RO Protection | Industrial | Mejillones, Chile

RO Membrane Protection for a Desalination Plant in Mejillones, Chile

Overview

Seawater desalination plants frequently utilize chlorination to prevent microbiological colonization on reverse osmosis membranes to avoid biofouling. Biofouling damages RO membrane performance: decreasing in flow and quality of the RO permeate, increasing differential pressure, resulting in more frequent chemical cleaning, and shortening RO lifetime. Due to its oxidizing nature, chlorine attacks the RO membrane polymers, so pre-RO dechlorination is required, which is usually carried out by in-line dosing of sodium metabisulfite. This procedure often promotes and increases the formation of biofilm.

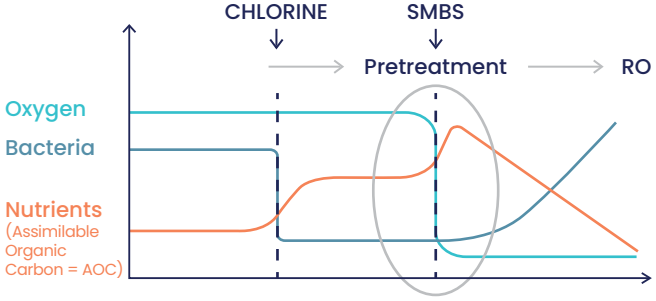
Atlantium developed an alternative treatment approach that minimizes membrane biofouling potential, minimizes anaerobic and aerobic bacterial growth, and protects RO membranes and other sensitive equipment without the use of chemicals. Atlantium HOD™ (Hydro-Optic Disinfection) UV systems combine ultraviolet water disinfection technology with hydraulic and optic principles. The HOD UV system features the unique Total Internal Reflection (TIR) technology that recycles UV light energy, ensures homogenous UV dose distribution, provides superior power (kW) efficiency compared to traditional UV, and achieves unprecedented micro-organism inactivation.

Recent studies propose a comprehensive approach to minimize the formation of bio-fouling considering all the factors involved in its formation and growth by evaluating the "potential for bacterial growth" according to microbiology: microorganism total count; the extracellular polymeric substances (EPS); and presence of available nutrients for bacteria, expressed as Assimilable Organic Carbon (AOCs).

Not all organic carbon compounds present in water are assimilable by bacteria. Only a fraction of it can be biodegraded and it enhances microbiological proliferation.

A side effect of chlorination is the oxidation of dissolved organic matter increasing the "assimilable" organic fraction, increasing the "potential for bacterial growth". Doses as small as 0.5 ppm of free chlorine can increase up to 80% the assimilable carbon content (Maria Kennedy, IHE Delft). Additionally, the dosage of a chlorine scavenger such as sodium metabisulfite, which is usually dosed in excess, simultaneously absorbs the dissolved oxygen, generating an environment favorable to the development of anaerobic microorganisms.

The biofilm is constituted of 80-85% of macromolecules segregated by microorganisms for their protection and growth: the Extracellular Polymeric Substances (EPS), so an accurate strategy to control biofouling must prioritize EPS minimization.

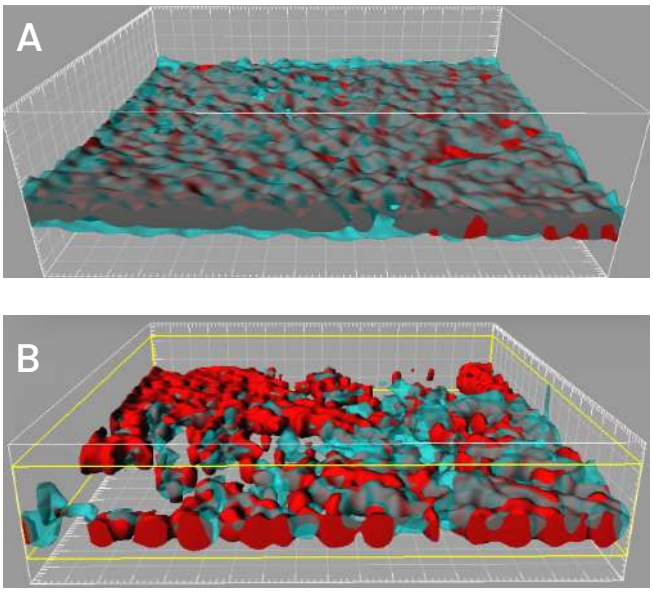


Evolution of concentrations at different stages of pretreatment

UV Radiation

UV radiation is used in relatively low doses and has a minor or no effect on the content of degradable organic matter. It has been widely proven that the use of medium-pressure (MP) lamps achieves cell inactivation, inhibiting repair mechanisms and simultaneously affecting vital functions like driving EPS secretion to reducing biovolume and making biofilm more porous.

The results obtained show that the HOD UV strongly impacts the RO membranes' surface biofilm characteristics, meaning more constancy in the flow and consequently an improvement in plant performance.



Confocal laser microscopy (CLSM) of biofilms with and without UV pretreatment

(A) Biological contamination layer without UV pretreatment.
(B) Biological contamination layer with Total EPS biomass (transparent light blue) and microorganisms (red), after UV pretreatment.

The content of EPS in the biofilm on the membrane that received the water irradiated with HOD UV was much lower in comparison to the membrane that did not receive this pretreatment.

The application of UV radiation for biofouling control allows several benefits in desalination plants:

- Maintaining flow at lower operating pressure = energy savings
- Fewer CIP processes are required allowing longer membrane useful life
- Increasing the duration between microfiltration cartridge replacement
- Allowed the replacement of existing chlorination or biocides.

The Challenge

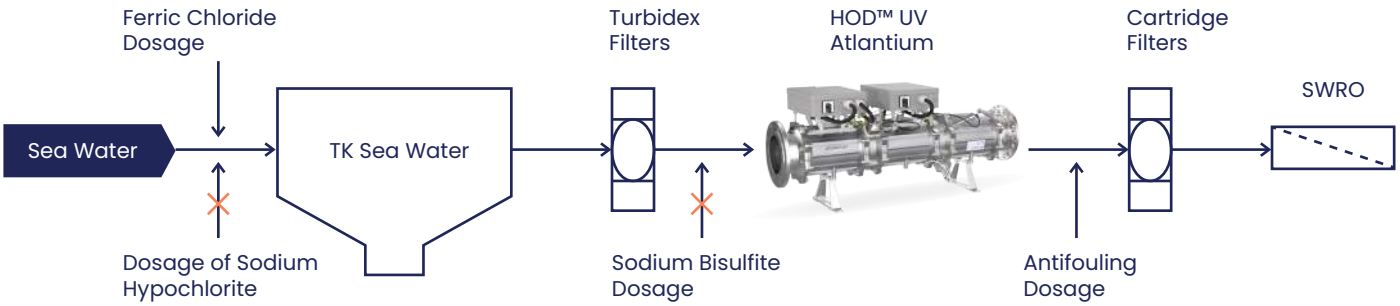
NORACID, a sulfuric acid production plant, in Mejillones, Chile wanted to assess the efficiency of HOD™ (Hydro-Optic Disinfection) UV technology for biofouling control on reverse osmosis membranes, replacing the use of chlorine and SMBS.

Noracid produces 720,000 tons/year of sulfuric acid for mining activity in the area and uses

demineralized water to feed its high-pressure boilers (electricity generation). The seawater desalination plant presented several performance problems:

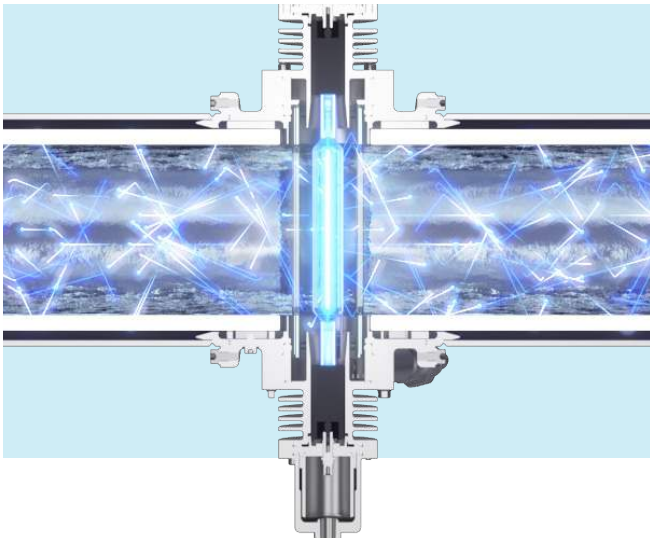
RO Permeate Flow:	30-35 m^3/hr
Membrane service life:	2 years
Cartridges replacement:	Every 4 days
CIPs frequency:	Every 13-30 days
Chlorine dosage:	2 ppm
MSBS dosage:	20 ppm
Ferric Chloride dosage:	3 ppm

A full study was carried out for more than 10 months with extremely successful results.



The Solution

On July 2022, a skid containing an Atlantium RZ Series system with one 2.3 kW medium-pressure lamp was installed with vertical mounting.



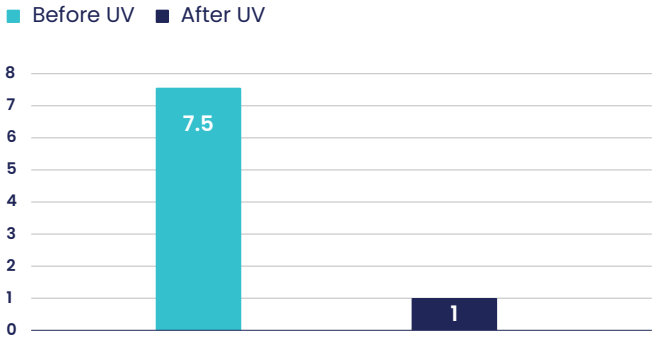
Results

Since its installation there has been notable performance improvements.

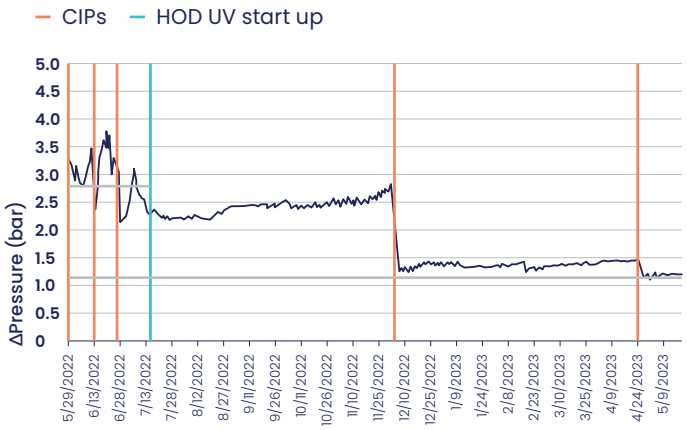
- Chlorine dosing was halted and consequently dechlorination with SMBS dosing was also halted.
- The dose of Ferric Chloride was gradually reduced, operating satisfactorily with only 0.5 ppm as there was no interaction with the other chemical reagents such as chlorine.

The benefits in terms of extending cartridge life and increasing the time between chemical cleanings by reducing biofouling were quickly verified, relative to microfiltration cartridge replacement and the feed-brine pressure difference (delta P).

Cartridges Replacement/Month

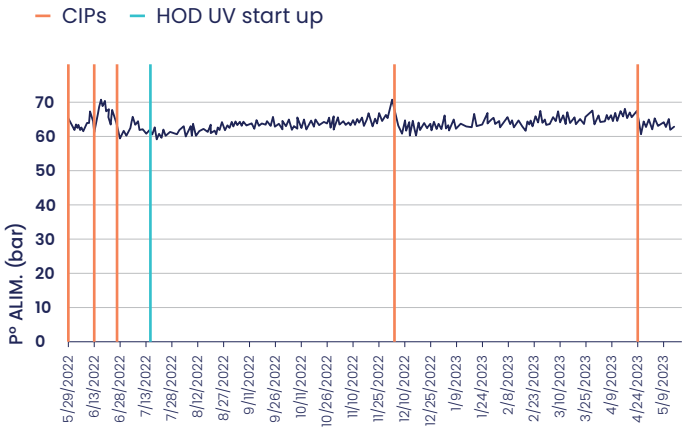


Differential Pressure

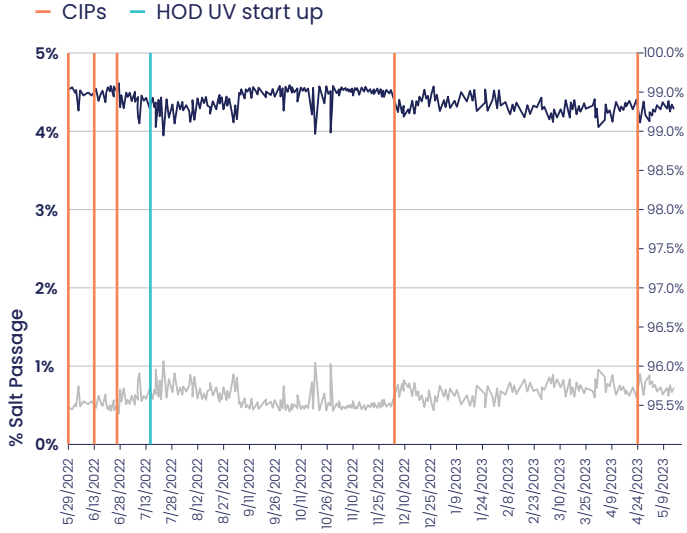


Transmembrane pressure differential (ΔP) achieved the lowest post-CIP ΔP (> 20 psi), which was never seen before. This means the changes in biofilm structure (less EPS) make CIP more effective, cleaning membranes more deeply, and even better, after the second CIP.

Feed Pressure



Salt Rejection %



Savings in OPEX Included:

- Removal of chlorination/dechlorination removal (SMBS) previously used for biofouling control.
- Reduction of coagulant dose, due to change in water characteristics after avoiding previous chlorination and related side reactions.
- CIP was reduced from once every 13 days to once every more than 5 months.
- Greater removal of biofilm, which is evidenced by the smaller transmembrane pressure difference.
- Fewer chemical residue measurements and consumption of analytical reagents.

Optimization of operation and maintenance included increased plant operational availability due to fewer events (cartridge replacements, CIP, etc.); no more time and safety risks due to chemical transfer and handling; reduces labor spent changing microfiltration cartridges and chemical cleaning; eliminates maintenance of metering pumps; and reduction of physicochemical control of residuals.

Savings in OPEX from the Installation of HOD™ UV

Performance improvement and service life extension

During this time the RO permeate flow rate and conductivity were maintained operating at lower feed pressure

Moreover, once a CIP was performed after 5 months with HOD™ UV pretreatment, the differential pressure fell like never before

Drastic decrease in chemical cleanings should mean a significant extension of RO membrane life

155 DAYS

The differential pressure shows a significant constancy for 155 days

SHOWS A REDUCTION

3% ↓

Consequently, energy consumption per m^3 produced

Annual Operating Cost Comparison
=> Return on Investment

Item	without HOD™ UV (US$)	Expected OPEX with HOD™ UV (US$)	Real OPEX with HOD™ UV (US$)
Chemicals	21,918.60	3,207.60	534.60
Membrane Cleaning	18,240.00	13,680.00	6,768.00
Microfiltration cartridges	18,264.00	13,698.00	2,401.92
Membrane lifetime (partial replacements) estimated	21,056.00	14,739.20	14,739.20
Indirect OPEX	6,000.00	3,000.00	1,440.00
UV lamps	-	4,000.00	4,000.00
Technical Assistance (bimonthly visit)	-	1,920.00	1,920.00
Total Operating Cost (year)	85,478.60	54,244.80	31,803.72
OPEX savings per year	-	31,233.80	53,674.88

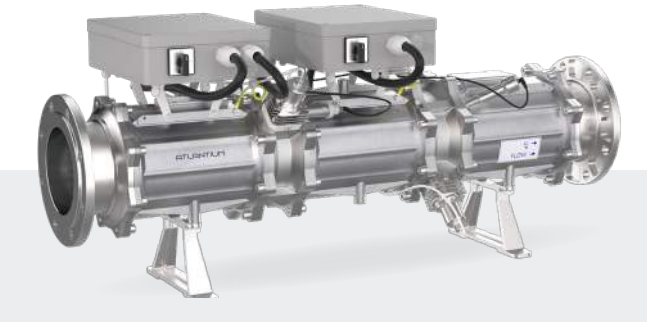
The comparison of operating results shows the economic advantage of implementing this pre-treatment with a very clear ROI. The performance of the desalination plant has improved significantly and is highly valued by the customer, who can concentrate more on its core business.

HOD UV is totally friendly to the environment, with no desired residuals. It allows the elimination or minimization of chemicals in line with the UN 2020 targets: “to achieve environmentally proper management of chemicals, in accordance with internationally agreed milestones, and significantly reduce their release into air, water, and soil to minimize their negative effects on human health and the environment”. In conclusion, it enables the best available solution in terms of efficiency and environmental care and guarantees the adequate pretreatment of seawater desalination plants.

Percentage of Savings

37%
Real OPEX with HOD™ UV (US$)

63%
Expected OPEX with HOD™ UV (US$)



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About us

For more than two decades, Atlantium Technologies has helped to ensure water safety with its innovative HOD™ (Hydro-Optic Disinfection) UV technology and novel approach to performance, monitoring, and control. Atlantium's superior, environmentally friendly water treatment solutions ensure stable, efficient, and dependable production.

With thousands of full-scale installations for leading brands in various industries globally, we’re committed to consistently meeting our customers' water quality needs, ensuring pure results.

Pure Performance

ATLANTIUM

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