GE
Water & Process Technologies

Case Study

Petro-Canada's Largest Oil Refinery Looks To GE For Municipal Effluent Water Reuse

Background

A groundbreaking public-private partnership between the City of Edmonton, Alberta and Petro-Canada is using advanced GE Water & Process Technologies ultrafiltration (UF) and reverse osmosis (RO) membranes to turn clarified secondary effluent into high purity water for the oil producer's manufacturing needs.

A GE tertiary ultrafiltration system at Edmonton's Gold Bar Wastewater Treatment Plant (WWTP) will provide a new, sustainable supply of high quality recycled water to Petro-Canada's largest oil refinery for use in its diesel fuel desulphurization process. By recycling wastewater Petro-Canada will significantly reduce water withdrawals from the North Saskatchewan River and will also protect the environment by decreasing wastewater effluent discharged to the river from the Gold Bar WWTP.

This innovative project has earned several prestigious awards for Edmonton, Petro-Canada, and Associated Engineering including:

- The Schreyer Award from the Association of Consulting Engineers of Canada;
- The Fred Heal Conservation Award from the Partners for the Saskatchewan River Basin;
- 2006 Steward of Excellence President's Award from the Canadian Association of Petroleum Producers;
- The Summit Award from the Association of Petroleum Engineers, Geologists and Geophysicists of Alberta;
- The Award of Excellence and Award of Merit from the Consulting Engineers of Alberta.

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Challenge

In 2002, Petro-Canada, one of Canada's largest oil and gas producers, began modifications to its Edmonton, Alberta refinery for the desulphurization of diesel fuels. The changes were necessary to ensure that sulphur concentrations in the fuel would be below the new limit of 15 ppb, a reduction of up to 90% from previously acceptable levels. Achieving the new lower sulphur levels meant that the Petro-Canada refinery would require significantly more water – of similar quality to high-pressure boiler feedwater – for the hydrogen and steam used in the desulphurization process.

The Alberta government recently introduced initiatives to balance municipal and industrial water use with the need to preserve the water quality, aquatic life, and aquatic habitat in the North Saskatchewan River. As a result, Petro-Canada could not increase its freshwater withdrawals from the river for use in the new desulphurization process. Thereby, in order to meet one set of fuel-based regulations Petro-Canada also had to be compliant with another set of water-related environmental regulations. Petro-Canada needed to find a solution that was environmentally responsible yet also economically viable.

As Petro-Canada's largest refinery, the Edmonton refinery is able to process approximately 135,000 barrels of crude oil per day, into a wide range of consumer products. To ensure sufficient water supplies to the refinery, Petro-Canada considered a variety of options including building an onsite system to treat water from the North Saskatchewan River, and purchasing water from Edmonton. In fact, the City authorities approached Petro-Canada with a proposal to provide membrane-treated wastewater effluent from its Gold Bar Wastewater Treatment Plant (WWTP) that could be used to make the hydrogen and steam.

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Located in the North Saskatchewan River Valley, the Gold Bar WWTP treats municipal and industrial wastewater for about 712,000 people in the greater Edmonton area. Its current treatment capacity is 82 MGD (310,400m^3/d). The wastewater treatment processes consist of pretreatment, primary treatment, activated sludge secondary treatment, a second set of bioreactors using a specialized biological reaction process to remove remaining impurities, and medium-pressure UV disinfection.

Solution

Following a thorough cost-benefit and environmental evaluation of the options, Petro-Canada agreed to work with Edmonton to develop a system that would enable it to use recycled municipal wastewater for its manufacturing needs at the refinery. This undertaking is Canada's first major industrial project to use the combination of hollow fiber UF and spiral wound Reverse Osmosis membranes for municipal wastewater recycling. This clearly demonstrates membranes can provide a cost-effective means of meeting increased water demands and reducing the environmental impact of industrial operations.

The City handled the design, construction and operation of the tertiary membrane filtration facility at its Gold Bar WWTP. Petro-Canada financed the plant construction and also constructed a 3.4-mile (5.5 km) pipeline to carry the water from Gold Bar WWTP to the hydrogen plant at the refinery site.

In selecting the membrane system, Edmonton compared several pressurized and immersed hollow-fiber membranes. GE's ZeeWeed* UF membranes were ultimately selected to treat the clarified secondary effluent from its recently constructed 8.4 MGD (31,800 m^3/d) biological nutrient removal (BNR) treatment. Reinforced ZeeWeed immersed UF membranes were the preferred choice for their ability to handle higher solids concentrations under upset conditions, proven ability to consistently deliver high quality water in demanding, large-scale applications, future expandability, low operating cost over a 25 year period, and compact footprint for the space constrained site.

ZeeWeed membranes are inherently insensitive to upsets caused by high turbidity or variable raw water quality and can consistently deliver high quality permeate that meets or exceeds continuous RO influent quality requirements. Typical feedwater quality results are silt density index (SDI)<3, turbidity <1 NTU and TSS <1 mg/L (Figure 1). This robust performance protects the RO membranes from fouling too quickly, extends the life of RO membrane modules, reduces operating costs, and permits a higher operating flux. The hollow fiber UF pore size operates on the edge of solubility acting as a physical barrier to any suspended material larger than 0.045 microns in size. These pores are ten times smaller than bacteria, ensuring that industry can receive the high quality water it requires.

The initial phase of the tertiary filtration system, with a capacity of 1.3 MGD (4900 m^3/d), was commissioned in December 2005. It is designed to allow further expansion to a final capacity of 10.5 MGD (39,800 m^3/d), and over the next few years the City plans to continue increasing it's production of recycled water for the irrigation of parklands and golf courses, recharging of park ponds, and for snow making at local ski clubs.

After screening, secondary effluent from the BNR train is pumped to an elevated membrane flow distribution channel, which distributes the flow evenly between the two membrane trains. The membranes are contained within isolated concrete tanks increasing the redundancy, reliability and flexibility of the system. By dividing the system into identical units, the overall system configuration simplifies operations and maintenance activities.

Permeate pumps draw from the common suction header and provide the typical -1 and -8 psi (-6.9 to -55 kPa) vacuum that draws water from the outside in through the hollow fiber membranes, leaving the suspended solids behind.

Periodically, the flow of permeate is reversed to backwash any foulants from the outside of the fiber. The surface of the membrane is also scoured by air introduced through a diffuser at the base of the membrane module. The air carries with it a high velocity stream of water that passes upward through the fiber bundle, sweeping away highly concentrated solids from the membrane surfaces. The accumulated solids are returned to the secondary clarifier where they become part of the normal waste activated sludge.

Treated effluent from the ZeeWeed system is chlorinated and flows through the pipeline to -, Petro-Canada's hydrogen and steam supplier. Two 400 gpm (90 m^3/hr) GE PRO series RO systems reduce the conductivity of the treated effluent from approximately 1,000 micro-mhos to 10-15 micro-mhos (Figure 2). The high purity water then flows through a GE sodium zeolite softener. This removes any last traces of total hardness. Following softening, the water is deaerated and brought up to boiler feedwater temperature.

Hydrogen production by the steam reforming process has not experienced any adverse effects on operation or quality since start up of the UF/RO treatment system. Initially there was some concern that the RO membranes would be fouled by calcium phosphate due to the presence of excess phosphate in the municipal effluent. Despite some high and prolonged spikes of phosphate (as shown in Figure 3) the membrane pretreatment, RO configuration and proprietary anti-scaling chemicals overcame the challenge. Permeate flow is consistently maintained and normal frequency recovery cleanings are performed.

Petro-Canada's hydrogen and steam supplier is currently installing two new GE PRO series skid-mounted RO systems to meet the increasing production needs of Petro-Canada. The skid-mounted systems can be quickly delivered and installed, and are scheduled to begin service in early 2008. They are designed to make 900 gpm (200 m^3/hr) of permeate bringing the plant capacity up to 2.1 MGD (8200 m^3/d)

By 2008, Petro-Canada will also begin using the ZeeWeed-treated tertiary effluent to supply up to 30% of the make-up water for its cooling towers. GE also supplies corrosion inhibition and scale control chemicals to Petro-Canada for the cooling towers and has done extensive modeling of the UF treated water. A custom-tailored treatment program ensures that cooling system integrity is maintained.

Results

Through a common goal Petro-Canada and Edmonton, enabled by GE membrane technology, have been able to provide a sustainable resource for the growth of both industry and citizens alike.

A membrane pilot plant was used to establish the parameters for the final design. This allowed the team to identify any potential downstream issues, which could occur when taking on such a project. The manner in which the project was completed is testimony to the efforts of all the stakeholders being part of the solution prior to construction of the final facility.

In seeking compliance with new regulations to reduce the sulphur content in fuel products, Petro-Canada was able to further decrease its environmental impact by reducing the need for fresh water too.

Edmonton has now gained greater insight and experience into the higher purity water requirements of industry and the impact this has on plant operations. The success of this project means that similar solutions are being offered to other local industrial sites, to take advantage of water reuse as a way to meet future development needs.

The Membrane filtration technology used in this project is a proven, cost-effective solution for water reuse projects of all sizes. (Figure 4)

Keeping aware of the long-term trends and the wider picture, the greatest success of this project is the ability to deliver recycled water for Petro-Canada, and the newly found water reuse opportunities for other local industries. All this is possible while still reducing the impact on the environment by ensuring a safer and longer lasting supply of fresh water for the benefit of local residents.

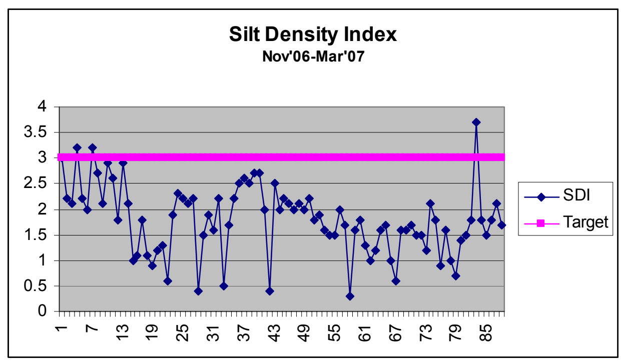

Figure 1 - SDI Levels

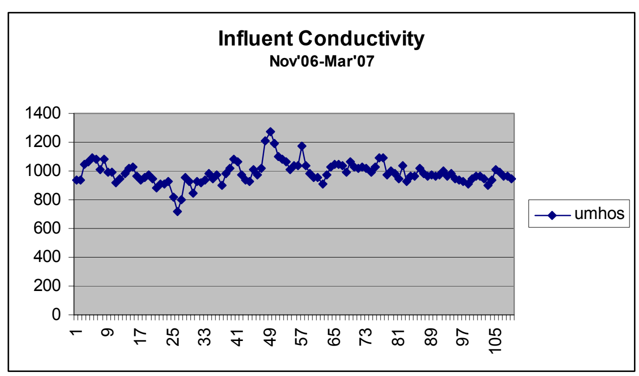

Figure 2 – Influent Conductivity Levels

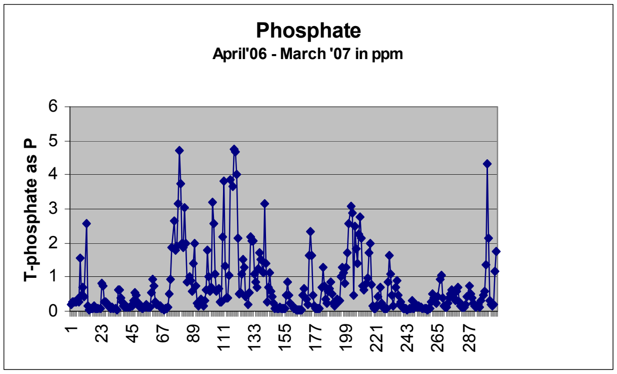

Figure 3 - Phosphate Levels

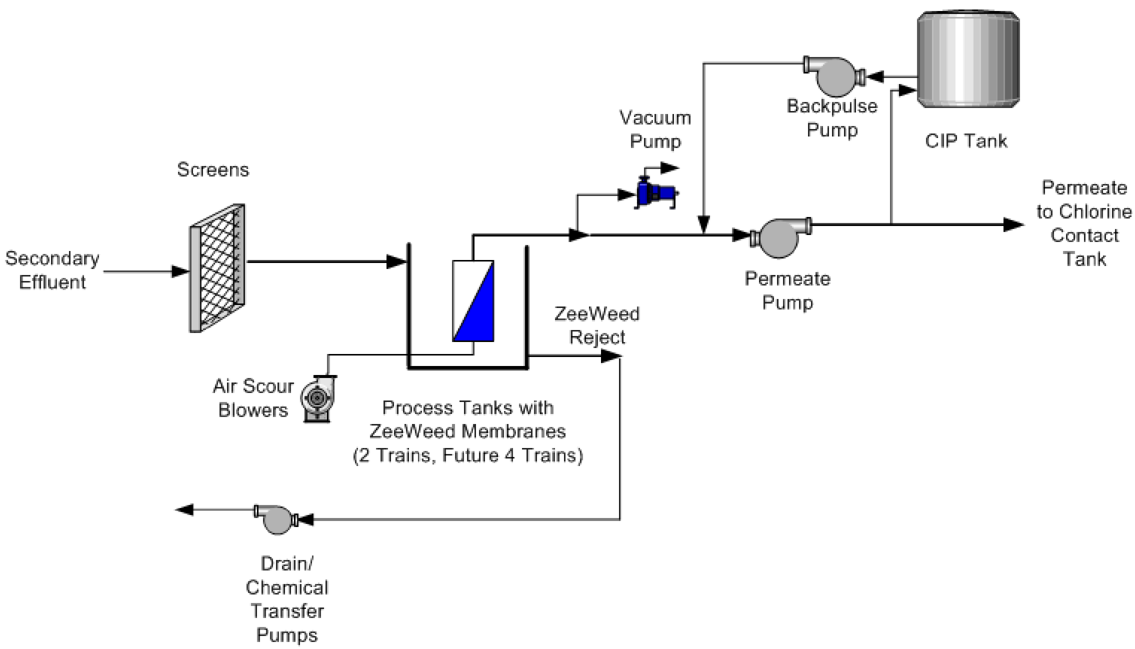

Figure 4 - Ultrafiltration System

Hollow-fibre membrane cassette being lowered into tank. The surface area of the membrane is 758.4 m².

Process equipment skid with membrane tank in background.