

Bryan W. Shaw, Ph.D., *Chairman*
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TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Protecting Texas by Reducing and Preventing Pollution

December 1, 2009

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

Subject: Request for an Exception to Use HF Membrane Treated Reclaim Wastewater Effluent from the River Road WWTP as a Source Water for the Jasper SWTP
River Road WWTP Effluent HF Membrane Pilot Study Reports
City of Wichita Falls – PWS ID #2430001
Wichita County, Texas

Dear Ms. Crawford:

We have reviewed the three hollow-fiber (HF) microfiltration (MF) and ultrafiltration (UF) membrane pilot study reports (Reports) received on August 20, 2009. These Reports were submitted to support the City of Wichita Falls' (City) exception request to use effluent from the City's River Road wastewater treatment plant (RRWWTP), with additional treatment, as a raw water source for the public water system's Jasper surface water treatment plant (SWTP). The proposed additional treatment will include passing the RRWWTP effluent through either a HF MF or UF membrane prior to discharge in the Jasper and Cypress SWTPs' secondary raw water reservoir. The use of the RRWWTP's treated effluent as a raw water source for a public water system requires the approval of the Texas Commission on Environmental Quality (TCEQ) and the granting of an exception under 30 TAC §290.39(l) and §290.42(g).

The City previously piloted Zenon's ZeeWeed® 500B and 1000 HF UF membranes for treating the wastewater effluent from the RRWWTP in 2001. The TCEQ granted an exception in our letter dated July 31, 2002, with specified design and operating conditions. Based on our understanding that GE Zenon performed the new pilot study to improve their design and operating conditions, **this letter replaces our letter dated July 31, 2002.** For us to complete our review of the Siemens Memcor® HF UF 4S10V, Pall Microza® UNA-620A HF MF and new GE Zenon ZeeWeed® 1000 HF UF membrane Reports, **please submit a revised Report with the following additional information:**

1. The Page 9-9, TABLE 9-5 of the Report indicated levels of simazine at 0.99 and 0.15 milligrams per liter (mg/L) for the filtrate of the Siemens Memcor® HF UF 4S10V membranes. These concentrations exceed the maximum contaminate level (MCL) of 0.004 mg/L. However, the simazine levels reported for the Pall Microza® UNA-620A HF MF (Page 9-15, TABLE 9-7) and new GE Zenon ZeeWeed® 1000 HF UF (Page 9-12, TABLE 9-6) membranes' were below the MCL. Also, the semi-volatile results in Appendix E on Page 4 of 7 indicate that the levels for the Siemens Memcor® HF UF 4S10V membranes were in microgram per liter (µg/L) not mg/L. Please clarify as to which units are correct. If the levels of simazine were actually measured in mg/L, explain the treatment for removal of this herbicide.
Also, there were no simazine analytical results included in TABLES 9-3 and 9-4 for the effluent from the RRWWTP and the raw water reservoir. Please add these results in your revised Report.

2. Include a detailed description of how the City will reduce the levels of nitrates prior to distribution of any potable water to meet the primary drinking water standard MCL of 10.0 mg/L.
3. Please provide *Cryptosporidium* oocysts results for City's existing raw surface water monitoring in a comparison table with the monitoring results of each of the three piloted HF membranes filtrate. In January of 2008, the TCEQ adopted rules to implement the federal Long Term 2 Enhanced Surface Water Treatment Rule (LT2) requirements in Texas. We agree that the effluent from the proposed HF membrane reclaim treatment train does not have to meet LT2 requirements for potable water prior to discharge into the City's public water system SWTP's raw water reservoir. However, the City must provide data that the RRWWTP HF membrane treated effluent will be the same or of a better quality than the existing raw water source with regards to *Cryptosporidium* oocysts. Depending on the results, the City could be required to meet the raw water monitoring requirements for this proposed raw water source specified in 30 TAC §290.111(b).
4. The submitted data did not include **detailed information and calculations** for each HF membrane vendor's test pressure (P_{test}) values and for all log removal values based on a direct integrity test (LRV_{DIT}). As indicated in Item #3 above, the TCEQ is concerned that the HF membranes are able to reduce the *Cryptosporidium* oocysts level in the filtrates to a level not greater than what is found in the existing raw surface water sources (not necessarily the same log removal requirements as for a SWTP). For this exception request, the TCEQ will only accept the equations and methods set forth in the EPA Membrane Filtration Guidance Manual – EPA 815-R-06-009, November 2005 (EPA MFGM), unless prior TCEQ approval has been received for an equation or value as noted in this letter.
 - A. Please provide detailed calculations and supporting documentation showing how Siemens', Pall's and GE-Zenon's reported minimum test pressures (P_{test}) plus back pressure (BP_{max}) meet the required direct integrity test (DIT) **resolution** to detect a 3.0 micron defect or larger. Since the surface tension (σ) changes with temperature, submit the P_{test} for each DIT using either a σ value that corresponds to the actual water temperature or a worse case σ value of 74.9 dynes/cm. Use EPA Equation 4.1 to support each calculation. [Equation 4.1 (for a 3.0 micron defect): $P_{test} = (0.193 \times \kappa \times \sigma \times \cos \theta) + BP_{max}$]
 1. Based on a minimum stack height of 81 inches for three GE Zenon modules, a minimum BP_{max} value of 2.9 psi should be used. However, use the actual water head to the bottom of the membrane stack during a DIT.
 2. Based on a fiber length 47 inches for the Siemens modules, the minimum BP_{max} value would be 1.7 psi. However, calculate the BP_{max} for the actual water head at the bottom of the membrane fiber during a DIT.
 3. Based on a fiber length of approximately 6.5 feet for the Pall membrane module, the minimum BP_{max} value would be 2.8 psi.
 - B. Using EPA Equation B.7 provide the minimum defect that could be detected for each P_{test} value used during the pilot study. Include the κ , σ and θ values used. [Equation B.7: $d_{feet} = (0.58 \times \kappa \times \sigma \times \cos \theta) \div P_{test}$]

- C. Provide the necessary data and detailed calculations using EPA MFGM's Sections 4.3.1.1 and 4.3.1.2 (specifically, Equations 4.3 or 4.9) to verify that the **sensitivity** of all of the DITs conducted during the pilot study were adequate to verify the proposed *Cryptosporidium* oocysts log removal value for each membrane piloted. Using EPA equations only, include the calculated LRV_{DIT} for each DIT conducted during the pilot study.

Equation 4.3: $LRV_{DIT} = \log [(Q_p) \div (VCF \times Q_{breach})]$

Equation 4.9: $LRV_{DIT} = \log [(Q_p \times ALCR \times P_{atm}) \div (\Delta P_{test} \times V_{sys} \times VCF)]$

1. volume of pressurized air (V_{sys}) in each HF membrane unit during each direct integrity test;
 2. the applicable volumetric concentration factor (**VCF**), that is approved by the TCEQ, for the site design and operation;
 3. **BP_{max}** on each HF membrane unit during a direct integrity test;
 4. air-liquid conversion ratio (**ALCR**);
 5. flow of air (Q_{air}) through the critical breach during a pressure based direct integrity test;
 6. flow of water through the Q_{breach} at the designed and approved maximum filtration rate;
 7. design capacity filtrate flow (Q_p);
 8. the P_{test} for each HF membrane unit; and,
 9. smallest rate of pressure decay (ΔP_{test}) that can be reliably measured and associated with a known breach during the direct integrity test.
- D. For the **ALCR** values use one of the methods and equations in Appendix C of the EPA MFGM only. Provide each membrane vendor's specific values used in each EPA equation. Please note that:
1. **T** is the historical **high** temperature over the last five years for the RRWWTP's effluent.
 2. **TMP** is the membrane vendor's maximum allowable operating transmembrane pressure.
 3. $\Delta P_{eff} = [(P_{test} - BP) \times \{(P_{test} + P_{atm}) + (BP + P_{atm})\}] \div [2 \times (BP + P_{atm})]$.
 4. P_{test} is the minimum test pressure for the resolution of a 3.0 micron defect.
 5. P_{atm} is the actual atmospheric pressure for the elevation at this site.
 6. If EPA Equation C.14 is to be used only if the water temperatures are between 32 and 86 °F, otherwise use EPA Equation C.15.
 7. The viscosity values for water (μ_{water}) and air (μ_{air}) are to be taken from CRC Handbook of tables for Applied Engineering Science, 2nd Edition. Our research has indicated that viscosity values at specified temperatures vary according to different scientific and engineering references. Since the EPA did not provide a reference, the TCEQ selected this source for consistency.
- E. Using EPA Equation 4.17 [$UCL = (Q_p \times ALCR \times P_{atm}) \div (10^{LRC} \times V_{sys} \times VCF)$] and worse case conditions, provide a single upper control limit (**UCL**) for each of the three piloted HF membranes at their requested log removal credit (**LRC**) and Q_p value, where:

Q_p is the filtrated flow rate based on a TCEQ filtrate flux rate adjusted to 20 °C.

5. State whether GE Zenon piloted their ZeeWeed® 1000 HF UF membrane with a CPX 0.80 or 0.95 fiber. Which fiber is proposed for this installation? If the CPX 0.95 fiber is proposed and the CPX 0.80 fiber was piloted, the TCEQ will need to receive comparison data for the two membranes piloted side-by-side on the same feed water demonstrating that the flux rate and duration and the backpulse, maintenance clean and CIP procedures and frequencies are the same.
6. It is noted that both Siemens and GE Zenon used VCF values of 1.0. **The TCEQ has not approved VCF values of 1.0 for these submerged membranes.** While the VCF values for the test units may be 1.0, we do not have data to support a VCF of 1.0 for a full-scale submerged membrane tank.

To date, GE-Zenon has furnished one set of third party data from a full-scale HF membrane SWTP filtration plant. This data had a maximum VCF value of 3.49 with an average of 1.383 for four 44-minute filtrate cycles, approximately three hours, measured at three different elevations at three different locations. This operation was based on a complete tank drain with each backpulse procedure between the filtrate modes. The lowest VCF values occurred near the feed water influent channel and with the higher values on the far side of the tank.

We have not received any data for VCF values at a full-scale Siemens submerged HF membrane filtration SWTP at this time. However, the EPA MFGM appears to support a value greater than 1.0.

7. Siemens reported LRV_{max} for TCEQ greater than 9.0. Please explain how these values were calculated. The TCEQ has been using the EPA MFGM's equations since revising our rules in January of 2008 to comply with LT2.
8. Siemens' equation #4 in Appendix B of the submittal does not match the corresponding EPA Equation in Chapter 4 of the EPA MFGM. Please correct in your revised Report.
9. Provide the detailed description of the Siemens backwash procedure that includes the aeration and water flow rates for a 3.0-minute backwash.
10. Provide the specifications of the basket strainer used with Pall's test unit.
11. Provide the detailed procedures for Pall's chemical clean-in-place (CIP) procedures. Our review found the chemical specifications, frequency, and several other CIP parameters. However, the detailed recirculation and soaks procedures used during the pilot study were not provided.

The TCEQ has approved the following membrane specific equations and values in lieu of those contained in the EPA MFGM. If TCEQ has not approved an alternative value, the worse case values.

- Pall Microza® UNA-620A HF MF membrane
 - A TCF equation of: $TCF_{20} = [(0.0004483 \times T^2 - 0.03946 \times T + 1.593)] \div 0.9826$
where
 TCF_{20} is multiplied times the filtrate flux rate at T

- T is the ambient water temperature.
- A **VCF** value of 1.0.
- GE Zenon ZeeWeed® 1000 HF UF membrane with a CPX 0.80 fiber
 - A liquid contact angle (θ) of 58.6 degrees.
 - A **VCF** value greater than 1.5.
- Siemens Memcor® HF UF 4S10V membrane
 - Only worse case values are approved at this time.
 - Since we have not received third party data to vary a Siemens' **VCF** value, this data must be submitted. TCEQ does not have any data supporting a **VCF** value of 1.0 for submerged membranes.

Base on our review, the pilot study included the following operating parameters. Please review and provide any necessary corrections with the revised Report.

- The treated effluent from the RRWWTP as a feed water source.
- 5 – 8 mg/L doses of ferric sulfate as a coagulant with 5.8 minutes of mixing time.
- A Siemens Memcor® XS test unit with:
 - Flow measuring device;
 - 500 micron strainer;
 - Membrane tank;
 - Four vacuum Memcor® HF UF S10V membrane modules;
 - One meter fiber lengths with 300 sf per module for a total of 1200 sf;
 - Outside-in flow path;
 - A maximum TMP of 14.7 psi;
 - A nominal pore size of 0.04 microns with a maximum pore size of 0.1 microns;
 - A pH operating range of 2 -10;
 - A temperature operating range of 110 °F;
 - Chlorine tolerance of 1000 mg/L;
 - A Q_{breach} value of 3.51E-11 cfs;
 - A Stage 2 average flux rate of 31 gfd at an average temperature of 19.9 °C for **a flux rate of 30.88 gfd temperature adjusted to 20 °C** using the EPA's TCF;
 - A backwash frequency of 22 minutes for a duration of 3.0 minutes using 0.25 minutes of aeration followed by reverse filtrate flow using 15.85 gallons of filtrate;
 - A maintenance clean once a day using a 300 ppm chlorine solution with a backwash procedure for 3.0 minutes, recirculation for 10.0 minutes at 3.0 gpm per module, a 20-minute soak and a final 3.0 minute backwash procedure for a total of 13.21 gallons of filtrate per 300 sf module;
 - A maintenance clean once every 72 hours using 0.1% hydrochloric acid solution with a 3.0-minute backwash, recirculation for 10.0 minutes at 3.0 gpm per 300 sf module, two 1.0-minute aeration and 9.0-minute soak cycles for 20 minutes and a final 3.0 minute backwash for a total of 13.21 gallons of filtrate per 300 sf module;
 - A chemical clean-in-place (CIP) procedure approximately once every 30 days with a 2% citric acid solution preheated to 38 °C recirculated for 30.0 minutes at 3.0 gpm per 300 sf

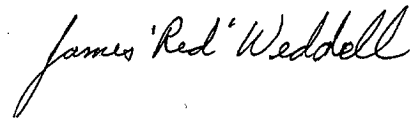
module followed by nine (90 minutes) 1.0-minute aeration and 9.0-minute soak cycles, a 500 to 1000 ppm free chlorine solution preheated to 20 °C recirculated for 30.0 minutes at 3.0 gpm per 300 sf module followed by 90.0 minutes of soaking for a total of 26.42 gallons of filtrate used per 300 sf module; and,

- Vacuum pump.
- A Pall Microza® UNA-620A HF MF test unit with:
 - A basket strainer;
 - Flow indicating device;
 - Feed tank;
 - A 538 sf pressure membrane module six inches in diameter with 6.56-foot long fibers;
 - A nominal pore size of 0.1 micron with a maximum pore size of 0.2 microns;
 - Outside-in flow path;
 - Dead-end filtration mode;
 - A pH operating range of 1 to 10;
 - A oxidant tolerance of 0 for ozone, 0.2 mg/L for chlorine dioxide, 5,000 ppm for free chlorine and 50 mg/L for potassium permanganate;
 - A temperature operating range of 0 °C to 40 °C;
 - A maximum allowable TMP of 43.5 psi;
 - A VCF of 1.0;
 - A Q_{breach} value of 0.00825 gpm;
 - A Stage 2 average flux rate of 72 gfd at an average temperature of 66.2 °F (19.0 °C) for a **filtrate flux rate of 72.24 gfd temperature adjusted to 68 °F (20.0 °C)** using Pall's TCEQ approved TCF equation;
 - A simultaneous air scour and reverse flush (SASRF) frequency every 16.5 minutes for a 1.0 minute duration with a filtrate flow rate of 8.0 gpm per module and an air flow of 3.0 SCFM at 30 psi;
 - Each SASRF is followed by a forward flush (FF) procedure for a duration of 0.5 minute using a flow rate of 17.0 gpm of feed water;
 - An enhanced filtration maintenance (EFM) once a day for duration of 30.0 minutes using a 400 mg/L sodium hypochlorite solution with 12.0 gallon are filtrate; and,
 - A chemical CIP frequency of 30 days for a duration of 4.0 hours using 160 gallon of filtrate using two preheated solutions, a 1% caustic/sodium hypochlorite at a pH of 12.6 and a 2% citric acid at a pH of 2.4.
- A GE Zenon ZeeWeed® 1000 HF UF test unit with:
 - A membrane tank;
 - Three 600 sf submerged modules 27.2 inches by 27.0 inches by 4.2 inches with 21.38-inch long fibers in a single stack with 1800 sf total area;
 - Outside in flow path;
 - A nominal pore size of 0.02 microns and a maximum pore size of 0.1 microns;
 - Temperature operating range of 1 °C to 40 °C;
 - Oxidant resistance of 1,000 ppm free chlorine at less than 30 °C and 500 ppm between 30 and 40 °C;
 - A maximum allowable TMP of ± 13.0 psi;
 - A Q_{breach} value of 6.6E-4 gpm;

- A Stage 2 average filtrate flux rate of 33 gfd at an average temperature of 19 °C for a **filtrate flux 33.6 gfd temperature adjusted to 20.0 °C** using the EPA TCF;
 - A backpulse frequency of 27 minutes for a 0.25 minute duration;
 - A maintenance clean once each day using either a 100 mg/L sodium hypochlorite or 2 g/L citric acid solution at a pH of 2.1 initiated with a backpulse/tank drain, fill tank with the maintenance clean solution, soak for 15 minutes and backpulse/tank flush prior to returning to service for 15 minutes;
 - A CIP procedure every 30 days using sequential soaking solutions of 500 mg/L sodium hypochlorite and a 2 g/L citric acid with a pH of 2.1 initiated with a backpulse and tank drain, fill tank with the CIP solution, soak for 4.0 hours, repeat with second solution and backpulse/tank drain prior to returning to service for 5 to 6 hour durations for each solution;
 - A vacuum pump.
- Individual membrane test unit feed and filtrate turbidity, pH and temperature monitoring and associated pressure indicating equipment.

If you have any questions concerning this letter, or if we may be of further assistance, please contact us at the letterhead's address or me 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
Texas Commission on Environmental Quality

JSW/av

cc: TCEQ Abilene Regional Office – R3
Mr. John Schilderwachter, Team Leader, TCEQ Drinking Water Protection Team – MC 155
Ms. Alicia Diehl, Ph.D., E.I.T., Team Leader, TCEQ Drinking Water Quality Team – MC 155
Ms. Vera Poe, P.E., Team Leader, TCEQ Utilities Technical Review Team – MC 153
Mr. Louis C. Herrin III, P.E., TCEQ Water Quality Division – MC 148