RO MEMBRANE LOADER FOR THE REPLACEMENT AT SEQWATER'S GOLD COAST DESALINATION PLANT

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ABSTRACT

Although the Reverse Osmosis (RO) membranes at Gold Coast Desalination Plant (GCDP) aged considerably well since the commissioning of the plant and were still suitable to produce drinking water, deterioration of the performance had been observed, particularly Salt Passage. The global RO market have also had supply outstripped by demand, consequently extending delivery times. Based on the volatile market condition and the revised operational forecast due to drought response operations and baseline network requirements at the time, GCD Alliance expedited the replacement program and initiated a full replacement of the RO membranes at GCDP.

In 2021, Seqwater's Gold Coast Desalination Plant replaced all 16,848 of its aged First Pass RO membranes (SWRO) and Second Pass RO membranes (BWRO) in the space of 12 working weeks. The delivery of this project presented several challenges specific to the site which were overcome by the teams through collaboration and innovation that could shift the industry's ways of working.

1.0 INTRODUCTION

After more than 10 years of operation, the RO membranes at GCDP have been scheduled for a full replacement.

RO membranes are traditionally loaded into the pressure vessels manually, and at 15-17 kg each and eight (8) membranes per vessel, a membrane change out of this magnitude comes with safety risks, mainly manual handling strains. A previous manual handling injury from this activity at a different treatment plant saw Seqwater prompt Veolia to consider and address the issues with manual loading. This had the project team focus heavily on safety.

Aspects and sources of the safety risks to consider for injury prevention include but are not limited to:

- Awkward body positions based on RO train/skid;
- Wet working environment from water, glycerine – sometimes at elevated heights;
- Strain from repetition depending on scale of the replacement;
- Time pressures;
- Excessive forces required due to stuck RO membranes; and
- Bending down and twisting during handling e.g. to align RO membranes.

Timeliness is also key in this project as the plant was operating as a part of the Seqwater's drought response so would need to work strictly under the allocated shutdown schedule. Veolia was driven to look for solutions to overcome said challenges to keep people safe and to get the job done on time and on budget.

2.0 DISCUSSION

2.1 Research and Site Investigation

Veolia conducted the initial research and began the concept ideation for a device to help with the loading/pushing of the RO membranes. The goal of the loading device is to reduce manual handling whilst being safe to operate and minimal rework (quality). The membrane loader must also have a failsafe mechanism to avoid damage to equipment e.g. pressure vessels, the RO membranes and their components.

In the earlier stages, Veolia kicked off the site investigation in 2020 to acquire data e.g. force tests showing force required and alignment tolerances on a First Pass SWRO train. The force test results are shown on Table 1 below.

Table 1: *Raw Force Test Data*

Test Element #	Max Push Force with Hydraulic Ram (kg)
1	90
2	90
3	90
4	100
5	100
6	90
7	100

2.2 Collaboration for Prototype Build

During the tender for installation work the following year, Safety and Timeliness weighed heavily for contract award. Neumann Contractors presented a concept idea as part of the tender submission which was inspired by a recent work at another water treatment plant where 1,500 RO membranes were installed manually, and similar issues were experienced.

The two parties quickly identified the opportunity to bring an idea to life through this project. Veolia has extensive experience with membrane loading/replacement and had done a concept design and acquired data based on site investigations, while Neumann Contractors had similar interest with the capacity to design and fabricate. This contributed to the award of the contract, and with a slightly extended scope, began the collaboration between Veolia and Neumann Contractors for the RO membrane replacement at GCDP. At this point, the plan was to fabricate and trial the device in the first phase of the project (replacement of the BWRO membranes), whilst having a contingency plan should the device not work, i.e. the workforce to complete the work with manual loading.

Veolia acted as a consultant providing data and design inputs, whilst Neumann Contractors designed and manufactured the prototypes. The membrane loader adopts a pneumatic system with a cartridge able to hold eight (8) RO membranes at a time. After one membrane is pushed, an operator can allow the next membrane to roll out of the cartridge and onto the membrane loader, ready to be pushed into the vessel.

Prototype testing took place at Neumann Contractor's workshop with GCDP pressure vessels and RO membranes provided by Veolia for design and testing purposes (refer to

Figure 1). These trials proved critical as the attendance of and feedback from Veolia's subject matter experts (30+ years of experience) were adopted to the final design.

Figure 1: ***RO Membrane Loader demo at Neumann Contractor's workshop***

2.3 Challenges

The team had two main challenges – designing and manufacturing a membrane loader that is safe-to-operate and suitable for the project prior to the planned installation start date, and to develop a workflow along with the required equipment and accessories to meet project schedule.

During the design process, the challenges include but are not limited to:

- Sourcing a pneumatic ram suitable for the required pushing force and length;
- Designing a clamping system that is fixed onto the pressure vessel and not the structural steel frame to help distribute the pushing load to the neck of the pressure vessel and avoid displacing the pressure vessels/causing damage;
- Incorporating alignment capabilities which is critical to avoid damage to RO membranes and interconnectors in the pushing motion;
- Efficient and delicate handling of RO membranes from preparation to loading into pressure vessels; and
- Time and resource constraints to deliver a working prototype and confirm feasibility.

Combining Neumann Contractors' equipment design experience and capability and Veolia's subject matter experts, the team was able to cooperate and produce the final design of the membrane loader system, shown in Figure 2, featuring the following:

- A clamping system that distributes the push force on neck of the vessel and not on the structural steel frame;
- Operator controls that ensure both hands are occupied to operate the loader;
- Indent button to prevent unintentional pressing of button;
- A self-aligning mechanism for alignment of the RO membranes prior to and during loading into the pressure vessel; and
- RO membrane cartridge that holds 8 RO membranes (one pressure vessel worth), mountable on the RO membrane loader to feed the RO membranes into the

pushing unit.

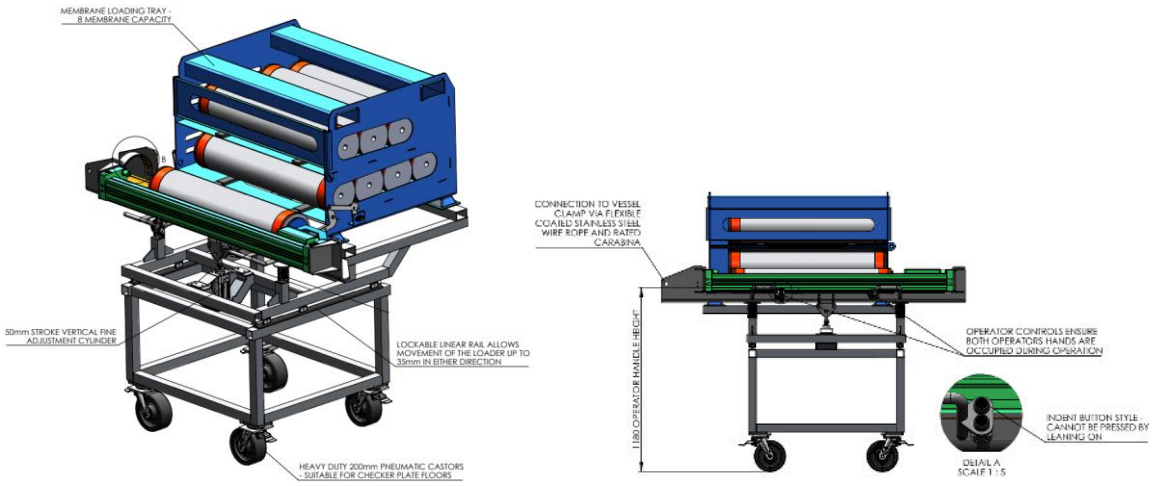

Figure 2: ***Diagram of the RO Membrane Loader and the RO Membrane Cartridge***

Along with other equipment and accessories, Neumann Contractors also manufactured a purpose-built table to unpack the RO membranes, scan serial numbers, lubricate the brine seals and fit the interconnectors before loading into the membrane cartridges. This is part of the developed workflow which also considered efficiency and safety for the process steps prior to loading.

2.4 Workflow Summary

Once all the permeate pipework and end caps have been removed the used RO membranes are ready to be removed, and the new ones loaded. The clamps are fitted on pressure vessels on the loading side and RO membrane preparation activities can commence. The RO membranes are fitted with the interconnectors (7 of the 8) and the brine seals are then lubricated with Glycerine and then rolled into the membrane cartridge. A purpose-built ‘cleaning pig’ is soaked in water and Glycerine and placed into the membrane cartridge, ready to be transported to the RO membrane loader for loading.

The membrane loader is attached to the clamp system fitted on the pressure vessel with industrial carabiners and aligned. The prepared RO membrane cartridge is mounted on the membrane loader, ready for loading.

The operator first places the cleaning pig against the first used RO membrane visible from the loading side. This pig is pushed in to clean (water) and lubricate (glycerine) the pressure vessel along the way. The first new membrane is then fed into the unit and pushed into the pressure vessel, pushing out one used element on the other side of the vessel. The process is repeated until the cleaning pig is retrieved on the receiving end, indicating that all used RO membranes have been unloaded.

The end cap on the receiving end is refitted and when confirmed and communicated, the membrane loader operator can drive the last RO membrane into the pressure vessel and with the help of a ‘push pig’ against the end cap on the other side. The push pig is retrieved and the end cap on the loading end is refitted, completing the loading process. Once all the RO membranes have been replaced on the RO train and all end caps refitted, the permeate pipework are reinstalled.

2.5 Membrane Replacement at GCDP

Second Pass BWRO Membrane Replacement was an opportunity to test out the membrane loader and the workflow developed to enable the use of the device and the team was met with challenges. There were numerous BWRO membranes with enlarged brine seals in the pressure vessel which saw the force required to push to be much higher than the design which was based on the force test results. The membrane loader was unable to push the membranes with enlarged brine seals out, which required forces of greater than 180kg. The team had suffered significant setbacks due to these, presenting risks to a timely project completion.

The first Second Pass BWRO train was the slowest run as the team was getting to understand the workflow around loading (preparation) and learning the loading device itself. The team progressively got a higher average daily load rate and hit a record of 54 pressure vessels in a day, which is much higher than the target of 30 vessels per day. Despite this, the team had to make a few variations but was still able to complete the replacement of the Second Pass BWRO membranes on time. All this was done with no rework or leaks associated with the membrane loader (e.g. rolled interconnector o-rings). Refer to Figure 3 for the RO membrane loader in use during this replacement period.

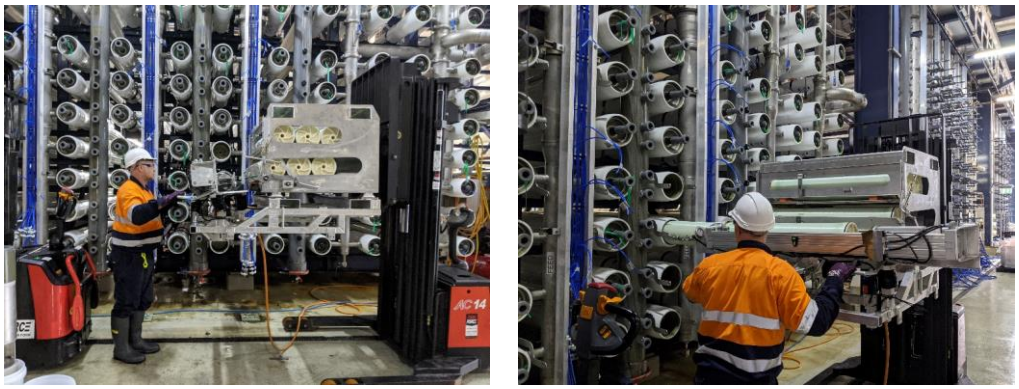

Figure 3: ***RO membrane replacement with the semi-automated membrane loader***

The enlarged brine seal issue was found to be unique to Second Pass SWRO Membranes and this is believed to be due to quality issues of the RO membrane parts delivered dating back to plant commissioning. The loading of the First Pass SWRO Membranes went smoothly with a record of 58 vessels loaded in one shift. There were more minor rework/leaks observed but they were associated with the end caps and the permeate pipework fitment, not with the membrane loader itself i.e. no damaged or crack interconnectors. No major reworks were required prior to commissioning of the train.

3.0 CONCLUSION

A collaboration between Veolia and Neumann Contractors saw the development of an RO membrane loader which was utilised during the full RO membrane replacement at GCDP. Buy-in from all parties was able to be obtained due to the novelty, significant reduction in manual handling risks (as observed) and minimal rework which has been proven historically by other sites to be costly.

The use of the membrane loader at GCDP saw an overall loading efficiency that is comparable to manual loading – some days exceeding the set baseline rate – which resulted in a timely completion of the project with minimal rework. No rework was associated with the loading or the use of the membrane loader itself, but most importantly with there were 0 injuries throughout the project.

The robust workflow the team developed is as important as the membrane loader and as critical to carry out the work. In reality, the process that was developed enabled the use of the membrane loader allows work to be adopted by any team and at any site; not just at GCDP.

The replacement of the RO membranes using the semi-automated membrane loader is arguably the first step in the right direction. The team was able to trial the loader during the Second Pass BWRO Membranes, and refine the workflow and equipment for the replacement of the First Pass SWRO Membranes. The next step is to improve, develop further and share to industry to consider using the tool to mitigate risks from manual handling, as appropriate. There should be no compromise in quality and with proper planning and scheduling, the method and equipment should be considered for future jobs.

4.0 ACKNOWLEDGEMENTS

We thank Tina Feenstra (Veolia) for initiating and for obtaining buy-in and approvals from stakeholders to launch this project. We also thank Scott Murphy (Veolia) and Vinay Muppala (Veolia) for sponsoring the initiative and for providing design considerations. We thank Daryl Harding (Veolia), who as Project Manager of the RO Membrane Replacement at GCDP endorsed the development of the RO Membrane Loader and managed project delivery risks associated with its use. We am immensely grateful to Filippo Vico (Veolia), Gilles Beurton (Veolia) and Mark Thompson (Emerald Process Engineering) for providing technical support and design inputs which were key to the RO membrane loader. We thank Ryan Green, Wayne Buckleton, Hans van der Zouwen and the extended Neumann Contractors team for taking on all challenges head on and for engineering solutions in all shapes and forms – from smart equipment to robust systems – to deliver at a high standard.