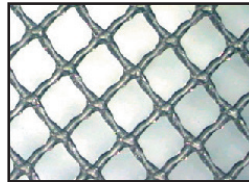


OPTIMAL DESIGN & OPERATION OF RO SYSTEMS



Images Courtesy: Sumitomo, David H. Paul, Inc., Bureau of Reclamation, City of Scottsdale

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REGISTER AT

www.dhpseminars.com

If you're an Original Equipment Manufacturer, you want to design the best RO system you can THAT WILL SELL. If you're a plant engineer, you want to identify a good, cost-effective RO system. If you're a buyer, you want the lowest capital 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, which includes the lowest capital AND 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 capital dollars but much more in O & M dollars over the 20+ years of the life of the plant. Not good! Unless you know the features of a good design, you won't understand how to operate the plant in the most cost effective manner. By understanding good design, you can troubleshoot problems more quickly and effectively.

This is a NEW 2011 seminar that is taught by David Paul and condenses what he's learned in 33+ years of experience including:

- 2.5 years as an operator of RO systems
- 1 year as a shift supervisor of RO systems
- 8 years as the manager of a \$120 million USD huge RO water treatment facility
- 22+ years of training and consulting at hundreds of RO water treatment facilities

This seminar will take you step by step through the features of good RO unit design, pretreatment and operation. This includes evaluating the scaling, fouling and chemical attack characteristics of different feedwaters, to good RO/NF unit designs to good operation. You will learn things that you will not get anywhere else. You can also consider this a consultant level understanding of RO systems seminar which is valuable both from a design standpoint and from an operations/troubleshooting standpoint.

Who Should Attend

This seminar provides valuable, practical knowledge to anyone wanting to understand the most important features of a well designed and operated RO system including:

- Design engineers
- Plant engineers
- Service technicians
- Buyers
- Plant Supervisors or Managers
- Operating & Maintenance Personnel

Why You Should Attend

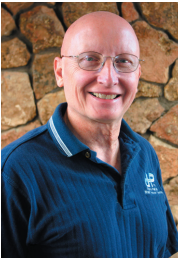
So you know the difference between low-bid, high-fouling, pain-in-the-pocket-book (and other places) RO systems and ones that can operate with the lowest life-cycle costs and fewest problems.

OPTIMAL DESIGN & OPERATION OF RO SYSTEMS

What You'll Receive

- 3 8-hour days of interesting, step-by-step, easy-to-understand, practical RO training
- A highly illustrated workbook
- Break refreshments

Instructors



David Paul has provided consulting services at several SWRO plants around the world including at the Tampa Bay Desal Plant in the United States. He is the author of over 150 published articles on membrane water treatment, has developed and administers a 4,000 page correspondence training program on advanced water treatment, and has created and administers on-campus Associate Degree in Advanced Water Treatment programs at four different locations in the United States. David is the President of David H. Paul, Inc. (DHP), an advanced water treatment training and consulting firm located in the USA. DHP has trained over 16,000 water treatment professionals worldwide since 1988.

Certificate of Completion

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

What Others Say About 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).

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

OPTIMAL DESIGN & OPERATION OF RO SYSTEMS

Detailed Agendum

NOTE: If you would like to discuss a particular plant or project, please bring a basic process flow diagram, raw water analysis/feedwater analysis and design of your RO unit (permeate flow, PVs/stage, model of elements and elements/PV)

Day One

7:45 Refreshments (Provided)

8:00 Introductions

Membrane Water Treatment
Water Treatment Examples

- Drinking water treatment
 - Point of Use (POU)
 - Conventional
 - Brackish water
 - Seawater
 - Membrane
 - Microfiltration (MF)
 - Ultrafiltration (UF)
 - Nanofiltration (NF)
 - Reverse Osmosis (RO)
 - Brackish water
 - Seawater
 - Industrial water treatment
 - Pharmaceutical/Biotech
 - Beverage
 - Power Generation
 - Semiconductor

9:00 Break (Refreshments Provided)

9:15 Source Waters (with examples)

- Fresh
- Brackish
- Seawater
- Well water/Surface water

Water Contaminants Overview

- Ions
- Gases
- Organics (including colloidal)
- Silica (including colloidal)
- Inorganic particles (including colloidal)
- Living particles

10:15 Break (Refreshments Provided)

10:30 How to Read a Complete Water Analysis Report

- Solution neutrality
- Cations/Anions
- Charge balance (ppm as CaCO₃ or meq/L)
- Total Hardness
- Alkalinity
- Carbon dioxide
- Total Dissolved Solids (TDS)_q/L)
- Temperature
- Using free software programs to determine a complete water analysis

11:30 Lunch Break

12:30 Workshop 1: Water Contaminants and Reading a Water Analysis Report

Evaluating Scaling Potentials
Scaling

- Carbonate scaling potential
 - Hardness & Alkalinity
 - pH
 - Temperature
 - Langelier Saturation Index (LSI), Stiff & Davis Saturation Index
- Non-carbonate scaling potential
 - Cation concentration
 - Anion concentration
 - Temperature
 - Ionic strength
 - Solubility product constant
- Silica scaling potential
 - Silica concentration
 - Temperature
 - pH
 - Using free software programs to calculate scaling potential

1:45 Break (Refreshments Provided)

2:00 Workshop 2: Evaluating scaling potential

Evaluating Non-Living Fouling Potentials

- Fouling Overview
- Turbidity
- TSS
- Silt Density Index (SDI)
- Oxidation reduction
- Iron (Fe)
- Manganese (Mn)
- Aluminum (Al)

3:15 Break (Refreshments Provided)

3:30 Evaluating Living Fouling Potentials

- Chlorination/dechlorination
- TOC
- BOD/COD
- AOC
- Biocounts
- Nitrate
- Phosphate
- SDI

Workshop 3: Evaluating Fouling Potentials

4:20 Summary & Conclusions

- Final Questions & Answers
- Day 1 Evaluation

4:20 Tour of Host Facility

5:00 End Day One

OPTIMAL DESIGN & OPERATION OF RO SYSTEMS

Day Two

7:45 Refreshments (Provided)

8:00 Review of Day 1

- RO Overview
- Semipermeable RO/NF Membranes
 - Structure
 - Water Flux
 - Salt Flux
 - Rejection of contaminants
- Osmosis & Reverse Osmosis
 - Osmotic pressure
 - Applied pressure
 - Net Driving Pressure
 - Water flux
 - Salt flux

9:00 Break (Refreshments Provided)

9:15 Good Design Means Low Fouling

- Water Flux
- Crossflow
- Sustainable Flux
- Humic Acid Compounds
- Colloidal Particles
- Zeta Potential
- Chlorination/Dechlorination

10:15 Break (Refreshments Provided)

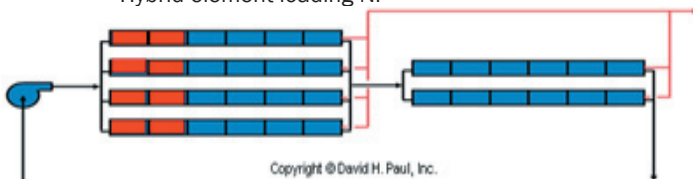
10:30 Lower Fouling RO Unit Designs

- Standard Designs-RO
- Workshop 4: Standard Designs-RO**
- Standard Designs-NF
- Workshop 5: Standard Designs-NF**

11:30 Lunch

12:30 Lower Fouling RO Unit Designs

- Hybrid element loading-NF

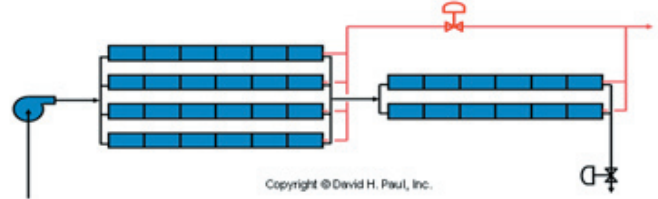


- Workshop 6: Hybrid element loading-NF
- Hybrid element loading-RO
- Workshop 7: Hybrid element loading-RO

1:45 Break (Refreshments Provided)

2:00 Lower Fouling RO Unit Designs

- First stage permeate backpressure-NF

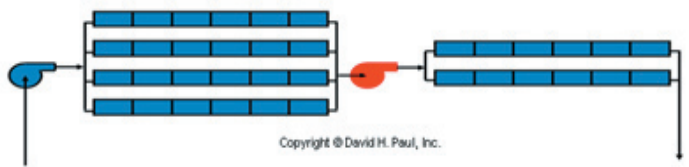


- Workshop 8: First stage permeate backpressure-NF
- First stage permeate backpressure-RO
- Workshop 9: First stage permeate backpressure-RO

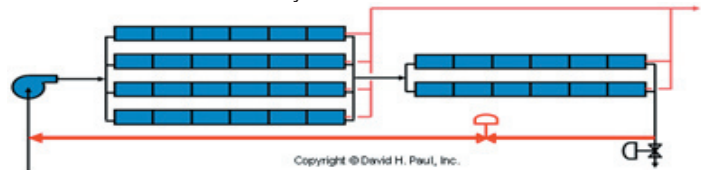
3:00 Break (Refreshments Provided)

3:15 Lower Fouling RO Unit Designs

- Interstage Booster Pumps



- Workshop 10: Interstage booster pump
- Concentrate Recycle



- Workshop 11: Concentrate Recycle

Open discussion to ask Gary Crisp any questions concerning the design, construction, startup and operation of large SWRO plants

4:30 Summary & Conclusions

- Final Questions & Answers
- Day 2 Evaluation

5:00 End Day Two

OPTIMAL DESIGN & OPERATION OF RO SYSTEMS

Day Three

7:45 Refreshments (Provided)

8:00 Pretreatment

- Scaling control
 - Recovery rate
 - Acid
 - Scale inhibitor
 - Softening
 - Post-shutdown flushes
 - Chemical cleaning
- Salt Flux
- Rejection of contaminants

Osmosis & Reverse Osmosis

- Osmotic pressure
- Applied pressure
- Net Driving Pressure
- Water flux
- Salt flux

Workshop 12: Quantify a feedwater's scaling potentials and recommend pretreatment

9:00 Break (Refreshments Provided)

9:15 Pretreatment

- Inorganic Fouling control
 - Water flux
 - Crossflow
 - Clarification
 - Media filtration
 - Coagulant enhanced media filtration
 - Microfiltration/ultrafiltration
 - Bag/Cartridge filtration
 - Dispersant injection
 - Low fouling elements
 - Chemical cleaning
 - Pilot study

Workshop 13: Quantify a feedwater's inorganic fouling potentials and recommend pretreatment

10:15 Break (Refreshments Provided)

10:30 Pretreatment

- Organic Fouling control
 - Dissolved air flotation
 - Ultrafiltration
 - Nanofiltration
 - Clarification
 - Activated carbon
 - Organic scavengers
 - Chemical cleaning
 - Pilot study

Workshop 14: Quantify a feedwater's organic fouling potential and recommend pretreatment

11:30 Lunch

12:30 Pretreatment

- Biofouling control
 - Operation
 - Post-shutdown flushes
 - Biocides
 - Hydrogen peroxide/peracetic acid
 - Chloramines
 - DBNPA
 - Chemical cleaning
 - Pilot study

Workshop 15: Quantify a feedwater's biofouling potential and recommend pretreatment

1:45 Break (Refreshments Provided)

2:00 Pretreatment

- Chemical Attack control
 - Activated carbon
 - Sulfite injection
 - Ultraviolet irradiation

Workshop 16: Quantify a feedwater's chemical attack potential and recommend pretreatment

3:00 Break (Refreshments Provided)

3:15 Workshop 16: Attendees' plants/issues

4:30 Summary & Conclusions

- Final Questions & Answers
- Day 3 Evaluation

5:00 End Day Three