

CASE STUDY: Enhanced Recovery Multivalent Separator

At a Glance

Industry:

Desalination, Mining,
Cooling Tower Blow Down

Wastewater:

Highly scaling waters:
permanently change
chemistry

Treatment

Requirements:

Extreme recoveries (>11%
salt mass brine) on
saturated gypsum
solutions without chemical
softening

Product:

Flex EDR MVS

Results:

96% recovery achieved,
high quality RO permeate,
and two non-scaling brine
streams

Economics:

30% reduction on
operating costs for an
inland zero-liquid
discharge (ZLD) project

Challenge

Membrane based technologies, such as reverse osmosis (RO), are prevalent in the desalination industry. Membrane systems are typically the lowest cost treatment method where there is a technical fit. However, due to the high scaling potential of brackish water, such as groundwater or mining waters, the performance and recovery of membrane systems are often limited, thus requiring expensive chemical softening. Low recoveries limit inland zero liquid discharge (ZLD) desalination projects since treating waste brine can be very expensive. Chemical softening often presents health and safety risks, operational challenges with lime systems, and costs of procuring chemical feedstock. It is therefore desirable to develop a low cost, chemical free, membrane system that can operate at extremely high recoveries and with a low volume brine discharge. Saltworks' innovative Multivalent Separator makes this possible.

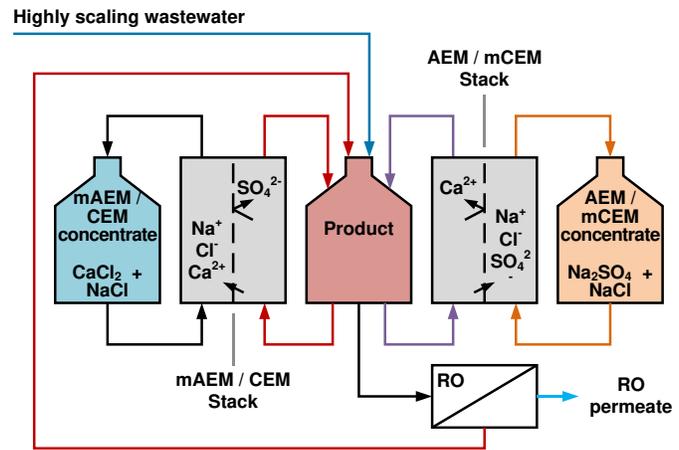
The scaling potential of brackish water is a result of low solubility multivalent salts (CaSO_4 , CaCO_3 , BaSO_4). These scaling salts often come in multivalent ion pairs (ions with a charge greater than one) and contribute to water hardness, which greatly reduces performance and recovery of traditional membrane based processes, increases equipment downtime, and ultimately increases operating costs. Permanently separating multivalent ion pairs into two separate process streams solves the scaling challenge, removes the need for chemical softening, and enables extremely high recovery and greater reliability.

Solution

Saltworks Technologies has developed a patent-pending Multivalent Separator (MVS) ion exchange membrane process that splits divalent cations from divalent anions, eliminating the scaling potential of the water. As an example, a mixed salinity high gypsum content water (CaSO_4 at 2,000 mg/L solubility with $\text{NaCl}_{(\text{aq})}$) can be split into two separate non-scaling streams: one stream containing Na_2SO_4 and the other stream containing CaCl_2 , both of which have a solubility limit greater than 150,000 mg/L. This represents a concentration factor increase of 75 and a waste volume only 1.33% of the original. MVS uses Saltworks' IonFlux Monovalent Selective ion exchange membranes, Flex EDR stack, and our advanced controls, all covered by a broad family of patents.

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Flex EDR utilizes a modular stack design incorporating IonFlux ion exchange membranes, electrode fouling protection, and automated self-cleaning capabilities. The modular stack design allows easy plant maintenance and capacity expansion. Flex EDR operates at 100 kPA without pressure differences across the membranes, reducing fouling. Under an electrical potential, IonFlux Monovalent Selective membranes flux monovalents (i.e. Na^+ or Cl^-) and selectively block multivalents (i.e. Ca^{2+} or SO_4^{2-}). The result is a product stream without multivalent salts, which can then be fed into an RO unit for extremely high recoveries.



Flex EDR MVS-RO simplified process flow diagram

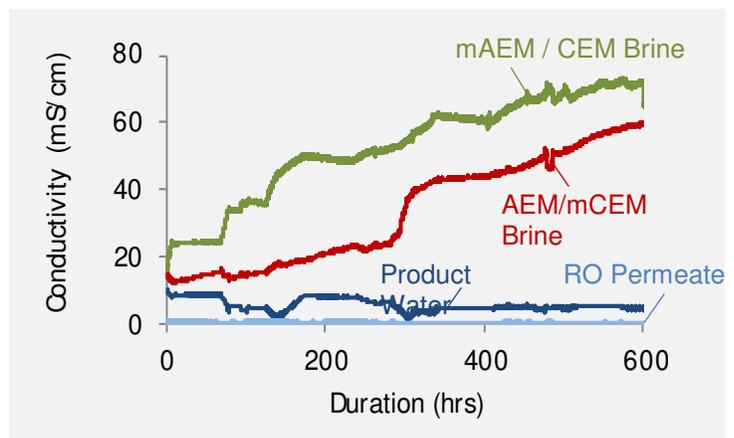
Results

A bench scale Flex EDR MVS-RO plant demonstrated high recovery on representative highly scaling brackish water without the use of chemicals. If the client operated a conventional lime-RO plant on this water source, they could expect a recovery of 80% using aggressive anti-scalants. Saltworks' MVS-RO achieved 93% recovery and the following results:

- Waste brine volume reduced by two-thirds in a simple low cost membrane system
- Non-scaling waste brines, enabling more reliable and lower cost downstream processing
- Lime softening eliminated: reduced safety risks, operational headaches, and ongoing chemical costs
- Two brines produced:
 - CaCl_2 brine (89,000 mg/L TDS): sulfate <25 mg/L
 - Na_2SO_4 brine (95,000 mg/L TDS): hardness <180 mg/L as CaCO_3
 - Concentrations of both brines were still increasing after 600 hours of operation, but already exceeded the client's goal of 90% recovery (93% readily achieved)
- High quality freshwater (RO permeate) produced with TDS <200 mg/L

Parameter (mg/L)	Raw brackish water
pH	7.8
Total Dissolved Solids	6,330
Total Hardness (as CaCO_3)	2,400
Sodium	1,395
Bicarbonate (as CaCO_3)	468
Calcium	425
Chloride	1,850
Magnesium	326
Sulfate	1,690

Raw Brackish Water Chemistry



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MVS-RO performance

Hours of Operation	Product Water TDS (mg/L)	RO Permeate TDS (mg/L)	m AEM / CEM Brine			AEM / m CEM Brine		
			TDS (mg/L)	Sulfate (mg/L)	Hardness (mg/L as CaCO ₃)	TDS (mg/L)	Sulfate (mg/L)	Hardness (mg/L as CaCO ₃)
64	5,628	50	13,772	-	6,402	10,073	3,269	35
145	1,524	90	34,892	10	15,979	21,403	8,925	47
169	5,084	90	45,716	9	21,897	28,341	13,056	41
245	4,834	140	48,818	15	23,830	62,485	16,252	64
268	3,925	60	51,612	20	25,133	76,752	21,556	73
293	3,163	20	54,406	18	26,884	81,304	25,704	95
410	3,074	70	60,368	25	30,518	86,190	35,292	138
438	3,426	100	66,396	20	31,416	87,975	37,638	129
579	2,958	160	84,524	15	41,279	93,033	54,196	164
600	2,843	100	89,056	21	44,810	94,933	58,038	180

MVS-RO Testing Analytical Results

(note: mAEM sulfate rejection is better than mCEM calcium rejection)

Summary

Saltworks Technologies completed an Flex EDR MVS-RO project demonstrating chemical-free, high water recoveries (93%) operating on a scaling brackish water source with a simple membrane system. Two highly concentrated low volume brines with low scaling potential were produced, which increases the reliability and reduces the capacity of downstream brine management systems. MVS successfully removed the need for chemical and lime pre-treatment, functioning as a chemical-free softening platform and removing chemical costs and lime sludge waste disposal. Economics for an Flex EDR MVS-RO plant result in up to a 30% decrease in total operating costs (site and water chemistry specific) for inland zero liquid discharge projects.

Saltworks would be pleased to complete an Flex EDR MVS performance and economic assessment of your brackish water source. Please contact projects@saltworkstech.com. Full scale purchase or lease, pilot plants, and bench scale plants are available.