

FLUENT LINES™

WASTEWATER, PROCESS WATER AND PRODUCED WATER SOLUTIONS FOR OIL & GAS PRODUCTION AND HYDROCARBON PROCESSING • NOVEMBER 2006

PRODUCED WATER SOLUTIONS

Produced Water Treatment Moves To The Forefront

Oilfield development and crude oil recovery are becoming increasingly dependent on achieving greater produced water treatment and removal efficiencies.

HIGH CRUDE PRICES ARE CREATING favorable conditions for oil producers to recover oil from aging fields and previously uneconomical heavy oil sites where enhanced oil recovery (EOR) is required.

Steam injection is a widely used EOR method, and it generates large amounts of produced water. Effectively dealing with this produced water has become an economic, environmental and operating challenge for these producers, Keith Minnich, Vice President of Veolia Water Solutions & Technologies (VWS), explains.

“Disposing of excess water through deep well injection within oil production zones or to disposal wells is often not an option. The two best options for most producers today are recycling the produced water for steam generation or treating it to meet the stringent regulatory parameters required for surface discharge.”



Veolia Water Solutions & Technologies provides oil and gas producers with robust treatment solutions for recycling produced water for steam generation and for efficient produced water removal via surface discharge.

Recycling produced water for steam generation can be an economical and environmental advantage for many producers because it provides a cost-effective source of water to supply the medium to high pressure steam generators or boilers. Producing high quality treated water for surface discharge has also become an increasingly viable option.

“Produced water typically represents little to no present value and contains a variety of components that makes its disposal highly regulated,” Minnich says. “But

treating it for surface discharge can solve many environmental, regulatory and operational problems for producers.”

Robust Solutions. VWS offers effective technologies for produced water recycling for steam generation and for generating high quality treated water suitable for surface discharge. These robust solutions can fully meet today’s growing produced water challenges in heavy crude oil and natural bitumen (oil sands) production areas, such as those in California, Canada, *continued on page 2.*

WASTEWATER TREATMENT

Hovensa Selects Veolia Water Solutions & Technologies

HOVENSA L.L.C. REFINERY IN ST. Croix, Virgin Islands, has awarded a contract to N.A. Water Systems to upgrade its wastewater treatment facilities.

The scope of the project for N.A. Water Systems, a Veolia Water Solutions & Technologies company, includes engineering and procurement for the new facilities at the refinery. Process operations will include wastewater cooling, equalization, sulfide oxidation, biological treatment in an activated sludge system, nitrification, post aeration, and filter press sludge dewatering. The design flow of the new facility will average 2,440 GPM, with a peak flow of 4,000 GPM.

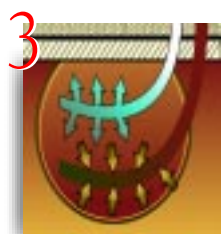
Hovensa operates one of the most modern refineries in the U.S. With crude oil processing capacity of 495,000 barrels per day, it is also the eighth largest oil refinery in the world.

For hydrocarbon processing facilities and oil and gas producers, N.A. Water Systems provides complete systems for water and wastewater projects, feasibility studies, environmental analysis, pre-design consultation, engineering and design-build services. ■

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Meeting Produced Water Challenges *continued from page 1*

the Middle East and South America.

“Many producers are turning to VWS to help meet produced water challenges,” Minnich says. “At a field in California, for example, we are currently completing a water treatment facilities project that will nearly triple soft water production for steam generation and will include our OPUS™ advanced treatment process (see article, below) to produce up to 50,000 BPD of treated water for discharge to a constructed post-treatment wetlands.” In addition, HPD evaporation



Removing excess produced water is becoming a highly critical requirement for producers.

technology can generate high quality water and very low waste volume in SAGD projects (see article, page 3). The recent acquisition of

Power Clean™ nutshell technology further broadens VWS’ portfolio of solutions for produced water treatment (see article, right). Also, the Autoflot™ Mechanical Induced Gas Flotation (IGF) Separator and other VWS technologies will soon be serving Petrozuata’s extra-heavy oil production activities in Venezuela’s Orinoco Belt (see article, page 5). ■

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EXPANDED RESOURCES

Whittier Filtration Acquires Nutshell Filtration

WHITTIER FILTRATION, A VEOLIA WATER Solutions & Technologies company, has acquired the assets of Power Clean Systems from C.J. Hensley, developer of the Power Clean Systems technology. The acquisition adds nutshell filtration to Whittier’s line of water treatment technologies for produced water treatment in the oil and gas industry. The Power Clean Systems technology also filters oily wastewater in petroleum refineries and other industrial applications.



The acquisition of Power Clean™ nutshell technology further broadens Veolia Water Solution & Technologies’ robust portfolio of produced water treatment solutions.

“Power Clean™ nutshell technology is recognized as one of the most reliable nutshell filters on the market, and it further broadens our robust portfolio of solutions for produced water treatment,” Luis Maturana, General Manager of Whittier Filtration, says. “The purchase of this innovative, patented technology also demonstrates Whittier Filtration and Veolia Water Solutions & Technologies’ commitment to the oil and gas industry.”



Nutshell filtration is one of the most advanced and low maintenance technologies for filtering solids to 5 microns.

Power Clean technology will soon be installed as part of a water treatment facilities expansion project for a California heavy oil production site. It will also soon be utilized in the treatment trains of two produced water treatment plants in Venezuela, for PDVSA and Petrozuata (see related article, page 5).

Nutshell filtration is one of the most advanced and low maintenance systems for filtering solids to 5 microns. Power Clean backwashable filter systems are ruggedly designed for years of continuous service in the harshest environments. ■

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OPUS™ TECHNOLOGY

High Water Quality, Low Waste Volume

Proprietary pretreatment and unique separation process provides optimized performance for produced water treatment.

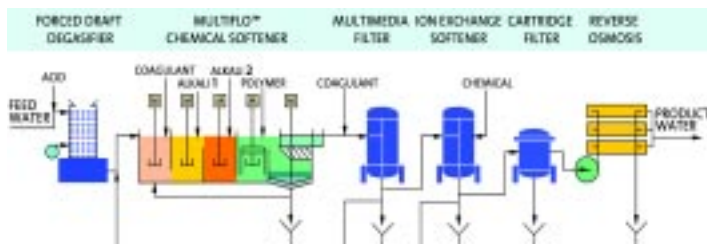
INCREASING VOLUMES OF PRODUCED WATER generated in aging oil and gas fields, coupled with stringent requirements for produced water discharge, are creating challenges for producers. The OPUS™ technology, developed by N.A. Water Systems, provides efficient treatment of produced water, thereby lowering oil production costs and allowing for more recovery of oil-in-place by converting the produced water into a potentially beneficial resource for use in groundwater recharge or irrigation water.

Multi-Process.

OPUS technology consists of multiple treatment processes involving degasification, chemical softening, media filtration, ion exchange softening, cartridge filtration, and reverse osmosis (RO) technologies. By combining the proprietary high rate chemical softening process, Multiflo™, with filtration, ion exchange and RO, this technology takes hypersaline feed water with high concentrations of silica, organics, hardness, boron and particulates, and generates high quality water with low waste volume. Pre-treatment processes ahead of RO are designed to reduce hardness, metals and suspended solids. The RO process operates at an elevated pH, which effectively controls biological, organic and particulate fouling, eliminates scaling due to silica, and increases the rejection of silica and boron.

“Producers demanded a technology with low life cycle costs that overcomes the limitations of existing technology, and that’s why we developed OPUS technology,” explains LNSP Nagghappan, Technical Director for N.A. Water Systems. “For a long time, the only proven technology for produced water desalination has been evaporation, which consumes approximately 70 kilowatt hours of power for every 1,000 gallons of water treated. OPUS technology treats the same volume of water for about 10 kilowatt hours of power.”

Conventional RO processes are more prone to scaling and fouling due to contaminants in produced water. Nagghappan says OPUS technology



OPUS™ technology combines a proprietary high rate chemical softening process, with filtration, ion exchange and reverse osmosis.

is designed to prevent the potential for scaling and fouling across the RO membranes.

“Whereas conventional RO will provide a 70-75 percent recovery rate, OPUS technology routinely achieves recovery rates as high as 90 percent. Salt rejection is also much higher with OPUS technology, Nagghappan says. “With conventional RO membranes you may get a 95-97 percent salt rejection rate, but with OPUS it is 99 percent plus.” ■

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AUTOFLOT™ IGF

Secondary Oil/Water Separation in Venezuela

Two Venezuela producers have selected Autoflot™ Induced Gas Flotation Separator from Whittier Filtration for secondary oil/water separation.

WHITTIER FILTRATION, A VEOLIA WATER Solutions & Technologies (VWS) company, is working closely with VWS Venezuela to provide two treatment plants that will serve Petroleos de Venezuela S.A.'s (PDVSA) San Joaquin operating center approximately 400 kilometers from Caracas.

In addition, VWS Venezuela will soon be providing a water treatment plant utilizing technology from Whittier Filtration to serve Petrozuata's extra-heavy oil production activities in Venezuela's Orinoco Belt. Petrozuata is a strategic association between PDVSA and Conoco.

For the PDVSA San Joaquin Field, one plant will treat 10,300 barrels per day (BPD) of produced

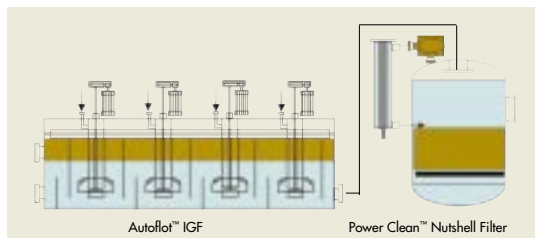
water for re-injection into disposal wells, and the other will treat 8,600 BPD of oily runoff water from the oil field for surface water discharge. The treatment plant serving Petrozuata will expand the existing produced water treatment capacity at the site from 10,000 to 15,000 BPD. VWS Venezuela is providing installation and startup of all three plants.

Autoflot™ IGF. Both the produced water treatment plant for PDVSA's San Joaquin Field and the Petrozuata treatment plant will include Whittier Filtration's highly effective Autoflot™ Mechanical Induced Gas Flotation (IGF) Separator. At the San Joaquin site, the IGF unit will be followed by Power Clean™ nutshell filtration (see related *Power Clean* article, page 2).

Secondary oil/water separation utilizes gas flotation to attach gas bubbles to small particles thereby increasing their buoyancy, to remove contaminants. The Autoflot IGF achieves this very efficiently.

"Autoflot produces the selective separation of solids and free oil based on the degree of surface hydrophobicity," says Catalina Reyna-Huerta, Applications Engineer for Whittier Filtration. "Cationic or anionic polyelectrolyte addition

applied within the unit causes particles to be selectively adsorbed, rendering one particle type hydrophobic while the other stays hydrophilic. Hydrophobic particles attach to small air bubbles added into a mixture of oil, fine solids and water, and float to the surface and are collected.



The two produced water treatment plants will include Whittier Filtration's highly effective Autoflot™ IGF. At one, IGF will be followed by Power Clean™ nutshell filtration.



Technology solutions from Whittier Filtration will be an integral part of three water treatment facilities in Venezuela.

SOLUTIONS & TECHNOLOGIES

Pitching In At Petrobras

WWS is helping this major Brazilian oil company meet the inherent challenges of refinery wastewater treatment.

BRAZIL'S PETROBRAS, SHORT FOR PETRÓLEO Brasileiro S.A., maintains an output of more than 2 million barrels of oil equivalent per day, operates 93 production platforms, 10 refineries, and almost 10,000 miles of pipeline. Veolia Water Solutions & Technologies works closely with Petrobras in helping it meet water quality challenges at many of its refinery operations.

"Currently we are deeply involved with Petrobras in the development and implementation of technologies to treat and reuse its refinery wastewater," says Giangiacomo Gallizioli, Commercial Director of VWS Brasil Ltda. "Over the past several years we have supplied Petrobras a number of innovative treatment plants and have carried out numerous pilot studies in partnership with their R&D group."

Veolia Water Solutions & Technologies is playing an important role in many of its Brazilian affiliate's activities by providing a number of key technologies and equipment for the Petrobras projects.

For example, ACTIFLO® high-rate clarification, an innovative process developed and patented by Veolia Water Solutions & Technologies, is gaining a significant amount of interest at several Petrobras refineries.

"We were recently contracted by Petrobras' Gabriel Passos Refinery (REGAP) to supply a 60 m³/h net capacity treatment system for the reuse of refinery wastewater in cooling tower make up," Gallizioli says. "ACTIFLO high-rate clarification will be an integral part of the process train, which will be followed by multi-media filtration, carbon filter, and Electro Dialysis Reverse (EDR)."

EDR and ACTIFLO are both being applied for the reuse of refinery wastewater for the first time. The ACTIFLO process was selected pri-



Veolia Water Solutions & Technologies has supplied several innovative wastewater treatment plants to Petrobras refineries.

marily due to its consistent production of high quality water even in varying raw water conditions and its extremely compact size, which offers increased treatment capacity without the large surface area requirements of conventional flocculation/sedimentation systems.

"Working in partnership with Petrobras' R&D group over the past several years, we have also carried out a number of ACTIFLO pilot studies for refinery wastewater treatment," Gallizioli says. "These studies have included using ACTIFLO to provide tertiary treatment following aerated lagoons; ACTIFLO following both aerated lagoons and rotating biological contactor (RBC) for ammonium (NH₄) removal; and ACTIFLO following activated sludge treatment. The process has performed extremely well in all of these studies." ■

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Alternative Technology Solutions FOR SAGD Produced Water Recycling

Veolia Water Solutions & Technologies can integrate produced water treatment and steam generation to provide the optimal solution for each application.

STEAM ASSIST GRAVITY DRAINAGE (SAGD) IS AN insitu method for recovering oil from tar sands. SAGD projects require large amounts of water for high-pressure steam generation to assist in producing low API crude such as that found in the Oil Sands of Alberta, Canada.

Recycling produced water for steam generation can be an economical and environmental advantage for SAGD projects. Recycling the produced water provides a cost-effective source of water to supply the medium to high pressure steam generators or boilers. Recycling also provides an alternative to expensive surface discharge or deep well injection of the produced water.

Veolia Water Solutions & Technologies (VWS) offers three different technology options for accomplishing highly effective produced water recycling for SAGD projects. Each of these options provide customers with its own set of benefits and advantages, depending upon the specific produced water parameters and generator requirements of the site.

1) Softening IX. Softening IX represents the “conventional” option for treating produced water through a series of chemical treatment steps to bring its quality up to meet the requirements of a once-through steam generator (OTSG). Here, the process train typically consists of induced gas flotation, nutshell filtration and primary and polishing ion exchange.

The Softening IX process was developed for conventional oil recovery, where hardness removal is important. Oil sands typically do not have hardness, however the produced water does contain high concentrations of silica, which is substantially removed by the warm lime process. The Softening IX process, which is currently being used at Suncor's Firebag I operation in Alberta and was provided by VWS, offers SAGD projects the most commonly used process design to produce water suitable for OTSGs.

Utilizing Water Tube Boilers. Water tube boilers can provide a number of advantages over once-through steam generators in SAGD projects. Water tube boilers are suitable for alternative fuels, such as the coke remaining after the up-

grading of bitumen. In addition, water tube boilers are available in larger capacities than OTSGs and can be available within significantly shorter delivery times. They can also be suitable for co-generation projects.

Water tube boilers, however, require a higher quality feed water than can be produced by the conventional Softening IX process. For this reason, VWS offers two alternative process water treatment technologies – Evaporation/ZLD and OPUS™. Each process provides the level of treatment required to serve water tube boilers..

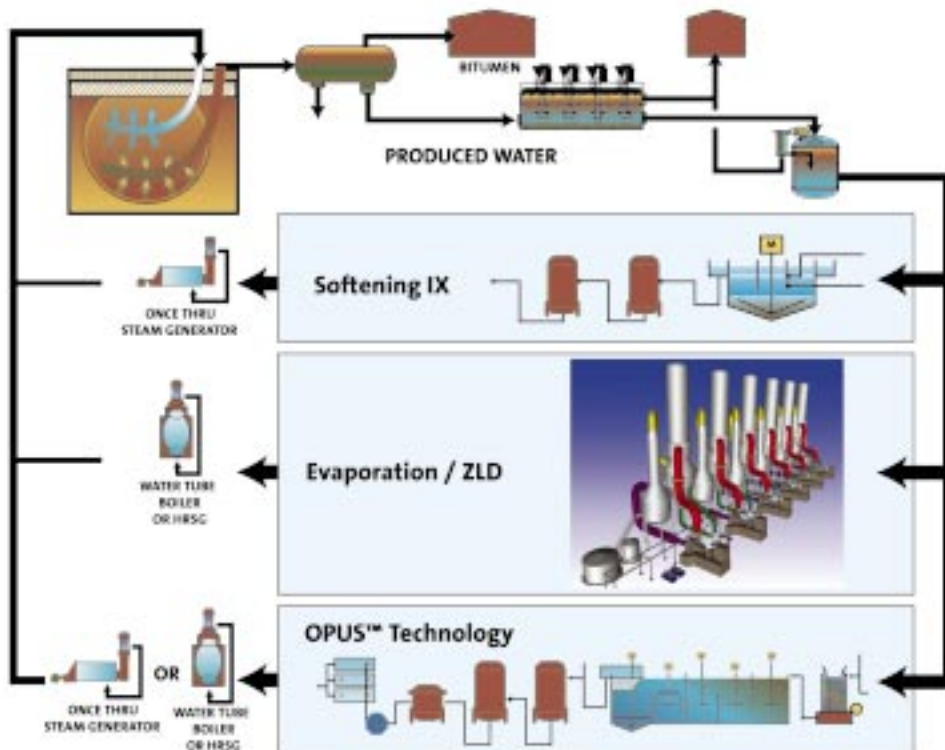
2) Evaporation/ZLD. The Evaporation/ZLD process is a simple, robust and proven technology, well suited to recycle produced water as boiler feed water. The produced water enters the Evaporator/ZLD system where as much as 95 percent of it becomes high quality distillate of less than 5 ppm TDS. Evaporation/ZLD is a more capital intensive process than conventional softening and ion exchange, but allows the use of water tube boilers and minimizes or even eliminates liquid waste. These features can provide

significant strategic advantages for SAGD projects.

3) OPUS™. OPUS technology combines the proprietary high rate chemical softening process, Multiflo™, with filtration, ion exchange and reverse osmosis to generate high quality water and very low waste volume at low power consumption. VWS developed OPUS technology and is currently applying it for produced water in California (see related articles, pages 1 and 2). It can produce the same high quality water as evaporation but has the advantage of less capital. And compared to the conventional softening ion exchange process, OPUS technology provides for a lower operating cost and less waste generation.

Successful Operations. Veolia Water Solutions & Technologies possesses the technological expertise to integrate produced water treatment and steam generation to provide the optimal solution for each application. All three of these effective technology options are designed to provide years of continuous and reliable operations. Advanced technologies, and knowledge of critical produced water treatment parameters are paramount to maximizing re-use and maintaining optimum steam generation. Veolia Water Solutions & Technologies helps ensure our customers successful produced water treatment operations. ■

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Veolia Water Solutions & Technologies offers three different technology options for accomplishing highly effective produced water recycling for SAGD projects.

VEOLIA WATER NEWS BRIEFS

CHINA

Veolia Water Partners With Sinopec

Veolia Water and Beijing Yanshan Petrochemicals (BYP), a subsidiary of China's leading oil refiner, Sinopec, have formed a partnership to operate facilities to collect, treat and recycle industrial wastewater at BYP's site at Yanshan, located 50 kilometers southwest of Beijing.

Under the 25-year agreement between Veolia Water and Sinopec, the joint venture will be managed by Veolia Water. The treatment facilities consist of four wastewater treatment plants with a total capacity of 129,000 m³/d and two recycling units that will re-inject water into the manufacturing cycle with a total capacity of 40,000 m³/d. Veolia Water will treat water from the refinery and the six petrochemical units that make up the Yanshan industrial complex, as well as the domestic wastewater from the site.

Veolia Water will contribute to the partnership its expertise in treating and recycling industrial wastewater. The partnership with the refining division of one of the world's leading oil companies confirms the credibility of the services that Veolia Water offers and the confidence of operators in our expertise in the industrial water cycle. ■

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Solutions & Technologies

FLUENT LINES™

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FLUENT LINES is published by Veolia Water Solutions & Technologies. For more information regarding technologies and services discussed in this publication, please fill out and mail the enclosed postage-paid reply card. Or contact:

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SEATTLE, WASH. / MILWAUKEE, WIS.

HPD Brings Key Additions To Sales & Engineering Team

HPD has added key personnel to senior process and commercial positions to provide additional expertise and support from two satellite offices in Milwaukee, Wis., and Seattle, Wash. This new staff will support the growing business activity of HPD and VWS in several key markets, including oil and gas and hydrocarbon processing with an emphasis on produced water, steam flood and ZLD applications.

In Milwaukee, Keith Minnich assumes the position of Vice President. Mark Nicholson, William Shaw and Dorothy Neu assume the position of Senior Process Engineer. Each has more than 20 years experience with evaporation,



Minnich



Nicholson



Shaw



Neu



Peterson



Schooley

tion, crystallization and industrial water treatment with Aquatech and Aqua-Chem.

In Seattle, Dan Peterson and Karen Schooley each assume the position of Senior Process Engineer. Peterson and Schooley have more than 30 years and 15 years experience, respectively, with evaporation, crystallization and industrial process experience with Ionics RCC. ■

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INDUSTRIAL SECTOR EXPERTISE

Veolia Water Solutions & Technologies: Serving The CPI Industry

Many chemical processors have turned to Veolia Water Solutions & Technologies to help solve key challenges for improving the safety and reliability, performance, and increasing the capacity of their critical water and wastewater systems.

"As experts in the optimization of water and wastewater processes and systems, we provide state-of-the-art technologies, engineering, and design proficiencies to help our CPI customers reduce costs, lower water consumption, and meet safety and environmental compliance parameters," Larry

Gurnari, CPI Market Manager for Veolia Water Solutions & Technologies, explains. "Water is a key element in the production of petrochemicals, basic chemicals, and specialty chemicals. The quality requirements are specific to each one, whether it is for utility make-up, process water, wastewater and recycling, or sludge treatment. The aim is to optimize the total management of the water cycle, reduce related costs, and improve the environmental performance, while maintaining plant safety."

Veolia Water Solutions & Technologies develops customized solutions to comply with its customers' treatment requirements for integrated water and difficult to treat wastewater streams.

"Through audits, feasibility studies and pilot demonstrations, we offer our clients solutions that are technically complete and economically attractive to their specific requirements," Gurnari says. "Water and wastewater treatment are expensive commodities for most chemical producers. Having to reduce production or not fully meeting wastewater limits can also be costly. Improving and operating key plant water and wastewater treatment processes is an ever-evolving practice for the chemical processing industry. Veolia Water Solutions & Technologies can provide all the necessary ingredients vital for success." ■

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Visit Our New Oil And Gas Website

Information exchange. An overused phrase, maybe. But how much information is enough? As maintaining process water, produced water and wastewater quality becomes more specialized and complex, useful information about critical processes becomes increasingly valuable.

Now you can quickly learn more about all the different processes that occur within the oil and gas industry at Veolia Water's new Oil and Gas Website – oilandgas.veoliawater.com. This easy-to-use, multitiered site provides detailed information on your important treatment flow trains – just move your mouse over each one for a brief overview. Or, click on the individual treatment trains for in-depth profiles as well as useful links to relevant websites. ■

oilandgas.veoliawater.com

HIGH PERFORMANCE MBR

NEOSEP™ MBR Process Provides Enhanced Water Reclamation Options For Refiners

State-of-the-art membrane bioreactor helps refineries meet stringent wastewater reuse quality requirements.

DIMINISHING FRESHWATER RESOURCES, increasingly stringent effluent quality requirements, and opportunities to save on process water and wastewater treatment and disposal costs are prompting more and more refineries to consider wastewater reuse options. NEOSEP™ membrane bioreactor (MBR), from Veolia Water Solutions & Technologies, provides a high performance solution that combines two proven technologies for the treatment of refinery wastewater for reuse for cooling tower and boiler feedwater makeup and a variety of other process water applications.

Ideal Solution. “The NEOSEP membrane bioreactor combines an aerobic biological process with an integrated, low-pressure membrane system to produce a very high quality effluent,” Herve Buisson, Vice President of Process Engineering for Veolia Water Solutions & Technologies, explains. “With NEOSEP, membranes are placed in direct contact with the biomass. The selection of a membrane with the right properties for refinery applications allows the process to deliver reliable water with enhanced micro-organism and organic removal in a very compact solution, compared to more conventional biological processes. Also NEOSEP

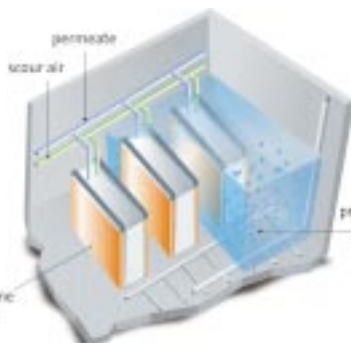
eliminates the constraints related to sludge settling and greatly simplifies the treatment line.”

Reclaimed Wastewater.

NEOSEP requires a smaller footprint than conventional aerobic biological processes, and adapts well to changing feed conditions.

“You don’t have to worry about having to deal with sludge carryover downstream with this process,” Buisson says. “Plus, it can be operated efficiently with higher salinity wastewaters. The membrane choice and process configuration were driven by energy considerations, the need to minimize fouling, and the ability to recover membrane performance in case of continuous or accidental fouling.”

Typically, NEOSEP-treated wastewater can be reused as cooling water make-up. Integrating the process with reverse osmosis (RO) or ion exchange (IX) results in effluent treated to a degree suitable for



NEOSEP™ combines an aerobic biological process with an integrated, low-pressure membrane system.



NEOSEP™ provides a compact, high performance solution for refinery wastewater reuse.

use as boiler make-up water or for other process water applications.

Buisson says the key advantages to NEOSEP are having a very good membrane with optimized engineering around that membrane.

“We have many years of experience with MBR. We have taken those lessons learned and now bring them to our clients in terms of an innovative design of key proprietary components for maintaining filtration performance and advanced control systems for carrying out various automated functions.”

VWS has completed a number of successful NEOSEP pilot projects (trade-named BIOSEP™ outside the U.S.), including a recent project for Petrobras. NEOSEP was shown to ensure effluent free of suspended solids and with complete removal of organics, providing these refineries with a number of options for efficient wastewater reuse. ■

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WHITTIER FILTRATION

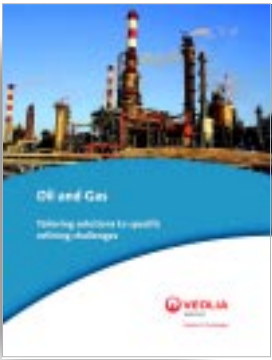
Whittier Filtration's broad range of filtration systems, including precoat filters, specialty ion exchange and media filters, are used for removing solid matter and impurities from liquid streams. (562)204-2550



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NEW LITERATURE AVAILABLE

Three new brochures are available from Veolia Water Solutions & Technologies:

- 1) *Tailoring Solutions To Specific Refinery Challenges*
- 2) *ACTIFLO® The Ultimate Clarification Process*
- 3) *OPUS™ Optimized Pretreatment & Unique Separation Technology*

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- Power Clean™ Nutshell Filtration. NEOSEP™ MBR Technology.
- Tailoring Solutions Brochure. ACTIFLO® Clarification. OPUS™ Technology

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WASTEWATER, PROCESS WATER, AND PRODUCED WATER SOLUTIONS FOR OIL & GAS PRODUCERS AND HPI

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