Garver, LLC advances zero liquid discharge research

Enhancing circular economy research with flow and liquid analysis

Garver, LLC
Founded in 1919, Garver provides innovative infrastructure solutions to communities across the United States. It offers engineering design services to various aviation, buildings, construction, enterprise solutions, federal, survey, transportation and water and wastewater industries.

Summary: On the consulting firm's 100th anniversary, Garver's Water Business Line was awarded the United States Bureau of Reclamation's (BOR) Pitch to Pilot Research Project, allowing their research team to embark on a journey to do something that is rarely accomplished in the research community: vetting a zero liquid discharge (ZLD) treatment train to recover the saline cooling tower blowdown. If successful, the project would prove how their pilot train prevents the salt from entering the sewer system and potentially serve as a model for future brackish water desalination. As a result, the treated water would be much better than what comes out of the faucet.

Garver conducted this research with the help of Red Rocks Community College, various industry subject matter experts and manufacturers, who donated more than $480,000 to the $200,000 BOR-funded research project. Endress+Hauser was one of the major contributors, donating several electromagnetic flowmeters, in-line water quality analyzers and data collection devices that were used to track the pilot trailer's treatment efficiency. Endress+Hauser's industry partner, Rockwell Automation, also significantly contributed variable frequency drives (VFDs) and power quality monitors.

Garver's research initiative stemmed from their understanding of how salt accumulation in watersheds threatens the viability of water supplies to meet the growing demand of a water-dependent

world. Water supplies are often contaminated by the salt in spent brine from residential or commercial water softeners, concentrate from inland desalination reverse osmosis, fertilizer run-off from agriculture and cooling tower blow-down from commercial, industrial and power industries.

Once the salt is introduced to the watershed it is difficult and expensive to remove. Often, best management practices can curtail the salt loading to the sewershed and reduce treatment needs, especially in the era of direct potable reuse.

However, the salt needs to be removed at the source.

The research team, led by then Garver's Water and Energy Practice Lead Eric Dole, knew they needed to study an efficient desalination treatment process focused on recovering the saline cooling tower blowdown to reduce salt loading to the sewershed and improve the water quality and water efficiency of a cooling tower while being a model for future inland desalination technologies.

According to the Central Arizona Salinity Study, many industrial and commercial cooling systems use evaporative cooling towers, with up to 50% of their water used for cooling purposes. Most cooling towers operate three to four cycles of concentration before scaling of the heat exchanger surfaces become fouled and a portion of the water is discharged to the local sewer system, commonly referred to as "blowdown." New, clean water from the distribution system is introduced to make up for the water lost in the blowdown and evaporation. This means the total dissolved solid (TDS) concentration entering the wastewater stream from blowdown increases three- to four-fold from the source water salinity level.

The research team developed a unique "electrified" treatment train that introduces electricity into the water as membrane pretreatment and in the concentrate treatment system. The electro-coagulation (EC) plus clarification (CLAR) plus microfiltration (MF) plus reverse osmosis (RO) was able to achieve 97% recovery without any chemical pretreatment. Vacuum-assisted electro-distillation (VAED) concentrate treatment closed the ZLD loop and produced low TDS distillate and a salt slurry.

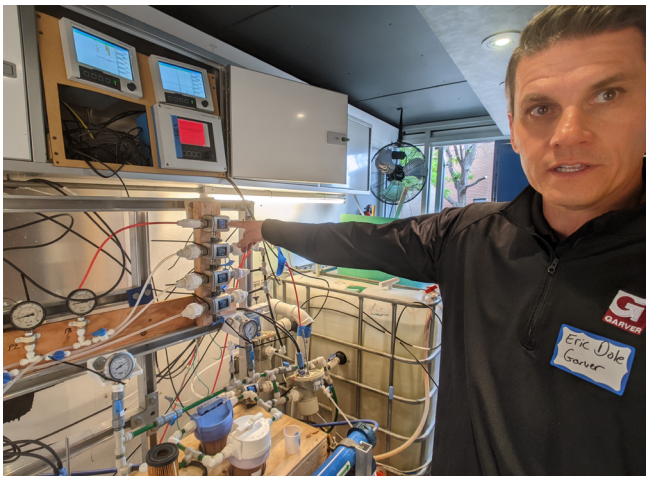
Challenge: Fouling of RO membranes is one of the most common problems, requiring intense chemical pretreatment and periodic chemical clean-in-place maintenance. Not properly designing, operating and maintaining an RO system can lead to high energy intensity and a high likelihood of failure. The main driver for the research was developing a disruptive desalination treatment train that requires less chemicals and energy than commercially available technologies while consistently achieving high-quality, low-salinity permeate. Discovering a technology that could consistently close the ZLD loop was a bonus.

Cooling tower blowdown is considered one of the most prevalent point sources of salt-loading to a watershed, especially in arid environments where water scarcity is prevalent and evaporative cooling is efficient. It just so happened that Red Rocks Community College had:

- A 600-ton cooling tower on-site used to manage campus heat loads
- A trailer that could be re-purposed to house Garver's treatment train
- Students and teachers willing to help with the construction and operation
- Staff electricians to assist with the electrical connection needed to power the pilot system

With the blowdown's sizeable effect on watershed health and at a time when water reuse is at the forefront of national and global discussions, Garver began looking for opportunities to research and create a system to improve saline blowdown from commercial and industrial cooling

Members of the research team give a tour of the Pitch to Pilot research trailer to members of the DOE, NREL and Lawrence Berkley Labs.



Garver's Principal Investigator points out the trends displayed from the various Endress+Hauser and Rockwell Automation instrumentation.

towers. This led to the collaboration with Endress+Hauser and Rockwell Automation to provide the necessary instrumentation and technology to trend treatment efficacy and energy intensity of each previously mentioned unit process.

Solution: By working with Endress+Hauser and Rockwell Automation, global leaders in process instrumentation and control, Garver successfully designed, constructed and operated a treatment train that was able to achieve ZLD treatment of the cooling tower blowdown and serve as a model for an "electrified" treatment train for future desalination systems. Specifically, the project entailed Endress+Hauser's line of liquid analysis sensors and Liquiline CM448 and CM442 transmitters, Picomag flowmeters and Memograph RSG45 advanced data managers, along with Rockwell Automation's Power Monitor 500 and Allen Bradly VFD on the raw water feed pump. The process became symbiotic with Endress+Hauser's and Rockwell Automation's instrumentation and technology and Garver's insight.

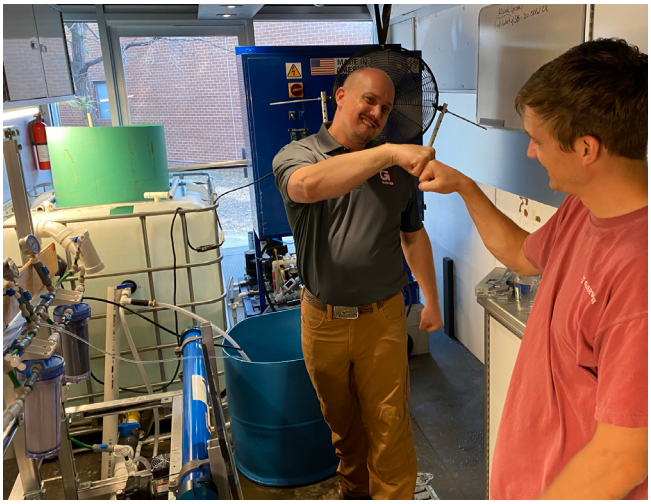
Throughout the process, Garver used Endress+Hauser's instrumentation to trend total flow, instantaneous flow, conductivity, pH, oxidation-reduction potential and temperature. The RSG45 and Rockwell Automation's power quality monitors were used to read kW and kWh.

The configuration helped Garver analyze each unit's water quality and energy intensity in a real-time environment so the pilot trailer operation staff could ensure consistent, low TDS permeate and distillate that could return to the cooling tower's recirculation water loop. Additionally, the salt slurry from the vacuum-assisted electro-distillation was examined for purity to potentially be used as feedstock for on-site sodium hypochlorite generation in the cooling tower to help build a circular economy.

Using the Endress+Hauser and Rockwell Automation technology, Garver's team also tracked kWh consumed per 1,000 gallons and real-time treatment efficacy.

Results: Following field testing using Endress+Hauser and Rockwell Automation instrumentation, Garver completed a successful research project and discovered that its EC + CLAR + MF + RO with VAED concentrate treatment train consistently met its water quality goals in a ZLD configuration, without any chemical pretreatment under start-stop operation (for up to four months of downtime without the addition of membrane preservatives), while consistently achieving > 99% TDS reduction. The pilot trailer is still in failure mode analysis under the "electric antiscalant" mode of operation without signs of fouling or chemical pretreatment.

VAED system distilling 110,000+ mg/L TDS concentrate at 122 °F.


Garver's Process Mechanical Design Lead instructs an intern on the start-up of the RO system.

Garver will continue focusing on opportunities to address critical topics such as salt accumulation in watersheds, and instrumentation and technology from manufacturers like Endress+Hauser and Rockwell Automation will continue to play a pivotal role in tackling those challenges.

A final research report can be found by visiting the Bureau of Reclamation

Since publishing this article, Eric is no longer with Garver and has joined Kimley Horn and Associates, Inc. as the Water Energy and Practice Builder in Denver, Colorado.

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