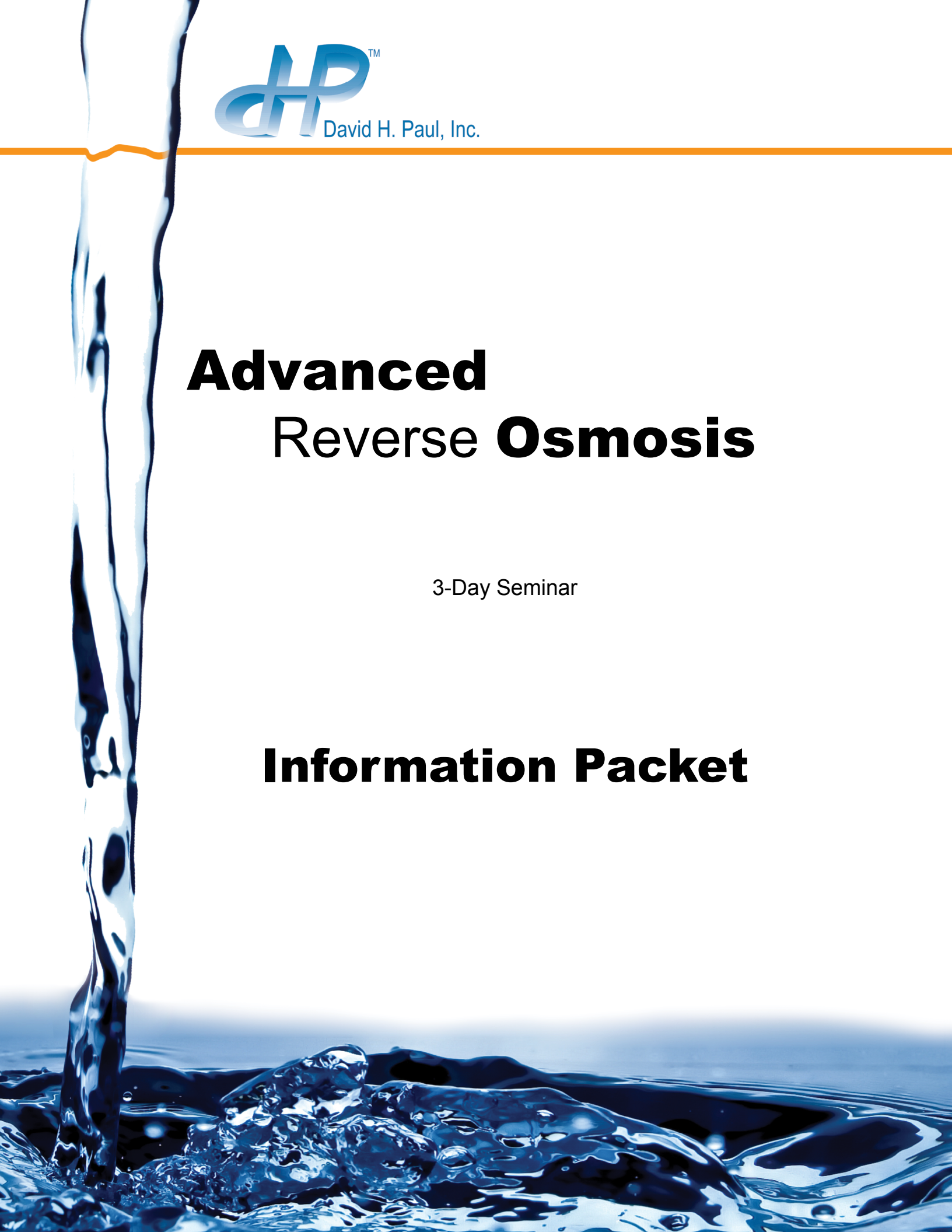
David H. Paul, Inc.

Advanced Reverse Osmosis

3-Day Seminar

Information Packet



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Seminar Cost - $2,399 USD

Seminar Length – 3 days; 8 hours per day

Seminar Description
This is a new seminar for 2014. While it is an advanced course, enough introductory material will be presented so that when more advanced concepts are covered, attendees will thoroughly understand the advanced concepts.

Each of the three days of this seminar series covers a different topic. The titles are:

- Day 1: RO Water Treatment Chemistry
- Day 2: How to Correct the Biggest BWRO & SWRO Problems
- Day 3: Optimal Design of RO Units

Day 1: RO Water Treatment Chemistry
You will understand the purpose for and the mechanism of action of every chemical injected ahead of or into an RO unit. This includes chlorine, chloramines, coagulants, flocculants, filter aids, sulfite, acid, biocides, cleaning chemicals as well as the chemistry inside activated carbon and UV units…and more. This seminar is an advanced course, so an advanced understanding of water treatment chemistry is provided. The training will be step by step so that no one will get lost. You only need to know that water is wet…we'll teach you the rest! You may learn enough to save a bunch of money, or make a bunch of money! A detailed agenda is located following the Testimonials below.

Day 2: How to Correct the Biggest BWRO & SWRO Problems
The reverse osmosis (RO) technology has been utilized for seawater and brackish water industrial and drinking water applications since the 1970s. You'd think all the problems would have been solved by now...Right?....Wrong! The information provided in Day 2 is practical and immediately usable to improve the performance of existing and future plants. The presentation covers the three most common problems in each of the following areas (a detailed agenda is located following the Testimonials below):

- Pretreatment
- RO Unit Design
- RO Unit Operation
- RO Unit Monitoring
- RO Unit Chemical Cleaning

Day 3: Optimal Design of RO Units
If you're an Original Equipment Manufacturer, you want to design the best RO system THAT WILL SELL. If you're a plant engineer, you want to specify a good, cost-effective RO system. If you're a buyer, you want the lowest capitol cost for an RO system. If you're a manager, you want to purchase an RO system that gives you the water you need at the lowest life-cycle cost, with includes the lowest capitol AND operation and maintenance (O & M) costs. If you operate and/or maintain an RO system, you want a system that runs all the time without a lot of time consuming problems. But unless you have knowledgeable people specifying systems you will likely receive a low-bid system that costs fewer capitol dollars but much more in O & M dollars over the 20+ years of life of the plant. Not good! Day 3 takes you step by step through evaluating feed waters for scaling and fouling potential, identifying the features of good RO unit design and some options for lower fouling designs. You will learn things that you will not get anywhere else. A detailed agenda is located following the Testimonials below.

Who Should Attend
The following personnel will find this information extremely valuable:

- Lead Operators
- Plant engineers
- Design engineers
- Original Equipment Manufacturers
- Service technicians
- Anyone that needs an advanced understanding of RO units

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Instructor Biography

Your instructor will be one or more of the following

David Paul is the President of David H. Paul, Inc. (DHP), an advanced water treatment training and consulting firm located in the USA. He has been involved in many aspects of RO water treatment since 1977. He was an operator 2.5 years, a shift supervisor for 1 year and the manager of a $500 million USD (today's value) huge water treatment plant that included reverse osmosis. He founded DHP in 1988. Since then he has provided training and consulting services at BWRO and SWRO plants around the world. He is the author of over 160 published articles and several books on membrane water treatment.

David Paul
David H. Paul, Inc.
President/Instructor/Consultant

Bill Dees provides water treatment training and consulting services for David H. Paul, Inc. (DHP). He has over 18 years of design, installation, operation, maintenance, troubleshooting, training and consulting experience of water treatment systems including membrane, ion exchange, pretreatment and post-treatment equipment. Bill is also the Technical Services Manager for DHP, responsible for membrane module autopsies and consulting. Bill holds an Associate of Applied Science Degree in Industrial Water Treatment from San Juan College, DHP's first on-campus, college degree program.

Bill Dees
David H. Paul, Inc.
Director of Training /
Instructor/Consultant

Richard (Dick) Youmans has over 30 years of experience in the industrial water treatment industry with 16 of those specializing in reverse osmosis chemical applications, training and troubleshooting. Dick received an Associate of Applied Science Degree in Industrial Water Treatment from San Juan College and David H. Paul, Inc. in 2002. As a corporate trainer, he has trained over 1,400 students in reverse osmosis technology and chemistry.

Dick Youmans
David H. Paul, Inc.
Director of Certification/
Instructor/Consultant

David H. Paul, Inc.

Certificate of Completion

Each attendee will receive a DHP certificate of completion following the course.

DHP Training Seminars

DHP has trained over 16,000 water treatment professionals worldwide since 1988. Trainees include industrial, governmental and drinking water clients. The average rating given by attendees for all DHP seminars, including this one, is over 9 (on a scale of 1-10, with 1 being a terrible rating and 10 being an outstanding rating).

Testimonials

The following are typical comments from attendees of DHP Seminars:

"Great Course! Well worth the time."
Bob Castle - Water Quality Manager, Marin Municipal Water District

"Excellent training materials and presentation."
Gary Trent - Abbott Laboratories

"Excellent… got what I was interested in and more, especially in the inner workings of UF."
Eric Lozano - Austin Energy

"Well presented and well worth the investment."
John Countz - Operations Manager, Consolidated Water Co.

"Excellent! More than I expected."
Mark Hall - Texas Water Development Board

"It was great!"
Trent Hughes - Civil Engineer, Black & Veatch

"Great Course."
Joe Gonzales - Xcel Energy

"Most Excellent!"
Mike Milner - Alternative H2O Solution

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RO Water Treatment Chemistry
Day 1

8:00 Introductions

- Seminar logistics
- Introductions
- Sample Process Flow Diagrams
  - Conventional Drinking Water
  - Semiconductor
  - Power Generation
  - Industrial Waste Water
  - Municipal Waste Water
  - Conventional Sea Water Pretreatment
  - Advanced Sea Water Pretreatment

Chlorine Compounds

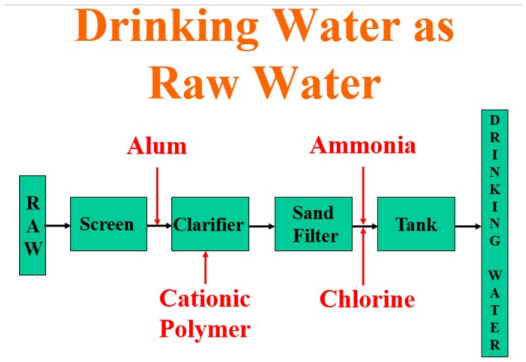
- Free
- Combined
- Total
- Chloramines

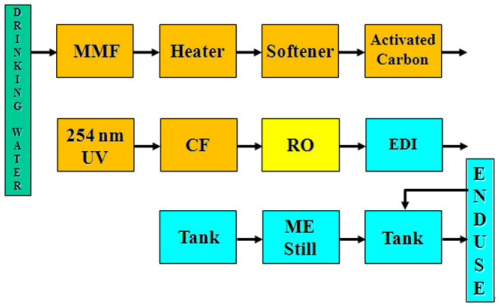
9:00 Break

9:15 Clarification

- Coagulants
  - Alum and aluminum salts
  - PAC
  - Ferric sulfate and ferric chloride
  - Other common coagulants
- Flocculants
  - Nonionic
  - Anionic
  - Cationic
- Jar Testing
  - Jar testing equipment
  - Make down procedures
  - Jar testing procedure
  - Hints on jar testing
- Filter Aids (media filters & MF/UF)
  - All common coagulants
  - Diatomaceous earth
  - Bentonite
  - Perlite

10:15 Break





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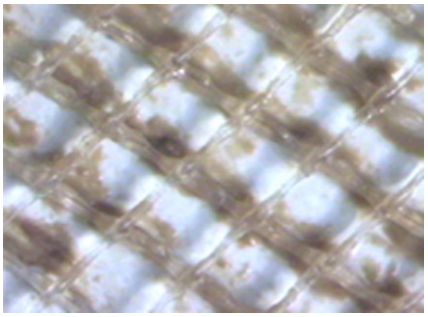
10:30 Dechlorination

- Sulfite compounds
  - Sodium Sulfite
  - Sodium bisulfite
  - Sodium metabisulfite
- Activated Carbon
  - Chemical reactions
  - Downstream impacts
    - Fouling by carbon fines
    - Microorganisms
- Ultraviolet Light
  - 185 nanometers
  - 254 nanometers



Biocides

- Metabolic Poisons
  - DBNPA
  - Isothiazolin
  - Carbamates
- Surface Active Biocides
  - Glutaraldehyde
- Oxidizing Biocides
  - Ozone
  - Chlorine Dioxide
  - Chlorine
  - Hydrogen Peroxide / Peracetic Acid

11:30 Lunch Break

12:15 Acids and Caustics

- Acid Donors
  - Hydrochloric Acid
  - Sulfuric Acid
- Caustic Donors
  - Sodium Hydroxide
  - Potassium Hydroxide
- Other pH Manipulators
  - Carbon Dioxide
  - Ammonia

Chemical cleaning products

- Commodity or Generic
  - Hydrochloric Acid
  - Citric Acid
  - Phosphoric Acid
  - Sulfamic Acid
  - Sodium Hydrosulfite
  - Ethylene Diamine Tetraacetic Acid
  - Caustic Soda
  - Sodium Tripolyphosphate
  - Trisodium Phosphate
  - Sodium Lauryl Sulfate
- Proprietary
  - Blending for specific problems

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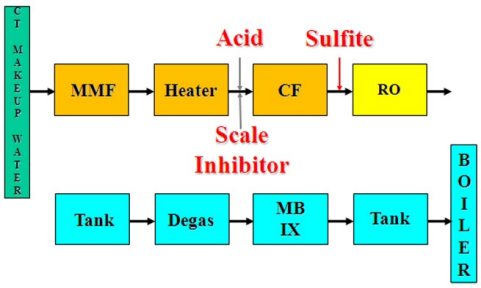
Scale Inhibitors & Dispersants

- Phosphonates
  - AMP
  - HEDP
  - PBTC
  - Others

- Polymers
  - Acrylic Acid
  - Acrylic Acid Copolymers
  - Acrylic Acid Terpolymers
  - Polymaleic acid
  - Others
- Preservatives
  - Sodium Benzoate
  - Isothiazolin
  - Others
    - Citric Acid
    - Sorbates
    - Ascorbic Acid

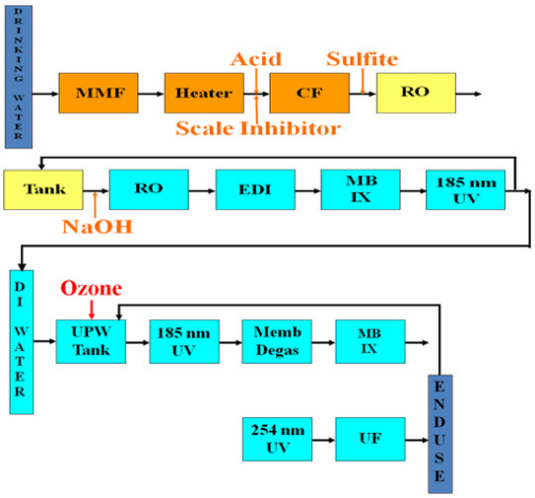


Draw Down Test and Scale Inhibitor Dosage Calculation

1:45 Break

2:00 Building and Stability Testing Your Own Products

- Choose Products to be Used
- Determine Desired Feed Rate
- Build a Formula
- Stability Test
- Consider Regulatory Issues



3:15 Break

3:30 Special Topics specific to group

Q & A

4:45 Summary & Conclusions

- Final Questions & Answers
- Seminar evaluation

5:00 End

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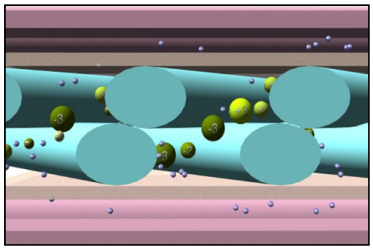
How to Correct the Biggest BWRO & SWRO Problems

Day 2

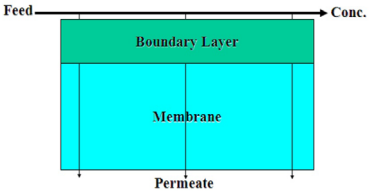
8:00 Introductions
RO water treatment
Water contaminants



9:00 Break

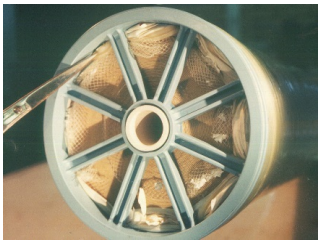
9:15 Semipermeable membranes
Osmosis & reverse osmosis
Membranes and membrane elements

10:15 Break



10:30 Pressure vessels
Staging
RO units
RO operation

11:30 Lunch

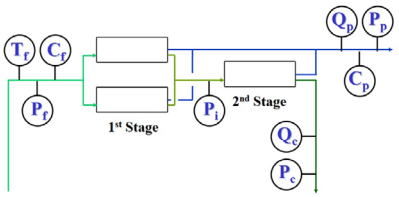


12:30 Potential problems
Pretreatment to minimize problems
The 3 biggest pretreatment problems and how to correct
1. Chlorination/dechlorination
2. Lack of MMF attention
3. Overfeeding sulfite

1:45 Break

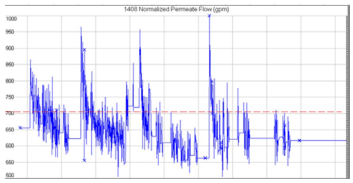
2:00 The 3 biggest RO unit design problems and how to correct
1. Overall water flux
2. First element water flux
3. Low crossflow rates

The 3 biggest RO unit operation problems and how to correct
1. Over capacity-Intermittent operation
2. Variable flow rates
3. Overcapacity



3:15 Break

3:30 The 3 biggest RO unit monitoring problems and how to correct
1. Not trending performance weekly
2. No DP monitoring across each stage
3. Instrument calibration



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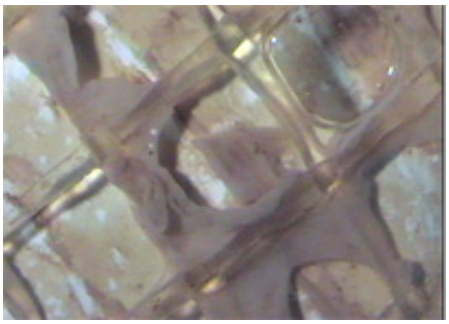
The 3 biggest RO unit chemical cleaning problems and how to correct

1. Waiting too long to clean
2. Inadequate cleaning pump
3. Not cleaning back to new/near new performance



4:45 Summary & Conclusions

- Final Questions & Answers
- Seminar evaluation

5:00 End

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Optimal Design of RO Systems

Day 3

8:00 Introductions
Membrane Water Treatment
Reverse Osmosis Overview
- Water contaminants
- Membranes
- Osmosis & Reverse Osmosis
- Net Driving Pressure
- Water flux
- RO unit operation
- Scaling, fouling & Chemical Attack

9:00 Break

9:15 Source Waters
- Fresh
- Brackish
- Seawater
- Well water, surface water

A Complete RO Feed Water Analysis
- Cations & anions
- Other

How to Read a Complete Water Analysis Report
- Solution neutrality
- Cations, anions
- Charge balance (ppm as $CaCO_3$ or meq/L)

10:15 Break

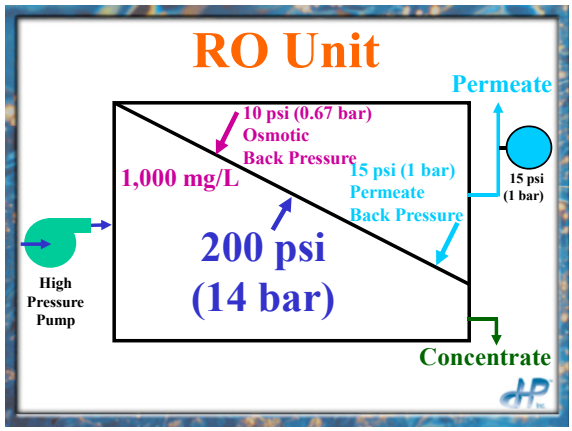
10:30 Using free software programs to evaluate feed waters
Workshop: Determining if a feed water analysis is complete and can be relied on

11:30 Lunch

12:30 Analysis that must be performed on-site
- pH
- Temperature
- Silt Density Index (SDI)
- Biological Activity Reaction Tests (BARTs)
- Hydrogen sulfide

Evaluating Scaling Potentials
- Scaling
- Carbonate scaling potential
  - Langelier Saturation Index (LSI), Stiff & Davis Saturation Index
- Non-carbonate scaling potential
  - % Saturation
- Silica scaling potential
  - Temperature
  - pH
  - Using free software programs to calculate scaling potential

1:45 Break



Ions	mg/l	ppm CaCO3	meq/l
Ammonium (NH4)	0	0.000	0.000
Potassium (K)	8.368	10.700	0.214
Sodium (Na)	49.658	108.000	2.160
Magnesium (Mg)	14.903	61.300	1.226
Calcium (Ca)	101.523	253.300	5.066
Strontium (Sr)	0.783	0.894	0.018
Barium (Ba)	0.018	0.013	0.000
Carbonate (CO3)	0.344	0.573	0.011
Bicarbonate (HCO3)	433.745	355.500	7.110
Nitrate (NO3)	0.489	0.394	0.008
Chloride (Cl)	52.045	73.400	1.468
Fluoride (F)	0.301	0.791	0.016
Sulfate (SO4)	16.704	17.400	0.348
Silica (SiO2)	68.8	n.a.	n.a.
Boron (B)	0	n.a.	n.a.

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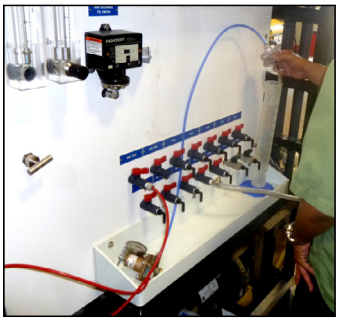
2:00 Evaluating Non-Living Fouling Potentials



- Fouling Overview
- Turbidity, TSS
- Silt Density Index (SDI)
- Oxidation: Iron, Manganese, Hydrogen sulfide
- Aluminum (Al)

Evaluating Living Fouling Potentials

- Temperature, TOC, Biocounts
- Chlorination/dechlorination
- Nitrate, Phosphate
- SDI

Good Design Means Low Fouling

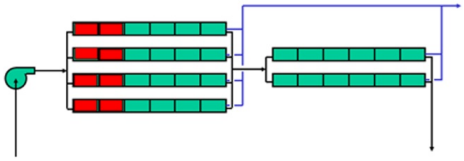
- Water Flux
- Crossflow
- Chlorination/Dechlorination

Standard NF/RO Unit Designs

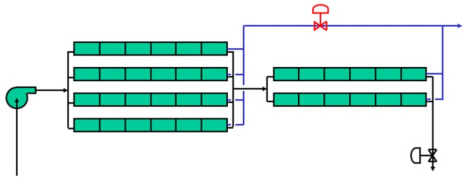
3:15 Break

3:30 Lower Fouling RO/NF Unit Designs

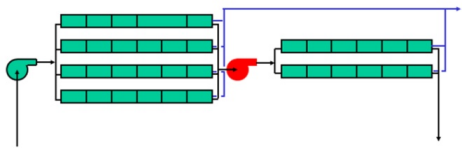
- Hybrid element loading



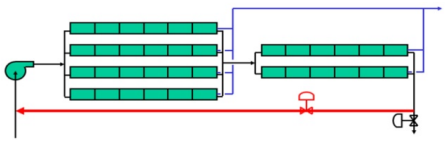
  - Workshop: Hybrid element loading
- First stage permeate backpressure



  - Workshop: First stage permeate backpressure
- Interstage Booster Pumps



  - Workshop: Interstage booster pump
- Concentrate Recycle



  - Workshop: Concentrate Recycle

4:30 Summary & Conclusions

Final Questions & Answers

Evaluation

5:00 End