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SAWACO — North Obhor SWRO Plant operational experience

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Abstract

Water is the most basic necessity of life. Unfortunately, water supplies are not always the water we expect them to be. The risk from contaminated water supplies from non-treated water sources are high and may cause health problems. Today, due to increasing demand from industry, a rapidly growing population, and climatic changes resulting in very little rainfall over the past few years, public desalination plants are struggling to provide enough freshwater for the communities needs. The current process of bringing water from natural wells is insufficient to cater the demand of large Saudi cities, and obviously the price is not affordable, especially during the periods of high demand. In response to the needs of peoples, families and business, Saudi Brothers Commercial Company established a water producing and supplying company capable of providing good quality water, free from salt and odor at an affordable price and a delivery service that could depend on.

SAWACO has in North Obhor, Jeddah, its state-of-the-art facility equipped with advanced technology processes at every stage of production. North Obhor Plant, one among many to be established, has been designed and engineered by internationally recognized companies to provide 12,500 m^3/day of potable desalinated water. Used technology ensures high-quality water conforming strictly to international standards. SAWACO assures quality water surpasses the standards set by the World Health Organization (WHO) and the Saudi Arabia Standard Organization (SASO). In recognition of SAWACO's advancement to such high-production standards, SAWACO is the first commercial water production plant to operate in the Kingdom under a license awarded by the Ministry of Water.

North Obhor Seawater Reverse Osmosis (SWRO) Plant was built in three phases. Raw water is extracted from deep wells. There are 5 SWRO trains in total and 2 BWRO trains. Phase I and Phase III are equipped with Hydranautics membranes. Two trains of Phase I are equipped with SWC1 membranes. Operation started in February 2002 and plant is in continuous operation since start up. Both trains of Phase I perform according to expectations and produce full capacity and requested quality. No cleaning took place up to date. The latest expansion – Phase III started in April 2006 and is equipped with Hydranautics SWC4+ membranes. Paper will present long-term operational experience with SWC1 as well as will describe experience with start up and performance of new generation membranes – SWC4+.

Today, due to increasing demand from industry, a rapidly growing population, and climatic changes resulting in very little rainfall over the past few years, public desalination plants are struggling to provide enough freshwater for

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the communities needs. The current process of bringing water from natural wells is insufficient to cater the demand of large Saudi cities, and obviously the price is not affordable, especially during the periods of high demand.

In response to the needs of business peoples and families, Saudi Brothers Commercial Company figured out to establish a water producing and supplying company capable of providing good quality water, free from salt and odor at an affordable price and a delivery service that could depend on, SAWACO is the answer for KSA's water dearth.

SAWACO North Obhor Plant, one among many to be established has been designed and engineered by internationally recognized companies to provide 12,500 m^3/day of potable desalinated water. SAWACO's Mission is to become the first choice for bulk water supply, catering the water needs of the people, business and institutions in Saudi Arabia. SAWACO is committed to provide unmatched level of services to its customers and to achieve overall customer satisfaction.

SAWACO has its HQ in North Obhor, Jeddah. Its state-of-the-art facility equipped with advanced technology processes at every stage of production ensures high-quality water conforming strictly to international standards. SAWACO assures quality water surpasses the standards set by the World Health Organization (WHO) and the Saudi Arabia Standard Organization (SASO). In recognition of SAWACO's advancement to such high-production standards, SAWACO is the first commercial water production plant to operate in the Kingdom under a license awarded by the Ministry of Water.

SAWACO has been blended with international process technology and operational experience from the leading process and equipment suppliers. SAWACO operates with more than 120 high-caliber manpower strength comprising executive management personnel, plant engineers, lab technicians, customer services, administrative personnel and delivery team.

Keywords: Sea water reverse osmosis; Beach wells; Normalized flow; Normalized salt passage; Biofouling

1. SAWACO – North Obhor SWRO desalination overview

SAWACO Plants are equipped with the innovative tools and equipments, comprising the following:

- Seawater Intake System
- Pre-treatment System
- Reverse Osmosis System
- Post-treatment System
- Product Distribution System
- Brine Disposal System
- Instrumentation & Control System

SAWACO adopted the seawater reverse osmosis (SWRO) technology to desalinate seawater in order to produce high quality of potable water suitable for drinking, as well as for residential, commercial and industrial uses.

The design output of the plant is 10,400 m^3/day. There are five skids or RO trains (2×2500, 2×1800, 1×1800) (Fig. 1). Phase I was commissioned in 2001 and two trains 2×2500 m^3/day are in operation since February 2002, for the last four and a half years producing consistent quality of potable water qualities requested by different customers. Phase II was added in 2004 and Phase III train started in May 2006.

For specific application 2×500 m^3/day brackish RO are available to further treat potable water to produce hi-purity water fit for specific industrial applications. Each RO skids of Phase I has 42 pressure vessels, each is designed to hold six Hydranautics SWC-1 membrane elements while Phase II has 25 pressure vessels and each is also designed to hold six 40" membrane elements made by different membrane manufacturer. Phase III train is equipped again with Hydranautics membranes SWC4+.

Schematic diagram of the plant is shown on Fig. 1. The pump chambers houses the three filter feed pumps and backwash pumps for Phase I

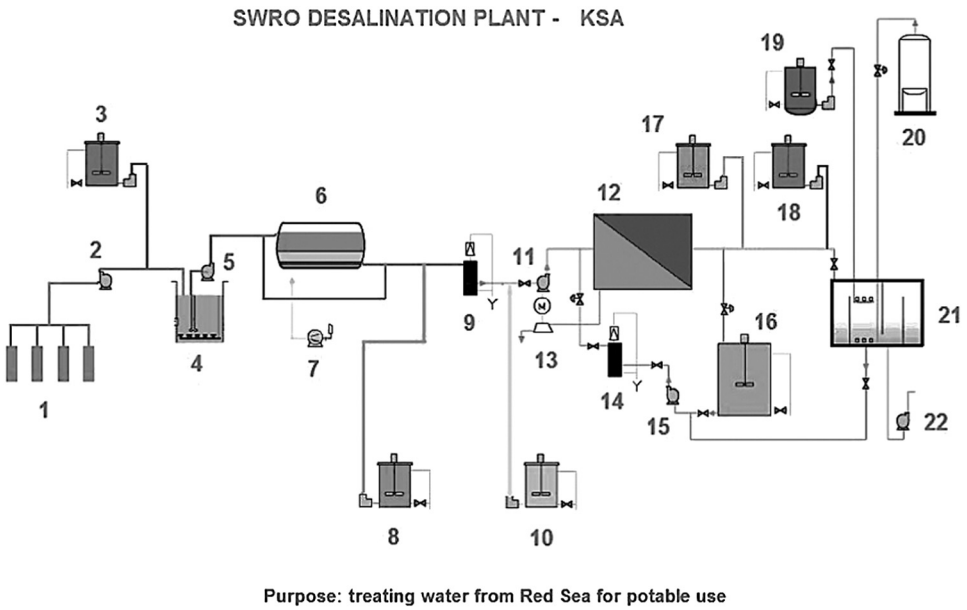

Fig. 1. SAWACO SWRO desalination North Obhor Plant schematic overview. 1: wells; 2: seawater pumps; 3: pre-chlorination dosing system; 4: raw water tank; 5: booster pumps; 6: sand filters; 7: air blower; 8: antiscalant dosing system; 9: cartridge filters (in feed line); 10: SBS de-chlorination dosing system; 11: high-pressure pump; 12: RO train; 13: recovery turbine (HTC type); 14: cartridge filters (in chemical cleaning line); 15: chemical cleaning pumps; 16: chemical cleaning tank; 17: post pH adjustment dosing system; 18: post-chlorination dosing system; 19: lime dosing system; 20: CO_2 dosing system; 21: permeate water tank; 22: permeate water pumps to distribution.
Plant characteristics. Plant location: Jeddah, KSA; commissioning date: 2001; plant capacity: 5250 m^3/day; recovery: 35%; wells number: 10; seawater pumps: 10; booster pumps: 3; sand filters: 4 closed filters, two layers; cartridge filters: 4; Trains number: 5; PV number: 39 per train; membranes number per PV: 6; membrane type: SWC1, 468 pcs SWC4+; high-pressure pumps: 2 (one per train); Recovery system: HTC; chemical dosing: antiscalant, sodium hydroxide; chemical cleaning pumps: 2; cleanings: not yet – not required.

and another 3 sets of filter feed pumps for Phase II. The raw water tanks and pumps chambers are designed to accommodate the future expansion of the desalination Phase III.

The seawater intake is located around the plant using the beach wells. Six (6) 25HP beach well pumps for Phase I and five 20HP beach well pumps for Phase II.

The feed water is drawn from the raw water tanks to feed the pumps. The filter feed pumps a total of six FFP for Phases I and II pump the raw water through the main feed water header to each phase.

In Phase I, four vertical multi media filters (MMF) containing sand and anthracite are installed, while Phase II is using the four horizontal fiberglass sand filters to remove suspended solids from the feed water. Both of Phases I and II have their own backwashing procedures to ensure the quality of the feed water prior major processing. Phase III pre-treatment consist only of filtration through 5 micron cartridge filters.

The remaining feed water is then split into two streams and reaches the second stage of filtration, two cartridge filters each streams. These two cartridge filters on each RO streams removes particles larger than 5 micron in size.

Chemical dosing of the feed water ensures that the silt density index (SDI), pH and chlorine

content of the feed water are controlled as necessary prior to reaching to membranes. SBS dosing is respectively used to carry this out.

Each RO stream has a high-pressure pumps that boost the pressure of the feed water. A turbo charger energy recovery device on each stream further boosts the pressure. The permeate flows into the flushing tank and thereafter to the water storage tanks in the plant area. Post-treatment of lime and chlorine ensure the product water quality.

The brine flows to the brine side of the turbo charger and thereafter to the reject tank (adjacent to the pump chamber) from where it is pumped back to the sea (by gravity only).

Other systems in the plant are the flushing system, for flushing the membranes and the cleaning system, for cleaning and post-treatment of the membranes.

Automatic control of the plant is by programmable logic controller (PLC) and by SCADA system.

SAWACO produces following quality of water

Required for	TDS	pH
Food & industry	200 ppm	7–7.5
Bottling	150–250 ppm	7–7.5
Pharmaceutical	150–200 ppm	6.8–7.5
Soft drinks co.	270–300 ppm	7–8.5
Demineralized water	<10 ppm	6.5–7.2
High chlorine water	250 ppm	7–7.5
No chlorine water	250 ppm	7–7.5

2. Plant performance overview

Trains A and B – Phase I started in February 2002. They are in continuous operation since that time, already four and half years. There was continuous chlorination–dechlorination process used in the pre-treatment during the first year of operation. Chlorination was stopped in March 2003, but dosing of chlorine scavenger continued and small amount of sodium bisulphite – 1.5 mg/L continued to be dosed. Many sites will use chlorine

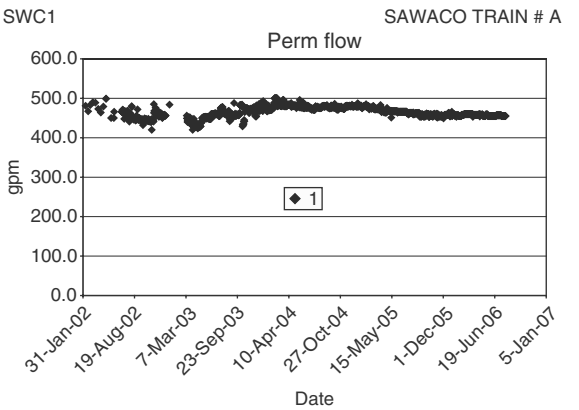

Chart 1. Phase I – Train A permeate flow.

to control biogrowth formation in the supply lines as well. Polyamide RO membranes, however, are degraded by chlorine, and are generally limited to an exposure of less than 0.01 ppm of free chlorine. Thus, if chlorination is used, chemicals must be added just before the RO system to consume the chlorine and ensure the RO feed is chlorine free. Although chlorine effectively controls biogrowth in the pipe or process equipment, many plants find that there is significant biofouling on the membrane [1,2]. This is due to regrowth of the bacteria, once the chlorine is removed. The bacterial growth rate was actually found to be higher immediately after chlorination/dechlorination compared to raw, unchlorinated water. This was attributed to the surviving bacteria

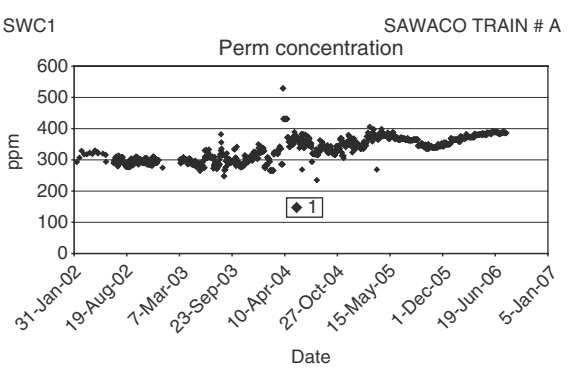

Chart 2. Phase I – Train A permeate salinity.

RO program licensed to:	*SR			
Calculation created by:	*SR			
Project name:	SAWACO - Train E Start		Permeate flow:	75.00 m^3/h
HP pump flow:	207.8 m^3/h		Raw water flow:	207.8 m^3/h
Recommended pump press.:	63.2 bar		Permeate throttling (variab.)	0.0 bar
Feed pressure:	**60.3**	61.1 bar	Permeate recovery:	36.1%
Feed water temperature:	31.0 C(88F)			
Feed water pH:	7.2		Element age:	14.0 days
Chem dose, ppm (100%):	3.5 H_2SO_4		Flux decline % per year:	7.7
Acidified feed CO_2:	7.97		Salt passage increase, %/y:	10.0
Average flux rate:	13.5 Lm^2 h		Feed type: Well water	

Stage	Perm. flow	Flow/Vessel Feed	Conc.	Flux	Beta	Conc. & throt. pressures		Element type	Elem. no.	Array
	m^3/h	m^3/h	m^3/h	L/m^2 h		bar	bar			
1–1	75.0	8.3	5.3	13.5	1.04	59.9	1.0	SWC4+	150	25 × 6

Ion	Raw water		Feed water		Permeate		Concentrate	
	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L	mg/L	meq/L
Ca	705.0	35.2	705.0	35.2	1.000	0.0	1102.7	55.0
Mg	1570.0	129.2	1570.0	129.2	2.227	0.2	2455.7	202.1
Na	13,638.8	593.0	13,638.8	593.0	92.740	4.0	21,291.6	925.7
K	420.0	10.8	420.0	10.8	3.569	0.1	655.3	16.8
NH_4	0.0	0.0	0.0	0.0	0.000	0.0	0.0	0.0
Ba	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0
Sr	0.000	0.0	0.000	0.0	0.000	0.0	0.000	0.0
CO_3	0.4	0.0	0.7	0.0	0.000	0.0	1.0	0.0
HCO_3	127.0	2.1	123.5	2.0	1.344	0.0	192.5	3.2
SO_4	3200.0	66.7	3203.4	66.7	4.850	0.1	5010.4	104.4
Cl	24,792.0	699.4	24,792.0	699.4	150.017	4.2	38,713.4	1092.1
F	0.0	0.0	0.0	0.0	0.000	0.0	0.0	0.0
NO_3	2.7	0.0	2.7	0.0	0.122	0.0	4.2	0.1
B	7.87		7.87		1.788		11.31	
SiO_2	0.0		0.0		0.00		0.0	
TDS	44,463.8		44,463.9		257.7	**242.0**	69,438.1	
pH	7.4		7.2		5.5		7.4	

Fig. 2. Projected data versus real start up data — start up data are in bold.

feeding on the new nutrients from the chlorine degraded organic material.

Biofouling of membranes in Phase I – trains A and B was reduced immediately as chlorination was stopped, but still continued, until SBS dosing was also stopped. Dosing of SBS was stopped in August 2003 and performance stabilized. It is important to point that water from beach wells has a very good quality with SDI values permanently below SDI 0.5. Still there is sufficient amount of organic material what is transformed to assimillable organic material and used by bacteria after dechlorination. Train A from phase I and train E from phase III were selected as typical examples of performance of SWC1 membranes and SWC4+ membranes.

Chart 1 represents permeate flow since the start up of the train A. Slight decline in flow during the first year was created by already discussed chlorination and consequent biofouling. Problem was solved when chlorination as well as dosing of SBS was stopped. Both trains A and B perform since that time in a steady way and no cleaning took place until today.

Chart 2 below presents permeate salinity behavior. It is possible to see very steady performance of

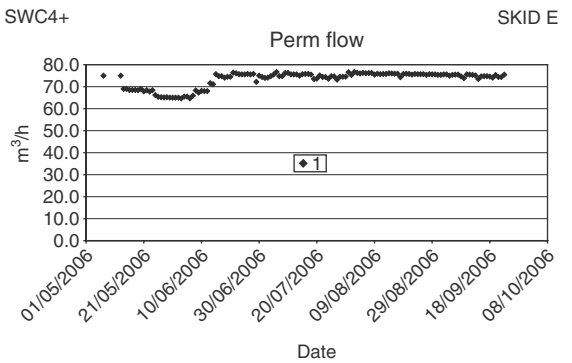

Chart 3. Phase III – Train E permeate flow.

SWC1 membranes. Trains are fed with feed water salinity of 44,500 mg/L of TDS and work with recovery of 35%. Temperature is steady over the whole year close to 30°C.

Train E from Phase III started in May 2006. Train is furnished by the latest membranes produced by Hydranautics – SWC4+. Fig. 2 presents start up data compared to projected data at operating conditions. Starting feed pressure was lower than projected and permeate quality was on a calculated level. Figures in red represent real start up values – feed pressure and product TDS.

Charts 3 and 4 present operational and normalized data of train E. Train E is fed by water

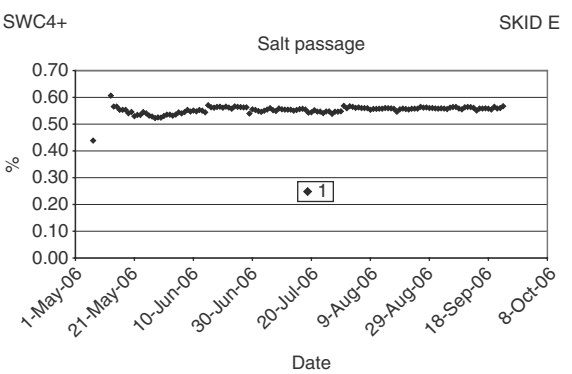

Chart 4. Phase III – Train E salt passage.

taken directly from wells and passing just through 5 micron cartridge filtration. As already mentioned – water from beach wells has a good quality and no media filtration or sand filtration is required. That is why it was decided during the design of Phase III that only cartridge filtration will be used as pre-treatment. Permeate flow as well as permeate salinity is very steady following calculated performance.

3. Conclusions

SAWACO SWRO installation in Jeddah – North Obhor area performs for almost 5 years in a very steady way and supplies water to clients in Jeddah area. Plant performs satisfactorily for many years due to very good regular maintenance and close care about membranes as well as close cooperation between membrane manufacturer and SAWACO Plant staff.

There was no replacement yet in trains A and B and no membrane cleanings. Trains are performing in a very good way and performance follows calculated way. SAWACO decided to partially exchange membranes in trains A and B and increase production as well as increase the recovery. Selected membranes are SWC4+.

Good cooperation between end user and membrane manufacturer is important for success of the installation.

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