WATER DESALINATION REPORT

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Tunisia

EPC CONTRACT AWARDED FOR SWRO PROJECT

SONEDE, Tunisia's national water supply authority and an autonomous public entity under the Ministry of Agriculture, has awarded an EPC contract for the construction of a 100,000 m^3/d (26.4 MGD) SWRO plant to a Cobra, Orascom, and Metito consortium. The plant will be located in Sfax, a Mediterranean port city located 270km (169 mi) south of Tunis, on the country's east coast.

The Tunisian government has signed a $329 million financing agreement with the Japanese International Cooperation Agency. The 30-month EPC contract includes two years of operation and maintenance and the construction of a 49.5km (31 mi) water transfer network.

The plant is scheduled to be operational in June 2023.

Low-Earth Orbit

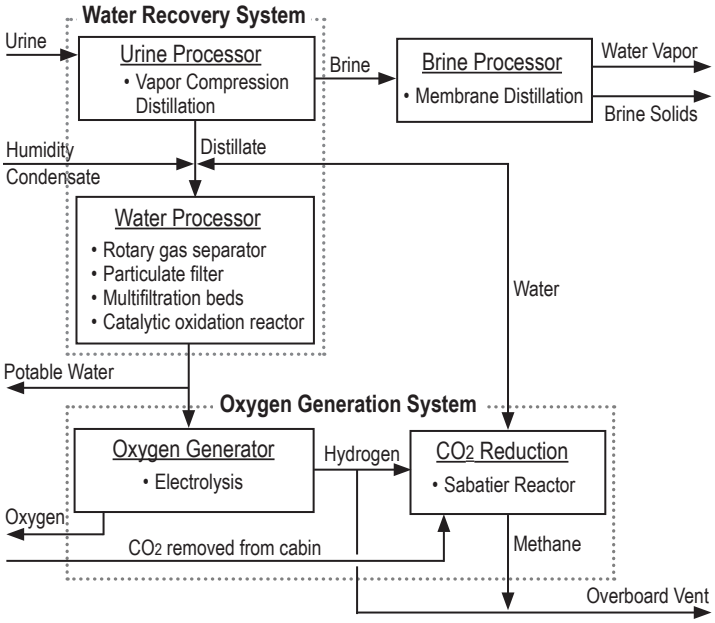
SPACE STATION TO CONCENTRATE BRINE

Two weeks ago, NASA launched a mission to resupply the International Space Station (ISS). Amid the 8,000 pounds (3,630 kg) of cargo was a water recovery upgrade of the ISS' Environmental Control and Life Support System (ECLSS). The upgrade consists of the addition of a brine processor unit to increase the water recovery of the existing urine treatment system from 87% to nearly 98%, boosting the ECLSS system's overall recovery—which recovers water from urine, hygiene, humidity condensate from crew sweat, respiration and air revitalization—to 93.5%.

The brine processor consists of a membrane distillation unit. According to a NASA description, "A dual-membrane bladder both contains the dewatered brine solids for disposal and selectively passes water vapor through into the cabin atmosphere. Once returned to the cabin, the water is recovered using the existing ISS condensing heat exchanger, which captures and delivers it to the water processor assembly. The water recovery cycle may take up to 26 days. The brine processor system also processes toxic level 2 fluids: Alternative Pretreatment Urine Brine and Baseline Pretreatment Urine Brine."

When a dewatering cycle is complete, the brine bladder is removed from the unit and packed into a cargo vehicle for disposal.

During the October 2020 Texas Desal virtual conference, Layne Carter, NASA's ISS water subsystem manager, told participants that each ISS crew member produces about 1.8 L/d of urine, and 1.5 L/d of humidity condensate. He estimated that since the water recovery system was first installed, it has recycled 46,500 L (12,285 gal) of water. Based on a re-supply cost of $68,000/kg ($30,900/lb), this means the water system has saved almost $3.2 billion.



The ISS Water Recovery and Management System

The increase in recovery provided by the new brine processor will not only further reduce the on-board cost of water, it will also open the door to leaving low-Earth orbit and enable long-duration space exploration missions where water re-supply is not an option. Carter said that RO, capacitive deionization and electrodialysis are also being considered in various architectures.

WATER IS OUR CONCERN

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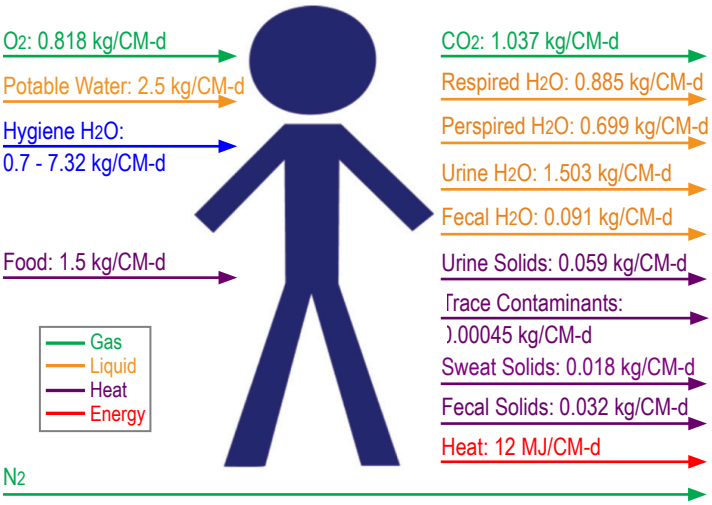


Mass Balance for an ISS Crew Member-day (CM-d)
Based on a reference 40-year-old, 82kg CM in a climate-controlled cabin

Editor's note: Following a joint research project, the Japan Aerospace Exploration Agency (JAXA) contracted Kurita Water Industries to design and supply a urine recycling system for testing within the Japanese Experiment Module 'Kibo' on the ISS.

According to Kurita, the system has a recovery rate of over 85% and removes calcium and magnesium components contained in the urine through ion exchange, before subjecting the organic matter to high-temperature, high-pressure electrolysis to completely break down persistent organic matter. The ions are then removed through electrodialysis, and the ion exchange resin is regenerated with the system, without the need to replace consumables.

Kurita delivered the unit to JAXA in late 2019, although no information is available on the status of the testing.

Technology
A Batch of RO options

Batch and semi-batch RO systems continue to receive attention for their ability to improve energy efficiency and reduce membrane fouling and/or scaling. Commercial semi-batch processes include CCRO from Desalitech, Pulse-Flow RO from IDE and Flow Reversal RO by Rotec/AdEdge. Batch processes are still under development, including one by MIT spinoff, Harmony Desalination, which employs a variable-volume bladder.

Within the past month, three papers on batch RO configurations using piston tanks have been published by Elsevier's journal *Desalination*. Two of the papers were prepared by David Warsinger's research group at Purdue University, and the third was done by Philip Davies' research group at the University of Birmingham in the UK.

Batch versus Semi-Batch

A *continuous RO* system is one in which brine is discharged from the system after passing through the membrane, whereas a *batch RO* process is one in which RO brine is recirculated through the RO membrane module without incorporating any fresh feed.

A *semi-batch RO process* is a time-variant process, usually one in which a pressurized concentrate is recirculated until a desired concentration or recovery level is achieved. In semi-batch RO processes, new feed-water then displaces concentrate from the system, without interrupting the feed or permeate flows.

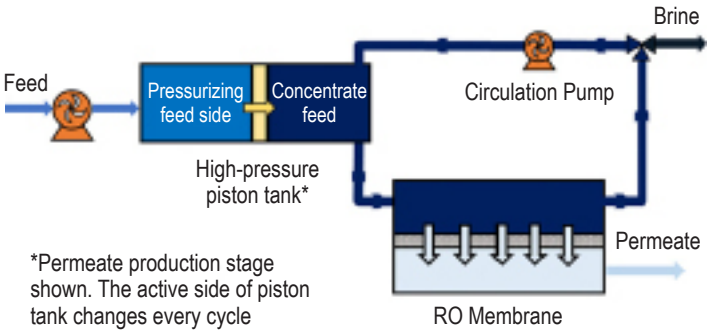
While an ideal batch process is generally considered to be the most energy-efficient approach to RO, there are practical challenges in constructing such a system, especially a large-scale system. The papers noted below provide new configurations that improve on some of the limitations experienced with previous attempts to construct batch RO systems.

The first of the Warsinger group papers, led by Sandra Cordoba, focuses on seawater desalination with a reciprocating piston tank, in which feed is alternately introduced in both sides of the membrane vessel, with one side concentrating at a time. This design is a variant of an earlier (circa 2015) Warsinger design, and reduces the downtime between cycles. It also reduces several sources of inefficiency, including some internal mixing. The Warsinger lab claims that this could be the most efficient RO configuration, capable of achieving <1.88 kW/m^3 (<7.12 kWh/kgal) at a flux of 15 LMH (8.82 gfd).

The second paper, by Abhimanyu Das and Warsinger, introduces the first osmotically assisted batch process for high-salinity RO, which it calls Batch Counterflow RO (BCFRO). The authors contend that it presents significant energy savings and implied cost benefits. According to Warsinger, "The key cost advantage of the process is that multi-staging is done using the same pumps over successive batch cycles, only requiring the addition of relatively inexpensive tanks to obtain high recoveries. This avoids additional multistage pumps, pressure exchangers, and other equipment required in alternative osmotically-assisted RO [OARO] processes, which have as many as seven stages."

The modeling included in the two papers is the most detailed yet provided for batch RO processes. The researchers include spatiotemporal salinity profiles, discretized along the membrane modules in both longitudinal and transverse flow directions, which also use unsteady mass conservation

Double-acting Batch RO Configuration



Feed Salinity 35,000 mg/L Permeate Flux 15 LMH	Specific Energy Consumption	Downtime
Previously predicted low with batch RO	1.97 kWh/m^3	14%
Improved double-acting batch RO	1.88 kWh/m^3	<10%

equations for enhanced accuracy. Cordoba's paper includes the first full hydraulic model for batch systems, which allows users to accurately predict the evolution of pressure over time in batch/semi-batch RO. These studies examine and optimize the relationship between energy, flux, concentration polarization, recovery ratio and recovery ratio per pass.

The free piston configuration of batch RO is potentially the most efficient method for high recovery desalination, to-date. However, in practice it runs into component sizing issues due to the coupled relationship between the piston size and recovery ratio. When designing a high recovery (>70%) system, the free piston size increases exponentially. In the third paper, Kiho Park and Davies show a hybrid semi-batch RO (HSBRO) process that allows the same components to operate in both semi-batch and full batch modes. This innovation solves the piston sizing issue, and even shows energy savings at high salinities. HSBRO creates more operational flexibility and provides a "more promising solution to zero liquid discharge".

Editor's note: The papers are available as follows:

"Double-acting batch RO configuration for best-in-class efficiency and low downtime" – https://doi.org/10.1016/j.desal.2021.114959.

"Batch Counterflow Reverse Osmosis" – https://doi.org/10.1016/j.desal.2021.115008

"A compact hybrid batch/semi-batch reverse osmosis system for high-recovery, low-energy desalination" – https://doi.org/10.1016/j.desal.2021.114976.

In brief

DuPont Water Solutions has been awarded a three-year, $1.3 million grant from **PUB**, Singapore's national water agency, on behalf of Singapore's National Research Foundation, to determine how DuPont's Closed Circuit Reverse Osmosis (CCRO) technology can be applied to make the desalination of seawater more energy efficient, flexible and reliable. DuPont said that the grant would enable it to make CCRO commercially viable for SWRO applications.

Research

Lab and pilot projects receive funding

Ten desalination research projects have been awarded a total of $3.6 million under the Bureau of Reclamation's Desalination and Water Purification Research Program, which seeks to improve technologies for water supply development from nontraditional waters, including seawater, brackish groundwater, and municipal wastewater.

The projects will be matched by $5.3 million in non-federal support, and include four pilot projects and six laboratory projects.

Awardee, Project Description	BoR Funding	Project Cost
Carollo Engineers – Pilot study for biological selenium removal from agricultural drainage water.	$403,002	$806,004
Sephton Water Technology – Pilot study of 200°C top brine temperature MED with UF & NF pretreatment to prevent scaling.	$139,968	$558,100
Gradiant – An 18-month pilot study of NF, RO, softening and CFRO of municipal effluent to achieve 99.8% overall recovery.	$800,000	$3,657,490
MIT – Last-mile pilot study of PV-powered, time-variant EDR from prototype to commercial product for rural/tribal communities.	$799,989	$1,010,843
Yale University – Novel electrosorption process for selective silica removal to increase recovery and reduce treatment costs.	$250,000	$351,143
New Mexico Institute of Mining and Technology – To develop a permanently hydrophilic PVDF membrane to remove DOM.	$249,969	$499,938
University of Cincinnati – To develop a high-temperature gradient ceramic membrane distillation process for produced water.	$249,630	$500,911
SolMem LLC – To develop, optimize and economically analyze a multi-effect, sunlight-driven MD process for high salinity water.	$241,506	$732,058
University of Houston – Research to overcome permeability-selectivity tradeoff limiting conventional polyamide RO membranes.	$249,466	$306,748
Rice University – To develop stimuli responsive, block copolymer brush-grafted CNT membrane coatings to control scaling.	$250,000	$473,865

Autodesk, the US-based software giant, has signed a definitive agreement to acquire **Innovyze**, the water infrastructure modeling company, in a $1 billion deal. Autodesk, the Oregon-based company whose flagship product, AutoCAD, was launched in 1982, has annual revenues of $3.27 billion. Innovyze was founded as a subsidiary of MWH in 1996 and was spun-out of MWH in 2011. It became part of Stantec in 2016, and was acquired by EQT Capital, the Swedish private equity firm, in 2017. It has been the largest pure-play water-focused software company in the world.

Nestlé S.A. said that it has reached an agreement to sell its regional spring water brands, purified water business and beverage delivery service in the US and Canada to One Rock Capital Partners, in partnership with Metropoulos & Company for $4.3 billion. The company's international premium brands including Perrier, S.Pellegrino and Acqua Panna are not a part of the deal. The sale does include Poland Spring, Ozark, Ice Mountain, Zephyrhills, Arrowhead Mountain Spring Water, Pure Life and Splash. It also includes the ReadyRefresh direct-to-consumer and office beverage delivery service.

AECOM, the US-based consulting firm, has launched the first large-scale demonstration of its De-Fluoro PFAS destruction technology in Melbourne, Australia. De-Fluoro offers complete destruction of PFAS via direct electron transfer on 'nonactive' anodes under room temperature and atmospheric pressure with relatively low energy consumption. The pilot program will be focused on undertaking destruction programs on Aqueous Film-Forming Foam (AFFF) stockpiles and multiple PFAS-impacted waste streams within Australia.

CalDesal will present a Zoom webinar program entitled ***Invitation to Innovate*** on Friday, 26 March, from 3:00 to 4:30 PM PDT. Mark Donovan (GHD) and Rich Svindland (CalAm Water) will moderate the event, in which water agency/entity panelists will participate in a focus group format to discuss what they would like to see on the desal innovation front, and to explore the direction of future innovative desal technology in California. For information, or to register, visit https://www.caldesal.org/events.

Last week, the judicial nanagers appointed to oversee the restructuring of **Hyflux**—the beleaguered Singaporean desal project developer—provided an update on the investor search process now underway. On 17 February, shortlisted investors were invited to submit their binding offers by 31 March. The judicial managers will then work towards finalizing and agreeing on binding term sheet(s) with the selected Investors by about 15 April. The judicial managers are not yet able to determine whether viable restructuring proposals will be submitted, or whether a viable restructuring of the Hyflux Group is likely. The company has previously received at least seven non-binding offers.

People

NX Filtration, the Netherlands-based membrane company, has expanded its international sales team as follows:

- ***Manish Ghogle*** has been appointed regional sales manager for India and the Sub-Continent. He is based in Ahmedabad, Gujarat, India, and may be contacted at m.ghogle@NXFiltration.com.
- ***James Iong*** has been appointed regional sales manager for Southeast Asia and is based in Singapore. He may be contacted at j.iong@NXFiltration.com.
- ***Umang Yagnik*** has been named commercial manager for North America. He is based in Vancouver, Canada, and may be contacted at u.yagnik@NXFiltration.com.

Masoud Aghajani has been appointed research and development engineer by WaterSurplus, where he will initially lead an RO process demonstration effort at Reclamation's BGNDRF facility in Alamogordo, New Mexico. Dr Aghajani may be contacted at Masoud.Aghajani@watersurplus.com.

Jobs

The Karlsruhe Institute of Technology's Institute for Advanced Membrane Technology seeks the following positions:

- *Postdoc* – Photocatalytic membrane processes for the removal of trace pollutants in water reuse. Applications close on 31 March.
- *Process engineer* – Renewable energy-powered membrane systems design & implementation in Africa. Applications close on 31 October.

For additional information on the 3-year positions visit: https://www.iamt.kit.edu/438.php.