

DESIGN ENHANCEMENTS

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Abstract

The Calder Dual Work Exchanger Energy Recovery technology, or DWEER™, was developed specifically for the SWRO desalination process more than 20 years ago. Recent upgrades include a new larger size for an increase in capacity to 350m³/hr (1550 US gpm), and the introduction of FRP vessels. These have been well received by the marketplace, and applied in some of the largest installations around the world.

The engineers at Calder and Flowserve have been busy refining the DWEER operating systems to address a coverage gap limiting its application in smaller installations. This presentation introduces a new smaller energy recovery device along with design enhancements for the DWEER system that expands the application range of the product line into those smaller SWRO units.



I. INTRODUCTION

It is the goal of Calder GmbH, A Flowserve Company, to continuously improve the design of the DWEER work exchanger product. Our objectives are: to achieve better efficiencies; to further reduce the power consumption; and to manufacture the product more economically.

Making potable water more affordable involves increasing equipment and system efficiency while also reducing specific power consumption. It is equally important, however, to minimize life cycle costs over the life of the plant. The change in desalination project structure from public projects to 20-25 year BOO or BOOT contracts – especially for large capacity projects - supports this goal.

Therefore, it is not just a question of efficiency, but also of durability, robustness and low cost maintenance. This paper details the improvements Calder has achieved over the last several years which are being implemented in a number of existing installations and with all future projects.

II. NEW PRODUCT RANGE

Over the last decade, the DWEER product has changed little. Calder never developed larger or smaller models. Smaller installations received the same product supplied to some of the biggest projects in the world, such as Ashkelon, Singapore, Sydney, Aguilas, etc. This very successful product is most economical for capacities of about 250 – 350 m³/h (1100 – 1550 US gpm) of brine flow per DWEER.

However, for smaller plants and retrofits a smaller DWEER would be more economical for capital as well as life cycle costs. Now, as part of an expanded product range, Calder has developed a smaller DWEER with an optimum capacity of about 150-250 m³/h (660 – 1000 US gpm). Chart 1 shows the range chart of the currently available DWEER models:

DWEER Model	Typical flow range		Comment
D 1550	250 – 350 m ³ /h	1100 – 1500 US gpm	All installations before 2010
D 1050	150 – 250 m ³ /h	660 – 1100 US gpm	New Product

Chart 1: DWEER range chart

Calder is also developing larger models of the DWEER. If the market continues to build larger plants with bigger trains or even center designs, a larger model would be very economical and competitive.

III. IMPROVEMENTS TO DWEER D 1550 AND D 1050

3.1. Electric Actuator

Most of the DWEER references have hydraulic actuators installed to stroke the LinX™ valves. Hydraulic actuation has proven to be very reliable and easy as well as economical to maintain – not just for the DWEER but also in many other industrial devices and applications. A significant advantage of the DWEER is that the controls allow for fine-tuning of the device to site specific operating conditions, which often are unknown until after commissioning. Although the DWEER can be operated without such fine-tuning and the controls and hydraulics are only used to ensure the

switching of the DWEERs based on a fixed timer, field experience has proven that the controls can do much more than just drive the LinX valve. For example, the controls also allow for an easy adjustment to the operating speed in case of significant flow fluctuations. For better accuracy and controllability, electric actuators can offer numerous advantages. To this end, Calder has developed a DWEER with an electric actuator (Figure 1).

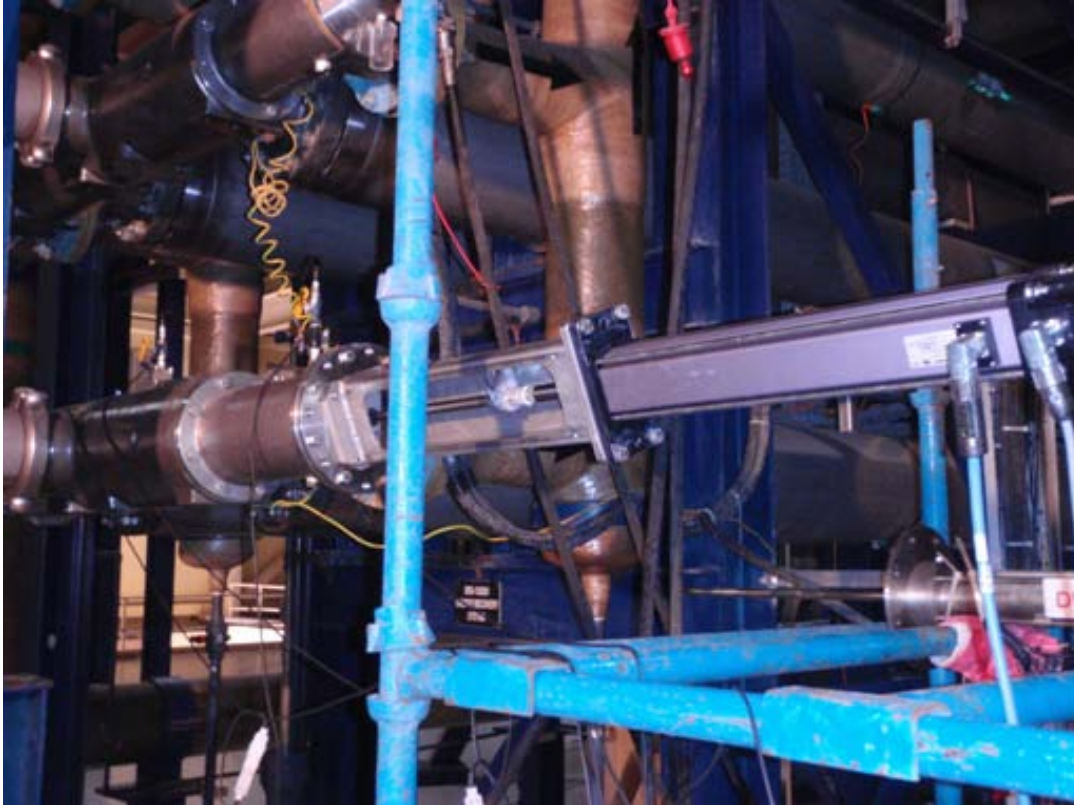


Figure 1: DWEER with electric actuator

After internal testing, an electrical actuator was field tested in Dubai at the Palm Jumeirah plant. The initial test results were very promising and as a result, Calder has decided to retrofit some existing DWEER installations fitted with hydraulic actuators with the new electric actuators to gain long-term operating experience.

Today, electric actuators are offered as an option to achieve:

- Better performance (especially important for projects with a wide operating range to ensure optimal efficiency at any given condition).
- Better controllability with regard to monitoring and diagnosis.
- Smoother operation through variable actuator velocity (each process step can be performed at its optimum velocity in regard to performance and durability).

3.2. Vertical Installation

In the past, the DWEER was installed in many different orientations: most often horizontally in a rack next to or underneath the membranes; in center design racks; or horizontally against a wall.

Calder also promoted vertical installations. There are a number of advantages with a vertical installation:

- minimum food print
- good accessibility to maintenance areas
- improved efficiency due to lower mixing

As part of a retrofit order in 2010, Calder supplied the Las Palmas Plant, located on Gran Canaria, DWEERs that were installed vertically next to the membranes. The main reason for the vertical installation of the DWEER was lack of space availability (Figure 2 and 3).



Figure 2: Las Palmas vertical installation



Figure 3: Las Palmas FRP vessel

The objective was to fit the DWEERs in-between the existing membrane rack and the wall of the building. The installation was made in late 2010 and commissioning was completed at the very beginning of 2011. As a benefit to the customer, the power consumption of this installation was significantly reduced and actually was below the guaranteed 2.4 kWh/m³ product. Chart 2 shows the achieved values.

	Guaranteed	Measured	Normalised
Flow rate per device	192	200	192
Brine pressure at DWEER HP inlet	60	63	60
DWEER operating speed (cpm)	3.5	3.5	3.5
LPdp (bar)	1.0	0.7	0.6
HPdp (bar)	0.6	0.6	0.6
Leakage (m3/h)	0.4	< 0.4 (0.2% of Brine Flow)	< 0.4
Mixing (% over DWEER)	2.5	2.5	2.5
Noise (dBa)	Max. 85	< 80 dBa	
Power Consumption RO section (kWh/m3)	2.4	2.3	

Chart 2: Actual values of the retrofit compared with the guarantee.

3.3. FRP Vessels

Since the introduction of Fiber Reinforced Plastic (FRP) vessels in 2008, Calder has supplied non-metallic vessels for more than 24 units. Besides a cost advantage, the non-metallic vessels can also help to further improve the efficiencies as ID tolerances can be kept low and therefore the mixing (the contamination of feed water with brine) is reduced. To date, Calder has about one year of successful operating experience with FRP vessels in the field.

3.4. New LinX Piston Seals

Another improvement that was successfully installed in Las Palmas but also in other installations was the double seal design in the LinX Valve (See Figure 5). As result the leakage (or also called lubrication flow) of the HP Brine could be reduced to basically 0%. In Las Palmas the leakage became so small that it was not possible to detect it in the field at all. This is especially important as out of all the losses in a DWEER this is basically the only loss that could reduce the efficiency over time. So by changing this low cost seal the efficiency can be kept constant over lifetime of the product.



Figure 4: Double LinX Piston seal design

IV. NEW DWEER D 1050

4.1. Main changes

Our main objective for developing the new smaller DWEER D-1050 (Figure 5) was to be able to offer a standard product for lower capacity installations – whether new construction or retrofit – that would be more competitive with regard to capital costs. In addition, this new model provided an opportunity to incorporate the operating experience and design knowledge of all the existing projects in different plants from all over the world.

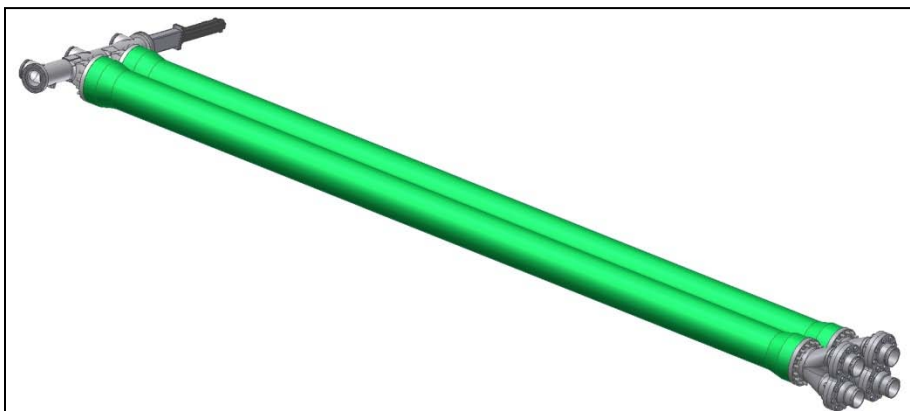


Figure 5: DWEER D 1050

The main design features introduced with the new DWEER D-1050 model are:

4.1.1. D- 1050 New LinX Valve

A new smaller LinX valve was designed with flow passages to achieve lowest possible HP and LP pressure losses. The number of component parts has been significantly reduced. The LinX piston is equipped with a double seal to ensure the targeted lowest leakage over the LinX stroke. Additionally, the electric actuator provides best possible controllability and simplicity.

4.1.2. D- 1050 Vessel

The new DWEER is furnished with FRP vessels, which are designed for low pressure loss and higher stroke volume. Due to tighter manufacturing tolerances, a lower mixing target can be achieved.

4.1.3. D- 1050 Check Valve

The new D- 1050 features a modified check valve design to ensure the lowest HP and LP Δp and to simplify the piping connections for the headers.

4.2. Performance

The performance that was targeted for the DWEER D- 1050 is:

	Design
Max. Flow (m ³ /h)	220
LPdp (bar)	1.2
HPdp (bar)	1.0
Leakage (m ³ /h)	0.5
Mixing (% over DWEER at 0% overflush)	2.5
Noise (dBA)	Max. 85

Chart 3: Performance targets for the DWEER D 6x400

A new test stand was designed and built (Figure 6) with the ability to confirm the above targets can be achieved. The test stand allows Calder to run the DWEER D 1050 at full design capacity and pressure. Currently, the company is endeavoring to further improve some of the operating parameters.

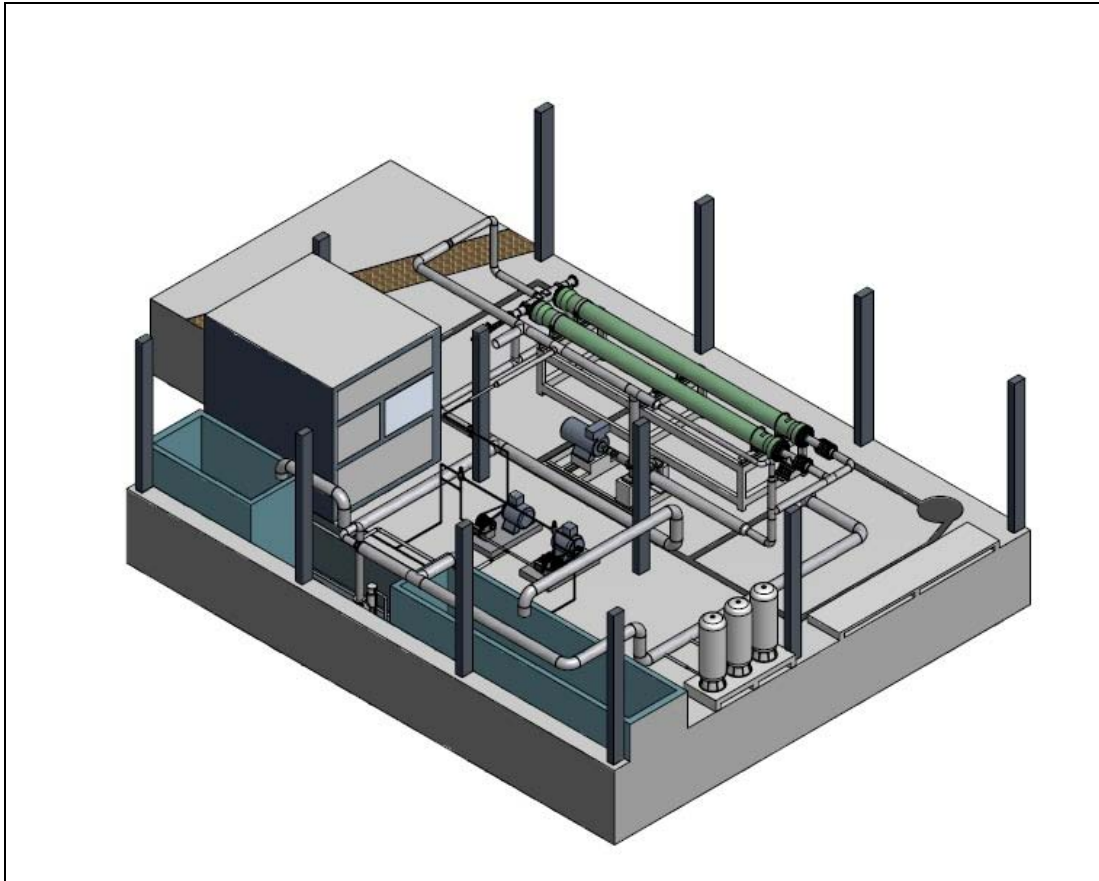


Figure 6: DWEER Test stand

Figure 7 shows the improved LinX Valve on the test stand. In this case we have installed the LinX Valve in a vertical position. An electrical actuator is controlling the stroke of the LinX Valve. In Figure 8 the improved Check Valve Nest can be seen. The HP Tee connecting the DWEER vessel with the two check valves was significantly improved with regard to flow passes. Additionally this design allows a much more compact design of the feed headers.



Figure 7: LinX on Test stand

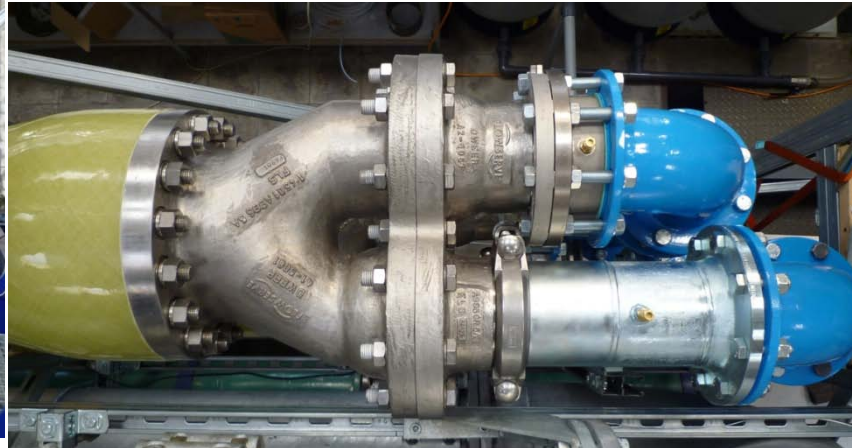


Figure 8: Check Valve Nest on Test stand

4.2.1 Differential Head

As know and presented in many other papers and technical articles the efficiency of an Isobaric Energy Recovery Device is mainly affected by the following losses:

- Mixing
- Leakage
- HP dp
- LP dp
- Overflush

With values for mixing at 2.5% and for leakage at 0.3% of the Brine flow, the DWEER D-1550 already achieves excellent results. The focus for the DWEER D-1050 was to further improve Hp dp and LP dp. To achieve best possible results with regard to Head losses, efforts took place in two main areas:

- LinX Valve
- Check Valve Nest

Below in figure 9 a simplified cross section of the improved DWEER is shown. The main improvements were made in the connection between LinX Valve and vessels (area 1) and in the connection of the Check Valve Nest with the vessels (area 2). In these areas the design was improved to minimize cavities that create turbulences and to increase the cross section in order to lower the velocities.

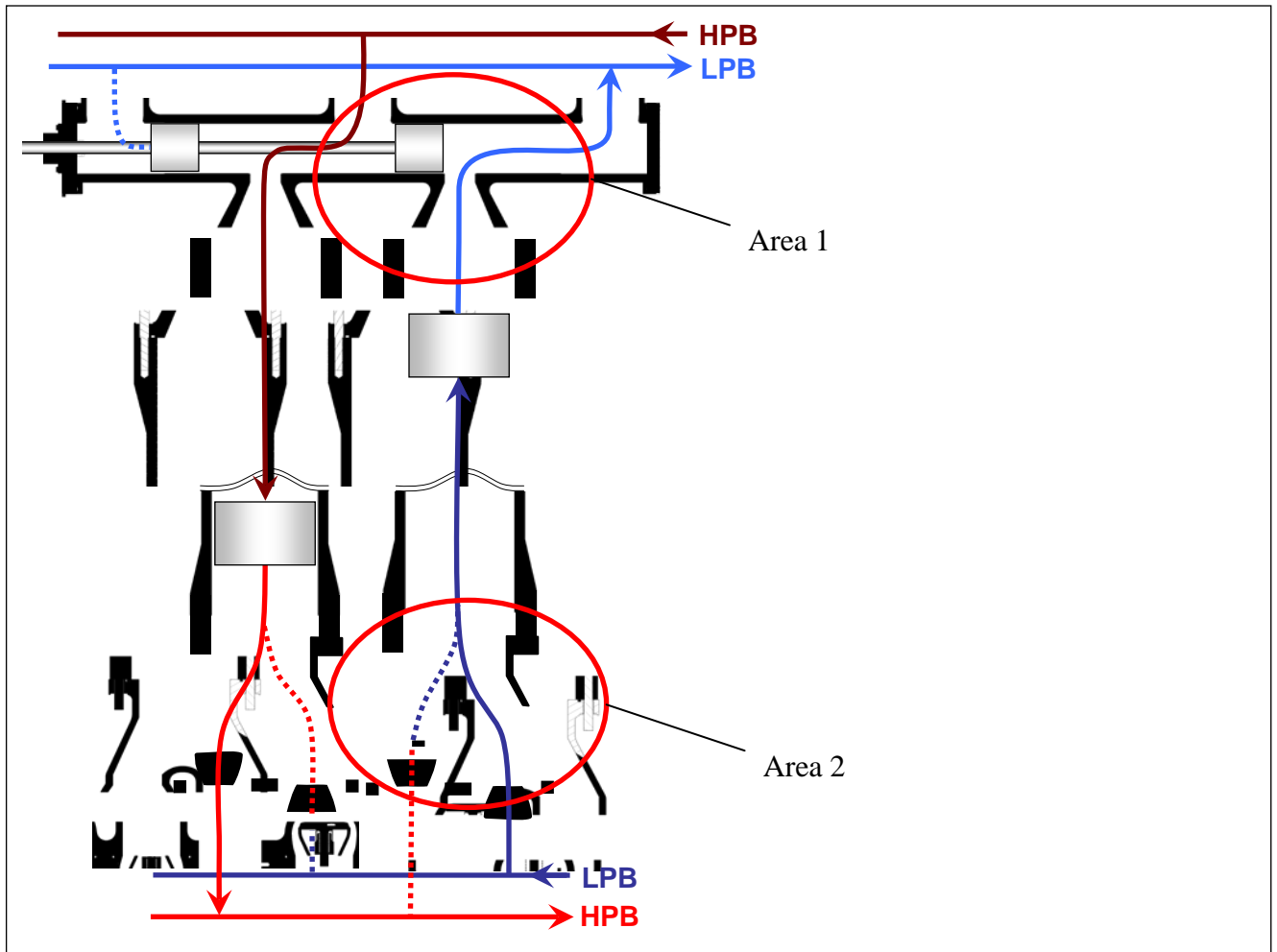


Figure 9: Working principle of new DWEER D- 1050

In these areas Flowserve Calder utilized the latest technologies such as CFD Analysis to improve the performance. Using a detailed CFD analysis the flow passage through the check valve nest and LinX Valve was significantly improved. Figure 10, Check Valve Side and figure 11, LinX Valve Side are showing examples of the CFD analysis carried out on the improved DWEER.

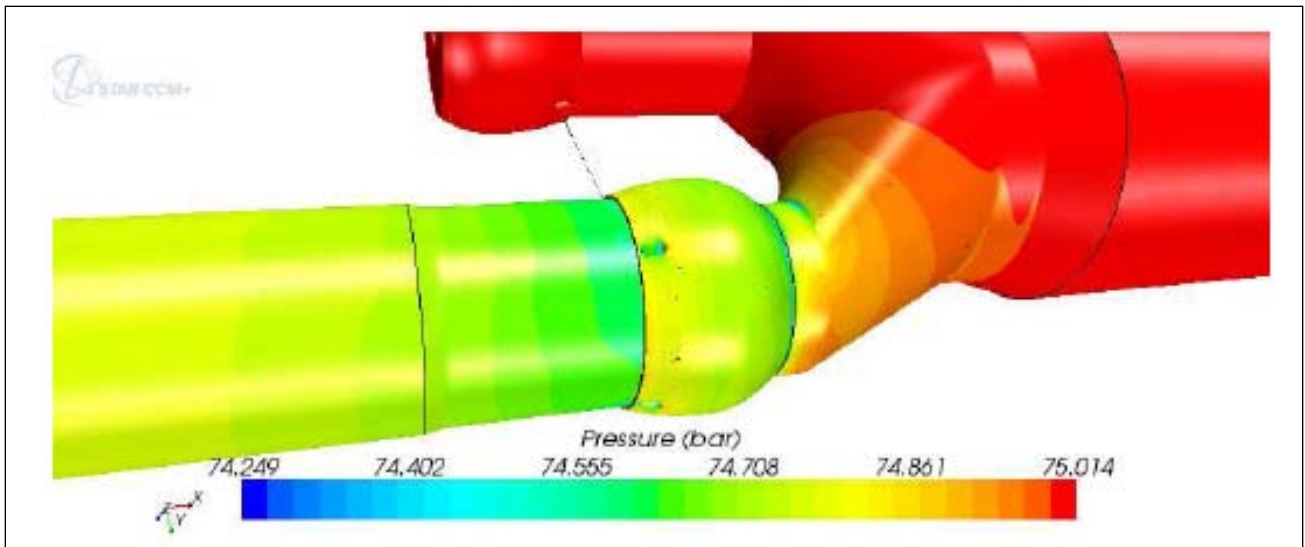


Figure 10: CFD Check Valve

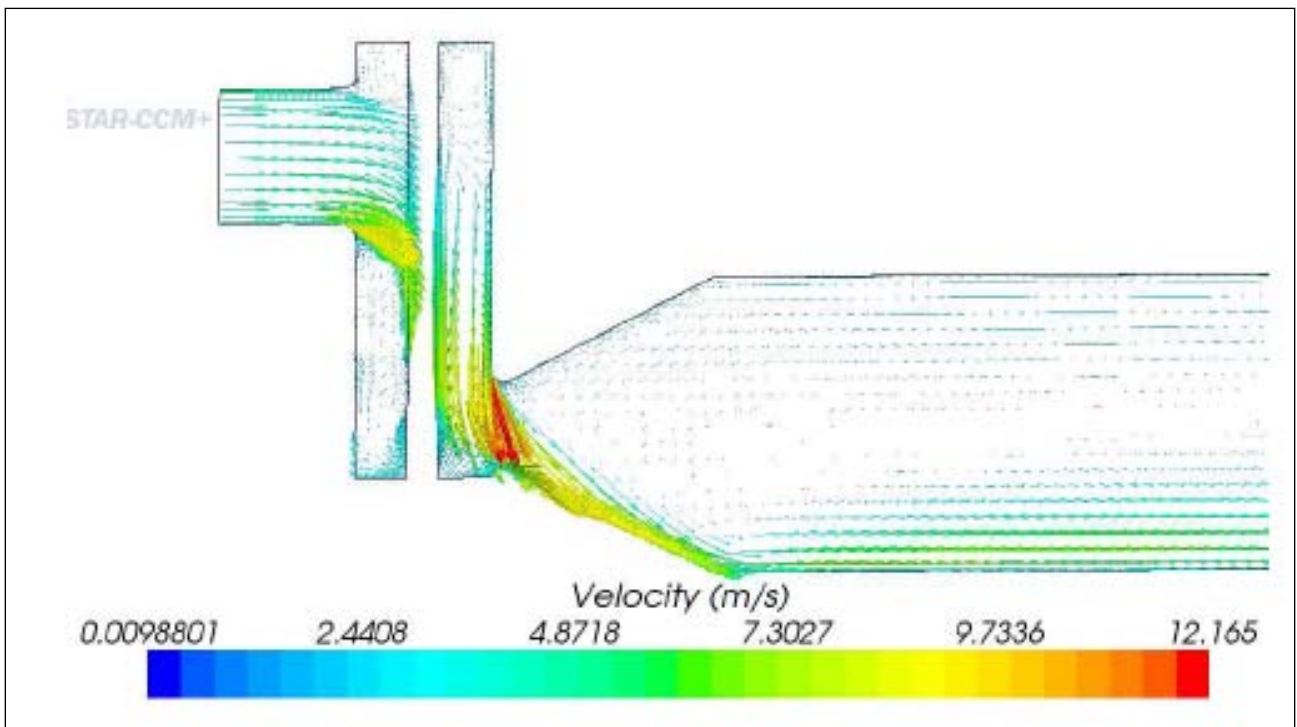


Figure 11: CFD LinX Valve

4.2.2 Test Results

In the test stand the DWEER was equipped with pressure sensors to measure the differential head. The below figure 12 does indicate the low pressure fill flow dp (dotted blue line) and the high pressure recovery dp (red line).

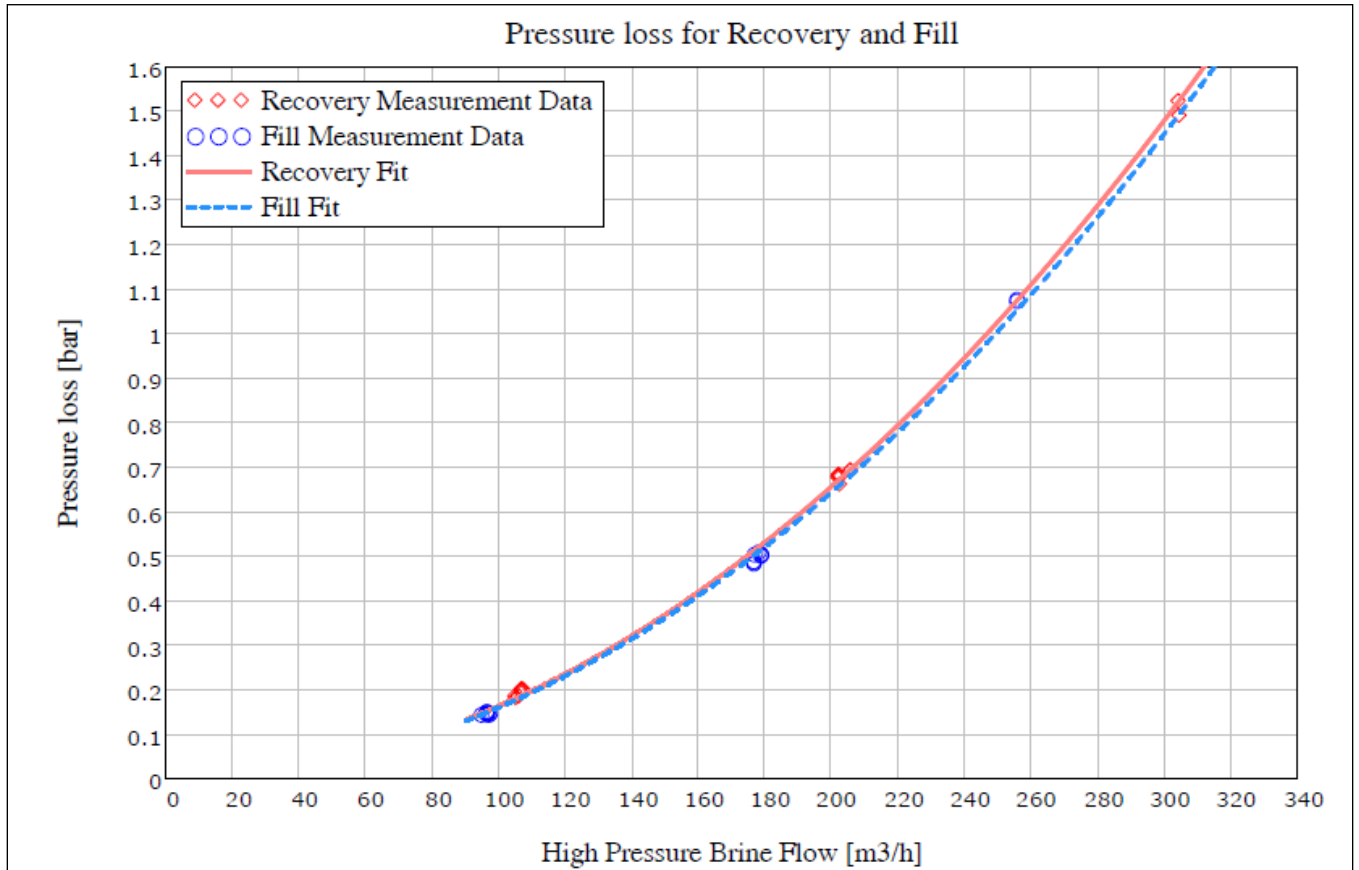


Figure 12: Hp and LP dp curve

The results were very impressive and the readings clearly below target of 1.2 bar for LP dp and 1.0 bar for HP dp. At the design flow of 220 m3/h the values measured were as low as 0.65 for HP and LP. The HP dp is about 40 % and the LP dp about 50 % lower than the specified values.

The results demonstrated that with the improved DWEER D- 1050 flows up to 260 m3/h could be achieved while still meeting the specified dp requirements.

V. CONCLUSIONS

Calder continues to work diligently to boost the peak efficiency of the DWEER product line. With the ongoing improvements and new model described above, the target to make the product more competitive, economical, flexible, and easier to operate is being achieved.

Life cycle cost advantages include:

- Increasing the operating range. This is accomplished by increasing the efficiency over the typical SWRO operating range with the potential to easily fine-tune the product on site to the actual operating conditions using electric actuators.
- Extending durability and reliability. Design the product to exceed a lifetime of 25 years with little maintenance costs.
- Providing robustness. The product should be able to accept SWRO specific conditions to ensure highest possible online availability.
- Maintaining efficiency. Ensure that initial efficiencies remain constant over time with normal maintenance.

To reduce capital costs, Calder focuses on:

- Increasing the product range to ensure a good product/application fit
- Implementing new manufacturing technologies and materials to control or reduce costs