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Reverse Osmosis

A year in the life of a Lewabrane membrane case study

An efficient RO process relies upon stability and durability for operational reliability. One of the targets in the Lewabrane development programme was to improve the membrane polymerisation chemistry to provide a more robust separation performance over the lifetime of the RO membrane element. This case history illustrates the operational results over a one-year timeline upon installation of new Lewabrane RO membrane elements.

Since the introduction of the new Lewabrane RO element brand during early 2012, there have been several thousand RO elements installed in more than 24 countries for both industrial and potable water application. Most users agree that process stability and durability are the key parameters of an excellent RO process, and that the technology and quality of the RO membrane elements are a fundamental factor in providing operational reliability.

Improved RO membrane chemistry

The development focus for this new Lewabrane RO membrane chemistry resulted in a polymerisation reaction that provides a higher degree of cross-linkage than the routine commercial RO elements available in the market. One of the key targets during the development of the new membrane chemistry was to improve the polymerisation reaction which forms the polyamide layer.

The new state-of-the-art production line in Germany employs a process that increases this polymerisation degree. This is achieved by the usage of high purity chemicals, and optimised process conditions, which reduce secondary reactions often causing reduced quality and yield of the polymerisation process.

In RO membrane preparation, the polyamide layer, which is responsible for the separation, has a thickness of around 0.1 µm. The high polymerisation degree is essential for the chemical and mechanical durability of the membrane. Further, the high degree of polymerisation also results in a lower negative surface charge of the membrane. This improves the fouling tendency during the treatment of difficult surface water supplies[1,2,3] and the salt rejection.

The higher salt rejection is achieved because the rejection is not caused by repulsion effects of the negative charged surface and the dissolved anions, but rather by apparent pore size and diffusion. Therefore, the concentration polarisation effects of ions on the membrane surface, which decrease the rejection of strong charged membranes, influences the salt rejection less, and helps to maintain high rejection [4].

The improved Lewabrane salt rejection performance was proven by laboratory tests with mixed salt solutions, including boron, nitrate and silica, using Lewabrane RO elements (HR types; 15.5 bar test pressure) and known industry countertypes. In these tests, it could be shown that the salt rejection was higher than competitive RO membranes of similar chemistry. The largest observed difference was the deviation was the salt passage coefficient for Nitrate, which was one half of the SP (salt passage) value compared to the best of the competitive RO membrane elements in the same test.

At a pH value of 9.2, the boric acid salt starts to dissociate so that the rejection in the case of a strong negative surface charge increases dramatically

Also, the Boron rejection at different pH is a strong indication that the salt rejection is caused by pore size or diffusion, and less influenced by anionic repulsion.

At its site in Bitterfeld, Lanxess manufactures ion exchange resins, which are used for water treatment among other applications.

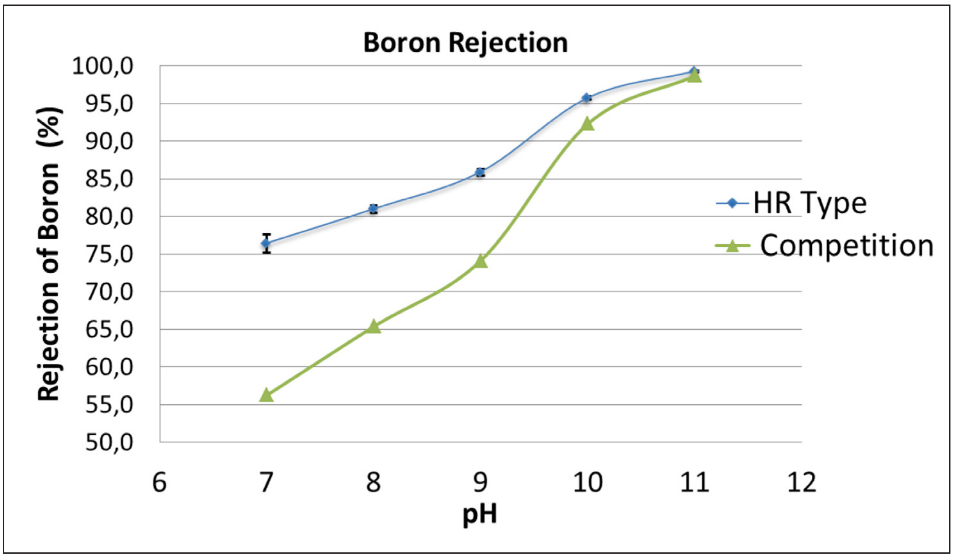


Figure 1: Rejection of Boron, shown as a percentage, in relation to pH value.

At a pH value of 9.2, the boric acid salt starts to dissociate (see Figure 1), so that the rejection in the case of a strong negative surface charge, increases dramatically. At lower pH values, the rejection is much lower compared to an RO membrane with ambient surface charge, but with higher cross-linkage (as in the case with Lewabrane RO membrane).

The superior rejection performance for Boron and Nitrate could also be demonstrated with the Low Pressure (10.3 bar test pressure; also known as Low Energy) membrane type, which has an even thinner polyamide layer to increase the performance of the membrane at lower pressure.

Case history: Lewabrane in Spain

One RO plant where this theoretical approach was confirmed in actual practice on a real industrial feed water was for an RO plant in Spain, operating for more than one year. The installation is a two-stage system with a capacity of 18m^3/h in the textile industry, and located in Blanes (Girona), in northern Spain. The feed water is brackish well with a TDS between 350-400ppm. The Lewabrane elements with 37m^2 and an average salt rejection of 99.7% were installed in August, 2012.

The plant has two RO lines which are alternating. In the other line, standard test pressure RO elements from another manufacturer were installed within two weeks of the Lewabrane installation, allowing a direct performance comparison to a commonly used RO membrane product. This RO plant was originally installed in 1998 as a pre-treatment step in front of a standard two bed ion exchange.

As expected, the initial flux from the high cross-linked membrane was slightly lower than the competitive one, but also a constant higher rejection could be observed. This is not unexpected as the higher cross-linkage membrane is slightly less permeable than the competitive membrane, but also has slightly better salt passage characteristics. This is supported by the graphs opposite for flow and rejection between the two side by side RO plants over the past year (Figure 2).

The higher rejection has a significant influence on performance of the downstream

Fouling resistant membrane cleans power station water

This case study looks at the use of Lanxess's fouling-resistant membrane technology on a large scale at the Dammweg thermal power station in Chemnitz, Germany. Filter elements apply a reverse osmosis process to cleanse pre-treated river water for steam generation purposes, bringing a 90% reduction in the organic contamination of river water demanded by the operator of the power plant which was achieved using fouling resistant membrane technology.

For the first time in Europe, Lanxess's fouling-resistant membrane technology is being used on a large scale at the Dammweg thermal power station in Chemnitz, Germany. A set of 60 Lewabrane RO B400 FR filter elements apply a reverse osmosis process to cleanse 50-60m^3 of pre-treated river water per hour for steam generation purposes. Dr Jens Lipnizki, head of Technical Marketing Membranes in the Liquid Purification Technologies business unit at Lanxess, explains that "the 90% reduction in the organic contamination of river water demanded by the operator of the power plant can be easily achieved using our membrane technology".

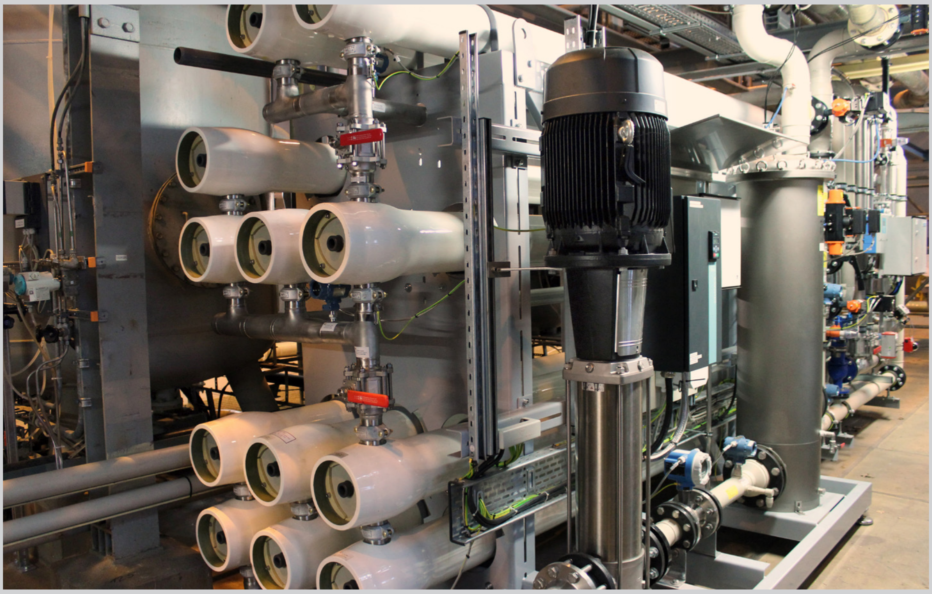
The reverse osmosis facility in the Chemnitz power plant was developed and designed by the Celle-based water technology company Berkefeld, a subsidiary of the global group Veolia Water Solutions & Technologies. Veolia's water technology division is one of the world's leading providers of water treatment solutions. Its core competencies lie in the planning and realisation of facilities for drinking and process water treatment, and the purification and recycling of wastewater.

Chemnitz powerhouse

The 'powerhouse' operator is eins energie in sachsen GmbH & Co KG. Southern Saxony's leading municipal energy service provider has around 400,000 private and business customers, including more than 1,000 industrial clients.

The Chemnitz thermal power plant, Saxony's highest structure with its 302 metre-high chimney, uses cogeneration to generate power and district heating. Two of the three blocks at the power plant are powered by native raw lignite using a low-emission incineration process with state-of-the-art dust removal and desulfurising of the flue gas. The other is powered with natural gas or, alternatively, heating oil. Cogeneration technology is an optimised solution for utilising fuels by simultaneously generating heat and electricity.

The power plant draws water for the cooling processes and steam production from the rivers Chemnitz and Zschopau. The water's intended use, as cooling water, process water or almost pure, completely desalinated water (demineralised water) for steam generation, determines the need for any complex mechanical and chemical treatment procedures. Even after it has been softened and desalinated using ion exchange resins, the water still contains a considerable amount of organic substances that cause excessive conductivity in the water-steam cycle that is harmful to the turbine and other components. The membrane filter elements from Lanxess lower the degree of fluctuation in water quality, and, in particular, filters out organic substances. Some 90% of the feed water, the permeate, is used for the ensuing processes. The remaining approximately 10%, the concentrate, is also put to further use by adding it to the process water.



Lewabrane membrane elements from Lanxess at the Dammweg thermal power plant's reverse osmosis facility in Chemnitz. Photo: eins energie in sachsen GmbH & Co. KG

Fouling potential

The membrane filter elements from the Lewabrane FR series that are used in the Chemnitz powerhouse are particularly suitable for water that has a high fouling potential. Each of the Lewabrane RO B400 FR elements has a membrane surface area of 37.2m^2 (400 ft^2) and diameter of 201mm (eight inches).

The products comprise a polyamide composite membrane that is wound in several layers to form a spiral-shaped element. "Our separation elements are characterised by a high degree of polymerisation and a low surface charge, which in itself reduces the formation of particle deposits," said Mr Lipnizki. Furthermore, a special feed spacer has been incorporated in the newly developed FR types. "The membrane elements were designed to generate greater turbulence on the inflow side, meaning that fewer particles can accumulate on the surface," explained the Lanxess membrane expert.

In filtration, fouling describes the process by which particles, referred to as colloids, form deposits on the membrane surface, leading to a reduction in filter capacity. The new FR elements from Lanxess reduce this kind of fouling, thereby extending maintenance intervals and increasing output capacity.

The separation elements, manufactured at the Lanxess site in Bitterfeld, Germany, were engineered specifically for industrial water treatment. Fields of application include the treatment of low-salinity, brackish and wastewater with a high potential for organic or biological fouling.

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ion exchange process as the chemical regeneration cycles could be extended. This leads to a lower consumption of chemicals for the regeneration in relation to the net produced water from the plant.

The actual data (Figure 3) show the challenge of working with real world data, and the difficulty in making direct comparisons. Unfortunately, the performance of the two lines decreased in the first hundreds days of service, drastically, or at least more than would be considered a routine productivity decline. The plant was designed to produce 18m^3/h at 11.3bar, but after 100 days in service, 14.3bar was required to produce 15m^3/h.

Autopsy – scope and findings

As a result of this poor productivity performance, the customer was requested to send the lead element and last Lewabrane element from the plant to Bitterfeld (in Germany) for autopsy. This autopsy included weight measurement, performance testing at standard test conditions, and surface analysis of the membrane by destructive opening of the element.

The autopsy revealed that the weight of the lead element was already 20% higher compared to a new element, and the standard tests showed a significant decrease of permeate flow with an increase of the pressure drop. The last element showed constant performance compared to the initial values of the new elements. In both cases, the salt rejection of the used RO element was as high as the new, original performance of the RO elements.

Also, the autopsy inspection on the outside of the lead element showed that the feed spacer had started to move, which is an indication that the feed spacer was clogged. The visual inspection after opening the element showed heavy biofouling in this area, which also explained the increase of the pressure drop. In total, 3kg of biomass were collected from this element.

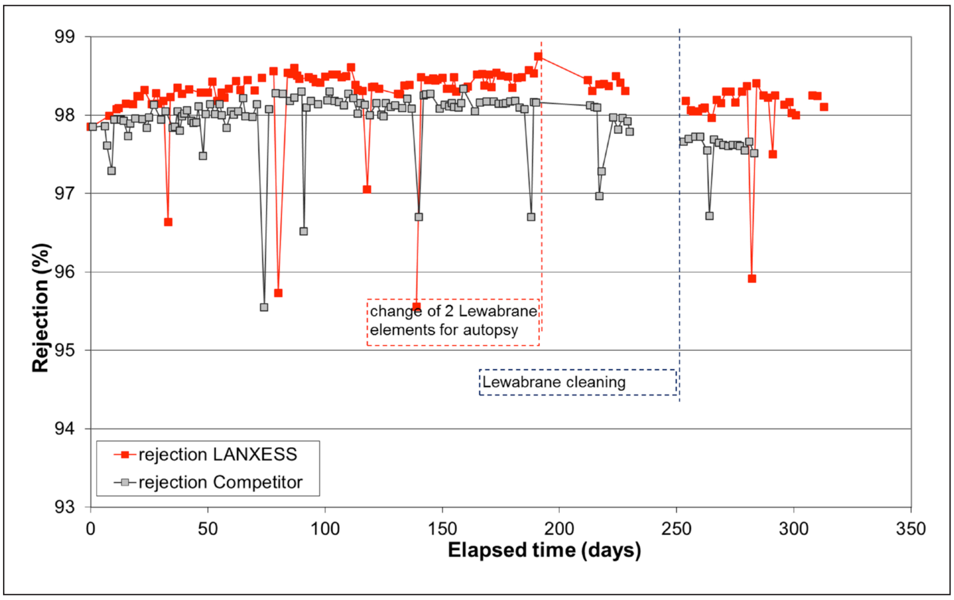

Figure 2: Rejection (in %) during a period of several months.

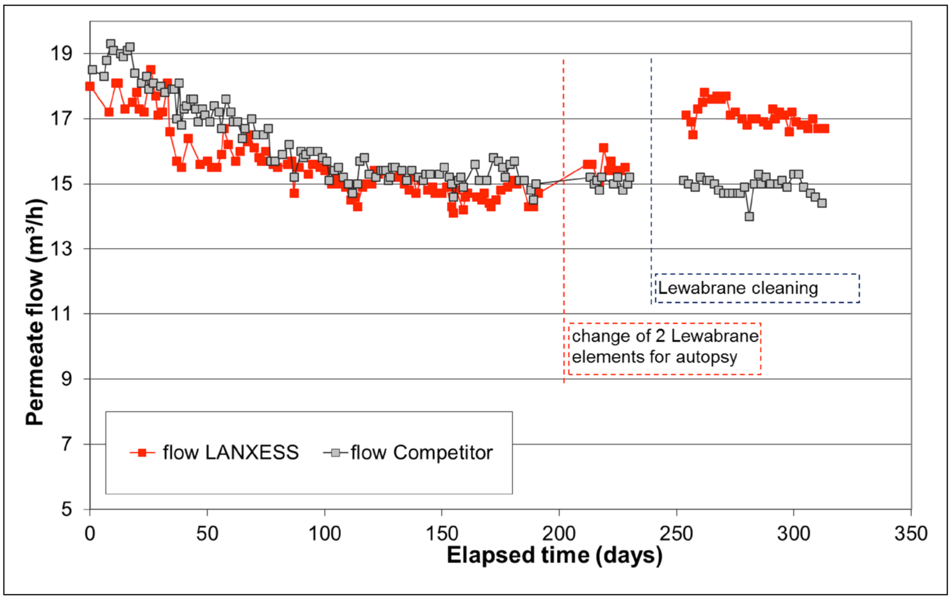

Figure 3: Permeate flow (in m^3/h) during a period of several months.

The results (fouled elements) were quite unexpected since the plant continuously adds biocides in the feed water to prevent biological fouling. It was recommended to switch from a continuous dosing to a shock dosing to avoid the genetic adaptation of the bacteria to the specific biocide.

As the RO elements which were sent to Bitterfeld for autopsy were replaced by new

At the Lanxess site in Bitterfeld is the ion exchange resins laboratory which conducts the development and quality control of monodisperse ion exchange resins used for water treatment.

The membranes are based on a three-layer composite structure that is manufactured in several production stages.

RO elements, the permeate flux of the Lewabrane trains was slightly higher than the competitive train. Another important point was to determine if the cleaning of the RO train after 230 days in operation led to a return of the initial water flux of the RO train. This data showed that even this heavy fouled RO train could be successfully cleaned.

LewaPlus performance modelling

The performance projection of the plant was prepared using the LewaPlus design software, which has the option to model the plant performance under different conditions. The design programme projected a water flux of 18m^3/h and a pressure 15.7bar, which is reasonably close to the observed reality after cleaning. The observed flux was in the range of 16.4- 17.5m^3/h at a pressure in the range of 14.7-16.0bar. Therefore, the promised performance of the plant could be held even though the RO plant experienced a severe biofouling.

After one year of successful performance, it can now be said that the system builder (OEM) of this RO plant was so convinced of the Lewabrane membrane reliability, technical performance, and vendor support, that six other plants were subsequently installed with Lewabrane elements.

Summary

Since the early 2012 Lewabrane product launch, this brand of RO elements are now installed in over 24 countries, worldwide. The product portfolio today covers a wide range of brackish water RO membranes, including Low Pressure (Low Energy) and Fouling Resistant membrane types. Additionally, since market entry, the Lewabrane brand as received the approval of the NSF for drinking water applications. And, looking to the future, Lanxess expects to launch RO membrane elements for seawater desalination by mid-2014.

Lanxess has 75 years of experience with Lewatit Ion Exchange Resins applied in water treatment applications. This success story can now be upgraded to include the realisation of a related water treatment application, reverse osmosis membrane application with Lewabrane RO elements.

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