.8.3 prior to startup of the pilot study and again before beginning the simulated full-scale plant test portion of the pilot study. Benchtop particle counters/monitors must be equipped with a sensor capable of identifying particle sizes in the 2 - 15 micron range and reporting the total count with a coincidence error of less than 10%.
 - D. On-line particle counters/monitors must have been calibrated according to the manufacturer's specification prior to the startup of the pilot study and verified weekly against the results of a calibrated benchtop particle counter/monitor. On-line particle counters and monitors must be equipped with a sensor capable of identifying particle sizes in the 2 - 15 micron range and reporting the total count at five-minute intervals for this range with a coincidence error of less than 10%.
- XII.** The pilot study report must contain the following graphs for each membrane unit being considered for full-scale installation. Each of the graphs must show the time the data was collected on the x-axis and the results of the measurements on the y-axis. The scale of each axis must be such that data at **four hour intervals** and all chemical cleaning events can be clearly identified.
- A. A graph showing the **daily** turbidity levels (using a Hach 1720C or TCEQ accepted equivalent) of the raw water and **any time there is a change that affected the operating parameters**;
 - B. A graph showing the total particle counts in the 2 to 15-micron range at **15-minute intervals** for the feed water and at **five-minute intervals** for the filtrate/permeate water;

or

A graph showing the turbidity levels at **15-minute intervals** for the feed water (using a Hach 1720C or TCEQ accepted equivalent) and at **five-minute intervals** for the filtrate/permeate water (using a Hach FilterTrak Model 660);
 - C. A graph showing filtrate/permeate flux rates and corresponding TMP at **four-hour intervals**;

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- D. A graph showing the daily filtrate/permeate flux rates and corresponding feed water temperatures;
- E. A graph showing the daily average specific flux rates (adjusted to 20° C) and % recovery of specific flux; and,
- F. A graph showing the % loss of original specific flux rate for each Stage 2 filtrate run and the corresponding feed water turbidity levels during the run.

XIII. A pilot report must contain each of the following data summary tables. Each of the tables must contain the number of data points collected, the range of data values (i.e., the maximum and minimum values), the average value, and the 95th percentile value if more than 10 data points were collected.

- A. A "log removal table" summarizing the feed water and filtrate/permeate water data and the level of daily removal achieved for each of the following parameters.
 - 1. Turbidity;
or
Particle counts;
 - 2. The calculated Log Removal Value; and,
 - 3. *E. coli* (if that data was collected).
- B. A "membrane performance table" summarizing the following operating conditions and each membrane module's performance during the pilot study.
 - 1. Feed water flow rate;
 - 2. Filtrate water flow rate;
 - 3. Recycle flow rate (if applicable);
 - 4. Reject flow rate (if applicable);
 - 5. Filtrate flux;
 - 6. TMP;
 - 7. Feed water temperature;
 - 8. Specific flux (adjusted to 20° C);
 - 9. % recovery of specific flux after a CIP;
 - 10. Each direct integrity test's beginning pressure, ending pressure and duration;
 - 11. The calculated maximum log removal based on: $LR_{max} = \text{LOG}[Q_{filtrate} / CF \times Q_{breach}]$
(Where, $Q_{filtrate}$ is the actual design flow, CF is the concentration factor, and Q_{breach} is the flow rate from a 3.0-micron breach in a module's components as detected by the required direct integrity test);
 - 12. % loss of original specific flux due to irreversible fouling;
 - 13. Backwash frequency;

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14. Backwash duration; and,
15. Backwash flow rate.

C. A "water quality table" summarizing the results of the following water quality analyses.

1. Raw water total hardness as calcium carbonate;
2. Raw water total alkalinity;
3. Raw water iron, manganese and aluminum;
4. Raw water total dissolved solids (TDS), total suspended solids (TSS) and conductivity;
5. Raw water pH;
6. Raw water algae count;
7. Feed water pH (if it was different from raw water);
8. Feed water algae count (if it was different from the raw water count);
9. Filtrate water pH;
10. Raw and filtrate TOC levels (if a coagulant was fed); and,
11. Filtrate water conductivity or TDS (if NF or RO membranes were piloted).
12. If NF or RO membranes are being used to remove regulated chemical constituents, include the calculations for determining a blending ratio that will produce a finished water quality that meets all state drinking water standards.

XIV. If a disinfectant was applied during the study, the pilot study report must include a "disinfection data table" for each of the following that includes the number of data points collected, the range of data values (i.e., the maximum and minimum values), and the average value.

- A. Each disinfectant and application point;**
- B. Disinfectant dosage;**
- C. All disinfectant residual levels;**
- D. Total Trihalomethanes (TTHM);**
- E. Haloacetic Acids (HAA5);**
- F. Chlorite (if chlorine dioxide was used); and,**
- G. Bromate (if ozone was used).**

XV. A pilot study report must include a detailed description of the site conditions and each membrane unit's testing. The following information must be included in this description.

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- A. A description of the raw water source, the raw water intake and all pretreatment facilities.
- B. A description of the manufacturer's required membrane preconditioning method that occurred prior to the pilot study.
- C. All rainfall events on the watershed during the pilot study.
- D. If conventional pretreatment (coagulation, flocculation, clarification) was not provided in the pilot study, then the pilot study period must have included at least one raw water spike associated with a major rainfall event or a turbidity spike created using a turbidity spiking technique. The raw water spike or turbidity spike must be representative of the source's historical raw water turbidity highs. The method of turbidity spiking must have received the TCEQ staff's prior approval and be included in the pilot study report.
- E. A description of how the results of the initial Stage 1 testing resulted in the selected Stage 2 simulated full-scale operating conditions piloted for each membrane unit.
- F. A description of any equipment failures and any resulting time delays.
- G. A detailed analysis of the pilot study data for each membrane unit.

END

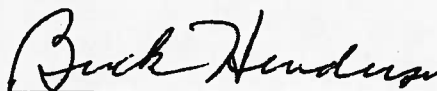
REFERENCES:

1. ASTM 2001 Draft: STANDARD PRACTICES FOR INTEGRITY TESTING OF WATER FILTRATION MEMBRANE SYSTEMS
2. AWWA MEMBRANE PRACTICES FOR WATER TREATMENT
3. AWWA WATER TREATMENT PLANT DESIGN
4. AWWA Manual: REVERSE OSMOSIS AND NANOFILTRATION (M46)
5. EPA's LT2ESWTR Draft Language
6. NSF Equipment Verification Testing Plan: MEMBRANE FILTRATION FOR THE REMOVAL OF MICROBIOLOGICAL AND PARTICULATE CONTAMINANTS

April 1, 2004

Effective Date

Expiration Date



Buck Henderson, Section Manager
Public Drinking Water Section
Water Supply Division

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

PDW PROGRAM STAFF GUIDANCE

Guidance Title: REVIEW OF PILOT STUDY PROTOCOLS FOR MEMBRANE FILTRATION

Rules Affected: Title 30 TAC §290.42(g), §290.104, §290.105, §290.110(B)(1) and §290.111(b)(2)

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This PDW Program Staff Guidance revises and replaces the previous PDW Program Staff Guidance titled, Review of Pilot Study Protocols for Membrane Filtration that had an effective date of March 1, 2001. The earlier document expires upon the effective date of this document.

Background

When innovative or alternate treatment techniques are proposed, 30 TAC §290.42(g) requires a licensed professional engineer to provide pilot test data or data collected at similar full-scale operations demonstrating that the proposed treatment technique will produce a finished water that meets the requirements of 30 TAC Chapter 290, Subchapter F, Drinking Water Standards Governing Water Quality and Reporting Requirements for Public Water Systems. Engineers can demonstrate this capability through the use of pilot study data submitted in a pilot study report to the Texas Commission on Environmental Quality (TCEQ) for review and acceptance prior to submitting site-specific engineering plans and specifications for a treatment facility using an innovative treatment technique. Some innovative treatment technologies being proposed are the use of microfiltration (MF) and ultrafiltration (UF) membranes in lieu of granular media filtration; and nanofiltration (NF) and reverse osmosis (RO) membranes to remove both undesirable chemical constituents and microorganisms. To ensure that a pilot study report contains the information needed by the TCEQ, a pilot study protocol should be submitted for the TCEQ's review and acceptance. (See PDW Program Staff Guidance: Review of Pilot Study Reports for Membrane Filtration for more information on pilot testing membrane technologies.)

Purpose of this PDW Program Staff Guidance

This PDW Program Staff Guidance is intended to facilitate consistent and timely reviews of pilot study protocols submitted for membrane filtration pilot studies and assist TCEQ staff in developing written responses to these submittals.

Also, if a system failed to submit an acceptable pilot study protocol or fails to conduct the pilot study in accordance with the accepted protocol, the TCEQ staff reviewing the pilot study report should use this PDW Program Staff Guidance to determine if the scope and nature of the study report and resulting data is adequate.

Pilot Study Protocol

The pilot study protocol is a written plan which defines the scope and duration of the pilot study. Its purpose is to help assure that the pilot study will produce all of the information needed for an engineer to design a site-specific, full-scale membrane filtration installation and verify that the finished water will meet minimum federal and state requirements for potable water quality and quantity.

When reviewing a pilot study protocol, the TCEQ staff should consider the following criteria prior to accepting the proposed protocol.

- I. A pilot study protocol should address each of the components and all of the information that will be required in a pilot study report (See PDW Program Staff Guidance: Review of Pilot Study Reports for Membrane Filtration).

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- II.** A pilot study protocol must be prepared under the direction of a professional engineer licensed by the Texas Board of Professional Engineers. A submitted pilot study protocol must be accompanied by a cover letter that is signed, sealed, and dated by the professional engineer representing the public water system and having oversight of the pilot study to be conducted.
- III.** A responsible official of the public water system or their professional engineer may request a meeting with TCEQ staff prior to submitting a pilot study protocol.
- IV.** If the professional engineer is requesting an exception to all or part of the TCEQ's pilot study requirements, the request for an exception must contain equivalent data from one or more of the following sources:
 - A.** A previous pilot study report, or reports, on the selected membrane unit conducted at a site with a source that has a similar or worse raw water quality than the proposed source for the selected membrane treatment process and a table comparing the raw water qualities.
 - B.** A full-scale water treatment plant using the selected membrane module at a site with a source that has a similar or worse raw water quality than the proposed source for the selected membrane treatment process and a table comparing the raw water qualities.
 - C.** An EPA/NSF Environmental Technology Verification (ETV) report on the selected membrane unit conducted at a site with a source that has a similar or worse raw water quality than the proposed source for the selected membrane treatment process and a table comparing the raw water qualities.
 - D.** The raw water comparison must include at least one years' worth of data for the minimum, average, and maximum water quality levels of the proposed raw water source and intake location for the following.
 - 1.** Water temperatures;
 - 2.** Turbidity levels;
 - 3.** Total suspended solids (TSS) and total dissolved solids (TDS);
 - 4.** pH;
 - 5.** Alkalinity;
 - 6.** Total hardness as calcium carbonate;
 - 7.** Conductivity; and,
 - 8.** Regulatory minerals and metals.
- V.** The pilot study protocol must contain a description of all pretreatment schemes to be tested. Any level of pretreatment proposed for a pilot study must be equivalent to (it can be less than, but not greater than) that which will be provided at the proposed site-specific, full-scale membrane filtration installation.

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- VI.** The membrane units being tested must be of the same design and contain fibers of the same length and type as that being evaluated for a full-scale membrane filtration water treatment plant. All membranes units (membrane and vessel) being tested must conform to the American National Standards Institute/National Sanitation Foundation (ANSI/NSF) Standard 61 and be certified by an organization accredited by ANSI.
- VII.** The membranes used in the pilot study must be "preconditioned" in accordance with manufacturers' recommendations. Preconditioning, if required, must be completed prior to beginning the pilot study.
- VIII.** All chemicals used during a pilot study must be the same as those that will be used in the proposed full-scale membrane installation and must conform to the ANSI/NSF Standard 60 and be certified by an organization accredited by ANSI. This includes any chemicals used to clean the membranes on-site.
- IX.** A pilot study must be conducted for a period of at least 90 days during a season that represents adverse operating conditions for a full-scale membrane installation. Pilot studies are normally conducted in three stages. However, the consulting engineer and system may choose to divide the pilot test into more stages of testing. As long as the submitted pilot study protocol includes each of the following activities during the course of the pilot study, it will meet the TCEQ's minimum requirements.
 - A.** The first stage of testing is used to pilot the membrane test units under different operating conditions. The Stage 1 test period must establish site-specific and full-scale pretreatment and operating parameters for each membrane unit to be tested. Be aware that the Stage 1 testing results may indicate site-specific conditions that require modification to a submitted and TCEQ accepted pilot study protocol. The following data must be collected and recorded to establish the test conditions that will be used during the two subsequent stages of the pilot test.
 - 1. Backwash/backflush/reverse flow duration;
 - 2. Backwash/backflush/reverse flow frequency;
 - 3. Backwash/backflush/reverse flow rate;
 - 4. Feed water flow rate;
 - 5. Range and average filtrate flux;
 - 6. Range and average transmembrane pressure (TMP);
 - 7. Specific and filtrate flux rate (temperature adjusted to 20° C);
 - 8. % element recovery (crossflow) or % system recovery (dead-end flow);
 - 9. Expected time frame between chemical clean-in-place (CIP) procedures;
 - 10. Frequency, duration and procedure for each CIP and chemicals used during each CIP;
 - 11. Frequency, duration, procedure and chemicals for any other chemical cleaning procedures such as vendor referenced "mini CIP," "chemical enhanced backwash (CEB)" and "chemical soaking;" and,

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12. Pretreatment requirements.

- B.** The Stage 2 test period includes testing each membrane unit under its optimum set of simulated, full-scale water treatment plant design conditions that will be determined from the data collected in the Stage 1 testing period. After conducting a TCEQ required CIP and direct integrity test, each manufacturer's membrane unit must be operated under its chosen full-scale plant design conditions for a period of not less than 30 days. For any unscheduled downtime greater than 24 hours, provisions must be included for contacting the TCEQ to see if the Stage 2 test will need to be restarted.

If at the end of the 30-day simulated full-scale water treatment plant test, a membrane unit has not fouled to a point where it requires a CIP, the engineer and the public water system may choose to continue the Stage 2 testing until the membrane unit's filtrate flux or TMP reaches unacceptable levels for a full-scale water treatment plant operation, or conduct a CIP procedure and direct integrity test and precede to the Stage 3 testing after 30 days of operation.

If a membrane unit fouls to a point that a CIP is required prior to the end of the 30-day simulated, full-scale test period, a CIP procedure and direct integrity test must be conducted. At this time the consulting engineer or system may choose to restart this stage of testing over using different pretreatment or membrane operating parameters, or continue the test until the required 30 days of operational testing is completed. The out of production time for the CIP procedure must be recorded. This CIP duration must be considered in the evaluation of the potential daily net production by TCEQ staff.

- C.** A Stage 3 test period must be conducted to determine the % loss of original specific flux and if irreversible fouling has occurred. After conducting a TCEQ required CIP procedure and direct integrity test, the membrane unit must be operated under the same simulated full-scale water treatment plant design conditions for at least 10 days. The duration of this Stage 3 testing period may be extended if the engineer and the public water system believe that additional time is needed to accurately determine if an undesirable % loss of original specific flux or irreversible fouling has occurred under the selected operating parameters.
- D.** Prior to beginning each testing period, a CIP procedure and direct integrity test must be conducted. During the Stage 1 testing period, additional CIP procedures may be conducted as dictated by the site-specific feed water quality, tested operating parameters, and manufacturers' recommendations. A direct integrity test of each tested membrane unit must be conducted after each CIP procedure using one of the following methods.
1. Diffusive air flow tests;
 2. Air pressure-hold (pressure or vacuum decay) test;
 3. Total Organic Carbon (TOC) and Soluble Dye tests (NF and RO membranes only); or,
 4. A TCEQ acceptable equivalent direct integrity test.

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Currently the TCEQ is accepting the calculation for determining the direct integrity test pressure or vacuum levels that detects at least a 3.0-micron defect as it is calculated in the July 2001 Draft, or finalized version, of ASTM's Standard Practice for Integrity Testing of Water Filtration Membrane Systems. This detection of at least a 3.0-micron defect is required for the TCEQ to grant removal credits for *Cryptosporidium* oocysts of 2.0-log and *Giardia lamblia* cysts of 3.0-log.

- X. A pilot study protocol must include a list of the analytical methods and equipment to be used during the pilot study. All flow measuring devices, rate-of-flow controllers and laboratory equipment must be calibrated as specified by the manufacturer prior to beginning the pilot study. A description of the calibration methods and frequency must be included for verification of data that will be collected.
 - A. Some acceptable analytical procedures, calibration procedures, frequency, and accuracy of measurement requirements are found in Title 30 TAC §290.46(s), §290.110(d), §290.111(d) and §290.119.
 - B. If ozone is used, residuals must be measured and reported to a minimum accuracy of ± 0.02 milligrams per liter using the Indigo Method as specified in Standard Methods, 20th Edition, 4500-O₃B.
 - C. Benchtop particle counters/monitors must be calibrated as specified in the EPA/NSF ETV Plan: Membrane Filtration for the Removal of Microbiological and Particulate Contaminants, Chapter 13.0, Section 13.8.3 prior to startup of a pilot study and again before beginning the full-scale plant testing stage. Benchtop particle counters/monitors should be equipped with a sensor capable of identifying particle sizes in the 2 - 15 micron range and reporting the total count with a coincidence error of less than 10%.
 - D. On-line particle counters/monitors must be calibrated according to the manufacturer's specification prior to the startup of a pilot study and again before any simulated full-scale water treatment plant test and verified against the results of a calibrated benchtop particle counter/monitor and verified weekly. Online particle counters/monitors shall be equipped with a sensor capable of identifying particle sizes in the 2 - 15 micron range and reporting the total count at five-minute intervals with a coincidence error of less than 10%.
- XI. A list of analytical procedures to be conducted at off-site laboratories must be included. These analytical procedures should be conducted using EPA or TCEQ approved methods.
- XII. The continuous integrity of each manufacturer's tested membrane unit must be monitored during a pilot study. This is to ensure that the o-rings, epoxy, or one or more of the fibers has not failed. Acceptable methods are:

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- A. On-line particle counters/monitors capable of identifying particle sizes in the 2 - 15 micron range, continuously monitoring the filtrate/permeate, and reporting the total particle counts in this range for each five-minute period to a recorder;
 - B. Hach's FilterTrak laser turbidimeter (Model HF660) with the ability to continuously monitor the filtrate/permeate and report the turbidity level for each five-minute period to a recorder;
 - C. When NF or RO membranes are being piloted, conductivity or TDS meters with the ability to continuously monitor the permeate and report the level for each five-minute period to a recorder; or,
 - D. An alternate method may be accepted if supporting documentation is provided indicating that the TCEQ's Surface Plant Evaluation Team has accepted this method.
- XIII.** The date, duration and amount of all rainfall events during the pilot study must be recorded. If conventional pretreatment (coagulation, flocculation, clarification) is not going to be provided during the pilot study and full-scale treatment plant, then the study period will need to include at least one raw water turbidity spike associated with a major rainfall event or provisions for creating a turbidity spike using a turbidity spiking technique approved by the TCEQ.
- XIV.** The following data must be collected during a pilot study to create data summary tables and graphs on each membrane test unit for the pilot study report. (See PDW Program Staff Guidance: Review of Pilot Study Reports for Membrane Filtration for more information.)
- A. During all stages of a pilot study, all pretreatment units used must be identified and the following pretreatment conditions shall be monitored and recorded at least **once each day and any time they are altered**.
 - 1. Flow rate and hydraulic detention time of each pretreatment unit;
 - 2. Type of chemicals being feed and their dosages; and,
 - 3. Chemical inject and monitoring points.
 - B. During all stages of a pilot study, the following indirect integrity monitoring data must be recorded at specified intervals or more frequently. Due to the extensive data collection requirements, the data should be recorded electronically. However, if charts are used, they must be of a size that each reading can be determined.
 - 1. Feed water turbidity levels at **15-minute intervals** (a Hach FilterTrak laser turbidimeter is not acceptable for monitoring membrane feed water because of its inaccuracy at turbidity levels greater than 1.0 NTU);
or
Feed water total particle counts in the 2 -15 micron range at **15-minute intervals**;

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2. Filtrate/permeate water turbidity level at **five-minute intervals** using a Hach FilterTrak laser turbidimeter;

or

Filtrate/permeate water total particle counts in the 2 - 15 micron range at **five-minute intervals** using particle counters and monitors;
 3. Feed water TDS or conductivity levels at 15-minute intervals (if NF or RO membranes are to be piloted); and,
 4. Permeate water TDS or conductivity levels at five-minute intervals (if NF or RO membranes are to be piloted).
- C. The pilot study protocol must include the provision for determining Log Removal Values (LRV) as defined in EPA guidance.
- D. During the Stage 1 test period of a pilot study, the following operational data must be recorded **at least once each day and each time an operational parameter is changed**. During Stages 2 and 3 of a pilot study, the data must be collected at **four-hour intervals** or more frequently.
1. Membrane rack/tank inlet pressure in pounds per square inch (psi);
 2. Membrane rack/tank outlet pressure in psi;
 3. Filtrate/permeate pressure in psi;
 4. Feed water flow rate in gallons per day (gpd);
 5. Instantaneous filtrate/permeate flux rate in gallons per square-foot of feed water side of the membrane per day (gfd);
 6. Reject/bleedby/concentrate water flow rate (if applicable) in gpd; and,
 7. Recycle water flow rate (if applicable) in gpd.
- E. During all stages of a pilot study, the following water process control data must be recorded **at least once each day and any time the raw water quality changes**.
1. Raw water turbidity;
 2. Raw water pH;
 3. Raw water alkalinity;
 4. Raw water temperature;
 5. Raw water TDS or conductivity (if NF or RO membranes are to be piloted);
 6. All disinfectant dosage levels at application points;
 7. All disinfectant residuals at monitoring points;
 8. Feed water pH (if it will be different from raw water pH);
 9. Feed water alkalinity (if it will be different from raw water alkalinity);
 10. Feed water temperature (if it will be different from raw water alkalinity);
 11. Feed water disinfectant residual levels;

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12. Filtrate water pH;
 13. Any proposed control chemical constituent levels of the permeate and any blended water (if NF or RO membranes are being piloted for the removal of undesirable chemicals);
 14. CIP, mini CIP, chemical enhanced backwash and chemical soaking solutions' pH, disinfectant residual and temperature levels;
 15. Backwash/backflush/reverse flow supply water's disinfectant residual and pH levels if adjusted; and,
 16. Filtrate/permeate water's disinfectant residual levels.
- F.** The following water quality data must be recorded at least once every 30 days during the pilot study period and at least once during the Stage 2 (simulated full-scale operation) test period.
1. If pretreatment units are to be provided, raw water algae counts;
 2. If a coagulant is to be fed in pretreatment, the raw and filtrate water's TOC concentrations;
 3. Feed water algae counts;
 4. Feed water total hardness as calcium carbonate;
 5. Feed water iron, manganese and aluminum; and,
 6. Feed water TDS and TSS.
- G.** If a disinfectant is to be applied during the Stage 2 test period, the following tests should be conducted on the filtrate water at least once during the Stage 2 test period.
1. Total Trihalomethanes (TTHM);
 2. Haloacetic Acids (HAA5);
 3. Chlorite (if chlorine dioxide is used); and,
 4. Bromate (if ozone is used).
- H.** The following data is not required by the TCEQ but may be collected at the discretion of the engineer and membrane vendor to properly design a site-specific, full-scale membrane filtration water treatment plant.
1. Silica concentrations;
 2. UV₂₅₄ absorbency;
 3. TOC concentrations (if a coagulant is not going to be fed in pretreatment);
 4. Dissolved organic carbon (DOC);
 5. Conductivity (optional for MF or UF membrane pilots only);
 6. Barium and strontium (can affect the performance of membranes, especially NF and RO);
 7. True and apparent color;

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8. Total coliform and *E. coli*; and,
9. Simulated distribution system (SDS) test for TTHM and HAA5 (It is recommended that the method used be the uniform formation conditions (UFC) specified by the ICR.).

XV. The TCEQ staff reviewing the pilot study protocol may request a meeting with a responsible official of the public water system or their professional engineer prior to issuing acceptance of the pilot study protocol. This meeting may be required if the staff member intends to reject part or all of the proposed protocol.

END

REFERENCES:

1. ASTM 2001 Draft: STANDARD PRACTICES FOR INTEGRITY TESTING OF WATER FILTRATION MEMBRANE SYSTEMS
2. AWWA MEMBRANE PRACTICES FOR WATER TREATMENT
3. AWWA WATER TREATMENT PLANT DESIGN
4. AWWA Manual: REVERSE OSMOSIS AND NANOFILTRATION (M46)
5. EPA's LT2ESWTR Draft Language
6. NSF Equipment Verification Testing Plan: MEMBRANE FILTRATION FOR THE REMOVAL OF MICROBIOLOGICAL AND PARTICULATE CONTAMINANTS

April 1, 2004
Effective Date

Expiration Date


Buck Henderson, Section Manager
Public Drinking Water Section
Water Supply Division