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# WATER TREATMENT

# Q&A

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**Hydrocarbon Engineering** questions a number of water treatment experts about R&D, regulatory compliance, productivity improvements and the overall market outlook.

**Johanna Ludwig, Chief Technology Officer, akvola Technologies**

Johanna Ludwig has over 10 years of experience in water treatment technology development, application and commercialisation. Her expertise in the field of water reuse and membrane technology has received many awards, including the 'European Water Innovation Award' and the 'IDA Leadership Award', and her career landed her on the 'Forbes 30 under 30' list. At akvola Technologies, Johanna has guided the R&D activities since its founding in 2011.

**Sid Dunn, Global Technical Director, Water Treatment – Baker Hughes, a GE company (BHGE)**

Sid Dunn has 39 years of experience in the water treatment industry, and currently serves as the Water Treatment Global Technical Director at Baker Hughes, a GE company. Throughout his career, Sid has held many technical roles, with a focus on engineering, sales, and business development. He owns three patents and has authored numerous technical presentations and papers. He is currently an advisory council member and discussion leader for the International Water Conference.

**Mike Preston, Project Engineer and Industrial Water Treatment Section Leader, Black & Veatch**

Mike Preston holds a BS degree in Chemical Engineering and is a registered professional engineer. As a Project Engineer, he has spent his 29 year career in Black & Veatch's Power and Oil and Gas Businesses, evaluating and designing industrial water and wastewater treatment systems. His responsibilities have ranged from licensing support and conceptual design studies to detailed design and startup, as well as commissioning support of clients around the world.

**R.C. Krichten, Global Boiler Group Leader, GE Water & Process Technologies**

Rick joined GE Water (Betz) in 1976. Over the following 40 years he has worked with water systems design and troubleshooting in most heavy industries, particularly refining, chemical and power. His product line experience covers all water systems – steam, cooling, wastewater and influent. He is currently global boiler group leader for chemical product applications. He is a contributing author to the Betz Handbook of Industrial Water Conditioning.

**Paulo Gomes, Marketing Director EMEA, Kurita Europe GmbH**

In 1998, Paulo Gomes started work in the Water Treatment business as Technical Manager. Over almost 20 years, he has been in charge of several product ranges, working on product development and innovations. In 2007, he joined the marketing department and in 2015 he took over the responsibility as Marketing Director at Kurita Europe. Since January 2017, Paulo has been the head of Kurita's Global Promotion team.

**Dr Werner Arts, Founder and Board Chairman of LAR Process Analysers AG**

Dr Arts' occupational career started in 1986 as General Manager of BIFAU e. V., Berliner Institute for Analytics and Environmental Technology. He was also Co-founder of LAR GmbH in 1986 and became General Manager in 1998. After restructuring of the company into LAR Process Analysers AG, he became President of the corporation. He is involved in the development of new analysers for water monitoring, process control and environmental protection.

**John Tracy, Senior Director, Marketing & Commercial Operations, Oasys Water Inc.**

John Tracy has over 15 years of experience in product management and strategic marketing, focusing on the development and promotion of complex systems to international customers. He has over 10 years of power industry and industrial water treatment experience with membrane systems. Prior to Oasys Water, John was a Product Line Manager with Axcelis Technologies, and held engineering and business development positions with ABB, Osmonics, and General Chemical Group.

**Bill Perpich, Director of Business Development, Veolia Water Technologies North America**

Bill Perpich's focus is on the downstream oil and gas industry. He has over 25 years of experience in the environmental field with expertise in the physical/chemical and biological treatment of industrial process water and wastewater systems. His background includes assessing, identifying and implementing systems that provide clients with a cost-effective, environmentally friendly and compliant solution.



## Q Why is water treatment so crucial to the downstream oil and gas industry?

### **Sid Dunn, Baker Hughes, a GE company (BHGE):**

Water treatment technologies ensure water systems are operating at optimal levels to maximise plant efficiency and ensure reliability. This includes preventing corrosion or scale in heat exchangers and critical equipment that directly affect the plant's profitability. This same water also has to be discharged from downstream facilities, which requires extensive treatment to ensure that the discharge has minimal impact on the environment.

**Mike Preston, Black & Veatch:** Water and wastewater treatment is critical to downstream facilities to preserve capital investments, ensure cost-effective, sustainable operation and ensure regulatory compliance.

**Paulo Gomes, Kurita Europe GmbH:** Water is essential for all kinds of industrial processes. The availability of water that can be used for production and processes is a key cost and efficiency factor.

Smart water treatment technologies protect the plant, decrease operational and energy costs and improve occupational safety.

**John Tracy, Oasys Water Inc.:** Refining and petrochemical operations consume large volumes of water and contaminate that water when used in various processes, from process unit cooling to catalyst regeneration, to stripping processes. Treatment requirements are becoming more complex, either for reuse or discharge. In many geographies around the world, water access is a bottleneck related to the expansion of existing facilities or construction of new facilities.

### **Bill Perpich, Veolia Water Technologies North America:**

Water treatment is critical to the successful operation of refineries and petrochemical plants. The need begins with high quality supply water for process operations, cooling water, and boiler feed water for steam generation. Refining processes generate various wastewater streams that contain oil, hydrocarbons, carbon and nitrogen compounds, selenium and various other contaminants. These waste streams require treatment for the removal of these contaminants prior to reuse or discharge. Physical, chemical, biological, membrane and thermal treatment processes may be needed to achieve the desired water quality, depending on the intended use of the treatment plant effluent.

Water reuse in refineries is becoming more prevalent as source water availability and discharge regulations become more stringent. An audit of water consumers and wastewater generators at a specific site is often the first step in developing a complete water management programme. The water quality

needed for each process step is taken into consideration and internal systems for recycle and reuse can be implemented to meet the water quality requirements of the water-consuming processes. Because of water availability restrictions and discharge requirements in certain locations, some oil and gas clients have found that a zero liquid discharge system is the most economical and sustainable solution to minimise water use and ensure regulatory compliance.

## Q What are the main applications for your company's water treatment technology within the downstream industry?

**Johanna Ludwig, akvola Technologies:** Our proprietary flotation-filtration technology, akvoFloat™, could be used in three main applications. Firstly, it can treat segregated effluents with the highest oil content (e.g. desalter effluent, tank bottom draws) in order to recover as much oil as possible and de-risk the performance of the wastewater treatment plant (WWTP). Secondly, it can replace conventional primary treatment to deliver a higher quality effluent (e.g. emulsion-free) to the biological treatment step. Finally, it can be used in tertiary treatment, as a pretreatment for any desalination technology in reuse applications.

**Dunn, Baker Hughes, a GE company (BHGE):** Baker Hughes, a GE company (BHGE) offers comprehensive water treatment solutions throughout the entire refining and petrochemical process, delivering technologies and services from influent to effluent. This includes raw water treatment, boiler pretreatment, boiler water treatment, cooling water treatment, process water treatment, and wastewater treatment.

**Preston, Black & Veatch:** Black & Veatch is technology neutral. Our value is our understanding of water and industrial facilities as well as our ability to survey the industry, evaluate alternatives, and implement integrated, cost-effective solutions.

### **R.C. Krichten, GE Water & Process Technologies:**

Main water treatment applications in downstream industries follow the water from river to outfall, inlet to waste effluent. GE Water & Process Technologies designs, builds and operates most water pretreatment equipment from clarification, filtration, ion exchange, membrane systems, and electrodeionisation, to temporary trailer-mounted systems, heat exchanger monitoring, etc. The company provides water treatment polymeric dispersants and corrosion inhibitors for steam generators and cooling towers, flocculants and coagulants for influent and effluent total suspended solids separators (clarifiers, lime softeners, gas flotation, sludge presses, digesters). In activated sludge facilities, we manage the biology

and health of bacterial organic conversion and provide enzymes to enhance biological health.

In cooling tower systems, chemical applications prevent inorganic scale from forming on hot process equipment and tower fill. Chemical inhibitors prevent corrosion of metal elements even in hot zones. Biocides and biodispersants prevent the accumulation of bacterial slime, fungi and algae, which form heat-insulating deposits and under-deposit corrosion if left unchecked. In the simplest case, a lack of proper chemicals and chemical feed control will lead to hotter process side, resulting in energy losses on surface condensers and high vapour pressure going to tankage, causing reprocessing. In complex cases, improper chemicals can lead to exchanger leaks with subsequent hydrocarbons contaminating the cooling water, exceeding allowable volatile organic carbon levels and resulting in serious environmental impact.

In steam systems, inferior chemicals and feed controls can lead to turbine failure from scaling and over speed, loss of energy for power production, gas compression, or equipment failure from general corrosion, pitting, or under-deposit corrosion. Proper chemical programmes keep the steam side in a safe pH zone to eliminate corrosion from acids or bases. Polymeric dispersants prevent the accumulation of inorganic salts – mainly calcium, magnesium or silica – on hot tube surfaces. Oxygen scavengers rapidly remove dissolved oxygen to avoid pitting corrosion. Steam system chemicals are even co-ordinated with process side chemistry to avoid amine-chloride deposits in atmospheric crude overhead exchangers.

**Gomes, Kurita Europe GmbH:** Kurita covers the full range of water treatment applications, from the preparation of raw water (including products for membrane processes) through cooling and boiler water to the purification of wastewater.

**Dr Werner Arts, LAR Process Analysers AG:** The main applications of LAR's online water analysers are pure water applications as water-steam-circuits. Here, especially total organic carbon analysers are used to monitor and control boiler feed water, steam and condensate return. Further applications are the monitoring of cooling water, which is relevant to (almost) all processing stages within the downstream industry. At the end of production processes, water is led into WWTPs. Here, LAR's analysers are used to control the water influent to protect the WWTP against shock loads and to optimise the treatment processes.

**Tracy, Oasys Water Inc.:** Oasys focuses on treatment processes to recover fresh water from impaired streams, by separating and concentrating dissolved solids and recovering a majority of fresh water, up to 80 or 90%.

**Perpich, Veolia Water Technologies:** In the downstream industry, Veolia offers solutions for the

entire water cycle, beginning with the supply water, boiler feed water, demineralisation systems, recycle/reuse systems, sour water treatment, desalter brine, condensate treatment, and finally wastewater treatment for reuse or discharge. Each application differs depending upon the desired effluent quality. Veolia has more than 350 proprietary technologies to choose from in developing the best options for each application, and we combine those with conventional treatment options to provide fully integrated systems delivered as engineer-procure, design-build or design-build-operate projects for our clients based on their needs, preferences and economic constraints.

**Q** What was your company's very first water treatment related equipment or technology aimed at the downstream oil and gas industry, and how did it function?

**Ludwig, akvola Technologies:** akvoFloat is a flotation-filtration technology based on novel ceramic membranes. It is cost-effective in the treatment of hard-to-treat oily effluents and has a high removal efficiency (99% for oils and total suspended solids [TSS]) at a competitive CAPEX and OPEX. The bubble generator technology embedded in akvoFloat has also been used stand-alone to revamp existing dissolved air flotation (DAF) units in order to improve its removal efficiency and reduce energy costs.

**Dunn, Baker Hughes, a GE company (BHGE):** From the inception of the oil industry, there were problems with water and oil separation. Producers were losing profits and there were growing environmental concerns. Pipeline operators and refiners refused to accept emulsified oil due to its corrosive impact on assets, and there was a risk of explosive steam pressures when oil with high water content was heated during processing. The unwanted off-specification oil filled up pits and tanks, spilling into nearby streams and rivers and taking up valuable processing capacity. This industry-wide problem was solved when William S. Barnickel invented the Tret-O-Lite demulsifier in 1914. This technology was the foundation of oil and water separation, and continues to contribute success to water-related issues across the oil and gas lifecycle.

**Krichten, GE Water & Process Technologies:** Our first significant technology in downstream plants was a cooling programme called Betz Dianodic, since it contained both chromate and phosphate for inhibition of general steel surface corrosion. Zinc was added later to stifle pitting function. Along with an effective dispersant for total suspended solids, this combination treatment was the most highly effective package geared specifically for hydrocarbon processing facilities. When chromates were replaced



by phosphates for anodic inhibition, the solubility of calcium phosphate became the greatest challenge. GE Water & Process Technologies was able to patent a highly effective polymeric dispersant, called 2020, which was later replaced by HPS, to allow the use of phosphates but avoid the serious scaling problems from calcium phosphate. This combination allowed the process industries to continue operating hot distillation towers and reactor coolers without the environmental impact of chromates.

**Dr Arts, LAR Process Analysers AG:** The first water analysing related equipment was the online total organic carbon (TOC) analyser QuickTOC®. This analyser was equipped with a robotic horizontal and vertical injection needle and a thermal combustion method at 1200°C. Petrochemical wastewater is characterised by suspended and dissolved pollutants and has a significantly more complex water composition than municipal wastewater. Due to the injection system, solids were handled within the TOC analyser, and the water samples were then completely oxidised to CO<sub>2</sub>. Typical incompatibilities with high salt samples of measuring systems using high temperature methods were fully avoided.

**Q** In what ways can water treatment technologies help to improve regulatory compliance and protect the environment?

**Krichten, GE Water & Process Technologies:** Water treatment has a major environmental impact, producing positive effects for water outfall and vaporious air emissions, as well as reduction in hazardous waste disposal. The use of total suspended solids removal aids, such as polymeric coagulants and flocculants in influent and effluent clarification, gas flotation, and coker clarifiers, has a direct impact by producing a wastewater with significantly reduced suspended solids that would otherwise flow to receiving bodies of water. In activated sludge or other biological oxygen demand/chemical oxygen demand removal processing units, bacterial health is vital to the ability to maximise the conversion of complex organics to CO<sub>2</sub>, nitrogen, and low molecular weight/low toxicity residual compounds. The use of recent advances in bacteria health monitoring and enzyme enhancement makes the wastewater plant more capable and resilient. So, water treatment reduces species that have environmental impacts by enhanced settling, or bio conversion of aqueous soluble hydrocarbons to more benign species.

Water and sludge treatment can do this at various operating units where toxic waste is concentrated, thereby reducing the loading at the wastewater bio plant or at each stage of the industrial wastewater plant.

Water treating equipment (e.g. ultrafiltration, solids contact clarifiers and filters, reverse osmosis,

electrodeionisation, and ultrafiltration membrane bioreactors) has worked to increase the efficiency of removal for total suspended solids and water soluble toxic compounds. A membrane bioreactor (MBR) to replace or improve standard activated sludge is becoming common to allow greater bacteria contact time and, therefore, conversion rates for soluble toxic species such as phenol in refining wastewater. The use of newer flexible membrane ultrafiltration box cartridges gives absolute assurance of total suspended solids (biological oxygen demand) removal and makes it convenient to reuse industrial treated wastewater after an additional polishing step with reverse osmosis. In drought-stricken areas, secondary and tertiary treatment is allowing refineries and chemical plants to send treated wastewater back to cooling and/or boiler makeup. This same equipment layout allows treated municipal wastewater to become the full influent for most industrial systems.

The areas in Los Angeles and Richmond, California, US, have demonstrated just how far one can push municipal reuse when incorporating sophisticated membrane technologies. In fact, Betz Laboratories first worked with the Hyperion project near Los Angeles in the early 1970s to fine tune required cooling water treatments to allow full reuse for cooling towers without sacrificing tower heat duties. Much more has been accomplished since those early days. Now, refineries benefit from the reuse of Title 22 municipal effluent water due to advances in cooling chemistry, particularly Halogen Resistant Azole that allows free chlorine residual without harm to cooling chemicals, and advanced calcium phosphate dispersants that allow much higher levels of phosphate without fear of deposition.

Air quality is improved with water treatment via the detection and prevention of volatile organic carbon emission from tower stacks. This often occurs because of cooling water exchanger leaks in refining gas or chemical plants processing low MW light ends. Early detection is key, followed by rapid isolation of the offending exchanger. GE Water & Process Technologies makes TOC analysers used for online monitoring. During troubleshooting, advanced chemistry is used in the cooling tower to allow ongoing plant operation without adverse corrosion impact. Chlorine/oxidant resistant chemical treatment (halogen resistant azole) allows for ongoing operation with very high oxidant levels, thus preventing the corrosive potential of sulfate-reducing bacteria. Prior to chlorine/oxidant resistant molecules, the presence of a hydrocarbon leak, particularly a sulfidic leak as often occurs in refineries, would lead to excessive corrosion and pitting in a short period of time. Boiler, cooling, wastewater, and reuse technology has had major impact on processing of hydrocarbons in downstream operations.

**Gomes, Kurita Europe GmbH:** In downstream processes, several water application fields need to be

taken into account, such as raw water, cooling, heating and wastewater treatment.

Optimal treatment solutions for water significantly reduce corrosion, scaling and fouling, which is essential for plant efficiency and lifecycles.

The generated wastewater contains oils and other pollutants that need to be eliminated prior to discharge or recycling. State-of-the-art treatment technologies are able to remove the undesired substances effectively to meet the regulatory compliance and optimise the quality and the quantity of recycling water.

With the application of chemicals from renewable natural resources, we help our customers to expand operational runtime, reduce water and energy consumption and thus support environmental protection. We want to contribute to an environment in which nature and man are in harmony.

**Dr Arts, LAR Process Analysers AG:** In recent years, one of the most relevant projects for LAR was its participation at a German-Vietnamese joint research project named 'AKIZ'. In Vietnam, more than 200 registered industrial zones (IZs) are without sustainable wastewater treatment. As such, this flagship project developed an integrated wastewater concept for IZs to secure the efficiency and sustainable operation of the whole wastewater system, including all of its technical components. Using containerised pilot plants in different branches of the Tra Noc IZ in Can Tho City, located in the Mekong-Delta, high-tech solutions for pretreatment of wastewaters, generation of energy from wastewater and recuperation of valuable substances has been adapted and verified by on-site pilot systems, taking into consideration the local conditions. This project highlights that water treatment technologies can help improve regulatory compliance and protect the environment in different ways.

**Q How can water treatment solutions help to tackle reliability issues and improve productivity in the downstream oil and gas industry?**

**Ludwig, akvola Technologies:** The composition of the different water effluents in a refinery varies constantly and these are prone to upsets (i.e. extreme peaks in the concentration of a particular component like oil emulsions). Conventional technologies (API, DAF/IGF and biological treatment) are technologically limited and unable to deal with such upsets, reducing the reliability of the system as a whole. This translates into higher operating costs by having to divert certain effluents to the slop tanks (and reducing profit by generating non-revenue oil), or worse, by non-compliance penalties in the discharge. Ceramic membranes have proven their suitability to handle challenging wastewaters and upsets by offering an absolute barrier against oil emulsions and particles.

In terms of productivity, when segregated effluents are treated, the recovered oil can be sent back to upstream operations for re-processing, reducing the amount of non-revenue oil.

**Preston, Black & Veatch:** Water that is properly treated for the application should reduce unforced outages and prolong the life of affected equipment. Boilers are good examples. Proper water treatment will minimise blowdown (increase energy efficiency), reduce corrosion-related failures (reduce downtime), and reduce long-term maintenance.

Water treatment solutions also allow downstream facilities to minimise fresh water consumption and wastewater discharge.

**Dr Arts, LAR Process Analysers AG:** The water quality in water-steam-cycles, for example, is crucial for productivity. Any contamination of feed water, high pressure steam or low pressure steam used for numerous production processes, can lead to increased formation of deposits, foam and corrosion. In the worst case, the entire boiler plant must be shut down.

Optimised online TOC analysers provide fast and reliable determination of pollutants in steam and condensate, so that in the case of pollution, only contaminated water and not the clean water will be drained off. Additionally, the processing of raw water to pure water is costly and energy intensive. Therefore, the detection of a shock load is just as important as the degradation. Otherwise, expensive, clean condensate is drained off.

In summary, the velocity and accuracy of determining contamination in water streams, as well as the water treatment, is crucial for productivity and profitability in the downstream oil and gas industry. Optimisation is only possible with fast and stable monitoring and control. Water treatment solutions also allow downstream facilities to minimise fresh water consumption and wastewater discharge.

**Tracy, Oasys:** When water recovery for reuse is accomplished with membrane processes as opposed to with thermal processes, the scaling, resulting heat transfer loss and higher maintenance frequencies can be avoided. Well-designed membrane processes for wastewater treatment can be run for greater than a month between cleaning cycles, and those cleaning cycles are 'clean-in-place', not requiring access to tube bundles or confined space entry.

**Q Talk us through your company's design process for new water treatment technologies or equipment.**

**Gomes, Kurita Europe GmbH:** We at Kurita are strongly committed to meet our clients needs. Our team provides services and can advise about improvement potentials, as well as listen to our



customers and their needs. Our R&D centres in Japan and Europe with around 350 scientists use this direct feedback for further developments and designs of new technologies – always focusing on our ecological responsibility. Regular training enables our sales and technical staff to improve existing applications and to implement new technologies. As a result, our customers benefit from economically and ecologically efficient treatment programmes.

**Tracy, Oasys Water Inc.:** We first establish a design basis for how the process must operate over time, maximum and minimum flows, dissolved and suspended solids levels, fouling or scaling constituents. With a known process window, a process design, piping and instrumentation diagram (P&ID), and equipment list can be established. Detailed design proceeds from these key pieces. Customer review and approval of the design elements along the way is critical.

**Perpich, Veolia Water Technologies:** Any new or improved technology from Veolia begins with addressing our clients' needs. Once a problem is identified, we begin to look for the best solution to meet our clients' expectations. Potentially, the first step is laboratory-scale testing to define a new process, or we may move to validation by pilot-scale tests prior to full-scale implementation. As part of the product development process, the impact of our proposed processes on the environment, such as environmental footprint, etc., is quantified through various tools that Veolia has developed. We have a research and innovation (R&I) team that is continuously seeking to improve processes and develop new solutions. However, the direction for the research projects most often comes from the local business units working closely with industry to solve the challenges faced by our clients every day.

In addition to the R&I facilities, Veolia has research capabilities with local business units that specialise in particular technologies. Any business unit within the company can apply for funding for research to meet a need identified in the marketplace. Work carried out locally is reviewed and validated by the corporate group to ensure that our solutions will fulfil the intended purpose. In this way, Veolia stays on the cutting edge of new technologies and innovations.

**Q Outline how water treatment technologies can have a positive impact on local communities.**

**Preston, Black & Veatch:** Improved wastewater treatment improves water quality. Fresh water demands to facilities can be reduced through intentional water management principles and expanded use of alternative water supplies (treated municipal wastewater, produced water, internally recycled water, etc.).

**Perpich, Veolia Water Technologies:** Water is a resource used by everyone. Our water treatment technologies are one way that Veolia fulfils its stated mission of 'Resourcing the World'. By this, we mean developing access to resources, as well as preserving and replenishing them. In the downstream industry, water reuse within plant processes enables facilities to take less water from the rivers and streams, preserving the resource for other purposes such as drinking water and recreational activities. Our water treatment technologies often produce effluent water that is cleaner than the river water that the facility takes in. In some locations, this clean effluent has been used to recharge aquifers or replenish water in rivers and streams. Studies have shown that in some cases, the clean water from our treatment plants improves the overall water quality of these receiving streams to the advantage of the ecosystem and the local residents.

Byproduct recovery is another way that our treatment processes can have a positive effect on local economies. Turning contaminants that were previously discarded as waste into useful, saleable products minimises the cost of disposal and provides a new source of revenue while decreasing the volume of waste in local landfills and preserving the environment. In some cases, recycling byproducts to the production process can offset the cost of using virgin materials.

**Q What has been your company's biggest achievement or technological breakthrough in terms of water treatment?**

**Ludwig, akvola:** akvoFloat has allowed a German refinery to reuse 99% of its wastewater where conventional and other membrane technologies had failed. This project made it possible for the refinery to reduce its intake of raw water and avoid discharging most of the water back to the river.

**Dunn, Baker Hughes, a GE company (BHGE):** Corrosion in cooling towers has been an ongoing operational concern, leading to decreased efficiency and even equipment failures. Traditional corrosion treatments contain phosphorous, which can be harmful to the environment. Because of this, new regulatory guidelines may restrict the amount of phosphorous in the plant discharge. Taking a proactive approach to find an alternate solution to address these limitations, Baker Hughes, a GE company (BHGE) developed the LIFESHIELD™ NP non-phosphorous corrosion inhibition programme. This new technology contains zero phosphorous, allowing operators to meet stringent environmental regulations while still confidently managing highly corrosive water systems. This not only increases

operational flexibility, but also improves equipment reliability and performance.

**Preston, Black & Veatch:** One recently completed project allowed a chemical facility in the Midwest US to switch from city water to treated municipal wastewater as a primary water supply for cooling tower makeup and boiler makeup. This reduced water cost for the facility and improved the city water availability for a community in a water stressed geographic region.

**Gomes, Kurita Europe GmbH:** Kurita has launched many innovations in the last 2 – 3 years, most of which are focused on water saving and process optimisation. One of our latest developments is a new molecule, Corrsave®, that provides corrosion inhibition with a low content of phosphorous, which significantly reduces the undesired phosphorous content in the wastewater. Another technology is our film-forming product range, Cetamine®. It provides energy savings in boiler systems due to an improved heat transfer. In addition, we recently launched our rejuvenation technology for reverse osmosis membranes, which helps to prolong the lifetime of membranes.

**Dr Arts, LAR Process Analysers AG:** LAR's biggest technological breakthrough was the development of TOC analysing equipment for the measurement of the most complex wastewater compositions in the industry. The analysers are able to handle samples with a high particle density, high salt concentrations as well as sticky, fatty and oily samples.

**Tracy, Oasys Water Inc.:** The ability to apply membrane processes to difficult waters and to concentrate streams to levels only achieved by thermal technologies previously has been our biggest achievement. To scale the technology from the laboratory, to pilot, to commercial systems processing >5000 m<sup>3</sup>/d of petrochemical plant wastewater has been rewarding and has required the capability to design and deliver complete systems, beyond just the core pieces of technology that we originally developed.

**Perpich, Veolia:** For the oil and gas industry, one technology that stands out as a significant development is our OPUS® technology. This technology is an integrated system that was first developed for upstream exploration and production operations to minimise deep well injection and enhance oil recovery. The technology, based on pretreatment followed by reverse osmosis (RO) operated at an elevated pH, has also been implemented in the mining and automotive industries to achieve zero liquid discharge. With some modifications, it is now being applied as a zero liquid discharge (ZLD) system for a refinery.

## Q How has the recent oil market volatility affected the water treatment industry?

### **Dunn, Baker Hughes, a GE company (BHGE):**

Successful water treatment is a necessity for plant operators, regardless of market conditions. When commodity prices are low, refiners look for ways to successfully process discounted crude blends to gain higher margins. This requires innovative technologies that can handle the additional challenges that come with processing heavy, acidic crude slates. When times are good, processing plants are still focused on the bottom line, but the opportunity shifts to identifying areas where they can maximise throughput and avoid bottlenecks. This includes confirming the plant is operating at optimal rates and conditions, identifying additional water re-use opportunities, as well as reducing contaminants in wastewater that could result in fines and penalties.

**Tracy, Oasys Water Inc.:** The downturn in oil and gas prices all but stopped the adoption of new innovations by either upstream or downstream operators, as they were forced to cut back on capital projects. There are now signs of life in cases where a clear contribution to profitability, and where project financing can be justified.

## Q Where do you see the water treatment market in 10 years' time?

**Ludwig, akvola:** Across all industries there has been an ongoing trend to fully outsource (waste)water treatment operations, due to the fact that these are outside of the core business of industrial players. This shifts most of the technological, operational and financial risks to the water technology and treatment suppliers, which have all the necessary know-how to deal with them. Additionally, this gives these companies an incentive to strive for the maximum operational efficiency, fostering innovation in the field.

We think that in 10 years' time most end-users will go for models such as build-own-operate (BOO), in which water treatment is delivered as a service with no capital expenditures for the end-users. In this new paradigm, solutions will be transformed into services.

**Dunn, Baker Hughes, a GE company (BHGE):** There is a huge opportunity for digitisation within the water treatment industry, as well as the downstream oil and gas market as a whole. Baker Hughes, a GE company (BHGE) is already testing out new digital technologies like sensors and monitoring tools that enable automatic adjustment to chemical treatment feeds. There are additional possibilities beyond automation and control that can actually predict, and therefore prevent, problematic conditions before they lead to costly problems. Applying digital learnings and relying



on big data will have a dramatic impact on the industry, improving efficiencies and reducing health, safety and environment (HSE) exposure by limiting human interaction where possible.

**Gomes, Kurita Europe GmbH:** The co-operation and collaboration between consumers and chemical service providers will be more intensive. Only together is it possible to analyse and optimise processes with the target to reduce water consumption and the ecological impact. A deep understanding and application of know-how is crucial for success.

Another big trend is the digitalisation and big data management. Digital services and support will change the way we are working together and will be key for the future. Kurita is working on solutions in order to provide customised offers to our clientele, which will make our lives easier.

**Dr Arts, LAR Process Analysers AG:** Water is known as the world's most vital resource. Already today, the water industry faces challenges that were not discussed years ago, such as micro-pollutants. In the future, more challenges will arise. Since fresh water is a limited source, the importance of a circular economy will increase significantly within the upcoming years. Robust water treatment technologies will minimise wastewater discharge and maximise water recovery. So called ZLD solutions will be beneficial to industrial and municipal organisations as

discharge, or effluent, will be avoided. Another trend will be based on Industry 4.0, the so-called Water 4.0. This buzzword describes the digitalisation and automation processes focused on the strategy for an efficient, flexible and automated water resource management. Based on these developments, the water treatment market will be subject to strong growth. In particular, the monitoring of water will take over a key role, since the control of water streams and water treatment plant's are only possible with reliable and fast measurements.

**Perpich, Veolia Water Technologies:** The future of water treatment will involve 'smart' water systems outfitted with sensors and data collection capabilities to optimise water treatment processes and improve reliability. With cloud-based platforms, these systems will enable operators to maximise the performance of not only their water systems but also their production processes that depend upon the supplied water quality. The reliability of water systems will be improved through predictive maintenance programmes that alert operators to potential problems before they occur. Machine learning will ensure continuous improvements in the performance of the water treatment systems. Thanks to the cumulative data collected through these smart systems, water treatment plants in the future will be smaller, more efficient and more reliable than those of today. 