

RESOLUTION NO. 2018 - III

A RESOLUTION BY THE BOARD OF COUNTY COMMISSIONERS OF ST. JOHNS COUNTY, FLORIDA, AUTHORIZING THE COUNTY ADMINISTRATOR, OR DESIGNEE, TO PURCHASE DOW MEMBRANE ELEMENTS FOR ST JOHNS COUNTY UTILITY DEPARTMENT AND TO EXECUTE A PURCHASE ORDER WITH DOW CHEMICALS COMPANY FOR THE PURCHASE.

RECITALS

WHEREAS, the County seeks to purchase Dow membrane Elements Model No. Filmtec BW30XFRLE-400/34 for St. Johns County Utility Department; and

WHEREAS, the purchase of the equipment will be funded by St. Johns County Utility Department; and

WHEREAS, the purchase of the equipment serves a public purpose.

NOW, THEREFORE BE IT RESOLVED BY THE BOARD OF COUNTY COMMISSIONERS OF ST. JOHNS COUNTY, FLORIDA:

Section 1. The above Recitals are incorporated by reference into the body of this Resolution and such Recitals are adopted as finds of fact.

Section 2. The County Administrator, or designee, is hereby authorized to purchase Dow Membrane Elements Model No. Filmtec BW30-XFRLE-400/34.

Section 3. The County Administrator, or designee, is further authorized to execute a purchase order in the amount of \$318,920.00 for the purchase of Dow Membrane Elements Model No. Filmtec BW30-XFRLE-400/34 from Dow Chemical Company, as the single source provider of the specified membranes.

Section 4. To the extent that there are typographical and/or administrative errors that do not change the tone, tenor, or concept of this Resolution, then this Resolution may be revised without subsequent approval by the Board of County Commissioners.

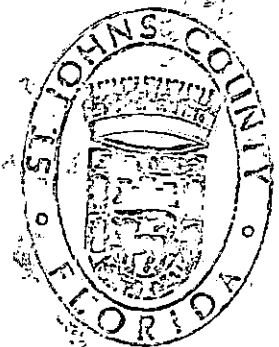
PASSED AND ADOPTED by the Board of County Commissioners of St. Johns County, Florida, this 17th day of April, 2018.

BOARD OF COUNTY COMMISSIONERS OF
ST. JOHNS COUNTY, FLORIDA

By: Henry Dean
Henry Dean, Chair

ATTEST: Hunter S. Gonrad, Clerk
By: Pam Halterman Deputy Clerk

RENDITION DATE 4/19/18





The Dow Chemical Company
Midland, MI 48674
U.S.A.

March 2, 2018

Teri Pinson, P.E.
St. Johns County Utility Department
St. Johns County Board of County Commissioners
1205 State Road 16, St. Augustine, FL 32084
904) 209-2604 Office (904) 466-5511 Cell

Email: tpinson@sjcf.us

Dear Teri:

The Dow Chemical Company is pleased to quote the following product and pricing. This quote is part of our submittals in response to the RFQ issued by St. Johns County (Reverse Osmosis (RO) Membrane):

Product	Quantity	Price
Supply Membrane Elements Model No. FILMTEC™ BW30XFRLE-400/34	680 pieces	\$469.00/each
TOTAL LUMP SUM PRICE:		318,920.00

Dow Will Commit to provide all spare parts and complete scope of work*

*Exceptions in next page

Transportation	Seller Absorbs Freight.
Payment Terms	Net 30 days from invoice date. Price and Terms only apply to sales within the continental U.S. Upon an accepted order, items will be shipped and invoiced pursuant to Seller's standard terms and conditions.
Quote Expires	This pricing is firm through June 1st, 2018 .
Availability	The actual availability will be determined at the time you are ready to place an order.
Customer Service	When ready to place your order, please contact John Shibilski in Dow Water & Process Solutions' Customer Service Group at 989/832-1143 or e-mail to jashibilski@dow.com .

Please let me know if you require additional information. Thank you for your interest in Dow Water & Process Solutions products.

Sincerely,

Laura

Laura Gallindo
Mailing Address
Dow Water & Process Solutions
Account Manager – Southeast
1881 W. Oak Parkway
Marietta, GA 30062
lgallindo@dow.com
PH: 989-259-5081

Advanced Structures Codeline Model E8L, 6-element pressure vessels.



The Dow Chemical Company
Midland, MI 48674
U.S.A.

Section 1.2 F. Software updates for managing data collection and monitoring. This is assumed to be fulfilled by a current version of FTNORM with applicable TCF coefficients and data entry adjusted for their available instrumentation. **Dow will not be responsible for any process control programming.**

Section 1.5 A. and Section 2.1 B. 6. **U-cup brine seals are proprietary in design and therefore not available commercially.**

Section 1.5 D. Wet test data is required for 10% of the elements supplied to the District 14 days prior to shipment and only approved elements can be shipped. **FilmTec does not manufacture "to order" and does not identify the specific elements for an order until it is time to load the truck for shipment. The COA data cannot be supplied as requested but will be provided via email on the day of shipment.**

Section 1.6 B. 1. a. 1) **The wet test for FILMTEC™ BW30XFRLE-400/34 elements is conducted with a 2,000 mg/l sodium chloride solution, not 500 mg/l as indicated in the specification.**

Section 1.6 B. 1. a. 3) **The FilmTec wet test is a 20 minute test, not 30 minutes as indicated in the specification.**

Section 1.6 B. 1. b.-d. **Differential Pressure under standard test conditions is not included in the COA data.**

Section 1.6 B. 1. e. **Representatives of the District are encouraged to visit the FilmTec manufacturing site for a tour where they will be allowed to witness element testing. FilmTec manufactures RO elements in a semi continuous process which is not conducive to stoppage for retesting of elements. For this reason, retesting of elements will not be possible.**

Section 2.1 B. 5. **FILMTEC BW30XFRLE-400/34 is manufactured with a feed spacer that has a nominal thickness of 0.034 inches. We will not be able to downgrade our product components to meet the specified nominal feed spacer thickness of 0.026-0.031 inches.**

Section 2.2 A. 7. **Spare membrane elements for long term storage should be dry elements.**

Section 3.1 A. **requires the elements to be available within 6 weeks of authorization. Product availability will be determined at the time the elements order is placed.**

Section 3.2 C. **We don't provide any legal certification other than verbal guidance and consultancy on-site**



MEMORANDUM

Single Source of Dow Filmtec Membranes for the CR 214 WTP

PREPARED FOR: St. Johns County Utility Department

PREPARED BY: Constantine Engineering, Inc

PROJECT NUMBER: 100408.13

DATE: March 13, 2018

The purpose of this memorandum is to request that County purchasing department single source the procurement of Dow Filmtec BW30XFRLE-400/34 series membranes for the replacement of membranes at St. Johns County Utility Department's (SJCUD's) CR 214 water treatment plant (WTP). The reasons for this single source request are as follows:

1. The existing membranes are Dow Filmtec membranes and have been in service and proven their performance for over 10 years. The County has data on the membrane performance and a full understanding of the operational parameters for the membranes. Because the water quality at every utility and aquifer is unique, changing to a new membrane manufacturer will require the performance testing of the new membranes
2. Other membrane manufacturers will have to conduct pilot tests for longer periods of time (about 1 year) to provide reliable pressure drop and fouling data that may allow such manufacturers to qualify to provide these membranes for the CR 214 WTP
3. The current membranes are at the end of their useful life and need to be replaced by fall 2018 to ensure full capacity at the CR 214 WTP. Fouling has caused a capacity reduction from the RO skids from 4 million gallons per day (mgd) to about 3.7 mgd (a 10% reduction in water production). Water from the NW WTP is being pumped to this CR 214 WTP to allow treated water to be delivered without disruption to customers
4. Delaying the procurement of the membranes to allow for pilot testing by 1 year or more may result in additional reductions in CR 214 capacity, risking the water supply to the County's customers in this area
5. Autopsies conducted on the existing Dow Filmtec membranes after 10 years in services provide a wealth of information on fouling and cleaning to sustain plant capacity with the new membranes. This data is simply impossible to obtain with any other membrane manufacturers because only the Dow Filmtec membranes have been in service at this WTP

Based on these considerations, it is Constantine's recommendation that the County single source the procurement of Dow Filmtec BW30XFRLE-400/34 series membranes for the replacement of membranes at SJCUD's CR 214 WTP



TECHNICAL MEMORANDUM NO. 2

CR 214 WTP Membrane Conclusions and Recommendations

PREPARED FOR: St. Johns County Utility Department

PREPARED BY: Constantine Engineering, Inc

PROJECT NUMBER: 100408.13

DATE: February 26, 2018

I. Introduction and Background

St. Johns County Utilities Department (SJCUD) began operation of the County Road 214 RO Water Treatment Plant (CR 214 WTP) in 2007 to treat groundwater from various wells, including Wells 42-49. The treatment plant uses reverse osmosis (RO) membranes to remove chlorides and air stripping to remove dissolved hydrogen sulfide. The RO membranes are now 10 years old, and the operating pressures have gradually increased after each cleaning cycle. Because the membranes have reached the end of their useful life, SJCUD has contracted Constantine Engineering in March 2017 to assist with Task Order 13 - Engineering Evaluation of Reverse Osmosis Membrane Replacement Evaluation for the CR 214 Water Treatment Plant (WTP).

The goals for the project include the following:

- To define the quality from the wells and consider future raw water quality
- To review the historical membrane/plant performance data and identify times of the year with better or worse raw water quality that could be the cause of these changes
- To develop criteria for the WTP membranes and screen membrane suppliers to identify up to three (3) vendors for bidding
- To obtain and analyze proposals from 3 suppliers
- To develop recommendations for membrane operations including pretreatment and cost

Technical Memorandum (TM) 2 presented herein includes a summary of previous reports, and also includes the results of a recent autopsy of existing membranes at CR214 WTP.

The objectives of TM 2 include the following:

- Present the autopsy data and conclusions
- Present specifications for new membranes to replace the existing original elements
- Present recommendations to improve membrane performance and reliability

The CR 214 WTP is permitted for a maximum daily demand capacity of 8.0 MGD. The facility uses a low-pressure reverse osmosis (LPRO) process for removal of chlorides and was placed into service in 2007. Figure 1 shows the Process Diagram for CR214 WTP. Raw water from the wells is split and scale inhibitor is added to 50% of the raw water. This

4 MGD of water is then treated with cartridge filtration before being pumped through the RO membranes. The RO treated water (permeate) is blended with the remaining 50% of the raw water and treated in packed tower strippers (degasifiers) for hydrogen sulfide removal after sulfuric acid addition. The sulfide stripped water is then chlorinated in a wet well for treatment with free chlorination. CO₂ is added to increase alkalinity. Ammonia is added to form a monochloramine residual that is required in the distribution system. The pH is adjusted with sodium hydroxide for corrosion control. The finished water is stored on site in two (2) ground storage tanks. The combined capacity of the ground storage tanks is 3.5 MG. Finished water is pumped into the distribution system with high service pumps.

The facility is staffed and operated 24 hours per day and 7 days a week in accordance with Category II facilities as defined in Chapter 62-699 of the Florida Administrative Code (FAC). With an average day demand of about 5.1 MGD and a maximum daily demand of about 5.8 MGD in 2016, this plant is already at 75% of its capacity. Thus, 1 MGD of water from the NW WTP is available to be pumped to the CR214 WTP for blending and disinfection before distribution.

II. Data Review and Water Quality Definition

Constantine recently prepared Technical Memorandum No. 1 – Data Review and Water Quality Definition, which provided a summary and review of water quality data and operating data. The Water quality data for the CR214 WTP wells and operating data for the membrane system indicate relatively moderate increases in feed water chlorides and conductivity. TM 1 hypothesized that the increases in feed pressures for the LPRO system have likely been the result of the chlorides increase, but it was also suspected that membrane cleaning had not been completely effective at restoring membrane performance. Contaminants that foul the membranes cause restrictions that are almost unnoticeable on daily reviews, but gradually affect flows/pressures over time. The membrane operating data supports this theory as operations staff have slightly increased feed pressures over months and years, then made higher feed pressure increases in 2008 and 2012. It is noted that the Aerex review in 2015 acknowledged the feed pressures had been increased to 150-155 psi, but the Filmtec operating manual provided for the original plant installation recommends limiting the feed pressure to not greater than 135 psi.

The following recommendations were presented in TM 1 for the CR214 WTP membranes:

- Perform a forensic autopsy of membranes from each skid/stage to identify foulants within the membranes.
- Consider improved cleaning techniques, including chemicals and methods used during the clean in place (CIP) procedures. The autopsy process will likely provide the data needed to make these adjustments to the cleaning process.
- Consider alternate pretreatment chemicals and dosages. The autopsy process will likely provide feedback to make these adjustments in pretreatment.
- Replace the current membrane elements and restore the feed operating pressures in the skids to desired levels. The autopsy process will also provide information to develop replacement element specifications.

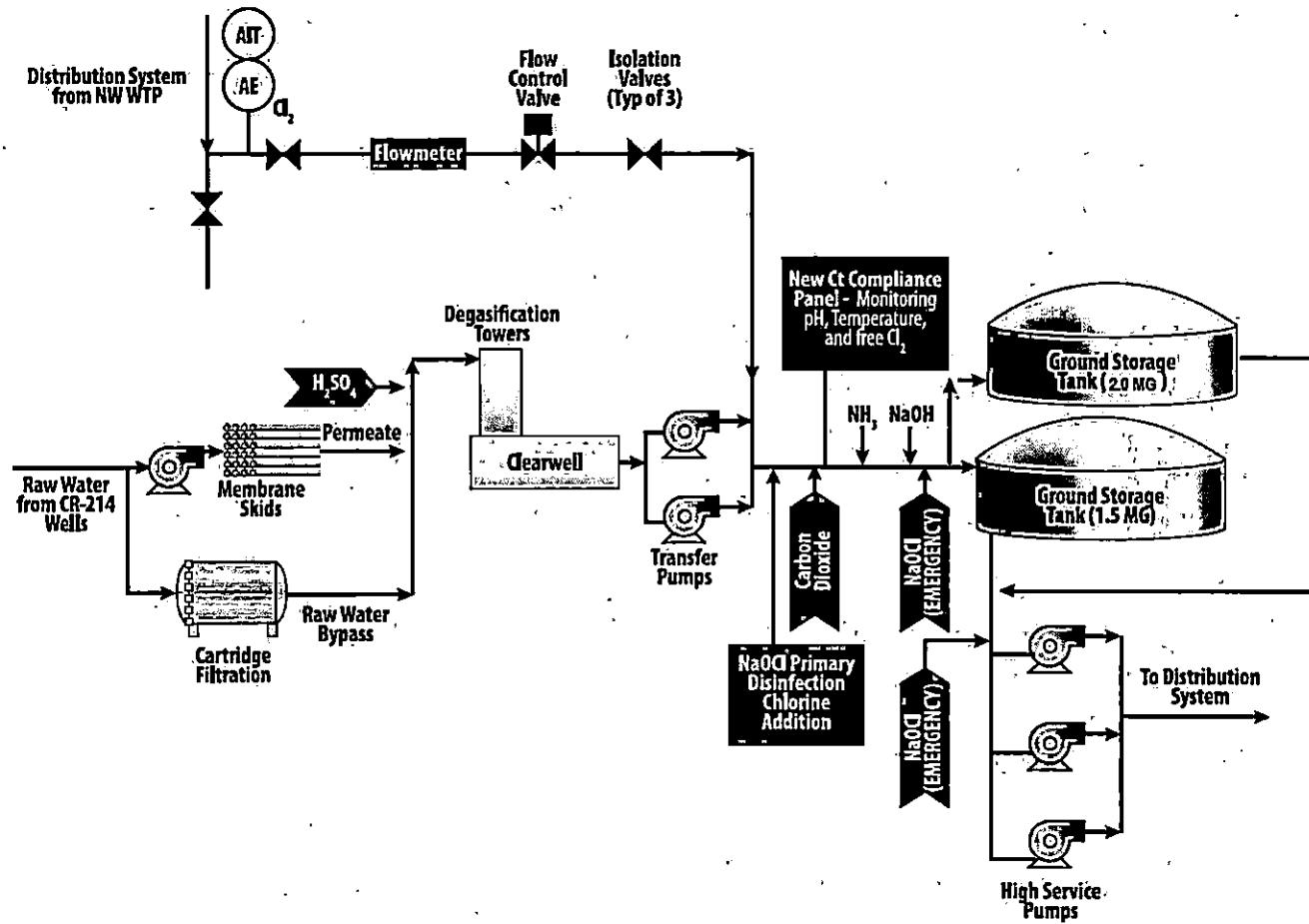


Figure 1. CR214 WTP Process Diagram

III. Autopsy Results

Constantine developed the scope for a membrane autopsy and SJCUD contracted with American Water Chemicals, Inc. (AWC) of Plant City, FL to provide analyses of membrane elements. The objectives of membrane autopsy were to provide information on the structural, surface, and subsurface components of the membranes in order to assist SJCUD with recommendations for system improvements.

Membrane elements from the lead and tail stages of each skid were removed, bagged, and shipped to AWC for analyses (total of 4 membrane elements). AWC analyses included the following tasks and tests:

- Visual inspection of external components
- Element performance tests
- Bubble tests
- Inspection of leaves and spacers
- Contact angle testing
- Foulant surface density testing
- Loss on ignition testing
- Cell testing
- Dye testing
- Chemical solubility testing
- Humic and fulvic acids testing
- Microscopy and spectroscopy imaging and analysis
- Dimensional elemental scanning
- Membrane surface analysis
- Fourier Transform Infrared (FTIR) spectrometry
- Biological Activity Reaction Tests (BART)

The autopsy reports were submitted to Constantine and SJCUD consisting of four (4) volumes: 1.) Skid 1 Lead, 2.) Skid 1 Tail, 3.) Skid 2 Lead, and 4.) Skid 2 Tail. These reports are too large to include as appendices to this TM, but have been provided as individual separate documents.

Table 1 provides a summary of the autopsy results. The results were very consistent between Skid 1 and Skid 2, and the lead sections showed more fouling than the tail sections as expected. In general, all the membranes showed fouling by biofilm, suspended solids, humic acids, and naturally occurring organic matter (NOM). The study also showed that cleaning with high pH and low pH solutions were very effective at removing foulants and restoring some of the membrane performance (especially high pH cleaning; low pH cleaning had little effect). The study also showed that much of the membrane structure had been damaged by particulates, which confirmed that the existing CR214 membranes need to be replaced.

Table 1. Autopsy Results Summary

	Skid 1 - Lead	Skid 1 - Tail	Skid 2 - Lead	Skid 2 - Tail
Brown deposits	Found on both ends	Found on both ends	Found on both ends	Brown/green deposits - Found on both ends
Membrane flux (% below the manufacturer's specification)	29%	16%	31%	24%
Membrane salt rejection (% compared to manufacturer's specification)	1.5% below	0.3% above	0.9% below	0.3% above
Element's differential pressure (higher than expected)	5.1 PSI	0.6 PSI	8.2 PSI	0.1 PSI
LOI test for brown foulant	82% Organic/18% Inorganic	66% Organic/34% Inorganic	82% Organic/18% Inorganic	69% Organic/31% Inorganic
Solubility in 50% NaOH	LOI residue – partially soluble – yielding a yellow solution	LOI residue and foulant – partially soluble – yielding a yellow solution	LOI residue and foulant – partially soluble – yielding a yellow solution	LOI residue and foulant – partially soluble – yielding a yellow solution
Solubility in 37% HCl	LOI residue and foulant – partially soluble – yielding a yellow solution – indicates presence of iron	LOI residue and foulant – partially soluble – yielding a yellow solution – indicates presence of iron	LOI residue and foulant – partially soluble – yielding a yellow/green solution	LOI residue and foulant – partially soluble – yielding a yellow solution – indicates presence of iron
Test foulant for humic acids	Positive	Positive	Positive	Positive
High pH cleaning	Increased the flux significantly	Increased the flux significantly	Increased the flux (was due to membrane swelling)	Increased the flux (was due to membrane swelling)
Low pH cleaning	No impact on flux; slightly lower salt rejection	No impact on flux; slightly lower salt rejection	Increased the flux further; lower salt rejection	Increased the flux further; lower salt rejection

	Skid 1 - Lead	Skid 1 - Tail	Skid 2 - Lead	Skid 2 - Tail
Membrane flux after overall cleaning (% below the manufacturer's specification)	11%	6%	14%	9%
Membrane salt rejection after overall cleaning (% below manufacturer's specification)	0.1%	0.4%	0.4%	0.5%
Pressurized Dye Testing	Light dye penetration to the permeate side -- suspended solids abrasion	Dye penetration to the permeate side, heavier penetration on the downstream side	Light dye penetration to the permeate side -- suspended solids abrasion	Light dye penetration to the permeate side -- suspended solids abrasion
SEM/EDS/SEI/PED analysis of the foulant	Mainly organic based matter; Sporadic deposits of stainless steel debris, iron hydroxide, silts/clays, lead sulfide and chloropolymer (possibly PVC)	Organic based matter, silts/clays, stainless steel debris and iron disulfide (pyrite)	Organic based matter; Iron disulfide (pyrite), stainless steel debris, calcium sulfate, iron hydroxide, chloropolymer (possibly PVC) and silts/clays	Organic based matter, silts/clays, iron disulfide (pyrite), chromium oxide and stainless-steel debris; sporadic deposits of iron hydroxide
Analysis of cleaned Membrane	Foulant removed from membrane surface	Foulant removed from membrane surface	Foulant removed from membrane surface; sporadic deposits of silts/clays remained	-
Membrane surface analysis	Damage due to suspended solids abrasion	Damage due to suspended solids abrasion	Damage due to suspended solids abrasion	Significant suspended solids abrasion
FTIR findings	Spectra associated with biofilm and silts/clays	Spectra associated with biofilm and silts/clays	Spectra associated with biofilm and silts/clays	Spectra associated with biofilm and silts/clays

	Skid 1 - Lead	Skid 1 - Tail	Skid 2 - Lead	Skid 2 - Tail
Optical microscopy results	Abundant particulate material - non-motile and motile bacteria as well as fungal hyphae and spores; slime forming bacteria, heterotrophic aerobic bacteria and iron related bacteria were detected.	Abundant particulate material - non-motile and motile bacteria as well as fungal hyphae and spores; slime forming bacteria, heterotrophic aerobic bacteria and iron related bacteria were detected.	Abundant particulate material - non-motile and motile bacteria as well as fungal hyphae and spores; slime forming bacteria, heterotrophic aerobic bacteria and iron related bacteria were detected.	Abundant particulate material - non-motile and motile bacteria as well as fungal hyphae and spores; slime forming bacteria, heterotrophic aerobic bacteria and iron related bacteria were detected.

The AWC notes from the autopsy are generalized as follows:

- Brown deposits were found on both ATDs, permeate tube on the feed end and the brine seal; however heavier deposit was found on the feed ATD. The Fiberglass shell was cracked near the concentrate end of the element.
- Initial performance testing of the element showed membrane flux to be 29%-31% below the manufacturer's specification. Membrane salt rejection for the lead sections was about 0.9%-1.5% lower than the manufacturer's specification. The lead elements for each stage had differential pressure that was 5.1 PSI to 8.2 PSI higher than expected.
- Brown deposits were found on both ends of the elements, however, heavier deposits were found on feed end of the element.
- Brown foulant was found on all the membrane leaves and feed spacers. The foulant surface density was 2.79 mg/cm² when hydrated and 175 µg/cm² when dehydrated. The LOI test determined the foulant to consist of ~82% organic matter and ~18% inorganic matter.
- The LOI residue was partially soluble in the 50% NaOH, yielding a yellow solution. The foulant and LOI residue were both partially soluble in the 37% HCl, yielding a yellow solution, which is typically indicative of the presence of iron within the deposit.
- The foulant was positive for humic acids.
- Samples collected along the flow path of the membranes had an average contact angle of ~78.3° (average for all stage sections together). Contact angle testing is used to determine the hydrophobicity of a membrane. Higher contact angles are directly correlated with a more hydrophobic surface. Membranes are less prone to fouling and have better productivity when they are less hydrophobic. After cleaning

the membranes, the average contact angle of the midstream 1 coupons decreased from $\sim 72.1^\circ$ to $\sim 50.7^\circ$, suggesting that a hydrophobic substance had been removed (true for all stage sections).

- Cleaning was performed in the cell test unit using 2% C-226 at pH 12.09 for 6 hours at 35°C followed by 2% C-234 at pH 1.69 for 4 hours at 25°C . The high pH cleaning increased the flux significantly; it is usually assumed that some of the flux increase after high pH cleaning may be due to membrane swelling. Low pH cleaning had no impact on flux but resulted in a slightly lower salt rejection.
- Overall, cleaning resulted in improved flux rates that ranged from 19.73 gfd to 24.28 gfd, with an average of 21.57 gfd compared to the manufacturer's specification of 28.75 gfd for new membranes. Similarly, cleaning also resulted in improved salt rejection that ranged from 97.82% to 99.63%, with an average of 98.88% compared to the manufacturer's specification of 99.3%.
- Pressurized dye testing found light dye penetration to the permeate side of the membrane. The pattern of the dye penetration suggested suspended solids abrasion.
- SEM/EDS/SEI/PED analysis of the membrane surface found the foulant to consist mainly of organic based matter. Sporadic deposits of stainless steel debris, iron hydroxide, silts/clays, lead sulfide and chloropolymer (possibly PVC) were also identified.
- Analysis of the cleaned membrane surface revealed the cleaning chemical had removed the foulant from the membrane surface.
- Membrane surface analysis revealed surface damage caused by suspended solids abrasion.
- FTIR found spectra associated with biofilm and silts/clays.

AWC included an evaluation of foulant solubility using different acidic and basic cleaning chemicals, which indicated very good results with a high pH solvent. AWC also provided a supplemental water chemistry model to evaluate and select the optimum anti-scalant for the CR 214 WTP raw water. The model results are included in Appendix B for reference.

Figure 2. Membrane Inlet Fouling

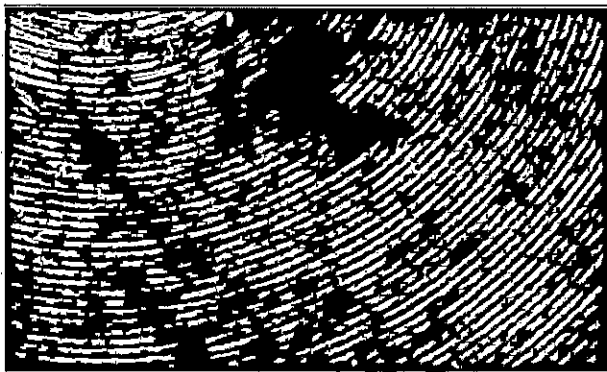


Figure 3. 1000X Scan of Fouling



IV. Conclusions and Recommendations

The autopsy confirmed prior opinions that historical increases in feed pressure combined with reductions in flux have been caused primarily by organic surface fouling that were not sufficiently cleaned during the clean in place attempts. The data and research information conclusions are discussed below, along with recommendations and action items to replace the existing membranes and implement new operating and maintenance protocol to optimize the useful life of the new membranes.

Conclusions

The following data and information sources were used to evaluate the performance and current status of the existing CR 214 RO membranes:

- Original operating and maintenance documents
- Historical reviews and assessments by others
- Historical operating data
- AWC autopsy results
- RO membrane manufacturer specification and performance data

After reviewing the data and information, it is believed that membrane fouling has gradually occurred over the 10-year life of the existing CR214 RO membranes. The foulants appear to consist mostly of organic matter, including subsequent growth of biological slimes within the membrane leaves. The foulants were readily removed in the autopsy tests using select cleaning chemicals, especially high pH solvents which also appeared to swell the membrane structure, increasing flux. The membrane structures also showed to be damaged through abrasion by suspended solids, which could be present in minute quantities in the raw water from the wells, or could be the result of infrequent appearance of suspended solids in the raw water (even upon initial startup of the CR214 wells and water supply system in 2007). The appearance of suspended solids and iron or manganese in the raw water on an ongoing basis could be indication that one or more wells experience contamination from an adjacent confined aquifer. This concern should be explored further by SJCUD sampling and testing on a routine schedule for specific raw water contaminants from each well.

Recommendations

The existing DOW Filmtec LE-400 RO membranes at CR214 WTP have performed very well since 2007, although the membrane operation has required an increase in feed pressure with decreases in permeate output. It is recommended that SJCUD include the following action items as part of the CR214 WTP improvements:

- Replace the existing RO membranes with new elements equal to the existing DOW Filmtec LE-400 elements
- Consider revised pretreatment consisting of finer screening and alternate anti-scalant

- Revise the clean in place chemicals and procedures to address the fouling identified in the autopsy
- Consider routine sampling well raw water for evidence of cross-contamination from adjacent aquifers

These recommendations are discussed below.

Membranes

Because the DOW Filmtec RO elements have performed very well for 10 years with regard to rejection of chlorides, it is recommended to replace the existing elements with an equal membrane design and construction. The current RO market consists of only three (3) manufacturers of RO membranes for municipal water treatment: DOW (Filmtec), Hydranautics, and Toray. However, DOW is the only manufacturer with qualified experience with the CR214 raw water quality. Because it is not feasible for other membrane manufacturers to conduct lengthy and obtrusive pilot testing of proposed membranes at CR214 WTP, it is recommended that SJCUD consider sole-source procurement of replacement elements from DOW.

Appendix A includes a draft technical specification for the purpose of bidding the replacement RO elements. It is recommended that SJCUD immediately advertise and bid the RO elements, followed by bids for installation of the new RO elements. Typical RO membrane delivery is 4 to 6 weeks following an approved purchase order to the manufacturer. Because SJCUD water demand typically increases each Spring season, it is recommended to postpone membrane replacement until after the Summer demand season is over at approximately October 1.

Pretreatment

The existing RO pretreatment cartridge filters are 5 microns, which have performed satisfactorily. However, it is recommended that SJCUD verify the pressure drop across the filters at 2 MGD (per train, assuming 50/50 blend of RO filtration with unfiltered raw water) to determine if the pretreatment filter needs to be replaced. If replacement is justified, it is recommended that SJCUD consider using 3-micron filter cartridge replacements to remove more suspended solids, which have apparently damaged the existing membrane elements.

Also, the existing anti-scalant chemical is an AWC potassium hydroxide (A-111), which has performed satisfactorily. Based on the autopsy results, AWC performed an anti-scalant model and recommends pretreatment with AWC A-102 anti-scalant. This water chemistry calculation is included in Appendix B. SJCUD should consider the A-102 as an alternate pretreatment chemical to replace the current anti-scalant. The data sheets for A-111 and A-102 are included in Appendix B.

Cleaning

The existing chemical clean in place system includes a 55-gallon acid tank (citric acid), 55-gallon basic tank (sodium hydroxide), and a 4,000-gallon chemical recovery tank. The asbuilt drawings for the existing cleaning system are included in Appendix C. The existing cleaning procedure was last performed in March 2012, and generally includes cleaning of

each stage using a soak/flush/rinse method with citric acid, sodium hydroxide and permeate.

Based on the autopsy results and cleaning tests, AWC recommends a revised cleaning procedure using the AWC A-C226 high pH product and the AWC A-C234 low pH product. Because the autopsy testing indicated high pH cleaning was very effective at removing the organic foulants on the membranes, the recommended cleaning protocol is revised to generally include three (3) cycles of high pH soak and recirculation for each stage (using AWC A-C226), followed by three (3) cycles of low pH soak and recirculation for each stage (using AWC A-C234). Appendix C includes the revised written cleaning sequence, and also includes data sheets for A-C226 and A-C234.

SJCUD should consider a test clean before the new membranes are installed, so that a skid cleaned with the new protocol can be compared to the existing skid without cleaning. This could also confirm the sensitivity of the existing membranes to the revised cleaning products and procedure. It is recommended that when the new membranes arrive, SJCUD clean one skid with the new chemicals and protocol, compare the performance of that skid with the other skid with existing membranes, then replace the other skid with new membranes and compare that performance. This involves an added cost that is not necessary, but can provide good base data for the new membranes and revised cleaning method.

Other

It is recommended that SJCUD consider monitoring the raw water quality for each of the wells for the CR214 WTP to confirm there is not cross contamination from adjacent aquifers. The presence of iron and manganese would indicate this potential, although current sampling and testing shows no significant levels of iron or manganese.

Because the goal of the project is to restore capacity to the CR214 RO WTP and life expectancy of the new membranes, time is of the essence to continue with improvements so that capacity is available by Spring 2019.

The tentative schedule for completing the action items and recommendations are as follows:

Dec 31, 2017 – SJCUD receive and review draft TM 2 for recommendations and new membrane specifications/vendors

Jan 9, 2018 – Constantine workshop with SJCUD to discuss recommendations and action items/schedule

Feb 16, 2018 – Constantine workshop with SJCUD to finalize recommendations, specifications, bid packages, and implementation schedule

Jun 1, 2018 – SJCUD receive bids and award contracts for new membrane materials and installation

Aug 1, 2018 – SJCUD receive new membranes shipped to CR214 WTP

Oct 1, 2018 – SJCUD perform test of revised CIP on a single existing membrane skid to compare results with other skid

Oct 8, 2018 – Installation contractor to start installation of new membranes in skid that was not cleaned via revised CIP. (to compare skids again)

Oct 22, 2018 – SJCUD perform test of revised CIP on a second membrane skid to compare results with first skid containing new elements

Nov 16, 2018 – Contractor/SJCUD complete installation and startup of all new membranes

Appendix A

Membrane Technical Specifications

**SECTION 00800
REVERSE OSMOSIS (RO) MEMBRANES**

PART I GENERAL

1.1 INTRODUCTION

- A. St. Johns County Utility Department (SJCUD) operates the CR 214 Mainland Water Treatment Plant in western St. Johns County, FL. The facility treats groundwater from various wells, including Wells 42-49. The treatment plant uses reverse osmosis (RO) membranes to remove chlorides and air stripping to remove dissolved hydrogen sulfide. This document pertains to the specification of reverse osmosis membrane elements for replacement of elements for first and second stage of two treatment trains.
- B. The membrane element manufacturer (herein called MEM) shall furnish the membrane elements and appurtenances in accordance with the requirements specified herein.

1.2 SCOPE OF WORK

The following items define the scope of work for this project:

- A. Furnish a quantity of six-hundred eighty (680) membrane elements (8-inches in diameter x 40-inches in length) as specified in Part 2 of Section 00800, herein. Of this total, three hundred thirty-six (336) will be initially installed in each existing RO skid, and eight (8) additional membranes will be shelf spares.
- B. Furnish new membrane element inter-connectors, end-cap adapters, O-rings for original installation and related spare parts, as specified in Part 2 of Section 00800, herein.
- C. Provide technical data related to proper installation, operation, cleaning and storage of the products supplied.
- D. Provide a membrane element warranty for all elements furnished in this contract, as specified in Section 3.03 below.
- E. Provide field support as specified to certify proper installation and startup of the new elements.
- F. Provide software upgrades as needed to collect and monitor operating data during and after the membrane replacement.

1.3 PROCESS DESCRIPTION

- A. The typical water quality for the blended raw water from the production wells to the CR214 WTP is as follows:

REVERSE OSMOSIS (RO) MEMBRANES

Parameter	Units	Maximum	Minimum	Average
Bicarbonate	mg/l as CaCO ₃	154	119	134
Carbonate	mg/l as CaCO ₃	20	13	17
Calcium	mg/l	113	99	105
Chlorides	mg/l	444	345	415
Iron	mg/l	0.1	0	0.074
Magnesium	mg/l	61	57	59
Potassium	mg/l	9	8	8.3
Sulfate	mg/l	280	192	251
Sodium	mg/l	260	162	203
Total Hardness	mg/l as CaCO ₃	529	482	508
Conductivity	uS	2023	1798	1964
TDS	mg/l	1192	1033	1147
pH	SU	7.80	7.15	7.50
Temperature	°C	24.6	22.6	23.7

(from CDM Smith 2014 Analysis)

- B. The CR 214 WTP is permitted for a maximum daily demand capacity of 8.0 MGD. The facility uses a low-pressure reverse osmosis (LPRO) process for removal of chlorides and was placed into service in 2007. Raw water from the wells is split and scale inhibitor is added to 50% of the raw water. This 4.0 MGD capacity of water is then treated with cartridge filtration before being pumped through the RO membranes. The permeate is blended with the remaining 50% of the raw water and treated in packed tower degasifiers for hydrogen sulfide removal after sulfuric acid addition. The sulfide stripped water is then chlorinated and ammonia is added to form a monochloramine residual. The pH is adjusted with sodium hydroxide and CO₂, and antiscalant is added for corrosion control. The finished water is stored on site in two (2) ground storage tanks.
- C. The RO system consists of two trains in parallel. Each train has a design capacity for permeate flow of 1,400 gpm at 85 percent recovery.
- D. The trains each consist of forty-eight (48), 8-inch diameter pressure vessels, configured in an 8:6 array. Each vessel contains seven (7) spiral-wound 8-inch diameter by 40-inch long membrane elements.
- E. Based on a nominal active membrane element area of 400 square feet per RO element, the average operating flux is approximately 15 gallons per square foot per day (gfd) at the design flow (1400 gpm) per train.
- F. Each train has a dedicated RO feed pump equipped with a variable frequency drive. The maximum available pump discharge pressure is approximately 180 psig at 1738 gpm.

1.4 REFERENCE STANDARDS

- A. American Society for Testing and Materials (ASTM): ASTM-D-4516
- B. American National Standards Institute (ANSI)/ National Sanitary Foundation (NSF) Standard 61.

REVERSE OSMOSIS (RO) MEMBRANES

1.5 SUBMITTALS

- A. MEM shall submit drawings and other information necessary to completely describe the membrane elements and related appurtenances, including dimensions, weight, element construction details (e.g., active membrane surface area and feed channel dimensions), standard performance parameters, installation instructions, interconnection instructions, storage and handling requirements. Information provided shall be sufficient to document compliance with all requirements specified herein. Included shall be standard commercial part numbers for the interconnector O-rings and U-cup brine seals.
- B. Also included with the shop drawings shall be standard operating and maintenance data and instruction sheets for the membrane elements, covering such topics as recommended cleaning solutions as well as long and short-term storage protocols.
- C. MEM shall submit proof of NSF 61 Certification
- D. Certified Test Data.
 - 1. The MEM shall submit certified wet test data for 10% of the elements furnished as specified herein.
 - 2. The test data shall be submitted at least 14 days prior to shipment of the membrane elements. The test data shall be accepted upon written approval from the District or its representative. The elements shall not be shipped to the site until such approval is obtained.

1.6 QUALITY ASSURANCE

- A. General
 - 1. All equipment furnished under this specification shall be new and shall be the standard product of a manufacturer, who is fully experienced, reputable, qualified and regularly engaged in the manufacture of the equipment to be furnished.
- B. Equipment Factory Testing and Inspection
 - 1. Membrane Elements

At least 10% of the membrane elements (68 elements total) shall be factory tested by the MEM and certified test data shall be supplied to the Owner prior to shipment. The test data shall be accepted by the Owner in writing prior to shipment.

 - a. The elements shall be tested under the following conditions:
 - 1) The feedwater to each element shall contain 500 mg/l of sodium chloride (as per manufacturer's standard test conditions) and it shall be at a temperature of 25°C (77°F) with a pH between 6.5 and 8.0.

REVERSE OSMOSIS (RO) MEMBRANES

- 2) The feedwater shall contain no foreign substance, such as large dye molecules, that will mask performance of the element.
- 3) The elements shall be under pressure test at 110-225 psig (as per manufacturer's standard test conditions) for a period of 30 minutes prior to data collection.
- 4) The recovery in each element under test shall be set at 15 percent.

- b. When tested under these conditions, individual elements shall be certified to have rejection equal to or better than the rejection specified below, the productivity shall fall within the range specified below, and the differential pressure shall be equal to or less than that specified below:

MEM	Model No.	Productivity Range (gpd)	Minimum Rejection (%)	Maximum dP (%)
DOW Filmtec	BW30XFRLE-400/34	9,520- 13,440	99.3	10.0

- c. While an individual element must have the test performance specified above, the average performance of all the elements shall meet the following minimum performance criteria:

MEM	Model No.	Average Productivity (gpd)	Minimum Rejection (%)	Average dP (psi)
Dow Filmtec	BW30XFRLE-400/34	11,500	99.3	15

- d. Certified test data shall consist of the element serial number, productivity, rejection, and differential pressure for each element. If the normalized test data is provided, the reference conditions shall be indicated.
- e. The Owner reserves the right to have a representative observe factory testing at any time during regular testing by the MEM. In addition, the Owner reserves the right to request retesting by the MEM of a random choice of the elements at no additional cost to the Owner. On retest, should any of the elements fail to meet the performance specified above, the Owner reserves the right to require the MEM to retest up to 100% of the elements at no additional cost to the Owner or reject the proposed shipment, at the sole discretion of the Owner.

REVERSE OSMOSIS (RO) MEMBRANES

PART 2 PRODUCTS

2.1 MEMBRANE ELEMENTS

A. Manufacturers:

1. Criteria:

- a. To be eligible, all MEMs shall be engaged in the manufacture of the membrane elements proposed for this project and shall maintain service facilities in the United States.
- b. Minimum requirements for qualification are as follows:
 - 1) The membrane has been tested in an RO system of at least 10 gpm permeate capacity, with a minimum average membrane permeate flux of 10 gfd and a minimum system recovery of 80 percent.
 - 2) The membrane in the qualifying system has logged at least 5,000 hours of cumulative on-line operation in United States municipal potable water treatment.
 - 3) Feed pressure to the qualifying system when operating at a minimum of 10 gfd and 80% recovery did not exceed 180 psig at 25°C.

2. Eligible MEMs

- a. The membranes qualified for use on this project are as follows:

MEM	Membrane Model Name
Filmtec	BW30XFRLE-400/34

B. Element Construction

1. The membrane elements must be NSF 61 certified for the production of potable water.
2. The membrane elements shall be spiral wound with feed and reject flow through the element parallel to the product water tube of the element. Elements shall have a reinforced fiberglass outer wrap. The element serial number and direction of feed/reject flow shall be clearly marked on each element.
3. The element permeate connection design and dimensions shall be the same for all elements supplied in this contract.
4. The elements shall have nominal dimensions of eight inches in diameter and 40 inches in length. The active membrane area of the elements shall be 400 square feet, minimum.
5. The feed/reject spacer material shall have a nominal thickness of between 0.026

REVERSE OSMOSIS (RO) MEMBRANES

and 0.031 inches.

6. Each element shall be furnished complete with element-to-element interconnector, inter-connector O-rings, and U-cup brine seal. O-rings and brine seals shall be constructed of ethylene propylene rubber, and shall be standard products available from vendors other than the Contractor.
7. The elements shall be fully compatible with the ProTec MODEL PR0-8-300-MSP, 7-element pressure vessels.
8. Prior to installation of the anti-telescoping device (ATD) on the feed and reject ends of each element, the rolled membrane sheets shall be flush-cut through the cured glue line to prevent the formation of membrane flaps or separation of the membrane sheets at the feed and reject ends of the element.
9. The MEM shall provide all adapters and adapter O-rings necessary to properly install the supplied elements in pressure vessels (including O-rings providing seal between adapter and pressure vessel end cap). The pressure vessels are ProTec MODEL PR0-8-300-MSP, 7-element pressure vessels.
10. Packing slips shipped with each container shall contain Material Safety Data Sheets (MSDS) indicating the properties and safe handling of chemical solutions entrained within the elements as a preservative.
11. Performance: Nominal membrane performance shall be as required under Article 1.06.B hereinbefore.

2.2 SPARE PARTS

- A. The MEM shall furnish the following spare components, in addition to those required for replacement installation of existing elements. Spare parts packaging shall indicate both an explicit written description (as shown below) and part number of the contents.
 1. Two (2) U-cup brine seals.
 2. One hundred (100) O-rings for the element interconnectors.
 3. Ten (10) O-rings for seal between pressure vessel end adapters and element.
 4. Five (5) O-rings for seal between pressure vessel end adapters and end cap.
 5. Five (5) element interconnectors.
 6. Two (2) pressure vessel end adapters.
 7. Eight (8) spare sealed membrane elements, shipped in individual permanent storage containers with manufacturer's storage solution to provide up to five (5) years of storage without degradation to element integrity.

REVERSE OSMOSIS (RO) MEMBRANES

PART 3 EXECUTION

3.1 SHIPMENT, HANDLING, AND STORAGE

- A. All equipment, including spare components, shall be delivered complete within six (6) weeks of authorization, but not later than the date specified in the Agreement. Shipment shall be made only after the Owner's written acceptance (via email) of MEM certified test data. Deliveries will be accepted at the treatment plant at the following location:

**St. Johns County Utility Department
CR214 Mainland Water Treatment Plant
2160 Water Plant Road
St. Augustine, FL 32092**

Deliveries are accepted between the hours of 8:30 a.m. and 3:30 p.m. only, Monday through Friday. No deliveries will be accepted on Saturday, Sunday, or holidays. Prior to shipping, the MEM shall contact Allen Klipstine with St. Johns County at (904) 209-2700 to schedule the date and time of delivery.

- B. Weight, handling instructions, type of storage required, and instructions for protective maintenance during storage shall be included with each shipment to the project site.
- C. Freight to the water plant to be included in the cost of the membranes.

3.2 INSTALLATION

- A. General: The MEM shall be available for remote technical support to ensure proper installation of membrane elements.
- B. Cleaning the Pressure Vessels
1. The Owner is responsible for cleaning the pressure vessels prior to installation of membrane elements. A non-chlorinated, clean water supply shall be used for cleaning the vessel prior to membrane loading.
- C. Loading of the Membranes and Startup
1. The Owner will provide a contractor to load the elements, who will perform element loading as directed by the MEM onsite technician.
 2. MEM to provide additional cost to provide on-site assistance and certification of the membrane installation and startup as follows:
 - i. At least four (4) man-days total over two (2) separate site visits for assistance and certification of membrane installation.
 - ii. At least four (4) man-days total over two (2) separate site visits for startup of both skids.

3.3 WARRANTIES

REVERSE OSMOSIS (RO) MEMBRANES

- A. The MEM shall furnish a warranty for the RO membrane elements. This warranty must be signed by an individual authorized to execute contracts on behalf of the membrane manufacturer (MEM) and shall state the following provisions with no additional conditions or exceptions:
1. The MEM shall warrant the performance of the membrane elements for a period of three (3) years from completion of membrane loading. The MEM shall guarantee the membrane elements during that three (3) year period in accordance with the performance requirements specified herein and the following prorated replacement conditions if the elements fail to meet the warranted performance.
 - a. The individual elements shall have a productivity of not less than 80% of the minimum productivity when tested at standard conditions as described in Paragraph 1.06B.
 - b. During the same three (3) year period, the individual element salt rejection shall not decline below 99.2% when tested at standard conditions as defined within Paragraph 1.06B.
- B. The warranty conditions specified above shall be valid under the following conditions:
1. The RO system has been operated as designed in terms of product water recovery, array configuration, and feedwater pH.
 2. The feedwater has not contained chemicals that chemically or physically destroy the elements.
 3. The elements are periodically cleaned with an effective cleaning solution to remove membrane foulants.
 4. The elements are cleaned using standard cleaning solutions prior to performance testing for warranty purposes.
 5. Biological matter or sparingly soluble substances in the feed water have not irreversibly fouled the elements.
 6. Should the RO train performance not meet the warranty requirements, the MEM shall provide sufficient replacement elements to achieve the specified train performance. The replacement elements will be provided at the current market price, less a credit of 1/36 of the purchase price for each unused month of the warranty period. The MEM shall guarantee that future replacement elements will be sold to the Owner at a price per element not to exceed an amount negotiated between SJCUD and the MEM prior to contract award for any time within three years from delivery of the RO membrane replacement elements.

END OF SECTION

SECTION 00800-8

Appendix B

Existing Anti-Scalant Data Sheet A-111

Proposed Anti-Scalant Data Sheet A-102

Anti-Scalant Water Chemistry Model

Product Information Sheet

ADVANTAGES

- Phosphorous-free antiscalant designed to inhibit inorganic scale formation in membrane separation processes
- Inhibits calcium carbonate scale up to a Calcium Carbonate Nucleation Index (CCNI) of 2.0
- Controls calcium carbonate, calcium sulfate, barium and strontium sulfates, as well as silica scales in waters with a high fouling potential
- Approved for use by all major membrane manufacturers
- Environmentally compatible, especially where discharge of waste into the environment is a concern
- Certified by NSF to NSF/ANSI Standard 60

TYPICAL PROPERTIES

Appearance	Colorless to light yellow liquid
Odor	Characteristic
Solubility in water	Complete
pH (as is) @ 25°C	3 - 5
Specific Gravity	1.10 ± 0.10

PACKAGING

5 gallon pails, 55 gallon non-returnable plastic drums, 275 gallon totes and bulk shipments

AWC A-111 Plus

Reverse Osmosis Membrane Antiscalant

SAFETY & HANDLING

Store in a cool, dry place. In accordance with good safety practice, handle with care and avoid contact with eyes and prolonged or repeated contact with skin. For more information, see the Safety Data Sheet provided with this product.

CHEMICAL FEEDING AND CONTROL

Normally fed continuously prior to the final cartridge filter. It should be injected by chemical dosing pump from a dilution tank or directly from the drum to the feedwater line. The amount of AWC A-111 PLUS required to inhibit scale formation depends on the quality of feedwater and size of the membrane system. An AWC technical representative will provide the specific control range and the approximate dosage rate for your system.



Product Information Sheet

ADVANTAGES

- A broad spectrum antiscalant designed to inhibit inorganic scale formation in membrane separation processes
- Inhibits calcium carbonate scale up to a Calcium Carbonate Nucleation Index (CCNI) of 2.2
- Effectively inhibits formation of calcium sulfate, calcium phosphate, calcium fluoride, barium sulfate, strontium sulfate and silica
- Stabilizes metal ions to prevent metal oxides precipitation and disperses existing metal oxides/hydroxides, silt and clay particles
- Approved for use by all major membrane manufacturers
- Environmentally compatible, especially where discharge of waste into the environment is a concern
- Certified by NSF to NSF/ANSI Standard 60

TYPICAL PROPERTIES

Appearance	Clear colorless to yellow liquid
Odor	Characteristic
Solubility in water	Complete
pH (as is) @ 25°C	3 - 4
Specific Gravity	1.10 ± 0.05

PACKAGING

5 gallon pails, 55 gallon non-returnable plastic drums, 275 gallon totes and bulk shipments

AWC A-102 PLUS

Membrane Antiscalant-Broad Spectrum

SAFETY & HANDLING

Store in a cool, dry place. In accordance with good safety practice, handle with care and avoid contact with eyes and prolonged or repeated contact with skin. For more information, see the Safety Data Sheet provided with this product.

CHEMICAL FEEDING AND CONTROL

Normally fed continuously prior to the final cartridge filter. It should be injected by chemical dosing pump from a dilution tank or directly from the drum to the feedwater line. The amount of AWC A-102 Plus required to inhibit scale formation depends on the quality of feed water and operational parameters of the membrane system. An AWC technical representative will provide you with the specific control range and the approximate dosage rate for your system.



Unit	Unit
Source: Well Water (Brackish)	Feed Pressure: psi 102.435
Feed Temperature: °C 24.000	Total Δ Pressure psi 19.868
Raw Water Flow/ Train: gal/min 1458.484	Elements:
Total Permeate Flow/ Train: gal/min 1212.000	Brine Pressure: psi 82.600
Average Flux Rate: gfd 12.990	Permeate Pressure: psi 0.000
Recycling Flow: gal/min 0.000	Fouling Factor: 1.000
	System Recovery: % 83.100
	Internal Recovery: % 83.100

Cations	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
Ca ²⁺	113.70	113.70	113.69	668.77	0.80
Mg ²⁺	62.79	62.79	62.78	369.32	0.44
Ba ²⁺	0.02	0.02	0.02	0.12	0.00
Sr ²⁺	7.77	7.77	7.77	45.72	0.05
Na ⁺	218.60	218.60	218.57	1240.09	10.83
K ⁺	8.37	8.37	8.37	47.46	0.41
Fe ²⁺	0.02	0.02	0.02	0.13	0.00
Fe ³⁺	0.06	0.06	0.06	0.33	0.00
Al ³⁺	0.00	0.00	0.00	0.00	0.00
Mn ²⁺	0.00	0.00	0.00	0.00	0.00
NH ₃ /NH ₄ - N	0.00	0.00	0.00	0.00	0.00

Anions	Raw water (mg/L)	Balanced Feed (mg/L)	Recycling + Feed (mg/L)	Reject (mg/L)	Permeate (mg/L)
HCO ₃ ⁻ Alk(CaCO ₃)	125.40	124.74	124.74	684.75	4.33
CO ₃ ²⁻ Alk(CaCO ₃)	0.00	1.81	1.81	73.63	0.00
Total Alk (CaCO ₃)	125.40	126.55	126.55	758.38	4.33
Ortho-PO ₄ ³⁻	0.15	0.15	0.15	0.88	0.00
SO ₄ ²⁻	279.70	279.70	279.70	1645.36	1.97
F ⁻	0.66	0.66	0.66	3.79	0.02
Cl ⁻	437.91	437.91	437.91	2516.44	15.21
Br ⁻	1.07	1.07	1.07	6.10	0.04
SiO ₂	23.16	23.16	23.16	133.24	0.77
NO ₃ -N	0.00	0.00	0.00	0.00	0.00
NO ₂ -N	0.00	0.00	0.00	0.00	0.00
Sulfides (as S ²⁻)	0.00	0.00	0.00	0.00	0.00
B	0.08	0.08	0.08	0.18	0.06
AS (III)	0.00	0.00	0.00	0.00	0.00
AS (V)	0.00	0.00	0.00	0.00	0.00
TDS:	1304.450	1304.450	1304.400	7542.340	35.810
Conductivity (µs/cm):	2056.000	2074.228	2074.227	11998.609	55.859
pH:	7.570	7.570	7.570	8.230	6.170
Flow: gal/min		1458.480	0.000	246.480	1212.000

Summary	Product:	Dosage:
pH adjusted using:	H ₂ SO ₄	0.000 mg/L
Selected product:	AWC A-102	2.031 mg/L



Membrane Aqueous Chemistry Calculator

REPORT: 3.067.01

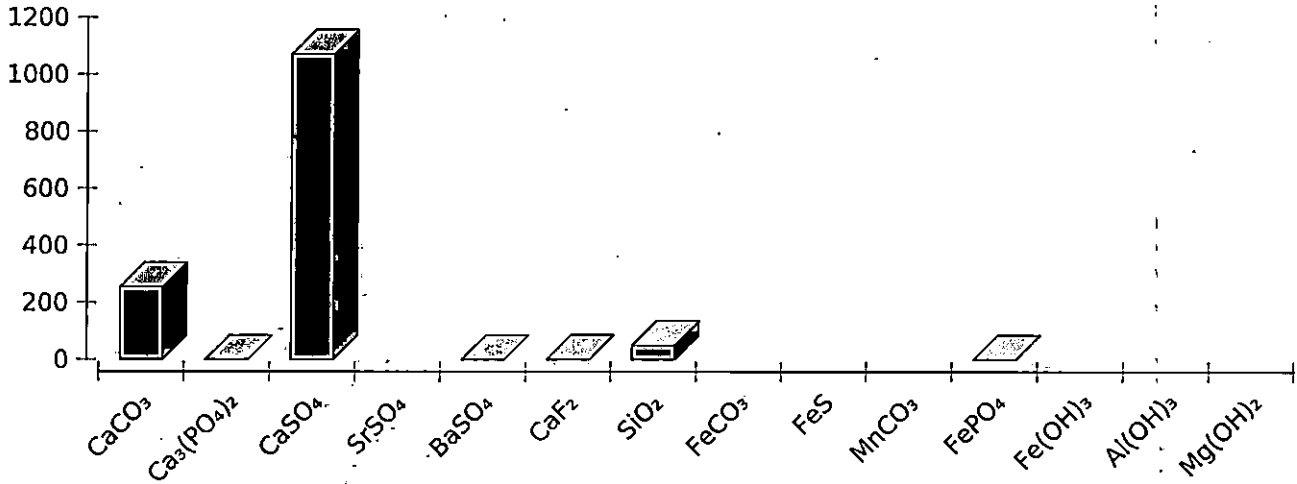
release date: Dec 8, 2017

Projection By: John Hall
 Client name: St. John's County
 Project: CR214 RO plant / No Acid
 Location: United States / Florida / St. Augustine

Unit	Stage 1	Stage 2
Total Elements:	224	112
Total Vessels:	32	16
Elements / Vessels:	7	7
Hydraulic/Interstage Pressure Losses: psi	0.000	0.000
Feed Pressure: psi	102.435	90.489
Permeate Throttle/Backpressure: psi	11.313	0.000
Interstage Boost Pressure: psi	0.000	0.000
Concentrate Pressure: psi	90.489	82.600
Feed Flow: gal/min	45.578	33.218
Concentrate Flow: gal/min	16.609	15.405

Hydraulics Details										
	Membrane Model:	Permeate Flow: gal/min	Average Flux: gfd	System Recovery: %	β	Feed Flow / PV: gal/min	Concentrate Flow / PV: gal/min	Δ Pressure: psi	Osmotic Pressure: psi	Net Driving Pressure: psi
Stage1		927.000	14.898	63.559	1.099	45.578	16.609	11.947	29.522	63.885
1	BW30XFRLE-4C	4.966	17.877	10.895	1.106	45.578	40.612	2.861	13.034	76.657
2	BW30XFRLE-4C	4.694	16.898	11.558	1.104	40.612	35.918	2.394	14.603	72.461
3	BW30XFRLE-4C	4.430	15.948	12.334	1.102	35.918	31.488	1.979	16.489	68.388
4	BW30XFRLE-4C	4.165	14.994	13.227	1.100	31.488	27.323	1.613	18.787	64.294
5	BW30XFRLE-4C	3.887	13.995	14.228	1.097	27.323	23.435	1.293	21.618	60.010
6	BW30XFRLE-4C	3.585	12.904	15.295	1.094	23.435	19.851	1.018	25.137	55.335
7	BW30XFRLE-4C	3.242	11.671	16.332	1.090	19.851	16.609	0.787	29.522	50.047
Stage2		285.000	9.161	53.623	1.108	33.218	15.405	7.889	60.185	51.583
1	BW30XFRLE-4C	3.620	13.033	10.899	1.084	33.218	29.597	1.780	33.713	55.886
2	BW30XFRLE-4C	3.270	11.774	11.050	1.078	29.597	26.327	1.496	37.475	50.486
3	BW30XFRLE-4C	2.912	10.483	11.060	1.071	26.327	23.415	1.255	41.636	44.950
4	BW30XFRLE-4C	2.545	9.164	10.871	1.064	23.415	20.870	1.054	46.137	39.295
5	BW30XFRLE-4C	2.177	7.836	10.429	1.056	20.870	18.693	0.890	50.860	33.600
6	BW30XFRLE-4C	1.815	6.533	9.708	1.047	18.693	16.878	0.759	55.620	28.015
7	BW30XFRLE-4C	1.473	5.303	8.728	1.039	16.878	15.405	0.656	60.185	22.740

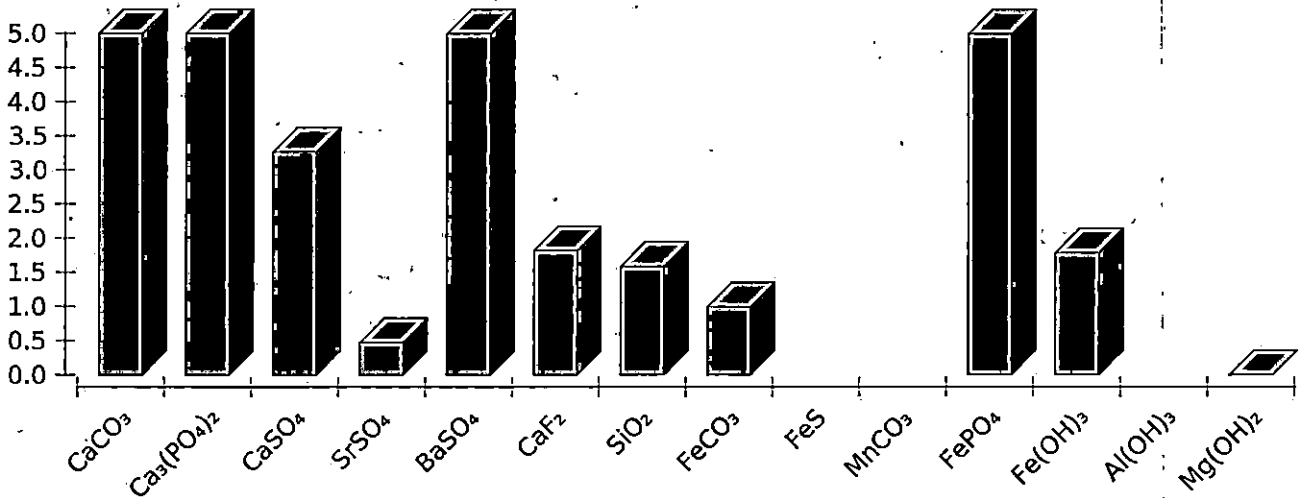
Summary Scale - Precipitation Potentials (mg/L)



Summary Scale - Precipitation Potentials (mg/L)

CaCO ₃	Ca ₃ (PO ₄) ₂	CaSO ₄	SrSO ₄	BaSO ₄	CaF ₂	SiO ₂	FeCO ₃	FeS	MnCO ₃	FePO ₄	Fe(OH) ₃	Al(OH) ₃	Mg(OH) ₂
255.04	0.379	1072.622	0	0.18	1.593	50.823	0	0	0	0.912	0	0	0

Summary Scale - X Saturation



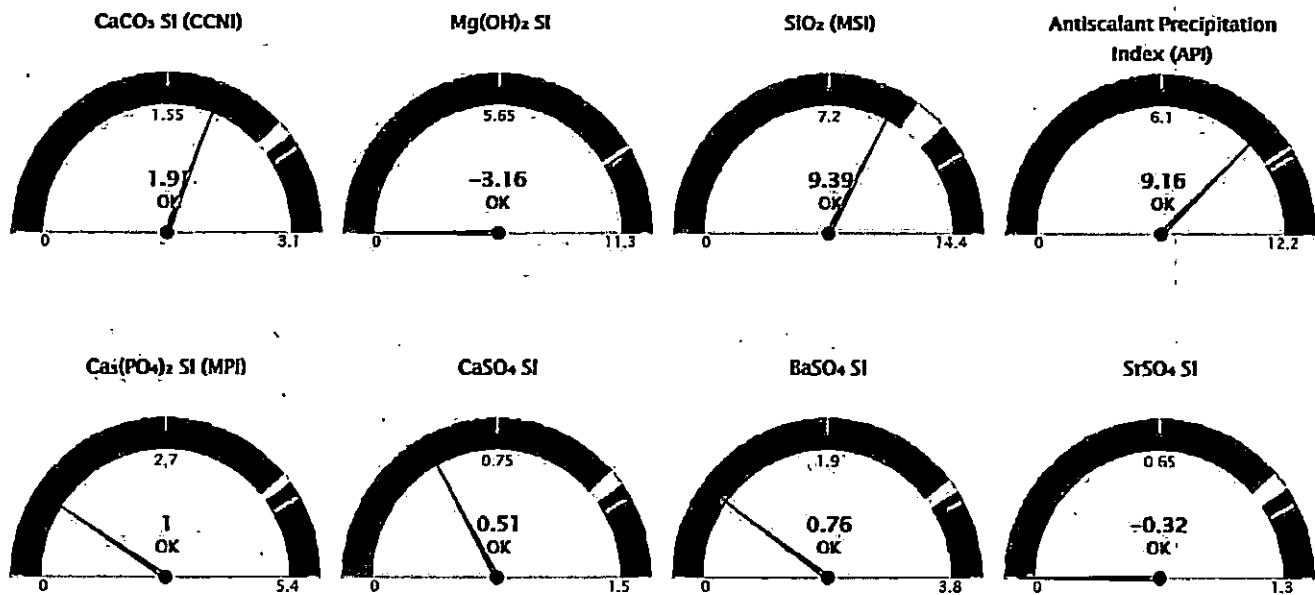
Summary Scale - X Saturation

CaCO ₃	Ca ₃ (PO ₄) ₂	CaSO ₄	SrSO ₄	BaSO ₄	CaF ₂	SiO ₂	FeCO ₃	FeS	MnCO ₃	FePO ₄	Fe(OH) ₃	Al(OH) ₃	Mg(OH) ₂
81.826	9.97	3.267	0.473	5.732	1.82	1.589	0.998	0	0	4139.04	1.79	0	0.001

Scales above 100% saturation

CaCO ₃	Saturation is 81.83 X; [Saturation Index is 1.91], Precipitation Potential: 255.04 mg/l
MgCO ₃	Saturation is 19.69 X; [Saturation Index is 1.29], Precipitation Potential: 0.00 mg/l
SrCO ₃	Saturation is 17.45 X; [Saturation Index is 1.24], Precipitation Potential: 45.82 mg/l
Ca ₃ (PO ₄) ₂	Saturation is 9.97 X; [Saturation Index is 1.00], Precipitation Potential: 0.38 mg/l
FePO ₄	Saturation is 4,139.04 X; [Saturation Index is 3.62], Precipitation Potential: 0.91 mg/l
CaSO ₄	Saturation is 3.27 X; [Saturation Index is 0.51], Precipitation Potential: 1,072.62 mg/l
BaSO ₄	Saturation is 5.73 X; [Saturation Index is 0.76], Precipitation Potential: 0.18 mg/l
CaF ₂	Saturation is 1.82 X; [Saturation Index is 0.26], Precipitation Potential: 1.59 mg/l
Fe(OH) ₃	Saturation is 1.79 X; [Saturation Index is 0.25], Precipitation Potential: 0.00 mg/l
Mg ₃ Si ₂ O ₅ (OH) ₄	Saturation is 8.22 X; [Saturation Index is 0.91], Precipitation Potential: 207.85 mg/l
SiO ₂	Saturation is 1.59 X; [Saturation Index is 0.20], Precipitation Potential: 50.82 mg/l

Critical Indices



Chemical dosing:

	AWC A-102	H2SO ₄
Calculated Dosage:	2.031 mg/L	0.000 mg/L
Total Dosage (modified by user):	2.031 mg/L	N/A
% Concentration:	N/A	93.000%
Density:	1.070 g/cm ³	1.835 g/cm ³
Dosing Pump:	10.480 ml/min	0.000 ml/min
Hours of Operation/Day:	24 hour(s)	24 hour(s)

Consumption per:

	AWC A-102	H2SO ₄
Day	16.148 kg	0.000 kg
Week	113.038 kg	0.000 kg
4 Weeks	452.151 kg	0.000 kg
Year	5894.113 kg	0.000 kg
5 Years	29470.565 kg	0.000 kg

Insert your additional comments below:

AWC | PROTON
Membrane Aqueous Chemistry Calculator

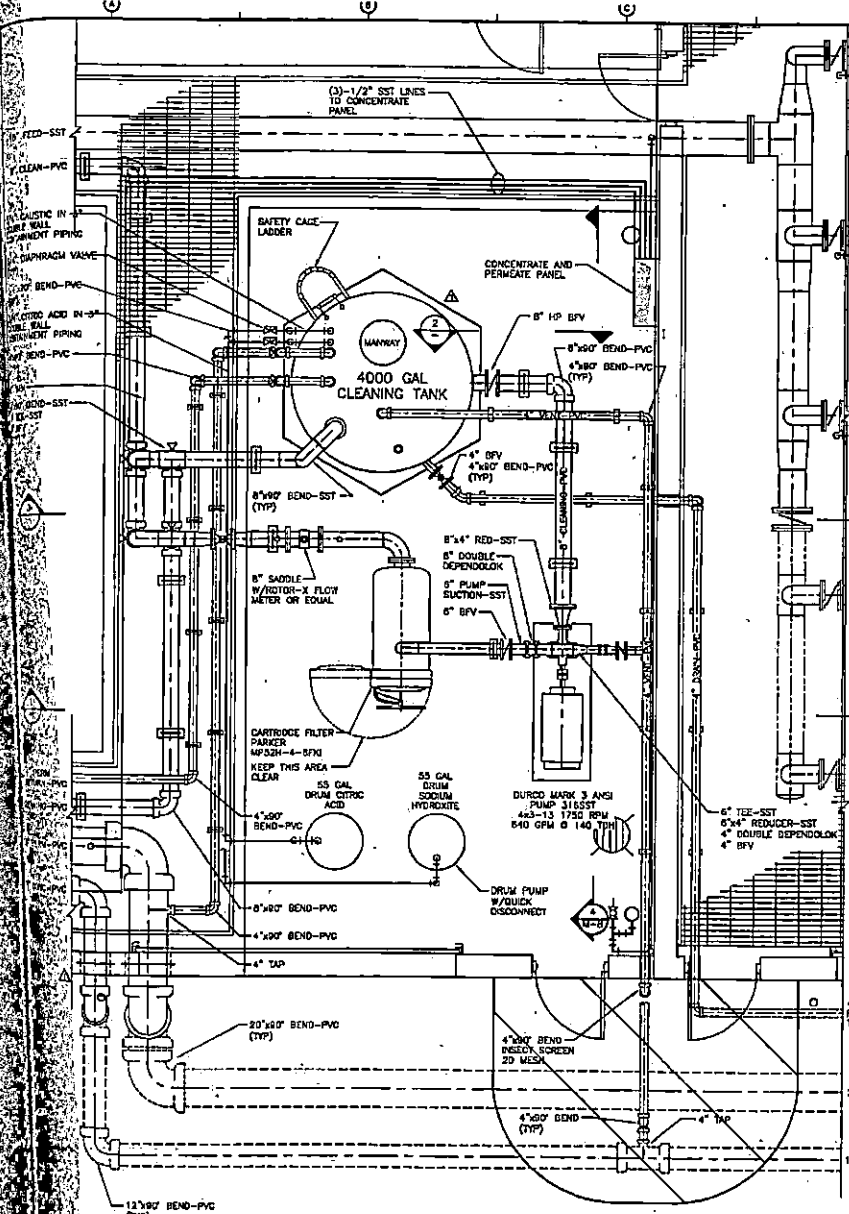
Projection By: John Hall
Client name: St. John's County
Project: CR214 RO plant / No Acid
Location: United States / Florida / St. Augustine

REPORT: 3.067.01 release date: Dec 8, 2017

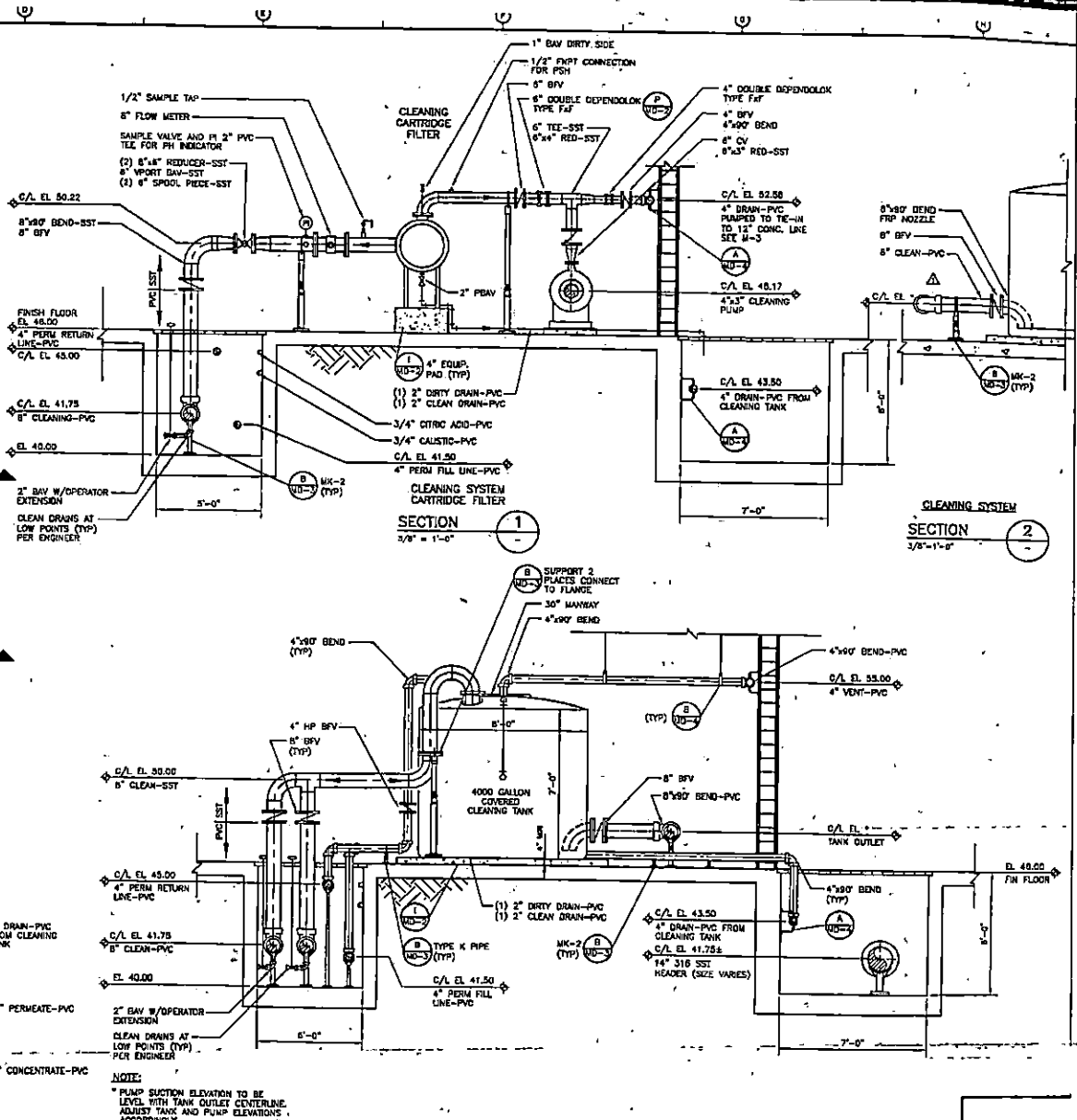
Comments...

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Appendix C
Existing Clean in Place Asbuilts
Revised Membrane Cleaning Procedure
Membrane Cleaning Chemicals Data Sheets



CLEANING SYSTEM
PLAN
 3/8" = 1'-0"

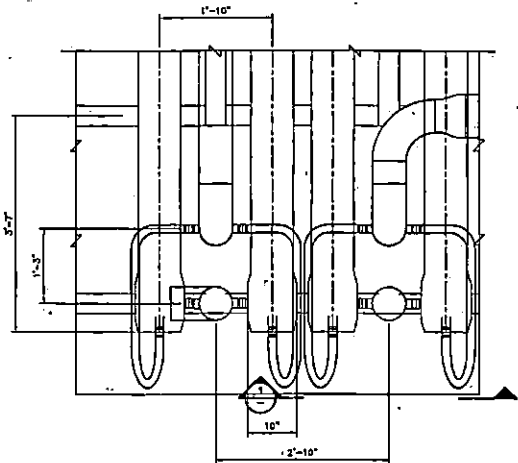


CLEANING SYSTEM
SECTION
 3/8" = 1'-0"

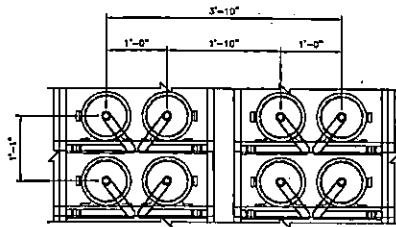
NOTE:
 * PUMP SUCTION ELEVATION TO BE LEVEL WITH TANK OUTLET CENTERLINE. ADJUST TANK AND PUMP ELEVATIONS ACCORDINGLY.

DONALD E. MAURER
 P.E., NO. 35575

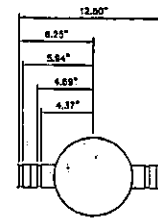
CONFORMED DRAWINGS
 FEBRUARY 2006



DETAIL PLAN A
1" = 1'-0"

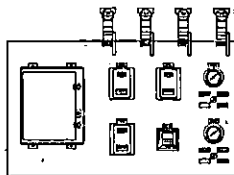


SECTION 1
1" = 1'-0"

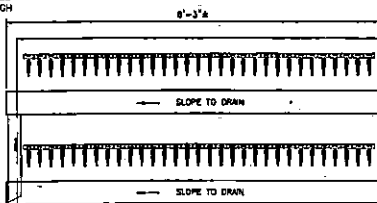


FEED AND CONCENTRATE
MANFOLD WITH PULLED TEES
DETAIL B
3" = 1'-0"

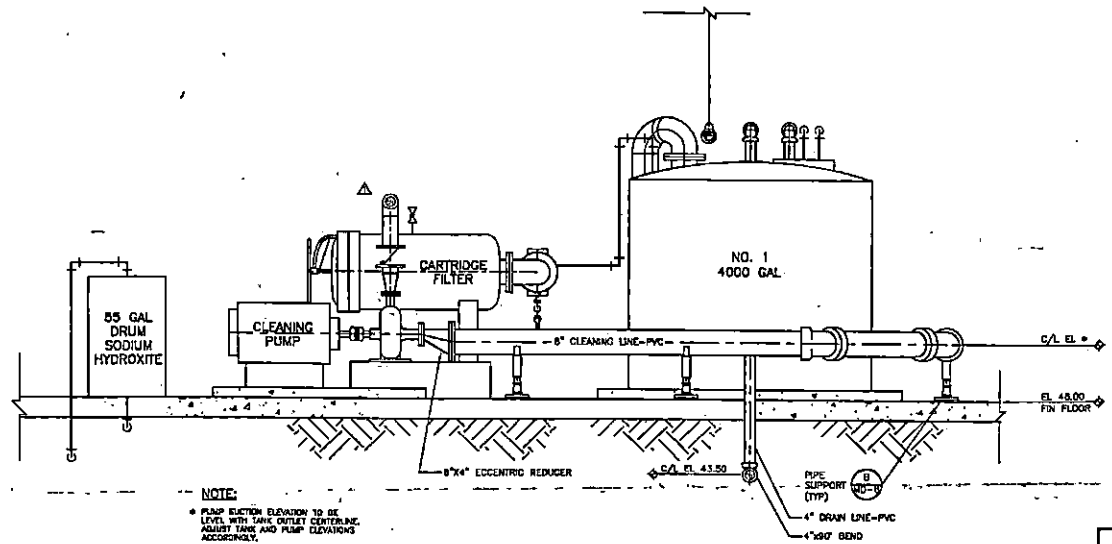
NOTE:
REFER TO PRESSURE VESSEL
MANUFACTURER INSTALLATION
DETAILS FOR DIMENSIONS AND
CLEARANCES.



NOTE:
PROVIDE SAMPLE POINT FOR EACH
PRESSURE VESSEL - STAGE 1 COMPOSITE
PERMEATE, STAGE 2 COMPOSITE
PERMEATE, CONCENTRATE, FEED, TOTAL
PERMEATE, AND INTERSTAGE FEED. USE
BLACK EASTMAN NYLON TUBING FOR
SAMPLE LINES.
SAMPLE PANEL AND TROUGH TO BE
FABRICATED WITH FRP PANEL W/HIGH
GLASS GEL COAT



SAMPLE PANEL
DETAIL C
3/4" = 1'-0"



NOTE:
PUMP SECTION ELEVATION TO BE
LEVEL WITH TANK OUTLET CENTERLINE.
ADJUST TANK AND PUMP ELEVATIONS
ACCORDINGLY.

SECTION 4
1/2" = 1'-0"

DONALD E. MAURER
P.E., NO. 35578

CONFORMED DRAWINGS
FEBRUARY 2006

CR214 RO WTP Membrane Recommended Cleaning Procedure:

HIGH pH CLEANING (AWC A-C226):

1. The CIP tank must be clean and the cartridge filter replaced.
2. Flush the skid with permeate water until you measure nearly the same conductivity of the permeate in the concentrate sample valve.
3. Open all the appropriate cleaning valves. Permeate return should always be open.
4. Mix 2% solution by weight. Convert the CIP volume (gals to pounds).
5. Measure the initial pH of the cleaning solution before circulation to the membrane. AWC A-C226 at 2% solution is approximately pH 12.
6. Start with low flow (25 gpm/vessel). The differential pressure between the cleaning feed and concentrate return must not exceed 70 psi for 7 elements/vessel (10 psi/element).
7. Circulate for 1 hour and soak for 1 hour while circulating 2nd stage. Total circulation time for each stage is 3 hours.
8. Note the cleaning flow of the 2nd stage is not the same as the first stage. It depends on the number of vessels.
9. Reading must be taken every 30 minutes. Add more cleaning chemicals if the pH drops by approximately 0.5 (maintain at least pH 11.5).
10. After 1 hour of circulation, increase the flow to 45 gpm if the differential pressure allows.
11. After 6 hours cleaning (3 cycles at 2 hours each) flush the skid with permeate water until the pH of water coming out from the concentrate sample valve is almost neutral.

LOW pH CLEANING (AWC A-C234):

1. Follow same procedure as high pH cleaning. AWC A-C234 solution at 2% is approximately pH 1.5.
2. The total circulation time depends on the pH change.

Product Information Sheet

ADVANTAGES

- High strength powder formulation specifically designed for use as a high pH cleaner of polyamide thin film composite membrane surfaces
- Effectively penetrates and lifts biofilms and removes oils, greases and other hydrocarbons from the membrane surface
- Disperses inorganic particulates such as silt, clay and metal oxides
- Helps remove silica fouling
- Chelates non-carbonate scales such as calcium fluoride, calcium sulfate, barium sulfate and strontium sulfate
- Compatible with all Thin Film Composite R.O. membranes from all major membrane suppliers
- Certified by NSF to NSF/ANSI Standard 60

TYPICAL PROPERTIES

Appearance	White to tan powder
Odor	Slight characteristic
Solubility in water	Soluble
pH (1% solution)	11 – 12

PACKAGING

45 lb. pails and 400 lb. non-returnable plastic drums

AWC C-226

Reverse Osmosis Membrane Cleaning Compound

SAFETY & HANDLING

Store in cool, dry and well ventilated area. Keep containers closed. Wash contaminated clothes before re-use. Wash thoroughly after handling. For more information, see the Safety Data Sheet provided with this product.

CHEMICAL FEEDING AND CONTROL

Cleaning solution should be prepared using potable water free of residual chlorine or other oxidizing agents. Solution should consist of 9–18 lbs of AWC C-226 for every 100 gallons of water (1 – 2 % by wt. solution). Adjust pH between 10–11 by adding more AWC C-226 if necessary. Circulate the cleaning solution throughout the system without exceeding pressures/flow rates recommended by the membrane manufacturer. Cleaning efficacy can be improved by heating the cleaning solution and alternately circulating the solution for 15 min and then soaking the membranes for 15 min. Repeat as many times as necessary. Add AWC C-226 as necessary to the cleaning solution to maintain the pH range of 10–11 throughout the entire cleaning process. Depending on severity of fouling, your AWC representative will recommend optimal cleaning times.



P: +1.813.246.5448 // E: info@membranechemicals.com // www.membranechemicals.com

Product Information Sheet

ADVANTAGES

- Concentrated liquid formulation designed for use as a low pH cleaner of polyamide thin film composite membrane surfaces
- Removes inorganic carbonate, phosphate and sulfate scalants as well as metal oxides
- Contains a synergistic blend of cleaners and scale removal agents for a thorough cleaning of the membrane
- Will remove certain inorganic precipitants that cannot be removed through the use of citric or hydrochloric acid
- May eliminate the need for repeat cleanings in cases of severe scaling
- Compatible with all Thin Film Composite R.O. membranes from all major membrane suppliers
- Certified by NSF to NSF/ANSI Standard 60

TYPICAL PROPERTIES

Appearance	Clear colorless to yellow liquid
Odor	Essentially no odor
Solubility in water	Complete
pH (as is) @ 25°C	< 2
Specific Gravity	1.15 ± 0.05

PACKAGING

5 gallon pails, 55 gallon non-returnable plastic drums and 275 gallon totes

AWC C-234

Reverse Osmosis Membrane Cleaning Compound

SAFETY & HANDLING

Store in cool, dry and well ventilated area: Keep containers closed. Wash contaminated clothes before re-use. Wash thoroughly after handling. For more information, see the Safety Data Sheet provided with this product.

CHEMICAL FEEDING AND CONTROL

The cleaning solution should be prepared using potable water that is free of residual chlorine or other oxidizing agents. Add 2 gallons of AWC C-234 to every 100 gallons of water (2% solution). Adjust the pH in the range 2-3. Recirculate the cleaning solution throughout the system, after redirecting the first 20% of the solution to drain. Do not exceed pressures, temperatures and flow rates recommended by the membrane manufacturer. Cleaning efficacy can be further improved by heating the cleaning solution and alternately circulating the solution for 15 minutes and then soaking the membranes for 15 minutes. Repeat as necessary. Monitor the pH range periodically throughout the cleaning. When pH increases above the desired range, it should be adjusted by adding more AWC C-234.





AWC C-226 HIGH pH CLEANING PROCEDURE

Safety Precautions:

1. Always add chemicals slowly to an agitated batch of make-up water.
2. Always wear **safety glasses** and appropriate protective gear when working with chemicals.
3. Don't mix concentrated acids with caustic solutions.
4. Always perform a high pH clean before the low pH clean.
5. Ensure that cartridge filters in cleaning skid are clean and that no water is remaining in the pipes from the last cleaning.
6. Be sure all hoses and piping can handle the temperatures, pressures and pH which will be encountered during cleaning.
7. During cleaning, do not exceed membrane manufacturer's recommendations for pH, temperature, pressure, flow rates.
8. Thoroughly rinse the 1st cleaning solution from the R.O. system before introducing the next solution.

Reverse Flow Permeate Flushing:

1. Fill cleaning tank with permeate water and adjust pH to 9.
2. Flush membranes in **reverse** flow using procedure from **Hydraulics Technical Service Bulletin 125.01**
3. Flushing water should go to drain, never back to the cleaning tank
4. Start at a low flow of 11 – 13 GPM (44 – 50 L/min) and observe ΔP
5. Flow can be increased to 23 GPM (88 L/min) **ONLY** if ΔP does not exceed 60 PSI
6. Maximum flow during **reverse** flushing should **NEVER** exceed 23 – 26 GPM (88 - 101 L/min)

Forward Flow Permeate Flushing:

1. Fill cleaning tank with permeate water and adjust pH to 9.
2. Flush in normal flow direction to drain.
3. Start at a low flow of 11 – 13 GPM (44 – 50 L/min) and observe ΔP
4. Flow can slowly be increased up to 50 GPM (189 L/min) **ONLY** if ΔP does not exceed 60 PSI.
5. Maximum flow during forward flushing should **NEVER** exceed 60 gallons per minute (227 L/min).



Cartridge Filters:

Always use **1 micron cartridge filters** for cleaning. This is to prevent suspended solids removed during cleaning from being re-introduced into the system. If ΔP exceeds 10PSI during cleaning, then the filters are heavily fouled and must be replaced.

High pH Clean:

The purpose of the High pH cleaning is to remove Organics, Biological Fouling and Silica that have deposited on the membrane. C-226 also contains proprietary ingredients that will remove some sulfate scales.

Preparing Cleaning Solution:

1. Calculate required cleaning solution. This can be estimated by assuming 10 Gal (40L) per 8" membrane. This will be referred to as "required volume". The value may vary depending on system piping, so you may need up to 20% additional volume (12 Gal per membrane)
2. Fill required volume of **chlorine-free permeate** water in Cleaning tank and heat to a temperature between 100 – 105 °F (37 - 41°C). **DO NOT EXCEED MEMBRANE'S MANUFACTURER RECOMMENDATIONS FOR TEMPERATURE RANGE AT ANY TIME DURING CLEANING.**
3. Add 1% AWC C-226 by volume (Approx. 84 LBS C-226 for every 1000 Gal of water, or 10 KG C-226 for every 1000 L of water). Mix well within the tank using recirculating pump. Do not send to membranes until chemicals are fully mixed.
4. Introduce the cleaning solution to the system. Divert the first 20% of cleaning solution (the most highly fouled cleaning solution) to drain in order to displace water already in the membranes. Route the remaining cleaning solution back to the CIP tank.
5. Add another 1% AWC C-226 by volume (Approx. 84 LBS C-226 for every 1000 Gal of water, or 10 KG C-226 for every 1000 L of water). Mix well within the tank using recirculating pump. Do not send to membranes until chemicals are fully mixed.
6. Check pH. pH should be > 12. If pH < 11.9, add more C-226 to reach target pH. Do not add more than 0.1% at a time (~8 LBS C-226 for every 1000 Gal of water, or ~1 KG C-226 for every 1000 L of water). Always continue mixing during pH adjustment by recirculating within the mixing tank. Never try to adjust pH in



stagnant water. Mix well within the tank using recirculating pump. Do not send to membranes until chemicals are fully dissolved.

NOTE: Do not at any time exceed pH and temperature beyond the membrane manufacturer's recommendations for cleaning procedures.

Cleaning procedure:

NOTE: Do not at any time exceed flow rates and pressures outlined by the membrane manufacturer for cleaning procedures.

7. Recirculate at low flow in the range of 10 – 12 GPM (37 – 45 L/min) and monitor every 15 minutes. Always ensure that Pressure Differential does not exceed 60 PSI (or pressure limit recommended by your membrane manufacturer)..
8. If ΔP does not exceed 60 PSI, increase recirculation flow to 20 – 24 GPM (76 – 91 L/min) and monitor every 15 minutes. If dP is > 60 PSI, maintain cleaning at low flow for a longer time period.
9. If ΔP does not exceed 60 PSI, increase recirculation flow to 35 – 40 GPM (132 – 151 L/min). If dP is > 60 PSI, maintain cleaning at low flow for a longer time period.
10. Check Differential Pressure (ΔP) every 15 minutes and verify that ΔP is decreasing to ensure that foulants in feedspacers are dissolving.
11. Check pH every 15 minutes throughout the entire cleaning process. If $pH < 11.9$, add more C-226 to reach target pH. Do not add more than 0.1% at a time (~8 LBS C-226 for every 1000 Gal of water, or ~1 KG C-226 for every 1000 L of water). **IF THE SOLUTION IS VERY DARK IN COLOR AND TURBID, THEN MAKE A FRESH SOLUTION.**
12. After 1 hour of circulation, soak for 30 minutes. (Stop circulation of cleaning solution, close valves to prevent drainage of pressure vessels and allow membrane to “soak” in the cleaning solution.)
13. Soaking for more than 1 hour is unnecessary. After soaking repeat steps 10 – 12.
14. A total cleaning time of 5 - 7 hours is recommended (this includes soaking time). Record ΔP , pH, temperature, flow rates, color and turbidity of the cleaning solution every 15 minutes during the entire cleaning period.
15. Longer cleaning times may be required if pH does not remain constant for at least 2 consecutive pH measurements (15 minute increments).



16. Cartridge filters should be monitored regularly during cleaning. If ΔP exceeds 10 PSI, cartridge filters should be changed.
17. Fill CIP tank with *chlorine free* Permeate water and flush with permeate until no more foaming appears in the rinse water (permeate flushing solution).
18. Flush with permeate until no more foaming appears in the rinse water. The pH and conductivity of the water exiting the concentrate side of the pressure vessels should be approximately equal to the pH and conductivity of the permeate entering the system:

pH in = pH out

Conductivity in = Conductivity out

Color in = Color out

19. Put the unit back into service. Send permeate to drain until pH and TDS of permeate meets QC specifications as required by your facility.



AWC C-234 LOW pH CLEANING PROCEDURE

Safety Precautions:

1. Always add chemicals slowly to an agitated batch of make-up water.
2. Always wear **safety glasses** and appropriate protective gear when working with chemicals.
3. Don't mix concentrated acids with caustic solutions.
4. Always perform a high pH clean before the low pH clean.
5. Ensure that cartridge filters in cleaning skid are clean and that no water is remaining in the pipes from the last cleaning.
6. Be sure all hoses and piping can handle the temperatures, pressures and pH which will be encountered during cleaning.
7. During cleaning, do not exceed membrane manufacturer's recommendations for pH, temperature, pressure, flow rates.
8. Thoroughly rinse the 1st cleaning solution from the R.O. system before introducing the next solution.

Low pH Clean:

The purpose of the low pH cleaning is to remove carbonate, phosphate and hydroxide scales that is deposited on the membrane. AWC C-234 also contains proprietary ingredients which help in the removal of various other inorganic foulants.

Preparing Cleaning Solution:

1. Calculate required cleaning solution. This can be estimated by assuming 10 Gal (40L) per 8" membrane. This will be referred to as "required volume". Depending on volume of piping, please allow up to 12 Gal per membrane if necessary.
2. Fill required volume of **chlorine-free permeate** water in Cleaning tank and heat to a temperature between 85 – 90 °F. **DO NOT EXCEED MEMBRANE MANUFACTURER'S RECOMMENDATIONS FOR TEMPERATURE RANGE AT ANY TIME DURING CLEANING.**
3. Add 2% AWC C-234 by volume (ie. Approx. 20 Gal C-234 for each 1000 Gal of water) . Mix well using recirculating pump.
4. pH should be between 2 – 3. If pH>3, add more AWC C-234 to adjust pH between 2– 3. For tightening membrane pores after a high pH cleaning, a pH of 2 is preferable. 0.1 – 0.2% HCl can be added to further decrease the pH to 2. Always continue mixing during pH adjustment. Never try to adjust pH in stagnant water.



Cleaning procedure:

NOTE: Do not at any time exceed flow rates and pressures outlined by the membrane manufacturer for cleaning procedures.

5. Introduce the cleaning solution to the first stage. Divert the first 20% of cleaning solution (the most highly fouled cleaning solution) to drain in order to displace water already in the membranes. Route the remaining cleaning solution back to the CIP tank.
6. Recirculate at low flow in the range of 10 – 12 GPM (37 – 45 L/min) and monitor every 15 minutes. Always ensure that Pressure Differential does not exceed 60 PSI (or pressure limit recommended by your membrane manufacturer).
7. If ΔP does not exceed 60 PSI, increase recirculation flow to 20 – 24 GPM (76 – 91 L/min) and monitor every 15 minutes. If dP is > 60 PSI, maintain cleaning at low flow for a longer time period.
8. If ΔP does not exceed 60 PSI, increase recirculation flow to 35 – 40 GPM (132 – 151 L/min). If dP is > 60 PSI, maintain cleaning at low flow for a longer time period.
9. Check Differential Pressure (ΔP) every 15 minutes and verify that ΔP is decreasing to ensure that foulants in feedspacers are dissolving.
10. Check pH. If pH has increased by more than 0.5 pH units, add AWC C-234 in 0.1% increments to the circulating solution to adjust pH to 2 – 3.
11. After 1 hour of circulation, soak for 30 minutes. Soaking at low pH provides more effective results in reversing increased salt passage from high pH cleaning. (Stop circulation of cleaning solution, close valves to prevent drainage of pressure vessels and allow membrane to “soak” in the cleaning solution.)
12. Soaking for more than 1 hour is unnecessary. After soaking repeat steps 8 – 11.
13. A total cleaning time of 4 – 6 hours is recommended (this includes soaking time). Record ΔP , pH, temperature, flow rates, color and turbidity of the cleaning solution every 15 minutes during the entire cleaning period.
14. Longer cleaning times may be required if pH does not remain constant for 2 consecutive pH measurements (15 minute increments).



15. Cartridge filters should be monitored regularly during cleaning. If ΔP exceeds 10 PSI, cartridge filters should be changed.
16. Fill CIP tank with chlorine free Permeate water.
17. Flush with permeate until pH and conductivity of the water exiting the concentrate side of the pressure vessels are approximately equal to the pH and conductivity of the permeate entering the system:

pH in = pH out

Conductivity in = Conductivity out

Color in = Color out

18. Put the unit back into service. Send permeate to drain until pH and TDS of permeate meets QC specifications as required by your facility.