



GUIDEBOOK

MEMBRANE DESALINATION TECHNOLOGY

Reverse Osmosis, Nanofiltration and Hybrid Systems Process, Design, Applications and Economics

*by Mark Wilf with chapters by Leon Awerbuch, Craig Bartels,
Mike Mickley, Greame Pearce and Nikolay Voutchkov*

This is a process and application guidebook that encompasses the latest state of the art of commercial membrane desalination technology. This unique book provides a thorough overview and understanding of the RO, NF, and hybrid system, all with a detailed discussion on how to apply, design and operate potable systems and how to evaluate project economics using innovative membrane technologies. A must-read for all project engineers, plant designers, planners, utility directors, and operation managers, involved in municipal and industrial membrane projects. Also scientists and academics interested in membrane desalination will find in this guidebook an insight into latest trends in commercial membrane desalination technologies for potable water applications. A step by step approach to design, operates and cost evaluation of membrane systems is explained in simple practical terms, all backed up by sample process calculations and case studies.

The contents of the book provides information, education and real life examples of the following major subjects:

Principles of membrane separation – provides explanation of membrane technology and factors that affect membrane element performance in field operation.

RO/NF system configurations and system design parameters – provides information on major components, process steps and configuration of desalination plants and modern approach to membrane plant design process including optimization of power consumption.

Application of RO and nanofiltration technology in wastewater reclamation plants – provides an overview of suitable membrane technology for wastewater processing, a practical range of design parameters and experience based performance expectation.

Cost estimation and planning process of membrane desalination projects – provides detailed information on cost factors to be considered in preparation of a desalination project budget. It also includes detailed discussion on their relative importance in different types of desalination project alternatives such as turn-key, DBB, DBO and BOOT.

Concentrate disposal – described in terms of concentrate disposal constraints and engineering solutions presently available. A detailed evaluation of economics of various concentrate disposal alternatives is included.

Hybrid systems – provides information on this new emerging technology and system configurations. It describes various alternatives of hybrid process configurations, potential economic benefits and provides a range of operating parameters.

Appendixes – includes examples of process configurations, budgeting of RO seawater systems and detailed evaluation of a specific case of concentrate disposal.

The contributors to the book are well known professionals in the desalination field with extensive involvement in research and development of membrane products and desalination processes. The book contents reflect their R&D work and experience in design, procurement and operation of numerous membrane systems. The information included in this guidebook represents the current state of the art of commercial membrane desalination technology.

TABLE OF CONTENTS

Introduction to reverse osmosis – basic terms	Organic matter
Water salinity – concentration units	Biofouling
The osmotic process	Permeate recovery ratio
Permeate recovery	Permeate flux rate
Average feed salinity	Membrane age
Net driving pressure	RO/NF system design
Salt separation in reverse osmosis process	System design guidelines
Water transport	The design process of RO/NF system
Salt transport	Site and feed water supply
Salt passage and salt rejection	Selection of pretreatment process
Temperature effect on transport rate	Energy consumption of RO process
Average permeate flux	Pumping equipment for RO applications
Specific permeability of a membrane	Optimization of energy consumption
Concentration polarization	Configuration of RO trains
Commercial RO-NF membrane technology	Control and monitoring system
Cellulose acetate membranes	Permeate processing
Composite polyamide membranes	Special design cases
Membrane module configurations	Achieving low boron limits with seawater
Plate and frame membrane elements	RO technology
Hollow fine fiber membrane elements	Nitrate reduction with brackish RO
Spiral wound membrane elements	membranes
Spiral wound elements categories	System design verification through operation of a
RO system configuration	pilot unit.
Membrane assembly unit	System commissioning
Concentrate staging	System operation
Flow distribution	Membrane fouling and performance restoration
Permeate staging	Membrane elements fouling process
Partial two pass configuration	Performance restoration
Calculation of system performance	Nanofiltration technology and applications
Manual method of membrane system performance	(by Craig Bartels)
calculations	Nanofiltration overview
Use of computer programs for projection	Nanofiltration membrane characteristics
of membrane performance	Membrane types
Normalization of system performance	Separation mechanism
Feed water supply systems and pretreatment	Membrane properties
Well water	Nanofiltration process consideration
Surface water	Pretreatment requirements
Raw water intake and concentrate discharge	Process design features
Conventional filtration pretreatment	Nanofiltration applications
Membrane filtration pretreatment	Potable water
(by Graeme Pearce)	Industrial process fluid purifications
Chemical stabilization of permeate	Other applications
RO/NF system design parameters	Wastewater treatment and reclamation by
Feed water types	RO and NF process (by Craig Bartels)
Feed water composition	Introduction
Feed water temperature	Background
Sparingly soluble constituents	Membrane selection
Particulate matter	Wastewater reclamation process design
	Permeate flux rate

- Biofouling control
- Recovery rate
- Commercial plant data and design
 - Singapore wastewater treatment plants
 - Southern California wastewater treatment plants
- Operating cost advantages
- Other wastewater treatment applications
- Conclusions
- Acknowledgements

Budgeting of membrane desalination projects
(by Nikolay Voutchkov)

- Overview of desalination cost estimating procedure and practice
 - Project cost definition
 - Definition of capital cost
 - Definition of operating and maintenance cost
 - Definition of cost of water
- Key factors influencing water cost
 - Cost factors within the control of plant owner
 - Project risk profile
 - Cost factors beyond the control of plant owner
- Types and accuracy of project cost estimates
 - Conceptual cost estimates
 - Preliminary cost estimates
 - Budgetary cost estimates
 - Detailed cost estimates
 - Cost models
- Preparation for project budgeting
- Project cost estimation and analysis
 - Capital cost
 - Construction cost
 - Costs for project engineering services
 - Project development costs
 - Project financing costs
 - Operation and maintenance cost
 - Waste stream disposal
 - Environmental and performance monitoring
 - Indirect O&M cost
- Cost of water
 - Fixed components of water cost
 - Other fixed costs
 - Variable components of water cost
- Trends of water cost
- Project implementation
 - Project delivery alternative
 - Design-Bid-Build (DBB)
 - Design-Bid-Operate (DBO)
 - Build-Own-Operate-Transfer (BOOT)
- Project schedule

Hybrid systems (by Leon Awerbuch)

- Introduction
- Distillation
- Description
- SWRO/Thermal
- RO membrane like
- Hybrid variations

Examples

- Dual purpose facilities
- Hybrid using NF
- Hybrid using vapor compression
- Hybrid using MSF–MED
- Hybrid and desalination aquifer storage recovery
- Resource conservation
- Environmental impact

RO concentrate management (by Mike Mickley)

- Nature of concentrate
- Concentrate management options
- Traditional concentrate disposal options
- Concentrate disposal challenges
- Consideration of concentrate management options
 - Beneficial use
 - Volume reduction
 - Zero liquid discharge
- Seawater desalination discharge
- Nanofiltration concentrate disposal
- Other topics related to concentrate disposal
 - Presence of contaminants
 - Major ion toxicity

References

Appendixes

- Examples of RO membrane unit configurations
- Example of desalination plant cost estimate.
(Nikolay Voutchkov)
- Example of feasibility evaluation of RO concentrate disposal alternatives (Mike Mickley)
- Units conversion table
- Common symbols used in process and instrumentation diagrams.



PLEASE ENTER MY ORDER FOR

GUIDEBOOK

MEMBRANE DESALINATION TECHNOLOGY

Reverse Osmosis, Nanofiltration and Hybrid Systems
Process, Design, Applications and Economics

*by Mark Wilf with chapters by Leon Awerbuch, Craig Bartels, Mike Mickley,
Greame Pearce and Nikolay Voutchkov*

ISBN 0-86689-065-3

Prepublication price €149 including shipping by air

Please send me _____ copy(ies) at €149 (or \$ equivalent) per copy

I enclose payment in the amount of € _____ by Check

Credit card Visa MasterCard

Card No. _____ Exp. date _____

Cardholder name _____ Signature _____

Name _____

Address _____

Country _____ Email _____

Tel. _____ Fax _____

Date _____

PLEASE SEND TO:

Miriam Balaban, Desalination Publications
Science and Technology Park of Abruzzo
Via Antica Arischia 1, 67100 L'Aquila, Italy
Tel. +39 0862 319954, +39 348 3348406
Fax +39 0862 3475213
Emails: balaban@desline.com
miriam.balaban@pstabruzzo.it

PAYMENT BY BANK TRANSFER TO:

Account Name: *Miriam Balaban*
Account N°: *10849.36*
Bank: *Monte dei Paschi di Siena*
67100 L'Aquila, Italy
ABI: *01030* CAB: *03600*
Swift Code: *PASCITMMAQU*
IBAN Code: *IT 92 I 01030 03600 000001084936*