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PRETREATMENT
solutions

Winter 2010

The Evolution of Scale Control in RO Membrane Systems

By: Dan Comstock, Karen Lindsey, and Sara Pietsch
Avista Technologies, Inc.

How is it possible to run a reverse osmosis design projection and be limited to 65% recovery without an antiscalant, but achieve 80% recovery on the very same water supply using a parts per million dosage of a liquid scale inhibitor?

As the industry continues to stretch the limits of threshold inhibition and scale control, it's worth taking a look at how pretreatment chemicals have evolved to make RO a viable option in feedwaters that would have been completely unsuitable only a few years ago.

Types of Scale and their Effect on RO Membranes:


Photo 1: Calcium carbonate

Without some means of scale inhibition, RO membranes and flow passages within membrane elements will scale due to the precipitation of sparingly soluble salts. Most of the scale formers we encounter in RO applications today are crystalline in nature and include calcium carbonate (Photo 1), barium sulfate, calcium sulfate, and strontium sulfate.

Silica scale is a unique exception in that it is not crystalline so threshold inhibitors designed to prevent crystalline scales have little inhibitory affect. Polymerized silica occurs naturally in most feedwaters in the range of 1-100 mg/l. Supersaturated silica can polymerize to form silica scale on RO membrane surfaces.

As shown in Figures 1 and 2, silica solubility is a function of both pH and temperature and determines the maximum allowable silica concentration in the concentrate stream. Silica solubility increases with pH due to the formation of silicate ion. Some hypothesize that the formation of cationic species may explain its increased solubility at low pH values.

Figure 1: Silica Solubility versus Temperature

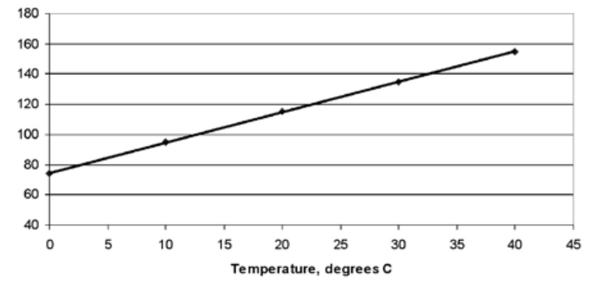
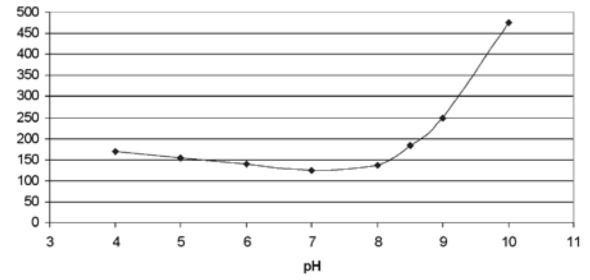


Figure 2: Silica Solubility versus pH



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President's Message

Peter M. Waldron

Dear AMTA Members:

Welcome to the Winter 2010 Edition of AMTA's "Solutions" newsletter. As we move forward from July's Annual Conference, our regional workshops begin and we hope that you are planning on attending an event near you or your utility. We are starting things off in Portland, OR in early November quickly followed with a joint AMTA/SCMA Workshop in El Paso, TX in December. Our workshops locations in 2011 include Dayton, OH, Sacramento, CA and Kansas City. Look for the announcements and save the dates!

This issue of "Solutions" is focused on membrane pretreatment. For those of us who have been involved in membrane plant operation, this issue is critical to the success of a plant especially those who have surface waters or seawater as a raw water source. Improper pretreatment can be devastating to a utility's operation budget. Unfortunately there are too many examples of this in our industry. So much has changed with pretreatment technologies and much knowledge has been gained as the awareness and education of this issue grows. We hope that the two articles in this newsletter will provide some guidance and useful information. There are articles from our regular contributors and committees which represent just a small example of the kinds of topics one can find at our conferences and workshops.

On behalf of AMTA's Board, we hope that you will be able to attend one our events or those of one of our regional affiliates. The continued goals of these events is to keep our members, or those considering membranes, updated on the advancement of the technologies, regulations, lessons learned and other valuable information. Please be sure to check our Calendar of Events on the back of the newsletter to find the specific dates of our next workshops.

We encourage your participation and appreciate your support. I look forward to seeing you and meeting new members at one of our upcoming events.

Peter M. Waldron
President - American Membrane Technology Association

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American Membrane Technology Association
2409 SE Dixie Hwy.
Stuart, FL 34996
772-463-0820
772-463-0860 (fax)
admin@amtaorg.com
www.amtaorg.com

Editors
Tom Seacord, P.E. and
Winnie Shih, Ph.D., Carollo Engineers, P.C.

PUBLICATION SCHEDULE

Winter
Pretreatment

Spring
Water Quality

Summer
New Facilities

Fall
Membrane Residuals

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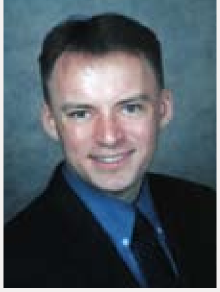



From the Editors

By: Tom Seacord, P.E. and Winnie Shih, Ph.D.

Welcome to the winter edition of AMTA *Solutions*. As we welcome the winter season, those of us living in cooler climates need to prepare for the changing weather. But whether you live in the cold or warm parts of the country, it's always time to prepare your membrane plant for the challenges associated with raw water quality. That's why once a year, AMTA *Solutions* dedicates an issue to the topic of pretreatment.

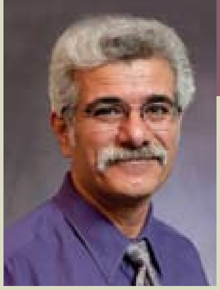
I think you will find this issue of AMTA *Solutions* interesting - particularly if you are looking to control fouling in your RO system. The first article presents a history of the use and chemistry of scale inhibitors. This article concludes with some very useful information pertaining to dose determination and how to evaluation of bids to help you get the best price. Our second technical article discusses the monitoring of an organic compound that has been linked to fouling in seawater RO systems. It provides some interesting insight on how pretreatment may be used to help control the occurrence of this compound in RO feed waters and how that may help reduce the rate of fouling.

AMTA strives to help our members better understand membrane technology to help them achieve success in its application. This publication, our workshops and annual conferences provide a great exchange of this type of useful information. Please let us know how we are doing and how we may do better for you.

If you are interested in submitting an article this publication, submissions and inquiries can be sent to either myself (tseacord@carollo.com) or Winnie Shih (wshih@carollo.com). Thank you and I look forward to your feed back on this and other issues of *Solutions*.

SUBMIT YOUR ARTICLE TODAY!

AMTA *Solutions* continually solicits technical articles for future issues. We are currently collecting articles in a variety of water treatment subject areas such as Pretreatment, Water Quality, New Facilities and Membrane Residuals. Contact AMTA for additional information.



Ben Movahed

Ben Mohlenhoff

Ben's Design Tip Corner

By: Ben Movahed, PE, BCEE, and Ben Mohlenhoff

If you have a tip or a suggestion for a future design article, please contact either Ben at:
Ben Movahed: 301-933-9690
movahed@watek.com

Ben Mohlenhoff: 772-546-6292
bmohlenhoff@aerexglobal.com

The Critical Role of Pretreatment

The salt rejection properties of desalting membranes (RO and NF) have been well known to the industry for decades. However, the compatibility of pretreated feed water with desalting membranes in terms of particulate matter, fouling and scaling rates, impact on membrane life and membrane degradation due to "poor" source waters are still being analyzed by engineers, manufacturers and end users. In fact, those of us involved in the membrane industry strongly believe that it is not the membranes that fail, it is improper application and/or inadequate pretreatment which causes failures in desalting membranes.

The primary objective of pretreatment is to make the feed water compatible with the desalting membrane. Pretreatment is also required to increase the efficiency and life expectancy of the membrane elements by minimizing fouling, scaling and degradation.

More frequent cleaning of RO and NF can sometimes "wash away" the impact of poor pretreatment but is not a substitute for good pretreatment practices. The down time, labor, chemical costs and potential premature aging of membranes associated with more frequent cleaning cannot be justified when compared to a true life cycle cost based on a properly selected pretreatment system.

There is not a single solution for an acceptable RO/NF pretreatment system. The solution depends on raw water composition, seasonal and historical water quality changes and the RO/NF system operational parameters.

Pretreatment for Seawater RO is often more critical than for groundwater, because most large seawater plants use open intakes that supply raw water which possess more pollutants (oil & grease, algae, phytoplankton), fluctuations in turbidity, organic matter and biological activities. In addition to conventional media filtration and dissolved air floatation, various MF/UF pretreatment technologies are now being applied in SWRO applications. This application is anticipated to grow as ceramic membranes and new technologies from developing markets are implemented. The more comprehensive and complex the pretreatment becomes, the more it should be viewed as a separate system and not a side process component.

The importance of a system approach and adequate pretreatment needs cannot be over emphasized and should be taken very seriously by design engineers and end users. ■

Colloidal silica may also be present and is capable of causing particulate fouling in first stage elements. In contrast to soluble silica, colloidal silica is a pretreatment issue and studies have shown that conventional coagulation-filtration and microfiltration provide excellent colloidal silica removal.

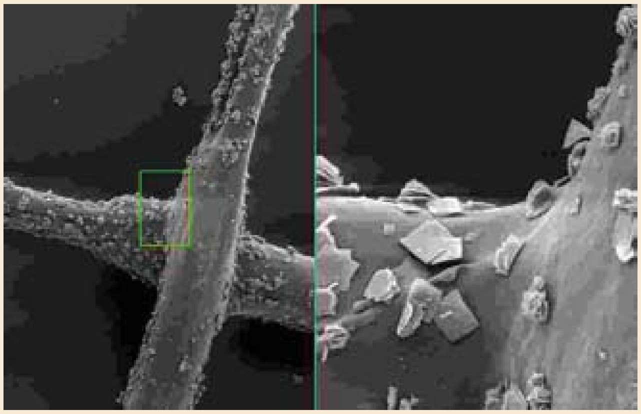


Photo 2 Scale foulants plug RO element feed passages

Methods of Scale Control:

While there are certainly effective cleaners designed to dissolve and remove scale, economics strongly favor prevention over cleaning. Scale foulants plug RO element feed passages (Photo 2), resulting in poor performance and requiring frequent cleanings which may affect the productive life of the membrane. Some scales are abrasive enough to permanently damage the active membrane layer.

Scale control has evolved over the years and began with the injection of acid in RO system feedwaters. This practice continues today primarily as a legacy from the industry's early years when RO systems used cellulose acetate (CA) membranes. CA membranes required acid to maintain feedwater pH in the range of 5 – 6 to avoid hydrolysis. Acid dosing had the coincidental effect of reducing calcium carbonate precipitation potential (CCPP).

With the introduction of polyamide thin film composite membranes, systems could operate at a much broader pH range (2–12) so pH reduction was no longer required. However, acid addition continued despite its many drawbacks including its capacity to form carbon dioxide (CO_2). CO_2 readily permeates RO membranes resulting in an increased load on downstream ion exchange beds. To prevent the subsequent increase in regeneration frequency, a method of degasification is required ahead of the resin beds to remove the CO_2 by-product.

Formulated antiscalants were introduced in the 1970's and 80's when the membrane separation industry began to address sulfate scales with polyphosphates. Sodium hexametaphosphate, or SHMP as it became affectionately known, was popular but proved to be a poor inhibitor for calcium carbonate. As a result, acid was also injected as a secondary chemistry to prevent calcium carbonate scale.

Though SHMP solutions were an improvement over simple acid, they were unstable and eventually reverted to orthophosphate with no scale inhibition properties. In fact, orthophosphate can precipitate with calcium to form calcium phosphate deposits on membrane surfaces and within element feed passages. In some cases, SHMP indirectly contributed to membrane fouling.

Next came the introduction of synthetic scale inhibitors, which were initially limited to several organic phosphonates and polyacrylic acid. Unlike SHMP, the new inhibitors were very effective against calcium carbonate. Most chemical antiscalants in wide use today possess threshold and/or dispersion properties. Threshold inhibition is the ability of an antiscalant to keep supersaturated solutions of sparingly soluble salts in solution. As crystals begin to form at the submicroscopic level, negative groups located on the antiscalant molecule attack the positive charges on scale nuclei. This interrupts crystal formation by tying up the active crystal growth sites. As a dispersant, the formulation scatters and distorts crystal structures. Classes of chemicals that possess threshold properties include phosphonates and many anionic polymers.

To prevent silica polymerization, we rely on dispersant polymers to form electrostatic and steric barriers around developing silica nuclei to prevent their contact and growth. Once the chemistry adsorbs onto the surfaces of the scale particles, it works to decrease the likelihood of contact between them by either imparting a high negative electrostatic charge or by forming a physical barrier (steric hindrance) around the particles. This prevents agglomeration which can lead to scale formation.

The benefits of modern antiscalants are numerous and include: relatively low injection rates (1 to 5 ppm), no increase in CO_2 and therefore no need for degasification, protection against a full spectrum of scale formers, and the chemistries are typically non-corrosive and approved for use in drinking water production.

Some specialty blends also have the significant benefit of being compatible with cationic coagulant polymers such as those injected ahead of granular media filters to improve efficiency. Coagulants may be added on-site by plant personnel or off-site by upstream municipal sources. In the latter case, downstream system operators may not even be aware of the addition until the coagulant and incompatible antiscalant combine to form a membrane foulant that reduces system productivity.

Dosage Determination:

Most specialty chemical companies offer a program that will recommend a product and dose rate based on site-specific water analysis data. An accurate and current feedwater analysis is critical to ensure that the product specified will address the unique challenges of each water source.

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The Evolution of Scale Control in RO Membrane Systems

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One of these challenges is silica. While many antiscalants are broad-spectrum inhibitors, they typically do not contain the chemistry necessary to control silica scale. Levels of silica in the feedwater combined with an aggressive system recovery can easily exceed saturation limits. In these cases, a formulation designed specifically to address silica scale is required.

Antiscalant Cost: Price per pound vs Usage Cost:

With such a variety of scale inhibitors on the market, it is very common for buyers, particularly in municipal applications, to compare costs based solely on the price per pound. However, this is not an accurate evaluation of the true operational cost of each option. Each formulation has a unique percent solids content which is a measure of the active ingredient. Typically, the higher the percent solids the more concentrated the formulation, meaning that the ratio of active ingredient to water is higher. Some antiscalants promoted as highly concentrated actually have the same or fewer percent solids than the neat versions of competing formulations.

Due to the wide variance in percent solids, cost comparisons based simply on the price per pound are not reliable. For example: Antiscalant A is dosed at 6 ppm and the cost per pound is half that of antiscalant B which is dosed at 2 ppm. In this example, even though the cost of antiscalant B is higher per pound, it requires only one third the dose rate so it is actually less expensive overall. In addition, the higher performance of some inhibitors may allow an increased system recovery over competitive offerings.

For all these reasons, the following calculation was developed to determine a true chemical cost for a specified value of produced water:

$$\frac{(1{,}000 / \%\ \text{system recovery as a decimal})\,(8.34)\,(\text{antiscalant dosage})\,(\text{price per lb})}{1{,}000{,}000} = \text{Chemical cost per 1,000 gallons of water produced}$$

The Myth Regarding Phosphonates:

While the efficacy and operational benefits of phosphonates are well known, there is an erroneous myth circulating regarding their use that needs to be corrected. It is a misconception that phosphonate residual in the brine will stimulate algae growth in discharge ponds and streams. The scientific fact is that the phosphorus contained in organic phosphonate compounds is unavailable as a nutrient source.

Future Evolution:

Formulating chemistries that continue to exceed performance expectations is a priority. High recovery projects push the limits of membrane performance and recognized saturation limits. In these and so many other applications, specialty chemistry plays a critical role in reducing technological barriers and supporting the successful operation of membrane systems. ■

Dan Comstock is the Vice President of Research and Development at Avista Technologies. He has been involved in membrane treatment for over 40 years and has been formulating specialty chemicals for two decades. Dan has extensive experience in reverse osmosis, microfiltration, and ultrafiltration technologies as well as the pretreatment equipment associated with these systems.

E-mail: dcomstock@avistatech.com

Karen Lindsey is the Vice President of Operations at Avista Technologies, Inc. She has 25 years experience in the water treatment industry working with companies that manufactured cellulose acetate membrane, produced polyamide elements or formulated water treatment chemicals.

E-mail: klindsey@avistatech.com

Sara Pietsch is a Research Scientist working in the laboratory at Avista Technologies Corporate office in California. She has a Bachelor of Science in Chemistry and completed extensive studies in analytical and inorganic chemistry and calcium carbonate thin films.

E-mail: spietsch@avistatech.com

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Transparent Exopolymer Particles (TEP): A Major Cause of Fouling in Membrane Systems?

By: Loreen O. Villacorte (a,b,), Rinnert Schurer (c), Maria D. Kennedy (a), Gary L. Amy (a,d,e), Jan C. Schippers (a)*
(a) UNESCO-IHE, Institute for Water Education, Westvest 7, 2611 AX Delft, The Netherlands
(b) Wetsus, Center of Excellence for Sustainable Water Technology, Agora 1, 8934 CJ Leeuwarden, The Netherlands
(c) EVIDES Waterbedrif, Berenplaat 10, 3207 LB Spijkenisse, The Netherlands
(d) Delft University of Technology, Stevinweg 1, 2628 CN Delft, The Netherlands
(e) Water Desalination and Reuse Research Center, 4700 KAUST, Thuwal 23955-6900, Kingdom of Saudi Arabia
**Corresponding author: l.villacorte@unesco-ihe.org*

In recent years, low-pressure membrane systems such as ultrafiltration (UF) and microfiltration (MF) are becoming a major feedwater pretreatment option for reverse osmosis (RO) systems. However, MF/UF are also susceptible to fouling by natural organic substances in the raw water. Once the membrane is experiencing organic fouling, physical cleaning (backwashing) is not always effective in adequately restoring performance. This often results in an increased membrane cleaning (e.g., chemically enhanced backwashing, cleaning-in-place) chemical consumption and additional pretreatment (e.g., in-line coagulation). Several studies have implicated polysaccharides as one of the main causes of fouling in UF/MF membranes [1,2]. But so far, the presence of polysaccharides in surface water and its adverse effects on membrane filtration are still not well documented and understood.

Transparent Exopolymer Particles (TEP)

A planktonic type of extracellular polymeric substance (EPS) known as transparent exopolymer particles (TEP) has been identified as a major component of polysaccharide substances in seawater and other aquatic systems [3,8]. TEPs are often characterized as transparent, sticky and amorphous substances ubiquitous in surface water, especially seawater. TEP substances are highly heterogeneous, as they may exist in different forms (e.g., strings, disks, sheets or fibers) and various dimensions (~3 nm in diameter up to 100s of µm long) [3]. TEP mainly originate from acidic polysaccharides released by phytoplankton and bacterioplankton [5]. However, some may have originated from other organisms such as some species of macroalgae, zooplanktons, benthic suspension-feeders (e.g., oysters, mussels) and corals [3]. Recently, the presence of TEP was also reported in feedwaters of various membrane plants treating surface water and secondary treated effluent [4-6,11].

TEP Fouling in Membrane Systems

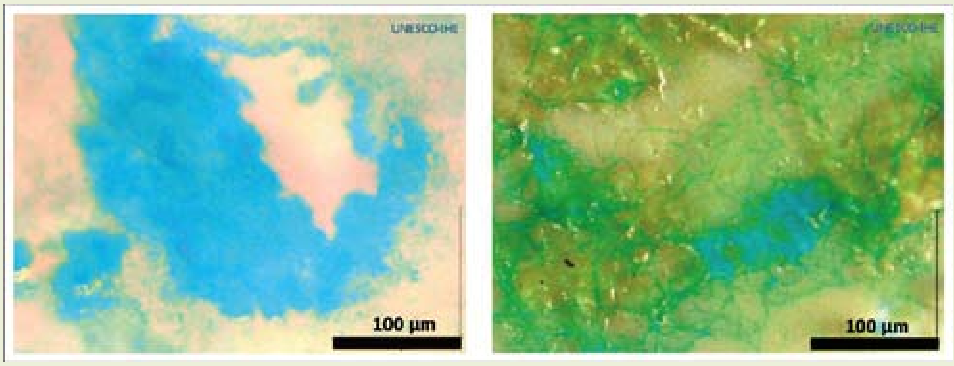
The potential link between TEP and membrane fouling was first proposed by Berman and Holenberg in 2005 [7]. They described TEP as a “major initiator” of biofilm formation in reverse osmosis (RO) systems, which may potentially lead to biofouling. Initially, the sticky TEP material may accumulate on RO membranes, including feed spacers, and create a conditioning film conducive for bacterial attachment. Once the bacteria are attached to the film, they can effectively utilise the available dissolved nutrients (C, P, N) in the feed water to grow into large colonies. If nutrients are not limited in the system, the initial TEP layer gradually transforms into a biofilm as colonies of attached bacteria start to produce more exopolymeric substances in addition to the further accumulation of TEP from the feedwater. Current anti-biofouling strategies are usually designed to limit the influx of nutrients to the RO system by pre-treatment or by applying a biocide to control bacterial population. Limiting biological activity in the system may not be enough to prevent organic fouling, considering that TEP may still accumulate on the RO membrane.

TEPs can potentially cause organic fouling and may also enhance particulate/colloidal fouling in dead-end membrane filtration systems (e.g., ultra- and microfiltration systems). Since TEPs consists of long macromolecules, they can be largely retained on MF/UF membranes. TEPs may also serve as a binding agent of other rejected materials (e.g., particles/colloids) while enhancing their accumulation on membrane surfaces during filtration. Moreover, abundant divalent ions in surface water such as calcium (Ca^{2+}) are known to promote the structural integrity of TEP gels by cationic bridge formation [3], possibly making them less porous. With their binding and aggregation capability, TEP may enhance formation of a fouling layer with high filtration resistance and low backwashability. As TEPs may cause several problems in membrane filtration systems, monitoring their presence in the feedwater of membrane plants is necessary to better understand and effectively mitigate their adverse effects.

TEP Monitoring

Although TEP has only been known for about 15 years, the presence of transparent marine substances that were detectable only by staining and

Figure 1
TEP substances (blue and green) stained with Alcian Blue on fouled RO membranes from plants treating lakewater (left) and estuarine water (right) [4].



electron microscope had been reported since the 1970's [10]. The transparent character of TEP complicated earlier studies in investigating their abundance in aquatic systems. In 1993, Alice Alldredge and co-workers developed a technique to visualise and identify TEP by applying Alcian Blue dye on filter-retained particles [9]. Alcian Blue is a cationic dye which complexes with the anionic groups of acidic polysaccharides to form insoluble blue precipitates. With the staining technique, and assuming that TEP consists mainly of acidic polysaccharides, TEP can be distinguished from other organic substances based on its reaction with Alcian Blue. Currently, there are four known methods to measure TEP. These methods either involve direct counting or spectrophotometric measurements. The spectrophotometric assay developed by Passow and Alldredge [10] is currently the most widely used method to measure TEP. In this method, TEPs are measured as acidic polysaccharides collected via sample filtration using 0.4µm filters under 0.2 bar of vacuum. Recent modifications of this method can measure TEP larger than 0.05µm, which means it can cover the particulate and portion of the colloidal fraction of these substances. The details of the modified spectrophotometric method are published in Villacorte et al. (2009) [4].

TEP concentrations can differ significantly in various water sources and in different locations. Based on several studies of raw water sources of membrane plants, TEP levels were generally higher in seawater sources than in fresh and brackish water sources. TEP concentrations are also expected to be higher in secondary treated wastewater effluent because of the abundance of bacteria in the biological treatment processes.

Seasonal variations can also affect TEP levels. During the spring season, TEP reach the peak concentration. This is the period when species of diatomaceous phytoplankton often flourish, primarily due to the rise in temperature, sufficient supply of nutrients and light during or immediately after the winter-spring transition period. Diatoms are one of the most common types of algae in aquatic systems and are known to produce the most significant concentrations of TEP in seawater [3]. Some peaks can also be observed in the summer and autumn seasons due to the emergence of other phytoplankton species as well as other TEP-producing aquatic organisms (e.g., macroalgae, mussels). In temperate zones, winter season is normally a period of low TEP levels due to low temperature and shorter daylight periods, deemed unsuitable for most phytoplankton species to grow.

Removal by MF/UF pretreatment

In theory, UF/MF pretreatment systems are more effective in removing TEP from the raw water than conventional pretreatment systems, mainly due to their higher rejection capacity. Several RO plants with an integrated membrane system (IMS) configuration were recently studied to assess the TEP removal efficiencies of UF/MF pretreatments. To measure pre-treatment removal, TEP concentrations were monitored in the pre-treatment processes. Two out of four UF/MF pretreatment systems investigated completely removed particulate TEP (>0.4um). None of them were found to completely removed colloidal TEP (0.05-0.4 um). Nevertheless, UF/MF pretreatments were observed to remove up to 75% of particulate and colloidal TEP combined [4]. To date, no one has reported 100% removal of TEP by MF/UF membranes. Incomplete removal of TEP by MF/UF membranes could be attributed to the flexibility in shape and size of the TEP particles. Moreover, membrane autopsy studies also found significant concentrations of TEP on fouled RO membranes from RO plants with MF/UF pretreatments (Figure 1).

Fouling in UF system

Fouling in dead-end membrane filtration (MF/UF) systems can be characterized by: reversible or backwashable fouling, physically irreversible or non-backwashable fouling and chemically irreversible fouling. Fouling is usually measured in terms of permeability ($J/\Delta P$) decline rate (slope of permeability vs. run time). Backwashable fouling is the permeability decline which can be recovered by physical backwashing while non-backwashable fouling signifies the permeability decline not recoverable by backwashing. Chemically irreversible

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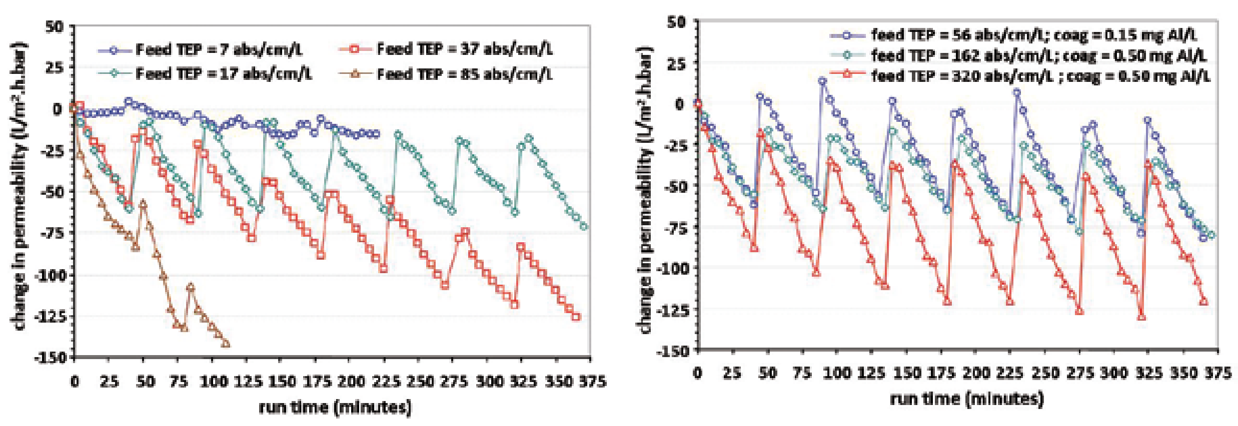
Figure 2
Permeability decline in the UF system at different levels of TEP with (right) and without coagulation (left) [11].



TEP's ability to adhere to surfaces (high stickiness [3]) and their conduciveness to bacterial colonization led some researchers to think that TEP may have a major role in organic and/or biological fouling in membrane systems.

fouling is recoverable only by chemically enhanced backwashing (CEB) or chemical cleaning. Non-backwashable fouling rate is often used as an over-all indicator of the operational performance of MF/UF systems.

In our recent study of a seawater UF-RO plant, the operational performance of the UF system was related to the concentration of TEP in the feedwater. Fouling rate in the UF system coincided with high TEP levels in the feedwater (Figure 2). It was also found that restoration of membrane permeability by backwashing can be improved by in-line coagulation. In this plant, low coagulant doses (0.15-0.5 mg Al^{3+}/L) were enough to significantly reduce non-backwashable fouling (Figure 2). The presence of coagulant may have enhanced the formation of a loose TEP cake layer on membrane surfaces that can be largely removed by backwashing.

High TEP levels in the feedwater is likely a major cause of fouling in UF systems but other factors such as the presence of suspended inorganic particles/colloids, planktons, humic substances and other biopolymers may have a major contribution as well. It is hypothesized that most of the non-backwashable fouling problems in the UF were due to the synergistic effect caused by combined fouling of TEP with other rejected particles/colloids on the membrane surface. There is a good indication that TEP have a major role in the development of a cake layer that can significantly reduce membrane permeability. Due to the sticky nature of TEP, it is likely that a stronger attachment between particles/colloids in the cake layer can form; hence, it is difficult to completely disperse this layer during backwashing.

A major cause of fouling in membrane systems?

TEP's ability to adhere to surfaces (high stickiness [3]) and their conduciveness to bacterial colonization led some researchers to think that TEP may have a major role in organic and/or biological fouling in membrane systems. Several studies already demonstrated the abundance of TEP in various water sources of membrane-based water treatment plants. TEP levels may significantly vary in different seasons, which may possibly explain why various membrane plants experience different degree of fouling at different seasons.

Moreover, significant concentrations of TEP were found to pass through pre-treatment systems of several RO plants. Membrane autopsy studies showed that TEP can accumulate on RO membranes. TEP can also foul low-pressure membranes (MF/UF) but in-line coagulation might be effective in controlling the fouling.

Are TEPs really a major cause of fouling in membrane systems? Most likely they are. Thus, TEP can be a promising parameter in evaluating the fouling potential of feedwater in membrane plants. However, a thorough study is still necessary to better measure and understand the adverse effects of TEP and how to effectively mitigate them, particularly in full-scale membrane installations.

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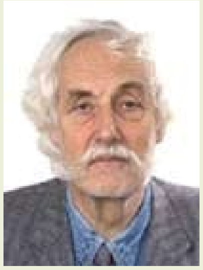
About the authors

Loreen O. Villacorte (l.villacorte@unesco-ihe.org) is a PhD research fellow of UNESCO-IHE Institute for Water Education and Wetsus Center of Excellence for Sustainable Water Technology in the Netherlands.

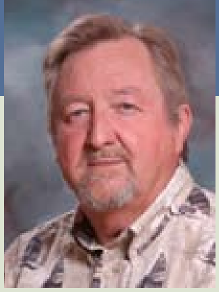
Rinnert Schurer is senior drinking water technologist at Evides Water Company, Rotterdam, The Netherlands.

Maria D. Kennedy is professor of Water Treatment Technologies at UNESCO-IHE Institute for Water Education.

Gary Amy is professor of environmental engineering and director of Water Desalination and Reuse Research Center at the King Abdullah University of Science and Technology in Saudi Arabia.



Jan C. Schippers is emeritus professor of urban water supply and sanitation at UNESCO-IHE Institute for Water Education.



Message from the Executive Director

Ian C. Watson, P.E.
Executive Director

On October 28th, we completed our last Webinar of the year, in co-operation with Water and Wastes Digest. The four topics featured this year were the Tampa Bay Desalter, by Dr. Christine Owen; the Kay Bailey Hutchinson plant in El Paso, by John Balliew, PE; the GWRS in Orange County, California, by Mehul Patel, PE; and the Split Feed NF plant in Jupiter, Florida, by Paul Jurcsak. We are planning a similar series for 2011

We will have one more workshop this year, in El Paso in December. Plan on coming to SW Texas for this one, it will be outstanding. Dayton, Ohio and Carmichael, California will be the locations of our workshops of 2011. We are also considering a third workshop for 2011, in the Kansas City, Kansas area.

2011 is also our return to Florida for our conference to be held jointly with SEDA in Miami Beach in July, in the storied Fontainebleu Hotel.

Membership growth continues to be a main focus for 2011. When talking about AMTA to your friends and colleagues, make sure they understand the benefits of AMTA membership. We are the only viable technical association that solely focuses on membrane technology for advanced water treatment. Anyone with an interest in the technology, who owns a membrane plant, who is thinking about building a membrane plant, or who is a consultant or supplier to this industry really needs to become part of our extended family. So go out there and recruit.

This issue the historic article is about seawater RO in the 70's. I am sure many of you are unaware that we had seawater RO in the 70's, but we did. For many of you, this will be the first and probably the last article you will ever read about the great B-10 permeator, at one time the T-Rex of membranes in the seawater RO market. And like the T-Rex, unfortunately no longer with us. I hope you enjoy this piece, and I would point out that in Table 2 a typical water cost is given a $4.25/kgal. Compare that to where we are today, even with inflation, and I would say that we have come a long way since then.

I wish you all a most pleasant holiday season, and look forward to seeing all of you in Miami in July. ■

MEDIA RELEASE

November 2010

WORLD TRADE CENTER San Diego Launches Water Technology Products and Services Export Program

The WORLD TRADE CENTER San Diego (WTCSD) has partnered with the United States Department of Commerce's International Trade Administration (ITA) to encourage the use of U.S. technology and products to help solve water issues in fourteen nations located in North Africa, the Middle East and India. The WTCSD is seeking U.S. based water technology manufacturers, suppliers, engineers and consultants that are interested in exporting to these regions to help address their critical water supply, treatment, and distribution needs.

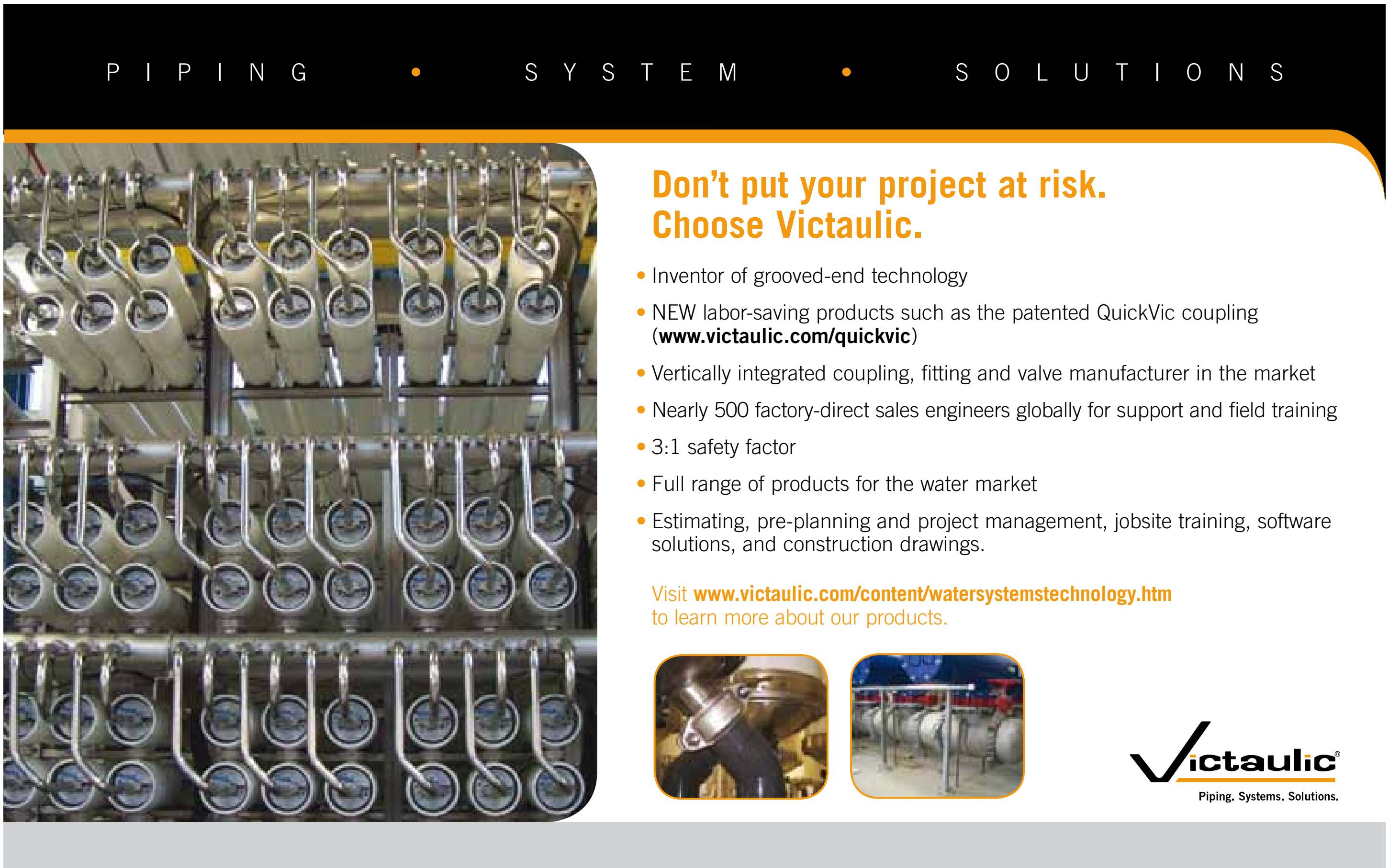
The market for developing water-related infrastructure and facilities within the targeted region is estimated at more than $200 billion dollars over the next 10 years. This is a result of increased population, declining supplies, and each nation's desire to improve the availability of safe drinking water, industrial and agricultural supply and wastewater treatment for their citizens.

The Water Technology Products and Services Export program focuses on a full range of potential export areas related to design, construction, and operation of water infrastructure and equipment. Small and mid-sized companies wishing to expand their business into the target markets are encouraged to participate in the program, including those already exporting their products and services, but desiring additional assistance through the program to add new markets.

The WTCSD program is designed to identify U.S. companies that are capable, committed, and interested in working within the target markets and match them with the needs of one or more of the nations that are included in the program. The program will assist companies through a variety of ways including conducting trade missions, hosting individual counseling sessions for interested U.S. companies, and providing financial assistance to attend trade missions and shows. The first trade mission being organized as part of the program will go to India between February 28 and March 4, 2011 in conjunction with the Aquatech India conference and trade show to be held in Mumbai.

To find out more information or get involved, contact the WTCSD or the ITA. The Project Director, Hugh Constant, can be reached by email at hconstant@wtcsd.org and the Project Leader, Ellen Bohon, at ellen.bohon@trade.gov.

Established in 1994 and licensed by the World Trade Centers Association in New York, the WORLD TRADE CENTER San Diego is a non-profit trade association that provides comprehensive international trade services and key global contacts to facilitate and expand trade for regional and worldwide clients. Members include individuals, businesses, and organizations involved with international trade. ■



Job Announcements

Woongjin Chemical America, Inc – Job Postings

1. Regional Sales Manager – East Coast US

Woongjin Chemical America, Inc, manufacturer of CSM membranes for reverse osmosis and nanofiltration, is seeking a Sales Manager for the East coast region. The Sales Manager will be responsible for developing customer relationships, identifying opportunities, reviewing project specifications, and writing technical proposals. Candidates must have +5 years of sales experience in the membrane industry. Main business operations will be based out of Florida.

To apply, please send resumes to kenyoon@wjcsm.com.

2. Regional Sales Manager – Midwest US

Woongjin Chemical America, Inc, manufacturer of CSM membranes for reverse osmosis and nanofiltration, is seeking a Sales Manager for the Midwest US region (including Montana and Kentucky). The Sales Manager will be responsible for developing customer relationships, identifying opportunities, reviewing project specifications, and writing technical proposals. Candidates must have +5 years of sales experience in the membrane industry.

To apply, please send resumes to kenyoon@wjcsm.com.

3. Manufacturing / Plant Manager

Woongjin Chemical America, Inc, manufacturer of CSM membranes for reverse osmosis and nanofiltration, is seeking a Manufacturing Manager for the new manufacturing facility in Anaheim, California. Responsibilities will include overseeing all aspects of the RO/NF assembly process, maintaining high-quality of products, cost reductions, and change management, and labor training. The candidate must have +5 years of experience in manufacturing of spiral-wound RO/NF membranes and those with an Engineering degree will be preferred.

To apply, please send resumes to kenyoon@wjcsm.com.

Hydranautics Career Opportunity

Global Key Account Executive

Hydranautics, an industry leader in membrane manufacturing, currently seeks a skilled professional who will drive revenue, growth, profitability and competitive differentiation with key global accounts and prospects. The Global Key Account Executive will develop and execute a sales strategy to increase sales volume and profitability including working with existing key accounts to uncover customers' purchasing decisions while managing the balance between short-term revenue results and long-term investments in value creation.

This position will be based in the US, but will travel internationally.

Minimum Requirements:

- Aptitude for success in a relationship driven business, as demonstrated by a proven general sales record for at least ten years.
- A proven sales record in the water treatment industry for at least five years, including experience managing large corporate accounts.
- Knowledge of water treatment technologies, including: reverse osmosis, softening and pre-treatment ultra-filtration.
- Ability to understand and work successfully in a global business environment.
- Ability to obtain results from others in a matrix organization structure.
- Demonstrated skills in MS Word, Excel, Outlook and PowerPoint, and customer relationship management databases.
- The ability to communicate value, sales and technical concepts to customers, in English, via oral presentations and written communications, at a level consistent with a Bachelors Degree in Engineering, Science, Business or Marketing.

Candidate Differentiators:

In addition to the minimum requirements for the position, the ideal candidate would also possess come of the following qualifications:

- Bilingual in two or more languages spoken by Hydranautics key accounts.
- Ability to create, deliver, measure and communicate value.
- Ability to apply principles of logical or scientific thinking to a wide range of water treatment problems.
- Established leadership and interpersonal skills necessary to communicate and negotiate effectively with Senior Executive teams and senior government officials.
- Ability to read, analyze and interpret complex specifications.
- Demonstrated ability to meet schedule commitments, deadlines and budget parameters.
- Experience with Salesforce.com

Application Procedure:

Send your resume, with salary requirements to:

Human Resources
401 Jones Road
Oceanside, CA 92054

hrresumes@hydranautics.com

EMPLOYMENT OPPORTUNITY

CITY OF SAN JUAN CAPISTRANO UTILITIES DEPARTMENT
INVITES YOU TO APPLY FOR:

CHIEF PLANT OPERATOR

Salary $6, 723 - $8,172 per month

APPLICATION DEADLINE:

INTERNAL FILING DEADLINE: FRIDAY, OCTOBER 29, 2010
EXTERNAL FILING DEADLINE: OPEN UNTIL FILLED

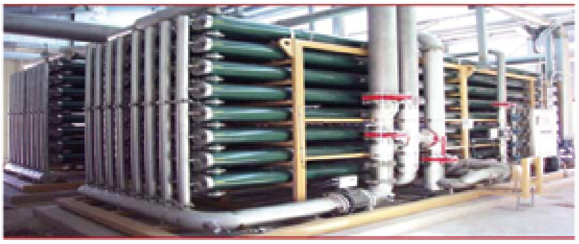
APPLICATION PROCEDURE:

Individuals wishing to apply must submit a City application to the Human Resources Department: 32400 Paseo Adelanto, San Juan Capistrano. CA 92675 Filing deadline for internal applicants is no later than **5:00 p.m. Friday, October 29, 2010.** Filing Deadline for external applicants is **Open Until Filled**. **Resumes will not be accepted in lieu of a completed application form.** Application forms and additional information may be obtained by accessing the City's website at www.sanjuancapistrano.org/employment or by contacting the Human Resources Department at (949) 443-6322.

SELECTION PROCEDURE:

Applications submitted are screened and evaluated based on qualifications. Those applicants identified to possess the most desirable qualifications will be invited to an oral interview and may include a written examination. Candidates selected for an interview will be contacted by phone. Notification by mail is sent out to candidates not selected for an interview.

Please read the minimum qualifications on the attached job specification prior to submitting a completed City employment application. You cannot be considered for the position unless you meet these requirements. Incomplete, ineligible, or fraudulent application packets may result in disqualification.



SPECIAL REQUIREMENTS:

- A valid Class C California driver's license and ability to maintain insurability under the City's Vehicle Insurance Policy.
- Possession of a California Water Treatment Grade IV, or the ability to obtain one within 12 months of hire date.
- Possession of a California Water Distribution Grade IV, or the ability to obtain one within 12 months of hire date.
- Possession of a California Water Environment Association Collection Systems Grade 1, or the ability to obtain one within 12 months of hire date.
- Ability to work extended hours and rotation shifts, including nights, weekends, and holidays.

COMPENSATIONS AND BENEFITS:

Comprehensive medical, dental, vision, life and disability insurance programs are provided. Paid vacation is 10 to 20 days per calendar year depending on length of service. Sick leave is 12 days per calendar year. The City is a member of the Orange County Employees Retirement System (OCERS), with a benefit of 2.7% at age 55. OCERS is reciprocal with PERS. The City also provides a $20/month deferred compensation match, up to $4,000 annually in tuition reimbursement, and a bonus plan for applicable certifications.

Equal Opportunity Employer

The City of San Juan Capistrano recruits and hires without regard to race, color, religious creed, physical or medical condition or handicap, sex, age, marital status, or natural origin, except in these specific instances whereby a bona fide occupational qualification demands otherwise. The herein does not represent an expressed or implied contract, and the provisions notes herein are intended only as a general guidance for prospective applicants and may be modified or revoked without prior notice or agreement.

Membranes Now and For the Future

AMTA Technology Transfer, Portland, Oregon

By: Tom Seacord, Workshop Chair (Carollo Engineers)

Workshop attendees enjoyed great food, beer and even a tour at the Bridgeport Brewery curtesy of event sponsors, HDR Engineering, Inc. and Pall Corporation.

Matthew Gallo (left) and Vin Tursi (right) of Victaulic Company listen to panelists answer questions at the MF/UF vendor forum.

In November of 2010, AMTA returned to Portland, Oregon to hold another successful Technology Transfer Workshop, our third ever in the Pacific Northwest. AMTA Board Member and Pacific Northwest resident, I welcomed attendees, thanked our sponsors, then planted a thought for consideration: "How about a membrane operators association in the Pacific Northwest?". Over the course of this two day workshop, attendees from 15 municipal agencies in Washington, Oregon, Idaho, Montana and Utah concurred that there is both interest and need for such an organization – whose focus would be helping operators get the most out of their membrane plants. That's what AMTA's all about – right? – *Advancing the "understanding and application of membrane technologies to create safe, affordable and reliable water supplies"* . We will keep you apprised as to the status of this development.

Over the course of the two day workshop, four technical sessions were held, with presentations on technology basics, regulations, application challenges, case studies from area membrane treatment plants, and a MF/UF manufacturer panel discussion. Mixed in the middle – our group also toured the Tri-City Water Pollution Control Facility (WPCF).

Technical sessions on Wednesday, November 10th focused on basics, regulations and applications including talks on use of coagulants in MF/UF applications (Paul Mueller, CH2M HILL), chemical cleaning MF/UF systems (Coli Ali, Professional Water Technologies), and regulations/integrity testing (Christine Owen, Tampa Bay Water and Dan Hugaboom, Carollo Engineers).

At the conclusion of the technical sessions on Wednesday, MWH and GE Water & Process Technologies hosted a tour of the Tri-City WPCF. The 4 mgd ADDF (10 mgd PHF) facility was under construction but to a point of completion where initial functional tests were being conducted. Those touring this facility were impressed by the use of space, sustainability and expansion features. We look forward to hearing from the plant staff at a future AMTA event to report how the facility is operating!

Wednesday evening, following the facility tour, HDR Engineering, Inc. and Pall Corporation hosted an evening Beer Tasting and Networking Reception at the historic Bridgeport Brewery. Attendees were given the option to tour the brewery, where all of the Bridgeport beer is made and distributed from. Did you know - the water quality in Portland is consistent, yet such that they have to add hardness to the water? A delicious spread of food and beer samples were enjoyed by all in this quaint, historic brew house.

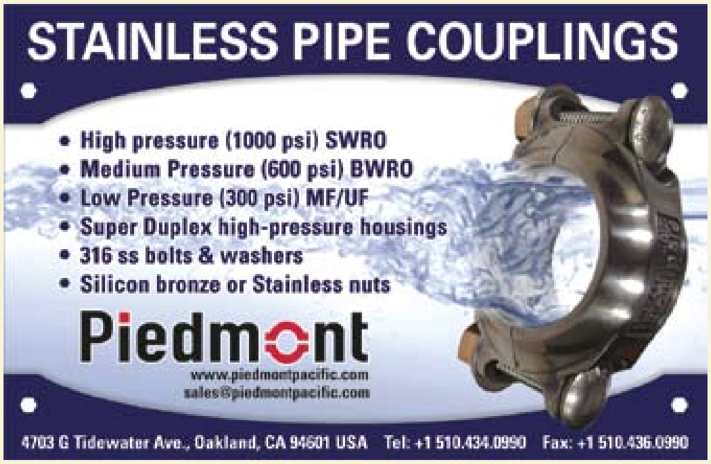
Thursday was a day for case studies. Dave Davis, John Giffin, and Bryan Black (HDR Engineering, Inc.) gave attendees

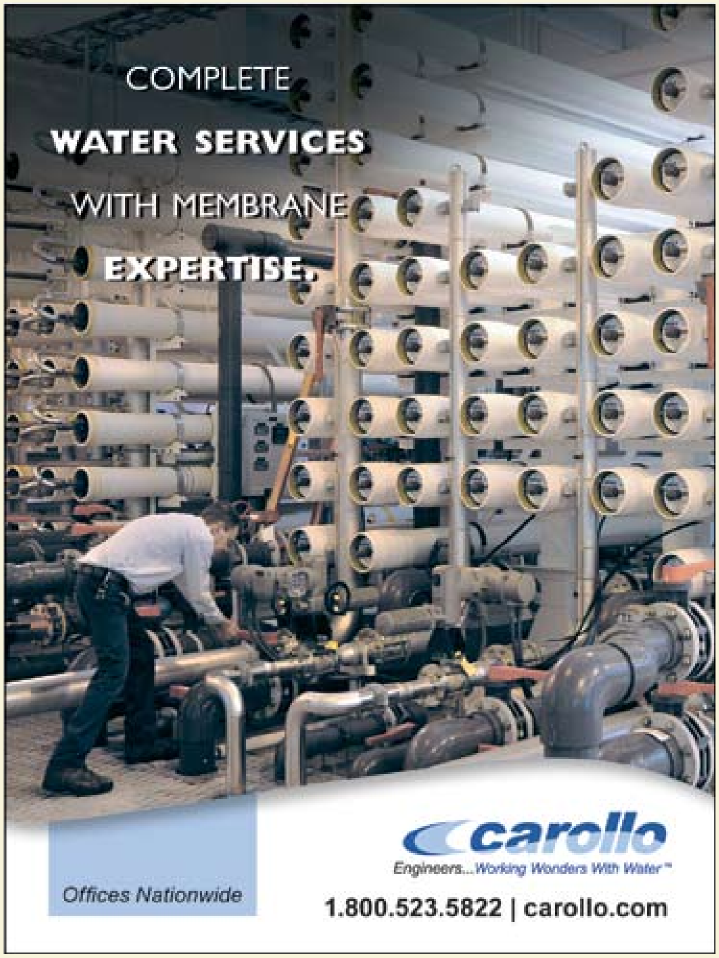
Over 60 workshop attendees toured the Tri-City WPCF which was going through its start-up phase of construction – Sponsors: GE Water & Process Technologies and MWH Americas, Inc.

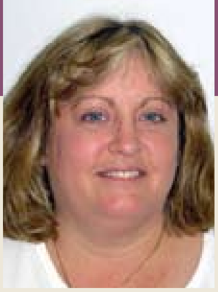
Tri-City WPCF tour guides Jude Grounds (MWH, Project Manager), Floyd Bayless (URS, Owner's Representative) and Randy Rosane (WES, Program Manager).

a history of the operations of the membrane facilities at North Clackamus (OR), Kennewick (WA) and St. Helens (OR), respectively. Following these case studies a MF/UF vendor forum was held where panelists were asked questions like "who should be responsible for determining the flux – engineers or manufacturers?" and "is your firm focusing on a market for replacement membranes at MF/UF facilities where the supplier is no longer selling replacements?" The discussion was thought provoking.

Events like this Portland Technology Transfer Workshop are a great chance to get out there and learn about membrane treatment, regulations and real world challenges and successes associated with using membrane technology. We hope you will join us for our annual conference, scheduled for July 18-21 at the Fountainebleau Resort in Miami Beach, Florida. This event, co-sponsored by our affiliate organization the Southeast Desalting Association, promises to be the "premiere" membrane technology event in 2011 with an exhibit hall featuring 100 exhibitors, operator specific sessions with "hands on" training, and over 100 papers on topics ranging from brackish and seawater desalination, to regulations, MF/UF applications, MBRs and concentrate treatment, recovery enhancement and residuals disposal. It's an event you don't want to miss! ■







Regulatory Update

Robert Huehmer, PE
Christine A. Owen

Legislative Affairs & Regulatory Programs Committee Co-Chairs

*A date to remember…*March 31st, 2012.

Nearly two decades ago, the emergence of new acute and chronic health effects as a result of drinking water contaminants resulted in a regulatory push for additional consumer protections. The resulting Safe Drinking Water Act Amendments of 1996, and subsequent thousands of pages of regulations and guidance, were developed to address these health effects. These rules and regulations, for the first time, explicitly contained regulatory language governing the use of low-pressure membrane filtration systems. The Long-Term 2 Enhanced Surface Water Treatment Rule (LT2ESWTR), and the accompanying guidance manual, have become tomes that utilities, manufacturers and consultants have struggled to interpret and implement. On March 31st, 2012 public drinking systems treating surface water and serving population greater than 100,000 people are required to comply with the provisions of the LT2ESWTR. This quarter, and for the next few quarters, we'll take a look at where various states are in terms of public dissemination of their regulatory efforts to prepare for the LT2ESWTR.

The emergence of new water treatment technologies has resulted in varied responses from regulatory agencies over the years. Few technologies have provided greater variation in their implementation than low-pressure membrane technologies. Utilities in Commonwealth of Virginia were early adopters of membrane technology, and currently possesses over 20 membrane filtration plants treating both groundwater under the direct influence of surface water and surface water sources. Regulation of the plants has evolved considerably; with early plants required to meet a pressure decay rate and turbidity, rather than a calculated Log Removal Value (LRV).

In a document entitled *Working Memo #880*, the Virginia Department of Health has documented requirements in the Commonwealth based upon their experiences and interpretation, and has been actively preparing for the compliance deadlines. Several other states in New-England and the Mid-Atlantic have simply incorporated the LT2ESWTR into their regulations by reference into state codes, rather than adopting their own published rules and guidance documents, including New Hampshire and Maine. In terms of publically available documents, Maine and Vermont have not yet amended their rules to incorporate the LT2ESWTR requirements. Connecticut has reported that they are working with EPA in a partnership to implement the rule. No specific language on LT2ESWTR or specific policies regarding membrane filtration is published on their website; however they do note that they are working on it. Massachusetts has long had a proactive approach, requiring new technology verifications and approvals prior to implementation. Rules and regulations, including 310 *CMR 22.00: Drinking Water and Guidelines for Public Water Systems* have been updated to incorporate LT2ESWTR requirements. Pennsylvania, which has been quietly adding many membrane plants over the last decade, has undergone a complete overhaul of membrane language in 2010. They have not only implemented LT2ESWTR language, but have also implemented LT2EWTR specific reporting guidelines and procedures for membrane plants.

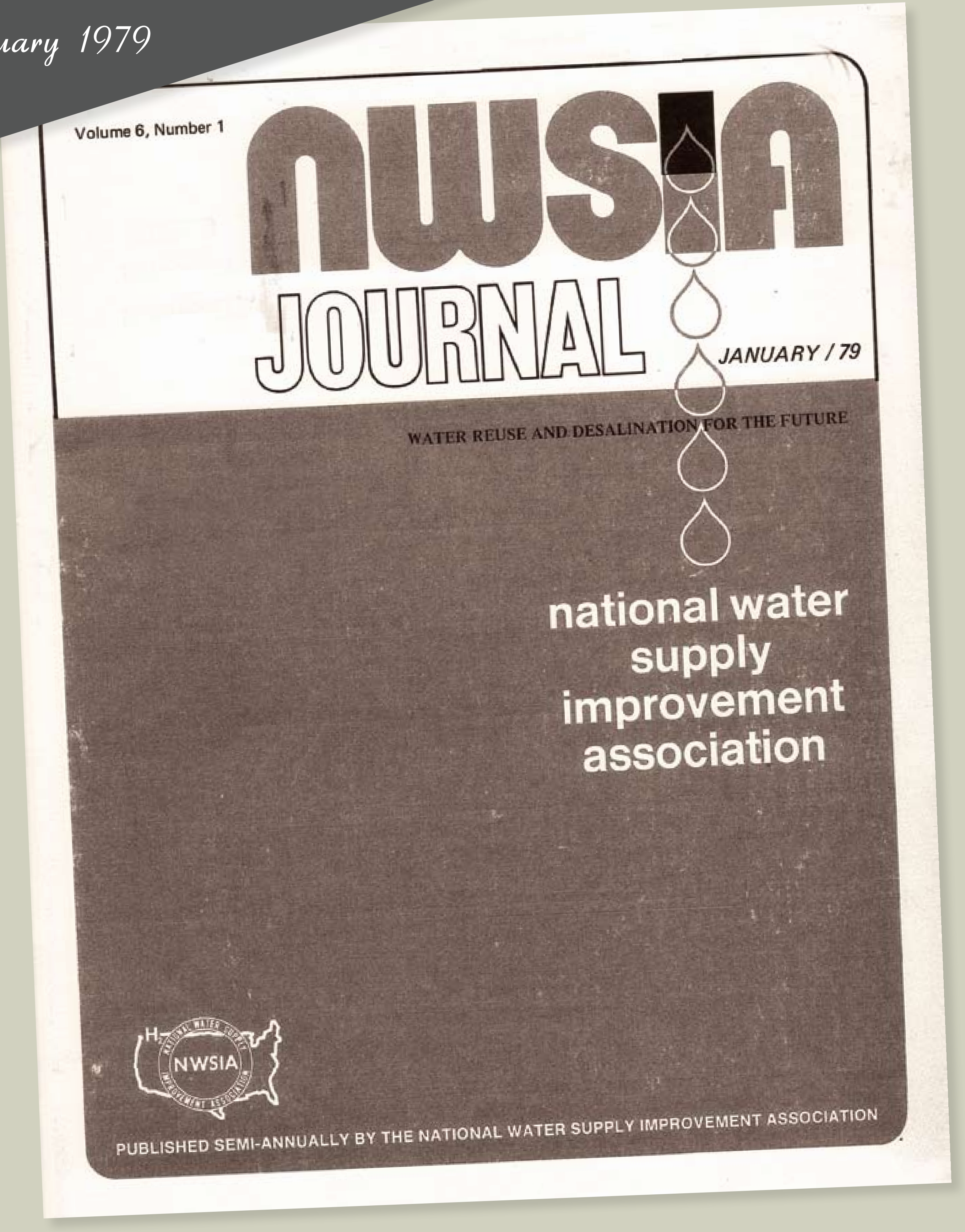
Most states in New England and Mid-Atlantic are making progress towards being regarding for March 31st, 2012. Their approach, and level of regulation, continues to vary from state to state – a trend which we will see next quarter, extends to the south-eastern United States as well.

Be safe!

Table 1
Drinking Water Regulatory Agencies in New England and the Mid-Atlantic (Selected References).

State	Guidelines/Regulations
Connecticut	Depart of Public Health - Drinking Water Section Guidelines for the Design and Operations of Public Water System Treatment, Works, and Sources http://www.ct.gov/dph/cwp/view.asp?a=3139&q=387294
Delaware	Health and Social Services, Division of Public Health, Office of Drinking Water TITLE 16 DEPARTMENT OF HEALTH & SOCIAL SERVICES, DELAWARE ADMINISTRATIVE CODE, 4400 Health Systems Protection, 4462 Public Drinking Water Systems - http://regulations.delaware.gov/AdminCode/title16/4000/4400/4462.pdf
Maine	Department of Human and Health services (http://www.maine.gov/dhhs/eng/water/) Drinking Water Rules -http://www.maine.gov/dhhs/boh/_rules_documents/DWP%20Rules%20Relating%20to%20Drinking%20Water.pdf Alternative Filtration Technologies - http://www.maine.gov/dhhs/eng/water/rules_policies/SWTR/altfiltration.htm List of Approved Alternative Filtration Technologies - http://www.maine.gov/dhhs/eng/water/rules_policies/SWTR/approvedaltfiltration.htm
Massachusetts	Department of Environmental Protection Guidelines for Public Water Systems Chapter 5 Design - http://www.mass.gov/dep/water/laws/glchpt5.doc 310 CMR 22.00: Drinking Water - http://www.mass.gov/dep/service/regulations/310cmr22.pdf
Maryland	Maryland Department of the Environment (MDE) - http://www.mde.maryland.gov/PROGRAMS/WATER/Pages/Programs/WaterPrograms/index.aspx Treatment Requirements for Surface Water Supplies and Ground Water Supplies Under Direct Influence of Surface Water - http://www.dsd.state.md.us/comar/comarhtml/26/26.04.01.05-2.htm Maximum Contaminant Level for Turbidity in Drinking Water - http://www.dsd.state.md.us/comar/comarhtml/26/26.04.01.08.htm
New Hampshire	Department of Environmental Services NEW HAMPSHIRE CODE OF ADMINISTRATIVE RULES, CHAPTER Env-Dw 700 WATER QUALITY: STANDARDS, MONITORING, TREATMENT, COMPLIANCE, AND REPORTING, PART Env-Dw 716 FILTRATION, DISINFECTION, AND WASTE RECYCLING http://des.nh.gov/organization/commissioner/legal/rules/documents/env-dw716.pdf
New Jersey	Department of Environmental Protection, Division of Water Supply STATE OF NEW JERSEY, DEPARTMENT OF ENVIRONMENTAL PROTECTION, BUREAU OF SAFE DRINKING WATER, SAFE DRINKING WATER ACT REGULATIONS, (N.J.A.C. 7:10), ADOPTED: November 4, 2004 - http://www.nj.gov/dep/watersupply/sdwarule.pdf Safe Drinking Water Works Facilities Approval Technical Manual - http://www.nj.gov/dep/watersupply/techman.pdf
New York	Department of Health Part 5, Subpart 5-1 Public Water Systems – http://www.nyhealth.gov/regulations/nycrr/title_10/part_5/subpart_5-1.htm
Pennsylvania	Department of Environmental Protection The Pennsylvania Code, Subchapter L. LONG-TERM 2 ENHANCED SURFACE WATER TREATMENT RULE -http://www.pacode.com/secure/data/025/chapter109/subchapLtoc.html Public Water Supply Manual - http://www.portal.state.pa.us/portal/server.pt/document/810870/public_water_supply_manual_-_part_ii_community_system_design_standards_pdf Pilot Study Requirements - http://www.portal.state.pa.us/portal/server.pt/document/810532/pilot_plant_filtration_studies_for_surface_water_sources_pdf
Vermont	Vermont Department of Environmental Conservation – Water Supply Division ENVIRONMENTAL PROTECTION RULES CHAPTER 21 WATER SUPPLY RULE - http://www.vermontdrinkingwater.org/wsrule/Vermont%20WSR%20April%202005.pdf
Virginia	Department of Health Working Memo #880 - http://townhall.virginia.gov/l/GetFile.cfm?File=E:%5Ctownhall%5Cdocroot%5CGuidanceDocs%5C601%5CGDoc_VDH_2547_v2.pdf

National Water Supply
Improvement Association
January 1979



Volume 6, Number 1

NWSIA
JOURNAL

JANUARY / 79

WATER REUSE AND DESALINATION FOR THE FUTURE

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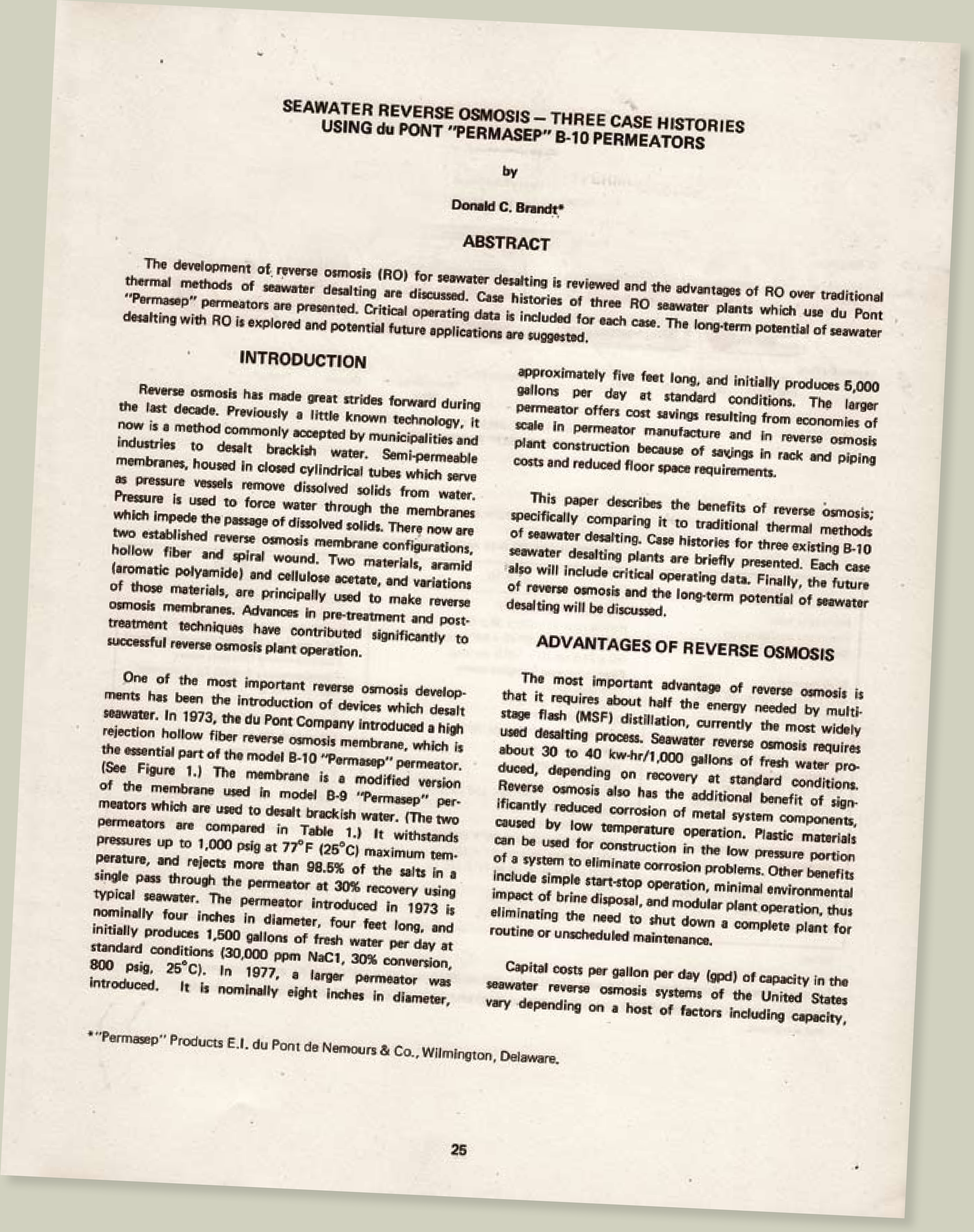

SEAWATER REVERSE OSMOSIS – THREE CASE HISTORIES USING du PONT "PERMASEP" B-10 PERMEATORS

by

Donald C. Brandt*

ABSTRACT

The development of reverse osmosis (RO) for seawater desalting is reviewed and the advantages of RO over traditional thermal methods of seawater desalting are discussed. Case histories of three RO seawater plants which use du Pont "Permasep" permeators are presented. Critical operating data is included for each case. The long-term potential of seawater desalting with RO is explored and potential future applications are suggested.

INTRODUCTION

Reverse osmosis has made great strides forward during the last decade. Previously a little known technology, it now is a method commonly accepted by municipalities and industries to desalt brackish water. Semi-permeable membranes, housed in closed cylindrical tubes which serve as pressure vessels remove dissolved solids from water. Pressure is used to force water through the membranes which impede the passage of dissolved solids. There now are two established reverse osmosis membrane configurations, hollow fiber and spiral wound. Two materials, aramid (aromatic polyamide) and cellulose acetate, and variations of those materials, are principally used to make reverse osmosis membranes. Advances in pre-treatment and post-treatment techniques have contributed significantly to successful reverse osmosis plant operation.

One of the most important reverse osmosis developments has been the introduction of devices which desalt seawater. In 1973, the du Pont Company introduced a high rejection hollow fiber reverse osmosis membrane, which is the essential part of the model B-10 "Permasep" permeator. (See Figure 1.) The membrane is a modified version of the membrane used in model B-9 "Permasep" permeators which are used to desalt brackish water. (The two permeators are compared in Table 1.) It withstands pressures up to 1,000 psig at 77°F (25°C) maximum temperature, and rejects more than 98.5% of the salts in a single pass through the permeator at 30% recovery using typical seawater. The permeator introduced in 1973 is nominally four inches in diameter, four feet long, and initially produces 1,500 gallons of fresh water per day at standard conditions (30,000 ppm NaCl, 30% conversion, 800 psig, 25°C). In 1977, a larger permeator was introduced. It is nominally eight inches in diameter, approximately five feet long, and initially produces 5,000 gallons per day at standard conditions. The larger permeator offers cost savings resulting from economies of scale in permeator manufacture and in reverse osmosis plant construction because of savings in rack and piping costs and reduced floor space requirements.

This paper describes the benefits of reverse osmosis; specifically comparing it to traditional thermal methods of seawater desalting. Case histories for three existing B-10 seawater desalting plants are briefly presented. Each case also will include critical operating data. Finally, the future of reverse osmosis and the long-term potential of seawater desalting will be discussed.

ADVANTAGES OF REVERSE OSMOSIS

The most important advantage of reverse osmosis is that it requires about half the energy needed by multi-stage flash (MSF) distillation, currently the most widely used desalting process. Seawater reverse osmosis requires about 30 to 40 kw-hr/1,000 gallons of fresh water produced, depending on recovery at standard conditions. Reverse osmosis also has the additional benefit of significantly reduced corrosion of metal system components, caused by low temperature operation. Plastic materials can be used for construction in the low pressure portion of a system to eliminate corrosion problems. Other benefits include simple start-stop operation, minimal environmental impact of brine disposal, and modular plant operation, thus eliminating the need to shut down a complete plant for routine or unscheduled maintenance.

Capital costs per gallon per day (gpd) of capacity in the seawater reverse osmosis systems of the United States vary depending on a host of factors including capacity,

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*"Permasep" Products E.I. du Pont de Nemours & Co., Wilmington, Delaware.

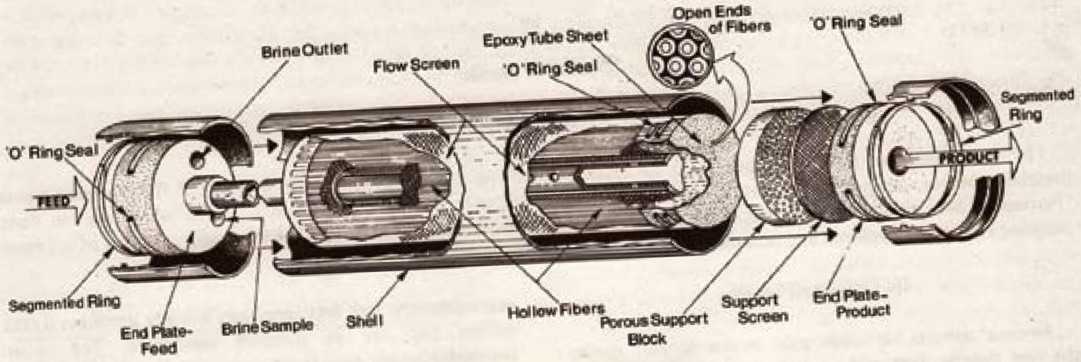


Figure 1. CUT-AWAY DRAWING B-10 "PERMASEP" PERMEATOR

TABLE 1

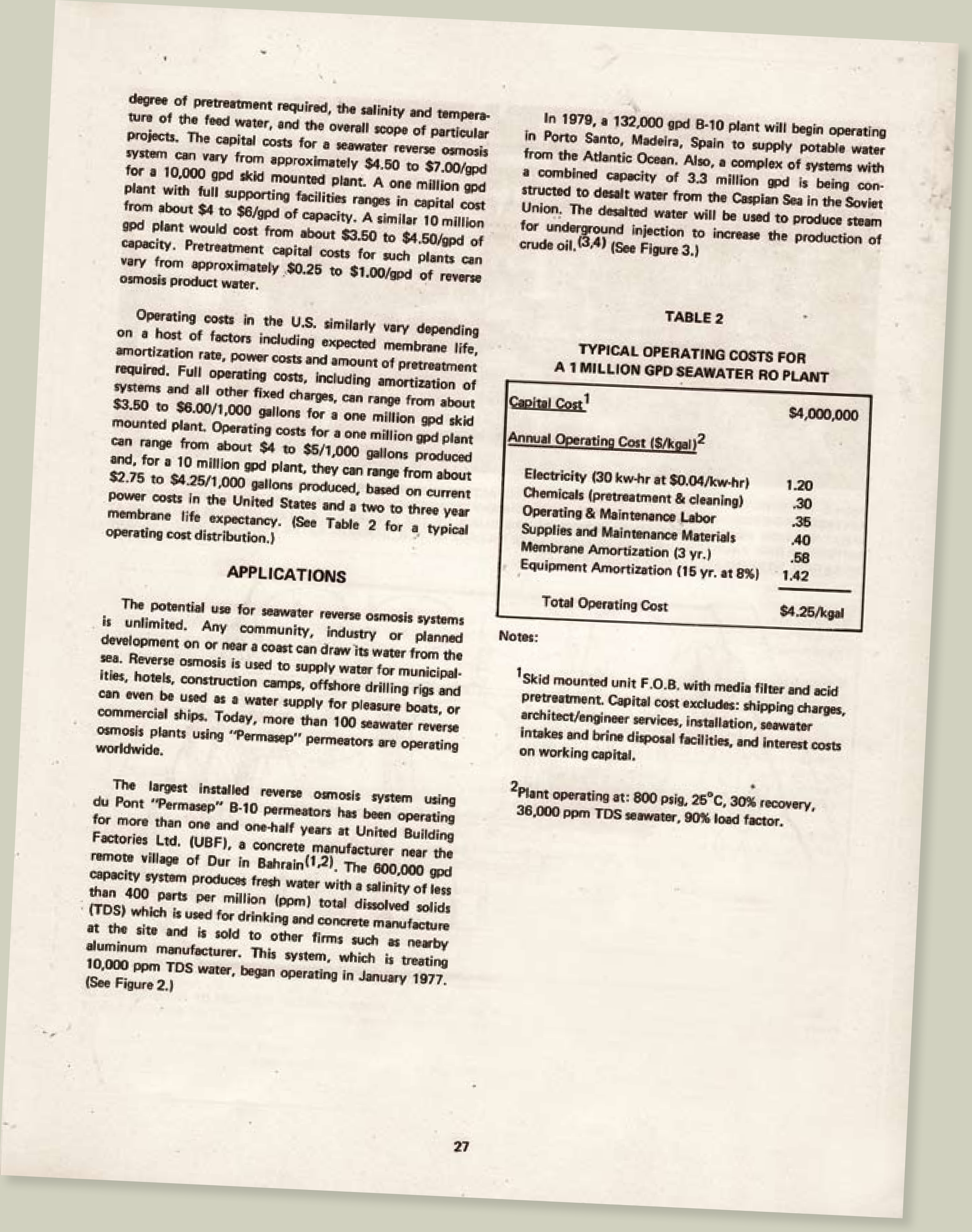
A COMPARISON OF B-10 AND B-9 PERMEATORS

Permeator Type	8" B-10	8" B-9
Membrane type	Aromatic Polyamide HFF	Aromatic Polyamide HFF
Membrane configuration	Hollow fiber 93 μ OD x 38 μ ID	Hollow fiber 89 μ OD x 41 μ ID
Shell dimensions	10-3/8" OD x 8-1/2" ID x 59" long (26.4 cm OD x 21.6 cm ID x 149.9 cm long)	9-1/2" OD x 8-1/2" ID x 48" long (24.1 cm OD x 21.6 cm ID x 122 cm long)
Shell material	Filament-wound fiberglass epoxy	Filament-wound fiberglass epoxy
End plates & segmented rings	Fiberglass epoxy	Fiberglass epoxy & 6063-T6 Aluminum
Connections	Feed, product and brine 3/4" female, NPT Brine sample, 3/8" female, NPT	feed, product and brine 3/8" female, NPT Brine sample, 3/8" female, NPT
Permeator weight, filled with water	165 pounds (75 kg.)	145 pounds (65.8 kg)
Operating position	Horizontal or vertical	Horizontal or vertical
Membrane flux, gpd/ft^2	0.9 (Note 1)	2.8 (Note 2)
Initial product water capacity	5,000 min. – 5,499 max. gpd (Note 1) (18.9 – 20.8 m^3/day)	15,500 min. – 16,999 max. gpd (Note 2) (58.7 min. – 64.3 max. m^3/day)
Salt passage	$\leq$ 1.5% (Note 1)	< 10% (Note 2)
Rated operating pressure at temperature	800 psig max. at up to 95°F (35°C) 900 psig max. at up to 81°F (30°C) 1000 psig max. at up to 77°F (25°C)	400 psig max. at up to 95°F (35°C)
pH range, continuous exposure	5-9	4-11
Minimum brine rate	6,000 gpd (22.7 m^3/day)	10,100 gpd 38.2 m^3/day)
Maximum brine rate	25,000 gpd (94.6 m^3/day)	25,000 gpd (94.6 m^3/day)

Notes:

[1] At standard test conditions: feed – 30,000 ppm (Mg/1) NaC1, 800 psi (5515 kPa), 77°F (25°C, 298°K), and 30% conversion.

[2] Based on operation with a feed of 1500 ppm NaC1 at 400 psi (2760 kPa), 77°F (25°C, 298°K), and 75% conversion, Standard test conditions.



degree of pretreatment required, the salinity and temperature of the feed water, and the overall scope of particular projects. The capital costs for a seawater reverse osmosis system can vary from approximately $4.50 to $7.00/gpd for a 10,000 gpd skid mounted plant. A one million gpd plant with full supporting facilities ranges in capital cost from about $4 to $6/gpd of capacity. A similar 10 million gpd plant would cost from about $3.50 to $4.50/gpd of capacity. Pretreatment capital costs for such plants can vary from approximately $0.25 to $1.00/gpd of reverse osmosis product water.

Operating costs in the U.S. similarly vary depending on a host of factors including expected membrane life, amortization rate, power costs and amount of pretreatment required. Full operating costs, including amortization of systems and all other fixed charges, can range from about $3.50 to $6.00/1,000 gallons for a one million gpd skid mounted plant. Operating costs for a one million gpd plant can range from about $4 to $5/1,000 gallons produced and, for a 10 million gpd plant, they can range from about $2.75 to $4.25/1,000 gallons produced, based on current power costs in the United States and a two to three year membrane life expectancy. (See Table 2 for a typical operating cost distribution.)

APPLICATIONS

The potential use for seawater reverse osmosis systems is unlimited. Any community, industry or planned development on or near a coast can draw its water from the sea. Reverse osmosis is used to supply water for municipalities, hotels, construction camps, offshore drilling rigs and can even be used as a water supply for pleasure boats, or commercial ships. Today, more than 100 seawater reverse osmosis plants using "Permasep" permeators are operating worldwide.

The largest installed reverse osmosis system using du Pont "Permasep" B-10 permeators has been operating for more than one and one-half years at United Building Factories Ltd. (UBF), a concrete manufacturer near the remote village of Dur in Bahrain[1,2]. The 600,000 gpd capacity system produces fresh water with a salinity of less than 400 parts per million (ppm) total dissolved solids (TDS) which is used for drinking and concrete manufacture at the site and is sold to other firms such as nearby aluminum manufacturer. This system, which is treating 10,000 ppm TDS water, began operating in January 1977. (See Figure 2.)

In 1979, a 132,000 gpd B-10 plant will begin operating in Porto Santo, Madeira, Spain to supply potable water from the Atlantic Ocean. Also, a complex of systems with a combined capacity of 3.3 million gpd is being constructed to desalt water from the Caspian Sea in the Soviet Union. The desalted water will be used to produce steam for underground injection to increase the production of crude oil.[3,4] (See Figure 3.)

TABLE 2

TYPICAL OPERATING COSTS FOR A 1 MILLION GPD SEAWATER RO PLANT

Capital Cost[1]	$4,000,000
Annual Operating Cost ($/kgal)[2]	
Electricity (30 kw-hr at $0.04/kw-hr)	1.20
Chemicals (pretreatment & cleaning)	.30
Operating & Maintenance Labor	.35
Supplies and Maintenance Materials	.40
Membrane Amortization (3 yr.)	.58
Equipment Amortization (15 yr. at 8%)	1.42
Total Operating Cost	$4.25/kgal

Notes:

[1] Skid mounted unit F.O.B. with media filter and acid pretreatment. Capital cost excludes: shipping charges, architect/engineer services, installation, seawater intakes and brine disposal facilities, and interest costs on working capital.

[2] Plant operating at: 800 psig, 25°C, 30% recovery, 36,000 ppm TDS seawater, 90% load factor.

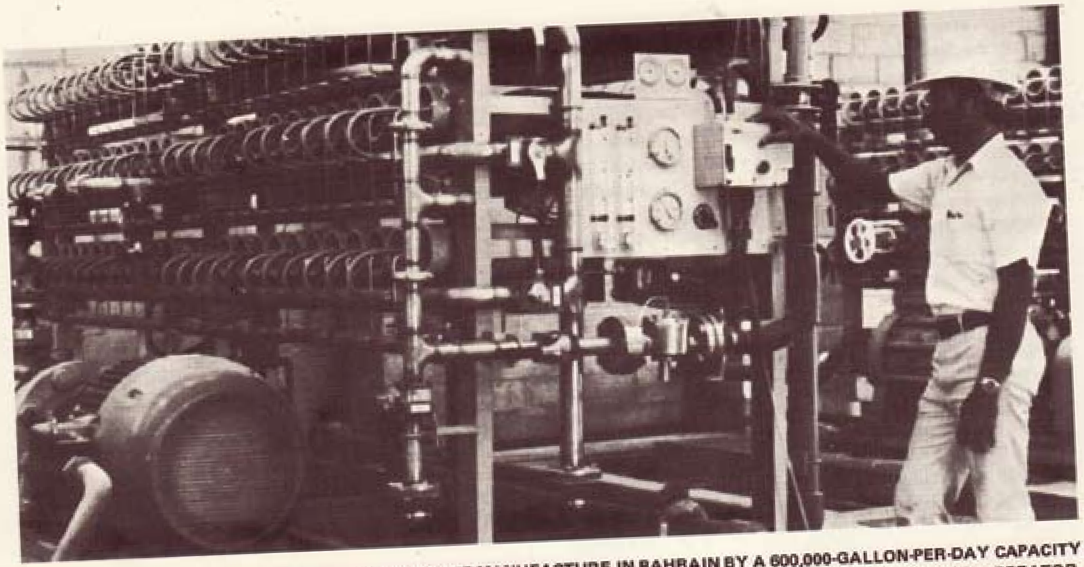


Figure 2. FRESHWATER IS PRODUCED FOR CONCRETE MANUFACTURE IN BAHRAIN BY A 600,000-GALLON-PER-DAY CAPACITY REVERSE OSMOSIS DESALTING SYSTEM USING Du PONT COMPANY "PERMASEP" PERMEATORS. HERE, THE SYSTEM OPERATOR, SAWAT VERASIN, MONITORS THE PERFORMANCE OF ONE BLOCK OF THE FIVE-BLOCK SYSTEM, WHICH IS INSTALLED AT UNITED BUILDING FACTORIES (UBF), NEAR THE REMOTE VILLAGE OF DUR, BAHRAIN. AFTER ONE AND A HALF YEARS OF OPERATION, NO PERMEATORS HAVE BEEN REPLACED.

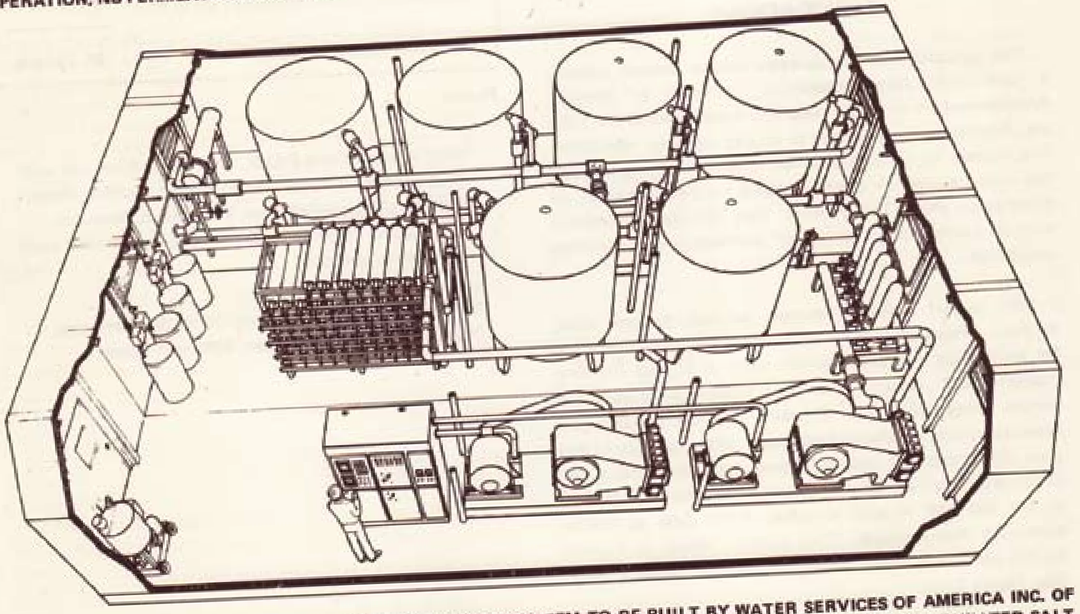


Figure 3. THIS 400,000-GALLON-PER-DAY DESALINATION SYSTEM TO BE BUILT BY WATER SERVICES OF AMERICA INC. OF MILWAUKEE WILL USE Du PONT COMPANY "PERMASEP" PERMEATORS WHICH REMOVE 98.5 PERCENT OF SEAWATER SALT CONTENT. IT WILL BE ONE OF NINE SYSTEMS THAT WILL CONSTITUTE THE WORLD'S LARGEST REVERSE OSMOSIS SEAWATER DESALINATION COMPLEX, A 3.3-MILLION-GALLON-PER-DAY FACILITY SERVING A SECONDARY OIL RECOVERY PROJECT IN THE SOVIET UNION NEAR THE CASPIAN SEA. (DRAWING BY WATER SERVICES OF AMERICA INC.)

CASE HISTORIES

South Caicos Island

In the spring of 1975, a 5,000 gpd reverse osmosis plant was installed at the Admiral Arms, a resort hotel in South Caicos, British West Indies.(5,6) This system was supplied by Purification Techniques Inc., which now is part of Neptune Microfloc of Corvallis, Oregon. (See Figure 4.) The system has been producing potable water from nearly 46,000 ppm TDS seawater for more than three years. (See Table 3.) The major reasons for choosing reverse osmosis instead of distillation were: A 30 percent lower capital cost, a 50 percent expected saving in operating costs, lower maintenance costs, and ease of operation. The system supplements the hotel's normal rainfall water supply and is operated when additional water is needed and during dry seasons.

TABLE 3

TYPICAL PERFORMANCE DATA FOR B-10 PLANT AT ADMIRAL ARMS HOTEL, SOUTH CACIOS, BRITISH WEST INDIES

Ionic Contaminants	Feed From Seawater Well (PPM as ion)	Product Water (PPM as ion)
Ca^{++}	600	8
Mg^{++}	1,118	<1
Na^{+}	16,000	133
HCO_3^-	190	20
SO_4^{--}	2,900	<1
Cl^-	25,000	210
F^-	3.8	0.2
pH	7.4	6.5
TDS	45,812*	373*

*Sum of individual ions.

Feed water is obtained from a seawell and pretreatment consists of chemical coagulation, a special diatomaceous earth filter, ultraviolet sterilization, and feed water pH adjustment. The plant operates at 25% recovery and consistently produces water containing less than 500 TDS. The reverse osmosis system consists of du Pont B-10 "Permasep" permeators, a high pressure stainless steel centrifugal pump, stainless steel and PVC piping and fittings. It is housed in a stainless steel cabinet. The pretreatment system is skid mounted and the entire system was installed and placed in operation in less than four days. The unit requires cleaning and membrane treatment at approximately six week intervals.

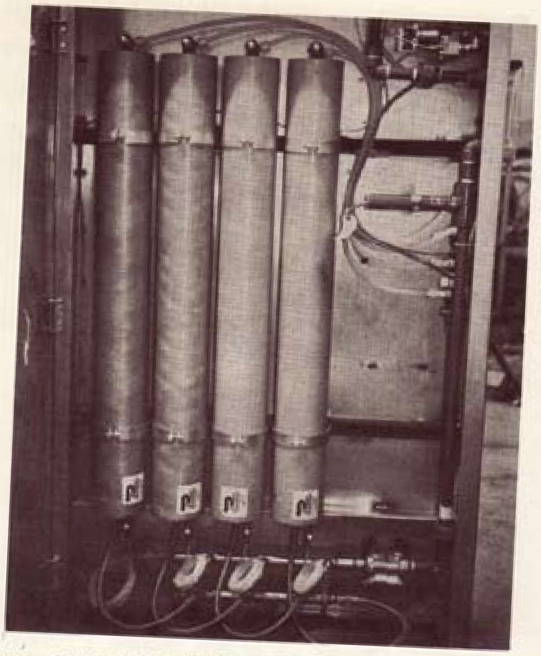
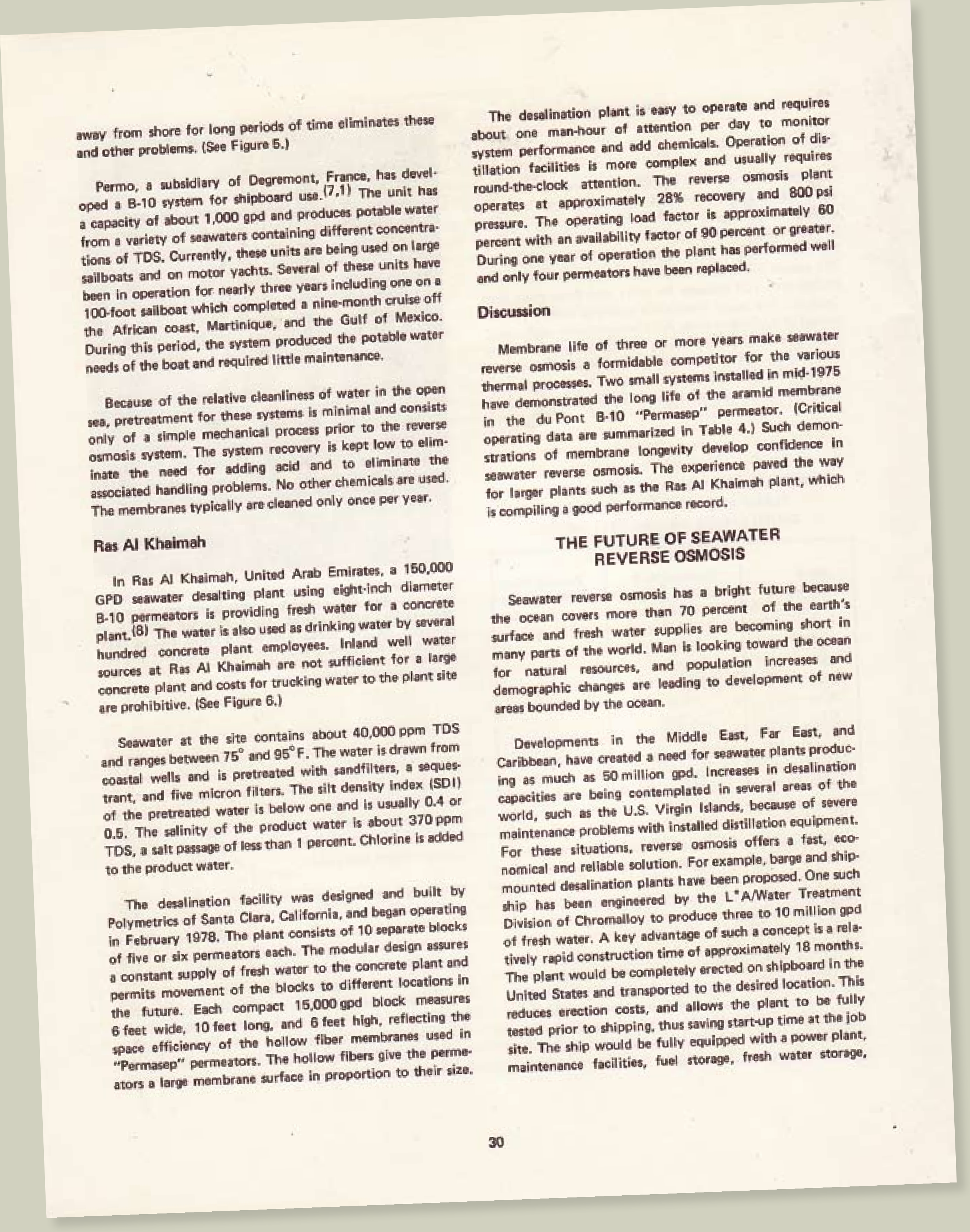


Figure 4. HEART OF THE DESALTING SYSTEM INSTALLED AT THE ADMIRAL ARMS HOTEL IS THIS BANK OF FOUR B-10 "PERMASEP" PERMEATORS. THEY REMOVE NEARLY 99 PERCENT OF THE DISSOLVED SALTS FROM THE HOTEL'S SEAWATER WELLS AND CAN PROVIDE 5,000 GALLONS PER DAY OF WATER, MEETING WORLD HEALTH ORGANIZATION STANDARDS FOR POTABILITY.

The operating costs are approximately $3.50/1,000 gallons of product water produced including membrane amortization based on a five year expected membrane life and power costs at $0.02/kw-hr. The power cost comprises approximately 40% of the total and an energy recovery system could drop operating costs to approximately $2.50/1,000 gallons.

Shipboard Systems

Traditionally, potable water on shipboard has been produced by distillation with recovered heat produced by the main engine cooling system or using a separate boiler. This is inconvenient for sailing ships and other crafts such as weather vessels and lightships as well as oil production platforms which are stationary. For example, the distilled water is usually reaerated and partially remineralized for drinking purposes. The use of reverse osmosis on cruise sailboats, motor yachts, fishing boats and other commercial vessels



away from shore for long periods of time eliminates these and other problems. (See Figure 5.)

Permo, a subsidiary of Degremont, France, has developed a B-10 system for shipboard use.(7,1) The unit has a capacity of about 1,000 gpd and produces potable water from a variety of seawaters containing different concentrations of TDS. Currently, these units are being used on large sailboats and on motor yachts. Several of these units have been in operation for nearly three years including one on a 100-foot sailboat which completed a nine-month cruise off the African coast, Martinique, and the Gulf of Mexico. During this period, the system produced the potable water needs of the boat and required little maintenance.

Because of the relative cleanliness of water in the open sea, pretreatment for these systems is minimal and consists only of a simple mechanical process prior to the reverse osmosis system. The system recovery is kept low to eliminate the need for adding acid and to eliminate the associated handling problems. No other chemicals are used. The membranes typically are cleaned only once per year.

Ras Al Khaimah

In Ras Al Khaimah, United Arab Emirates, a 150,000 GPD seawater desalting plant using eight-inch diameter B-10 permeators is providing fresh water for a concrete plant.(8) The water is also used as drinking water by several hundred concrete plant employees. Inland well water sources at Ras Al Khaimah are not sufficient for a large concrete plant and costs for trucking water to the plant site are prohibitive. (See Figure 6.)

Seawater at the site contains about 40,000 ppm TDS and ranges between 75° and 95°F. The water is drawn from coastal wells and is pretreated with sandfilters, a sequestrant, and five micron filters. The silt density index (SDI) of the pretreated water is below one and is usually 0.4 or 0.5. The salinity of the product water is about 370 ppm TDS, a salt passage of less than 1 percent. Chlorine is added to the product water.

The desalination facility was designed and built by Polymetrics of Santa Clara, California, and began operating in February 1978. The plant consists of 10 separate blocks of five or six permeators each. The modular design assures a constant supply of fresh water to the concrete plant and permits movement of the blocks to different locations in the future. Each compact 15,000 gpd block measures 6 feet wide, 10 feet long, and 6 feet high, reflecting the space efficiency of the hollow fiber membranes used in "Permasep" permeators. The hollow fibers give the permeators a large membrane surface in proportion to their size.

The desalination plant is easy to operate and requires about one man-hour of attention per day to monitor system performance and add chemicals. Operation of distillation facilities is more complex and usually requires round-the-clock attention. The reverse osmosis plant operates at approximately 28% recovery and 800 psi pressure. The operating load factor is approximately 60 percent with an availability factor of 90 percent or greater. During one year of operation the plant has performed well and only four permeators have been replaced.

Discussion

Membrane life of three or more years make seawater reverse osmosis a formidable competitor for the various thermal processes. Two small systems installed in mid-1975 have demonstrated the long life of the aramid membrane in the du Pont B-10 "Permasep" permeator. (Critical operating data are summarized in Table 4.) Such demonstrations of membrane longevity develop confidence in seawater reverse osmosis. The experience paved the way for larger plants such as the Ras Al Khaimah plant, which is compiling a good performance record.

THE FUTURE OF SEAWATER REVERSE OSMOSIS

Seawater reverse osmosis has a bright future because the ocean covers more than 70 percent of the earth's surface and fresh water supplies are becoming short in many parts of the world. Man is looking toward the ocean for natural resources, and population increases and demographic changes are leading to development of new areas bounded by the ocean.

Developments in the Middle East, Far East, and Caribbean, have created a need for seawater plants producing as much as 50 million gpd. Increases in desalination capacities are being contemplated in several areas of the world, such as the U.S. Virgin Islands, because of severe maintenance problems with installed distillation equipment. For these situations, reverse osmosis offers a fast, economical and reliable solution. For example, barge and ship-mounted desalination plants have been proposed. One such ship has been engineered by the L*A/Water Treatment Division of Chromalloy to produce three to 10 million gpd of fresh water. A key advantage of such a concept is a relatively rapid construction time of approximately 18 months. The plant would be completely erected on shipboard in the United States and transported to the desired location. This reduces erection costs, and allows the plant to be fully tested prior to shipping, thus saving start-up time at the job site. The ship would be fully equipped with a power plant, maintenance facilities, fuel storage, fresh water storage,

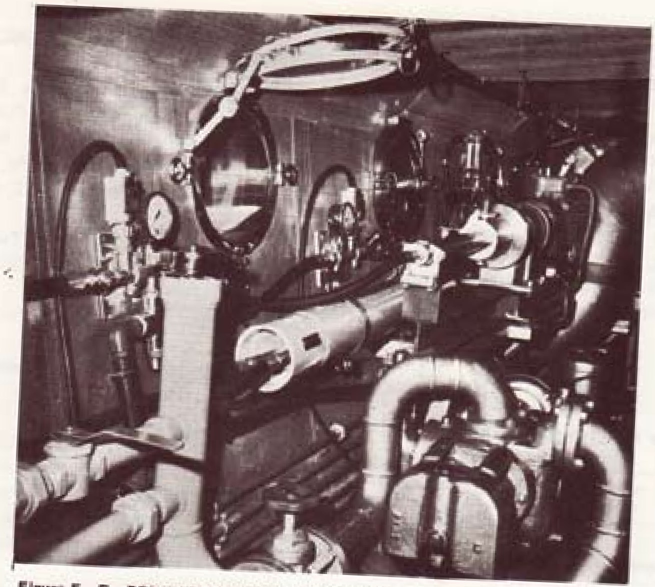


Figure 5. Du PONT "PERMASEP" PERMEATORS ARE PART OF COMPACT SEAWATER DESALINATION SYSTEMS USED BY LARGE SAILBOATS, MOTORBOATS AND OTHER OCEAN GOING VESSELS TO PRODUCE FRESH WATER. THIS SYSTEM WAS DESIGNED AND BUILT BY PERMO, A SUBSIDIARY OF DEGREMONT, FRANCE.

Figure 6. FRESH WATER FROM THE SEA IS PRODUCED IN RAS AL KHAIMAH, UNITED ARAB EMIRATES, BY THIS 150,000-GALLON-PER-DAY DESALTING FACILITY USING 8-INCH DIAMETER Du PONT REVERSE OSMOSIS B-10 "PERMASEP" PERMEATORS. THE FRESH WATER IS USED BY AN ADJACENT CONCRETE PLANT WHICH MAKES PRECAST CONCRETE FOR USE IN NEARBY SAUDI ARABIA.

chemical storage and crew quarters. If desired, such a unit could readily be moved from one location to another.

Future progress is expected in seawater reverse osmosis economics resulting from membranes with improved salt rejection and higher flux. Recovery of the energy lost on the high pressure discharged brine offers about a 40 to 50 percent reduction in energy costs. Such concepts are currently being tested. A combination of these factors will have a substantial and favorable impact on the capital and operating costs of future seawater reverse osmosis systems.

TABLE 4

SUMMARY OF THREE B-10 PLANTS

System	Admiral Arms	Shipboard System	Ras Al Khaimah
A. BASIC DATA			
Location	South Caicos, British West Indies	Various Oceans and Seas	United Arab Emirates
Application	Potable (Hotel)	Potable (Shipboard)	Industrial and Potable
Start-Up	May, 1975	June, 1975	February, 1978
Number "Permasep" Permeators	4 (4") B-10	1 (4") B-10	50 (8") B-10
System Rated Capacity, gpd	5000	1000	150,000
Operating Pressure, psig	800	800	800
Operating Temperature °F	78	Various	75-95
Recovery, %	25	< 15	28
Load Factor, %	Variable Depending on Rainfall	25% Average	60%
Representative Feed Water TDS (Mg/1)	45,800	38,000	40,000
Representative Salt Passage (%)	0.8	1.3	1.0
B. MEMBRANE LIFE-EXPERIENCE TO DATE (12/78)			
Elapsed Operating Time (yrs.)	3-1/2	3-1/2	1 year
Permeator Replacement (%) to date (12/78)	0	0	8%

REFERENCES

(1) Shields, C.P., Five Years Experience with Reverse Osmosis Systems Using du Pont 'Permasep' Permeators, presented at The Sixth International Symposium On Fresh Water From The Sea, Las Palmas, Canary Islands, September 17 to 22, 1978, Vol. 3, 395-414.

(2) *Industry News*, du Pont Public Affairs Department, Wilmington, Delaware 19898 (7/17/78).

(3) *du Pont Permasep News*, Vol. II, Issue 1 (1978)

(4) Smith, R.A., *Water Desalination Report*, Vol. XIV, No. 21 (May 25, 1978).

(5) Johansen, E.W. Jr., D.C.M. Crabbe, Design Parameters and Operation of Small and Medium Size Municipal Reverse Osmosis in North America, presented at: First Desalination Congress at the American Continent, Mexico City, Mexico, October 27, 1976.

(6) *Industry News*, du Pont Public Affairs Department, Wilmington, Delaware 19898 (5/18/76).

(7) Lerat, H., "Off Shore Sea Water Reverse Osmosis Plants", *Desalination*, Vol. 19, 1976 pp. 201-210.

(8) *Industry News*, du Pont Public Affairs Department, Wilmington, Delaware 19898 (10/13/78).

Q&A

Town of Jupiter -
Webinar Questions & Answers

by Paul Jurczak, Town of Jupiter and Ian Watson, P.E., AMTA Executive Director

Did you add a coagulant to your prefilters?

Yes we did but only temporarily when a certain group of wells produced a post cartridge SDI over 5. We added 2.0 mg/l of Solisep MPT 150 18% DADMAC polymer. Since it was incompatible with our anti-scalant during the test we halted addition of the anti-scalant and ran the feed pH at 5.5 instead of 6.5. The filter loading rate was 15 gpm/sq ft of media.

Why the change from Hydrannautics to Dow/FilmTec?

The Hydranautics' membranes removed too much hardness for our purposes. We not only had a TDS target for the permeate but also for the concentrate. We sell our NF concentrate to the local waste water utility to augment their IQ water supply and certain TDS of the concentrate was required.

What is the silica level?

Total silica of 12.5 mg/l.

What kind of antiscalant and iron dispersant did you use? What dose?

We use Aquafeed 1025 at a dose of 2.0 mg/l.

What loading rate have you actually run the prefilters at?

We have been normally been operating at a loading rate of 9 gpm/sq. ft. of media area.

What is the brand of NF elements?

Dow/FilmTec NF 270.

Where are the nanofilters located in the aerial photo?

The Nanofiltration building is the long building at the bottom of the photo.

Did the cold lime softening give lower hardness levels?

Yes, the lime plant averaged a total hardness between 65-70 mg/l as CaCO3.

Do you have an official tool for removing the membrane elements from the end feed vessels?

Yes we did receive a removal tool.

Is the removal of hardness considered normal?

There really is no "normal" when talking about NF membranes. The NF 270 is considered a fairly "loose" NF membrane, and gives higher hardness passage than say the NF 90 or Koch TFCS. Since the permeate will be blended with RO permeate, which has virtually no hardness, the resultant blend will be much closer to the current Jupiter hardness than the NF permeate alone.

What is the capital cost of the plant?

The overall capital cost was about $36M. At design capacity, this is $2.48/gal/day.

Does split feed allow recoveries as high as conventional two or three stage systems?

Typically NF plants in Florida are designed for 85-90% recovery. With a split feed 6element vessel, the Jupiter plant runs at 85% recovery.

I do not understand the hydraulics across the membranes?

In the Jupiter split feed system, the feedside water flow is across only three membranes in each stage, at each end of the vessel. This makes it a six element flow path, as compared to a 14 element flow path in a typical Florida two stage 7 element/stage system. Thus the energy economy depends on saving the hydraulic pressure drop across the additional 8 element flow path. At ~4 psi/element, the required feed pressure is only about ½-2/3 of a conventional NF system, in which the dP across the membranes is by far the most significant parasitic pressure loss, and in which 1st stage permeate backpressure is normally required.

Challenges of Inland Desalting

AMTA Technology Transfer, El Paso, Texas

By: John Balliew, Workshop Co-Chair (El Paso Water Utilities)

AMTA members converged in El Paso on Dec. 8 to attend the two-day Technology Transfer Workshop. The workshop, which explored the challenges of inland desalting, was held at El Paso Water Utilities' TecH2O Water Resources Learning Center and adjacent to the Kay Bailey Hutchison Desalination Plant. Attendees were eligible to receive contact hours and CEU credits.

Co-Chairs John Balliew, AMTA Board Member and David Derr, SCMA President, opened the workshop with introductions and remarks. They were followed by the Session 1 presentations, moderated by David Derr. Anai Padilla (El Paso Water Utilities) kicked off the morning session with a discussion on the importance of public information.

The session also included presentations on membrane basics and regulations. W. Shane Walker (University of Texas at El Paso) presented information on the concentration of supersaturated BWRO concentrate with electrodialysis and Rex Sistek (TraceDetect, Inc.) discussed online selenium analysis in concentrate.

After a presentation on treating extreme pH waters with membranes by Paul Diaz (Industrial Water Services), Thomas Davis (University of Texas at El Paso) discussed zero discharge desalination technology. The session ended with Kristina Mena's (University of Houston) presentation on promoting public health through membrane technology.

The afternoon session, moderated by Co-Chair John Balliew included a tour of the desalination plant and two demonstrations. The hands-on membrane cleaning demonstration by Roger Tominello (King Lee Technologies) was followed by a membrane autopsy demonstration by Stuart Mitchell (Avista Technologies). Attendees enjoyed dinner at Cattleman's Steakhouse, one of the El Paso area's most popular restaurants.

The second day's morning session was devoted to membrane case studies and moderated by Bill Norris (NRS Consulting Engineers Inc.). John Jansing (Gray-Jansing & Associates Inc.) presented information on the Horizon City Brackish Water RO Plant; Mark Threadgill (City of Alamogordo) described the Alamogordo Plant permitting struggle; Robert McCandless (Brown and Caldwell) summarized his research on using NF and RO to remove microconstituents; and Douglas Brown (CDM Inc.) discussed special applications for drinking water membranes. Scott Reinert's (El Paso Water Utilities) overview of deep well injection for concentrate disposal was followed by a presentation from Randy Shaw (U.S. Bureau of Reclamation) on the Brackish Groundwater National Desalination Research Facility.

The final session, which examined membrane applications and discussion items, was moderated by Lynne Gulizia (Toray Membrane USA Inc.). Anthony Tarquin (University of Texas at El Paso) summarized his research on concentrate volume reduction and Karl Wood (New Mexico State University) presented information about brackish water resources in New Mexico. The session ended with reports on WRF concentrate research from Rick Bond (Black & Veatch Corp.) and a report on turbochargers for BWRO systems from Peter Waldron (Energy Recovery Inc.). Co-Chairs John Balliew and David Derr made closing remarks.

CDM and CH2M HILL, Inc. were the workshop's major sponsors. Other sponsors included: Afton Pumps Inc., Alpha Southwest, Brown and Caldwell, Filtration Technology Corp., Gannett Flemming Inc., Industrial Water Services, King Lee Technologies, Moreno Cardenas Inc., NRS Consulting Engineers Inc., Parkhill, Smith & Cooper, Professional Water Technologies, Reynolds Inc., SJ Louis, TraceDectect Inc. and Western Summit Constructors Inc. ■

Membership Update

Lynne Gulizia
Steve Malloy
Membership Co-Chairs

Since our last newsletter we have welcomed 11 new members!

Denney Eames P.E.
Surplus Management, Inc.

Matt Gallo
Victaulic Company

Darren Kitzmiller
Washoe County DWR - Longley Lane WTF

Rowena Patawaran P.E.
I.Kruger - Veolia Water Solutions

Sara Pietsch
Avista Technologies, Inc.

James R. Prasil
Layne Christensen Company

Khalique U. Rehman M.D.
Kontel Technologies USA, Inc.

Sahkil-Ur Rehman
Kontel Technologies USA, Inc./CBI

Ken E. Robinson
Avista Technologies, Inc.

Joe Theaman
Washoe County DWR - Longley Lane WTF

John Webley
Innovative Labs, LLC

Now is the Time to Renew Your AMTA Membership

Membership renewal forms have been mailed, so please look for yours in your in-box today.

Division 1 Members are public agencies, industrial users, and water suppliers to end users. There are three levels of membership based upon how many customers are served by your organization.

Division 2 Members are manufacturers, suppliers, consultants, engineers or architects in the membrane industry. There are four levels of membership available based upon how many members your organization would like join AMTA.

You may be an Associate Member (what we at AMTA call a Division 3 Member) which means that your renewal dues may be lower or already covered because your organization has joined as either a Division 1 or Division 2 member as described above.

The benefits of joining AMTA include networking at AMTA workshops, seminars and conferences with others that are currently using membrane treatment. Share operating experiences and cost-savings ideas. Discuss how to meet regulatory requirements. Meet university researchers to learn of their latest research projects.

If you are considering installing a new project, AMTA programs are a great venue to attend facilities tours of existing treatment plants, attend presentations to learn about their recent membrane projects, and meet design consultants to consider for your next membrane job.

At the 2011 Annual Conference in Miami to be held in July, you will able to compare manufacturers' products side by side. The exhibit hall will be filled with membrane specific products making this a very time-efficient way to take the pulse of the membrane industry. And if you are an operator there will be multiple interesting sessions in which you can earn Continuing Education Units.

We cannot list all the other benefits of being an AMTA member as we need space below to list our newest AMTA members. Be sure that your name is listed in the next issue by sending in your AMTA membership renewal today. ■

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The Evolution of Scale Control in RO Membrane Systems

Evolution of Scale Control

Calendar of Events

2011 Events

Feb. 7-9, 2011	SWMOA Annual Conference, Las Vegas, NV
Feb. 10, 2011	AMTA Board Meeting, Las Vegas, NV
Mar. 28-31, 2011	AWWA Membrane Conference, Long Beach, CA
April 28, 2011	SWMOA Workshop, Location TBD
May 3, 2011	SWMOA Workshop, Peoria, AZ
May 23-25, 2011	AMTA Technology Transfer Workshop, Dayton, OH
June 12-16, 2011	AWWA Annual Conference & Expo (ACE), Washington, DC
July 18-21, 2011	AMTA/SEDA Joint Conference & Exposition, Miami Beach, FL
Aug. 11, 2011	SWMOA Workshop, San Luis Obispo, CA
Aug. 17-19, 2011	SCMA 2011 Annual Conference & Membership Meeting, San Antonio, TX
Sept. 4-9, 2011	IDA World Congress 2011, Perth, Australia
Sept. 27-29, 2011	AMTA/SWMOA Joint Technology Transfer Workshop, Sacramento, CA
Oct. 23-25, 2011	SEDA Fall Symposium, Clearwater Beach, FL

Contact the following organizations for more information regarding their listed events:
AMTA – 772-463-0820, admin@amtaorg.com, www.amtaorg.com
AWWA – 303-794-7711, awwamktg@awwa.org, www.awwa.org
CaribDA – 599-9-463-2000, hgouverneur@aqualectra.com, www.caribda.com
IDA – 978-887-0410, paburke@idadesal.org, www.idadesal.org
SCMA – 512-236-8500, info@scmembrane.org, www.scmembrane.org
SEDA – 772-781-7698, admin@southeastdesalting.com, www.southeastdesalting.com
SWMOA – 888-463-0830, admin@swmoa.org, www.swmoa.org