Reverse Osmosis for Refinery Wastewater Treatment

The Challenge: Establishing Cost-Effective Wastewater Treatment

Chevron’s refinery in Pascagoula, Mississippi, upgrades asphalt using a nickel-molybdenum catalyst in its residuum desulfurization (RDS) plant. Periodically, Chevron must remove spent catalyst from the reactor and recharge it with fresh catalyst. Reactor downtime is expensive, so quick and efficient turnarounds are essential.

Chevron removes spent catalyst in a process called “wet-dumping” which uses hydrodrilling techniques (highly pressurized water jets) to blast the reactor clean. Wet-dumping speeds catalyst removal and moderates the catalyst’s pyrophoric properties. The process, however, generates about two million gallons of wastewater per year, the primary contaminant being nickel. Suspended and dissolved contaminants in the wastewater must be removed prior to discharge. Direct discharge or treatment at Chevron’s on-site wastewater treatment facilities are not options.

Chevron and Rochem Environmental (Houston, Texas) worked together to implement a patented reverse osmosis (RO) membrane system for treating wastewater. The reverse osmosis system produces clean water that is suitable for use as boiler feed water—and reduces treatment costs by 30% compared to the old method.

The New Way

Due to its high-volume throughput and the quality of crude-oil stock used for asphalt, the Chevron RDS plant uses more nickel-molybdenum catalyst than any other refinery in the United States—and generates a considerable amount of nickel-laden wastewater in the reactor cleaning process. Catalyst is dislodged from the reactors by hydrodrilling with a high pressure water system. Most of the solid nickel catalyst particles are conveyed to dump trucks, then carried to a covered catalyst pad to be packaged and sent to a metals recovery facility. The remaining catalytic wastewater slurry is pumped from the reactors to filter presses where suspended nickel is removed. The nickel-bearing cake from the filter is sent to the metals recovery facility. The filtrate, which may still contain dissolved nickel, is recovered and recycled to the hydrodrilling operation as wash water.

Excess wash water that builds up in the recycle loop over the course of the hydrodrilling operation must be treated and released from the system before the next reactor turnaround. To maintain wastewater discharge standards, dissolved nickel used to be removed from the wash water by precipitation with a caustic reactant, followed by filtration before it could be discharged to a treatment facility. This cumbersome process was labor intensive and expensive. The process also required laboratory testing due to the wide variability in water quality. Chevron wanted a better method.

Reverse osmosis treats wastewater contaminated with a metal catalyst. Recovered water is used as boiler feed water, thereby reducing costs while protecting the environment.

The New Way

In 1994, Chevron installed a reverse osmosis system to treat the excess wastewater stream. The RO system separates filter press effluent into two streams: a permeate, which is boiler feed quality water, and a reject stream, which is recycled to the hydrodrilling operation. Reverse osmosis treatment improves the efficiency of the catalyst removal operation because wastewater can be treated and recycled while hydrodrilling is carried out. The permeate produced contains only about 1 ppm total dissolved solids and a nickel concentration of less than 0.1 ppm.

Chevron’s Pascagoula refinery utilizes a two-stage reverse osmosis system. The system incorporates 30 modules in the first stage that feed 15 modules in the second stage. The modules are fed by two positive displacement 75 hp pumps, operating at pressures ranging from 300 psi to 1100 psi. Wastewater flows through the membranes in one direction, filtering the catalyst from the water and leaving a nickel-free permeate stream. Chevron’s reverse osmosis system produces 25 to 40 gallons of clean water per minute.

Over successive reactor dumps, the contaminants build up in the drilling water to the point where the reverse osmosis system cannot maintain the desired clean water standards. When nickel concentration in the permeate is too high, about every tenth dump, the water is treated by the old precipitation method with the nickel precipitates sent to the metals recovery facility along with the bulk of the spent catalyst.
The Results: Reduced Costs at No Cost to the Environment

Chevron’s RO system reduced labor and chemical usage, while converting wastewater into usable boiler feed water.

Reduced Water Consumption. Because Chevron reclaims water from one process for use in another, the company purchases less water from its local utility.

Lower Operating Costs. The RO system reduces the expense for precipitation chemicals and labor. In addition, Chevron can now recycle close to two million gallons of water per year for use as boiler feed water.

Reduced Environmental Testing. The RO system, which reliably recovers clean water from contaminated wastewater, minimizes the need for water quality testing.

Flexibility. RO systems can operate at pressures up to 3,000 psig which can treat concentrated wastewater streams having high osmotic pressures.

What Did It Cost?

Rochem Environmental provides the reverse osmosis equipment and operating labor to treat the drilling water from the RDS plant under a service contract with Chevron. In addition to providing reverse osmosis services, Rochem also provides solid/liquid separation services. Through this contract, Chevron saves more than $300,000 per year when compared with the old method.

The cost of an RO system depends on system capacity, wastewater composition, and clean water purity requirements. Reverse osmosis systems can cost from $20,000 for small systems to several million dollars for large systems. Operating costs, including energy, cleaning chemicals, and membrane replacement are normally less than one cent per gallon, making RO attractive for many applications.

The Bottom Line: Recycling Nickel and Saving Nickels

By implementing the RO system, Chevron saves money and resources while protecting the environment.