

Information Source Guide

Water Desalination

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INTRODUCTION

This source guide is an attempt to compile information resources on desalination subject as one the main research program elements of Water Resources Division (WRD) at KISR. The guide aims to assist professionals at KISR-WRD who specialized in desalination technology to access and to locate information easily in their area of interest.

Hence, the guide includes two types of information sources, print and electronic. Print sources represented in NSTIC collection, which includes books, periodicals, and KISR-research reports. Where as electronic sources include NSTIC CD-ROM databases, selected organizations and associations and Websites specialized in desalination technology.

The guide begins with featured article on the "Perspectives and Challenges for Desalination in the 21st Century" and ends with glossary of terms in desalination field.

Featured Article

Perspectives and Challenges for Desalination in the 21st Century

Manuel Schiffler

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Abstract

While the importance of desalination has been increasing steadily over the past decades, views on the merits of desalination among water professionals differ. Some portray desalination as a panacea for much of the world's water woes. Others perceive desalination very negatively because of its alleged high costs, energy intensity and environmental impacts. While none of these extreme positions appears to be justified, it remains even more necessary to gain an objective understanding of the real stakes in desalination in the context of integrated water resources management. The World Bank has undertaken a regional study that aims at improving the understanding of desalination within the Bank and among some of its clients in the Middle East, North Africa and Central Asia. It also tries to clarify the conditions under which desalination can help in reaching the United Nation's Millennium Development Goals (MDGs) for water supply and sanitation. The study, which has been funded by the Bank-Netherlands Water Partnership, includes case studies of Algeria, Cyprus, Jordan, Malta, Tunisia and Uzbekistan. A key conclusion of the study is that desalination alone cannot deliver the promise of improved water supply. The ability to make the best use of desalination is subject to a series of wider water sector related conditions. In some countries weak water utilities, politically determined low tariffs, high water losses and poor sector policies mean that desalinated water, just like any other new source of bulk water, may not be used wisely or that plants are at risk of falling into disrepair. Under these conditions, there is a risk that substantial amounts of money are going to be used inefficiently, and that desalination cannot deliver its promise to alleviate water scarcity and to contribute to the achievement of the MDGs. It may be preferable not to engage on desalination on a large scale unless the underlying weaknesses of the water sector are being seriously addressed. A program to address these weaknesses should include a reduction of non-revenue water; appropriate cost recovery; limited use of targeted subsidies; sound investment planning; integrated water resources management; proper environmental impact assessments; and capacity building in desalination as well as in water resources management and utility management. In any case, desalination should remain the last resort, and should only be applied after having carefully considered cheaper alternatives in terms of supply and demand management. A second conclusion is that the private sector can play a useful and important role in funding and operating desalination plants, but only if the above conditions are met. If these conditions are absent, there is a risk that excessive investments in desalination become a drain to the national budget, either directly under public financing or indirectly through implicit or explicit guarantees under private financing. A third conclusion is that desalination technology itself has evolved substantially, making it significantly cheaper, more reliable, less energy-intensive and more environmentally friendly than it was a few decades ago. This is especially true for reverse osmosis, which is gaining a large share of the market outside the Gulf countries which continue to use mainly distillation technologies.

(Desalination, Volume 165, 15 August 2004, Pages 1-9)

Desalination Technologies

<http://www.waterdesalination.com/factssample1.htm>

A number of technologies have been developed for desalination which include distillation, reverse osmosis (RO), electrodialysis, and vacuum freezing. Two of these technologies, distillation and reverse osmosis, are being considered by municipalities, water districts and private companies for development of sea water desalination. A description of these technologies are described below:

Distillation

In the distillation process, sea water is heated and then evaporated to separate out the dissolved salts. The most common methods of distillation include vapor compression (VC), multi-stage flash (MSF) and multi-effect distillation (MED). The vapor compression process involves evaporating the input water and then compressing the vapor. The vapor is then condensed, and the heat released is used to evaporate the input water. In the multi-stage flash process, saline feedwater is heated and the pressure is lowered; so that the water "flashes" into steam. This process constitutes one stage, and there are a number of stages in series, each of which is at a lower pressure. In multi-effect distillation, there are a number of evaporators in series, and vapor from one series is used to evaporate water in the next effect. Some distillation plants are a hybrid of more than one of these technologies. The waste product from these processes is a high salt concentration brine solution.

Reverse Osmosis

In reverse osmosis, the sea water is pre-treated to remove particles that would clog the membranes. The sea water is pumped at high pressure through membranes, separating the salt from the water. The quality of the water produced is dependent upon the pressure, the concentration of salts in the feedwater and the salt permeation constant of the membrane. The quality of the product water from reverse osmosis plants can be improved by adding a second stage of membranes.

Input Water

Desalination plants may use sea water from the ocean or brackish water from groundwater wells as input water. Brackish water has a lower salt concentration and may produce water at a lower cost than sea water plants. Brackish water plants typically use reverse osmosis technology. Therefore, most plants that are built or proposed in the coastal zone are distillation plants. Desalination intake pipes should be located away from sewage treatment plant discharges; but if some of these discharges or other types of pollutants are included in the intake, the pre-treatment and post-treatment processes should remove them.

Product Water

Distillation plants produce a high-quality product water that ranges from 2 to 50 parts per million (ppm) total dissolved solids (tds). (Note: The recommended California drinking water standard for maximum total dissolved solids level is 500 ppm). Reverse osmosis produces potable product water that ranges from 10 to 500 ppm total dissolved solids. In desalination plants that are producing water for domestic use, post treatment processes are often employed to ensure that the product water meets the health standards for drinking water. The desalination product water may be used in its pure form, (i.e., in power plant turbines, or it may be mixed with less

pure water and used for irrigation, drinking water, or other uses. The water that is produced with desalination is usually more pure than the drinking water standards, so when the product water is intended for municipal use, it may be mixed with water that contains higher levels of total dissolved solids. The pure desalination water has a high acidity level, which is corrosive to pipes. Therefore, it needs to be adjusted for the correct pH level and hardness before it is piped offsite. If not, other sources of water that it is mixed with will have to be piped on site.

Pretreatment Processes

Pretreatment processes are needed to remove substances that would interfere with the reverse osmosis membranes. Algae and bacteria can grow in both reverse osmosis and distillation plants, so both require some type of biocide to clean the system (usually chlorine is added - about 1 ppm). Some reverse osmosis membranes cannot tolerate chlorine, so dechlorination techniques are required. Ozone or ultraviolet light may also be used to remove marine organisms. If ozone is used, it must be removed with chemicals prior to reaching the membranes. In reverse osmosis plants, particles in the inflow water must be removed to reduce fouling of the membranes. Metals in the inflow water are removed with acids or ion exchange. Suspended solids are removed with coagulation and filtration.

Filter Backwashing

Membrane Cleaning and Storage and Pipe Cleaning The filters for pretreatment of plant water at a reverse osmosis plant must be cleaned every few days (backwashed) to clear the accumulation of sand and solids. The reverse osmosis membranes must be cleaned approximately four times a year and must be replaced every three to five years. Alkaline cleaners are used to remove organic fouling, and acid cleaners are used to remove scales and other inorganic precipitates. All or a portion of the plant must be shut down when the membranes are replaced. When reverse osmosis plants are not used continuously, the membranes must be stored in a chemical disinfection/preservation solution, which must be disposed of after use. For both reverse osmosis and distillation systems, the intake and outfall structures will become fouled with organisms and will have to be cleaned by applying chemicals or high temperatures. The plant components must be cleaned to reduce scaling. Scaling is a condition where salts deposit on pipe surfaces or other parts of the desalination plants. It is caused by the high salt concentration of the sea water and can result in reduced efficiency of the plants and corrosion of the pipes. Scaling can be reduced by introducing additives to inhibit crystal growth, reducing temperature and/or salt concentrations, removing the scale forming constituents, or seeding to form particles. Once scales have formed, they can be removed with chemical or mechanical means. Scaling is a concern for reverse osmosis plants and distillation plants unless lower temperatures are used, which reduces the potential for scaling. The input water may also be deaerated to reduce corrosion.

NSTIC-COLLECTION

A- BOOKS

CALL NUMBER: TP159 M4 M458 2001

TITLE: Membrane technology in the chemical industry / S.P. Nunes and K.-V. Peinemann (eds.).

PUBLICATION: Weinheim ; New York : Wiley-VCH, c2001.

CALL NUMBER: TD788.4 S83 2000

AUTHOR: Stephenson, Tom.

TITLE: Membrane bioreactors for wastewater treatment/ T. Stephenson [et al.].

PUBLICATION: London : IWA, 2000.

CALL NUMBER: TP156 D5 S85 1998

AUTHOR: Stichlmair, Johann.

TITLE: Distillation : principles and practices / Johann Stichlmair and James R. Fair.

PUBLICATION: New York : Wiley, c1998.

CALL NUMBER: TP159 M4 P76 1996

TITLE: Profile of the international membrane industry.

OTHER TITLE: Subtitle on cover: Market prospects to 2000

PUBLICATION: Oxford, UK : Elsevier Advanced Technology, c1996.

CALL NUMBER: TD479.4 W360 1996

AUTHOR: Wangnick, Klaus.

TITLE: 1996 IDA worldwide desalting plants inventory / Klaus Wangnick.

PUBLICATION: Gnarrenburg, Germany : Wangnick Consulting, c1996.

CALL NUMBER: TP156 O7 B97 1995

AUTHOR: Byrne, Wes.

TITLE: Reverse osmosis : a practical guide for industrial users / Wes Byrne.

EDITION: 1st ed.

PUBLICATION: Littleton, CO : Tall Oaks Pub., c1995.

CALL NUMBER: TD201 I57 1994

AUTHOR: International Specialist Conference on Desalination and Water Reuse (1994 : Perth, Western Australia)

TITLE: International Specialist Conference on Desalination and Water Reuse / organised by Australian Water and Wastewater Association ; sponsored by International Water Supply Association .. [et al.]

PUBLICATION: Perth, Australia : The Association, 1994.

CALL NUMBER: QP601 M49 v.220
TITLE: Membrane fusion techniques. Part A / edited by Nejat DLuzgLunes.
PUBLICATION: San Diego, Calif. : Academic Press, c1993.

CALL NUMBER: TP159 M4 S23 1993
AUTHOR: Safar, Mohamad A. M.
TITLE: Investigations of artificial scale simulation and effect of compaction on FT30 membrane & computer analysis of hollow fibre module / by Mohamad A. M. Safar.
PUBLICATION: 1993.

CALL NUMBER: TP155.75 D95 1993
TITLE: Dynamics and control of chemical reactors, distillation columns, and batch processes : selected papers from the 3rd IFAC Symposium, Maryland, USA, 26-29, 1992 / edited by J.G. Balchen.
EDITION: 1st ed.
PUBLICATION: Oxford ; New York : Published for the International

CALL NUMBER: TP156 D5 K555 1992
AUTHOR: Kister, Henry Z.
TITLE: Distillation design / Henry Z. Kister.
PUBLICATION: New York : McGraw-Hill, c1992.

CALL NUMBER: TP156 O7 A45 1992
AUTHOR: Amjad, Zahid.
TITLE: Reverse osmosis : membrane technology, water chemistry & industrial applications / edited by Zahid Amjad.
PUBLICATION: New York : Van Nostrand Reinhold, c1993.

CALL NUMBER: TP159 D5 P73 1992
TITLE: Practical distillation control / William L. Luyben, editor.
PUBLICATION: New York : Van Nostrand Reinhold, c1992.

CALL NUMBER: TD479.4 W360 1992
AUTHOR: Wangnick, Klaus.
TITLE: 1992 IDA worldwide desalting plants inventory / Klaus Wangnick.
PUBLICATION: Gnarrenburg, Germany : Wangnick Consulting, c1992.

CALL NUMBER: TP248.25 M46 B58 1991
AUTHOR: Bitter, J. G. A.
TITLE: Transport mechanisms in membrane separation processes / J.G.A. Bitter.
PUBLICATION: New York : Plenum Press, c1991.

CALL NUMBER: TD478 D44 1991

TITLE: Desalination and water re-use : proceedings of the twelfth international symposium / Miriam Balaban (editor).

PUBLICATION: Rugby, UK : Institution of Chemical Engineers ; New York :

CALL NUMBER: TD479 C66 1991

AUTHOR: Conference on Desalination : Putting the Technology into Practice (1991 : Okland, CA)

TITLE: Desalination : putting the technology into practice : presented at SF Hyatt Regency, Embarcadero, April 29, 1991.

PUBLICATION: Oakland, CA : ABAG Training Center for Excellence, [1992?]

CALL NUMBER: TD478 D44 1991

TITLE: Desalination and water re-use : proceedings of the twelfth international symposium / Miriam Balaban (editor).

PUBLICATION: Rugby, UK : Institution of Chemical Engineers ; New York : Hemisphere Pub. Corp., c1991.

CALL NUMBER: TD479 S25 1990

TITLE: Saline water processing : desalination and treatment of seawater, brackish water, and industrial waste water / edited by Hans-Gunter Heitmann.

PUBLICATION: Weinheim, Federal Republic of Germany ; New York, NY, USA : VCH, c1990.

CALL NUMBER: TP156 D5 K56 1990

AUTHOR: Kister, Henry Z.

TITLE: Distillation operations / Henry Z. Kister.

PUBLICATION: New York : McGraw-Hill, c1990.

CALL NUMBER: TP248.25 M45 M45 1989

TITLE: Membrane reactor technology / Rakesh Govind and Naotsugu Itoh, editor[s] ; [contributors], Gerardo Catapano ... [et al.].

PUBLICATION: New York, N.Y. : American Institute of Chemical Engineers, 1989.

CALL NUMBER: TP159 M4 M453 1989

TITLE: Membrane separations in chemical engineering / A.E. Fouda ... [et al.], editors.

PUBLICATION: New York, N.Y. : American Institute of Chemical Engineers,

CALL NUMBER: TD480.4 R48 1988

TITLE: Reverse osmosis technology : applications for high-purity-water production / edited by Bipin S. Parekh.

PUBLICATION: New York : M. Dekker, c1988.

CALL NUMBER: TD313 K9 K8 1987

AUTHOR: Kuwait Symposium on Management and Technology of Water Resources in Arid Zones (1987 : Kuwait)

TITLE: Proceedings of the Kuwait Symposium on Management and Technology of Water Resources in Arid Zones : Kuwait, Oct. 5-7 1987 / edited by A. Al-Homoud ... [et al.]

PUBLICATION: Amsterdam : Elsevier, 1989.

CALL NUMBER: TP690.3 A79 1986

TITLE: Automatic control in petroleum, petrochemical, and desalination industries : proceedings of the IFAC Workshop, Kuwait 6-8 January, 1986 / edited by Samir Kotob.

EDITION: 1st ed.

PUBLICATION: Oxford [Oxfordshire] ; New York : Published for the International Federation of Automatic Control by Pergamon

CALL NUMBER: TN863 A70 1986

TITLE: Automatic control in petroleum, petrochemical and desalination industries : preprints of the Workshop, January 6-8 1986, Kuwait / edited by Samir Kotob, Imad Al-Atiqi.

PUBLICATION: Oxford ; New York : Published for the International Federation of Automatic Control by Pergamon Press, [1986]

CALL NUMBER: TD478.6 K8 A40 1986

AUTHOR: Al-Zubaidi, Ali.

TITLE: Sea water desalination in Kuwait : a report on 33 years experience / by Ali Al-Zubaidi.

PUBLICATION: Kuwait : Water Resources Development Centre, 1986.

CALL NUMBER: QD63 D6 A84 1985a

AUTHOR: Alatiqi, Imad M.

TITLE: Composition control of distillation systems separating ternary mixtures with small intermediate feed concentrations / by Imad M. Alatiqi.

PUBLICATION: 1985.

CALL NUMBER: TD478.6 K9 A40 1984a

AUTHOR: Ali, Mahmood Yoosef A.

TITLE: A study of halomethanes in waters associated with the production of potable water by desalination, in Kuwait / by Mahmood Yoosef A. Ali.

PUBLICATION: 1984.

CALL NUMBER: QD63 D6 K713 1982

AUTHOR: Krell, Erich.

TITLE: Handbook of laboratory distillation : with an introduction into the pilot plant distillation / Erich Krell.

EDITION: [3rd] completely rev. 2nd ed.

PUBLICATION: Amsterdam ; New York : Elsevier Scientific Pub. Co. ; New York : Distribution for the U.S.A. and Canada, Elsevier North-Holland, 1982.

CALL NUMBER: TP156 M3 A43 1980

AUTHOR: American Institute of Chemical Engineers.

TITLE: AIChEMI modular instruction : series B, stagewise and mass transfer operations.

PUBLICATION: New York : American Institute of Chemical Engineers, c1980-<c1984 >

CALL NUMBER: TD478.6 K8 W3 1978 no.4

AUTHOR: Malek, Abdul Latif A..

TITLE: Testing of three different types of reverse osmosis membranes / by Abdul Latif A.

PUBLICATION: Kuwait : Water Resources Development Centre, 1978.

CALL NUMBER: TD478.6 K8 W3 1973 no.5

TITLE: The Government of Kuwait's sea water desalination plants : a report on 20 years experience / by members of the Research and Development Section of the Water Resources Development Centre, Kuwait, under the supervision of J. Reside.

PUBLICATION: Kuwait : Water Resources Development Centre, 1973.

CALL NUMBER: TD478.6 K8 W3 1972 no.3

AUTHOR: Elliot, M. N.

TITLE: A study of the effects of increasing the blowdown concentration of the Shuwaikh F 1 evaporator / by M. B. Elliot, A. H. Bou-Hasan, A. S. M. Hussan.

PUBLICATION: Kuwait : Water Resources Development Centre, 1972.

CALL NUMBER: TD480.4 O63 1969

TITLE: Operation of the Gulf environmental systems : 4,000 U.S.G.P.D. reverse osmosis unit : part 1, results obtained during operation from 21/10/69-16/12/69 and from 11/12/71-19/3/72 by M. N. Elliot ... [et al.]

PUBLICATION: Kuwait : W.R.D.C., 1972.

CALL NUMBER: TD478 L4 1968

AUTHOR: Levine, Sumner N., comp.

TITLE: Selected papers on desalination and ocean technology, edited by Sumner N. Levine.

PUBLICATION: New York, Dover Publications [1968]

B- KISR-Reports

CALL NUMBER: WT 006C KISR 6771

AUTHOR: Jafar, M.

TITLE: Development of seawater pretreatment applications using zeeweed membranes / M. Jafar.

PUBLICATION: Kuwait : KISr, 2003.

CALL NUMBER: WT 002S KISR 6475R

AUTHOR: Al-Odwani, A.

TITLE: Comparison study between spiral welded carbon steel and ductile iron pipes in Kuwait's fresh water networks / A. Al-Odwani, M. Abdel-Jawad, M. Al-Tabtabaei.

PUBLICATION: Kuwait : KISR, 2002.

CALL NUMBER: WT 003G KISR 6454

AUTHOR: Al-Odwani, A.

TITLE: Car-wash water reclamation / A. Al-Odwani, M. Ahmed, A. Al-Hijji.

PUBLICATION: Kuwait : KISR, 2002.

CALL NUMBER: WD 009C KISR 6353

AUTHOR: Al-Wazzan, Y.

TITLE: Pretreatment of seawater feed for desalination plants using nanofiltration technique / Y. Al-Wazzan, E. El-Sayed, M. Safar

PUBLICATION: Kuwait: KISR, 2002.

CALL NUMBER: WT 004C KISR 6473

AUTHOR: Al-Odwani, A.

TITLE: Mutistage flash distillation plants : evaluation of materials performance in the heat recovery section / A. Al-Odwani ... [et al.]

PUBLICATION: Kuwait : KISR, 2002.

CALL NUMBER: EA 009K KISR 6425

AUTHOR: Habib, K.

TITLE: Electrochemical behavior of copper alloys in desalination plants by optical interferometry / K. Habib.

PUBLICATION: Kuwait : KISR, 2002.

CALL NUMBER: EA 007G KISR 6561

AUTHOR: Habib, K.

TITLE: Risk assessment and evaluation of materials commonly used in desalination plants subjected to stress corrosion cracking in polluted marine environments / K. Habib, O. Al-Matar, B. Al-Feeli.

PUBLICATION: Kuwait : KISR, 2002.

CALL NUMBER: EA 008G KISR 6575

AUTHOR: Habib, K.

TITLE: Risk assessment and evaluation of materials commonly used in desalination plants subjected to pollution impact of the oil spill and oil fires in marine environment / K. Habib, A. Fakhraldeem.

PUBLICATION: Kuwait : KISR, 2002.

CALL NUMBER: WD 009C KISR 6140

AUTHOR: Al-Wazzan, Y.

TITLE: Pretreatment of seawater feed for desalination plants using nanofiltration technique mobilization / Y. Al-Wazzan, M. Abdel-jawad.

PUBLICATION: Kuwait: KISR, 2001.

CALL NUMBER: WD 009C KISR 6031

AUTHOR: Al-Wazzan, Y.

TITLE: Pretreatment of seawater feed for desalination plants using nanofiltration technique / Y. Al-Wazzan, M. Abdel-Jawad.

PUBLICATION: Kuwait : KISR , 2001.

CALL NUMBER: WT 001C KISR 6152

AUTHOR: El-Sayed, E.

TITLE: Feasibility of an innovative improvement of the MSF process / E. El-Sayed.

PUBLICATION: Kuwait : KISR, 2001.

CALL NUMBER: WT 004C KISR 6328

AUTHOR: Al-Odwani, A.

TITLE: Multistage flash distillation of plants: Evaluation of materials performance in heat recovery section / A. Al-Odwani.

PUBLICATION: Kuwait : KISR, 2001.

CALL NUMBER: WD 002C KISR 5983

AUTHOR: Al-Hawaj, O.

TITLE: Development and evaluation study of a new multi-effect desalination apparatus / O. Al-Hawaj, S. Bou-Hamad.

PUBLICATION: Kuwait : KISR, 2000.

CALL NUMBER: WD 001 KISR 5602

TITLE: Development of the pressure exchanger for reverse osmosis desalting plants / E. F. El-Sayed ... [et al.]

PUBLICATION: Kuwait : KISR 1999.

CALL NUMBER: WD 002C KISR 5586

AUTHOR: Al-Hawaj, O.

TITLE: Development and evaluation study of a new multi-effect desalination apparatus : (testing and modification) / O. Al-Hawaj, S. Bou-Hamed.

PUBLICATION: Kuwait : KISR, 1999.
Sciences.

CALL NUMBER: WB 006C KISR 5514

TITLE: Characterization of seawater quality and design criteria for future construction of RO pretreatment systems at Az-Zour north and Sabiya sites / M. Abdel-Jawad ... [et al.]

PUBLICATION: Kuwait : KISR, 1999.

CALL NUMBER: WD 001C KISR 5719

AUTHOR: Al-Wazzan, Y.

TITLE: A pilot study for the treatment and reuse of drainage water in residential areas of Kuwait : Operation and evaluation / Y. Al-Wazzan ... [et al.]

PUBLICATION: Kuwait : KISR, 1999.

CALL NUMBER: WD 006C KISR 5638

AUTHOR: Abdel-Jawad, M.

TITLE: Characterization of seawater quality and design criteria for future construction of RO pretreatment systems at Az-zour North and Sabiya sites / M. Abdel-Jawad [et al.]

PUBLICATION: Kuwait : KISR, 1999.

CALL NUMBER: WW 004K KISR 5337

TITLE: Treatment of tertiary treated wastewater by microfiltration / S. Bou-Hamad ... [et al.].

PUBLICATION: Kuwait : KISR, 1998.

CALL NUMBER: WD 006C KISR 5426

AUTHOR: Abdel-Jawad, M.

TITLE: Characterization of seawater quality and design criteria for future construction of RO pretreatment systems at Az-Zour North and Sabiya Sites / M. Abdel-Jawad.

PUBLICATION: Kuwait : KISR, 1998.

CALL NUMBER: WD 002C KISR 5292

AUTHOR: Al-Hawaj, Osamah.

TITLE: Development and evaluation study of a new multi-effect desalination apparatus : (fabrication) / O. Al-Hawaj.

PUBLICATION: Kuwait : KISR, 1998.

CALL NUMBER: WD 002C KISR 5433

AUTHOR: Al-Hawaj, O.

TITLE: Development and evaluation study of a new multi-effect desalination apparatus : (Fabrication) / O. Al-Hawaj.

PUBLICATION: Kuwait : KISR, 1998.
Sciences.

CALL NUMBER: WD 005 KISR 5350

TITLE: Seawater desalination by reverse osmosis : Phase III / M. Abdel-Jawad ... [et al.].

PUBLICATION: Kuwait: KISR, 1998.

CALL NUMBER: WD 005k KISR 5123

AUTHOR: Bou-Hamad, S.

TITLE: Treatment of tertiary treated wastewater by microfiltration / S. Bou-Hamad, Water desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1997.

CALL NUMBER: WW 001c KISR 5116

AUTHOR: Abdel-Jawad.

TITLE: Municipal wastewater desalination by reverse osmosis / M. Abdel-Jawad, Water Desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1997.

CALL NUMBER: WD 005 KISR 5203

AUTHOR: Abdel-Jawad, Mahmoud.

TITLE: Seawater desalination by reverse osmosis: Phase III / Mahmoud Abdel-Jawad, Esam El-Saed.

PUBLICATION: Kuwait: KISR, 1997.

CALL NUMBER: WD 001C KISR 5180

AUTHOR: Al-Wazzan, Y.

TITLE: A pilot study for the treatment and reuse of drying water in residential areas of Kuwait / Y. Al-Wazzan, S. Ebrahim.

PUBLICATION: Kuwait: KISR, 1997.

CALL NUMBER: WD 002 KISR 4884a

AUTHOR: Ebrahim, S.

TITLE: Research and development on desalination by reverse osmosis, Summary / S. Ebrahim...[et al.], Water Desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1996.

CALL NUMBER: WD 003 KISR 4933

AUTHOR: Ebrahim, S.

TITLE: Surface seawater pretreatment by microfiltration / S. Ebrahim...[et al.], Water desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1996.

CALL NUMBER: WD 002c KISR 4936

AUTHOR: Al-Hawaj, O.

TITLE: Development and evaluation study of a new multi-effect desalination apparatus / O. Al-Hawaj, Water desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1996.

CALL NUMBER: WD 004k KISR 4946

AUTHOR: Jafar, M.

TITLE: Fully automated reverse osmosis plant / M. Jafar...[et al.], Water Desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1996.

CALL NUMBER: WD 002 KISR 4884b

AUTHOR: Abdel-Jawad, M.

TITLE: Research and development on desalination by reverse osmosis, vol. I, Conventional pretreatment / M. Abdel-Jawad...[et al.], Water Desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1996.

CALL NUMBER: WD 002 KISR 4884c

AUTHOR: Ebrahim, S.

TITLE: Research and development on desalination by reverse osmosis, Vol. II, Membrane testing and restoration / S. Ebrahim...[et al.], Water Desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1996.

CALL NUMBER: WD 002 KISR 4884d

AUTHOR: Al-Odwani, A.

TITLE: Research and development on desalination by reverse osmosis, Vol. III, Material selection and corrosion / A. Al-Odwani...[et al.], Water Desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1996.

CALL NUMBER: WD 002 KISR 4884e

AUTHOR: El-Sayed, E.

TITLE: Research and development on desalination by reverse osmosis,

Vol. IV, System configuration / E. El-Sayed...[et al.],
Water Desalination Department, Water Resources Division.
PUBLICATION: Kuwait : KISR, 1996.

CALL NUMBER: WD 004k KISR 4867

AUTHOR: Jafar, M. M.

TITLE: Fully automated RO plant / M. M. Jafar, Water Desalination
Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1996.

CALL NUMBER: WD 001k KISR 4664

AUTHOR: Sayed, S. A. S.

TITLE: A pilot study for the treatment and reuse of drainage water
in residential areas of Kuwait / S. A. S. Sayed and S.
Ebrahim, Water Desalination Department, Water Resources
Division.

PUBLICATION: Kuwait : KISR, 1995.

CALL NUMBER: WW 001c KISR 4655

AUTHOR: Ebrahim, S.

TITLE: Municipal wastewater desalination by reverse osmosis / S.
Embrahim and M. Abdel-Jawad, Water Desalination Department,
Water Resources Division.

PUBLICATION: Kuwait : KISR, 1995.

CALL NUMBER: WD 005c KISR 4654r

AUTHOR: Abdel-Jawad, M.

TITLE: Seawater desalination by reverse osmosis, Phase III / M.
Abdel-Jawad, Water Desalination Department, Water Resources
Division.

PUBLICATION: Kuwait : KISR, 1995.

CALL NUMBER: WD 002 KISR 4374

AUTHOR: Abdel-Jawad, M.

TITLE: Research and development on desalination by reverse osmosis / M.
Abdel-Jawad, S. Ebrahim, Water Desalination Department, Water
Resources Division.

PUBLICATION: Kuwait : KISR, 1994.

CALL NUMBER: DOE GEN KISR 4314

AUTHOR: Maheshwari, G. P.

TITLE: Efficiency of electricity and water sector / G. P.
Maheshwari...[et al.], Energy Department, Engineering
Division.

PUBLICATION: Kuwait : KISR, 1993.

CALL NUMBER: WD 003 KISR 4368

AUTHOR: Ebrahim, S.

TITLE: Surface seawater pretreatment by micro / ultrafiltration /
S. Ebrahim, Water Desalination Department, Water Resources
Division.

PUBLICATION: Kuwait: KISR, 1993.

CALL NUMBER: WATER 2 KISR 4211

AUTHOR: Ebrahim, S.

TITLE: Assessment of impact of oil pollution on feed water for, and product
water from, desalination plants in Kuwait / S Ebrahim, Water
Desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1993.

CALL NUMBER: WATER 2 KISR 4162

AUTHOR: Ebrahim, S.

TITLE: Assessment of the impact of oil pollution on feed water for, and
product water from, desalination plants in Kuwait / S.
Ebrahim, M. Safar, Water desalination Department, Water
Resources Division.

PUBLICATION: Kuwait : KISR, 1992.

CALL NUMBER: WATER 2 KISR 4090

AUTHOR: Ebrahim, S.

TITLE: Assessment of the impact of oil pollution on feed water for, and
product water from, desalination plants in Kuwait / S.Ebrahim, Y. Al-
Wazzan, Water Desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1992.

CALL NUMBER: WD 004 KISR 3508

AUTHOR: Abdel-Jawad, M.

TITLE: Seawater desalination by reverse osmosis. Phase II / M.
Abdel-Jawad, Water Desalination Department, Water Resources
Division and Ministry of Electricity and Water.

PUBLICATION: Kuwait : KISR, 1991.

CALL NUMBER: WD 003 KISR 3281-B

AUTHOR: Qamhiyah, Z.

TITLE: Surface seawater pretreatment by micro/ultrafiltration / Z. Qamhiyah,
Water Desalination Department, Water Resources Division.

PUBLICATION: Kuwait : KISR, 1990.

CALL NUMBER: WD 005 KISR 3442

AUTHOR: Abdel-Jawad, M.

TITLE: Seawater desalination by reverse osmosis. Phase III / M.
Abdel-Jawad, Water Desalination Department, Water Resources
Division.

PUBLICATION: Kuwait : KISR, 1990.

- CALL NUMBER:** WATER 2 KISR 4011-B
AUTHOR: Ebrahim, S.
TITLE: Assessment of the impact of oil pollution on feed water and product water from desalination plants in Kuwait / S. Ibrahim, Y. Al-Wazzan, Water Desalination Department, Water Resources Division.
- CALL NUMBER:** SE 64 KISR 3085
AUTHOR: Al-Homoud, A. A.
TITLE: Development of fresh water production system for desert areas / A. A. Al-Homoud, Energy Department, Engineering Division.
PUBLICATION: Kuwait : KISR, 1989.
- CALL NUMBER:** WD 002 KISR 2401-B
AUTHOR: Abdel-Jawad, M.
TITLE: Research and development on desalination by reverse osmosis / M. Abdel-Jawad...[et al.], Water Resources Division.
PUBLICATION: Kuwait : KISR, 1989.
- CALL NUMBER:** MS 67 KISR 3034
AUTHOR: Qamhiyah, Z.
TITLE: Beach well seawater intake / Z. Qamhiyah, Water Desalination Department, Water Resources Division.
PUBLICATION: Kuwait: KISR, 1989.
- CALL NUMBER:** WD 004 KISR 3061
AUTHOR: Abdel-Jawad, M.
TITLE: Water desalination by reverse osmosis / M. Abdel-Jawad, Water Desalination Department, Water Resources Division.
PUBLICATION: Kuwait : KISR, 1989.
Petrochemicals and Materials Division).
- CALL NUMBER:** SE 64 KISR 2556
AUTHOR: Al-Homoud, A. A.
TITLE: Development of fresh water production system for desert areas / A. A. Al-Homoud, Energy Department, Engineering Division.
PUBLICATION: Kuwait: KISR, 1988.
- CALL NUMBER:** MS 56 KISR 2767
AUTHOR: Gouda, V. K.
TITLE: Failure of evaporator stage tubes in the desalination water plant of KNPC-MAA. Case study No. 2 / V. K. Gouda, W. T. Riad, Corrosion Program, Materials Application Department, Petroleum, Petrochemicals and Materials Division.
PUBLICATION: Kuwait : KISR, 1988.

CALL NUMBER: MS 68 KISR 2833

AUTHOR: Ebrahim, S.

TITLE: Doha ro-plant data evaluation / S. Ebrahim, O. Alameddine, Reverse Osmosis Program, Materials Application Department, Petroleum, Petrochemicals and Materials Division, Kuwait Scientific Center.

PUBLICATION: Kuwait : KISR, 1988.

CALL NUMBER: MS 17 KISR 2610

AUTHOR: Abdel-Jawad, M.

TITLE: Water desalination by reverse osmosis, Vol. I / M. Abdel-Jawad, W. Franke, Materials Applications Department, Petroleum, Petrochemicals and Materials Division, Water Resources Development Center (MEW), Kuwait and Federal Republic of Germany.

PUBLICATION: Kuwait : KISR, 1988.

CALL NUMBER: MS 17 KISR 2610

AUTHOR: Abdel-Jawad, M.

TITLE: Water desalination by reverse osmosis. Vol. II / M. Abdel-Jawad, W. Franke, Materials Applications Department, Petroleum, Petrochemicals and Materials Division, Water Resources Development (MEW), Kuwait and Federal Republic of Germany.

PUBLICATION: Kuwait : KISR, 1988.

CALL NUMBER: MS 17 KISR 2610

AUTHOR: Abdel-Jawad, M.

TITLE: Water desalination by reverse osmosis. Vol. III / M. Abdel-Jawad, W. Franke, Materials Applications Department, Petroleum, Petrochemicals and Materials Division, Water Resources Development Center (MEW), Kuwait and Federal Republic of Germany.

PUBLICATION: Kuwait : KISR, 1988.

CALL NUMBER: MS 17 KISR 2610

AUTHOR: Abdel-Jawad, M.

TITLE: Water desalination by reverse osmosis. Vol. IV / M. Abdel-Jawad, W. Franke, Materials Applications Department, Petroleum, Petrochemicals and Materials Division, Water Resources Development Center (MEW), Kuwait and Federal Republic of Germany.

PUBLICATION: Kuwait : KISR, 1988.

CALL NUMBER: MS 17 KISR 2878

AUTHOR: Abdel-Halim, M. M.

TITLE: Comprehensive cost and economic analysis of seawater desalination by reverse osmosis systems in Kuwait / A. A.

Abdel-halim, J. F. Dahdah, M. Abdel-Jawad, Techno-Economics
Division and Petroleum, Petrochemicals and Materials
Division

PUBLICATION: Kuwait : KISR, 1988.

CALL NUMBER: EES 88 KISR 2623

AUTHOR: Abou-Seida, M. M.

TITLE: Hydraulic studies and environmental impact assessment for Subiya
power station. Vol. VI of xi / M. M. Abou-Seida...[et
al.], Environmental and Earth Sciences Division.

PUBLICATION: Kuwait : KISR, 1988.

CALL NUMBER: MS 60 KISR 2817

AUTHOR: Abdel-Jawad, M.

TITLE: Water desalination by reverse osmosis, Phase II / M.
Abdel-Jawad, Materials Application Department, Petroleum,
Petrochemicals and Materials Division.

PUBLICATION: Kuwait : KISR, 1988.

CALL NUMBER: MS 61 KISR 2401

AUTHOR: Abdel-Jawad, M.

TITLE: Research and development on desalination by reverse osmosis
/ M. Abdel-Jawad...[et al.], Reverse Osmosis Program,
Materials Application Department, Petroleum, Petrochemicals
and Materials Division.

PUBLICATION: Kuwait : KISR, 1987.

CALL NUMBER: SE 64 KISR 2458

AUTHOR: Al-Homoud, A. A.

TITLE: Development of fresh water production system for desert
areas / A. A. Al-Homoud, A. Marafie, K. Bastaki, Energy
Department, Engineering Division.

PUBLICATION: Kuwait : KISR, 1987.

CALL NUMBER: ENG 27 KISR 2349

AUTHOR: Al-Kandari, A.

TITLE: Operation and maintenance manual for the Sulaibiya solar
program/ A. Al-Kandari, P. K. Suri, G. P. Maheshwari,
Energy Department, Engineering Division.

PUBLICATION: Kuwait : KISR, 1987.

CALL NUMBER: MS 61 KISR 2168

AUTHOR: Abdel-Jawad, M.

TITLE: Research and development on desalination by reverse osmosis
/ M. Abdel-Jawad, Reverse Osmosis Program, Materials
Application Department, Petroleum, Petrochemicals and
Materials Division.

PUBLICATION: Kuwait : KISR, 1986.

CALL NUMBER: SE GEN KISR 2046

AUTHOR: Al-Jamal, K.

TITLE: Operation and performance evaluation of KISR MSF plant / K. Kamal, N. Shaban, Energy Department, Engineering Division

PUBLICATION: Kuwait: KISR, 1986.

CALL NUMBER: RFP 107 KISR 1932

AUTHOR: Al-Homoud, A. A.

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AUTHOR: Al-Kandari, A.

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PUBLICATION: Kuwait : KISR, 1986.

CALL NUMBER: MS 60 KISR 2166-A

AUTHOR: Abdel-Jawad, M.

TITLE: Water Desalination by reverse osmosis. Phase II / M. Abdel-Jawad, Petroleum, Petrochemicals and Materials Division.

PUBLICATION: Kuwait : KISR, 1986.

CALL NUMBER: MS 17 KISR 1953

AUTHOR: Abdel-Jawad, M.

TITLE: Water desalination by reverse osmosis / M. Abdel-Jawad, Material Science and Applications Department, Petroleum, Petrochemicals and Materials Division, Water Resources Development Center (MEW), Kuwait and The Federal Republic of Germany.

PUBLICATION: Kuwait : KISR, 1986.

CALL NUMBER: ENG 27 KISR 1616-B

AUTHOR: Moustafa, S.

TITLE: Operation readiness and maintenance of the Sulaihiya solar complex / S. Moustafa, Sulaihiya Solar Program, Engineering Division.

PUBLICATION: Kuwait : KISR, 1985.

CALL NUMBER: SE GEN KISR 1449

AUTHOR: Al-Jamal, K.

TITLE: Solar reverse osmosis desalination technoeconomic evaluation / K. Kamal, Energy Department, Engineering Division
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CALL NUMBER: MS 17 KISR 1450

AUTHOR: Abdel-Jawad, M.

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PUBLICATION: Kuwait : KISR, 1984.

CALL NUMBER: MS GEN KISR 1561

AUTHOR: Lalwani, S.

TITLE: Production of magnesla from brine water of desalination plants / S. Lalwani, Materials Application Department, Petroleum, Petrochemicals and Materials Department.

PUBLICATION: Kuwait : KISR, 1984.

CALL NUMBER: TE GEN KISR 1396

AUTHOR: Abdel-Halim, M. M.

TITLE: Techno-economic assessment of the DDS reverse osmosis seawater desalination system / M. M. Abdel-Halim, M. Gigis, Techno-Economics Division.

PUBLICATION: Kuwait : KISR, 1984.

CALL NUMBER: RFP 52 KISR 1181-A

AUTHOR: Girgis, M.

TITLE: A techno-economic assessment of alternative water sources and water utilization in Kuwait / M. Girgis, Techno-Economics Division.

PUBLICATION: Kuwait : KISR, 1983.

CALL NUMBER: ENG GEN KISR 835

SECURITY LVL: General.

AUTHOR: Al-Jamal, K.

TITLE: Technical and economical evaluation of desalination by freezing / K. Al-Jamal, Energy Department, Engineering Division.

PUBLICATION: Kuwait : KISR, 1982.

CALL NUMBER: MS 17 KISR 575

AUTHOR: Hassan, A.

TITLE: Water desalination by reverse osmosis / A. Hassan, Material Science and Applications Department, Petroleum, Petrochemicals and Materials Division, Water Resources Development Center, Kuwait, The Federal Republic of Germany.

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PUBLICATION: Kuwait : KISR, 1982.

CALL NUMBER: SE 5 KISR 795

AUTHOR: Moustafa, S.

TITLE: An integrated diesel powered greenhouse MSF desalination system for desert application / S. Moustafa...[et al.], Solar Energy Department, Engineering Division.

PUBLICATION: Kuwait : KISR, 1982

CALL NUMBER: MS 17 KISR 806

AUTHOR: Andrady, A. L.

TITLE: Examination of faulty reverse osmosis module / A. L. Andrady, Products Department, Petroleum, Petrochemicals and Materials Division.

PUBLICATION: Kuwait : KISR, 1982.

CALL NUMBER: MS 13 KISR 575

AUTHOR: Hassan, A.

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PUBLICATION: Kuwait : KISR, 1982.

CALL NUMBER: MS 17 KISR 324

AUTHOR: Butt, F.

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PUBLICATION: Kuwait : KISR, 1981.

CALL NUMBER: MS 17 KISR 305

AUTHOR: Hassan, A.

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PUBLICATION: Kuwait : KISR, 1981.

CALL NUMBER: MS 17 KISR 327

AUTHOR: Hassan, A.

TITLE: Water desalination by reverse osmosis / A. Hassan, Material

Application Department, Petroleum and Materials Division;
Water Resources Development Center; GKSS, Germany.

PUBLICATION: Kuwait : KISR, 1981.

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AUTHOR: Hassan, A.

TITLE: Water desalination by reverse osmosis / A. Hassan, Material Science and Applications Department, Petroleum, Petrochemicals and Materials Division.

PUBLICATION: Kuwait : KISR, 1981.

CALL NUMBER: MS 17 KISR/ PPI/037/ PMM-P- R-7903

AUTHOR: Hassan, A.

TITLE: Water desalination by reverse osmosis / A. Hassan, Material Science and Applications Department, Petroleum, Petrochemicals and Materials Division.

PUBLICATION: Kuwait : KISR, 1979.

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AUTHOR: Moustafa, S.

TITLE: Solar multistage flash desalination / S. Moustafa, Solar Energy Department, Engineering Division.

PUBLICATION: Kuwait : KISR, 1979.

CALL NUMBER: SE 26 KISR/ PPI/148/ ENS-RF- R-7920

AUTHOR: Malik, M. A.

TITLE: Solar desalination / M. A. Malik; contributors H. Aburshaid, S. F. Ahmed, K. Al-Tukhaim, A. K. Khatry, V. M. Puri, V. Seshadri , Solar Energy Department, Engineering Division.

PUBLICATION: Kuwait : KISR, 1979.

CALL NUMBER: KISR PPI-R- RT-7801

AUTHOR: Kuwait Institute for Scientific Research.

TITLE: Arab institute for water desalination and resources / Kuwait Institute for Scientific Research, Water Resources Development Center, Kuwait

PUBLICATION: Kuwait : KISR, 1977.

CALL NUMBER: PET 00 KISR 0000

AUTHOR: Al-Jarallah, S.

TITLE: A study and preliminary experiment on desalination of seawater by solvent extraction / S. Al-Jarallah, Petroleum, Petrochemicals and Materials Division.

PUBLICATION: Kuwait : KISR, 1975.

C- PERIODICALS:

Following is the list of periodical titles at NSTIC. The list includes NSTIC subscription date of the journal with link to its electronic version.

- Advances in Water Resources. 1992-
<http://www.sciencedirect.com/science/journal/03091708>
- American Water Works Association Journal. 1992-
<http://www.awwa.org/journal/jfeature.htm>
- Desalination. 1992-
<http://www.elsevier.nl/inca/publications/store/5/0/2/6/8/3/>
- Filtration and Separation. 1992-
<http://www.sciencedirect.com/science/journal/00151882>
- International Desalination and Water Reuse Quarterly. 1992-
<http://www.ida.bm/pages/Publications/quarterly.htm>
- International Journal of Water Resources Development. 1992-
<http://www.tandf.co.uk/journals/frame loader.html?http://www.tandf.co.uk/journals/carfax/07900627.html>
- Journal of Membrane Science. 1992-
<http://www.elsevier.nl/inca/publications/store/5/0/2/6/9/2/>
- Membrane Technology. 1992-
<http://www.sciencedirect.com/science/journal/09582118>
- Water Quality Research Journal of Canada. 1995-
<http://www.cciw.ca/wqric/>
- Water Research. 1992-
<http://www.elsevier.nl/inca/publications/store/3/0/9/>
- Water Resources Bulletin. 1992-
<http://www.elsevier.nl/inca/publications/store/4/6/4/>
- Water Resources Research. 1992-
http://www.agu.org/pubs/agu_jourwrr.html

D- DATABASES:

AQALINE

The Aqualine database provides comprehensive focus on trade, technical and scientific literature concerning all aspects of water resources. Major subjects of coverage include water resources and supplies management, water legislation, water quality, potable water distribution, wastewater collection, water treatment technologies, wastewater and sewage treatment, and ecological and environmental effects of water pollution. Articles on these topics are drawn from a source list of approximately 300 journals as well as from conference proceedings, scientific reports, books and theses. Each entry includes bibliographic citation, abstract, geographic index terms and subject index terms. Beginning June 2004, Aqualine is being indexed with the Water Resources Thesaurus. Some terms from the controlled vocabulary of Aqualine were added to the Water Resources Thesaurus. The thesaurus is available as an online search tool. Previously published by the well-known and respected WRc in England, Aqualine is now produced in joint cooperation with WRc and Cambridge Scientific Abstracts.

Dates of Coverage: 1960 - current

EI-Compendex

Ei Compendex® the most comprehensive interdisciplinary engineering databases in the world, with over six million summaries of journal articles, technical reports, and conference papers and proceedings in electronic form, dating from 1970. Abstracts from over 5,000 international journals, conferences papers and technical reports are included. Each year, over 220,000 new abstracts are added from 175 disciplines and major specialties.

Dates of Coverage: 1970-Present

PASCAL

The world renowned PASCAL database is a unique multidisciplinary and multilingual bibliographic database. It covers all the major international journals, reports, conference proceedings, periodical articles and doctoral dissertations in all aspects of the Sciences and Medical Sciences and is an unrivaled international bibliographic resource for professionals everywhere. Unique tri-lingual indexing means that the records in PASCAL can be searched using French, English or Spanish keywords, regardless of the original language of the article concerned.

Coverage: 1987-Present

ScienceDirect

ScienceDirect is the world's largest electronic collection of science, technology and medicine full text and bibliographic information.

Investing in ScienceDirect means investing in an evolving solution, and you will find us a reliable partner.

Since its launch in 1997, ScienceDirect has evolved from a web database of Elsevier journals to one of the world's largest providers of scientific, technical and medical (STM) literature.

E- STANDARDS:

ASTM: American Society for Testing and Materials:

ASTM International is one of the largest voluntary standards development organizations in the world-a trusted source for technical standards for materials, products, systems, and services. The ASTM Covers130 areas including subjects such as energy, environment, consumer products, medical services and devices, computerized system, electronics, and many others.

Format: CD-ROM and print.

AWWA: American Water Works Association.

The American Water Works Association (AWWA) is an international nonprofit scientific and educational society dedicated to the improvement of drinking water quality and supply. AWWA is defined by six core competencies, through which it communicates and interacts with all of its audiences. Together, the competencies distinguish AWWA as the authoritative resource for knowledge, information, and advocacy to improve the quality and supply of drinking water in North America and beyond.

Format: CD-ROM

BSI: Organization: British Standards Institute.

The BSI provides standard tests to ensure products efficiency and safety in the area of global trade, inspection, environment management, and information security. BSI works with manufacturing and service industries, businesses, governments and consumers to facilitate the production of British, European and international standards. As the UK's National Standards Body (NSB), BSI represents UK interests across all of the European and international standards organizations and through their committees.

Format: CD-ROM.

Websites Sources

Aqua-Chem, Inc

For over 70 years, Aqua-Chem, Inc. and its Divisions, Cleaver-Brooks, Water Technologies, Lincoln Manufacturing, Gonzales Manufacturing, Energy Recovery International, Industrial Combustion, and Nebraska Boiler have provided energy and environmental solutions in the form of water treatment, commercial heating comfort, and industrial processes in partnership with customers in more than 100 countries around the world. Under the brand name, Aqua-Chem, the company's Water Technologies Division is known as a world leader in the design and production of water treatment products for commercial, government, military, and industrial applications. It enjoys a solid market share across all industries.

http://www.aqua-chem.com/aq_about.htm

Desalination Directory Online

The *Desalination Directory* is an invaluable electronic network to academic, government and private institutions, organizations, companies and individuals concerned with desalination and water reuse. It covers the entire water desalination and purification field all over the world.

<http://www.desline.com/>

Industrial Services, Inc. (ISI)

Provides engineering consulting support for reverse osmosis desalinated water projects. We offer BOOT contract and bid services, desalination feasibility studies, pilot plant installation and monitoring, drilling and seawater or brackish water supply design, membrane equipment design and installation, equipment retrofits, desalination plant expansions, process and piping design, procurement and troubleshooting expertise. ISI will even provide turnkey equipment installation at your site.

<http://desalt.net/index>

Middle East Desalination Research Center

Conduct, facilitate, promote, co-ordinate and support basic and applied research in water Desalination technology and supporting fields. To raise the standard of living in the Middle East and elsewhere by cost reduction and quality improvement in the technical processes of water desalination.

<http://www.medrc.org/>

Filtration and Separation

Our purpose is to enhance knowledge and understanding of filtration and separation technology throughout the world. The web site supports the short duration courses where the most important aspect is how these models can help improve productivity or designs, not the derivation of the equations.

<http://www.filtration-and-separation.com/>

UNESCO Center for Membrane Science and Technology

The Centre for Membrane Science and Technology brings together membrane research activities in the Departments of Biophysics (School of Physics) and Chemical Engineering (School of Chemical Engineering and Industrial Chemistry). Both of these groups already had long standing membrane research programs in place and it was recognised that studies of the behaviour of bio-membranes and the experimental and theoretical analytical tools developed for the study of bio-membranes, could hold keys to the successful development of high performance membranes for industrial purposes.

<http://www.membrane.unsw.edu.au/>

The Water Infrastructure Network (WIN)

is a broad-based coalition of local elected officials, drinking water and wastewater service providers, state environmental and health administrators, engineers and environmentalists dedicated to preserving and protecting the health, environmental and economic gains that America's drinking water and wastewater infrastructure provides.

<http://win-water.org/>

Toray Membrane

Toray Group aims to be a corporate group that will grow globally based on science and technology. Toray Reverse Osmosis Membrane Elements are used in the diversified market for water desalination and purification.

<http://www.toray-membrane.com/index.html>

Water Desalination International (WDI)

"WDI", a Los Angeles based company, aspires to achieve technical and product leadership of low-cost, turnkey desalination plants based upon its proprietary technology. Furthermore, WDI aspires to become a leader in research and development for the advancements of desalination in such areas as cogeneration/regeneration, low maintenance, enhanced reliability, and energy conservation; while providing the highest quality of water.

<http://www.waterdesalination.com/index.html>

Water online

Water Online is the leading industry online sourcing service and bi-weekly e-newsletter, focused on the industrial and municipal wastewater treatment, drinking water purification, stormwater management, valve, pipe and flow control markets. Water Online has been serving the needs of engineering professionals since 1995.

<http://www.wateronline.com/content/homepage/default.asp>

Worldwide Water

The World's Water, a site dedicated to providing up-to-date water information, data, and web connections to organizations, institutions, and individuals working on a wide range of global freshwater problems and solutions.

<http://www.worldwater.org/>

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<http://www.ief-energy.org;>
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Key Desalination Facts

<http://www.waterdesalination.com/factssample1.htm>

Distillation

The intake water is exchanged from a liquid to vapor (steam). The vapor is then condensed to produce product water.

Reverse Osmosis

Pressure is applied to the intake water, forcing the water molecules through a semipermeable membrane. The salt molecules do not pass through the membrane, and the water that passes through becomes potable product water.

Ranges In Plant Capacity

(Other than off shore oil and gas platforms.) 16 - 112,000 AF/year (One acre-foot is equivalent to 326,000 gallons). This is equivalent to the amount of water that two to three households would consume in one year. In most cases, conversions can not be made directly from gallons per day (gpd) to acre-feet per year (AF/year) since most plants will not operate every day of the year.

Costs

Most sea water plants in California would produce water in the range of \$1,300 to \$2,200/AF.

Energy Use

2,500 to 12,000 kWh/AF.

Efficiency

(Percent of product water recovery to input flow.) For every 100 gallons of sea water input, 15 to 73 gallons of fresh water would be produced. The remainder would be waste brine solution and solid wastes.

Water Quality

2 to 500 ppm tds (the recommended California drinking water standard or maximum total dissolved solids level is 500 ppm.)

Plant Size Area

This varies according to how spread out the design of the plant is. Proposed or existing California plants range from 80 square feet for a 16 AF/year plant to 7.5 acres for a 5,000 AF/year plant.

Height

Typical distillation equipment 30 to 530 feet. (Typical reverse osmosis equipment 15 to 20 feet).

GLOSSARY

<http://www.waterdesalination.com/factssample1.htm>

Acre-foot (AF)

A unit for measuring the volume of water. One acre-foot equals 326,000 gallons.

Biocide

A chemical used to kill biological organisms, e.g. chlorine.

Brine.

Water that contains a high concentration of salt. Brine discharges from desalination plants may include constituents used in pretreatment processes, in addition to the high salt concentration seawater.

Capacity Factor

An electric utility's annual capacity factor is defined as the annual kilowatt-hour sales divided by the product of the total hours in a year and the rated capacity of the utility in kilowatts.

Coagulation

A pretreatment process in desalination plants. A substance, (e.g., ferric chloride), is added to a solution to cause certain elements to become thickened into a coherent mass, so that they may be removed.

Cogeneration

A power plant that is designed to conserve energy by using the waste heat from generating electricity for another purpose.

Deaeration

Removal of oxygen. A pretreatment process in desalination plants to reduce corrosion.

Distillation

A process of desalination where the intake water is converted to steam. The steam is then condensed to produce a product water with low salt concentration.

Electrodialysis

A process of desalination whereby an electrical current is used to separate out salt and impurities in the intake water. Most of the impurities in water are present in an ionized (electrically charged) state and will conduct electric current. When high voltage is applied, the impurities migrate towards the positive and negative electrodes, and the intermediate area becomes purified product water. This technology is used for brackish waters, but is not currently available for desalting seawater on a commercial scale.

Ion exchange

A pretreatment process in desalination plants. An electrical charge is used to remove charged particles from solution.

Kilowatt

(kW); One thousand watts. The watt is a measure of power used by electricity generating plants. One watt is equivalent to 1 Joule/second or 3.412 BTU/hour.

Multi-effect Distillation (MED)

A form of distillation. Evaporators are in series, and vapor from one series is used to evaporate water in the next one. This technology is in several forms, one of the most common of which is the Vertical Tube Evaporator (VTE).

Multi-stage Flash (MSF)

A form of distillation. The intake water is pressurized and heated. It is discharged into a chamber maintained slightly below the saturation vapor pressure of the water, and a fraction of the water content flashes into steam. The steam condenses on the exterior surface of heat transfer tubing and becomes product water. The unflashed brine enters a second chamber, where brine flashes to steam at a lower temperature. Each evaporation and condensation series is called a stage.

Reverse Osmosis (RO)

A process of desalination where pressure is applied to the feedwater, forcing the water molecules through a semipermeable membrane. The water that has passed through the membrane leaves the unit as product water, and most of the dissolved impurities remain behind and are discharged in a waste stream.

Scaling

Salt deposits on the interior surfaces of a desalination plant.

Total dissolved solids (tds)

Total salt and calcium carbonate concentration in a sample of water. The state recommended Maximum Contaminant Level (MCL) drinking water standard for total dissolved solids is 500 ppm. The upper MCL is 1,000 ppm, and the short-term permitted level is 1,500 ppm.

Vacuum Freezing (VF)

A process of desalination where the temperature and pressure of the sea water is lowered so that the pure water forms ice crystals. The ice is then washed and melted to produce the product water. This technology is still being developed, and is not yet commercially competitive.

Vapor Compression (VC)

A form of distillation. The intake water is evaporated, and the vapor is sent to a compressor. Mechanical or thermal energy is used to compress the vapor, which increases its temperature. The vapor is then condensed to produce product water, and the heat that is given off is used to evaporate the feedwater.

