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Las Palmas' ERD experience

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ABSTRACT

A reverse osmosis seawater desalination plant on the island of Las Palmas in the Canary Islands has been operating successfully for more than 20 years. The original installation featured Calder™ Energy Recovery Turbines, which helped to drive the membrane feed pumps. At that time, this was the most efficient energy recovery method available, while offering the ease of operation because of the direct drive connection with the membrane feed pumps. The opportunity arose to retrofit the installation using isobaric machines in order to improve the efficiency and capacity of the installation. The DWEER™ was used because it had the highest efficiency available, and also fit in the restricted footprint available at the existing site. Flowserve provided a turnkey installation for the retrofit of all the relevant pumps and the Energy Recovery Device (ERD). The compact nature of the site and the overall length of the DWEER required a clever solution for the installation's packaging. This paper reviews the engineering solutions provided and compares the operating results after the conversion was completed, using data for three full years of operation incorporating some of the latest improvements of the DWEER.

Keywords: SWRO; Energy recovery turbines; DWEER; Isobaric energy recovery devices

1. Las Palmas III Desalination Plant: the story of a continuous improvement process

The Desalination Plant of Las Palmas III, owned by EMALSA, is located on a narrow piece of land surrounded by the Atlantic Ocean, a power plant and the main highway, which crosses the island of Gran Canaria from North to South.

The plant was built in the late 1980s and was put in operation in March of 1990. It has been working continuously for years "manufacturing" water for the islanders since then (Fig. 1).

One of the main characteristics of the Las Palmas III Plant, the one which differentiates it from all the others in the area, is the unwavering desire to continually upgrade equipment and procedures, which makes the plant and specifically, the people who manage and handle the plant, true pioneers in the market, being followed by the rest of desalination plants no matter where they are located.

In particular, this plant has always pursued ways to find the best and most efficient method to recover

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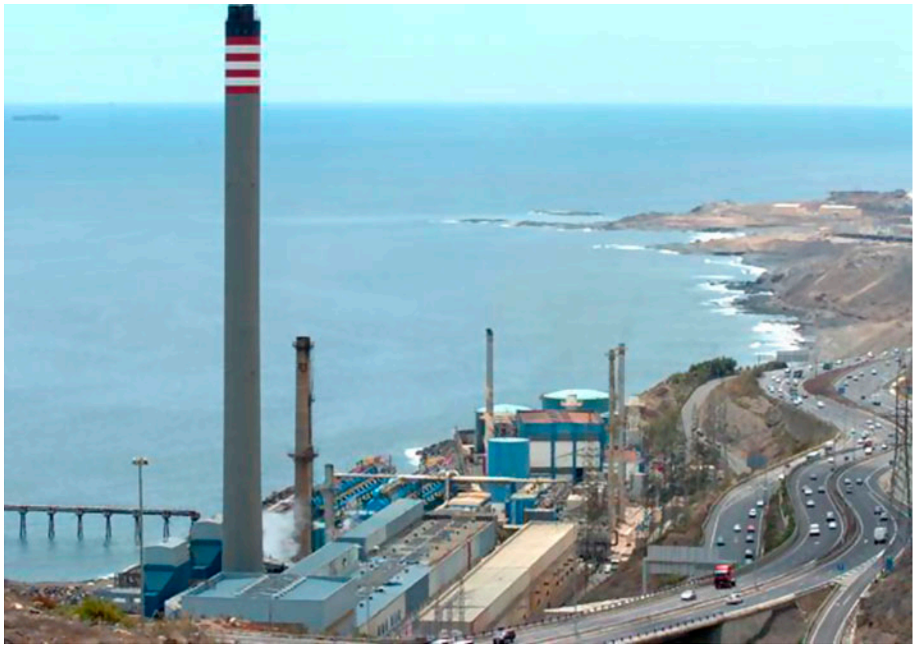

Fig. 1. Las Palmas III SWRO plant location.

the wasted energy of the reverse osmosis (RO) process. Starting with Francis turbines, continuing with Pelton turbines, and lastly with the isobaric type energy recovery devices, the quest to decrease the specific energy consumption has always been the goal of the plant managers and operators (Fig. 2).

The original production rate was 36,000 m^3/d (9 MGD). Over the years, the plant continued to expand and reached its current capacity of 86,000 m^3/d (81.5 MGD), making it the largest capacity plant of all seven islands which form the Canarias Archipelago (Fig. 3).

The latest upgrade of the system was carried out in 2010. At that time, the energy recovery devices used were Pelton turbines, which already had been improved with high-efficiency wheels and other features during their long and successful lifetime. The upgrade not only consisted of replacing the existing ERTs with isobaric chamber type Energy Recovery Device (ERD) and all that it implied, but also re-engineering the traditional RO layout with an innovative and never before seen layout. It was designed to optimize the plant by increasing the permeate production at the same time that the consumed energy was reduced to the lowest possible number in the industry.

This new design was internationally patented in 2011 (with the number WO/2013/057328) [1] under the authorship of several members of the EMALSA technical team (Mr Falcon, Mr Curbelo, and Mr Lemes), and its implementation in some of the racks has been successfully operating since.

The patent abstract states:

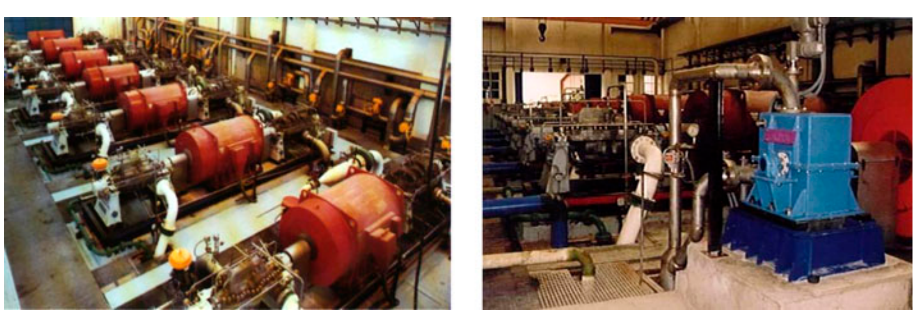

Fig. 2. Original plant layout with Francis ERT's and first retrofit to Pelton type ERT's.

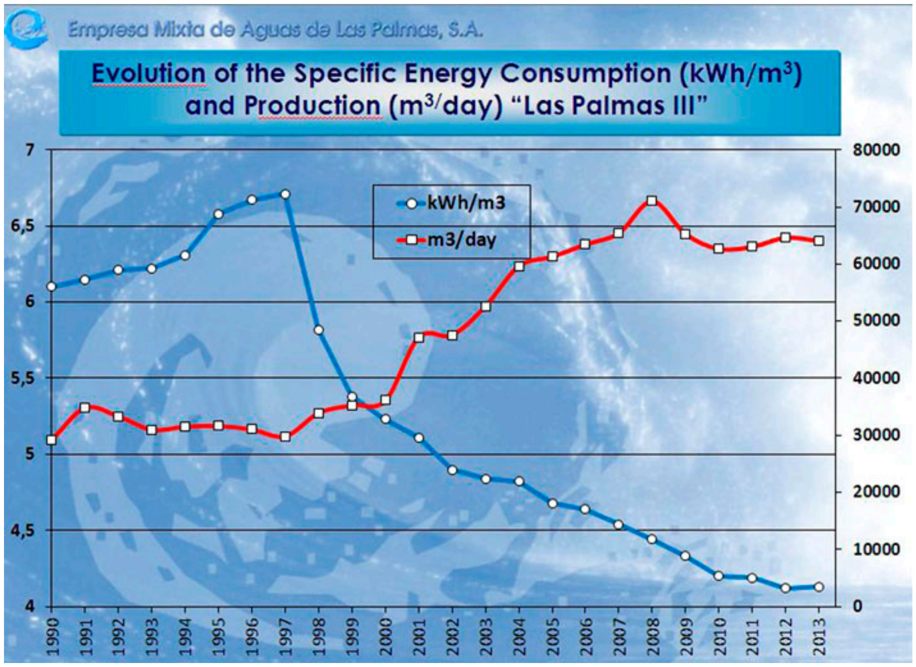

Fig. 3. The energy cost to produce 1 m^3 of potable water from 1990 to 2013 initially increased from 6.10 to 6.71 kWh, and then decreased to 4.13, while production more than doubled (source: EMALSA).

> The brine in the first stage (5) is pressurized using a booster pump (13) and enters the second stage (15). The brine from the second step (15) is carried to the high-pressure intake of an isobaric chamber (6) having a low-pressure seawater intake (26) and in which the high-pressure seawater outlet is connected to a booster pump (14) which carries the water into the second stage (15) which receives a mix of seawater and brine from the first stage (5). The desalinated water of the two stages combined comes out via a pipe (29).

The numbers of the new design are indisputable: the conversion factor, or the percentage of sea water converted into fresh water, has remained at values higher than 50% and the specific energy consumption for the HP pumps with ERD have decreased to 2.30 kWh/m^3 of produced fresh water, which represents an annual energy savings of 3,657,500 kWh, the equivalent of sending around 2,200 tons of CO_2 per year into the atmosphere (Fig. 4).

2. Equipment details

All the high-pressure pumps installed in Las Palmas III are Flowserve model 6x13DMX-5 stages. In this specific upgraded rack (Bastidor 1A), the HP pump has been hydraulically rerated by Flowserve Services and Solutions to deliver 392 m^3/h (1,725 gpm) from the original 560 m^3/h (2,464 gpm) with a minimum loss of efficiency.

The new energy recovery device, which replaces the existing Calder Pelton turbine, is a duplex DWEER model D-1550 with a nominal flow of 415 m^3/h (1,827 gpm). The combined permeate rate of the racks is around 400 m^3/h (1,761 gpm), which means almost 10,000 m^3/d (2.5 MGD) with a combined conversion factor of 50% and a specific energy consumption of 2.22 kWh/m^3, as shown in Fig. 5.

One of the challenges that the owner had to face at the time of the new design implementation was the reduced space that remained after the erection of the two membrane racks, new booster pumps, pipes, and accessories to install the ERD. Thanks to the versatility of the DWEER units, the required footprint needed for installation became minimal when the units were placed in vertical position. The two DWEER units in Las Palmas III were installed in vertical position between the membrane rack and the plant's surrounding walls, optimizing the small available space (Fig. 6).

3. DWEER 1550

The DWEER 1550 used in Las Palmas included new design features, which further improved the performance, overall efficiency, and reliability of the equipment.

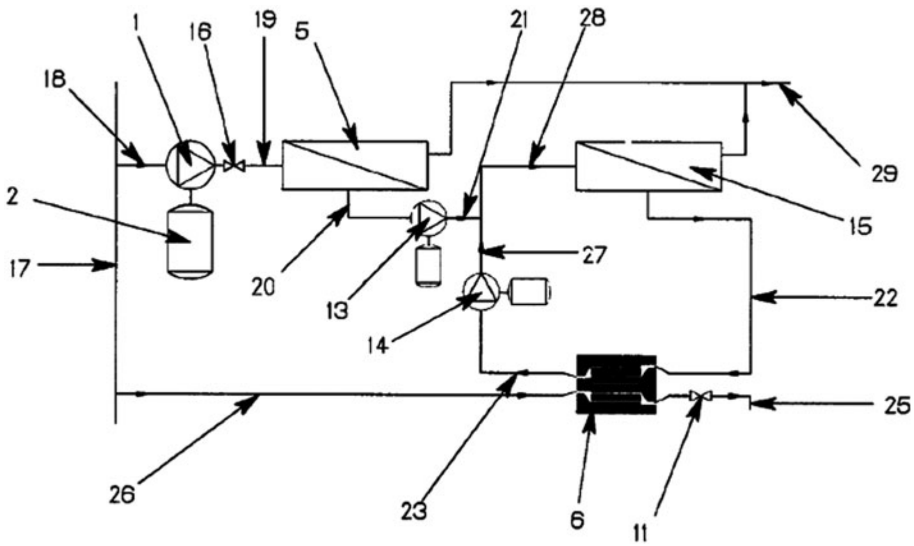

Fig. 4. Flow diagram from patent number WO/2013/057328 [1].

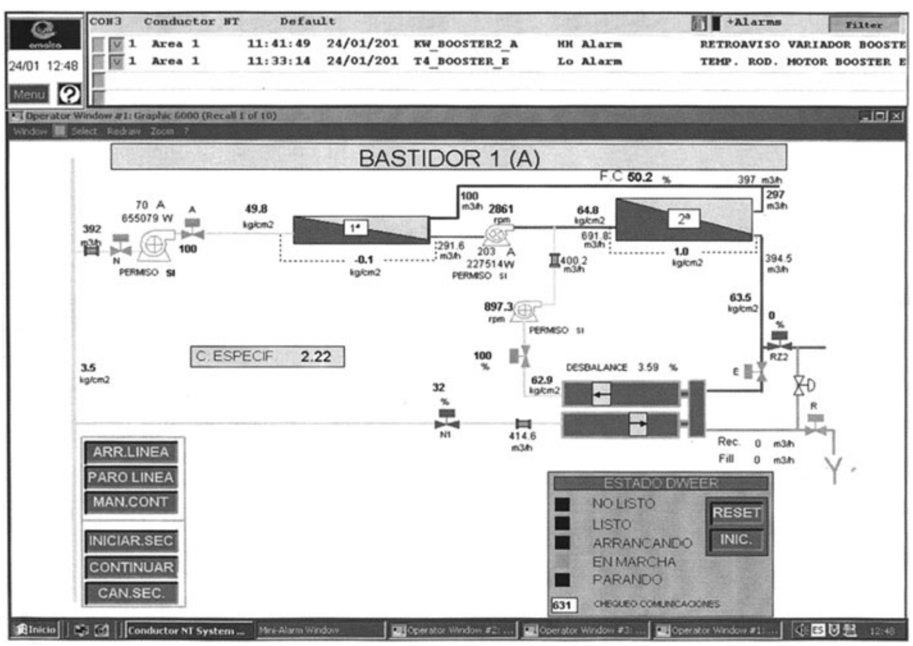

Fig. 5. Actual screenshot from control room panel for Rack 1(A).

3.1. *LinX™ valve*

The DWEER 1550 LinX valve installed is equipped with an improved hydraulic that allows lower differential heads, and therefore improves the hydraulic efficiency. In addition, the sealing technology using captive pressure-balanced seals does ensure zero leakage. The installed LinX design with the upgraded double-glide sealing rings has provided excellent performance for more than three consecutive years of operation with no leakage, and no maintenance has been required to this part (Fig. 7).

3.2. *Vessel*

The DWEER 1550 installed in Las Palmas was the first DWEER utilizing fiber-reinforced plastic (FRP)

Fig. 6. Construction of the new membrane racks and equipment with the DWEER installation in vertical position. Note the Lynx™ control valve mounted underneath.

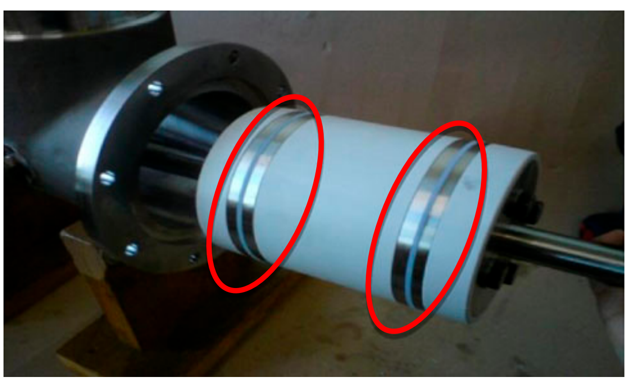

Fig. 7. LinX valve piston. Note the double-glide sealing rings.

vessels in commercial operation. During almost four years of operation, the FRP vessels provided excellent performance with zero downtime. The development of the FRP vessels for the DWEER equipment and its specific requirement provided technical as well as commercial advantages. All the expected improvements with the FRP vessel fulfilled, and even exceeded expectations. Besides the obvious advantages of corrosion resistance, the FRP vessel also proved a lower vessel elongation due to pressurization, and therefore minimizes potential forces on connecting pipework and equipment. After more than three years of operation, the equivalent of about 8 million cycles, the FRP vessel demonstrated no signs of fatigue or wear.

3.3. Check valves

For the DWEER 1550, Calder developed check valves to fulfill requirements specific to an isobaric device. To achieve another significant reduction in head losses over the device, even at higher flow capacities, the hydraulic flow passages have been optimized.

In addition, the profile of the check valve disc and seat was improved, which led to significantly reduced

Fig. 8. Check valve disc with updated profile.

Fig. 9. Desalination plant of Morrojable with electric actuator and FRP vessels.

maintenance. In the case of Las Palmas, there have been no signs of wear in the check valves since commercial operation started (Fig. 8).

3.4. Electric actuator

Unfortunately, the Las Palmas DWEERs were supplied just before releasing the electrical actuator as a standard option to drive the DWEER LinX valve. Therefore, Las Palmas is using the latest version of our hydraulic actuator. However, in Fig. 9, you can see the DWEER 1550 as supplied to Morrojable, another project in Spain, incorporating FRP vessels, the latest LinX valve technology and electrical actuators. The electric actuators provide a number of significant advantages. Due to the use of the electrical actuator, all the hydraulic installation and the hydraulic control units are no longer required. This obviously eliminates all the maintenance work associated with the hydraulics such as oil filters, oil changes, seals, etc. In addition, the electrical actuator offers clear advantages with regard to simplifying the installation and commissioning. At the same time, the performance of the DWEERs can be improved due to the better accuracy and controllability of the electric actuator.

4. Conclusions

After commissioning and startup, the DWEER units have been working continuously for more than three years without significant problems or shutdowns beyond standard plant maintenance. This translates into an availability of 99.95%. The very high unit efficiency and low rates of leakage and mixing shown by the DWEER along with the high efficiency of the Flowserve high-pressure and booster pumps have resulted in one of the lowest specific energy consumptions in the industry.

This system design change has been the latest, but may not be the final one in the long history of the Las Palmas III Desalination Plant. The EMALSA technical staff, in close cooperation with Flowserve as the Original Equipment Manufacturer (OEM) of the main equipment in the plant, is already thinking and “inventing” how to improve the very high levels of excellence already achieved, keeping alive this success story of the continuous improvement process.

Acknowledgment

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Reference

[1] Patent No. WO/2013/057328 A1 (Raul Falcón, Jacinto Curbelo, Raul Lemes).