

## Sulfate Reduction

### Background

The Kizomba A field is located in Block 15 and is one of the first trenches of deepwater acreage offered by the Angolan Government. The consortium is operated by Exxon Mobil's subsidiary, Esso Exploration Angola, which has a 40% stake. It also includes Agip Angola (with a 20% share), BP Exploration (with a 26.67% share) and Statoil (with a 13.33% share). SONANGOL, the Angolan State Oil Company is the concessionaire.

It is being developed with a combination of a surface wellhead platform and subsea completions tied back to an FPSO. The process facilities located on the FPSO are designed to process 138,600 bpd of crude oil, and inject 350,000 bpd of seawater.

Water Injection is necessary to maintain reservoir productivity. However, barium sulfate scaling would occur when the formation water mixes with the untreated injection water.

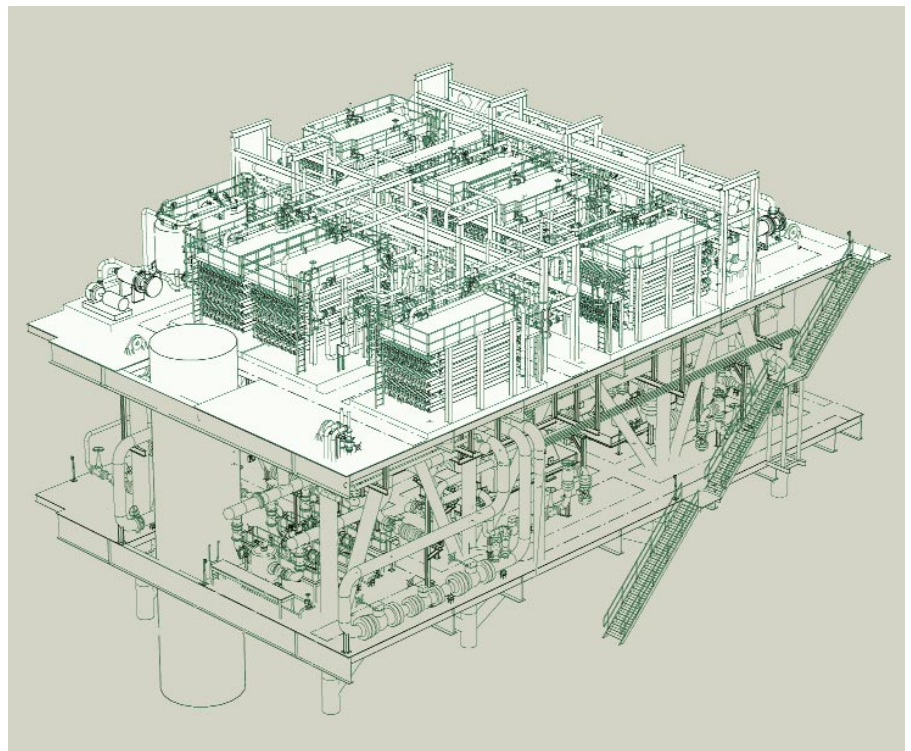
### Solution

Sulfate reduction via nanofiltration membranes process was selected as the best overall solution given the complex nature of the development: barium present, deep subsea wells, long perforation intervals, monitoring challenges and high costs of treatments and risks.

The sulfate reduction system (see picture above) is part of the total water injection system designed and supplied by NATCO. There are seven Sulfate reduction modules, each 8.5m x 5.6m x 6.5m (l x W x H) and weighing 37, 180 kg dry.

### Process design

Process requirements called for a membrane separation system capable of producing 350,000 bpd (2319 m<sup>3</sup>/h) low



The Kizomba A membrane assembly



One of seven membrane modules capable of producing 350,000 bpd low sulfate seawater for Kizomba A field at NATCO's New Iberia facility

sulfate seawater (guaranteed 44 mg/l). The system is supplied with 466,667 bpd (3092 m<sup>3</sup>/h) of strained and chlorinated seawater. Hiperfilter SFX Dual media filters then treat the water to give an SDI of less than 5 thus ensuring that colloidal and small particulate matter does not foul the membranes. The water is then deaerated by the HiperVac vacuum towers and pressurized before passing through



Sulfate reduction system installed on BP Amoco © ETAP

cartridge filters. The pressurization enables the separation of divalent ions (sulfate, calcium, and magnesium) in the membrane system (see table for typical predicted feed and product compositions). Each of the seven 2:1 staged membrane trains employs Dow Filmtec™ SR90-400 nanofiltration membrane elements.

A chemical dosing system and an off-line membrane cleaning facility was also provided within NATCO's scope.

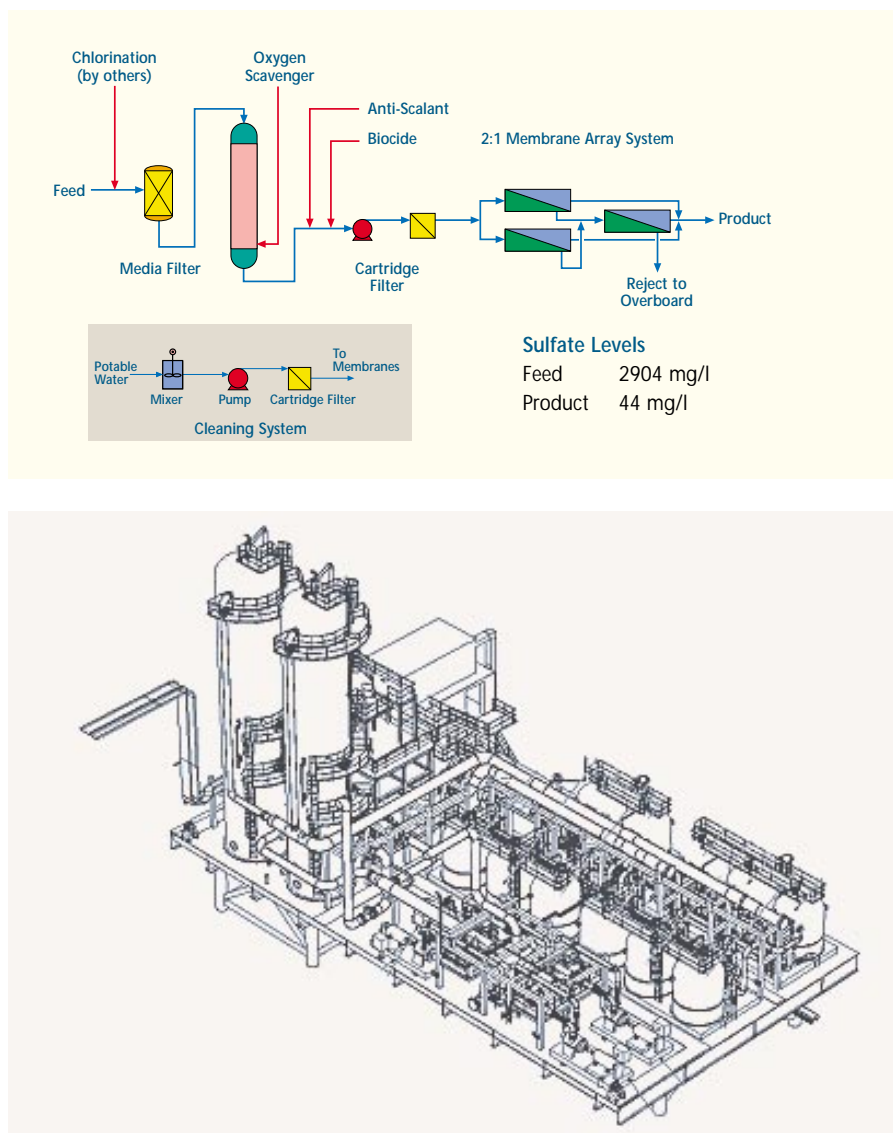
Sulfate reduction systems are in operation in several locations around the world. The original facility on Marathon's Brae A platform has been in operation for over 15 years. At the time of going to print NATCO had just been awarded an identical system for the Kizomba B FPSO.

NATCO are a sub-licensed original equipment manufacturer for the application of the technology, patented by Marathon Oil and licensed by the Dow Chemical Company.

	Seawater Feed (mg/l)	Predicted Low Sulfate Water (mg/l)
Sodium	11200	10690
Potassium	370	320
Calcium	400	330
Magnesium	1400	330
Chloride	19750	19000
Sulfate	2650	40
Bicarbonate	140	20
<b>Total</b>	<b>35910</b>	<b>30730</b>



One of two huge Deaerator Towers destined for Angola, in NATCO's New Iberia fabrication shop



**Sulfate Levels**  
 Feed 2904 mg/l  
 Product 44 mg/l

Hiperfilter SFX and HiperVac pretreatment packages

For more information on NATCO Sulfate Reduction or other NATCO Group products contact:

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