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Gold Coast desalination plant commissioning and operation after one year with isobaric ERDs

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ABSTRACT

One year after successfully commissioning the Gold Coast plant in Tugun, Australia, the performance of the plant is well above expected values. This performance is in part attributable to the DWEER™ energy recovery device whose efficiency is significantly higher than contracted values. One component to this success is the DWEER controllability which has allowed the customer to operate the plant over a wide range of flows to suit the desired output. The controllability of the Dweer also optimizes the efficiency at each flow condition. A number of challenges where encountered, but they were overcome in conjunction with the customer during the commissioning phase.

Keywords: Energy recovery devices; ERD; DWEER; Efficiency; Controllability; Challenges; Commissioning

1. Introduction

The Gold Coast desalination plant (Fig. 1) located in Tugun, Australia, was built by the Gold Coast Desalination Alliance (GCDA), an alliance of John Holland Pty Ltd., Veolia Water, and Watersecure. The construction of the RO plant started in November 2006 and the first water was produced in February 2009.

The plant was constructed to supply a maximum of 133,000 m^3/d (35 MGD) of drinking water, which is approximately 20% of the South East Queensland's water needs. Commissioning of the Energy Recovery Devices (ERDs) was completed in July 2009 with a successful performance test. In February 2010, a second detailed performance test was also completed as part of proving trials.

The project scope incorporated two additional components — a pipeline an intermediate pumping station and inlet and outlet to the ocean. Neither of these components are discussed in this paper.

The RO facility is comprises a 1st pass and a 2nd pass. The 1st pass is divided into nine equal trains, each containing a set of membranes, recirculation pump and an ERD. The ERD used in this facility is a quad Dual Work Exchange Energy Recovery (DWEER™) featuring 4 DWEERs located above each other in a single rack to limit the footprint of each train.

2. DWEER performance and efficiency

Testing of the inlet and outlet flow salinity, recording of pressure losses and leakage show the DWEER's performance is on average 29% better than the required performance values. This amounts to an additional savings to the client of \$160,000/y (assumed energy cost of 8¢/KWh and 80% utilisation) above the savings anticipated from the ERD.

The methodology used to calculate the overall performance is presented in a Calder™ paper [1]. It relates how hydraulic pressure losses across the DWEER (HP and LP) are added to the leakage (loss of HP brine), mixing (brine

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Fig. 1. Gold Coast desalination plant [Water secure fact sheet "Desalination"].

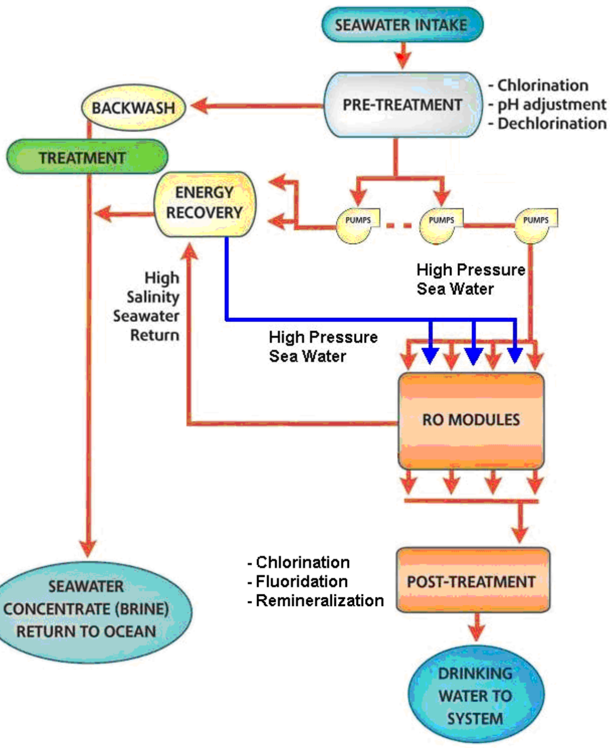

Fig. 2. Simplified schematic of desalination process.

into seawater) and Overflush (seawater into brine). Each of these five losses is weighted depending on the energy impact of each loss. A final real efficiency can then be calculated and compared against energy consumption.

It should be noted that ALL losses, both primary and secondary, are calculated in this manner. This method is therefore not limited to just hydraulic losses.

3. Commissioning: lessons learned

A great deal can be learned from the commissioning of RO systems.

3.1. Air entrainment

During commissioning air was not completely purged from the feed water. This air became entrained in the system and contributed to heavy knocking at the DWEERs during depressurization. Air creates additional forces due to expansion when depressurizing. No damage or failure was identified on the DWEER or within the rest of the RO system during this period. This confirms the robust nature of the DWEERs as few other devices could withstand this level of entrained air.

Calder recommends that all air is purged from any RO system. During commissioning it is recommended that RO systems are not operated for prolonged periods until the air is purged, in order to avoid damage to other parts of the RO system such as membranes and pumps.

3.2. Smooth flow

To maintain a smooth flow in the RO system with a discrete device such as the isobaric work exchanger, a number of methods are used to prevent flow changes and therefore pressure variation. The DWEER utilizes four methods to reduce pressure variation during the changeover from one vessel to another:

3.2.1. Over lapping the opening and closing of vessels

The HP flow is most critical in the RO process as this will affect the membranes and HP pump. In order to minimize any variations in flow, each vessel changeover has a

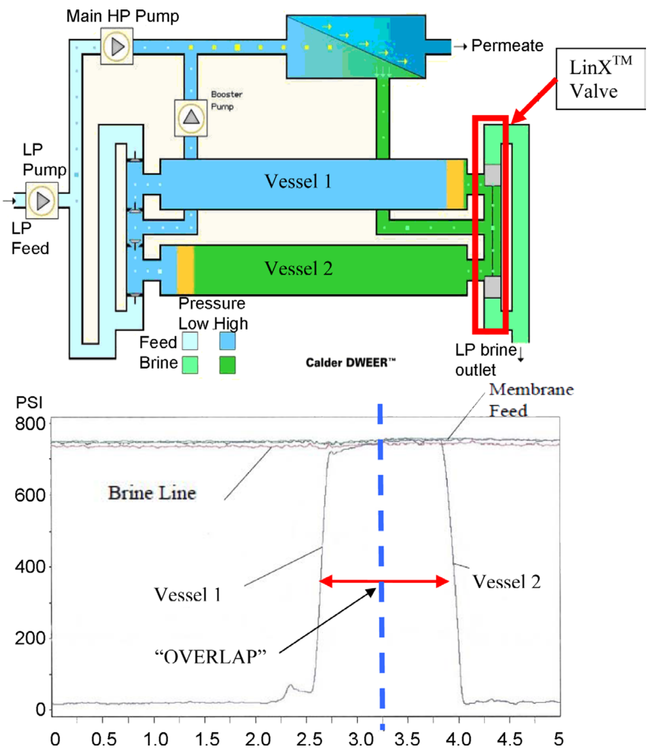

Fig. 3. Overlap pressure trace (dotted line shows valve position related to schematic above).

small element of overlap between vessels. This means that both vessels are open simultaneously for a brief period. That is, the vessel that was closing is still open when the second vessel is opening. This ensures that the HP loop is never dead headed which would create a pressure pulse.

Fig. 3 shows the vessels in mid-transition where both vessels are still partially open. The graph shows the pressure change in the vessels and resulting constant HP pressure on the membranes.

3.2.2. Piston nose

The shape of the valve and piston (piston nose area) determine how smooth the flow starts or stops. The LinX piston is designed with a small nose at each end that throttles flow specifically to minimize any disturbance as the valve opens and closes (Fig. 4).

During commissioning it was found that the nose profile of the LinX valve created a pressure pulse from the DWEERs which is not desired.

A new nose profile was developed and parts installed, eliminating any significant pressure pulse. As a result the system now has little or no pressure pulsations as the LinX valve now opens and closes flow smoothly from start to finish. This upgraded nose profile will be utilized in all future projects.

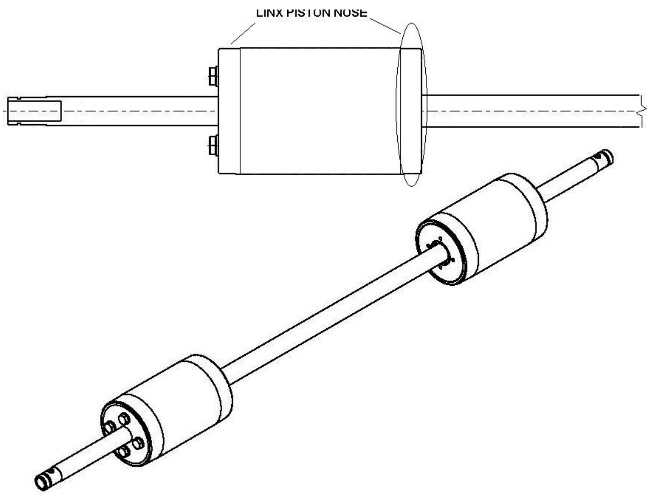

Fig. 4. LinX piston nose.

3.2.3. Changeover speed

The speed of the changeover is set by the number of cycles per minute that the vessels must be changed over to meet the desired flow rate. In the new PLC program, as the flow rate is reduced so is the changeover speed.

3.2.4. Control software

The control software can provide adjustment by stopping the movement of the valves midway to reduce the sudden effect of the valve opening and closing. The control system can also vary the timing at which the valve moves.

3.3. Flow range

It is quite common for projects to have several duty points as RO plants are not always at full production. Originally this project had only two set flow rates; therefore the DWEER control system was designed with these rates in mind.

The default and fail safe control system for the DWEERs allows for basically any flow variation by maintaining the standard fill time between vessel changeovers. As the flow rate varies, the amount the vessel actually fills changes, i.e. if the flow rate is reduced then the vessels are simply under utilized. This method is very robust, but it is optimized to the design flow rate and does continuously optimize to the current flow rate.

During commissioning it became apparent that the plant would run regularly at any number of intermediate flow rates and could be varied weekly. Rather than running at a duty point and accepting the loss in efficiency, Calder decided to implement an optimization program. In order to recover this additional efficiency, a small PLC program was written to change the timing of the vessel changeover as the flow rate changed. The controllability of the DWEERs' cycle speed allows for the devices to simply slow down as the flow rate is lowered to save both energy and wear. Mixing increases the more times an isobaric vessel is switched, the slower operating speed also results in lower mixing rates. The optimization program works on an internally measured and calculated flow rate or from a flow rate supplied by the customer. Should a failure occur the default design condition is applied and the flow variation is accomplished by vessel utilization as detailed earlier.

With this controllability and tolerance to flow variation, the system has the capability to not only control the output of the plant by turning trains on and off, but can also change the flows in each train to achieve the desired output. This also allows optimization of each train as the membranes age.

This is an important feature as this plant and many others are being used to maintain water supply on varying demand factors. The site is given a particular demand from the network and can readily adjust the flow throughout the plant to achieve the desired flow rate.

3.4. DWEER connection piping

A sample piping layout is shown in Fig. 5. The connections can be made in a number of different configurations described in our design literature.

Due to the low operating speed, the DWEER system is particularly tolerant to pipe induced imbalances which can be resolved by any of the methods mentioned in paragraph 3.2. As the system is controlled by a centrally timed PLC, flow imbalances only create areas of inefficiency rather than resulting in damage to or failure of the ERD. Once a significant imbalance is identified in commissioning (and hopefully avoided in design) several methods can be used to reduce the impact of the piping.

3.4.1. High pressure piping to the LinX valve

Imbalances in flow should be avoided in design or can be corrected during commissioning with a number of different methods. When an imbalance occurs very close to the LinX valve, turbulence is created that is difficult to correct (see Fig. 6 for details).

Calder is currently investigating the use of flow straightening elbows for installations where imbalances are found due to site layout restrictions etc. This solution is not new, many pump installation have had to install this form of piping adjustment in order to ensure correct entry into the pump suction. It should be understood that this type of correction is not optimal but this solution may recover some of the efficiency.

There are several methods used in flow straightening elbows. Many designs are available and are able to correct most problems. The most complex elbows feature multiple vanes throughout. The simplest have only one vane at the exit to the elbow and can easily be retrofitted.

At sites where an imbalance occurs and a simple form of flow straightening is implemented, the straightening of the entry flow is likely to reduce under-flush (mixing) and over-flush. This can amount to a savings of $60,000/y (assuming 80% utilisation with an energy cost of 8c/KWh) in a plant of this size.

3.4.2. Low pressure brine piping

It is also important that the speed of all flows is kept relatively low, at about 3 m/s or 10 ft/s. This not only

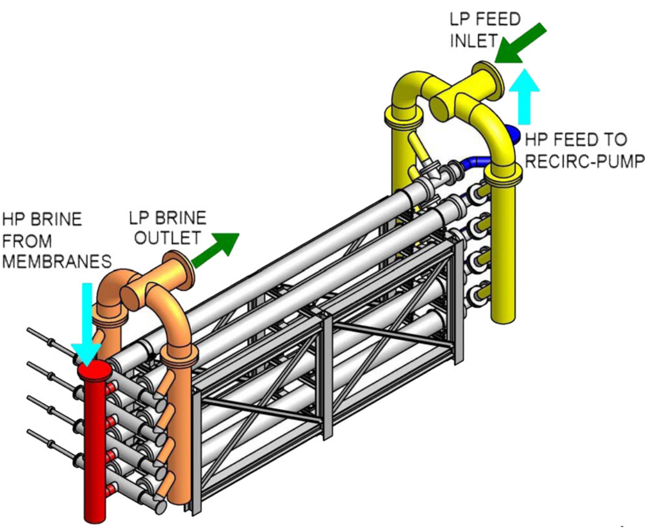

Fig. 5. Standard piping layout.

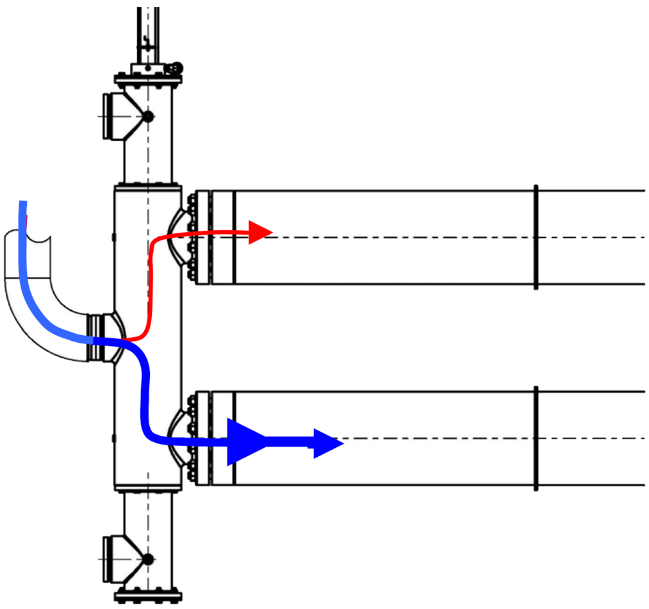

Fig. 6. Imbalance in flow in each vessel (due to turbulence from elbow on the same plane).

reduces pressure losses but also reduces the turbulent effects created at entry.

It is especially important that the velocity of the LP brine leaving the LinX valve be kept at or below the specifications. If the piping internal diameter is too small, it will restrict the exit to the LinX valve and will affect the performance of the DWEER. In particular polyethylene (PE) pipe has many different wall thicknesses which can create reduced internal diameters.

4. Operating performance after one year

The site now has been operating for over a year and the ERD performance can be evaluated over time.

4.1. Performance

Two performance tests were conducted during and after commissioning. The performance tests were separated by six months. The results show that the efficiency did not deteriorate after commissioning and is expected to remain high for the life of the equipment.

4.2. Low noise

The DWEERs remain relatively quiet at below 83 dBA. In general, the noise created around the DWEERs by other equipment (such as recirculation pump and back pressure devices) far outweighs the noise created by the DWEER. The noisiest part of the DWEER is in fact the electric motor of the actuator. With the exception of a small number of pistons the DWEER vessels and LinX valve basically work without creating significant noise.

4.3. Smooth operation

During commissioning precise monitoring of pressures was conducted by Calder to determine if there were any problems within the DWEER or within the remainder of the RO system.

The DWEERs operate at a smooth flow with little or no significant pressure changes. Fig. 7 shows a pressure trace taken at 100 ms intervals over a 3-min period at the end of commissioning, showing basically no pressure changes or flow variations.

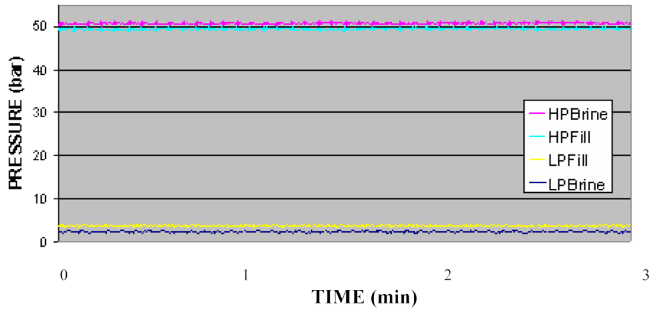

Fig. 7. Smooth pressure trace of DWEER sea water feed and brine.

4.4. Remote access

On a few occasions Calder has been requested to view the DWEER PLC via a remote connection to determine a fault or download data from the PLC. This remote connection and the ability to monitor the data stored in the PLC provide a high level of confidence that should a problem occur it can be resolved without delay. Remote access is a tool that is offered on all projects to assist the client to optimize utilization of the ERD.

5. Conclusion

Several conclusions can be drawn from the commissioning and operating activities associated with the ERDs in the Gold Coast desalination plant:

- The DWEERs continue to operate at efficiencies significantly above expected values, resulting in a reduction of operating costs.
- The DWEERs are providing smooth and reliable operation.
- The DWEERs have been proven to be robust and able to withstand adverse conditions during startup which are not unusual on a plant of this size.
- Startup field support is very important to discover and rectify any operating conditions that are less than desirable prior to commissioning.

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