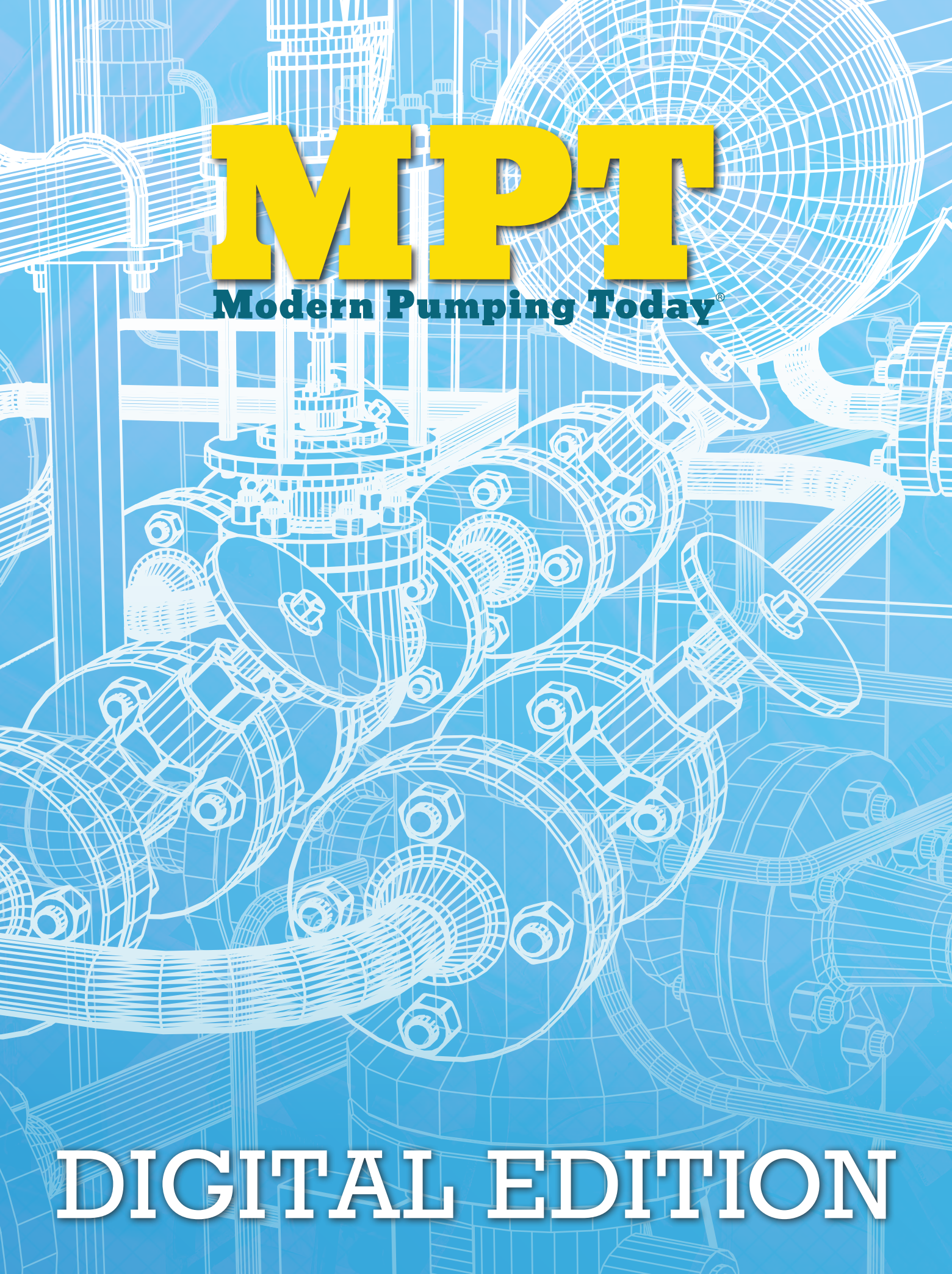

MPT
Modern Pumping Today®
DIGITAL EDITION

A FRESH PUMP

A SOLUTION EVERY TIME!

Delivers Monthly

Modern Pumping Today is a publication with solution-based content designed to keep the industrial pump, fluid flow, and rotating equipment markets engaged and informed.

modernpumpingtoday.com

MAY 2020

MPT

Modern Pumping Today®

Providing Solutions for the Worldwide Pump Industry

Meet the Next Generation of Industrial Pumps

Why Do Mechanical Seals Fail?

How a Pandemic Increases Sewer Pump Clogs

www.mptmag.com

Relays you can Rely on

to protect your motors and your budget

proSense®

Motor Protection Relays
Starting at:
$24.00

Motor Protection Relays

AutomationDirect's ProSense® motor protection relays provide a cost-effective solution to monitor motor conditions and prevent costly failures and repairs.

Phase Monitoring Relays *(above right starting at $39.00)*

Phase monitoring relays provide protection against premature equipment failure caused by voltage faults on 3-phase systems.

Intrinsically Safe Relays *(above left, starting at $75.00)*

Intrinsically Safe Relays provide a safe and reliable method to control up to four loads (motor starters, relays, etc.) with up to four input devices (switches, sensors, etc.) located in a hazardous area.

Alternating Relays *(starting at $24.00)*

Alternating relays are used in special applications where the optimization of load usage is required by equalizing the run time of two loads.

Pump Seal Failure Relays *(starting at $49.00)*

Designed to monitor the shaft seals of submersible pumps, the relay output can be used to give an alarm indication of a leaking seal and will automatically reset when the fault condition clears.

Also Available

Overload Relays

Definite Purpose Contactors

Motor Disconnects

Research, price, buy at:

www.automationdirect.com/motor-control-relays

Order Today, Ships Fast!

VOTED Best in SERVICE 15 YEARS

AUTOMATIONDIRECT.com
1-800-633-0405 the #1 value in automation

Hydra-Cell®

Seal-less Pumps

More reliable pumping with "less"

Seal-less

Reduce maintenance and downtime because Hydra-Cell has no seals, cups, or packing to leak, wear, or replace. Handles abrasive particulates. No VOC emissions. Runs dry without damage.

Pulse-less

Precise metering and linear, pulse-less flow without the need for expensive pulsation dampeners. Exceeds API 675 for accuracy, linearity, and repeatability.

Contact us today for application-specific information and your nearest distributor.

Wanner Engineering, Inc.

www.Hydra-Cell.com • sales@wannereng.com

Coming Soon...

Service

Customer Focus

Speed

Made in the USA

A CHANGE

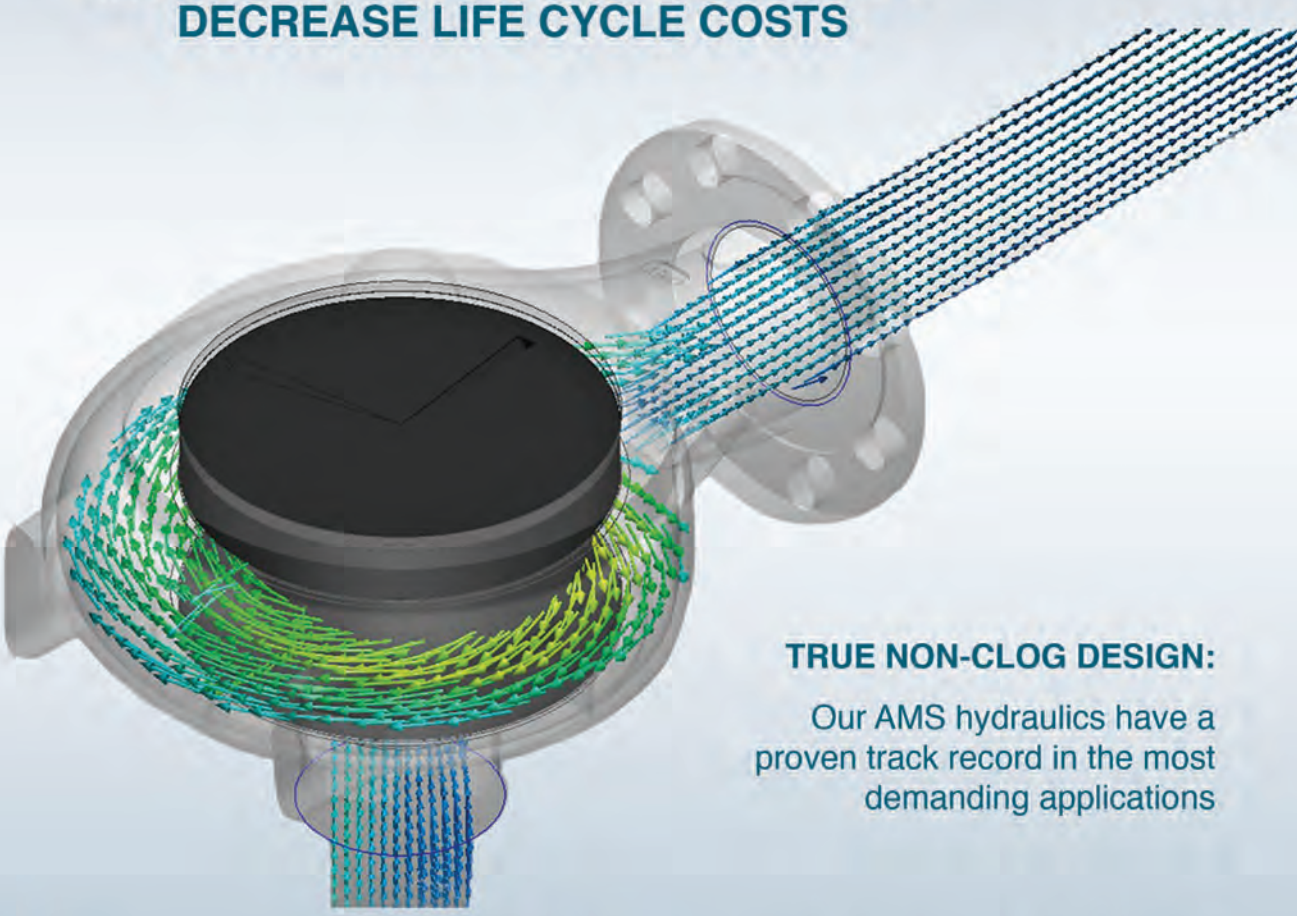
momentum SEAL

www.momentumseal.com

HOMA®

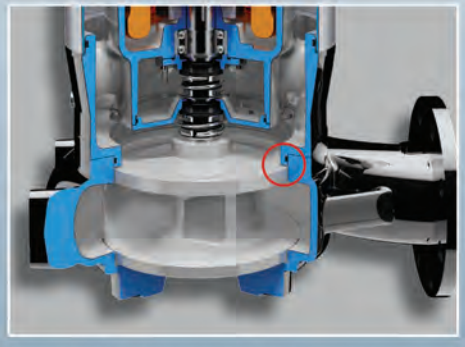
PUMP TECHNOLOGY

INCREASE PUMP STATION EFFICIENCY
DECREASE LIFE CYCLE COSTS

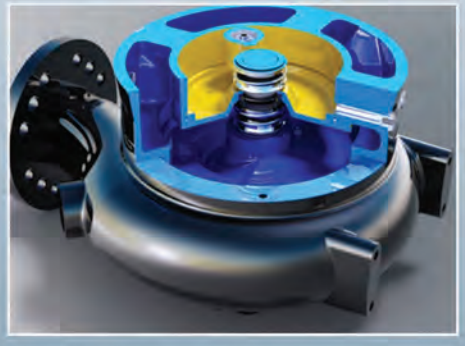


TRUE NON-CLOG DESIGN:

Our AMS hydraulics have a proven track record in the most demanding applications



CONTROLLED RADIAL TOLERANCE: No frequent, expensive maintenance or adjustments required



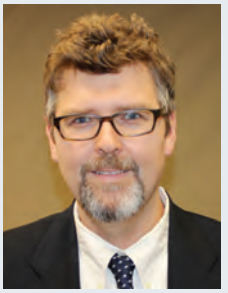
PERMACOOL™: Our patented cooling system design eliminates jacket clogs

AVAILABILITY: Our over $15 Million inventory means lead times in days, not weeks or months

Homa Pump Technology | info@homapump.com | (203) 736 - 8890 | www.homapump.com

MAY 2020

A NOTE ON THIS ISSUE:



J. Campbell, Editor
Modern Pumping Today

Welcome to the May issue of MPT! In our Water & Wastewater Solutions section, Stacy Belanger and Troy Heimerl of JWC Environmental follow up on their recent webinar "No TP. Now What?" with an article highlighting the unseen consequences of a pandemic on wastewater systems (pg. 22). As some consumers found themselves with limited access to toilet paper, they turned to other materials for their hygienic needs, materials that can have serious ramifications in the sewer system.

In this month's Pump Solutions section, we put the spotlight on new arrivals in the industrial pump sector. Joshua Allen of Xylem Industrial Solutions runs down the details of the company's new e-MP, e-XC, and vertical turbine pumps (pg. 32). These heavy-duty additions to the Xylem catalog are on the cutting edge of pumping and process technologies.

Finally, on a recent episode of MPT's podcast, The Efficiency Point, Mark Anderson, Comau's head of robotics and automation products for North America, discussed his company's role in bringing wearable robotics and exoskeletons out of science fiction and into the workforce, explaining what he calls "HUMANufacturing" (pg. 44).

MPT
Modern Pumping Today®

www.mptmag.com
P.O. Box 660197 | Birmingham, Alabama 35266

@modpumpmag

J. CAMPBELL Editor
jay@mptmag.com

TONYA BROWNING Vice President
tonya@mptmag.com

JEFF FLETCHER National Sales Manager
jeff@mptmag.com

LISA AVERY Art Director

CRISTELA TSCHUMY Graphic Designer

SETH SAUNDERS Digital Media Specialist

INGRID BERKY Office Manager

SUBSCRIPTION
inquiries or changes:
205.380.2048

HIGHLANDS PUBLICATIONS
www.highlandspublications.com
312 Lorna Square | Birmingham, Alabama 35216
866.251.1777

TIM GARMON
CEO

RUSSELL HADDOCK
President

CHRIS GARMON
CFO

DONNA CAMPBELL
Vice President, Editorial

TONYA BROWNING
Vice President

RESTORE YOUR MEMBRANES TO 100% FLUX
Compatible with UF, RO, Ceramic and NF Systems.

MATCH FORMULATED CLEANER TO INDUSTRIAL SOIL		
IPC CLEANERS	**CLEANER pH**	**TYPICAL SOILS REMOVED**
Micro-90® Alkaline Cleaner	9.5	Greases, Oils, Metals
Micro® Green Clean Biodegradable Cleaner	9.5	Greases, Oils
Micro® A07 Citric Acid Cleaner	3.0	Hard water salts, scales
Zymit® Pro Enzyme Cleaner	7.5	Biological, protein, polysaccharides

PRODUCT ADVANTAGES

- Fast, effective soil removal
- **Reduce** or **eliminate** membrane replacement
- Save **TIME**, **ENERGY** & **LABOR COSTS**
- **Eliminate** multiple step cleaning cycles
- Concentrated liquid formulas **dilute easier** than powder detergents

International Products Corporation (IPC) has been selling cleaners to the filter membrane industry for over 30 years. Our proprietary formulated cleaners work effectively at restoring 100% flux at safe pH ranges. We have a wide range of chemistries available for all membranes and soils and an on-site R&D laboratory that offers free technical support and assistance. **All of our cleaners are free of solvents, phosphates, silicates, phenols, and Substances of Very High Concern.**

NSF
Nonfood Compounds Program Listed A1

Try Before You Buy! Request your FREE SAMPLE!

Email: membrane@ipcol.com Website: www.ipcol.com

Telephone: 609-386-8770 Fax: 609-386-8438

Silicon-free Lubricants for Pump Maintenance and Repair.

P-80®

TEMPORARY RUBBER LUBRICANTS

Many critical pump components are made of rubber. P-80® lubricants provide a high degree of lubricity when wet, but because they do not contain silicon or other persistent ingredients, once dry the slipping action goes away. P-80® lubricants are free of petroleum distillates, so they will not dry, crack or otherwise harm rubber parts.

P-80® is effective in assembly operations involving:

- Boots
- Bushings
- Bumpers
- Diaphragms
- Foam grips
- Grommets
- Hoses
- Insulators
- Mounts
- O-rings
- Plugs
- Rubber moldings
- Seals
- Sleeves
- Tires
- Rubber washers
- Wire harnesses
- ..and hundreds of plastic and rubber parts!

Sprayers Available for Purchase!

MANUFACTURED IN THE USA

Request your FREE P-80® sample kit at sample@ipcol.com

A P-80® formula for every need! 4 industrial and 2 NSF formulas available.

P-80® EMULSION	P-80® THIX	P-80® GRIP-IT	P-80® REDILUBE
"The Original." A biodegradable emulsion that provides a thin film of lubrication to significantly reduce friction.	A biodegradable, non-dripping thixotropic gel that is ideal for overhead and vertical assembly operations. Provides excellent lubrication.	A quick-drying, mixture that dries tacky to help parts stay in place. Excellent for use on pressure-tested hoses.	A biodegradable, low-residue lubricant designed for use on non-porous and coated rubber surfaces. Lubricates well but dries quickly and completely.

International Products CORPORATION

Manufacturing Specialty Cleaners and Lubricants since 1923

4 WAYS TO CONTACT US:

1. PH. 609-386-8770
2. FAX. 609-386-8438
3. WWW.IPCOL.COM
4. MKT@IPCOL.COM

CONTENTS

Covid-19 Responses: Our facility is open and working • 24/7 Emergency Service On-Site

Babbitt Bearing Repair, Refurbishment & Manufacturing

BABBITT BEARING REPAIR
We can help you with babbitt bearing repair, rebabbitting, and rebuilds. When you choose Fusion for babbitt bearing repair, your parts will be returned to their original condition or better.

ARC FLAME SPRAY
Arc flame spray builds up metal on worn bearings and components; they are then machined to OEM specifications. This application also allows us to apply other arc spray metals like bronze, steel & cast iron as well.

REVERSE ENGINEERING
Our reverse engineering team possesses the expertise and tools to duplicate bearings that are no longer available from the original OEM supplier. We can help you with spare parts and when bearings are beyond repair.

CENTRIFUGAL CASTING
Centrifugal casting offers a stronger bond and the best bearing integrity; extending the life of your bearings. On top of that, we assure quality with dye penetrant testing and an ultrasonic bond certification.

NEW MANUFACTURE
Our facility is equipped to manufacture bearings to exact OEM specifications. On top of drawing documentation and support components, we offer quick turnaround times and high-quality end products.

ACCESSORIES
We have bearing parts and products available for sale; including hydrogen seals, oil rings, oil seals, resistance temperature detectors, thermocouples, and thrust plates. Give us a call for a quote on bearing accessories.

ASTM VIRGIN TIN BABBITT

98-100% MOLECULAR BOND GUARANTEE • IN-HOUSE ULTRASONIC LEVEL II TESTING

FUSION
BABBITTING CO., INC.

Since 1989

ISO9001:2015

CALL (414) 645-5800 OR EMAIL SALES@FUSIONBABBITTING.COM

Milwaukee, WI

NEW REGIONAL MANAGER NAMED FOR INVERTEK DRIVES USA

David Dillon has joined Invertek Drives USA as regional sales manager covering the Eastern United States. Dillon has more than twenty years' experience in sales having worked for companies in the motion control, optical sensor, and fluid power industries. He was previously channel sales manager at Lenze before being promoted to regional sales manager for the Southeast.

"It's great to welcome David to Invertek. His wealth of experience and knowledge of the variable frequency drive industry and associated sectors where our technology is applied will help us continue our growth in the North American market," says Wayne Morris, vice president of Invertek Drives USA.

Dillon assumed his appointment on April 1 based at Huntersville in North Carolina and covering from Florida to Maine.

"It's an exciting time to be joining Invertek Drives as it becomes a significant player in the U.S. drives market. The high quality and reliability of its Optidrive range of variable frequency drives is a key reason for joining the company," says Dillon.

CONSTRUCTION BEGINS ON NEW TURBO LAB SYMPOSIUM OFFICE

After months of designing and bidding, construction has officially begun on the new Turbomachinery Laboratory Symposium Office. The new office will be adjacent to the Turbomachinery Laboratory on George Bush Dr. West. It will be one story and approximately 6,050 square feet. The office will contain thirteen new faculty and staff offices, six research associate workstations, a fifty-person conference and meeting room, new restrooms, mechanical and electrical rooms, and an updated HVAC chiller to serve both the laboratory and its new addition.

"We are thrilled to have the opportunity to consolidate the Turbo Lab staff, faculty, and students in a single location," says Dr. Eric Petersen, Turbo Lab director. "Our mission is to make a vital impact on turbomachinery and related industries through research, education, and workforce development. Combining all three aspects of the center's daily activities within a permanent, centralized space will allow us to better support this mission."

The new Turbo Lab Symposium Office will take approximately twelve months to complete, with a tentative move-in date of February 2021.

BLACOH™
SURGE CONTROL

Finally,

TRANSIENT PRESSURE MONITORING THAT MAKES SENSE!

- Fast (4G LTE Connectivity)
- Dual Analog Channels
- Capture Pressure, Flow, Level and More

HIGH SPEED TRANSIENT MONITORING WHEN YOU NEED IT, TRADITIONAL MONITORING WHEN YOU DON'T!

Are you tired of making the choice between too much data to manage and store, or not enough data to supply you with the information that you need?

The patented **Blacoh SurgeWave** monitors your pumping and pipelines 24/7, reviewing the data at speeds of more than 100 times per second to identify pressure transients that you cannot capture with gauges or traditional SCADA. If a pressure transient occurs, the unit will store the high speed data that you need to understand what is happening in your system but, if nothing of interest is detected it stores minimal data needed to observe the overall trends.

Review your data anywhere and anytime. This IIOT device uploads the data to the cloud for convenient viewing on your PC or mobile device.

SURGEWAVE™
TRANSIENT MONITORING SYSTEM

BlacohSurge.com | 951.342.3100 | Surgesales@Blacoh.com

MADE IN USA

Phanni Peddi

Avantika

ANUE WATER ADDS TWO EXPERTS TO TECHNICAL STAFF

Anue Water Technologies, the leading supplier of cost-effective oxygen, ozone, and other sustainable and high-performance technologies to prevent odor, corrosion, scale, bacteria, and FOG (fats, oil, and grease) in municipal and industrial wastewater applications, has substantially strengthened its technical bench through the hiring of Phani Peddi as technical services manager and Avantika (Avi) as applications engineer. Both Phani and Avi will provide day-to-day technical assistance to Anue Water's channel partners and end-user customers.

Anue Vice President and General Manager Greg Bock declares, "The addition of both Avi and Phani give Anue Water the ability to provide the kind of first rate technical assistance to customers we have always wanted. I'm very pleased about these two strong additions to the Anue Water technical team."

SIEMENS APPOINTS NEW CHIEF EXECUTIVE OFFICER

Siemens AG has named Roland Busch, currently the company's deputy CEO, a new five-year contract, effective April 1. Busch, already responsible for planning and implementing the budget for the fiscal year 2021, will also assume all relevant responsibilities within the managing board and handle integration and management of Siemens' businesses, such as smart infrastructure, digital industries, and mobility.

Outgoing president and CEO Joe Kaeser told the company's supervisory board that he will not seek a contract extension. Effective immediately, Kaeser will, in addition to his current duties, assume responsibility within the managing board for Siemens Energy, including Siemens Gamesa Renewable Energy.

The move was just one of several C-level changes at Siemens. Maria Ferraro, current chief financial officer of Siemens Digital Industries, will become chief financial officer of Siemens Energy, while Rudolf Basson, current chief financial officer of Siemens China, will assume her previous position. Also, Christian Bruch has been named chief executive officer of Siemens Gas and Power and Siemens Energy.

Bring Calm to the Storm

The U1000 Industrial Matrix Drive

Whether it's managing your systems after a big storm, or getting through your chaotic daily schedule, the Yaskawa U1000 Industrial Matrix Drive can bring calm to the commotion.

Make the complex simple. Our U1000 Industrial Matrix Drives are the smallest, fastest to commission low harmonic, regenerative drives on the market.

Want a fast commission? Call Yaskawa at 1-800-YASKAWA today.

IT'S PERSONAL

https://www.yaskawa.com/u1000

Yaskawa America, Inc. Drives & Motion Division 1-800-YASKAWA yaskawa.com

YASKAWA

WATSON-MARLOW ACQUIRES FIRST NSF/ANSI/CAN 61 ACCREDITATION FOR CHEMICAL METERING HOSE PUMPS

Watson-Marlow Fluid Technology Group has received the first NSF/ANSI/CAN 61 accreditation in the world for its chemical metering hose pumps for drinking water supply. Companies manufacturing, selling or distributing water treatment or distribution products in North America must ensure their products comply with NSF/ANSI/CAN 61: Drinking Water System Components—Health Effects. This global performance-based standard evaluates the quantity of contaminants that leach from equipment and the components and materials that come into contact with drinking water. These indirect additives can occur at any point in the journey from source to tap, including production, treatment, and distribution.

Models in WMFTG's Bredel and APEX ranges are the first chemical metering hose pumps to achieve NSF/ANSI/CAN 61 certification. Other Watson-Marlow products, including Qdos peristaltic chemical metering pumps, also carry the certification.

In the U.S. and Canada, drinking water system components are regulated from the water treatment works to the water meter. The NSF certification process ensures only the highest quality components come into contact with drinking water.

WARBURG PINCUS COMPLETES ACQUISITION OF SUNDYNE

Sundyne, a global leader in the design and manufacture of API compliant pumps and compressors, announced that leading global private equity firm Warburg Pincus has completed the acquisition of Sundyne, from BC Partners Advisors L.P. and The Carlyle Group.

This acquisition was initially announced on January 6, 2020. Financial terms of the transaction were not disclosed. As stated in January, Sundyne's current management team led by CEO Mark Sefcik, will continue under Warburg Pincus' ownership.

"Warburg Pincus's and Sundyne's interests align perfectly, and there is no better financial partner for Sundyne than Warburg Pincus," says Chief Executive Officer Mark Sefcik. "All of our channel partner agreements remain in place and all of our product brand names remain. We have already jointly-identified a number of ways in which Warburg Pincus can help Sundyne accelerate growth and enhance opportunities for our customers, channel partners, and employees."

Sundyne and Warburg Pincus have launched a ninety-day transition period to formally identify areas of opportunity for developing and funding strategic initiatives that will broaden product offerings and enhance customer services globally. ◆

TOSHIBA

TOSHIBA INTERNATIONAL CORPORATION

Toshiba water/wastewater products are built with an emphasis on the factors that matter most to the industry – efficiency and reliability. The resulting product line reduces transformer losses and eliminates significant harmonic content to the power grid, all while operating in a compact footprint to reduce energy consumption and production costs.

- Reliability and Up-time
- Lower Lifecycle Costs and Extended Life
- Excellent Performance and Efficiency for Reduced Energy Costs
- Superior Support and Reduced Maintenance Costs
- One Stop Solution – Single Source Supplier of Integrated Motor & Drive Systems

TIC-ASD@toshiba.com
Toshiba.com/TIC
800-231-1412
Toshiba International Corporation
13131 West Little York Rd.
Houston, TX 77041

Sizing a Wastewater System

By SWPA Executive Director Adam Stolberg and David M. Williams, Liberty Pumps

Correctly sizing a wastewater system requires assessing several component aspects as well as situational use. Below, SWPA Executive Director Adam Stolberg and David M. Williams, director of engineering for Liberty Pumps, discuss the importance of a properly sized wastewater system and how to best avoid common missteps before they require costly replacements or repairs.

What are some of the dangers from an undersized wastewater system? Is it possible to oversize?

An improperly sized wastewater system can lead to many issues. A system that is taxed beyond its designed capacity will suffer increased maintenance and downtime issues due to wear and tear on equipment, and at peak flows may simply not be able to keep up resulting in back-ups or overflows. An oversized system can also lead to significant issues. A pump that is too large for the application will run on the far-right side of the curve resulting in decreased efficiency, higher current draw, potential overload, or circuit breaker tripping, and likely long-term damage due to cavitation. An oversized basin can lead to infrequent cycling and eventual settling of material in the basin and piping, and the contents of the basin can turn septic and lead to odor issues and increased corrosion.

What role does a lift station perform in the waste stream and how can problems with a lift station domino throughout the entire system?

Lift stations play a key role in the overall wastewater system. A well designed and properly functioning lift station maintains a smooth flow and prevents back-up issues upstream and helps to prevent surges or clogging downstream. It also allows operators to focus resources on system management and improvement rather than having to deal with urgent maintenance issues and repairs.

How critical is the link between a pump's discharge size and a sewage pipe system?

Besides the obvious physical connection compatibility between the pump discharge and piping, the major factor in determining sewage piping diameter is ensuring that it is properly sized to handle maximum flow while still maintaining adequate scouring velocities at lower flows.

Which performance attributes should one consider in selecting the right pump?

When selecting a pump, it is critical to have a good understanding of the hydraulics of the system, but it is also important to consider other factors such as potential for challenging materials in the wastewater that could lead to clogging, or special risks associated with downtime. For example, a main lift station for a hospital or nursing home would likely see challenging materials such as washcloths, wipes, and diapers, and would also be very sensitive to downtime. In this type of application, a grinder or chopper pump may be preferred over a solids-handling option to ensure optimum reliability.

How does pump selection influence component selection—like choosing a control panel or check valves?

It is critical that pumps and other components be selected to ensure proper function of the overall system. In the case of control panels, items such as circuit breakers, overloads, moisture detection hardware, thermostats, and start circuits (for single phase pumps) must all be correctly matched to the pump requirements. Further, in the case where hazardous location pumps are needed, intrinsically safe control panels and non-sparking guide rails will be required. Check valves must be chosen based on pump flow to ensure that maximum fluid velocities specified by the manufacturer are not exceeded. These are just a few of the items that must be properly selected when designing a pump station, and just one incorrectly

specified component can be the difference between a trouble-free system and a maintenance headache. It is for these reasons that SWPA and its member companies preach the benefits of the systems approach to station design and promote taking advantage of complete packages designed and produced by manufacturers using proven hardware combinations.

If replacing an existing pump rather than starting from scratch, how does this change which factors to consider?

In some ways, selecting a replacement pump can be more difficult than a clean sheet design. When it is time for an existing pump to be replaced, it is critical to take a fresh look at the application as well as the physical condition of the equipment. A common issue is that replacement pumps are often selected and ordered based on old file documentation from the original station installation. In a perfect world, that would seem like logical path, but there are many ways in which this can lead to undesirable surprises. Here are a few key things that should be considered before selecting a replacement pump.

1. Visit the site and inspect the existing equipment, comparing it to the documentation. It is often the case that the pump in the pit may be a different model or horsepower or sometimes even a different voltage than what is reflected in the records. Similarly, control panels may have been updated or replaced over time. Verify and document the condition of the panel as well as overload and circuit breaker sizes so you can be sure that they are adequately sized for the replacement pump. Some components in a control panel may be incompatible with a potential replacement pump. It is also important to inspect the wet well and verify the style and condition of the guiderail hardware. This is required to ensure proper selection of pump discharge configuration, but also it is frequently discovered that the guide rails may need to be replaced due to corrosion.

2. Review the application and history of maintenance issues. Has the system loading increased significantly due to additional connections, or in the case of a force main, has there been a change to system working pressures? Is there a significant history of clogging issues that would suggest the need for a grinder pump rather than solids handling solution?

Taking time up front will provide a solid footing for selecting the optimal replacement pump and set the stage for a smooth retrofit and long-term station reliability. ◆

A Solution for "Watered In" Landfill Gas Wells

QED's AutoPump® keeps the green power on for thousands of Florida homes

By David Kaminski, QED Environmental Systems, Inc.

Waste Management's Springhill Regional Landfill near Campbellton, Florida generates "green" energy by extracting and burning the methane in landfill gas. Its $7 million landfill gas energy (LFGE) plant, with six large Caterpillar engines running twenty-four hours a day, seven days a week, is capable of producing 4.8 million watts of power. Most of the energy goes to the Alabama Electric Cooperative for distribution to customers. When operating at its peak, the landfill can generate enough energy to supply the electrical needs of 4,000 homes.

However, the plant was receiving only enough gas to run two of the six engines. Consulting engineers determined that many of the landfill gas extraction wells were "watered in." High levels of liquid, primarily condensed water vapor, flooded most of the wells' available surface area, reducing gas extraction efficiency drastically. It was not a job for ordinary electric submersible pumps.

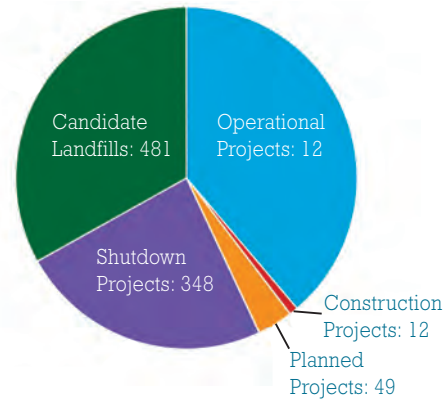
PUMPS THAT CAN TAKE THE HEAT

The excess liquid had to be pumped down. Temperatures in the wells exceed 140 degrees Fahrenheit (60 degrees Celsius), and the presence of dissolved sulfur dioxide, another waste decomposition byproduct, makes the condensate highly corrosive. In essence, the pumps must survive operating in hot sulfuric acid. With their rugged, high-clearance design and unique range of corrosion-resistant materials, air-powered AutoPumps from QED Environmental Systems deliver the durable, reliable performance demanded by challenging applications like this one.

AutoPumps were developed specifically for difficult pumping applications at landfills and petroleum and solvent spill remediation sites, and are in use in these applications worldwide. These pumps provide a unique combination of safety, simplicity, and long service life under conditions that challenge other submersible pumps, such as elevated temperatures, high solids levels, high viscosity fluids and corrosive fluids. The facility ordered six AutoPump AP4 units, followed by

LFG Energy Project and Candidate Landfill Summary (March 2020)

The EPA estimates nearly 500 or so American landfills are reasonable candidates for energy projects.



another six two months later. By the time all twelve were up and running, the landfill's gas supply was back to nominal levels and all six engines were running at capacity, generating the full 4.8 megawatts.

EXPANDING LANDFILL ENERGY PRODUCTION

Nationwide, approximately 650 of the 2,500 existing landfills extract methane for green energy, either to burn it and produce electricity or pipe the gas to industrial consumers who use it to heat and power their facilities. While some sites are too small or too old to produce enough methane for the process to be economically viable, another 500 or so American landfills are reasonable candidates for energy projects. According to the EPA, annual benefits of the operating LFGE efforts include:

- About 16 billion kilowatt hours of electricity
- Equivalent energy for electricity for 724,000 homes and heat for 1.3 million homes
- Saving the equivalent of CO_2 emissions from more than 14.9 billion gallons of gasoline consumed

Installing landfill gas energy plants at the remaining landfill candidates could almost double these contributions to the public good. To bring it closer to home, the average American produces about 4.5 pounds of trash per day. This amount of trash in an LFGE process would produce enough energy to run a stereo for half an hour or light a 60-watt bulb for fifteen minutes. As a valuable tool for ensuring the viability of new landfill gas energy projects, QED AutoPumps can help to mitigate greenhouse gas emissions while providing energy to more and more communities. ◆

David Kaminski is senior vice president at QED Environmental Systems, Inc. QED Environmental Systems is the leading manufacturer of innovative environmental products. For over thirty years their expertise has included pumping systems, landfill products, and air strippers. For more information, visit **www.qedenv.com**.

Opposite page: QED AutoPump® models are available to pump fluids up to 250 degrees Fahrenheit (121 degrees Celsius). Top: With QED AutoPumps, the landfill can generate enough energy to power 4,000 homes. Bottom: Waste Management's Springhill Regional Landfill uses QED AutoPumps to dewater gas wells in corrosive, high temperature conditions.

On-site Electro-oxidation of Difficult to Treat Wastewater

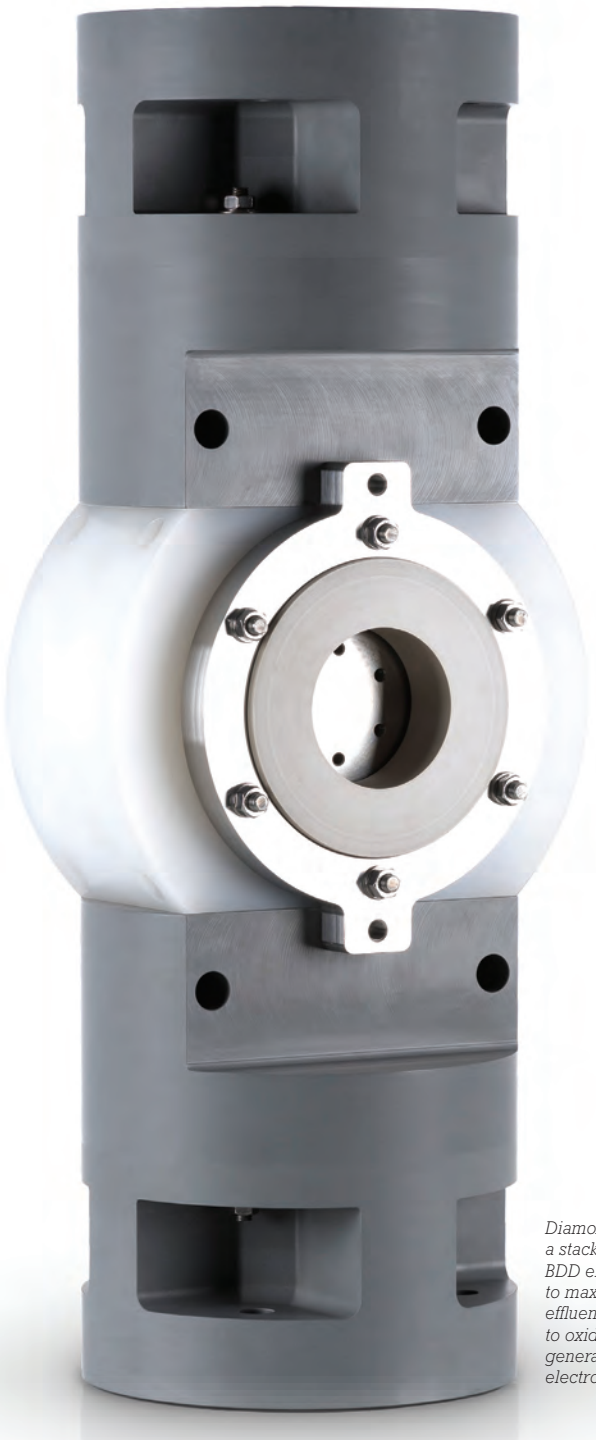
By Hossein Zarrin, Element Six

Water supply is a global concern and, driven by population growth and global industrialization, the demand for clean water is growing at a rate of 5 to 8 percent per annum. The United Nations (UN, UNESCO, and FAO) is responsible for providing the world's water consumption data. Worldwide, agriculture accounts for 70 percent of all water consumption, compared to 20 percent for industry and 10 percent for domestic use. In industrialized nations, however, industries consume more than half of the water available for human use.

THE NEED FOR ON-SITE TREATMENT OPTIONS

Public awareness about environmental problems has driven many governments to introduce legislation that limits the discharge of pollutants. This has increased the demand for on-site effective treatment at the generation point of the effluent. Rather than transporting wastewater to treatment plants, on-site treatment reduces cost, minimizes the risk of contamination and makes recycling wastewater viable. Various treatments that originated from sewage and wastewater treatment have been used to treat bio-recalcitrant compounds. All of them have inherent problems that make them less than ideal processes for the removal of bio-recalcitrant compounds such as phenolic, and biocides such as ammonia; often, even in large central plants, these types of waste streams are challenging to treat.

Difficult to treat industrial wastewaters sometimes contain a high amount of total dissolved solids, or are often high in chemical oxygen demand (COD), low in biodegradability, and potentially toxic to biological processes. These wastewaters are typically trucked off-site for treatment. With recent developments in electrochemical advanced oxidation processes, on-site treatment is now possible for these difficult to treat wastewaters. Electro-oxidation can remove recalcitrant organic pollutants in industrial wastewater by mineralizing them to CO_2 and H_2. This process terminates toxic organics without leaving any sludge



Diamox™ contains a stack of bipolar BDD electrodes to maximize the effluent's exposure to oxidizing species generated at the electrode surface.

or solid waste. The other main byproducts are typically oxygen and nitrogen. Wastewaters produced by the petrochemical, fine chemical, refining, and pharmaceutical industries are potentially toxic to biological wastewater processes. They can contain COD values of greater than 10,000 milligrams per liter, and may additionally be highly odorous, present hazards to operators, or produce foaming. The problematic components in the wastewater can be complex organics, halogenated organics, reduced sulfur species, and nitrogen-containing compounds.

ADVANCED OXIDATION PROCESSES

Most common advanced oxidation processes use a strong oxidizing reagent such as hydrogen peroxide or ozone in combination with ultraviolet light activation to generate hydroxyl radicals. Electrochemicals generate the hydroxyl radical directly at the surface of electrodes placed in the effluent stream. Electro-oxidation processes are attractive as they are simpler to operate and do not require purchase, storage, and handling of strong oxidizing reactive reagents, which are hazardous in their own way. Electrochemical hydroxyl radical generation requires the application of such extremely high electrode potentials that most electrically conductive materials themselves oxidize, including titanium-based dimensionally stable anodes and lead dioxide versions. These challenges, that previously prevented rapid acceptance of this technology, have recently been overcome by the use of free-standing solid polycrystalline boron-doped diamond (BDD) electrodes.

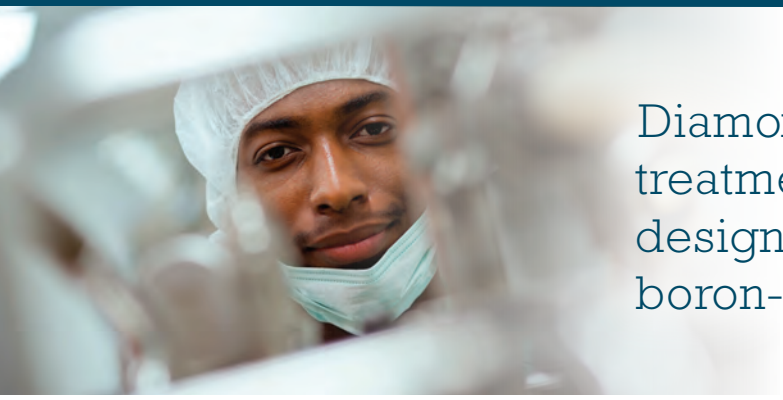
BORON-DOPED DIAMOND ELECTRODES

Diamond is a semiconductor material that can be heavily doped with boron to give it metal-like electrical conductivity, while retaining its renowned robust properties such as chemical inertness and exceptional hardness. Utilizing the chemical vapor deposition (CVD) method of growing diamond, synthetic BDD electrodes can be manufactured. BDD electrodes have a much lower catalytic effect on water, and instead of electrolyzing water they generate hydroxyl radical first, leading to higher oxidation of contaminants via direct or indirect oxidation. The microwave plasma-enhanced CVD method can be used to manufacture disks of free-standing, solid conducting polycrystalline BDD on an industrial scale, which can be used for electrodes in the electro-oxidation treatment.

Diamond is the world's hardest material and as an electrode has extreme dimensional stability.

These BDD electrodes can withstand the demanding requirements needed for an industrial electrode material. Diamond is the world's hardest material and as an electrode has extreme dimensional stability. Free-standing BDD electrodes, while small in area, have the ability to operate at a higher current density (>20,000 A/m^2) than all types of conventional electrode materials and thin film BDD coatings. This enables the construction of compact electrochemical reactors that are capable of high throughput and productivity in a small footprint.

Diamox™ is an efficient wastewater treatment electrochemical reactor, designed using free-standing, boron-doped diamond electrodes. When integrated into an electrochemical wastewater processing system, it is effective in treating extremely contaminated industrial wastewater that cannot be treated by biological



Diamox™ is an efficient wastewater treatment electrochemical reactor, designed using free-standing, boron-doped diamond electrodes.

methods. This packaged reactor is simple to implement into on-site industrial wastewater treatment systems, providing an environmentally cleaner and versatile solution that can be used across various types of effluents, without producing sludge.

THE MOVE TOWARD ON-SITE TREATMENT OPTIONS

On-site treatment systems are used for the treatment and disposal of relatively small volumes of wastewater. They collect, treat, and discharge or reclaim wastewater from an individual manufacturing site without the use of community-wide sewers or a centralized treatment facility. Over the last decade, a number of on-site wastewater treatment plants have been installed all over the world. These systems do well in terms of performance, land area requirement, and capital, operation, and maintenance costs. Some textile and pharmaceutical plants are currently using electrochemical oxidation processes for the treatment of wastewater streams, where the bio-refractory contaminants are decomposed into harmless or biodegradable products.

The removal of dyes from aqueous effluents is of significant environmental importance. Synthetic dyes possess certain properties, such as resistance to abrasion, photolytic stability, and resistance to chemical and bacterial attack. Therefore, they pose a double environmental problem from both the aesthetic and toxicological standpoint. The metabolites of several dyes have been reported as substances that have potentially carcinogenic, mutagenic, and/or teratogenic effects on aquatic life. treatment methods for the removal of dyes include reverse osmosis, coagulation flocculation, and chemical oxidation. These are physical methods that are not destructive, and for this reason, some dyes or their metabolites are often discharged into water streams.

Diamox™ has proven reliability and is easy to integrate into your water treatment technology.

Wastewater from pharmaceutical manufacturing sites often contains active pharmaceutical ingredients (API) that need to be removed or neutralized. These molecules are best treated by being oxidized and broken up rather than filtered. Electro-oxidation is the most effective way of processing API.

Spent caustic streams from refineries typically have a high chemical oxygen demand (20-300 g/L) and contain chemicals that are hazardous, inhibitory, or bio-refractory. The potential chemicals in the spent caustic wastewater include reduced sulfur compounds such as sulfides and mercaptans, as well as organic species such as the sodium salts of naphthenic and cresylic acids. Due to the types of chemicals contained in the spent caustic, such wastewaters can be environmentally hazardous and difficult to treat with conventional biological treatments. Electro-oxidation can be used as a treatment process to significantly reduce COD, eliminate toxicity, and produce an effluent that can be disposed of using biological post-processes.

Biological oxidation is certainly the inexpensive process, but the presence of toxic or bio-refractory molecules may hinder this approach. In many situations, a combination of electro-oxidation and biological processes may be the most cost-saving treatment when the traditional incineration method cannot be used. Effective treatment at the generation point of liquid pollutants is possible with electro-oxidation. A small footprint, low-odor, and low-noise operation make electro-oxidation viable in any plant. Its ability to mineralize effluents and denature compounds in solution opens up potential applications in water recycling since the effluents are being continuously removed from the process. ◆

Element Six is a global leader in the design, development, and production of synthetic diamond and tungsten carbide supermaterials. Part of the De Beers Group, Element Six employs over 1,900 people and its primary manufacturing sites are located in the United Kingdom, Ireland, Germany, South Africa, and the United States. For more information, visit **www.e6.com**.

Toilet Paper Shortage Causing Sewer Pump Clogs? Here's the Remedy!

The unseen consequences of a pandemic on wastewater systems

By Stacy Belanger and Troy Heimerl, JWC Environmental

You've seen the news reports and posts on social media, maybe even experienced it firsthand, about an increase in sewer clogs since the toilet paper shortage caused by COVID-19 concerns. The assumption is people are using alternative materials to toilet paper such as baby wipes, wet wipes, paper towels, and even shredded clothing. Unfortunately, these materials do not disintegrate in the sewer system like toilet paper. As a result, they collect on sewer pumps causing them to clog and mix with fats, oils, grease, and other sewage in the pipes to form so-called fatbergs. While people should only flush the three P's—pee, poop, and (toilet) paper—the reality is all sorts of material—wipes, cotton swabs, hair, the occasional children's toy—are flushed down the toilet.

Although these materials may not cause immediate consequences at the toilet, they can have serious ramifications in the sewer system. These materials clog sewer pumps and pipes, leading to very unpleasant sewage overflows.

WHAT IS TO BE DONE?

Without a change in human behavior, what can be done to prevent these sewage clogs? One solution is to install a dual-shafted sewage grinder, such as JWC Environmental's Muffin Monster®, in the sewer line. Dual-shafted sewage grinders have two rows of sharp cutters that rotate slowly and with high torque. The two shafts of the shredder rotate at different speeds. The two intermeshing cutters act like a pair of extremely powerful scissors, effectively cutting up any solids into smaller pieces that can then typically flow smoothly through the sewer line without clogging equipment.

SHREDDING CLOGS BEFORE THEY START

Unfortunately, sometimes shredding these solid materials is not enough. If the material is shredded into long strips, they may reweave with hair and FOG (fats, oils, and grease) later in the sewer line, causing clogs at that time. JWC developed its Wipes Ready® technologies for the Muffin Monster specifically to shred material in a confetti-cut, effectively preventing material from reweaving downstream when mixed with FOG and hair.

When wipes, diapers, rags, and other flushed solids cause pump problems, a Muffin Monster with Wipes Ready can cut these materials down to a size that will not re-solidify. Pumps remain clean and operational. There is no unplanned maintenance and sewage overflows are avoided when pumps do not clog, saving time and money.

KEEPING THE LINES CLEAN

The shortage of toilet paper is leading people to use alternative materials that should not be flushed down the toilet. The best practice to keep our sewage systems functioning properly is to flush only the three P's. But if you are experiencing an increased frequency of pump clogs, a Muffin Monster with Wipes Ready technology from JWC installed before the pumps may be the next best solution. We encourage everyone to follow best practices during the COVID-19 pandemic—practice good hygiene, maintain social distancing, stay home if you feel unwell, and seek appropriate medical help. And make our wastewater treatment crews' jobs easier by flushing only the three P's, so they do not need to unclog pumps and clean out fatbergs that are preventable with appropriate flushing practices. ◆

VIEW THE WEBINAR

For more on this topic, view the JWC Environmental webinar **"No TP. Now What?"** at www.modernpumpingtoday.com/webinar-jwce.
Completion of the webinar is worth 1 Professional Development Hour.

JWC Environmental, a Sulzer brand, is a world leader in solids reduction and removal for the wastewater industry with its Muffin Monster grinders and Monster screening, compaction and washing systems. JWC also solves challenging size reduction and processing problems in commercial and industrial applications with its Monster Industrial products. JWC Environmental is headquartered in Santa Ana, California, and has a global network of representatives, distributors and regional service centers to provide customer support. For more information, visit **www.jwce.com.**

Protecting Industrial Facilities from Harsh Environmental Corrosion

Innovative Chemically Bonded Phosphate Ceramic coatings provide durable protection from atmospheric and chemical corrosion

By Del Williams

In industrial process facilities, corrosion is the biggest single cause of plant and equipment breakdown, including machinery, vessels, structures, supports, and pipelines. While atmospheric corrosion in the form of air (oxygen), and water (moisture, humidity, vapor, etc.) is the main culprit, environmental factors including high temperatures and pressures as well as harsh substances, chemicals, and gasses can also accelerate the corrosion of carbon steel and other metals.

Beyond marine environments exposed to salt spray or compounds that cause corrosion, common gaseous industrial air pollutants, such as sulfur dioxide, ozone, and nitrogen dioxide, can be corrosion inducing. So can exposure to industrial chemicals such as chlorides, acetic acid, and formaldehyde.

"There is a huge need for an anti-corrosion coating that can go on in areas where conventional coatings tend to fail," says Joey Taylor, president of IPI Inc., an Elkview, West Virginia-based paint/coating contractor for commercial and industrial construction. "On certain projects, chlorides need to be removed in order to meet peak performance. But in most cases, this can be cost prohibitive."

Fortunately, for industrial facilities with assets prone to environmental corrosion, a new category of tough, Chemically Bonded Phosphate Ceramic (CBPC) coatings is helping to stop corrosion, ease application, and reduce production downtime.

LONG-TERM ENVIRONMENTAL CORROSION PROTECTION

When aluminum is recycled, it is melted to separate the pure metal from the impurities. The process creates a waste product called salt cake, which contains compounds that can promote corrosion.

As a result, typical barrier-type anti-corrosion coatings, such as polymer paints, can fail prematurely. This is particularly true when the paint is scratched, chipped, or breached and corrosion promoters enter the gap between the substrate and coating. Then the coating can act like a greenhouse—trapping the corrosion promoters—that allows the corrosion to spread under the coating.

Therefore, when an aluminum recycling plant in West Virginia required corrosion protection for its operation, it sought a long-term term solution that would not require frequent recoating, according to Taylor, who was involved with the project.

"The recycling plant was not having much luck with conventional anti-corrosion coatings, which only lasted about three or four years," says Taylor. "Really, anyone trying to protect their assets from corrosion wants their coating to last much longer than that."

LONG-TERM CORROSION PROTECTION

To provide long-term corrosion protection in a tough environment, the aluminum recycling plant and Taylor turned to EonCoat, a spray applied inorganic coating from the Raleigh, North Carolina-based company of the same name. EonCoat represents a new category of rugged, Chemically Bonded Phosphate Ceramics (CBPCs) with unique properties.

In contrast to traditional polymer coatings that sit on top of the substrate, the corrosion resistant CBPC coating bonds through a chemical reaction with the substrate. The coating can even be applied over flash rusted, damp steel. An alloy layer is formed. This makes it impossible for corrosion promoters like oxygen and humidity to get behind the coating the way they do with ordinary paints.

Although traditional polymer coatings mechanically bond to substrates that have been extensively prepared, if gouged, moisture and oxygen will migrate under the coating's film from all sides of the gouge.

By contrast, the same damage to the ceramic-coated substrate will not spread corrosion in industrial infrastructure because the carbon steel's surface is turned into an alloy of stable oxides. Once the steel's surface is stable (the way noble metals like gold and silver are stable) it will no longer react with the environment and cannot corrode.

NO GAPS, NO CORROSION

Visible in scanning electron microscope photography, EonCoat does not leave a gap between the steel and the coating because the bond is chemical rather than mechanical. Since there is no gap, even if moisture was to get through to the steel due to a gouge, there is

nowhere for the moisture to travel, which effectively stops corrosion in industrial applications.

The corrosion barrier is also covered by a ceramic layer that resists corrosion, water, impact, abrasion, and chemicals as well as fire and temperatures up to 842 degrees Fahrenheit (450 degrees Celsius).

For such durable corrosion protection, IPI Inc. successfully sprayed EonCoat on two industrial dust collectors (one 60,000 CFM and one 40,000 CFM), including four tanks as large as 40 feet tall and associated ductwork, according to Taylor.

"The CBPC anti-corrosion coating is designed to last significantly longer than traditional coatings, so frequent recoating should not be an issue," says Taylor.

BENEFITS OF CBPC COATINGS

Industrial operation managers or corrosion engineers looking to reduce costs are also finding additional advantages with CBPC coatings like EonCoat beyond corrosion resistance.

Such coatings consist of two non-hazardous components that do not interact until applied with a standard industrial plural spray system like those commonly used to apply polyurethane foam or polyurea coatings. Since CBPC coatings are inorganic and non-toxic, there are no VOCs, no HAPs, and no odor. This means the water soluble, non-flammable coatings can be applied safely even in confined spaces, or when adjacent parts of a plant continue to operate.

"With the CBPC coating, since there are no VOCs or odor, coating can be done around plant employees or other contractors without restrictions," says Taylor.

One of the greatest benefits, however, is quick return to service that minimizes facility downtime. The time saved on anti-corrosion coating projects comes both from simplified surface preparation and expedited curing time. With a typical industrial coating, near white metal blast cleaning (NACE 2 / SSPC-SP 10) is required to prepare the surface. But with the ceramic coating, only a NACE 3 / SSPC-SP 6 commercial blast cleaning is typically necessary.

"The CBPC anti-corrosion coating is designed to last significantly longer than traditional coatings, so frequent recoating should not be an issue."

ADVANTAGES OVER TRADITIONAL COATINGS

With traditional coatings, extensive surface preparation is required and done a little at a time to avoid surface oxidation, commonly known as "flash rust," which can require re-blasting.

However, with the CBPC coating, flash rust is no issue. There is no need to "hold the blast." The reason for this unique CBPC characteristic is due to the presence of iron in the rust, which helps to create the magnesium iron phosphate alloy layer. It is this alloy layer that allows CBPCs to so effectively protect carbon steel from corrosion.

"Conventional coatings require you to prime the substrate every day so you do not lose your blast," says Taylor. "You have to stop sandblasting in the early afternoon, and then prime [the substrate] the rest of the day. This requires time-consuming daily teardown and set up of paint equipment."

SAVING EQUIPMENT AND SAVING TIME

"With EonCoat, however, once you have a clean substrate surface, free of mill scale and coating, it will not hurt it to let it flash rust," adds Taylor. "So, you can continue coating [the next day] without having to re-blast the substrate, re-prime it, or set up and teardown paint equipment each day. You can continue to blast the entire twelve-hour shift. That saved us about a fifty-hour workweek on the project."

For traditional "three-part system" coatings utilizing polyurethanes or epoxies, the cure time may also be days or weeks before the next coat can be applied, depending on the product. In contrast, a corrosion resistant coating for carbon steel, utilizing the ceramic coating in a single coat, requires almost no curing time.

"We were able to complete the project from start to finish in nine weeks, including substrate preparation, spraying, and adding a high-performance topcoat with minimal disruption to the plant's operations," says Taylor.

Industrial facility managers looking for more reliable, long-term corrosion protection in harsh environments will find that CBPC coatings add significantly to safety, production, and the bottom line. ◆

EonCoat manufactures and sells its patented EonCoat anti-corrosive coating to large industrial customers throughout the world. EonCoat is focused on preventing corrosion on a wide scale, and the company only works with corporations of significant size, often those that are publicly traded with multinational operations. For more information, call 754.222.4919 or visit **www.eoncoat.com**.

Analysis of Peristaltic Pumping Technology in the Mining Industry

Part 1 of 2

By Rob Martindale, Watson-Marlow Fluid Technology Group

The importance of water cannot be underestimated, and consequently all mines must carefully assess the impact of mining on local and regional water quantity and quality in order to retain a social license to operate. With this in mind, best practice water management defines credibility for the mining industry while negating the potential impact of additional costs.

In a paper prepared for the International Council on Mining and Metals, it was suggested that water access, quality, use, and environmental impact directly affect the ability of the industry to operate worldwide. Despite these challenges, mine operators face ever increasing obligations to reduce water consumption.

There are key benefits associated with using peristaltic pump technology in the mining sector with respect to added value and cost reduction.

LESS WATER EQUALS FEWER COSTS

Among the key drivers for water reduction and greater water re-use in the mining sector are:

- Environmental responsibility. For instance, the Pascau Lama project on the Chilean-Argentinean border was delayed by a decade because of possible environmental impact.
- The limited availability of water at mines located in desert areas or at altitude.
- Increasing price of water.
- Intake water needs to be conditioned i.e. alum dosing, pH control, etc.
- Effluent water of operation needs to be treated.

In order to increase production and, at the same time, minimize rising costs, companies need to optimize their mining procedures.

The less time a mine requires to pump, add, or remove water in the course of processes translates into reduced operating costs. However, the relationship between maintaining a reliable supply of water to support mineral processing, and using as little water as possible in order to have the smallest volume on hand at any time, means that water inventories must be managed carefully.

Pumps have a vital role to play, and peristaltic pumps specifically can be considered water-saving devices, not simply because they accommodate very high solids-content materials found commonly in mining operations, but because they do not have seals they don't require water for flushing, thus eliminating the requirements to both treat process wastewater or provide pump service water.

BENEFITS OF PERISTALTIC PUMP TECHNOLOGY FOR MINING APPLICATIONS

Peristaltic pumps supplied by Watson-Marlow Fluid Technology Group (WMFTG) can be considered as inherent metering pumps offering repeatability of 99.5 percent.

Best practice water management defines credibility for the mining industry.

Bredel hose pumps have a corrosion-resistant enclosure which suits arduous mining environments.

Bredel hose pumps from WMFTG, for instance, accommodate continuous flow rates up to 28,500 gallons per hour and are extremely durable (pressures up to 16 bar). There are no internal universal joints, valves, dead corners, or glands to impact flow, and they are reversible for back-flushing.

HANDLING THICKER SLURRY FLOWS

Although one main goal of mine operators is to use less water in the transportation process, doing so creates thicker, more paste-like slurries, which in turn creates other issues. More product can be transferred at lower velocities, but pumps and hoses must be designed to handle thicker flows.

Bredel hose pumps can handle undiluted tailings and thickener underflow up to 80 percent solids. No seal water flush systems, strainers, dampeners, in-line check valves, run-dry protection devices, or other ancillary equipment is needed. The entire family of pumps are self-priming to 29.5 feet, can run dry safely and can meter accurately to ±1 percent.

This innovative technology fits the demand for more efficient modes of high concentration slurry transport. The ultimate aim is to reduce water use, energy consumption, and capital costs, as well as improve slurry transport reliability by establishing a more fundamental understanding of slurry flow behavior and design.

OPTIMIZING THE TRANSFER OF PASTE BACKFILL

One of the most commonly pumped materials in mining operations is paste backfill, a cementitious composite that is similar to concrete. It consists primarily of mine tailings mixed with hydraulic binders, which are typically Portland cement and some form of supplementary cementing materials, and water. Residues, slimes, or "tailings" are the

materials left over after the process of separating the valuable fraction from the worthless fraction (gangue) of an ore or mineral.

Paste technology is introduced to make the backfill quicker, easier, and more cost effective to transport, deposit, and cure. The goal for the high density paste formulations is to produce a pumpable material that does not segregate when transferred—the fines content should be a minimum of 15 percent by weight of the paste. Naturally, choosing the right pump technology for the task is vital.

Bredel hose pumps have a corrosion-resistant enclosure which suits arduous mining environments.

ACCOMMODATING HIGH SOLIDS CONTENT

Pumping applications in the mining sector frequently involve abrasive, corrosive, shear sensitive, and viscous liquid products. Solids such as rocks, sand, and ore comprise different mineral contents and pump systems must be able to accommodate these variations.

Mining slurries often feature sub-micron solid contents of 80 percent by weight, with specific gravity often greater than 2.0. In addition to offering abrasion resistant slurry pumping performance in arduous conditions for extended periods, pumps must be capable of high operating pressures and flow rates to ensure a smooth liquid passage and deny the opportunity for the product to settle.

Other features include repeatable and reliable flow, self-priming functionality, and low and easy maintenance. However, with so many pump types available it is little wonder mines frequently end up employing technology unsuitable for the task. Ultimately this leads to inefficiency and increased costs, typically due to excessive wear and downtime.

LIMITATIONS OF CENTRIFUGAL PUMPS

While centrifugal pumps have traditionally dominated the mining sector, particularly for operations such as thickener underflow applications, they are not without their shortcomings. For instance, the amount of dry solids that can be handled by centrifugal pumps is limited. In several applications, rotors or impellers on slurry pumps last only weeks and membrane pumps clog, leak, or fail due to factors such as strong acidity in a matter of months. Attempting to overcome these problems, some mine operators purchased highly expensive special pumps constructed from acid-resistant materials.

For these reasons peristaltic hose pumps are taking ever greater slices of market share. Among the many benefits of peristaltic hose pumps are:

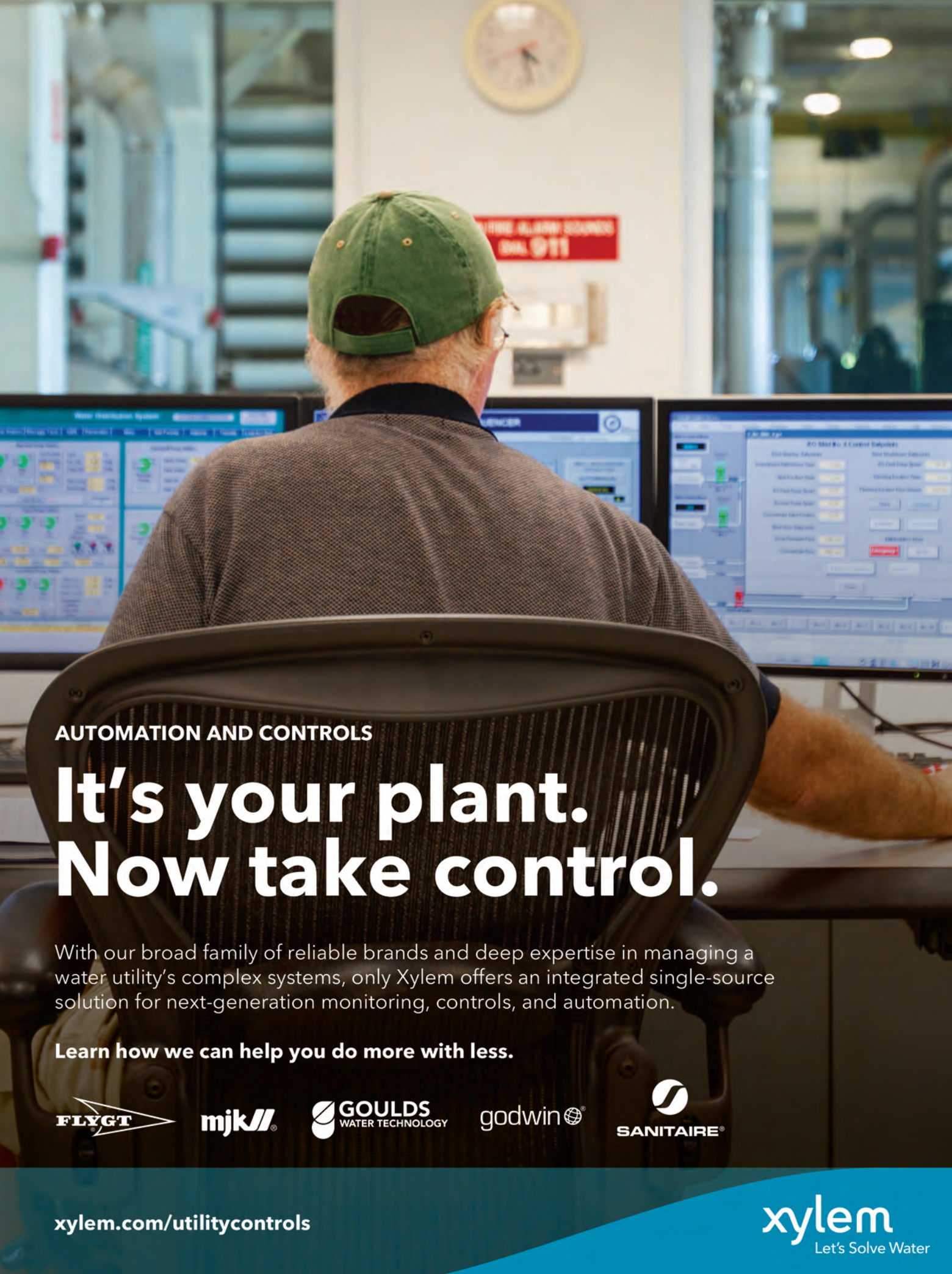
- No mechanical seals.
- No requirement for seal gland water.
- No seal water flush systems.
- No moving parts in the product zone.
- Low and easy maintenance—just one wearing part: the hose.
- Almost all materials can be pumped, including slurries.
- Backflow and siphoning are prevented without the need for valves.
- Wear-free performance.

For the mining sector this last point is arguably the most advantageous. Obviously, the longer a pump can operate without maintenance or failure, the better. The wear-free performance of peristaltic pumps is an attribute that results from a unique operating principle. Unlike other pumps, the abrasive nature of the product has no bearing on pump life and the need for routine maintenance and spare parts is reduced greatly.

A LOOK AHEAD

The hose is at the heart of peristaltic operations, and in next month's conclusion to this article, we'll highlight its benefits as well as calculate savings of using a peristaltic hose pump over a rubber lined centrifugal pump. ◆

Watson-Marlow Fluid Technology Group (WMFTG) is the world leader in peristaltic pumps and associated fluid path technologies. The group comprises ten established brands, each with their own area of expertise. Together they provide leading engineering solutions across the food, pharmaceutical, chemical, and environmental industries. WMFTG is a wholly owned subsidiary of Spirax-Sarco Engineering PLC. For more information, visit **www.wmftg.com**.



AUTOMATION AND CONTROLS

It's your plant. Now take control.

With our broad family of reliable brands and deep expertise in managing a water utility's complex systems, only Xylem offers an integrated single-source solution for next-generation monitoring, controls, and automation.

Learn how we can help you do more with less.

FLYGT mjkJ GOULDS WATER TECHNOLOGY godwin SANITAIRE

xylem.com/utilitycontrols

xylem
Let's Solve Water

New Industrial-strength Pumps Handle Critical Water Challenges

Xylem debuts a versatile line-up of heavy-duty equipment

By Joshua Allen, Xylem Industrial Solutions

Xylem continues to advance its holistic approach to smart industrial water and fluid management by expanding its leading pump portfolio to include the rugged and efficient e-MP multistage ring section pumps, e-XC single stage double suction centrifugal pumps, and larger vertical turbine pumps.

From intake to discharge, Xylem's superior expertise of the entire use cycle coupled with the introduction of these robust products provides a wide range of industrial applications with increased production and profitability.

Large capacity vertical turbine, multistage ring section, and double suction centrifugal pumps solve water and fluid management intensive applications.

TAKING ON THE BIG CHALLENGES

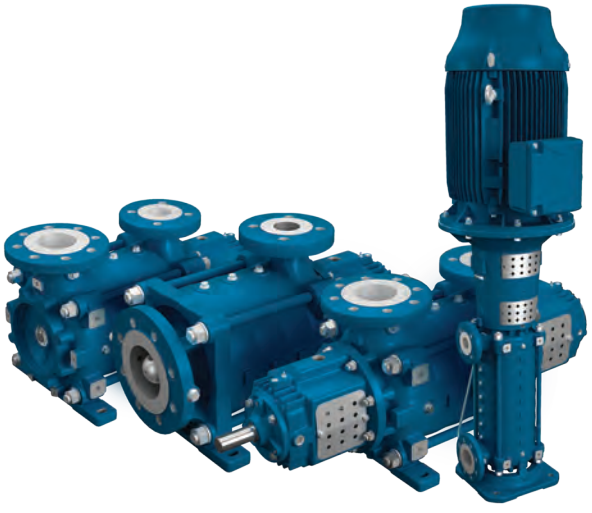
Designed to address the biggest issues in industrial pumping and processes, including minimizing downtime, costs and environmental impact, and boosting and transporting water as efficiently as possible, these products seamlessly integrate with industrial operations for sustainable production.

Industries ranging from pulp and paper to automotive to food and beverage rely on technology, innovation and dependability in the products they choose to strike the right balance of output, efficiency and costs. Drawing on more than 170 years of experience, our experts developed these solutions to minimize downtime and meet environmental regulations.

MEET THE TEAM

Xylem's e-MP, e-XC, and vertical turbine pumps are customizable to meet the demands of industrial applications—from water intake and boosting to wastewater discharge. Built on the thinking that every step in industrial operations is part of a process versus a stand-alone function, these products are safer, stronger, and more efficient for lower life-cycle costs and energy demands. More benefits of the products are outlined below.

The multistage ring section pump is ideal for high-pressure applications, such as filtration, reverse osmosis, boiler feed, and scrubbers. Versatile mechanical configuration and optimized pump hydraulics enable reduced energy consumption and wear and tear, while intelligent pumping features boost monitoring and control



e-MP Multistage Ring Section Pump

e-XC Single Stage Double Suction Centrifugal Pump

performance with multiple sensor interfaces and options.

Designed for maximum durability and performance in even the harshest environments, the e-XC comes in multiple models, configurations, and a wide range of materials to handle aggressive applications. A corrosion-resistant stainless steel impeller and wear rings as standard reduce downtime, increase efficiency, and enhance overall performance.

The highly efficient extension to the existing Xylem vertical turbine product line, it's scaled with

Vertical Turbine Pump

capacities up to 50,000 gallons per minute for the largest industrial fluid needs, including raw water intake and boosting, fluid transfer, and machine tool cooling. With bowl efficiencies near 90 percent and broad hydraulic coverage, operators can realize greater energy savings while maintaining superior pumping power.

WELCOME TO THE CUTTING EDGE OF PUMPING

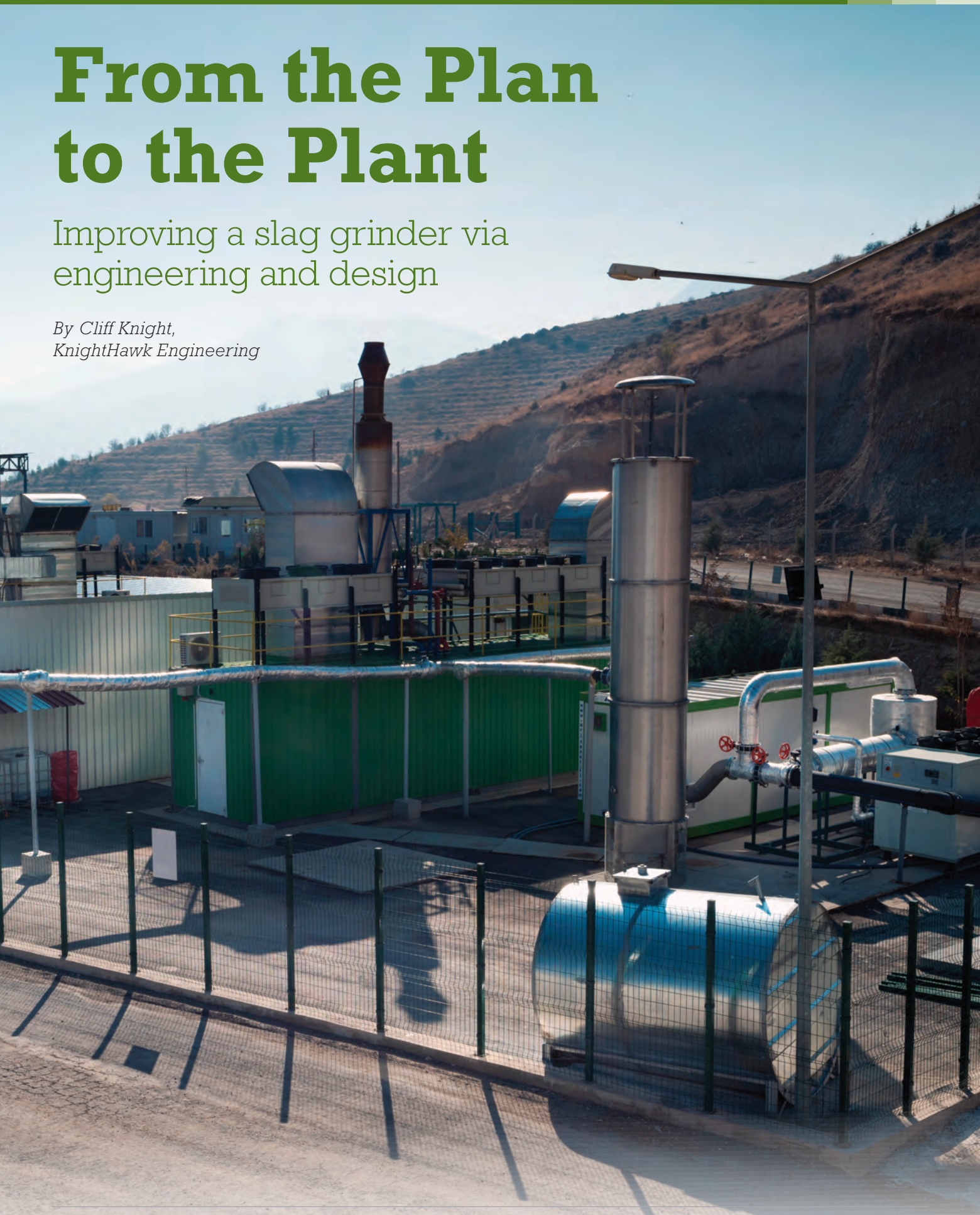
Industrial operations need to stay on the cutting edge of pumping and process technologies, and the reliable e-MP, e-XC, and vertical turbine pumps can advance their business, keeping facilities online, and helping achieve cost and energy savings. ◆

Xylem is a leading water technology company committed to "solving water" by creating innovative and smart technology solutions to meet the world's water, wastewater, and energy needs. In a world of ever-growing challenges, Xylem's technological strength across the life-cycle of water is second-to-none. From collection and distribution to reuse and return to nature, its highly efficient water technologies, industrial pumps, and application solutions not only use less energy and reduce life-cycle costs, but also promote sustainability. For more information, visit **www.xylem.com**.

From the Plan to the Plant

Improving a slag grinder via engineering and design

By Cliff Knight, KnightHawk Engineering



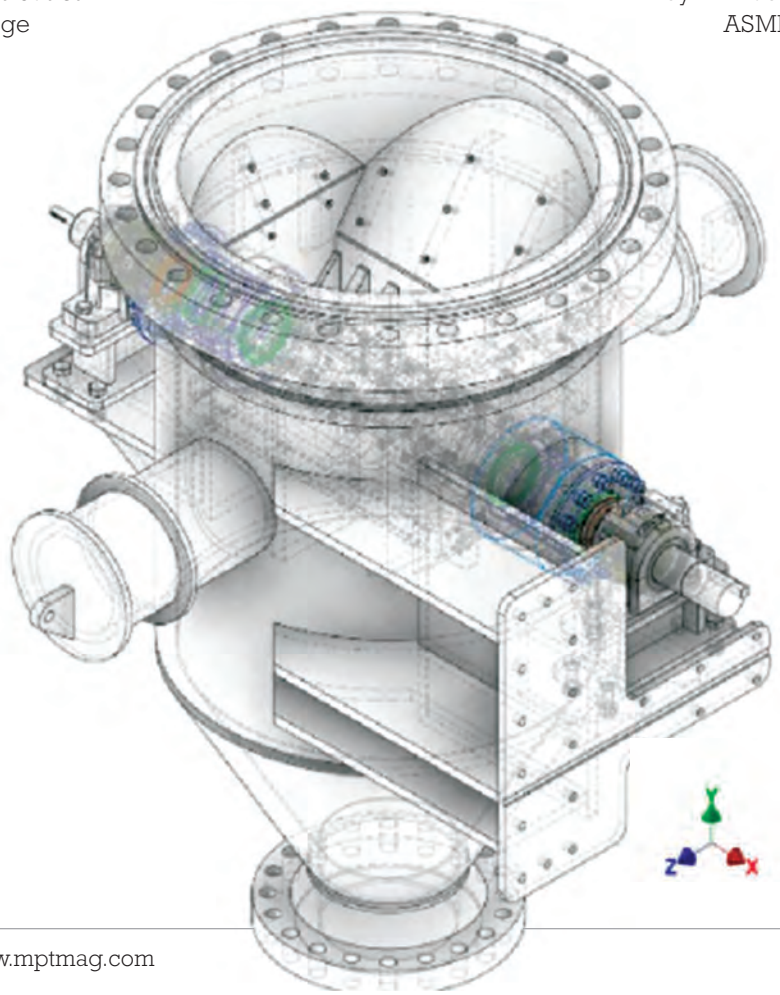
Crushers and slag grinders are often applied in materials handling and gasification plants to reduce the size of quenched slag from the gasifier's tap-hole or break clinkers from slow moving bed reactors. These clinkers are typically brittle and relatively easy to crush, but may be larger and very hard and abrasive when sintered during a reactor transient or upset conditions. Also, these crushers are often of toothed roller type, integrated in a pressure vessel subject to charge / discharge cycles, slow rotating yet transmitting very high torques and crushing forces. This makes it simultaneously a "machine" and a "pressure vessel."

PROBLEM: INTEGRATING ON-SITE NEEDS

A slag breaker dating from the 1970s required replacement. The new design had to incorporate lessons learned in operations and maintenance, fit accurately into the existing structure and inlet-outlet flange face-to-face envelope, and re-use the existing drivetrain. The crusher must reduce slag as well as occasional refractory tiles or bricks, dislodged from the gasifier hot face, to no more than 1 inch in size to avoid bridging and arching in the outlet. The equipment must be designed, manufactured, tested, and delivered to site under schedule constraints, in time for the next scheduled shutdown.

SOLUTION: BRINGING THE DESIGN TO LIFE

KnightHawk engineering digitized hand drawn blue-prints and developed 3D CAD models (below) applied in concept development, client reviews, and manufacturer reviews and design. Detailed 2D CAD drawings and part lists as well as geometry and meshing for Finite Element (FEA) designs, were developed from this model. The pressure vessel was designed as per ASME VIII Division 1 with supplementary analysis by FEA as per ASME/API 579-1 Fitness for Service (FFS) by using the methods and guidelines from ASME VIII Division 2 Part 5.



The rotating parts and breaker element were integrated into the pressure vessel by shaft, breaker tooth, breaker plates, gland seals, end bearings, and a bolt-on cantilever drive unit (not shown) consisting of a motor, gearbox, and coupling. The breaker element is protected from overpower, including an auto reverse, circuit breaker, shear pin, and hydraulic coupling.

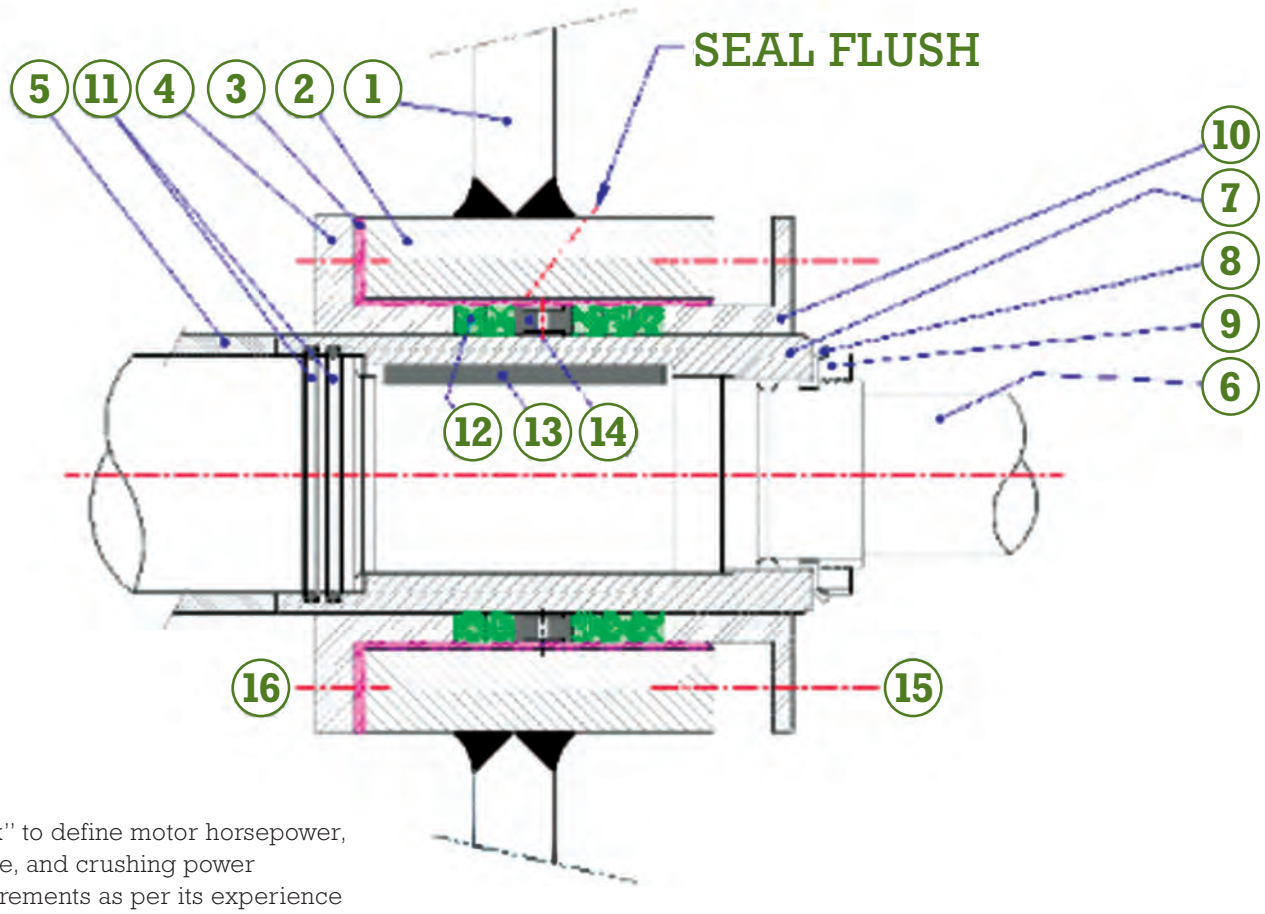
The breaker element and teeth must be accurately sized and designed for particle size reduction, throughput and slag crush strength requirements, to ensure effective crushing yet avoid jammed rotor and lockup conditions. KHE determined the required grinding energy by the third comminution theory as per Bond's equation using a "Work

ACHIEVING SUCCESS

Successful design was achieved by:

- A multi-party, collaborative design process including original OEM Designer, owner-operator, KHE Specialty Engineering, and manufacturers all with significant experience in industry.
- A multi-disciplinary approach including process, mechanical, metallurgical, and controls.
- A multi-physics approach including code "design by rules," FEA "design by analysis," first principle machine and structural design by correlations as well as fatigue, thermal, and modal analysis.

This ensured a design fit for purposes and with adequate protection against failure.



Index" to define motor horsepower, torque, and crushing power requirements as per its experience for this type of equipment.

PRESSURE VESSEL CONSIDERATIONS

The pressure vessel design must include for considerations of (1) internal pressure-temperature design, (2) fatigue loading from batched feed and pressure cycles, (3) bending and crushing forces from drivetrain weight and work, (4) thermal loading from batch cycles, and (5) modal analysis to ensure no coupling between any fundamental natural frequency, fN, and any of the forcing functions or excitations from the rotating parts result in resonant vibrations.

Materials selection, stainless steel, and tungsten carbide weld overlay of internal surfaces subject to corrosion, impact, crushing, and flow-erosion must be carefully selected to provide a robust yet manufacturable and cost effective equipment fit for service over its design life.

The seal design must include for effective sealing against varying pressure-temperature conditions, a seal flush to ensure cooling, lubrication, and avoid intrusion of abrasive particles. The seal design is schematically shown right. This seal design is typically a multi packing ring compressible gland type with lantern ring assembly. ◆

SEAL DESIGN: A CLOSER LOOK

The seal acts in the annular space between the shaft nozzle housing (2) and the rotating shaft (6). The nozzle bore is weld overlaid (3) in Stainless Steel and final machined to diameter and surface finish presenting the outer seal surface. A shaft sleeve (7) is located by a key (13), retaining washer (8) and threaded lock nut (9). This shaft sleeve is located by the breaker teeth hub (5). An inner compression ring (4) is bolted (16) to the housing. Sealing between the shaft sleeve and the shaft, preventing slurry intrusion and leakage is provided for by two O-rings (11).

Why Do Mechanical Seals Fail?

A brief inventory of common causes of seal wear and damage

By David Chisholm, Dura Pump

Mechanical seals prevent pumps from leaking by containing the pressure of the pumping process and withstanding the friction caused by the pump shaft rotating. This leads to less wasted product, money saving, and less clean up.

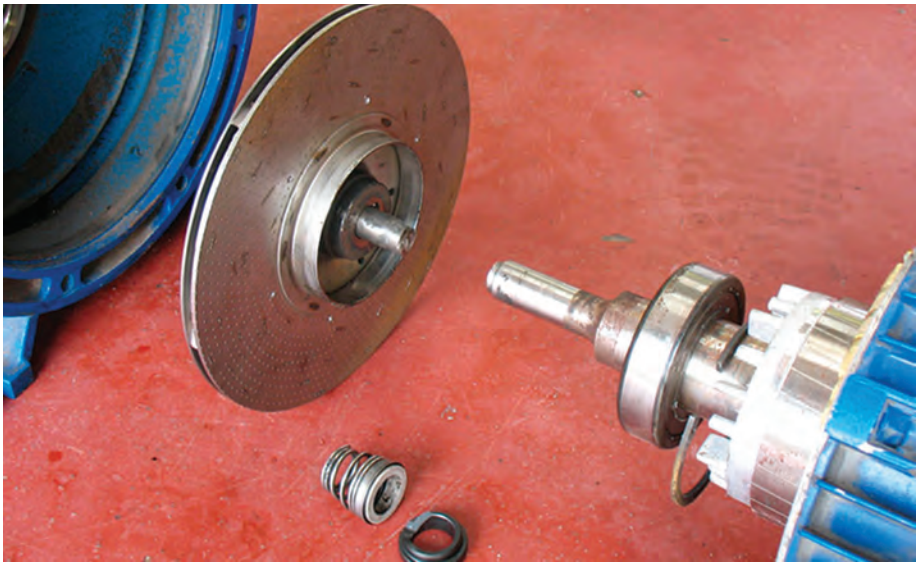
Mechanical seals are the most common cause of pump downtime and account for more pump repair costs than any other part of a pump. Therefore, it's important that they are installed and maintained properly to prevent failures. Here are some of the things you should be looking out for.

INSTALLATION ERRORS

Installation errors can easily damage mechanical seals so it's incredibly important that mechanical seals are installed by a professional and that the installation instructions are followed exactly. If a pump is started with an incorrectly installed seal major damage could occur and potentially damage other parts of the pump as well as the seal.

Potential errors include:

- Shaft misalignment
- Seals not mounted perpendicular to the shaft
- Axially moving shaft
- Wrong assembly length
- Dirt on the seal face
- Over-tightening of fasteners
- Hammering couplings into the shaft
- Using the wrong seal



POOR OR ABSENT LUBRICATION

A mechanical seal might fail due to poor lubrication, or no lubrication at all. When there is no liquid around the seal it will be subjected to increased amounts of friction which will increase the temperature inside the pump. This rapid increase in temperature can cause burnt elastomeric parts and damage o-rings or rubber on the seal. This usually happens when there is no pumped medium in contact with the seal rings to transfer the heat.

Also, when lubrication is poor or absent mechanical seals made of hard materials will make quite a loud noise, this will cause parts of the seal to vibrate which can reduce the life expectancy of both the seal and the pump.

SYSTEM FAILURES DUE TO CHANGES IN OPERATING PARAMETERS

It is vital that the operating parameters of your pump system are what the pump system was designed for, or least the parameters can be met by the pump system you are using. A change in operating conditions may affect the performance of the mechanical seal.

The following parameters affect the performance of a mechanical seal.

- The pressure in the seal chamber
- The temperature around the shaft seal in the seal chamber
- The pumped medium
- The speed
- The shaft seal dimensions

Any adjustments to these parameters could result in malfunction or damage to the mechanical seal. If you plan to make any adjustments to any of these parameters, we would recommend consulting a professional first. Dura Pump can talk you through your pump system to ensure that it is actually capable of running with the adjusted parameters.

HIGH CHEMICAL AND PHYSICAL DEMANDS

All parts of the mechanical seal need to be resistant to the chemical and physical demands of the pumping process. Severe chemical or physical loading can reduce the expected working life of the seal and potentially lead to rapid degeneration and malfunction. It is vital that the pump system is designed to handle such demands and if any changes are made to the level of chemical and physical demand of your pump process, the pump system should be assessed to ensure it can handle it.

Also, when seals are exposed to high-pressure gas at elevated temperatures for a prolonged period of time the gas absorbs into the rubber. If the pressure is decreased and the absorbed gas cannot escape as fast as the pressure is decreased the gas will expand and cause blisters and ruptures on the seal surface. This could cause complete destruction of the seal and even an explosion due to decompression. On the other hand, if the volume of trapped gas is small, the blisters may recede as the pressure is equalized with little effect on seal integrity.

PUMPING SLURRY

Slurry is a semi-liquid mixture typically of fine particles of manure, cement, or coal and water; however, it can be any type of solid suspended in any liquid. A slurry is particularly likely to damage mechanical seals. Some of the problems they can cause include:

- Clogging of the flexing parts of the mechanical seal causing the lapped faces to open
- Wear on rotating components
- Eroding of the impeller
- Wear will gradually decrease the efficiency of the pump

EXPERIENCING PROBLEMS WITH YOUR MECHANICAL SEAL?

Dura Pump's team of experienced pump engineers are available for repairs 24/7. If you are experiencing problems with your mechanical seal, get in touch and we'll send out an engineer who will attempt to carry out repairs on site. If this isn't possible, we use our state-of-the-art workshop to get everything back up and running quickly and efficiently.

To maintain our high standards of service we currently operate within a two-hour radius from Northampton with our trusted partner companies covering the remainder of the United Kingdom. So whether customers need a simple, urgent pump repair, or a whole new system, Dura Pump's team can provide options to help. ◆

Dura Pump's dedicated team of pump specialists key aim is to ensure we provide customers with specialist fluid control that guarantees increased productivity and profitability for our clients through reliable and efficient solutions. For more information, visit **www.durapump.co.uk**.

The Show Must Go On!

EASA® 2020 REIMAGINED

WHEN:
JUNE 15-17

WHERE:
Wherever you are!

GAIN THE ADVANTAGE

Gain the Advantage with This Unique Online EASA Event!

- EASA 2020 Reimagined features expert-led online sessions from EASA's support team and thought leaders in sales, marketing and management.
- Participate in general sessions outlining the latest EASA/AEMT research on maintaining the efficiency of rewound premium efficient motors and the economic outlook.
- Gene Vogel, EASA Pump + Vibration Specialist, will present sessions specifically focused on pumps.
- Explore the virtual exhibit hall to find suppliers for your electromechanical needs.

Register today at easa.com/convention!

EASA Members Attend This Event For FREE! Join EASA Now!

MEMBER EASA® The Electro•Mechanical Authority

More than 90% of EASA members repair pumps in addition to other electromechanical equipment. Join the association of pump repairers and attend EASA 2020 Reimagined for free, access to EASA's technical support service including a dedicated pump and vibration specialist and more!

Get started at easa.com/join!

EASA® The Electro•Mechanical Authority
1331 Baur Blvd. • St. Louis, MO 63132 USA
+1 314 993 2220 • easainfo@easa.com • easa.com

Featured Product

YASKAWA AMERICA, INC.

GA500 Industrial Microdrive

The Drives & Motion division of Yaskawa America, Inc. proudly introduces the GA500 Industrial Microdrive, reflecting Yaskawa's continued customer commitment to providing sustainable, flexible, and easy-to-use products.

It is designed to meet RoHS2, providing a sustainable and an environmentally friendly drive. Its TUV safety rating allows our customers to meet the most stringent safety ratings for their machine and provides a long mission time for the life of their equipment.

The GA500 also provides customers a wide range of flexibility. The drive is rated up to 40 horsepower and can be applied to 240 VAC single-phase, 240 VAC three-phase, or 480 VAC three-phase incoming power.

For customers that use DC as their power source, the drive is [UL] rated to accept DC as its primary power source. The GA500 can operate a variety of motors, which include induction, permanent magnet (SPM and IPM), and synchronous reluctance (SynRM).

For customers that require network communications with their drives, the GA500 offers a variety of industrial protocols that help be part of the Industrial Internet of Things (IIoT), which include EtherNet/IP, PROFINET, Modbus TCP/IP, and EtherCAT. Traditional fieldbus protocols like DeviceNet, PROFIBUS, and Modbus RTU (embedded) are also available.

The easy-to-use GA500 is designed to maximize one of the most valuable user resources, time. The GA500 can be programmed without main power applied, which means users can set up the drive so it is ready to run before main power is available.

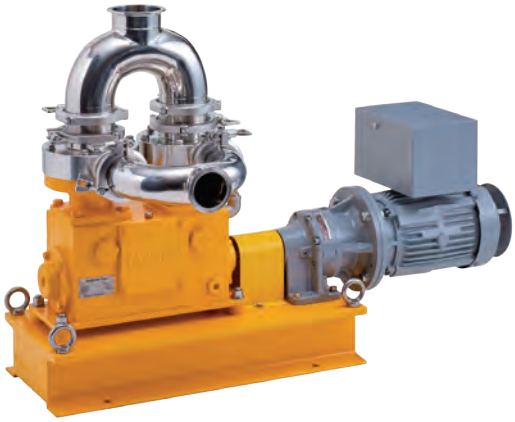
A highly visual LED status ring provides drive status at a glance. Yaskawa's mobile app, DriveWizard Mobile, provides the ability to program and/or monitor the GA500 through mobile devices like a smartphone or tablet. DriveWizard Mobile instantly accesses the Yaskawa Drive Cloud, providing a safe location to store drive information with instant access anywhere.

Learn more about the GA500 at **www.yaskawa.com/GA500**.

AUTOMATIONDIRECT

BRX Stackable Micro Brick PLCs

BRX stackable micro brick PLCs include communications modules, universal analog I/O modules, and universal temperature combination I/O modules. Expansion modules snap onto the side of any BRX Micro PLC Unit (MPU) or BRX Remote I/O controller, creating a sturdy and rugged PLC platform. Added BRX serial communications modules provide four isolated RS-232 ports that support communications flow control or RS-422 serial ports. Also available are BRX single-channel RS-232 (with flow control) and RS-422 Pluggable Option Modules. Supported protocols include Do-more! Protocol, Modbus RTU (Master/Slave), K-Sequence, and ASCII (In/Out). Data rates are 1,200 to 115,200 bps. For more information, visit **www.automationdirect.com/brx-plcs.**



TACMINA

Ultra-High Viscosity Smoothflow Pump

Tacmina Smoothflow pumps are well-known for the ability to move difficult-to-transfer fluids and now an even more powerful and robust VPL series of pumps is available. The VPL series of Smoothflow pumps can transfer high-viscosity materials up to and exceeding 300,000 centipoise viscosity at flow rates of up to 2.6 gallons per minute. All Tacmina Smoothflow pumps are designed for gentle, low shear, handling of fluids with no damage or separation of process material. Smoothflow pumps are easy to maintain and are extremely wear resistant. In addition, they provide accurate, precise, and repeatable flow rate. For more information, visit **www.tacminausa.com.**

VERTIFLO PUMP COMPANY

Series 800 Immersion Sump Pump

Series 800 immersion sump pump applications include sump drainage, flood control and process drainage to meet EPA and OSHA requirements. Heads to 230 feet, temperatures to 350 degrees Fahrenheit (177 degrees Celsius), pit depths to 26 feet, and up to 3,000 gallons per minute. Semiopen impeller, external adjustment, standard NEMA C face motor. Cast iron, 316 SS or Alloy 20 construction. Series 700 sewage ejector pump applications include industrial wastes, sanitary wastes, process wastes, rendering wastes and pollution control. Heads to 100 feet, pit depths to 26 feet, and up to 1,500 gallons per minute. For more information, visit **www.vertiflopump.com.**

PFANNENBERG

PMF LED-Hi LED Multifunction Light

The versatile PMF LED-Hi offers three different signaling modes, including a blinking light that is highly efficient for permanent warning; a flashing light, which is brighter than comparable xenon flashing light; and a rotating beacon effect, without mechanical rotating mirrors. The availability of eight operating modes means users can switch off individual sectors to align signaling precisely and avoid unwanted reflections or glare. For more information on, visit **www.pfannenberg.com/en/signaling-technologies/visual-signaling/led-lights/pmf-led-hi.**

What Is HUMANufacturing?

Mark Anderson on the partnership of humans and machines and the future of manufacturing

Comau is a leading global company in industrial automation. With over four decades of field-tested experience, Comau develops a wide assortment of innovative Industry 4.0-enabled systems, products, and services. On a recent episode of MPT's podcast, The Efficiency Point, Mark Anderson, Comau's head of robotics and automation products for North America, discussed his company's push in the increasing role of wearable robotics and exoskeletons in the workforce.

MPT: Outside of maybe science fiction, what's a brief history of exoskeletons in the workforce?

Mark Anderson: That's a great question. Exoskeletons in the workforce are fairly new. We're unique in our venture in exoskeletons, where we have one particular product that could be used over a wide range of body types with various settings for load and assistance.

Our MATE product has been used in many different applications over our brief history—for example, automotive applications where users would be working in an overhead situation. If you imagine a vehicle coming down a production line with workers underneath the vehicle, hanging exhaust components or running wiring harnesses, the exoskeleton will be used to relieve fatigue and the wear for user's shoulders.

In general industry, we've seen demand in everywhere from industrial baking, where wearers would be pulling bread or pies out of an oven and then putting oven racks on the shells or different carts. It's been a pretty wide range of demand in the market.

MPT: What would you say is the average learning curve on the MATE exoskeleton would be?

Mark Anderson: It's pretty straightforward. Usually we have a small manual that can be referenced, where the operator could probably thumb through pretty quickly and understand how it's to be used. Generally speaking, we like to do a remote training session. So if somebody were to purchase one or rent one, we would call a teleconference meeting and have a camera in to guide them through putting it on, taking it off, adjusting it correctly. That way, they're happy with it. You want to make sure that it's comfortable, that they're wearing it right, and it's adjusted properly for their body type and the application.

MPT: Which industries do you see moving more towards exoskeletons and other robotics? Is there a growth market you're looking at?

Mark Anderson: There are growth markets we're looking at, for sure. We're fully owned by FCA [Fiat Chrysler Automobiles], so naturally we're in the automotive industry pretty heavily—it's just in our DNA. However, we've introduced the exoskeletons, such as AutoMATE, in recent trade shows and there's been a very big demand in general industry.

I think that most companies are dealing with the same type of issue the automotive industry is seeing in which we have workers getting older. I mean, everybody every day is getting older, and the use of and access of exoskeletons in the work force reduces fatigue, which would allow them to do the same type of repetitive work over and over again.

That's something that we call HUMANufacturing, a term that Comau uses to really stress the importance of the human in the workplace. Years ago when you heard the word *automation*, you would automatically think robots, but automation could be as simple as giving a user a better tool to do a job.◆

To listen to an extended version of this interview, be sure to subscribe to MPT's podcast, The Efficiency Point.

WE'RE HERE FOR YOU

UNMATCHED RESPONSIBILITY

Vaughan
60 years
OF QUALITY AND ADVANCEMENT

A MESSAGE FROM VAUGHAN COMPANY.

At Vaughan, we believe that our family stretches across the world, and throughout every industry we serve. As we navigate these uncharted waters, our primary responsibility is to every person and community affected during this unprecedented time by supporting one another and keeping critical staff and infrastructure safe.

For years, flushable wipes have been a serious and expensive problem for wastewater collection systems, now more so than ever. These systems are critical for your health and the health of your children, loved ones and community. Equipment failure caused by flushable wipes force critical staff to work in tight spaces to repair clogged pumps. Now is not the time to put these people or systems in jeopardy.

We want to make sure you know that our pump can help with overall system robustness and reliability. This eliminates costly repairs and risks to workers' safety when resources are stretched thin. We have many different solutions for the difficulties you are experiencing. Vaughan Company has been here for 60 years, and we will continue to stand by and support you. To learn more, visit **chopperpumps.com/vaughanresponse**

The Vaughan Family

Chopper

CHOPPERPUMPS.COM | 360.249.4042 | INFO@CHOPPERPUMPS.COM

MANUFACTURED IN THE USA

WHEREVER PUMPS ARE NEEDED, GORMAN-RUPP SENDS THEIR BEST.

Keeping flood waters at bay in New Orleans.

GORMAN-RUPP COMPANY

After Hurricane Katrina, New Orleans undertook a massive flood control project to ensure that the next major event wouldn't wreak such devastation. To handle the potential water volume, they chose eight H_2O Works™ SAFV mixed flow pumps from Gorman-Rupp's Patterson Pump Company. From municipal and construction to industrial and fire protection, any application that needs a pump can use a solution from one of our family of brands. Wherever life takes you, there's Gorman-Rupp. The high-water mark in pumps.

For more information, contact your nearest Gorman-Rupp distributor or visit GormanRupp.com.

The Pump People®

GORMAN-RUPP USA / GORMAN-RUPP CANADA / GORMAN-RUPP AFRICA / GORMAN-RUPP EUROPE / PATTERSON PUMP COMPANY / PATTERSON PUMP IRELAND
NATIONAL PUMP COMPANY / GORMAN-RUPP INDUSTRIES / AMT PUMP COMPANY