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10 PUMP PROFESSIONALS TO WATCH

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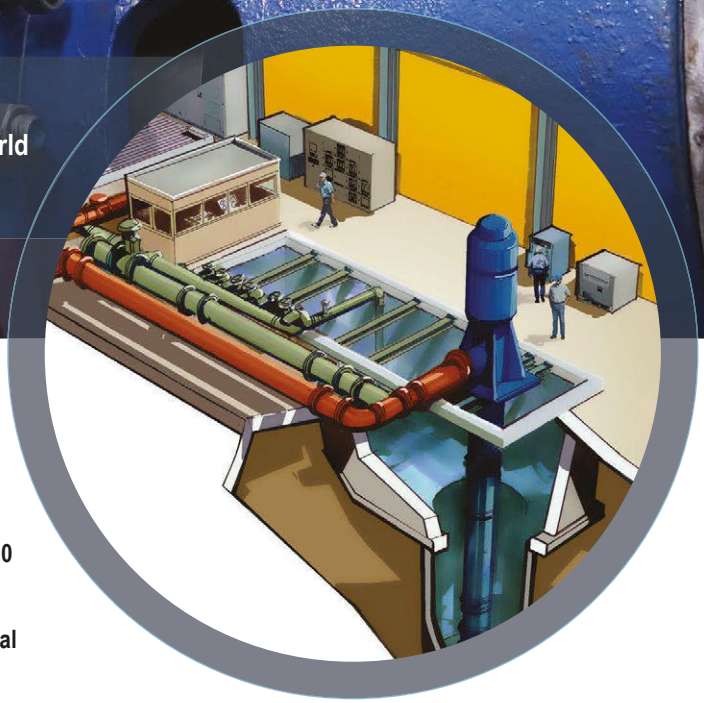

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"Work hard." This was always my grandfather's parting response.

Richard Sage, my maternal grandfather who had worked as a chemical engineer for Exxon, was born in 1922. He was 7 years old when the Great Depression began. The lessons he learned as a child definitely stuck with him—we used to joke that he would wash and reuse the same handkerchief over and over again if we didn't gift him a new supply from L.L. Bean every Christmas.

My paternal grandfather, Donald Dome, was born in 1930 and ended his career as CFO for the YMCA William Sloane House in New York City. He shared a similar mentality to my other grandfather—waste not, want not. Both of them were quietly successful; they were never flashy, and always willing to help family members in need.

That mantra—"Work hard"—was ingrained in both of my grandfathers. Passing on this message from their generation—that a good life and an admirable career was possible if you worked hard—was important to them.

I think the 10 young professionals we are honoring in this year's 10 Pump Professionals to Watch (starting on page 21) must have received the same message from their grandparents (or great-grandparents), as well. After learning more about each of this year's winners, and hearing the praise from those who nominated them, a picture emerged of a group of professionals who knows what it means to put in their time, who learn from those who came before them, and who strive to help others.

One of our winners, Adam Osburn, a foreman at Manhattan Mechanical Services in Illinois, said it best when he offered advice to newcomers and students interested in this industry. He said: "My advice would be to find a mentor. Find someone who has been doing it for 20-plus years working in this field and work with them. Technology changes all the time, so it is good to read up on all that, but nothing beats the knowledge of a person that has been doing it day in and day out for their entire working career. Classes offer a lot to a new student, but I feel that you are really going to need some hands-on time in the field with a mentor to be your best."

As I grow in my career as editor of Pumps & Systems, I wish my grandfathers were here to talk about chemical engineering in oil and gas, or help me to understand more about finances. I can now see why it's imperative that, while we have them with us, we tap into the knowledge possessed by older generations of workers. We're happy to see that the 10 Pump Professionals to Watch for 2020 recognize the wealth of information they can learn from their colleagues. As we head into a new year, they'll need those resources to navigate these uncertain and unprecedented times.

So, congratulations to the 2020 winners of the 10 Pump Professionals to Watch! We look forward to you becoming mentors for the next generation.

Jennifer King

Editor, Jennifer King
jdking@cahabamedia.com

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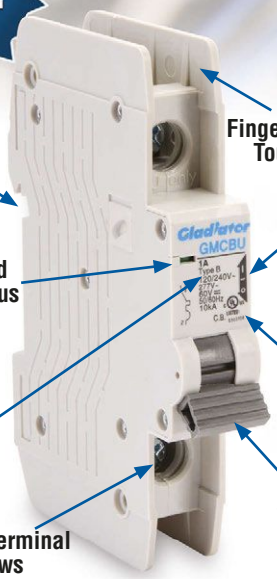

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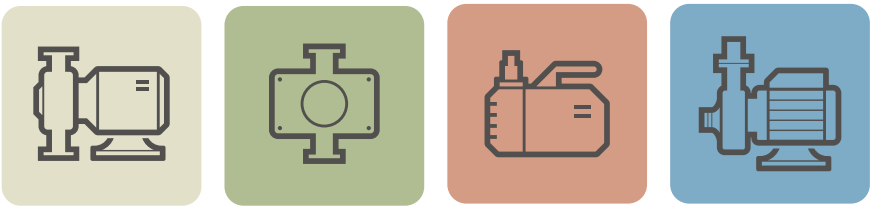

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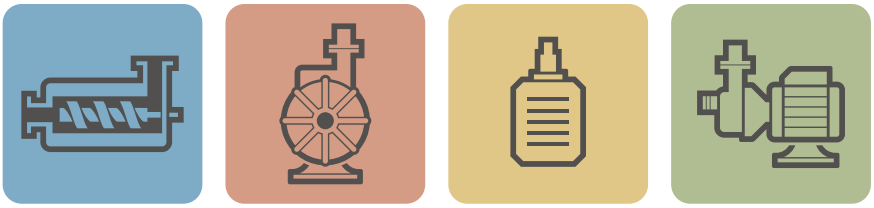

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NEW HIRES, PROMOTIONS & RECOGNITIONS

POUL DUE JENSEN

GRUNDFOS

BJERRINGBRO, Denmark – Grundfos Holding's board of directors has appointed Group Executive Vice President Poul Due Jensen as the new CEO of Grundfos.

Due Jensen will be the third generation of his family to lead the company since its founding in 1945. Due Jensen has an MBA in business administration and marketing and executive education from Stanford University. He was appointed group executive vice president in 2015 with responsibilities in sales, marketing and service. Before joining Grundfos, he worked as sales manager for Computerstore from 1995-2000. At Grundfos, he has held numerous positions in marketing, as a segment director, as a group senior vice president and more since 2000. ■

grundfos.com

LUIS MATURANA

KSB

RICHMOND, Va. – KSB named Luis Maturana president. Maturana joined KSB in 2018 and has served as vice president of the water and wastewater division. He earned a Bachelor of Science in materials science engineering from Simón Bolivar University in Caracas, Venezuela. He previously served in multiple executive roles at ChemTreat and Veolia Water Technologies.

Prior president Falk Schäfer remains with KSB, where he is moving to the global headquarters in Frankenthal, Germany, and will serve in General Industry as vice president of applications. ■

ksb.com

SCOTT BRADLEY & LUIS ORNELAS

BLACOH

RIVERSIDE, Calif. – Scott Bradley joined the Blacoh Surge division. Bradley began his career managing multiple projects from award stage to ready-to-ship for CSI Compressco and later went on to manage a team of engineers at HPF Consultants, Inc. Luis Ornelas was hired as a quality engineer. Before joining Blacoh, Ornelas led a team of quality inspectors for EGR Incorpora. ■

blacoh.com

CHRIS KARASCH

SEEPEX

ENON, Ohio – SEEPEX announced the promotion of Chris Karasch to national sales manager. Karasch joined SEEPEX more than 12 years ago as a territory manager. Karasch has worked to grow the business and further his career advancing from territory manager to district manager to regional sales manager to director of sales and now national sales manager. ■

seepex.com

ROSS WOTHERSPOON

MOTION INDUSTRIES

BIRMINGHAM, Ala. – Motion Asia Pacific announced the appointment of Ross Wotherspoon as chief operating officer, Australia.

Ross will oversee Motion Asia Pacific's Australian operations and business brands that include CBC, BSC, Hardy Spicer, Cram, Seal Innovations, SpecFast and AIP. ■

motionindustries.com

ANDREW MATSUYAMA, NEIL LANGDOWN & COLIN GUPPY

SUNDYNE

ARVADA, Colo. – Sundyne announced the appointment of Andrew Matsuyama as chief financial officer. Matsuyama brings nearly 15 years of experience as CFO of Norican Group and its predecessor, Wheelabrator Group, a private equity owned engineered equipment manufacturer. Sundyne also announced that Neil Langdown has been promoted to a new strategic role of commercial excellence leader. Langdown will also continue to serve Sundyne customers in his current role as vice president for Asia. Sundyne announced that Colin Guppy has been promoted to chief commercial officer.

In this newly created role, Guppy will lead the original equipment and aftermarket strategies for Sundyne's vertical markets in the Americas, Europe, the Middle East, Africa and India. ■

sundyne.com

IAN GOVE

HAYWARD TYLER

LUTON, U.K. – Hayward Tyler has named Ian Gove as the regional sales manager for the North Sea, United Kingdom and Europe. Gove has two decades of experience in the oil and gas industry.

He is multilingual and has a bachelor's degree in mechanical engineering.

Gove will lead sales in the North Sea region and support new and existing Hayward Tyler clients. ■

haywardtyler.com

CHARLES FERRER

HUNT VALVE

SALEM, Ohio – Hunt Valve Company announced that Charles Ferrer has been promoted to president and chief executive officer (CEO). He joins and will report to the board of directors of Hunt Valve.

Hunt Valve is a May River portfolio company. ■

huntvalve.com

FERNANDO GUTIERREZ

TACHYUS

Tachyus, a provider of data-driven production optimization software to the oil and gas industry, has announced the appointment of former vice president of customer success Fernando Gutierrez to CEO. Gutierrez will oversee the implementation of Tachyus' vision and mission while working closely with the leadership team to further establish strategies and solutions within the upstream space. ■

tachyus.com

MAX ROHR

CALEFFI

MILWAUKEE, Wis. – Caleffi North America announced Max Rohr as newest education and training manager. He will partner with Caleffi representatives to offer product and system design training for engineers, contractors and wholesalers. Rohr has worked in the plumbing and hydronics

industry since early childhood with his father, Bob "Hot Rod" Rohr. After college, he interned at Caleffi headquarters in Italy for a year. ■
caleffi.com

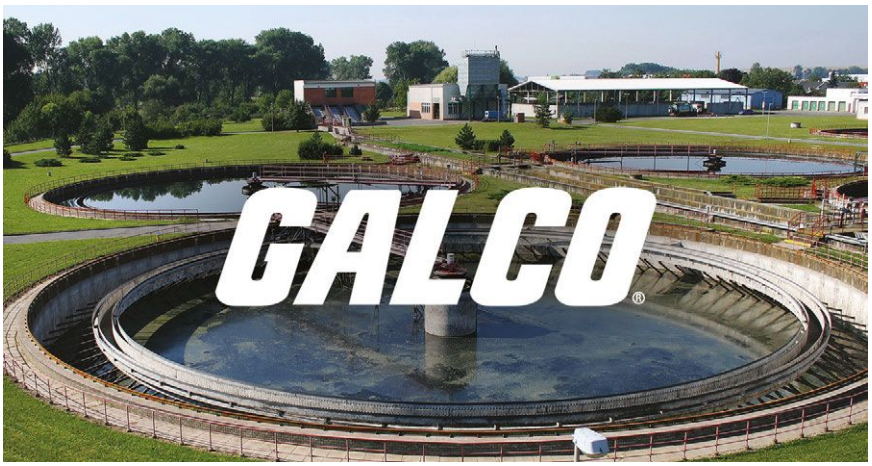
DANIEL ONDIK

WAGO
GERMANTOWN, Wis. – Daniel Ondik has been hired as the new regional sales manager for the Chicago region. Daniel is a graduate of Penn State University with a degree in electrical engineering. Ondik gained experience at Rockwell in Nashville for three years as a sales engineer before moving back home to Illinois and working at Rittal for four years as an account manager. ■
wago.com

CHRISTOPHER BRISTOL
TSURUMI
GLENDALE HEIGHTS, Ill. – Tsurumi has appointed Christopher Bristol as municipal product sales manager for North America. Bristol will use his experience in the water and pump industry to support Tsurumi's regional sales team and distribution network in the implementation of the company's new product line of explosion-proof pumps. ■
tsurumipump.com

LISA LATTU & CHRISTOPHER CLARK

LAN
HOUSTON – Lisa Lattu joined planning, engineering and program management firm Lockwood, Andrews & Newnam, Inc. (LAN) as a senior project manager. In this role, Lattu will be responsible for providing project management and growing the firm's water resources and planning services. Christopher Clark joined LAN as a project manager. In this role, he will design and manage wastewater treatment, collection and distribution projects in central Texas. ■
lan-inc.com.



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AROUND THE INDUSTRY

AHR 2021 Canceled; Update on Other Shows

AHR Expo Show Management announced the forced cancellation of the 2021 AHR Expo after working with McCormick Place to tentatively reschedule the show for March 2021.

With roadblocks set in place by the ongoing COVID-19 pandemic and the resulting current state and local restrictions that prohibit mass gatherings over 50 people, an in-person event will not take place in 2021.

Coronavirus has taken its toll on the industry trade shows, with many of them switching to a virtual format or canceling altogether.

The International Production & Processing Expo (IPPE) made the decision to not hold the in-person component of IPPE 2021 in Atlanta, scheduled for Jan. 26-28. IPPE show management will offer exhibitor marketplace engagement and a slate of educational programs for attendees and exhibitors during the week the event is scheduled and beyond. Further details regarding the education programs and engagement opportunities are forthcoming.

American Water Works Association's (AWWA) Water Matters! Fly-In will be an online event in April 2021.

Holding the event virtually will maintain the direct connection between AWWA members and their representatives and senators in the U.S. Congress, while observing social distancing recommendations. The targeted time frame is during the week of April 26.

The TEES Turbomachinery Laboratory has decided to transition the face-to-face Asia Turbomachinery & Pump Symposium event to a virtual setting. All short courses and technical sessions, as well as the exhibition, will be held online. The symposium dates will continue to be Feb. 23-25, with short courses on Feb. 22, 2021.

However, the Turbo Lab is holding its annual Turbomachinery & Pump Symposia this month, but doing it virtually from Dec. 7-10. Information is at tps.tamu.edu.

As of press time, the previously scheduled PowerGen International show previously scheduled for December 2020 is still on as an in-person event March 30-April 1, 2021.

Another December virtual event is Groundwater Week (groundwaterweek.com), set for Dec. 8-11.

WEF has indicated that all of its training events will be virtual through April 2021.

Visit pumpsandsystems.com/events for more updates regarding trade shows. ■

Mergers & Acquisitions

Dresser Natural Gas Solutions Acquires Flow Safe
Nov. 3, 2020

Badger Meter Acquires s::can
Nov. 3, 2020

Siemens Acquires Culgi
Nov. 2, 2020

Flex-A-Seal Merges With Momentum Engineered Systems
Oct. 13, 2020

Emerson Acquires Progea Group
Oct. 1, 2020

Recommended Practice for Motor Repair Re-Approved as ANSI Standard

ST. LOUIS – An updated edition of the only American National Standard for repair of motors and generators—ANSI/EASA AR100-2020: Recommended Practice for the Repair of Rotating Electrical Apparatus—was recently published for use by the repair industry and its customers. The standard describes industry best practices for the repair, rewinding, and testing of electrical apparatus to maintain or enhance the reliability and energy efficiency of both alternating current (AC) and direct current (DC) motors and generators.

This is the fourth release of this standard. ANSI requires review and re-approval at least every five years. The 2020 edition contains more than 40 revisions. Changes include revised performance levels for the surge testing of motor windings, as well as new requirements relating to terminal leads, cooling systems, and thermal protectors. The Recommended Practice is available to download at easa.com.

"Since ANSI recognizes only one standard on a topic, EASA's ANSI/EASA AR100 is the standard for repair of rotating electrical equipment," said Linda Raynes, EASA president and CEO. "If a service center conducts repairs in accordance with ANSI/EASA AR100-2020, end users can rest assured they receive a quality repair that maintains reliability and efficiency."

■ *easa.com*

Hydraulic Institute PSAP Certification Now Offered Remotely

PARSIPPANY, N.J. – The Hydraulic Institute (HI) is now offering remote online-proctored exams as a safe, secure way to take the PSAP Certification Exam. PSAP candidates can now schedule and take their certification exam from their home or office on a day and time that is convenient for them.

PSAP candidates are able to schedule the exam on any day or time and will have a live proctor administer the certification exam. Remote online proctored exams require a desktop or laptop with a Windows or Apple operating system, a high-speed internet connection, a webcam (internal or external), and a microphone. A live proctor and lockdown browser are used to monitor and secure the examination process.

At the conclusion of the certification exam, candidates will be able to view their pass or fail result on their screen. Successful results are posted on the HI website. For more information, contact HI via email at psap@pumps.org.

■ *pumps.org*

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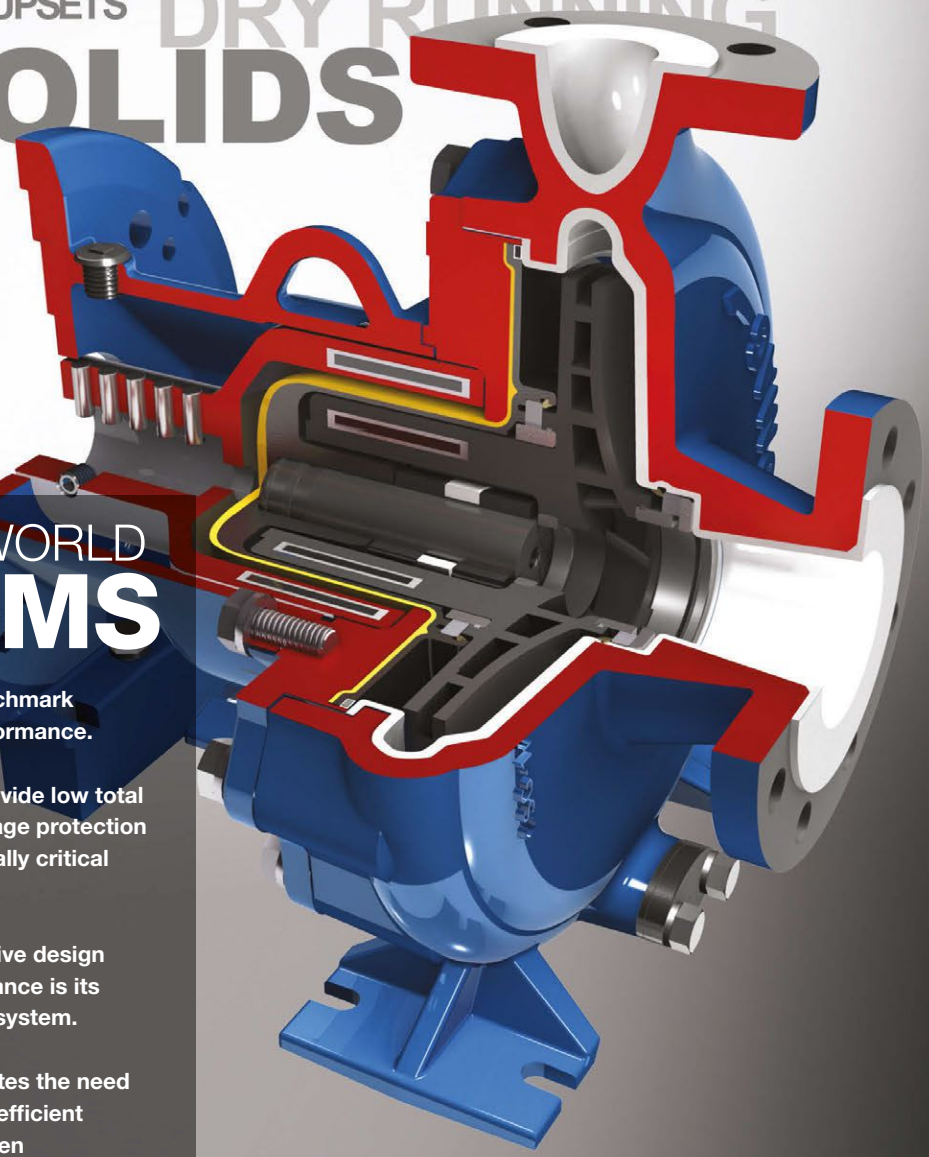

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Will Infrastructure Investment Receive Bipartisan Support in 2021?

The president-elect's plans include creating jobs and providing clean drinking water for all communities.

JENNIFER KING | Pumps & Systems

The infrastructure improvements that are needed across the United States will now be in the hands of Congress and former Vice President Joe Biden, who as of press time for this issue of Pumps & Systems has been named the president-elect by the Associated Press.

While the ballots were still being tallied in early November, the National Utility Contractors Association (NUCA) released a statement from its CEO Doug Carlson, who said that in order for these projects to come to fruition, it will take commitment from Congress, which must allocate resources, and from the administration to plan and manage the programs.

"America needs to make infrastructure an immediate priority," Carlson said. "Repairing or building new infrastructure for our American communities can dramatically solve several of today's severe challenges, whether it be clean water, economic recovery, jobs, better highways and bridges, or modern telecom needs. A party label doesn't matter when clean water isn't delivered safely to constituents, or their wastewater isn't efficiently taken away, or their internet connection is too slow." Carlson noted that since "support for infrastructure investment cuts across age, gender, party, geography and ideology; there shouldn't be an argument about its need."

Investment in the country's crumbling infrastructure has received bipartisan support in the past, and there is some knowledge of what the Biden Administration will likely do.

During his campaign, Biden announced a $2 trillion proposal for infrastructure and clean energy projects, plus a $1.3 trillion infrastructure plan as part of the Build Back Better program, according to the American Society of Civil Engineers (ASCE).

The campaign website explains that the goal is to "create millions of good, union jobs rebuilding America's crumbling infrastructure—from roads and bridges to green spaces and water systems to electricity grids and universal broadband—to lay a new foundation for sustainable growth, compete in the global economy, withstand the impacts of climate change, and improve public health, including access to clean air and clean water."

> "Support for infrastructure investment cuts across age, gender, party, geography and ideology; there shouldn't be an argument about its need."

Along with laying out the goal to build modern infrastructure, the website states: "Americans deserve infrastructure they can trust, infrastructure that is resilient to floods, fires, and other climate threats, not fragile in the face of these increasing risks. We need infrastructure that supports healthy, safe communities, rather than locking in the cumulative impacts of polluted air and poisonous water. And we need infrastructure, like universal broadband, that unleashes innovation and shared economic progress and educational opportunity to every community, rather than slowing it down."

One part of the president-elect's proposal is to ensure clean, safe drinking water for all communities. According to the Biden campaign website, this would take "investing in the repair of water pipelines and sewer systems, replacement of lead service pipes, upgrade of treatment plants, and integration of efficiency and water quality monitoring technologies. This includes protecting our watersheds and clean water infrastructure from manmade and natural disasters by conserving and restoring wetlands and developing green infrastructure and natural solutions."

Under President Donald Trump, the recent update to the National Environmental Policy Act (NEPA) of 1970 was focused on speeding up the permitting process, the ASCE states. NEPA was put in place to require the consideration of the environmental impact of certain federal projects, including "the construction of roads, bridges, highways, transmission lines, conventional and renewable energy projects, broadband deployment, and water infrastructure." The update the Trump administration made earlier this year stated that the intention was to modernize "its regulations to streamline the development of infrastructure projects and promote better decision-making by the federal government."

Trump also proposed a $1.5 trillion infrastructure plan in 2018, which included items such as investment in the rural U.S. and returning decision-making authority to the state and local governments. ■

Jennifer King is editor of Pumps & Systems.

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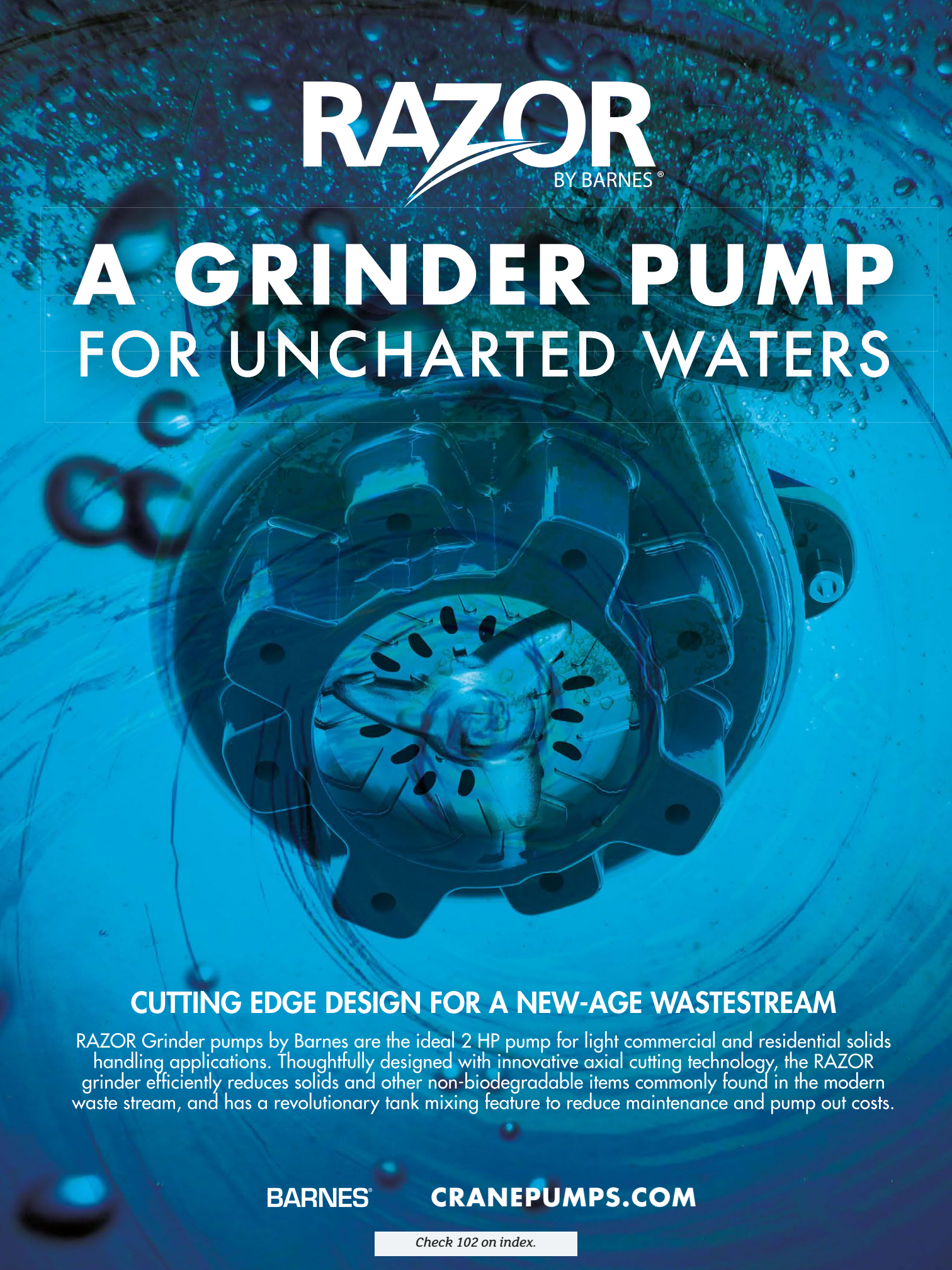

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Pump Efficiency & the Pursuit of Perfection, Part 2

JIM ELSEY | Summit Pump Inc.

In my November 2020 Pumps & Systems column, we looked at efficiency and reasons why pumps may not be as efficient as we'd like. Now, let's focus on how to make the pump more efficient.

A pump engineer can make several design changes that will increase the pump efficiency. Efficiency improvements are most often tradeoffs that may also sacrifice reliability and cost/price.

To make a pump more efficient, we can:

1. Make the wetted surfaces smoother (reduce the roughness). The smoother the surface finish of the casing and impeller, the more efficient the pump will be—another valid reason why investment casings are a good choice especially for smaller pumps. Ceramic materials or coatings (if applied properly) are another step that can help increase the efficiency.
2. Reduce the clearances. The smaller the clearance, the lower the leakage rate across the opening. This means more liquid is going through the pump only once, and it is not recirculating.
3. Reduce or mitigate design leakage paths. Examples include impeller back ring leakage to suction and leakage rates for balance drums and discs (features that mitigate axial thrust).
4. Reduce the liquid shock losses. Imagine what a drop of liquid experiences as it transits the pump—it involves several right angle turns at high speeds and at high rates of change. The addition of an inducer can add some prerotation "swirl" to the fluid to mitigate entrance losses. The optimum inlet angle of the impeller blade (vane) can be altered and, just as importantly, act as the profile shape of the leading edge of that blade.
5. Change the curvature and rate of curvature for the impeller vanes to be more "backwards."
6. Add or remove impeller vanes in some impeller designs and/or reduce the thickness of the blade (vane).
7. Remove diffusor vanes and the additional cutwaters required on dual volutes.
8. Offset the casing centerline from the impeller centerline so the volute has an ever-increasing cross-sectional area for the fluid to exit.
9. Increase the pump speed and size. The faster and larger the pump, the more efficient. The smaller the impeller, the more negative the effect of disc friction. It is just a simple case of proportionality.

Efficiency Over Reliability

Better surface finish and investment castings for impellers and casings will cost more money. Smoother surfaces on the wetted parts are not as effective in reducing efficiency as the viscosity increases because the flow regime of viscous fluids tends to be laminar.

The dual volute, diffusor vanes and concentric volutes all help the pump to be more reliable by mitigating the radial thrust. These features also aid in reducing shaft and bearing sizes.

Thinner impeller vanes reduce the amount of torque that can be applied, consequently reducing the workload capacity of the pump. There is an optimum number of impeller vanes for ideal pump/impeller efficiency, but that number may be at odds with the pump's functioning and its ability to handle solids and fibers or a desired curve shape.

Closer wear ring clearances require more operator control of both the warmup and cool-down cycles (think: the rate of change of temperature).

Close clearances also require a more robust shaft to prevent deflection at off-design operating conditions and potential rotor sag at low speeds, especially when on turning gear and during startup evolutions. Close clearances do not handle suspended solids very well—galling and scoring will occur to the wear ring surfaces.

Maintaining closer clearances will require more frequent outages for maintenance and possibly more expensive materials—and gee whiz, it will also become imperative to turn the pump off when the supply source is empty.

The proper material selection for efficiency may be the wrong material to handle the liquid properties. An inducer will help reduce shock losses and help with net positive suction head (NPSH) issues, but it may reduce the head capability of the pump. A pump with close clearances is overall a less forgiving pump.

Steps To Help Efficiency

- Design and operate systems that allow for more efficient operation.
- Design for the long run, not just for this quarter's profit levels and stock performance.
- Monitor and manage the pump performance.
- Adjust the pump speed in lieu of impeller trimming or discharge valve throttling.
- For pumps with external impeller clearance settings, make sure the pump impeller clearance is set to the recommended clearance.
- On pumps with wear rings, monitor the pump hydraulic performance and renew the clearances when performance diminishes.
- Close bypass valves when not needed. Review and rewrite the program on the programmable logic controller (PLC) for

three-way process control valves.

- Size the pump and/or the speed to match system requirements. Throttling the discharge valve should be a temporary fix, not a permanent solution.
- The effect of viscosity on a centrifugal pump is dramatic. Make sure that the pump is designed for the application, and that the liquid is up to design temperature (it should lower the viscosity) before starting the pump. Question if the liquid should be pumped with a positive displacement pump.
- Probably, the most important step the to take is to have the system curve available and compare it to the current pump curve to ascertain where the pump is operating on the curve, then make revisions as necessary

Many system designers attempt to solve three or more problems with one pump, though they could be better off with three different pumps in the same system. The three pumps could be different sizes and speeds. Perhaps it is as simple as pumps in series and/or parallel or the addition of a "pony" pump. One of the biggest energy mistakes I witness is the operation of two pumps in parallel when only one is needed.

Do What You Gotta Do

Not all pumps are designed to be efficient. Some pumps are designed for special purposes. Like special teams in a football game, they have a very specific job to do where function and reliability are more important than efficiency. Examples may be a slurry or trash-handling pump, a low-flow, high-head pump and/or a vortex or disc pump. When selecting the sump pump that prevents flooding in the basement of my home, I am more focused on reliability and functionality and not on efficiency. Note: I have two pumps installed.

In Conclusion: My Issue

For 50 years, I have witnessed increasing pressure to make pumps more efficient. This is something most users don't want to pay extra for, and I appreciate that. However, I am a witness to a trend in which the careless pump operation renders the overall system inefficient. There are companies that have proactive programs, but there is a large percentage that do not.

The mission for increasing pumps efficiency must come from the top down (CEO and board)—not as a platitude or a poster on the bulletin board, but as a mandate, a priority and a proactive method of operation. Old paradigms must be changed, and the entire staff must be educated. There are incentive programs that will pay dividends to initiate these goals. At the end of the game, you will actually save money. Like grandma used to say: "What good is an efficient pump running at dead head?" ■

Jim Elsey is a mechanical engineer with more than 48 years of design and operating experience, primarily focused on rotating equipment reliability in most industrial applications and markets around the world. Elsey is an active member of the American Society of Mechanical Engineers, the American Society of Metals, the National Association of Corrosion Engineers and the Naval Submarine League. Elsey is the principal of MaDDog Pump Consultants LLC and may be reached at jim.elsey@spiohio.com.

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New Terms, Exciting Technologies, Yet Basic Truths Remain

RAY HARDEE | Engineered Software Inc.

As I was writing this, I searched the internet for digital twin and found over 460 million "hits" about the subject. Topics like Industry 4.0 (over 470 million) and IIoT (over 12 million) are pervasive, too. These articles were full of exciting concepts such as big data, cloud computing, artificial intelligence (AI), machine learning, smart devices, edge technology and even the old standby, paradigm shift.

Each of these terms describe a process that uses new technology to improve and expand on existing processes. For example, in 1982, my first microcomputer, which weighed 21 pounds, had two 90-kilobyte floppy disks to store the program and data, a single eight-bit processor, 64 kilobytes of random-access memory, a keyboard, and 5-inch monitor. The piping program that we developed could calculate the balanced flow rates and pressures in a network of over 500 pipelines and send the results to a printer.

As I write today, this program still calculates the balanced flow rates and pressures within a piping system. But now data can be stored on the cloud, and the application can run on an array of computers with the horsepower to swiftly process data from systems of any size. The calculated results can be displayed on multiple monitors, provide insight to system operation, or input data directly into other mission critical applications.

So, instead of dwelling today on technology features and how they'll provide a "paradigm shift" into the future, I'll focus on how new technology enhances the established methods you're already familiar with.

Limiting the discussion to fluid piping systems, we'll start with the concept of digital twin and how it offers an accurate simulation of physical piping systems. Then we'll look at the IIoT—the industrial internet of things—and see how the availability of low-cost instruments can give us better insights into how a system is really operating. Finally, we'll discuss Industry 4.0 and smart devices, and examine their integrated approach to improving equipment efficiency and their ability to alert you to potential issues that can impact operations.

Digital Twin: Operational Intelligence Across a System's Life Cycle

A digital twin is more than a software program, a computer-aided design (CAD) drawing or an equipment database. It is a computer simulation of a physical piping system that can be used throughout the life of the facility. Four key elements are:

- A mathematical model describing the system.
- Industry-specific data inserted into the model to describe how the system is built.
- Measured values from plant instrumentation to simulate the system's operation and validate the calculated results.
- Methods to analyze those results to gain insights into the operation of the physical piping systems.

The mathematical model is the foundation of the digital twin. For piping systems, it is based on a system's energy balance, which accounts for the change in energy through each item within the system. It takes the fluid energy supplied by the pump elements and balances it with the energy consumed by the process and control elements, and is expressed in Equation 1.

The next step involves entering the data needed to determine how each item uses the energy. The energy transferred is well understood for each item in the system, including the pumps, pipelines, process equipment and controls.

$$\text{Pump Energy} = \text{Process Energy} + \text{Control Energy} \qquad \text{Equation 1}$$

Since the digital twin is a life cycle document, the degree of detail will vary over the project's life. As the system progresses from the conceptual design to a physical system, more details become available. These details are provided in equipment specifications, manufacturer-supplied test data and the installed plant instrumentation. Once the system is built and the as-built data is entered, the digital twin is ready to simulate how the system will operate.

Once the system is placed into service, it is operated in order to meet market conditions. By specifying the system's as-operating data and its as-built model, the digital twin can simulate the operation of the total system. The as-operating data can either be manually entered or automatically imported from the facility's supervisory control and data acquisition (SCADA) system.

Measured operating data from the physical system can validate the accuracy of the digital twin. For example, if the as-measured values of the installed plant instrumentation match the corresponding results of the digital twin, the model is valid and accurate.

The results of the digital twin simulation can provide greater insight into system operation. As I've discussed in previous articles, pump cavitation is harmful to both pumps and systems, yet there is no instrument that can directly measure the presence of cavitation.

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At ITT, our workplace is defined by innovation and the successes of our talented employees. Today and every day, we celebrate ITTers who are creating solutions and solving challenges for our customers and the world. That's why in the December issue, we're proud to feature Claudia Mueller, a Design Engineer inspiring the best in her team and future generations.

"It is best to take on new adventures with an open mind and heart—being receptive to change, feedback, and even difficulties that probably lay ahead. In the end, these experiences make us more knowledgeable and prepared for the future" - *Claudia Mueller*

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That can only be done by calculating the net positive suction head available (NPSHa) at the pump suction, and by comparing the results with the pump's net positive suction head required (NPSHr) from the pump curve. Because the digital twin calculates the NPSHa at the pump suction, and the manufacturer-supplied pump curve specifies the NPSHr for the operating pump, the digital twin automatically checks for the presence of cavitation and provides notification. This is an example of the insight that digital twin technology provides to system operation.

IIoT: New Sources of Raw Data

In the past, plant instrumentation was expensive to purchase, install and maintain. Most plant instrumentation was used to control the process and offer indications on system operation to the plant's staff.

IIoT technology consists of low-cost instruments for determining pressure, temperature, vibration or flow rates. This, combined with wireless technology to connect the low-cost instrument with the installed SCADA system, makes it much more affordable to measure and record system data. Storing data on the cloud further reduces the cost of the information, but that begs the question, "what do you do with the data?"

Many IIoT articles talk about storing the operating data on the cloud, where machine-learning algorithms use artificial intelligence to provide greater insight for system operation.

Instead of compiling large amounts of data and letting machine learning "discover" the connections, the digital twin can simulate system operation and identify the differences between how the system should be operating and how the system is actually operating.

Using IIoT technology, more system operating parameters can be measured and used to further cross-validate the accuracy of the digital twin.

For example, if each pump used IIoT devices to obtain suction and discharge pressures and the power values from pump motors, these additional as-measured values would be able to provide more data points for this cross-validation.

Industry 4.0: Making Pumps Smarter

Industry 4.0 refers to the fourth phase of the Industrial Revolution and focuses on machine interconnectivity, automation, machine learning and real-time data.

When applied to a specific item of equipment, it is often referred to as a smart device or edge technology.

More pump manufacturers are installing smart pump packages that integrate low-cost sensors, variable speed drives and controllers to process the data locally. The added sensors measure pump suction and discharge pressures, pump vibration and temperatures of the pump seal, bearings and motor.

The addition of variable speed drives (VSDs) provides a measurement of pump power along with the ability to impact the process by controlling the pump head.

Instead of sending all the information to the cloud for further analysis, the smart device processes the measured data on the local controller and is able to give a warning when a pump is operating outside the control parameters. Since these calculations occur on a device outside the SCADA system, smart pumps can be considered edge technology.

So, how does the smart pump controller provide operational insight?

It is another example of a digital twin being used to simulate the performance of a physical pump.

The mathematical model is based on the energy balance in the pump; specifically, how electrical energy supplied to the pump drive is converted to fluid energy leaving the pump discharge nozzle. The data describing pump operation is found on the manufacturer's pump curve. Some of the installed instruments give the digital twin the as-operating data it needs to simulate pump performance; others provide the as-measured values needed to validate the accuracy of the digital twin.

Insights from smart pumps can detect many things, such as dry running, operating below a minimum flow, pumping against a closed discharge valve and high temperature and pressure conditions, when the pump is not operating efficiently. They enable you to control the process by adjusting pump speed.

As always, smart devices can still send the operating data and the results to the cloud where machine learning algorithms using AI can provide additional insight about the operation of the piping system.

New Technologies Improve Sound Engineering Practices

The digital twin, IIoT and Industry 4.0 have been getting plenty of press in technical publications. Each of these technologies is based on well-established processes, and their greatest value is the speed and accuracy of doing tasks that were manually performed in the past. For example, I remember from my student days when my fluid dynamics class discussed how to calculate pressure drop in a pipeline.

The first step was understanding the mathematical model describing the pressure drop calculation. Then we had a homework assignment where we used the mathematical model, along with pipe and fluid data, to calculate the pressure drop for a given flow rate. Then we were off to the fluids lab to measure the flow rate through the pipe along with inlet and outlet pressures. We compared the as-measured values from the lab to the calculated results of our homework, and used the results to learn about the effects of flow rate on pressure drop. The entire experience took three classes, one four-hour lab, and hours of hand calculations for a single pipeline.

As you can see, we were using the foundational elements of the digital twin way back in 1969, before it was cool. Using today's technology, the same process can occur on systems with hundreds of pipelines, equipped with SCADA data to determine if the results of the digital twin match the measured values.

The results provide insights for all areas of fluid piping systems.

In other words, it's not just new technology that provides insight; you need a clear understanding of what's occurring, and why, to meet your goals. ■

Ray Hardee is a principal founder of Engineered Software, creators of PIPE-FLO and PUMP-FLO software. At Engineered Software, he helped develop two training courses and teaches these courses internationally. He may be reached at askray@eng-software.com.

Pure Oil Mist Lubricates Electric Motor Bearings

HEINZ P. BLOCH | Process Machinery Consulting

Editor's Note: In the November 2020 issue of Pumps & Systems, we mistakenly ran another article in the space dedicated to Heinz P. Bloch's article on oil mist lubrication. We apologize for this mistake, and are happy to print the correct article here in full.

The issue of oil mist lubrication for electric motors in sizes up to 3,000 kilowatts (kW), and equipped with rolling element bearings, should not be an issue at all. If someone has kept track of articles on the subject, they may have found the answers to relevant questions in the March 1977 issue of Hydrocarbon Processing. An enlightened manager-technical expert encouraged the author (43 years old at the time) to share what was known: Oil mist was a superior lubrication method since the mid-1960s, when best-in-class users began to apply oil mist with great success on process pumps and electric motors.

Installations using pure oil mist allowed us to permanently dispense with troublesome oil rings, constant level lubricators, periodic oil changes and replenishing grease in electric motor bearings. Even ascertaining oil cleanliness became a non-issue because bearing housings were dry, oil mist floated to the top take-off "branches" of the large pipes that were called "headers," and dust particles were left behind. Oil mist was soon recognized as the ultimate filter, and open oil containers were no longer defacing the well-scrubbed walkways in the company's clean process units.

The 1977 article was candid in confirming that with the then available elastomeric V-rings between bearings and motor interiors, small amounts of oil mist traveled into the motor windings. However, two important facts were established:

1. The lubricants used in pumps and motors did not attack or degrade epoxy insulations on motors manufactured since about 1953.
2. The temperature rise measured on oil-coated windings remained well within allowable limits.

But 1977 is a long time ago, and two key developments[1] should by now satisfy anyone contemplating the use of oil mist on electric motors. The more recent developments are described in two or three findings:

1. Oil mist inlet and outlet ports should be arranged for through-flow, per Image 1, and small collector pots should be installed at the edge of the baseplate. Coalesced mist is removed one per month from these pots; the coalesced oil can also be pumped back into the oil

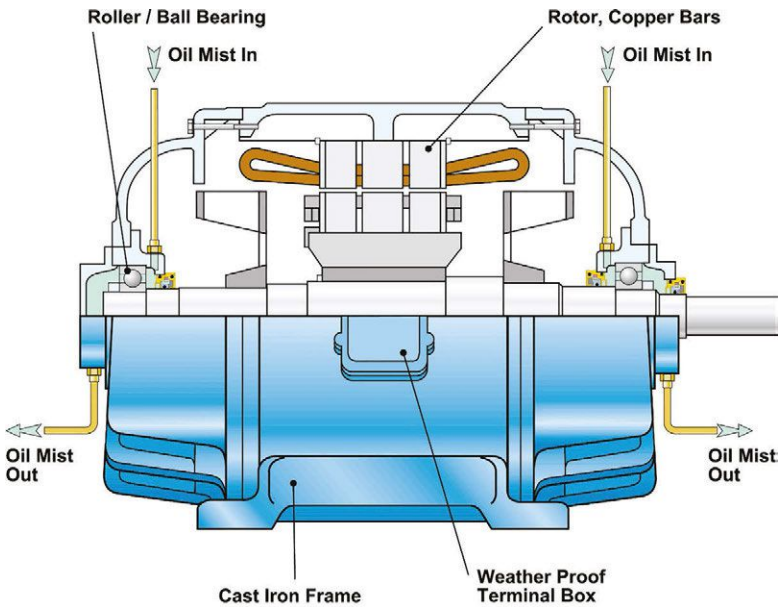

IMAGE 1: Oil mist lubricated electric motor (Image courtesy of the author)

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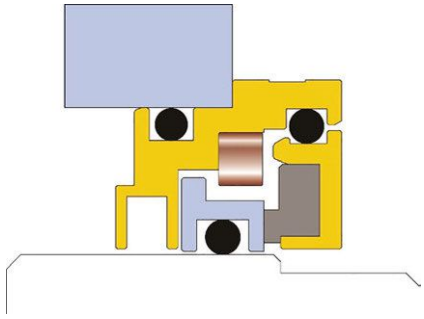

IMAGE 2: Bearing protector seal developed for oil mist applications in pumps and motors (Image courtesy of AESSEAL, Inc.)

mist header from where it flows back (by gravity) into the oil mist generator reservoir.

2. The purpose-designed magnetic face seal in Image 2 will prevent oil mist migration into the motor windings.[2]
3. Electric motors should have an open weep hole for automatic moisture drain off.

The bearing protector seal in Image 2 is designed with an advantageous closing pressure of only 0.5 pounds per square inch (psi); its face temperature increase is 5 to 8 degrees C (9 to 14 degrees F) below that of its nearest competitor. Some of the products shown here have been in service for three years without discernable leakage, while similar products from other sources have been observed to leak after a few months of operation.

The cost justifications for plant-wide oil mist lubrication and for pump component upgrading are described in references 2 and 3. Facilities that include electric motors in their plant-wide oil mist systems obtain rapid payback for their incremental investment. In the past 40 or more years, oil mist has yielded the additional benefit of protecting both running and standby equipment against the intrusion of dust and moisture. The frictional energy normally expended by bearings using liquid oil and grease is measurably reduced. By using the best available engineered product, even the unsightly occasional leakage will no longer be a concern. ■

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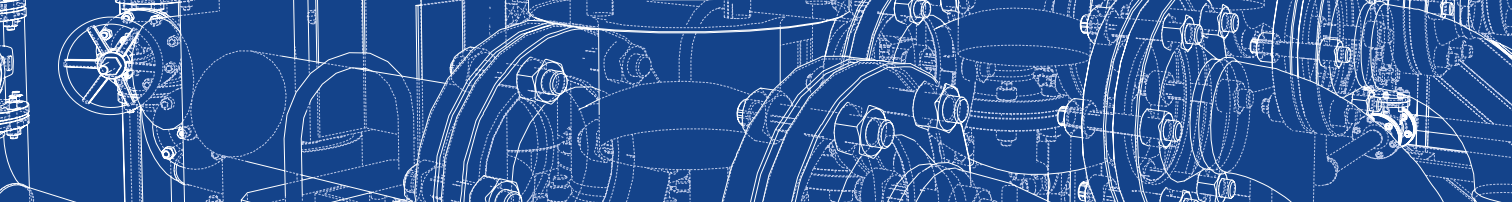
Heinz P. Bloch resides in Montgomery, Texas. His professional career commenced in 1962 and included long-term assignments as Exxon Chemical's Regional Machinery Specialist for the United States. He has authored or co-written over 770 publications, among them 22 comprehensive books on practical machinery management, failure analysis, failure avoidance, compressors, steam turbines, pumps, oil mist lubrication and optimized lubrication for industry. Bloch holds Bachelor of Science and a Master of Science (cum laude) in mechanical engineering from Newark College of Engineering. He is an ASME Life Fellow and was awarded lifetime registration as a professional engineer in New Jersey.



PUMPS & SYSTEMS

10 TO WATCH

PUMP PROFESSIONALS

Pete Gaydon

Sam Hodel

Subodh Khobragade

Kathleen McCabe

Claudia Mueller

Oliver Nobels

Adam Osburn

Manish Verma

Yanhui Xu

Gabriel Young

It has been a tough year, stemming mostly from the COVID-19 pandemic removing much of the norm from our workplaces and personal lives. So, this year especially, the December issue has become one of our favorites, as we get to celebrate 10 up-and-coming pump professionals. This is one way to help show off the dynamic personalities that work in this industry. We hold them up as an example for the next generation, by honoring the accomplishments and drive of current outstanding employees.

In the next five pages, you will meet 10 individuals who were nominated by someone at their company as an up-and-comer to keep your eye on. These 10 people range from directors of inside sales to foremen and process engineers. Their experience ranges from 18 years to just three. They come from different parts of the world and represent great diversity in the industry. They are excited about ushering in sustainability goals, technological advancements and finding meaning in a career where their knowledge is needed in every sector of the industry.

Nominations were collected from readers for the 10 Pump Professionals to Watch starting in June. Applications were reviewed by magazine editors as well as members of our Editorial Advisory Board. These professionals—all under 40 years of age—were chosen for the roles they serve in, the education they've completed, the boards and associations they belong to, and the effort they put in as they seek to contribute to their companies and communities. We are honored to congratulate Pumps & Systems' second group of 10 Pump Professionals to Watch. Pay attention—they're just getting started. ■

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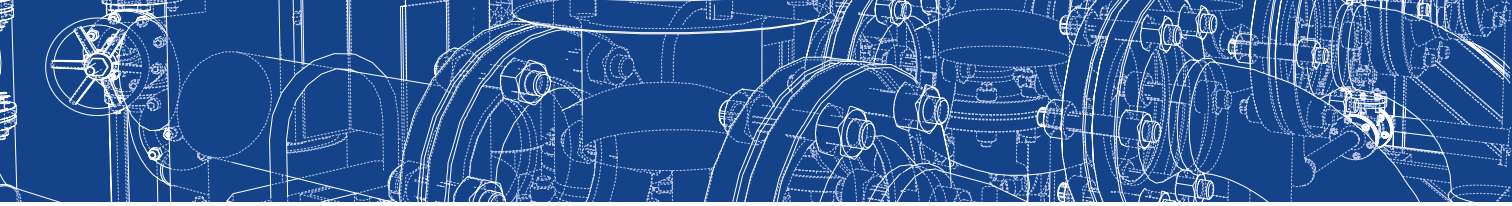


Pete Gaydon

Technical Director
HYDRAULIC INSTITUTE

Pete Gaydon's first job out of college prepared him for his role today, which is serving as the Hydraulic Institute's (HI) technical director.

Gaydon, 39, previously worked for pump manufacturers, learning the industry basics as an intern at Flowserve in Taneytown, Maryland, while in college. From there, he went to work for Chempump as a pump design engineer. He then went back to Flowserve to work as a pump improvement engineer in the technical services group. It was during his time working for Chempump that Gaydon served on the HI standards committee.

"So, I had an understanding of the institute, how it worked and served the industry, and the technical experience," Gaydon said. "Therefore, the technical director role was a good fit for me and provided a great opportunity to grow my experiences and work with the best pump engineers to advance the industry."

In 10 years, Gaydon said he hopes to "have an improved understanding of how trade associations support their industries, and I hope to be a leader in that space."

Gaydon has written articles for Pumps & Systems magazine, and he has been a guest on the magazine's podcast. He organizes the monthly section for HI Pump Frequently Asked Questions as well. Gaydon wants young people in the industry to understand the amount of available opportunities that are open to them.

"Sometimes it seems like the news is always talking about how manufacturing is going away, but this is not my observation," Gaydon said. "My advice is to be patient, and learn from others. Most of what I have learned was from others in my work experience, which helped me much more in my career than my academic experience."

How do you spend your time outside of work?
"I spend most of my time with my wonderful wife Katie, and our two young boys Jack (2 years) and Charlie (9 months). When I am not spending time with them, I enjoy running with a local running club."

What's on your bucket list?
"Katie and I have discussed taking the kids to see all the national parks in the United States. Accomplishing this would be great, but seems like a daunting task at their current ages."

Sam Hodel

Applications
Engineering Manager
GPM, INC.

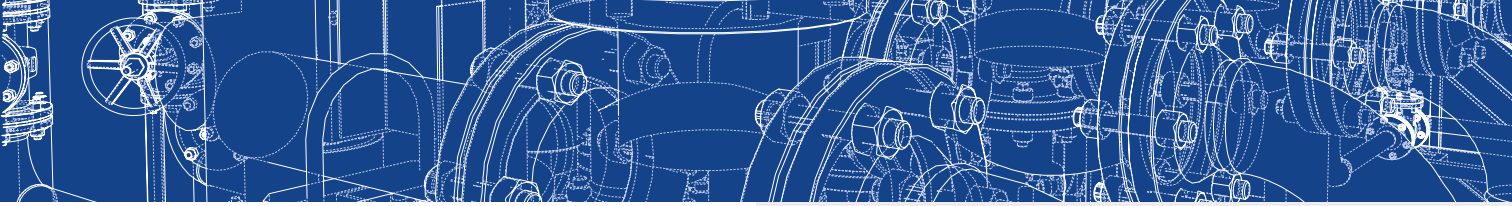
Sam Hodel, 30, started off his time at GPM, Inc., as an intern in 2012 while still in his senior year at the University of Duluth-Minnesota, where he earned a Bachelor of Science in mechanical engineering. He then joined the company full-time in 2013 as a service engineer, and is now an applications engineering manager, a role he has held for three years. "Over the years, Sam has excelled in every engineering role and department that he worked in including service, safety, OEM manufacturing and now applications engineering," said Blake Kolquist, GPM's marketing director. "Sam has worked tirelessly to continue learning and applying that knowledge with an emphasis in electric submersible motors, vibration analytics, condition monitoring, FMEA [failure mode and effects analysis], and more."

Hodel has been leading the engineering team on large-scale custom slurry and dewatering pumping projects beginning with concept design work, engineering, all the way through manufacturing, commissioning, startup and condition monitoring. Hodel has a Cat Level II vibration analyst certificate and also assists in training members of the GPM service and field service team on condition monitoring, failure analysis and quality control. He is a member of the Engineers Club of Northern Minnesota.

"Sam continues to educate himself, his teammates and our customers on the latest industry trends, best practices and also new technologies and tools, all of which are in the best interests of the end users and the industry in general," Kolquist said.

Hodel is known for being dedicated to the industry and enjoys building up the people around him, making him a true team player.

"He never wants the credit for success, but rather he is the first one to dive in to help the team solve the next challenge that comes along," Kolquist said.



Subodh Khobragade

Field Service Engineer
PETROTEC

Subodh Khobragade, 31, has now spent over 10 years in the pump industry. His journey began with industrial trade training in machining. He then worked as an apprentice in the L&T tool room in Mumbai, India. "My major breakthrough came after I applied for a vacancy in Flowserve," Khobragade noted.

He worked at Flowserve Pumps in the United Arab Emirates as a precision assembler for five years, then as a pump mechanic for Hydro Inc. in the United States, and now he works for Petrotec and Flowserve's Pump Certified Service Center in Qatar as a pump specialist. Here, he has set up a pump repair workshop, leads operations, handles aftermarket services, and works as a field service specialist. His love of problem-solving combined with his "unassailable passion and fascination for turbomachinery" eventually led him to become a specialist in API pumps.

Khobragade's manager, Nathan Venter, wrote, "He can be trusted to give clear answers and a way forward when there are pump difficulties on-site. What is noteworthy is that he often deals with rotating equipment engineers who are 10 to 20 years his senior and earns their respect."

In his nomination, Venter wrote how Khobragade is often sent into high-stress situations on-site where there are many unknowns. "Our clients are oil and gas giants that are demanding and who expect performance at the highest levels." Venter said. "Before he starts, there is confusion and stress, but once Subodh has completed his job, often a solution is found and implemented, and we end up with a calm and grateful customer."

Regarding his recommendation for industry newcomers, Khobragade said, "the only advice I would like to give to the upcoming talent is to get a real-world experience, and the best way to do so is via internships, certifications and investing in learning."

Khobragade continues his own education by attending training, doing certification courses, working with 3D design software, doing DIY projects, and subscribing to industrial blogs. We also wanted to know what was on his bucket list. His answer: "work as a freelancer, travel around all seven continents and start my own DIY and crafts YouTube channel."

Kathleen McCabe

Director of Inside Sales & Engineering
GLOBAL PUMP

Kathleen "Katie" McCabe started her career off at Global Pump, a Mersino Company, as an administrative assistant. Through hard work, she has risen from soil boring technician at the Ann Arbor (Michigan) Wastewater Treatment Plant to project manager and estimator, inside sales and estimating manager and now director of sales and engineering.

McCabe, who earned a Bachelor of Science in environmental resource and planning, came into the pump industry by way of dewatering; Global Pump specializes in moving water after events such as hurricanes.

"To best understand dewatering, you need to effectively understand pumps," McCabe said. "That's where my knowledge base started, then expanded deeper into the pumping application world. Years of estimating and project management with Mersino along with my obsession with learning, and my patience, have groomed me into the training role I am in today."

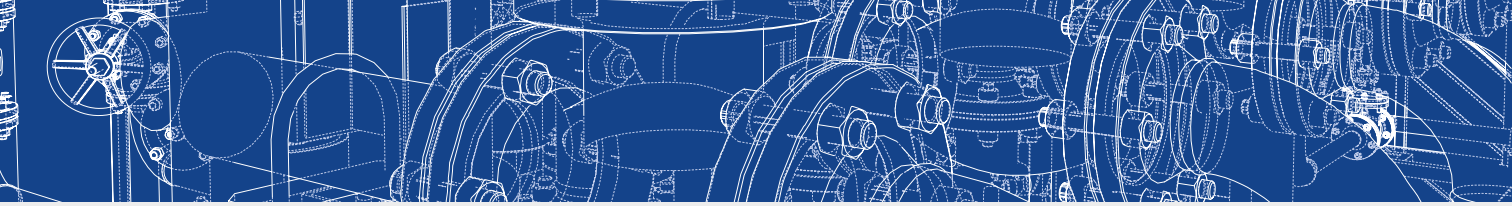
Like many others in the industry, McCabe, 35, said she enjoys teaching people. "I enjoy giving them the opportunities to learn and better understand this wonderful industry by establishing a foundation of knowledge and feeding into their curiosities," McCabe said.

Knowing the basics is the first step to solving problems when you come across challenges in this field, McCabe said. Field experience is a major benefit for young engineers, even if they do not have an engineering degree.

"[The most challenging part is] the continual problem-solving and learning opportunities," McCabe said. "No projects are ever the same, so you have to constantly think critically, gather information, determine designs and stay up to date on the ever-evolving technology."

What advice would you give to a newcomer or a student considering this industry?

"Get in the field to see applications in the real world, get dirty, don't be afraid to ask questions and keep learning. You don't have to have the answer for everything, you just need to know the basics, ask the right questions to gather the right information and use your resources. The rest will come with time and experience."



Claudia Mueller

Process Engineer III
ITT BORNEMANN

Claudia Mueller, 33, studied chemical engineering at the Technical University in Munich, Germany, where she grew up. But during graduate school, she fell in love with Canada while working there on her thesis in collaboration with the University of Calgary. "Being exposed to several different industry branches, I determined that my main interest lies in process engineering in the oil and gas industry," Mueller said. "My passion in this field continued to evolve when I spent six months in Calgary, a leading city in Alberta's and Canada's oil and gas industry."

Now Mueller lives in Canada where she works for ITT Bornemann, in the department for Bornemann multiphase pump packaging. "Our team works cohesively, collaboratively and efficiently on multimillion-dollar multiphase pump package projects. As we are a small team, you can see everyone's impact on the successful completion of very large projects. I am proud to be part of such a fantastic team of individuals," Mueller said.

"I strongly believe that multiphase pumping is a growing market in the oil and gas industry, and that there is room for new developments and optimization of oil production utilizing multiphase pump technology," she said. "I would like to use my skills to further develop and improve the progress in this field of technology."

ITT Bornemann's Gord Heather, executive director and general manager, Americas, nominated Mueller for this award.

"She is recognized for her strong technical background, outstanding performance and high potential for future growth in our business," Heather said. "Claudia is well respected by ITT senior leadership and has a global reach across the company. She works well with other cultures, colleagues and is described as a team player."

In the future, Mueller said she sees herself leading a small team in a fast-paced, growing climate. She would like to mentor newcomers to the industry.

"The current environmental and economic challenges make it exciting to witness and to be part of the developments in this industry," Mueller said. "As an example, the multiphase pump skids that we are designing are making an effort to reduce the need of flaring and to increase the efficiency of oil production. I am expecting to see more developments and design optimizations like these helping to fuel the future."

Oliver Nobels

Application Engineer
SCHURCO SLURRY

Oliver Nobels, 28, says the key to success is to realize you don't know it all. "I've done training and webinars, but I find the best way to learn more is to talk to people around you with a depth of knowledge." Learning from people like Schurco Slurry CEO Nicholas Schur and Vice President of Engineering Will Pierce has made all the difference for Nobels.

Nobels has a bachelor's degree in physics from Presbyterian College and a bachelor's degree in mechanical engineering from Clemson University. He started working at Schurco Slurry in 2017 and realized there was much more to the world of pumping than he previously knew existed. Nobels started as an application engineer, but as he's grown in his position, he's also taken on a sales role. He said he enjoys managing the project every step of the way. His favorite part of the industry is the people. "Everyone's stand-up," Nobels said.

One of the challenges he faces in his job is trying to get people to look at the big picture. Nobels wants end users to look at the system as a whole and not just about the part that needs replacing. "We want to know the environment the pump would be in. What is going to be the best solution for the entire system and application?"

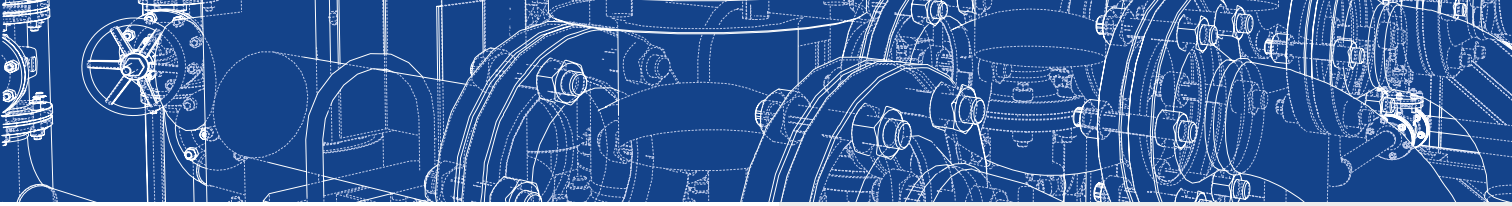
Nobels sees himself staying in pumping in the future, but he is open to possibilities of what roles he could step into, including more of a management position. "Once you're in [the pump industry], you want to stay," Nobels said.

Outside of slurry pumping, Nobels enjoys playing golf, tackling home projects, and being around the water, regardless of whether it's a beach, lake or river.

What advice would you give to a newcomer or a student considering this industry?

"Keep an open mind. When I came into this industry, I didn't know exactly how it worked, but once you get a foothold, it opens up so many possibilities. There are so many types of pumps, and the industry is filled with really good people.

"Many young engineers only think about automotive or aerospace when trying to decide what field they want to pursue a career in, but they should consider the pump industry. Pumps are everywhere, and there are so many options to choose from."



Adam Osburn

Foreman
MANHATTAN MECHANICAL SERVICES

The term "tinker" would be an appropriate description for Adam Osburn, who said he grew up wanting to figure out how things work.

"I can remember as a kid, taking old appliances apart to see what was inside and how they work," he said. "That led me to experimenting with small engines and working on cars. I believe that was the beginning of it all. I decided to see if I could use my mechanical abilities in an industrial setting and got into the trades."

Osburn, 38, who completed the Project Management Institute program at Purdue University, started his career working for a contractor at a corn milling plant.

This was his first introduction to working with pumps and other mechanical systems in an industrial setting.

"I really enjoyed the fast pace of maintaining the equipment at that plant," he said. "To know that production schedules are on the line when equipment goes down, and my crew and I were responsible for getting [everything] up and running again was kind of a rush. That can also go the other way, too. Production managers looking over your shoulder while performing repairs can be hectic at times, but getting the job done and done right is very rewarding."

Osburn, who earned certifications from the National Center for Construction Education and Research, and the National Commission for the Certification of Crane Operators, said that while automation is taking over the industry, it is also creating new jobs at the same time.

"What once was a job for humans is being replaced by a machine. That really is job security for all of us in this industry," Osburn said. "Machines are always going to need us to repair them, program them and build them.

"People that lose their positions to machines now have an opportunity to educate themselves, attend training, and join this industry in maintaining and building these systems."

Cory Burfield, who sent in Osburn's nomination, described him as a dedicated, well-rounded and knowledgeable tradesman.

"When the pandemic hit, Adam stepped up and took on an additional role. He is currently supervising a cleaning crew that is tasked with sanitizing a large oil refinery," Burfield said.

"Adam has made it clear that keeping refinery workers safe and healthy has been his main priority lately. He and his crew are making a difference every day during the global pandemic, and he truly enjoys doing so in order to keep the processes running and people healthy."

Manish Verma

Business Development Specialist
TMEIC

Manish Verma's passion about electrical engineering and variable frequency drives is evident.

Verma, 36, finished degrees at Virginia Tech and went to work for TMEIC, his current employer where he is a business development specialist. He participated in an Engineering Excellence program at TMEIC where he learned about motor controls for applications such as pumping and material handling.

"The initial training taught me how to communicate with clients about technical merits, how the technology works and key considerations when specifying, evaluating, procuring, and installing medium-voltage VFDs [variable frequency drives]," Verma said. "I had always wanted to pursue electrical engineering due to my initial internship at a captive gas-fired power station and desalination plant in an aluminum smelter that caught my interest in the subfield of electrical power and additional focus on power conversion such as VFDs through my post-graduate employment."

He realized that industry veterans take "immense pride" in teaching newcomers, and he wants to pass that knowledge down as well.

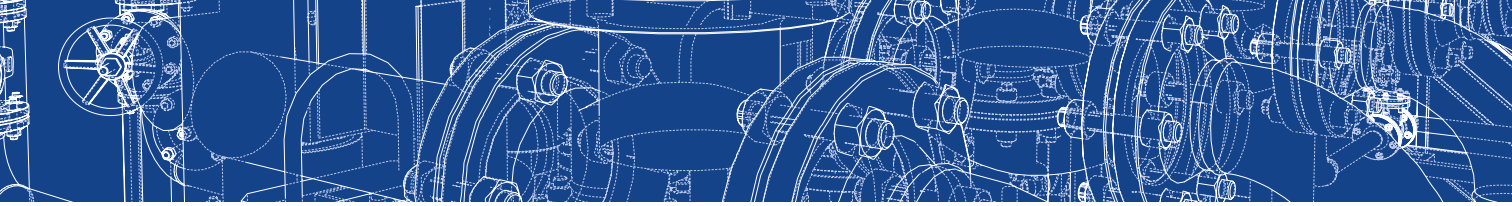
"In a typical industrial facility, roughly 60 to 70 percent of the energy is consumed by electric motors. A large majority of them are applied to pumps," Verma said. "By applying VFDs to pumps, one not only gets motor control, but also immense energy savings and efficient utilization of upstream power delivery apparatus."

He also added that, "If you are a person who is a sponge for knowledge, there is a ton to absorb and apply immediately."

Verma is especially interested in the future of the industry as it relates to VFDs.

"Digitalization and energy management holds potential in the VFD and pumps industry," Verma said. "If the infrastructure bill is passed, I believe it will spur more investment here at home to upgrade roads, water infrastructure, etc."

What's on your bucket list?
"Personally, travel to Europe and Southeast Asia. Professionally, learn more about [the] commercial/business side and pursue an MBA."



Yanhui Xu

Director End User Sales & Services
JOHN CRANE

Yanhui Xu started his career as an engineering trainee for John Crane United Kingdom, but that was only the beginning. Xu, 39, has held positions such as application engineer, SAP data team manager, wet seal engineering manager and engineering director at John Crane. He is currently the director of end user sales and service in Tianjin. This diverse array of positions has only added to his skill set. Xu said he enjoys jumping out of his comfort zone to get a deeper understanding of the industry and to challenge his way of thinking.

Xu likes working with mechanical seals because of the crossover of different areas in the industry. "It involves mechanical, materials, fluid dynamic engineering and is also applied into wide process industries," Xu said. He said the most challenging thing is to keep innovating. Users cannot get complacent in terms of the technology and solutions available. "Keep positive and proactive," he said. Xu believes that artificial intelligence (AI), big data and the cloud will continue to make big changes in pumping.

In 10 years, Xu wants to be a key contributor and driver in the industry, as well as have the opportunity to share that knowledge and experience with young engineers. "We are the natural momentum of this industry," Xu said. For now, his advice for young engineers is to keep hungry, foolish and ready to learn. "Walking out of school is just the beginning of our learning," he said.

What is on Xu's bucket list? In the short term, he's looking forward to a globally available vaccine to the coronavirus and the ability to travel with his family. For the long term, Xu wants to learn more about sales and service management and take on more responsibility to help lead his team to a healthy, stable and growing business.

Why did you decide to focus on this industry and area of expertise?
"Initially, I chose it because the mechanical seal industry is an multidisciplinary area. It involves mechanical, materials, fluid dynamic engineering, etc., and also applied into wide process industry. [I thought,] this is very interesting and [I can] motivate myself on learning. Later, once I started getting more insight [into the] mechanical seal, I liked it, especially the sense of achievement after providing a successful solution to the customer."

Gabriel Young

Senior Engineer
EAGLEBURGMANN

With 11 years in the pump industry behind him now, Gabriel Young, 32, found his start in the industry as a petrochemical manufacturer in Texas where he worked as a maintenance and reliability engineer. His experience with pumps and mechanical seals there prepared him for his current role at EagleBurgmann.

John Merrill, a senior engineer at EagleBurgmann who nominated Young, wrote that, "He investigates technical challenges from different perspectives well beyond his role and shares what he finds with his colleagues." He also noted that, "He does an excellent job bridging the gap between highly experienced experts that are entering retirement and new engineers just out of college."

When asked to share advice to industry newcomers, Young commented that, "this industry can be quite intimidating when first starting out, but don't let that scare you off. Whenever possible, reach out to senior staff and subject matter experts within your organization and ask them questions. That is the best way to learn." Young continues his own education by reading white papers, case studies and attending online lectures. He said, "I still seek out subject matter experts on topics of interest to me and ask those people questions."

What's your favorite part of the industry?
"No two projects are the same. Each application offers an opportunity to learn something new."

What's the most challenging part of this industry?
"The demand to solve problems and respond to emergencies in a short period of time to avoid extended downtime or loss of revenue for a customer."

Where do you see yourself in 10 years?
"Participating in additional technical committees and organizations within the industry. Hopefully acting as a mentor to a younger engineer."

What has you most excited about the future of this industry?
"The increase in remote sensors and IIoT. It offers the opportunity for equipment manufacturers and end users to learn more about how rotating equipment truly behaves and will provide opportunities for design improvements and optimization."

7 Ways to Optimize Maintenance Strategies in Power Generation

Ensure minimal disruption of assets in your facility.

STEVE DESKEVICH | GE Digital

Many industrial companies face challenges that include aging generating assets, a growing knowledge gap, changing generation profile and utilization, and the growing need for transparency with regulatory agencies. A key to meeting these challenges is the design and standardization of an asset management process that optimizes maintenance strategies with a focus on improving work management, reliability, advanced technology, information management and asset planning. In asset-intensive industries, asset management is moving from simple maintenance to a business operation's core competency.

This points to the rising need for risk-based maintenance, the need to maximize economic return on assets, and the increasing adoption of cloud-based applications to support global business.

Energy and utility companies have been challenged repeatedly by changes brought on by globalization and new environmental policies. Among these companies, operational excellence means getting more from the assets that serve their customers.

Consider these seven strategies that companies can employ to ensure their assets keep running to minimize disruption in operations.

IMAGE 1: Asset management is moving from simple maintenance to a business operation's core competency (Image courtesy of GE Digital)

1 Gather Data & Correlate It

Multiple systems of machine data, alarms and alerts can create a chaotic environment. The inability to create a single view of time-based data means that operations must manually attempt to understand dependencies and downstream impacts. The ability to gather all the data into one secured environment for correlation and management, specifically designed for machine data analytics, is the first step in optimizing control of a user's operating environment.

Asset management solutions can collect data across operating assets and environments, with self-service visualizations that provide a window into key performance indicators, asset relationships, and data analysis as well as other data sources, like work order history and weather.

2 Filter Out the Noise

Projections for autonomously connected industrial endpoints are only set to grow as the industry continues to automate. The value of data collected from these connections depends on systems that can identify key events, correlate alerts and alarms, and grant operators a view into actions that are of primary importance.

Alarm management has been part of plant operations for years. However, filtering out false positives and understanding

In asset-intensive industries, asset management is moving from simple maintenance to a business operation's core competency.

priorities in an automated way has been a challenge. Analytics (descriptive, diagnostic, predictive and prescriptive) are now core elements of asset management systems, where individual asset sensor data as well as relationships between multiple asset information can be examined.

Analytics are employed to identify which alerts are likely to be critical, guiding operations staff with action prioritization. Using this data, sophisticated algorithms can filter out random variation and key in on critical issues.

3 Get a Bird's-Eye View With a Zoom Lens

Traditional operations consist of multiple systems, each designed to measure and monitor singular machines or small groups of equipment. Asset management solutions can provide the ability to consolidate and provide that "single pane of glass" that operations management and staff need to see how operations are performing—holistically—across the plant and across multiple plants.

The truth is that both are required: the ability to drill down to each piece of equipment, but also to understand how an issue will influence the overall health and production output of the environment.

Asset management solutions are designed to provide this level of visibility, with understanding of individual assets as well as interdependencies between assets and workflows. With case management combined with decision analytics, operators can assess their environments at the portfolio, plant, asset class and equipment layers, allowing them to drill down to meet their immediate needs.

4 Enable Mobility Anytime, Anywhere

Modern industrial companies must optimize for mobile form factors (smartphone, tablet, etc.) to provide the most effective workflow in an operating environment. Mobile workers need to be able to measure performance and input data directly into their systems. Applications must allow a mobile worker to be "in the facility" around all equipment, across the plant.

The benefit of this configuration is that issues with the equipment can be addressed quickly through maintenance data captured by the system in real time, reducing incidents of lost data and errors that can occur when manual paper processes are used.

In addition, the current COVID-19 pandemic situation is making it important for power generation companies to enable remote operations solutions to ensure worker safety and operations continuity with secure remote/mobile operator controls.

These solutions ensure operational reliability to leverage worker location flexibility, allow operators to cope with reduced staff by using centralized remote expertise to augment essential local staffing, and provide the ability to act with urgency as needed.

5 Proactively Respond Before Incidents Occur

The results of unplanned downtime can be severe for every industrial company, with real bottom-line impacts. Predictive maintenance uses machine data and analytics to understand when components are likely to fail. Proactive measures can then be taken to order new parts and schedule maintenance during off-production peak times, providing longer windows of continuous operation.

This also has positive impacts on workforce efficiencies, emissions controls (fewer startup emissions) and asset life extension for improved capital management. Asset performance management software solutions must leverage analytics to identify assets that are likely to fail, the root cause of the failure, and the priority of impending events.

These solutions can perform automatically, continuously and relentlessly—24 hours a day—for optimized or for the most reliable asset operation under the existing conditions.

6 Improve Your Safety Profile

There is always a need to create safer work environments by reducing the number of emergency incidents and creating more organized and scheduled maintenance that drive improved safety key performance indicators (KPIs).

Whenever an unexpected failure occurs in an operating environment, there is a level of uncertainty and risk. Risk can come in the form of worker exposure to toxic materials, electrical components and combustible elements.

It also comes in the form of vehicle accidents or environmental hazards that put workers and the public in danger.

Following predetermined procedures proven to reduce safety and environmental hazards results in fewer incidents overall. Capturing responses and actions and then leveraging process-based analytics can inform safer responses in the future.

7 Reduce Dependence on Communal Knowledge

Operator response is often based on an individual's historic knowledge of an asset's idiosyncrasies rather than a systematic approach. This situation is acceptable only if that operator remains working in the same capacity. What happens as employees retire and that communal knowledge is lost?

Leveraging machine data collected and correlated in a common repository provides the basis for leveraging prescriptive analytics to understand operator responses in an automated way. This data store is the basis of a knowledge center that can support a "recommendation engine," finely tuned to provide the best response results. Over time, common patterns emerge, and best practices are identified that become part of recommended operator responses. The result is greater consistency and automation for incident management and response across all employees and functional teams.

The challenges of aging generating assets, knowledge gaps, changing generation profiles and increasing transparency demands by regulatory agencies are real.

Using an asset management approach with digital solutions focused on asset management practices can help to optimize maintenance strategies, provide deeper insights of assets, systems and processes, and can help to address these challenges in ways that can optimize plant operations and increase asset availability while mitigating the risks of business evolutions. ■

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Steve Deskevich is vice president of digital product management for GE Digital. He may be reached at stephen.deskevich@ge.com. For more information, visit ge.com.

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FGD Systems: Fighting Abrasive Wear in Expansion Joints

Select the right expansion joint for your coal-fired power station.

BRANDON PHILLIPS | Garlock

Flue gas desulfurization (FGD) is an efficient process commonly used in coal-fired power stations to remove sulfur dioxide, an environmentally harmful byproduct of burning coal, from flue gas. Because of component operational stresses and unplanned outage concerns, FGD system maintenance can be challenging. Due to the operational cycle length expected in coal-fired plants, regularly scheduled maintenance coupled with optimal component selection is essential to minimizing downtime.

Various types of FGD systems are in operation, with the most common being wet and dry types that use a lime or limestone slurry reagent. Pumping harsh slurry mixtures in a constant recycle loop imposes unrelenting wear on the piping components, creating the potential for unexpected failures. Expansion joints can be used to absorb the movement and vibration in piping systems, thereby preventing leaks or more serious damage.

Expansion joints are critical to the limestone slurry recirculating pumps in the gas desulfurization scrubber system. Identifying the correct expansion joints to use is not an easy task considering the vast number of products in the market and their varied uses. However, diligent product selection in lieu of a quick and easy replacement could mean the difference between uninterrupted operation and unplanned downtime.

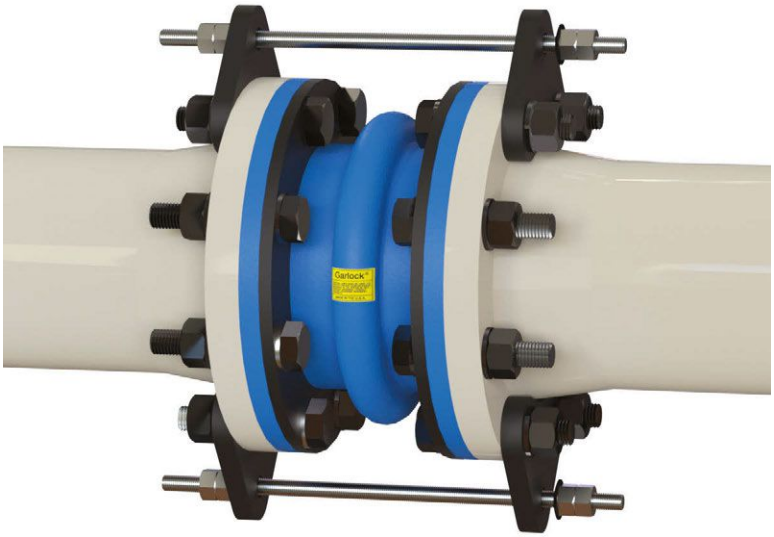

IMAGE 1: Rubber expansion joint (Images courtesy of Garlock)

Expansion Joint Styles

The first step in product selection is determining whether a metallic or nonmetallic expansion joint is best suited to the application. Metal expansion joint construction consists of thin-gauge steel configured into multiple bellows or convolutions. This configuration is best suited to high-temperature, high-pressure applications. Because component life is defined by a set number of cycles, metal fatigue can play a troubling role in the service life of metal expansion joints. Fatiguing the metal long enough to fulfill its cycle count will likely result in an abrupt failure.

By contrast, rubber expansion joints (Image 1) are constructed from layers of natural or synthetic rubber and fabric. This composite is resistant to abrupt cycle fatigue failures; instead, it deteriorates slowly over time. Rubber decay is gradual depending on the temperature and environment, but visual cues indicative of potential problems will typically present themselves long before a failure occurs. Other advantages of rubber expansion joints are noise/vibration dampening, greater pipe movement and improved abrasion resistance.

Because of the highly abrasive nature of the limestone slurries employed in FGD systems, most expansion joints are made of rubber. Solid particulates from the slurry can get trapped in the corrugations of a metal joint, mechanically restricting it as it attempts to absorb pipe movement. To avoid this, a rubber expansion joint can be configured with a filled arch to present a smooth bore (Image 2). Because the arch is filled with a flexible rubber compound, the overall design remains flexible enough to absorb the thermal expansion/contraction in the piping while also allowing the slurry to flow without interruption over the smooth bore.

Materials

In FGD systems, the two most important factors when selecting expansion joint materials are abrasion and temperature resistance. Natural rubber is the material most commonly selected for abrasion resistance, but the performance of the elastomer itself can vary from one

manufacturer to another depending on the elastomer blend used. Taking advantage of standardized testing to measure abrasion resistance of the elastomer is a pragmatic approach to maximize service life through material selection.

Making an informed decision on materials can be accomplished by requesting test data from the expansion joint manufacturer. The American Society for Testing and Materials (ASTM) D2228 Pico Abrasion Index is an industry-standard test that quantifies the wear resistance of elastomers when subjected to a force by a sharp blade. Another popular test is the European standard DIN 53516 method which abrades the rubber specimen by constant contact with a rotating drum of coarse sandpaper. Higher percentages of material wearing away during the test indicates poorer performance of the elastomer.

Results from these tests can translate into longer life expectancy and improved overall system reliability.

For example, millable polyurethane (Image 2, p. 32) is a new material used in expansion joints that provides wear resistance properties in applications with high solids content, such as limestone slurries. Polyurethane scores two to three times higher in resistance to abrasion compared to natural rubber on the Pico Abrasion Index.

The second critical factor to consider is the temperature resistance of the materials used in the expansion joint. Air aging tests are an accepted methodology in the rubber industry, which consists of subjecting the elastomer to an elevated temperature for a specified time. Heat resistance is gauged by the change in physical properties such as hardness, tensile strength and elongation percentage. Large variances from nominal are indicative of poor heat resistance.

While manufacturers set temperature ratings based on the results of these heat-aging tests, there is a lack of continuity in the allowable decline of the referenced physical properties. Two distinct natural rubber blends could share the same temperature rating, but the rate of physical decay could be different depending on how

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IMAGE 2: Filled arch expansion joint with polyurethane liner

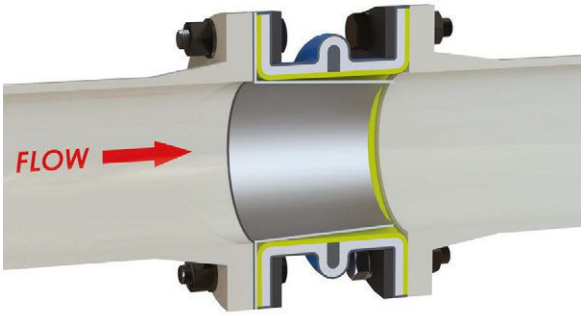

IMAGE 3: Direction of flow in piping with flow liner

the two compounds are cured, the grade of the polymer or other formulation variances. These variables are why it is important to request heat resistance test data from expansion joint providers. This ensures a like-for-like comparison of materials. The Fluid Sealing Association (FSA) provides industry standards for sealing products, including expansion joints, which can be referenced for elastomer specific heat resistance test parameters.

Intermittent temperature spikes can unknowingly play a significant role in the deterioration of expansion joints. For example, it is inadvisable to use natural rubber in an application when temperatures above 180 F are known to occur. It is common in FGD systems to source ethylene propylene diene monomer (EPDM) as an alternative because EPDM is generally rated up to 300 F. However, using EPDM as a liner material to withstand higher temperatures comes at the cost of the rubber's overall abrasion resistance.

Hydrogenated nitrile butadiene rubber (HNBR) is an optimal liner material for wear resistance at elevated temperatures. Like EPDM, the recommended service temperature is typically up to 300 F, but HNBR has roughly 50 percent greater resistance to abrasion, according to the DIN 53516 test method.

Flow Liners

Abrasive flow in piping is often accompanied by substantial flow velocity, particularly in the small diameter piping seen in absorber bleed pump systems. A flow liner can be used to reduce turbulence and eliminate concentrated wear point areas of the expansion joint lining. In general, contact between the rubber itself and abrasive media is limited without sacrificing the range of movement the expansion joint provides. Protecting the rubber lining is critical because, if compromised, the expansion joint will fail in just a matter of time.

Flow direction is the only consideration required for use of a flow liner. Flow must be traveling into the leading edge of the flow liner (Image 3), otherwise solid particulates in the slurry mixture will collect behind the flow liner impacting the movement capabilities of the expansion joint over time.

The use of flow liners in vertical pipe runs requires flow direction to follow natural gravity. In most FGD systems, the recycle pumps for slurry recovery discharge vertically up the scrubber wall to the spray nozzles. With the flow opposing gravity, once the system turns off, any remaining slurry will fall and build up behind the flow liner. It is more effective to use the flow liner in horizontal piping, such as the suction side of the recycle pump or absorber bleed pump discharge lines.

Preventative Maintenance & Reliability Services

Reliability engineers have the important responsibility of accounting for every system component, no matter how small, to ensure the station maintains uninterrupted operation. It is unrealistic, however, to expect reliability engineers, maintenance crew/contractors or other component buyers to be experts on every part in the system. Preventative maintenance and reliability (PMR) partnerships between the plant and an expansion joint manufacturer can lift some of that burden from plant personnel.

Permanent distortion of piping resulting from years of thermal movement, foundation settlement or installation of rebuilt pumps can all result in misalignment issues. If there is excessive misalignment between a pump and related piping, a custom-sized expansion joint can be used to bridge the deformed gap. Failure of expansion joints in highly abrasive applications are exacerbated by unnecessary stresses caused by twisting, bending and stretching an expansion joint to fit a malformed pipe gap. Not only will the expansion joint be under stress at startup, but there will be resultant loads on the pump casing as well.

One solution is to ask the expansion joint manufacturer to measure and document the piping misalignment and recommend a custom-crafted expansion joint to fit the gap. These services also include recommendations on existing part conditions, so components can be replaced at the optimal time. Using manufacturers' PMR services can help remove some of the guesswork from selecting the correct expansion joint, as well as help ensure maximum service life.

The life cycle duration of expansion joints in highly abrasive piping applications can be extended through careful product selection. Styles, materials, flow liners and manufacturer services are key areas of consideration when implementing expansion joints into FGD systems. ■

Brandon Phillips is a product engineer for Garlock Sealing Technologies and a graduate of the University at Buffalo with a bachelor's degree in Mechanical Engineering. For more information, visit garlock.com.

Analysis & Engineering Upgrades Solve Ring Section Pump Failure

Corrections were made to identical segmental ring section pumps exhibiting the same issues at multiple power plants.

ROBBY BYROM | Evans Hydro, A Hydro Company

A major power plant in the United States experienced high vibration and recirculation issues with several ring section (BB4) boiler feed pumps, resulting in multiple catastrophic failures and unplanned outages. This case study details one of the pumps that was shipped to an aftermarket pump service center for a full analysis, troubleshooting, repair plan, rebuild and performance testing.

Combined-cycle power plants are the "new kids on the block" of the power generation industry. Designed to combine both gas and steam turbines, combined-cycle power plants can produce up to 50 percent more electricity with the same fuel usage as simple-cycle power plants. Modern combined-cycle plants can also react quickly to power grid demands with the ability to begin producing energy in less than 10 minutes and run at full capacity in less than 60 minutes. This provides an efficient complement to intermittent renewable technology.

As electricity demand has changed and combined-cycle plants have begun replacing conventional fossil and thermal power plants, the type of pumps used has also changed. Fossil power plants often use robust, long-lasting barrel pumps. These pumps operate for long, uninterrupted periods, and plants are generally fitted with two 100-percent or three 50-percent installed pumps per unit.

In combined-cycle plants, the demand for robust, yet expensive, barrel pumps diminished as the industry moved toward less expensive segmental rings pumps. Due to the recent shifts in the power industry, operators often face a shorter mean time between repair (MTBR), internal wear and high vibration issues on newly installed units.

Background

After experiencing numerous boiler feed pump performance and reliability issues at their power plant, the plant owner opted to pursue a comprehensive root cause analysis and repair plan with an aftermarket pump service center in Los Angeles, California. The investigation ultimately revealed a series of underlying issues linked to the performance problems and unexpected pump failures.

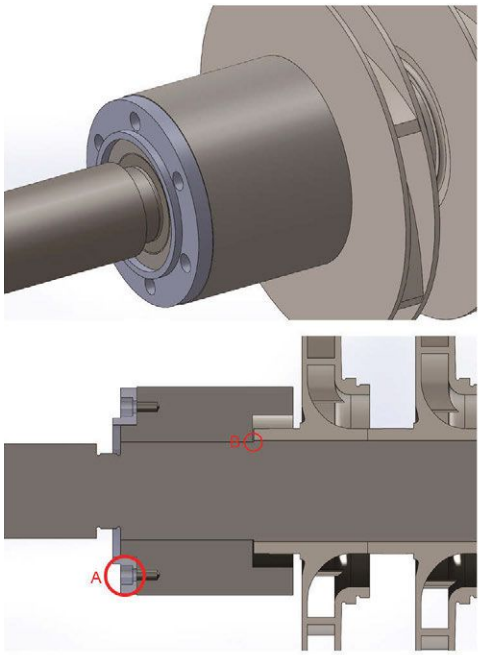

IMAGE 1: The redesigned balance sleeve will have an additional retainer ring for support and a gap to allow the impellers to "hop" onto the shaft during momentary reverse thrust. (Images courtesy of Evans Hydro)

Findings, Engineered Solutions & Recommendations

During the first unit's initial inspection and analysis, it was noted that the balance sleeve had a tapered fit in relation to the shaft. This type of design is uncommon because it requires high pressure and a special tool to install or remove the balance sleeve from the shaft. This is also a major safety concern.

Additionally, a tapered fit balance sleeve was installed near the yield point onto the shaft. The high pressure and tapered fit resulted in an undesired fit onto the shaft, producing high-stress concentration areas. The outside diameter did not run true to the shaft, which resulted in unequal peripheral pressure or force around the balance sleeve. In return, it created a scenario in which the shaft could bend. The reverse force, or bending moment, accrues 3,550 times per minute, causing significant bending moments at the root of the balance sleeve, eventually fatiguing the pump shaft.

A proposal was made to redesign the balance sleeve by making it a straight fit and making it longer to reduce the axial gap between the last stage impeller and the balance sleeve (Image 1). This prevents "disengagement" of the wear ring, which results in the destabilization of the rotor.

The phenomenon where the impellers hop forward and then return to their original position still exists, but due to the reduced gap, the impeller cannot restrict flow to the balance device.

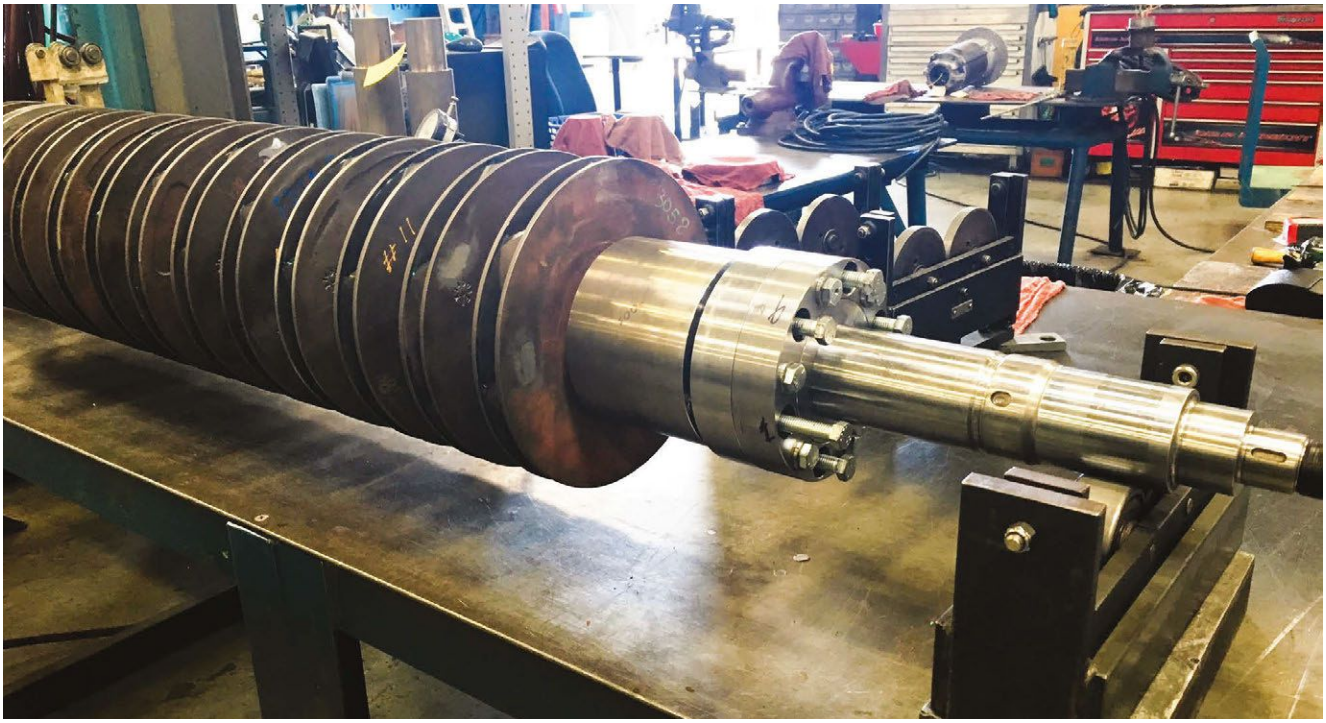

IMAGE 2: The service center used a custom-designed tensioning tool to verify the perpendicularity and parallelism of all impellers.

The service center found that the pump's original design required assembly by face-to-face configuration using anti-rotation pins. Because the last stage diffuser in the pump did not have a pin in the original design, the cover needed to "squeeze" the diffuser to prevent rotation. The gap produced by this design resulted in premature O-ring failure and also limited the pressure-carrying capacity. To improve both the pump reliability and the pressure-carrying capacity of the last stage joint, the diffuser's faces were precision ground. By tightening the stack-up tolerances, the pressure-carrying capacity of the last stage joint is also improved.

Another major finding was that the slide fit impellers held each other on the shaft at the proper place with the help of the hub faces. However, the faces were not perpendicular, which forced the rotor to bend, causing high vibration problems.

When the rotor was placed on rollers to check runout, the TIR (total indicator runout) appeared to be within tolerance. However, the shaft would bend due to the faces not being precisely perpendicular to the bore once the pump was running and hydraulic forces were applied to the impellers. The issue was challenging to detect without imitating hydraulic force.

The service center designed and developed a special tensioning tool to verify the perpendicularity and parallelism of all impellers. Using this tool prevented the rotor from bending under dynamic conditions (Image 2).

The service center recalculated and machined the cover faces to produce an artificial cover sag that perfectly followed the natural rotor sag.

The recalculated offsets for the covers allowed the use of tighter clearances between the balance sleeve and balance bushing, therefore reducing the flow through the balance line. The balance line pressure on average was reduced by about 30 pounds per square inch gauge (psig), which also extended the MTBR.

Challenges

Initially, the power plant was hesitant to modify the pump's original design and execute an engineered upgrade, which created a challenge for the service center to fully resolve the issue and potential shaft breakage. During the upgrade negotiations, another one of the plant's boiler feed units failed unexpectedly with a broken shaft. As the service center anticipated, this additional failure served to confirm the issue at hand and emphasized the urgent need for a design modification.

Due to the urgency of the situation and the data provided, the power plant opted to send the additional pump for further analysis and proceeded with the proposed design upgrades.

Performance Testing for Validation

Power plants use balance line pressure as a main reference point in establishing a baseline for a BB4 pump's overall health. The balance line pressure will increase along with greater internal clearances of critical fits, tolerances and other mitigating factors that can easily be missed during assembly. Therefore, performance testing that closely duplicates the actual conditions of a pump in service is a critical step in the repair process.

After repair, the pump was sent to a Hydraulic Institute-certified pump test lab in Chicago. Here, the pumps underwent

IMAGE 3: The ring section pump (BB4) was tested at a test lab.

standard testing protocols to measure vibration, pressure and flow. For reliability, the most important data point collected is the balance line pressure, a unique feature in testing segmental ring pumps. With the test lab's engineering support, the service center was able to design and set up a testing procedure that closely mimicked the installed pump's field conditions.

Back in Service

Once the repair and testing were completed and the pumps were installed, the service center received a number of identical segmental ring section pumps from multiple power plants exhibiting the same issues. Using the knowledge from the previous rebuilds, the service center was able to execute a series of similar repairs for these additional boiler feed pumps in an expedited time frame.

Today, all of the segmental ring section pumps have been placed back into service and are performing correctly without reliability issues.

The service center used a thorough inspection process, extensive process control procedures and stringent acceptance criteria to accomplish these repairs. ■

Robby Byrom is the vice president of sales at Evans Hydro. Located near Los Angeles, California, Evans Hydro is a pump repair facility dedicated to serving pump users across the West Coast and other areas of North America. For more information, visit evans-hydro.com.

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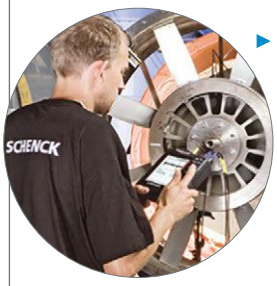

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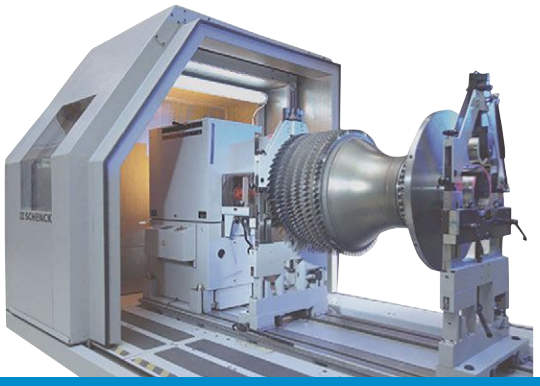

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Finding Success in Stepping Outside the Norm

Progressive cavity pumps solve maintenance problems at generating station.

ADRIENNE KREIGHBAUM | SEEPEX

IMAGE 1: Progressive cavity metering pump station (Images courtesy of SEEPEX)

One generating station maintenance manager found himself in a familiar situation when handling reoccurring maintenance issues with diaphragm pumps: doing the same thing over and over again because that is the way it has always been done, but knowing there could be a better way to accomplish what was needed. However, the risk of trying something new and potentially failing seemed high.

The Arkansas Electric Cooperative Corporation (AECC) Magnet Cove Generating Station was experiencing a high level of maintenance with their diaphragm metering pumps. These pumps were part of the plant's selective catalytic reduction (SCR) process. A solution of 29 percent aqueous ammonia and 71 percent water was being injected into the system to reduce nitrogen oxide (NOx) emissions.

This process takes place in the heat recovery steam generator (HRSG) and is crucial to the operation of the plant. The hot gases being discharged into the atmosphere from the HRSG must meet government regulations in regards to NOx emissions for public safety. If the SCR process malfunctions, the entire system must be shut down, and no power can be generated.

The Problem

The high level of maintenance required by the diaphragm pumps was not only costly, but also a safety hazard to the maintenance crew. Anytime users are around aqueous ammonia, they have to take precautions because there is a safety risk. The maintenance crew was spending approximately 16 hours a month working on these pumps around the aqueous ammonia solution.

"We would have to rebuild each of the pumps once a year. This was a huge expense at $1,500 to $2,000 in parts alone, plus the maintenance time," said Joey Vanmeter, maintenance supervisor at AECC. "We were replacing the bladders three times a year at $500 each as well. Operators and maintenance personnel were constantly in the pit having to make adjustments to the old diaphragm pumps. This was a huge safety risk."

The Solution

A sales engineer was responsible for calling on the Magnet Cove Generating Station. The sales engineer learned of the high maintenance level the diaphragm metering pumps were requiring and suggested Vanmeter look into a progressive cavity metering pump.

Vanmeter was familiar with progressive cavity pumps working well in oil applications but was hesitant to switch to a different product for such a critical process. Diaphragm metering pumps are the most commonly used pump for this application in the generating plant world. Going outside the "norm" and switching to something different would be a huge risk.

Vanmeter also knew he had to have a pump that could handle a range in suction pressures, specifically down to low levels. Within the SCR process, valves open and close on demand, varying the flow rate, and therefore varying the amount of pressure in the piping. Aqueous ammonia (ammonium hydroxide) begins vaporizing at approximately 85 F. This change from a liquid state to a gaseous vapor results in a change in pressure as well. These two factors along with the installation taking place outdoors in varying high summer temperatures mean the net positive suction head available (NPSHa) can dramatically decrease. A pump with a low net positive suction head requirement (NPSHr) is needed to keep the operation running smoothly throughout all levels of NPSHa.

NPSH is the difference between suction pressure and vapor pressure. NPSHa and NPSHr are critical to understanding if the system is designed correctly and if the pump selected is the correct style for the system. NPSHa refers to how much pressure the system has available for the pump to use, and NPSHr is the minimum amount of pressure the pump can operate at without cavitation. NPSHa must always be greater than NPSHr.

Progressive cavity pumps have a low NPSHr and may be a solution for this type of application. The design of the interference fit between the rotor and stator allows for the low NPSHr. A pump with a high NPSHr and not enough NPSHa would cavitate and ultimately fail.

IMAGE 2: Metering pump

Vanmeter continued his research and spoke with a manager at a water treatment facility in Florida using progressive cavity metering pumps on a solution of bleach and 19 percent aqueous ammonia. The reference spoke about the pump's performance, low maintenance and the fact that they do not run dry.

After hearing this positive feedback from an end user, Vanmeter decided to move forward with the purchase of a progressive cavity metering pump to use as a trial. The pump was installed temporarily to ensure it would work before taking out the old diaphragm pumps. This was a big change in the thought process for this application and inherently had some risk. If the metering pump had failed on this critical application, Vanmeter would have needed the redundancy of the installed diaphragm pumps to ensure he would be able to get the system up and running.

The Result

The progressive cavity metering pump had no problems during the trial installation and was later installed permanently along with two more that replaced the three previously used diaphragm metering pumps.

Since installation, Vanmeter has had nothing but praise for the pumps.

The metering pumps have been installed since April/May of 2019 and have required no maintenance. This meant reduction in maintenance and the elimination of a large safety risk for his crew.

The energy savings has also been welcomed. The SCR system that controls the NOx emissions now runs on one metering pump.

"The reliability has been great," Vanmeter said. "The upfront costs and maintenance costs are less, they work, no pulsation dampeners are required, we are saving energy, and the safety benefits are all positives.

"We had to change our mindset, but it was an all-around gain." ■

Adrienne Kreighbaum is the senior marketing communications specialist for progressive cavity pump manufacturer SEEPEX Inc. She may be reached at akreighbaum@seepex.com. For more information, visit seepex.com.

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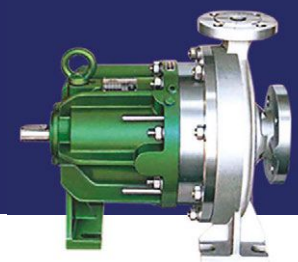

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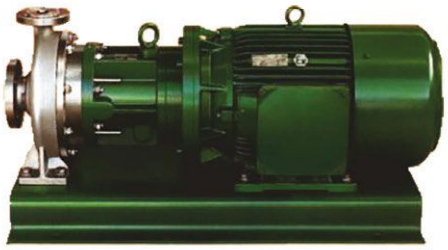

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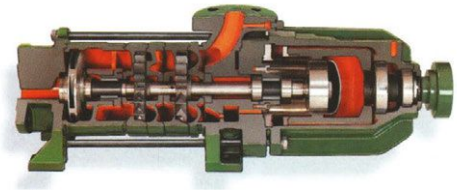

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Taking a Holistic Approach to Utility Compressor Seal Problems

Effective root cause analysis gets to the crux of the issue.

JOE DELRAHIM | John Crane

Many power generation plants rely on integrally geared centrifugal compressors designed to boost the flow of natural gas to turbines. The day-to-day reliability of these compressors is critical for these plants to deliver uninterrupted power to ratepayers and stakeholders.

Repeated compressor failures, on the other hand, can quickly drain millions of dollars from the bottom line in repair and maintenance costs—not to mention the potential power supply problem passed on to the public. Oftentimes, the trouble can be linked to faulty compressor dry gas seals (DGS) that are critical for containing compressor pressure as well as preventing leaks.

Correctly troubleshooting the seal problem calls for a holistic and comprehensive root cause analysis (RCA) of the problem to arrive at the most effective way to solve the issue. An RCA is a time-tested method of solving problems employed by many industries.

A proper DGS RCA goes well beyond seal performance, or lack of it. It also includes the mechanical and operational functions of the gas compressor and the related system to isolate the underlying cause of the seal failure.

A Holistic RCA Approach

While power production plants vary in design, technology and output, a standard RCA approach may be used in most cases. Again, an effective RCA takes into account the big picture, understanding that every change made affects the entire compressor. The analysis goes well beyond the seal to establish the underlying differences and unique reasons for a DGS failure.

An RCA encompasses the mechanical and operational functions of the gas compressor, including related systems design and settings. These include:

- damage analysis of failed dry gas seals, internal compressor parts and labyrinth seals
- sequencing of events encompassing speed, pressures, process temperature, flows, shaft radial/axial vibrations, shaft axial position, gas seal leakage, gas composition and system settings
- operating procedures
- compressor operating trends and history
- startup and shutdown procedures
- gas compositions
- system designs and transmitters settings
- DGS design and related inspection reports

A proper dry gas seals root cause analysis goes well beyond seal performance, or lack of it. It also includes the mechanical and operational functions of the gas compressor and the related system to isolate the underlying cause of the seal failure.

RCA Case in Point

An example of an effective RCA can be found at a power generation plant located on the East Coast that provides power to a major city where operational reliability of the plant is vital to its customers. This plant's system is typical of those found in other natural gas-fired, combined-cycle power plants.

For years, the DGS installed in the plant's gas booster compressors operated without interruption or needing repair. However, in 2017, plant engineers at this electric generation site found that the gas seals were failing multiple times on three multistage, high-speed bull gear compressors.

The >800 megawatt (MW), combined-cycle power plant continuously ran two 30,000 to 45,000 rpm compressor trains, each equipped with a low-pressure and high-pressure DGS. The generating station depended on the third compressor train, also equipped with two DGS, to provide backup gas in case one or both primary trains went down.

The frequent DGS failures threatened the potential for all three compressor trains to simultaneously be out of service. That was unacceptable to plant management.

The power plant's compressor included a thrust bearing and bidirectional DGS as part of the original design. The original DGS supplier suggested the problem was the quality of the incoming gas and did not consider other mechanical or operational causes. After repeated attempts to remedy the problem, the plant went another route.

At the request of the power company's management, an RCA was conducted, finding that some of the failures were catastrophic. The RCA concluded:

- There was no sign of heavy compressor surge.
- There was signs of liquid condensate and clear oil in spite of a well-designed DGS buffer gas conditioning unit.
- There was erratic seal leakage flow during operation.
- There were signs of face contact at both the primary and secondary face.
- The primary face contact was mostly at the entire face.
- The secondary contact was mostly at the face inside diameter.

Ultimately, the RCA determined that DGS problems were linked to improper settings on the DGS control system related to change in gas composition because of new process gas sourcing, reinforcing that every change made affects the entire compressor/plant operational reliability.

A Multifaceted Solution

The solution included replacing the backup compressors' low- and high-pressure original DGS with more robust noncontacting gas seals that could stand up to the demanding environment of the high-speed compressor.

The analysis showed that inadequate primary vent back pressure made the secondary sealing unstable and required resetting the control system's transmitters to maintain an optimal 15 pounds per square inch (psi) primary vent back pressure.

The team also increased the DGS buffer gas temperature to avoid process condensate forming at the seal faces in extreme weather conditions. Attention was given to seal balancing due to the high speed of the operation. Back pressure was introduced at the primary vent to improve secondary seal performance, provide dampening across the seal face, and provide a way to monitor seal performance according to the American Petroleum Institute (API) 692 standard. Finally, the flow of dry and clean buffer gas was also increased to the DGS to optimize the reliability of the DGS.

Since 2017, the compressors have performed without interruption or repair since the RCA and subsequent improvements. Additionally, most of the of DGS at the plant have been replaced with new DGS to ensure reliability and lower cost of ownership. ■

Joe Delrahim is a manager in John Crane's technical turbomachinery group and has published articles on gas seals and systems for organizations and publishing companies around the world. For more information, visit johncrane.com.

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Performance Insurance for Mission Critical Pumps in a Peaking Power Plant

Why having a user's pump disassembled, cleaned and inspected is a sensible approach.

JIM SORENSEN | CIRCOR

Whether a reliability engineer or a purchasing manager in a power plant, no one ever wants to learn that their pump in a mission critical application is beyond repair. Yet, this can happen when health checks of a pump are never scheduled, particularly if, due to a fortunate choice in equipment, the pump has operated reliably for several decades.

This occurred with a primary supplier of backup electrical power, which provides supplemental power to residential and commercial customers in its territory when the power grid becomes overloaded.

Process conditions changed several times over the years as federal emission standards required power suppliers to curtail pollution. But what had not changed was the reliability of the plant's two twin screw fuel pumps. Neither pump had failed during that time, despite their age of more than 40 years. However, fuel viscosities were reduced several times over the decades as process conditions were altered, and the pumps were not designed to operate in this situation.

The two twin screw pumps provided fuel to two separated turbines, which generated the power. Each ran separately, with only one needed at a time to provide 100 percent of the plant's output obligations, and the second was backup if needed. However, the reliable, consistent performance of the pumps had given the plant a false sense of security, and the plant had not stocked major or minor repair kits to respond to unexpected downtime if it ever occurred.

The twin screw pump manufacturer conducted a plantwide audit. Elements evaluated included aging equipment, mission critical applications and processes that had undergone dramatic system changes. With all three of these conditions present, a run-to-failure approach on pumps more than 40 years old carried significant risks. Lacking in-stock parts kits, repair options would be more limited and the power plant would have to wait longer for a new replacement pump.

Recognizing the precarious situation, plant personnel partnered with their supplier's authorized service center to conduct a two-week, comprehensive teardown, inspection and analysis on one of the two twin screw pumps that had been sold new in 1979. The analysis and findings, with recommendations, included:

Pump Case

All four bore locations had areas of galling from screw contact in the suction and discharge areas. The bore inside diameters measured up to 0.0085 inches over the designed high tolerance. This body was cast iron and could not be restored.

» *Recommendation: Replace*

Rotating Assembly

The screw flanks showed excessive wear, which was indicative of an improper timing of the screw shafts to the gears. Both sides of the flanks showed contact. Both long and short shafts had detached coating on the suction and discharge ends of the screw. This matched the heavy contact areas noted above in the casing bores. Outside diameters measured both higher and lower than design depending on the point of measurement. This was a result of wear and raised material on the surface of the screws from flank contact. The flank clearances measured as much as 0.012 inches, which was 0.005 inches over the high tolerance. This added clearance resulted in a loss in delivered flow during operation. The timing gears showed evidence of heavy fretting, and the inside diameter of the gear bores exceeded designed tolerance.

> A run-to-failure approach on pumps more than 40 years old carried significant risks.

» *Recommendation: Replace; the repair price was more than 60 percent of the price of a new pump*

Bearing Brackets

The front and rear bearing brackets required some minor cleaning to thoroughly flush the seal ports, but they could be used as is once cleaning and deburring occurred.

» *Recommendation: Reuse*

Timing Gear Housing & Front Head

Both of these items were deemed to be usable in their current state, following cleaning and deburring.

» *Recommendation: Reuse*

Bottom line: The pump auditors found that improper timing of the screws had caused excessive wear to the screw flanks, preventing economical repair of the unit.

The turbines operated on light fuel oil viscosity. Assuming a fuel oil viscosity of 44 Saybolt Seconds Universal (SSU), the smallest pitch for a 1,250-frame-size pump (0.875 inches) at the highest rotations per minute (rpm) (1,550), and a differential pressure of 1,000 pounds per square inch gauge (psig) (as listed on the nameplate), a new replacement rotating element and reused body would still operate with a volumetric efficiency of only 30 percent, resulting in excessive loss in volumetric efficiency and heat generation.

The audit made it possible for plant personnel to make an educated decision on next steps, which included:

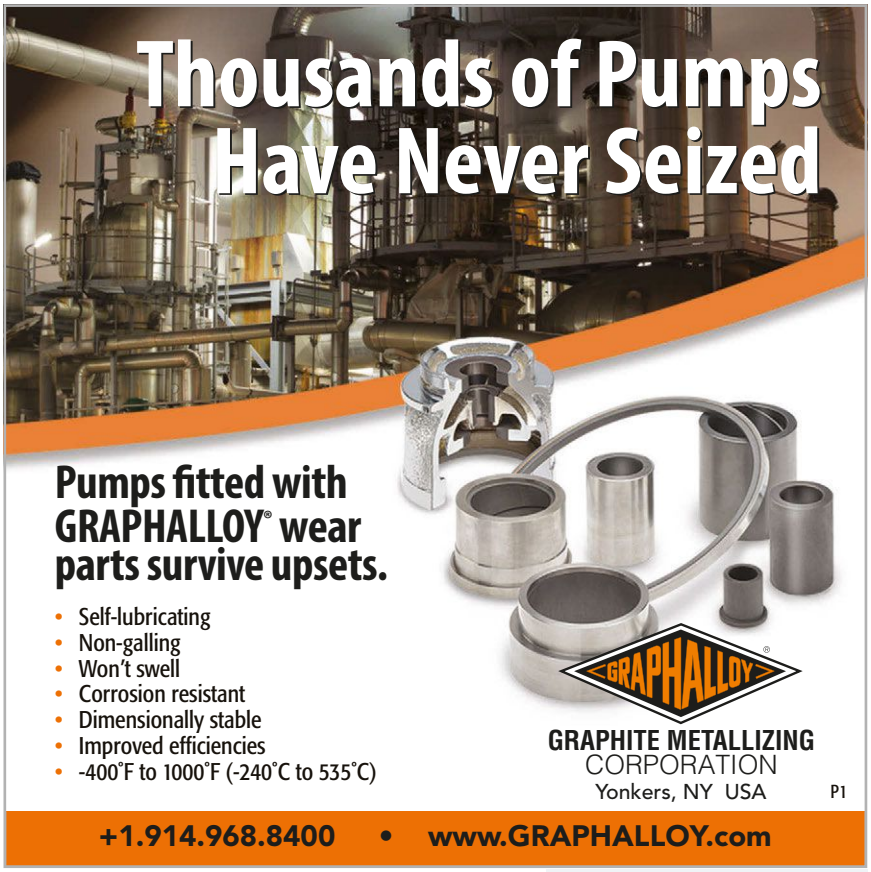
- options for replacement of normal wearing parts where simply reassembling and reinstalling the pump could make sense
- a detailed understanding of the state of all major internal elements, tolerances and wear
- options for executing any repair
- options to replace the pump

In the end, a minor or major repair was not viewed as an effective way to mitigate the power plant's risk due to the substantial performance losses that would still remain. Thus, the decision was made to temporarily use the reassembled pump as an emergency backup and order a new twin screw pump. The pump supplier's authorized service center reassembled the pump within a week for that purpose.

Upon successful installation of the new pump, the power plant took its second unit offline and executed the same process, with the same results and success, providing the plant with the peace of mind that comes with knowing a risk of operational failure had been eliminated for many years to come.

Lessons for Operators

It is common knowledge that mechanical seals, bearings and gaskets have a finite life and require periodic and ongoing replacement. A small amount of seal leakage (about 10 drops per hour per seal) is normal and necessary; anything in excess of this requires repair or replacement with a seal compatible with



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the pump's operating conditions. Bearings and gaskets should be cleaned, deburred, lubricated and checked regularly for noise and/or abnormal vibrations and rough operation to ensure that all connections are tight.

But it should also be common knowledge that a laissez-faire approach with the pump case and main workings is never recommended for mission critical operations.

Here is why having a user's pump disassembled, cleaned and inspected is a sensible approach compared to running into costly failure:

- **Timing gears:** In the rotating assembly, the timing gears of a screw pump are central to its flow performance. If design tolerances have been exceeded and fretting damage is excessive, the assembly usually must be replaced.
- **Pump-driver alignment:** The system can experience unusual levels of vibration or large variances in operating temperatures if out of alignment.
- **Pump body:** Galling damage from screw contact in the suction and discharge ports can cause bore sites to exceed design tolerances. Restoration may not be possible.

When wear is so excessive that a unit cannot be repaired economically, a complete pump replacement is the best remedy in a worst-case scenario. In better-case scenarios, stocking both minor and major kits can save the day—even when the plant has enjoyed decades of reliable operation with no downtime. In the end, however, no one knows the screw pump like the team that built it, and health checks conducted by certified technicians set the stage for restoring the factory clearances and design tolerances that equipment was built for—so that end users can focus on what they do best. ■

Jim Sorensen is CIRCOR Industrial Group Americas' Western USA distribution manager. He earned a mechanical engineering degree from Texas A&M University and is a Six Sigma Black Belt. Sorensen has more than 20 years of experience in the pump industry. For more information, visit circorpt.com.

Safety Playbook for Equipment Rentals

Ensure COVID-19 protocols include contactless drive-up service, and pre-rental and last-touch disinfecting.

ANTWAN HOUSTON |
United Rentals Fluid Solutions

There are nine key protocols that users should expect from equipment rental services during the COVID-19 pandemic. All reliable rental companies should have implemented new measures for the safety of their employees and customers, both inside and outside their branches, in response to the worldwide emergency.

Here are the nine protocols that users should expect for safe operations when considering rental equipment for their needs:

Contactless & Worksite Protocols

In-Branch Protocols

1 **Drive-up service and designated drop zones:** Contactless drive-up service allows customers to pick up or drop off equipment in designated areas without going inside the branch.

2 **Last-touch disinfecting:** Drivers from the rental company should disinfect commonly touched surfaces upon delivering equipment at a worksite. This should be the second time equipment is disinfected before it is put in the customer's hands (see pre-rental disinfecting).

3 **Driver precautions:** Rental company drivers must maintain safe social distancing at customer sites and wear a mask when safe distancing is not possible.

4 **Digital capabilities:** If users can browse equipment, schedule rentals and designate equipment off-rent from their computer or mobile app, this will provide a contactless transaction. These capabilities enhance safe access to a user's rental needs.

5 **Social distancing:** Rental personnel must maintain safe social distancing at branches and equipment yards, outlined by floor decals.

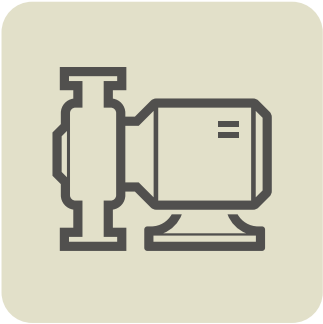
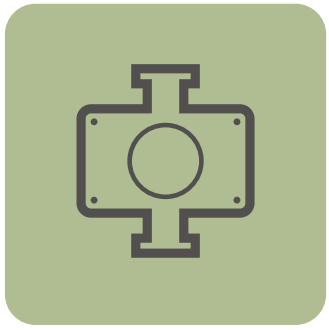
6 **Pre-rental disinfecting:** In addition to performing safety and mechanical checks, the rental company should disinfect equipment before each rental, paying particular attention to controls, latches, seat belts and other high-touch surfaces.

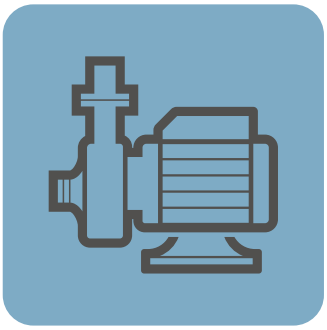
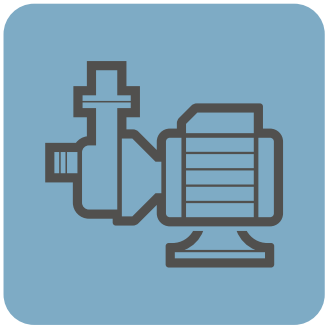
7 **Plexiglass counter barriers:** Branches should have plexiglass barriers installed at service counters to provide added protection during in-person transactions.

8 **Communications:** Safety messaging should be communicated regularly to all rental company sites. Protocols should be emphasized at daily safety huddles with branch teams. In addition, there should be periodic employee town halls, reinforcement of top-down safety messaging, and constant input from branch and district managers to ensure that local conditions are taken into account.

9 **Personal protection equipment (PPE):** Rental company employees should be required to wear face coverings where social distancing cannot be achieved, and additional PPE as needed. PPE should be provided to employees and, where available, to customers who need it to enter the branch.

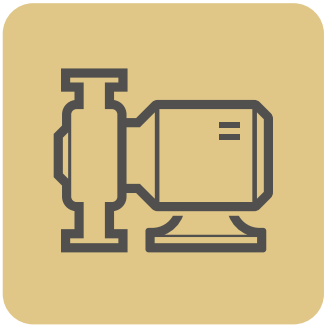
Antwan Houston is director of operations preparedness with United Rentals. For more information, visit unitedrentals.com.

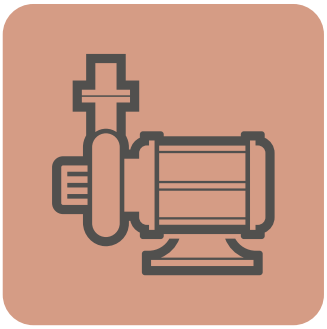



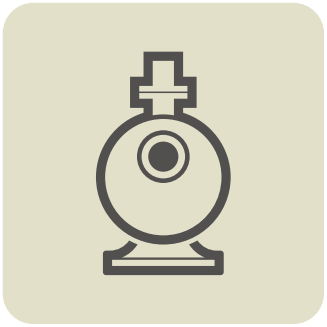
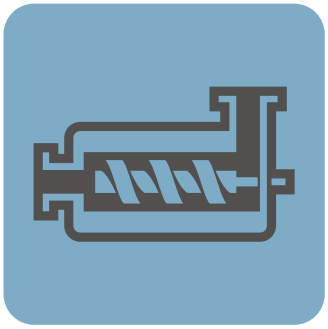
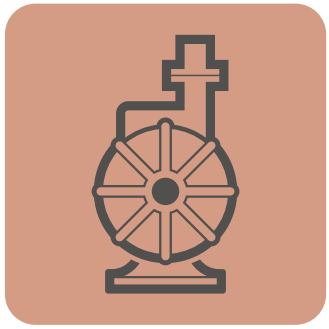
ANNUAL PRODUCT SHOWCASE

Innovative products, technologies and solutions from our partners



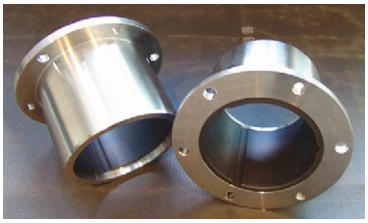


- BEARINGS
- CENTRIFUGAL PUMPS
- CONDITION MONITORING
- DIAPHRAGM PUMPS
- EQUIPMENT MONITORING
- HORIZONTAL PUMPS
- INSTRUMENTATION/ CONTROLS
- MAGNETIC COUPLINGS
- MOTORS & DRIVES
- PACKAGED PUMPING SYSTEMS
- PARTS
- SEALS
- SLUDGE/ SLURRY PUMPS
- VALVES

BEARINGS

Composite Bearings



Tenmax's high-performance thermoplastic composite bearings eliminate failure in rotating equipment like industrial pumps. All bearings are applicable in high-demand environments under high temperatures and with a large range of chemicals. Tenmax is a global supplier for bearings and seals in customer specific designs. One of Tenmax's specially developed materials TMCS25 fills the gap between all current thermoplastic and SiC/ceramic materials. TMCS25 outperforms in wear resistance and still has all benefits of a thermoplastic. In many applications TMCS25 can replace the SiC/ceramic bearings or wear parts. Besides TMCS25, Tenmax has many other thermoplastic composites to extend MTBR.

Tenmax B.V.
+31 26 37 23 060
info@tenmax.nl
tenmax.nl

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CENTRIFUGAL PUMPS

High Pressure Pump

The Thomas Pump T-GTO & T-GTO XD pumps produce high-pressure, pulsation-free flow. With an operating window of 600 to 1500 psi and flow rates from 30 to 400 gpm, there are many critical applications that utilize a pitot tube pump: high-pressure sanitation, boiler feed, paper mill shower, mill descaling and carbon black process. Thomas Pump designs new pump systems and can help determine application fit for its products. Thomas Pump also created the 24/7 Xchange program to eliminate critical process downtime, shipping replacement pumps within 24 hours. The T-GTO is proudly manufactured in the USA.

Thomas Pump
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tpump@thomaspump.com
thomaspump.com

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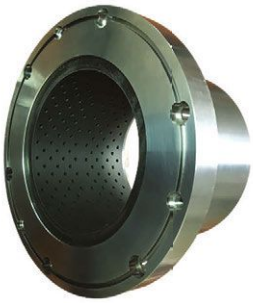
CENTRIFUGAL PUMPS

Seal Pattern



Boulden has developed the patented PERF-Seal design to augment the performance of components made from Vespel® CR-6100 and B-Series composites. The PERF-Seal is an engineered pattern of holes, drilled radially through a composite insert wear part. Due to the rotation of the pump and the differential pressure of the fluid across the part, the PERF-Seal creates a beneficial field of turbulence to improve component performance and reliability. Benefits include reduced leakage across the component by up to 25 percent compared to a smooth bore component and improved pump efficiency because of reduced leakage across components.

Boulden Company
800-523-0569
sales@bouldencompany.com
bouldencompany.com

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CONDITION MONITORING

IoT Hub

Eliminate downtime, waste, and safety issues with the SMARTdiagnostics IoT HUB, the latest asset health solution offered by KCF Technologies to handle complex asset monitoring needs, including triggered data collection, high temperature environments, and shielded areas with weak wireless signal strength. Seven input ports collect data from a wide variety of sensors including vibration, temperature, and pressure, each on its own schedule or timed relative to an external triggering signal. The IoT Hub also features flexible power options, making it configurable to meet unique location requirements, while providing the convenience of wireless data transfer to SMARTdiagnostics software.

KCF Technologies, Inc.
814-867-4097
sales@kcftech.com
kcftech.com

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CONDITION MONITORING

Sight Glass

A critical tool in early detection of contamination, the new Hex-Duty Oil Sight Glass by Esco Products, Inc., allows for constant monitoring of your oil condition. Applications include pumps, gearboxes or any piece of lubricating equipment that has a drain valve. The innovative, hexagonal bottom allows for easy installation and disassembly, and the single-piece bottle design is stronger and more durable, with double the pressure rating at 400 psi. The Hex-Duty Oil Sight Glass is a recommended, best practice addition to increase equipment life, view the presence of sediment and view and purge accumulated water contamination.

Esco Products, Inc.
877-525-0924
info@esco-inc.com
escopro.com

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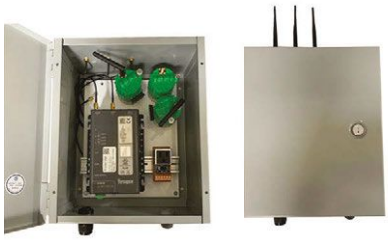
CONDITION MONITORING

Accessory Box



FORECYTE, an asset condition monitoring platform, is now available as an add-on for both horizontal and vertical Titan branded motors from U.S. MOTORS. This optional accessory box can include one gateway, one or more vibration sensors for motor bearings, and one or more temperature sensors to measure winding temperature. This solution was built to minimize unexpected downtime by monitoring and analyzing vibration and temperature data to determine overall equipment health and alert you of issues before failure. FORECYTE helps you plan maintenance, minimize failure, reduce operating costs, and extend service life.

Nidec Motor Corporation
315-595-8000
contactus@nidec-motor.com
nidec-motor.com

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DIAPHRAGM PUMPS

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processtech@graco.com
graco.com/eodd

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DIAPHRAGM PUMPS

High-Volume Diaphragm Pump

Pumps 2000 was established to offer pumps capable of handling abrasive, solid-laden and corrosive fluids in mining environments and to create an alternative to heavy, maintenance-intensive diaphragm pumps. Pumps 2000 introduced the world's first high-volume designs delivering maximum flow rates of 540 gpm. The advantages of Pumps 2000 are now being realized in all industries: longer maintenance-free operation, no end of life, fewer wear parts and lower air consumption.

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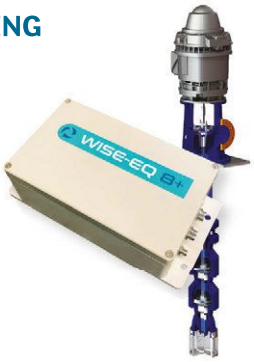
EQUIPMENT MONITORING

Remote Equipment Monitoring



Integrity Pump & Motor is leading the way with integrity equipment monitoring. Our remote equipment monitoring allows you to keep an eye on your equipment directly from your phone, tablet, or computer. We use the newest technology, edge computing hardware, coupled with our state-of-the-art cloud-based software. This provides the most effective and efficient package, alerting you of changes or problems with your equipment and allowing shutdown or startup of the system from anywhere. It provides active monitoring of pressure, amperage, temperature, vibration, humidity, water level, and near real-time text and email alerts, all at a low cost.

Integrity Pump & Motor
615-544-7072
rsmith@integritypumpandmotor.com
integritypumpandmotor.com

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HORIZONTAL PUMPS

Low End Suction Pump

Vertiflo Pump Company's Series 1600 horizontal close-coupled, vortex end-suction pumps have a wide range of applications including food processing solids, wastewater treatment, pollution control, slurries, and solids. The Series 1600 has capacities up to 1,600 gpm, heads to 170 feet TDH, and temperatures to 250 F. These pumps are designed with a variety of constructions such as cast iron, 316 stainless steel fitted, all 316 stainless steel, alloy 20 or CD4MCu. Additionally, the pumps are designed with a convenient back pull-out cost-saving feature to allow for easy inspection or service/maintenance without disturbing the piping to the pump.

Vertiflo Pump Company
513-530-0888
sales@vertiflo.com
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INSTRUMENTATION/CONTROLS

Phase Monitor Relays with Communication

New PC Series phase monitor relays protect your motors against circuit failure and communicate voltage faults via Modbus TCP. This industry-first technology from Macromatic makes data continuously available for assessment, providing real-time alerts and intelligent evaluation of voltage systems. Now you can remotely monitor voltage faults to improve decision-making within a network control system. PC Series relays monitor phase loss, phase reversal, phase unbalance, under voltage and over voltage in three-phase systems. A universal monitored voltage range of 190 to 600V AC covers most global applications. A 60 mm wide enclosure allows DIN-rail or screw mounting with extendable clips.

Macromatic Industrial Controls, Inc.
800-238-7474
sales@macromatic.com
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MAGNETIC COUPLINGS

Magnetic Couplings

DST magnetic couplings and canisters eliminate all shaft seal and leak issues for pump and agitator manufacturers. DST is a global supplier for magnetic couplings and canisters in standard or customer specific designs. The torque range is 1 Newton meters (Nm) to 15,000 Nm. IC Flow is the North American extension for DST. Call today with your inquiry.

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MOTORS & DRIVES

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LS's H100 VFD features lead-lag pumping without external control devices such as a SCADA system or PLC. This reduces pump wear, increases system efficiency and improves reliability. It is a simple setup with the H100's standard keypad. Lead-Lag macro simplifies programming. RS485 connection between each VFD allows parameters to be shared across the connected VFDs that streamline and reduce startup. New lead VFD automatically continues operation in case of failure or outage. Automatic pump alternation is based on sequencing (FILO/FIFO). System can use a single transducer (shared of the network) or have multiple for redundancy. Supports up to 8 H100 VFDs.

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MOTORS & DRIVES

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Tele Controls Inc.
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PACKAGED PUMPING SYSTEMS

Packaged Pumping System

All SyncroFlo IronHeart and packaged pumping systems are manufactured to the highest quality standards in our 155,000-square-foot Atlanta, Georgia, manufacturing facility. SyncroFlo has a superior quality management system that is ISO 9001:2015 certified. All systems bear the UL and ETL labels and are certified to UL 778 and UL 508A standards. All our domestic water systems are NSF/ANSI 61, 372 & Annex G certified for drinking water applications. Control panels are assembled in a UL 508A panel shop with a QR (quick reference) code identification for web-based access to the project documents. All systems are factory tested in a NIST traceable test stand.

SyncroFlo, Inc.
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jkahren@syncroflo.com
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PARTS

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Innovation by experience, Heinrichs has been a reliable partner in business for more than 80 years, delivery IATF 16949:2016 and ISO 14001:2015 certified. Heinrichs serves the drives and controls industries with smart solutions for sealing, venting and gauging at highly competitive prices, including metric, BSP and UNF threads. Heinrichs is a global partner for high-precision turned parts.

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SEALS

Wear Parts & Seals

Certified to ISO 9001:2015, Junty has been servicing the fluid and gas control industries for over 20 years. Specializing in wear-resistant materials, including but not limited to RBSIC, SSIC, tungsten carbide, carbon graphite, zirconia, and alumina, Junty provides seals and pump parts to more than 40 countries worldwide. To ensure consistent quality, each Junty product is precisely manufactured, inspected and documented prior to dispatch.

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SLUDGE/SLURRY PUMPS

Submersible Pumps

The GPM-Eliminator lineup of submersible slurry and dewatering pumps have been industry-proven solutions for decades in the most challenging applications. These pumps are available in sizes from 5 hp up to 800 hp, have the ability to pump clean water or slurries up to 70 percent solids and can pass 4.5-inch diameter particles with GPM's unique sump agitation technology. Pumps are available in standard submersible, horizontal end-suction and extended-shaft arrangements. Pumps are made tough, made in the USA.

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VALVES

Insertion Valve

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Hydra-Stop
708-389-5111
contact_us@hydra-stop.com
hydra-stop.com

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Elastomeric Coupling Solutions for Pump Applications

The right coupling type, when installed correctly, can improve pump and motor efficiency and reduce wear.

NATHAN MAXWELL | Motion Industries &
JOHN SMIHAL | TB Wood's

IMAGE 1: Sleeve couplings feature two metal hubs and a choice of EPDM rubber, neoprene, thermoplastic elastomer or urethane elastomeric elements. (Images courtesy of Motion Industries)

IMAGE 2: Rigid gear couplings are ideal for high torque applications.

While much emphasis is placed on the selection of motors and pumps, the importance of selecting the ideal coupling that connects these two expensive components is often underestimated.

Also, proper procedure for installation and alignment of the selected coupling is frequently overlooked. Faulty installation and/or uncontrolled misalignment can cause premature wear and potential failure of the coupling, as well as possible damage to the pump and/or motor.

A coupling's basic function is to transmit power, accommodate misalignment and compensate for axial movement (end movement of shafts). Sometimes, a coupling is expected to absorb shock or vibration. Choosing the right coupling depends on four basic conditions of shaft misalignment or movement:

1. Parallel misalignment occurs when the two shafts do not share the same rotation axis. Their end faces may be parallel, but their center axes are laterally displaced in respect to each other.
2. Angular misalignment applies when shafts are neither coaxial nor parallel. The angle at which the shafts are misaligned may be symmetrical or asymmetrical.
3. End float occurs when either or both shafts display axial movement, moving in and out. A sleeve-bearing motor, for example, "floats" as the rotor hunts for the magnetic center of the winding. Temperature variation can also cause thermal expansion and variation in position of the shafts.
4. Torsional flexibility is the torsional movement in planes perpendicular to the shaft axis. Shock or vibration typically causes this. A torsionally flexible coupling absorbs and dampens these movements.[1]

Most flexible couplings consist of two flanges or hubs that attach to the shafts being coupled, and a connecting element that could be metallic (such as in disc couplings), or a sleeve made out of elastomeric material such as ethylene propylene diene monomer (EPDM) rubber, neoprene, thermoplastic elastomer, urethane, or a mechanical connection such as a U-joint or gear coupling (Image 1).

To be considered flexible, a coupling must handle parallel and angular misalignment. Couplings with four-way flexibility accommodate both end float and torsional movement.[1] The following overview of the various coupling types available reveals the pros and cons of each.

Couplings for High Speed, High Torque Applications

While elastomeric couplings are commonly used for numerous general industrial pump applications running up to 115 horsepower (hp)/100 revolutions per minute (rpm), elastomeric material limits are surpassed in applications that need transmission of higher torques and speeds.

Gear couplings are excellent performers in higher torque applications. However, these stiffer couplings do not provide much torsional dampening, which results in more vibration getting transmitted from the motor to the pump (Image 2). Grid couplings are torsionally flexible and provide some torsional dampening (Image 3).

Disc couplings can rotate at high speeds, making them a good choice for pumps operating at a high rpm. However, these couplings only accommodate small amounts of axial misalignment. Flexing of a disc or metallic component beyond its yield point can cause fatigue, and extensive axial movement can cause failure (Image 4).

Elastomeric Coupling Choices

There are three basic types of elastomeric couplings: tire-type, sleeve-type and jaw-type. Tire-type and sleeve-type couplings

IMAGE 3: Grid couplings incorporate a steel grid spring that operates in compression.

IMAGE 4: Disc couplings use flexing metallic discs and are a preferred choice for high speed applications.

operate in shear (versus compression) to absorb shock and protect equipment. The elastomeric flexible member in these couplings can deform in shear, displacing under a load. The amount of torsional displacement or elastomer windup is a measure of the shock that can be absorbed. The element also compresses easily and can accommodate end float.

The torsional flexibility allows these two elastomeric shear couplings to dampen the amplitude of vibrations, isolating one shaft from the effects of the other.

The energy generated during shock loads is essentially absorbed by the elastomer in a twisting action.

One of the biggest benefits of tire-type and sleeve-type elastomeric shear couplings is that they are designed to fail under excessive shock loads and disconnect the pump from the motor to protect the pump in the event of a lockup or any other condition creating excessive shock.

The cost savings and ability to better analyze failures can be invaluable. Depending on brand and environment, elastomers used in sleeve-type couplings can degrade from excessive changes in

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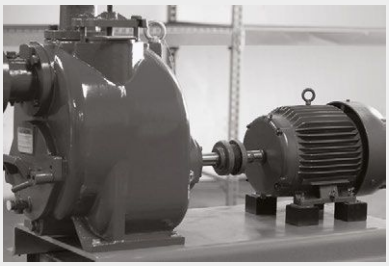
Proper Coupling Installation Helps Avoid Problems



The greatest issue with the tire-type couplings is misalignment. These couplings, while easy to install, must be checked for optimal pump performance. During installation, be sure to check the alignment. Excessive misalignment can cause bearing wear/failure. It is important with any repair or maintenance to replace bearings (greased per specification) in both the pump and motor to reduce downtime.

Problems can occur with coupling installations due to improper shimming/alignment/soft foot that can be detrimental to the pump, motor and coupling. End float, or the movement of the shaft on the motor or pump toward or away from the coupling, can cause the sleeve to cup.

Most importantly, no matter which coupling type is installed, always remember to check the alignment before putting the system into service.

temperature and chemical exposure.

Tire-type couplings are popular for use on continuous-duty American National Standards Institute (ANSI) pumps in varying applications that require minimal vibration. For example, these work well with applications that require variable flow rates. As flow rate changes, the chances of vibration increase throughout the pump and is harder on bearings. The tire-type coupling acts as a dampener and handles vibration more consistently. The big advantage to tire-type couplings is that they can be easily replaced without having to move the pump and motor (Image 5).

IMAGE 5 (left): Tire couplings allow for easy replacement without moving the pump or motor. IMAGE 6 (right): Sleeve-type in shear couplings are a good choice for many general purpose pump applications.

IMAGE 7: Jaw couplings use a variety of elastomeric spider elements in compression.

Sleeve-type couplings are a good choice for use with many general-purpose pumps, including centrifugal pumps used with variable frequency drives. These torsionally soft couplings are ideal for moderate misalignment applications. Typical sleeve coupling applications include pit pumps, vertical end suction centrifugal pumps, vertical turbine pumps and some horizontal split case pumps (Image 6).

Economical elastomer sleeve couplings typically have a misalignment capability of 1/4 to 1 degree, while moderately priced elastomer tire couplings typically have a misalignment capability of 2 to 4 degrees.

Jaw-type couplings use elastomeric material in compression and do not have the same amount of misalignment capacity or axial and torsional dampening capabilities as in shear couplings. In compression, the rubber element is squeezed to transmit torque, rather than twisted. These couplings are generally used on lower power applications where cost is a primary selection criteria. Jaw-type couplings can be found on a wide range of pumping applications including viscous material gear, screw, progressive cavity and lobe positive displacement pumps (Image 7).

A big advantage to jaw couplings is their fail-safe design. Equipment will continue to drive if the elastomer fails.

With coupling selection, pump users need to beware of the "more is better" trap. Oversizing a coupling can result in reduced flexibility or misalignment compensation, and a coupling that is too large can put added stresses on the pump and motor being coupled.

Conversely, a coupling with too much misalignment capability may be too soft or yielding, which can cause vibration or an unbalanced condition in rotation.

After a pump/motor has been installed, it is always a good rule of thumb to recheck the alignment in about six months. The pump/motor base may settle and could throw the pump out of alignment. It is important when choosing the right elastomeric coupling to first check the surrounding environment where the pump/motor will be operating. Question if it will be exposed to extreme variations in temperature.

Also, understand what type of torque (service factor) is required to pump the material from point A to point B. Lastly, it is important to consider if the pump will be under any pipe strain that could cause it to fall out of alignment over time. ■

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John Smihal has been product manager–elastomeric couplings at TB Wood's for more than 16 years, and holds a Bachelor of Science in mechanical engineering technology from the University of Pittsburgh. For more information, visit motionIndustries.com/pumpsandsystems or see the MiHow2 video "How to Select the Proper Elastomeric Coupling for Various Applications" (tinyurl.com/y8yefgof).

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Decline of Cast Iron Pump Efficiency as a Result of Pandemic Lockdown

Stagnant water may lead to severe corrosion of cast iron impellers and casings.

ANNA SHEINA | Mechanical Engineer

IMAGE 1: Corrosion damage on the surface of a cast iron impeller after seven years of maintenance. The left and middle images show the external surface; the right image shows the internal surface. (Images courtesy of the author)

The majority of water supply systems could have been stopped without preserving them due to the coronavirus lockdown in early 2020, as was discussed in the article "COVID-19's Effect on Large Buildings" published in Pumps & Systems magazine in June 2020. It is common knowledge that cast iron pumps are widely used in water supply systems. The process of conveying hot and cold water leads to severe corrosion of cast iron impellers and casings. But how may strong cast iron pumps be affected by leaving them in stagnant water for a couple of months due to the lockdown?

In this article, a cast iron impeller is taken as an example to find the answer to this question: How does stagnant water corrosion affect pump efficiency? The cast iron impeller had been conveying hot water at 70 C (158 F) during seven years of maintenance (Image 1). The maintenance schedule was not specified, but the pump had been stopped for half a year without preserving it.

The internal surface of the cast iron impeller shows that the channels between the vanes are severely damaged by corrosion (Image 1, far right). The corrosion fouling could occupy small parts between the vanes. In this case, the head may be slightly decreased. Unfortunately, the corrosion fouling could occupy the whole space between the vanes, which means that one of the channels would be not included in the processes of water conveying. This would result in the considerable decrease of head and flow. The way flow and head may decrease due to the corrosion damage can be shown in a pump performance curve (Image 2).

Pump Operating Point I represents the state when an installed pump is new and there is no corrosion damage in the pipelines. If pipelines are worn and corrosion fouling occupies a significant part of the pipelines, then less flow may be conveyed through the pipelines. If flow losses increase due to the pipeline's wear, the pump operating point will move to Operating Point II.

If a cast iron impeller is damaged by corrosion, it may lead to a considerable decrease of flow and head. A theoretical image of an impeller with velocity triangles will help users understand how different velocities are connected with each other and how corrosion damage causes pump efficiency to decrease (Image 3).

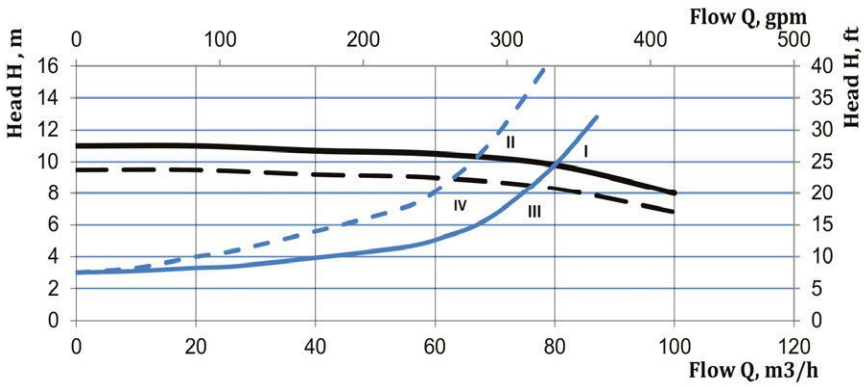

IMAGE 2: A pump performance curve

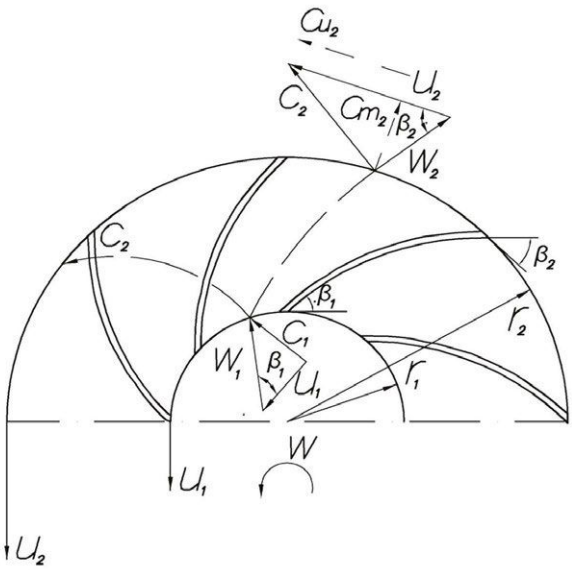

IMAGE 3: Impeller with velocity triangles at inlet and outlet

$$H_i = u_2 \times c_{u2} / g$$

Equation 1

The u_1 and u_2 are peripheral velocities of impeller blades at inlet and outlet. Flow enters the impeller at a c_1 velocity and at a radius r_1 and leaves it at a c_2 velocity and at a radius r_2. The c_1 and c_2 are absolute velocities. The blade design forces the relative velocity, i.e., the velocity that is experienced by an observer traveling with the blade movement, to alter its magnitude and direction from w_1 to w_2. The absolute velocity consists of tangential c_u and radial c_m velocities.

The theoretical head may be calculated using Equation 1 if flow enters the impeller when $c_{u1}=0$[1].

The head depends on peripheral velocity u_1 and tangential c_{u2}. If c_{m2} increases and the β_2 angle remains the same, the velocity vector c_{m2} will move to the left from its initial position (Image 3). It is possible that if a pump works under operating conditions that are different from initial startup, that this will lead to a decrease of c_{u2} and head.

$$c_m = Q / 2 \times \pi \times r \times b$$

Where:
Q = flow (gpm, m^3/s)
r = impeller radius (meters)
b = weight between impeller vanes

Equation 2

The theoretical c_m velocity may be calculated using Equation 2.[1]

As the weight b between vanes decreases, the c_{m2} velocity increases (see Equation 2) and this leads to head decreasing (see Equation 1).

If corrosion fouling occupies a significant part between the impeller vanes, it leads to a decrease of head and flow (Image 2, Operating Point III). If there is corrosion damage inside the pipelines and a cast iron pump, the operating point will move to Point IV. If the whole weight between vanes is occupied with corrosion fouling, it means that the whole channel will not be included into the process of operating conveying liquid.

Actually, so many centrifugal pumps are oversized and even significant decrease of head and flow cannot affect the system in which they are installed. Nevertheless, there are many applications where even a slight decrease of pump efficiency may result in considerable financial loss. Cast iron pumps are widely used in different cleaning services, such as railcar or oil depot cleaning services. If it takes longer to clean one railcar, it means that the cleaning of all other railcars will be slowed down correspondingly. All cleaning processes at petroleum terminals are scheduled, and if it becomes necessary to clean an oil depot for longer, it means that a petroleum terminal will stay without one depot.

Many railcar or oil depot cleaning schedules have been rearranged due to the COVID-19 pandemic lockdown, and cast iron pumps used for cleaning services could have been left in the pipelines filled with water. The pump used as the example in this article had been stopped for half a year. This may prove why some of the impeller channels show considerable corrosion fouling between the vanes.

It is hardly possible to predict when malls, hotels, business centers and stadiums will be fully open again, but measures to prevent corrosion and microbial growth in water supply systems should be taken before shutting down piping systems becomes necessary. Otherwise, such problems as microbial growth and corrosion may surface, which leads to the decrease of pump efficiency. ■

IMAGE 4: Impeller vanes

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How Your Pumps & Fluid Handling Assets Get Hacked

Understand why it can happen and what you can do to mitigate cyberthreats.

DUSTIN HEATH | Vigilant Cyber Systems

The past decade has seen a dramatic increase in cyberattacks focused beyond traditional desktops and servers. The security industry refers to this sector as operational technology (OT), internet of things (IoT), or industrial internet of things (IIoT), and it includes systems such as heating, ventilation and air conditioning (HVAC), embedded devices, and systems typically controlled by programmable logic controllers (PLCs) including pumps, turbines, pressure regulating valves, and tanks. These devices are typically outside the traditional scope of a normal information technology (IT) department.

In 2010, the world was alerted to the threat of malware over industrial systems as Stuxnet attacked Iranian nuclear enrichment facilities. The past 10 years have shown an increase in cyberattack tools developed specifically for industrial control systems (ICS), not just from single actors, but from nation-state offensive cyber groups from countries like the U.S., Israel, China, Russia, Iran and North Korea. These groups are classified by security specialists as advanced persistent threat (APT) groups. After Stuxnet, the security industry found Havex, a piece of ICS malware attributed to a Russian APT group in 2014 used to scan industrial networks.

Since 2014, ICS malware has been seen at an increasing rate around the world, with notable attacks in Ukraine on Dec. 23, 2015 when malware named BlackEnergy successfully compromised supervisory control and data acquisition (SCADA) systems remotely switching substations off, disabling IT infrastructure, and disabling the call center for customer support during the outage.

Ukraine suffered another power grid attack on Dec. 17, 2016 when malware named Industroyer was used to cut off power to the capital city of Kiev for an hour.

In November 2017, the TRISIS malware was discovered in a Saudi Arabian petrochemical plant. This disabled the safety instrumentation systems and security controls.

IMAGE 1: Steam and chilled water production facilities, Texas Medical Center, Houston (Images courtesy of Vigilant Cyber Systems)

The National Vulnerability Database (NVD), which is a repository of security-related information maintained by the National Institute of Standards and Technology (NIST), has a separate category for ICS attacks. These types of attacks have exploded in the last year. Between the first quarter of 2019 and Q1 2020, the water and wastewater industry has seen an increase of 122 percent of common vulnerabilities and exposures (CVEs). Critical manufacturing is up 87.3 percent in CVEs, and energy is up 58.92 percent.[3] While cyberattacks on OT systems are still flying below the radar of more common IT hacks, the momentum in this space is quickly building.

It is a perfect storm, as many OT system owners want to take advantage of new technologies for automation and monitoring that require internet connectivity, without recognizing the cyber risk that comes with that connection.

Why It Can Happen to Users & Their Assets

An adversarial group decides to target a user's facilities. The attacker and their reasons could be anything from a disgruntled employee, an international criminal organization, or a nation-state sponsored APT. Financial gain motivates criminal organizations who are using ransomware to hold systems hostage and extract a ransom to return it to operation. Recent years have witnessed several high-profile examples of ransomware on OT systems, including the EKANS ransomware that specifically targets ICS. This was recently used against Honda and the global clean energy provider Enel, resulting in disruption to production.[4] Critical

IMAGE 2: Steam and chilled water production facilities, Texas Medical Center

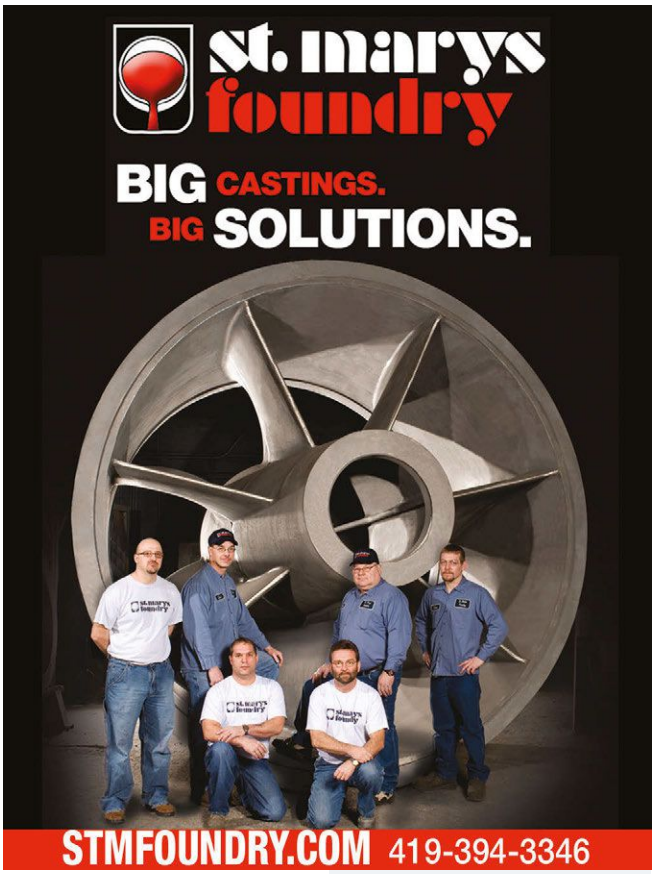
IMAGE 3: Interstate natural gas pipeline pressure regulation station

infrastructure systems such as public utilities are targets for a nation or state looking to disrupt the stability of an adversary.

Regardless of the specific threat, any adversary will look for an opportunity to exploit user systems. Most commonly, this means stealing credentials or cracking a weak password (78 percent according to a Verizon 2020 Security Report).[5] However, in the case of IoT and OT, there are many vulnerable endpoints available that can be found easily using public tools such as Shodan and Censys.io. These search engines crawl the entire internet approximately once per month and update their databases with information about exposed devices.

A current search of Shodan (the search engine for internet connected devices) for a specific industrial protocol shows that there are approximately 5,000 industrial control devices exposed to anyone with an internet connection.

Once the adversary has accessed the system through stolen credentials or by simply connecting into it through an unsecured device that someone left on the internet, they will look to pivot through an engineering workstation, historian or similar system that is on both the IT network, and also on an OT network. Once on an OT network, an experienced adversary will be able to manipulate vulnerable devices, such as PLCs, to accomplish their goals. Stuxnet demonstrated how malware can cause catastrophic physical damage to equipment without triggering any alarms. The TRISIS malware in Saudi Arabia showed how an adversary can disable safety controls and endanger personnel. Adversaries can use these tactics to hold users ransom, damage their systems, or potentially harm employees working on the systems.



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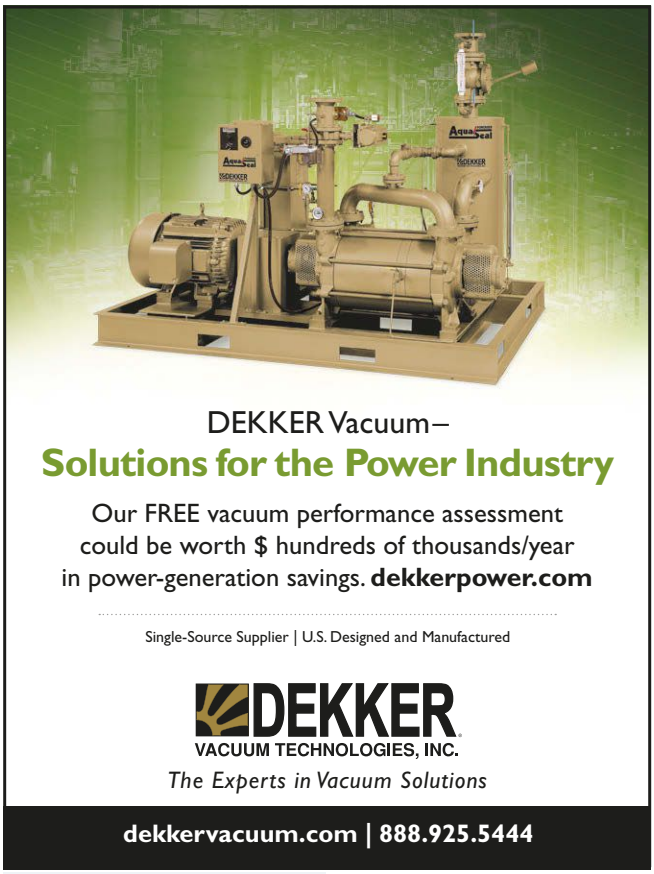

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IMAGE 4: Natural gas distribution delivery station, Texas Medical Center

Available Resources

Cyberthreats are impacting OT at an alarming rate and the security industry is responding. Comprehensive best practices are being established and communicated for specific industries, and cybersecurity companies are developing OT security tools and services to combat the rising threats.

A comprehensive risk management process has four components: framing, assessing, responding and monitoring. These activities should be interdependent processes that occur simultaneously and continuously. Framing is the process of building a model or framework which can be used to assess risk and make risk management decisions. Assessing is the process of identifying the threats to, vulnerabilities in, and consequences of an attack for the entity under risk management.

Responding is the process of accepting, avoiding, mitigating, and transferring risk. Risk monitoring is the process of implementing and assessing controls and compliance, as well as identifying changes.

The practical steps that an ICS security team can take when developing a risk management framework are summarized in the following steps. For framing, the security team should consult with a broad spectrum of the leadership to identify the assumptions and risk tolerance of the enterprise. For companies that do not have in-house OT security expertise, we recommend conducting a walk-through with experts. Once the initial framework for risk assessment is complete, the best practice for implementing an ICS Security Risk Management Framework is to perform the following four distinct steps. First, define the OT systems and conduct an inventory of the OT assets. This inventory should include basic information for each asset including manufacturer, operating system and applications installed, and the latest patch date.

All interfaces to other systems should also be defined. Second, a security plan should be developed. This plan should document the security controls that are selected. NIST SP 800-18 Rev 1, Guide for Developing Security Plans for Federal Information Systems is a good reference for developing a security plan. The third step is to perform a risk assessment. This detail of the risk assessment should be commensurate with the risk framework.

IMAGE 5: Pressure regulating valve, steam and chilled water production facilities

Most risk averse organizations will conduct multiple risk assessments for the entire enterprise. Others may perform a detailed risk assessment for the highest impact systems and less detailed assessments for other systems.

Risk assessments are often conducted multiple times during a system's life cycle, and organizations with multiple locations may alternate assessments among sites. The final step in establishing a risk management framework is to implement the security controls based upon the security plan and the analysis of the risk assessment. Review the references noted at the end of the article to understand which policies will need to be implemented. There is also one example of a robust patch management policy.

The world of cybersecurity is a cat and mouse game between security firms and attackers, with the attackers constantly evolving and creating new tools to find loopholes in existing security systems, and the cybersecurity companies plugging those holes through patches.

If a system cannot receive regular patches, it is extremely vulnerable, as it lacks the ability to adapt to the evolving threat landscape. Robust cybersecurity is not static.

After implementing an ICS cyber risk framework, many organizations conduct cooperative vulnerability assessments and red team assessments. This testing is like the final exam for the entire process outlined above, validating and ensuring that the risk framework processes are working correctly and have not missed anything. Usually this testing is performed by an outside firm so it can independently validate the security posture without creator or maintainer bias. ■

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Dustin Heath is co-founder and COO of Vigilant Cyber Systems, with services related to the identification of cyberthreats to OT/ICS infrastructure and communications technologies. For more information, visit vigilantsys.com.

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Pump Vibration Driven by Engines, Plus Pump Assessment Tasks

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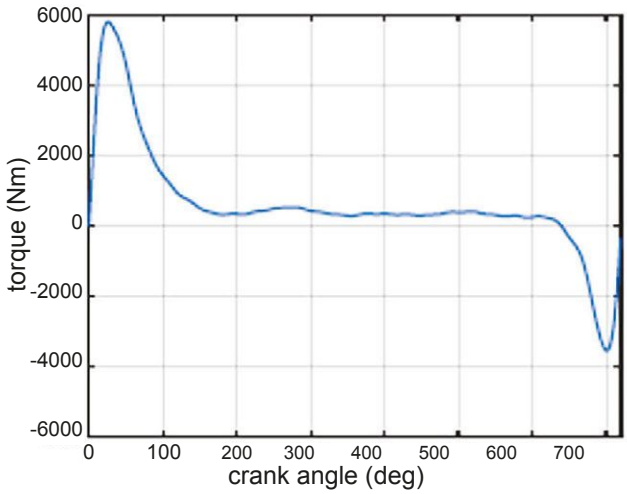

IMAGE 2: Typical single cylinder torque pulse

How will pump vibration differ when driven by an engine compared to an electric motor?

Engines do not have the same characteristics as that of a motor drive. An electric motor produces a smooth torque to drive the load and does so without any reciprocating parts or significantly unbalanced rotating components. Typically, the motor rotor is balanced to a tight tolerance to minimize vibration caused by unbalance forces occurring at the rotating frequency. There may be some slight torque ripple at line frequency (i.e., 50 hertz [Hz] or 60 Hz) or higher harmonics of line frequency, but these are typically in a range of 1 to 2 percent of mean torque, if they exist at all.

An engine generates torque in a fundamentally different manner than an electric motor. Fuel is burned in a cylinder, and the expanding gas generates torque on a crankshaft through a slider crank mechanism containing a piston and connecting rod, as seen in Image 1. This firing process inherently generates greater vibration levels as compared to electric motor drives because engine generated torque is not smooth.

IMAGE 1: Slider crank assembly (Images courtesy of the Hydraulic Institute)

The torque profile depicted in Image 2 is how a single cylinder of an engine produces power and is normal. The resulting load on the pump will include both lateral forces at the bearings as well as torque transmitted through the engine coupling. This load versus time is not a smooth sine wave, which can lead to generation of strong harmonics of the firing frequency. Furthermore, the cylinder to cylinder combustion process is typically not uniform and in a four-cycle engine, there are noticeable, and possibly dominating, harmonics at half-engine running speed, which can be transmitted to the pump.

Generally, the pump is designed for these forces and the measurable vibration at the pump bearings are at normal levels, but the number of harmonics and variable speed increase the chance of resonance occurring. In the case of resonance, a normal forced vibration can be amplified and result in excessive pump vibration.

What is the acceptable pump vibration when driven by an engine? This is a common question. The American National Standards, ANSI/HI 9.6.4-2016 Rotodynamic Pumps for Vibration Measurement and Allowable Values standard excludes pumps driven by stationary reciprocating engines. The purpose of HI's Paper Vibration Characteristics of Stationary Engine Driven Rotodynamic Pump Systems describes stationary engine vibration characteristics and informs readers that the HI is working on a data collection project that has an end goal of expanding the scope of ANSI/HI 9.6.4 to include guidance for acceptable vibration limits of rotodynamic pumps driven by stationary reciprocating engines.

For more information on engine driven pump vibration, refer to the free paper "Vibration Characteristics of Stationary Engine Driven Rotodynamic Pump Systems" at pumps.org.

What should be considered in a pump system assessment and report?

Pump systems that are not optimized have an enormous impact on operating cost, the environment, sustainability and corporate profits. Negative impacts include higher energy and maintenance costs, shortened mean time between repairs (MTBR), higher safety risks and increased carbon dioxide (CO_2) emissions. To reduce these negative impacts, it is advisable to screen pumping systems and conduct assessments on systems that have a high probability of savings. In fact, energy savings of 20 to 60 percent are routinely possible in centrifugal pump systems based on recommendations made through a pump systems assessment without considering the non-energy impacts such as reduced maintenance and increased safety, which often outweigh the energy benefits.

While pump systems assessments may vary depending on the market and application, understanding how the pump, system and process controls interact is a key outcome. This allows an understanding of how components interact, and how making mechanical or control changes may improve system performance.

The Hydraulic Institute's Pump System Assessment Professional (PSAP) certification outlines 13 tasks that are completed to conduct a pump system assessment.

1. Determine if system is amenable to a pump system assessment
2. Obtain and analyze initial information about the pump system (i.e., prescreening).
3. Define pump system assessment team, roles and responsibilities, project scope and boundary conditions.
4. Conduct a visual assessment of the pump system, obtain additional information and finalize the project scope.
5. Interview stakeholders to answer questions, verify information and provide additional information.
6. Obtain real-time pump system operation data.
7. Cross-validate the pump system data collected to ensure accuracy.
8. Analyze data based on the project scope and the boundary conditions.
9. Interpret the analysis, establish initial findings and options for optimization.
10. Formulate specific recommendations for optimization.
11. Prepare pump system assessment report with sufficient data and prioritized recommendations with costs and benefits.
12. Present the report to stakeholders and assist in the transition from assessment to implementation.
13. Perform post-implementation measurement and verification and generate a report.

These 13 tasks can be summarized as collecting and analyzing design and operating data on applicable systems, and generating an assessment report that includes cost effective recommendations to optimize the system.

It is advised that a certified PSAP perform the pump system assessment. This is a qualification certified by HI that ensures certified individuals have validated pumping system knowledge and demonstrate expertise in the field.

To learn more about the PSAP certification course or to register, visit pumps.org. ■

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Suction Piping, NPSH & Cavitation

Practical notes and useful guidelines for dealing with these aspects of centrifugal pumps.

AMIN ALMASI | Principal Machinery/Mechanical Consultant

Most pumps used in different industries have been centrifugal pumps. This is because of their flexibility, reliability, favored head-flow curves and reasonable prices. This article discusses key aspects of centrifugal pumps such as suction piping, net positive suction head (NPSH) and cavitation.

Suction piping systems of pumps have always been challenging due to the sensitivity of the pump to the flow pressure drop on the suction and the relatively larger size of the piping used in the suction. On one hand, the suction piping should be straight, simple and short, which is unique to suction piping, to mitigate issues associated with NPSH, and a mandatory minimum pressure should be maintained at the pump entrance to ensure the proper operation of the pump. On the other hand, the piping is relatively larger in diameter, so nozzle load limits are more challenging.

NPSH

NPSH is particularly important to dynamic pumps such as centrifugal pumps. These pumps are vulnerable to cavitation. If cavitation occurs, the drag and friction in impeller vanes increase drastically, seriously restricting the flow and interrupting the operation. Cavitation has many adverse effects on impellers and generally on pumps. Prolonged exposure to cavitation can damage the impellers. NPSH refers to two quantities:

- NPSH available (NPSHa): a measure of how close the liquid at a given point is to boiling, and so to cavitation. NPSHa is usually calculated at the suction flange of the pump.
- NPSH required (NPSHr): the head value at a specific point (usually the inlet of a pump) required to keep the liquid from cavitation in a pump.

An appropriate NPSH margin (NPSHa minus NPSHr) should always be provided for the entire operating range. In other words, the NPSH margin is the NPSH that is available more than the pump's NPSHr.

Cavitation & NPSH

When a liquid enters the eye of a pump impeller, it accelerates as it is drawn into the impeller. This acceleration creates a pressure drop in the liquid at the impeller eye. If the liquid is close to its boiling point (bubble point), the pressure drop may be great enough to cause some of the liquid to boil. The bubbles that are formed by the boiling liquid enter the pump impeller along with the liquid. As the liquid (and bubbles) flow toward the tip of the impeller, the pressure rises and the bubbles collapse or implode. When these bubbles collapse, a large amount of energy is transferred from the fluid to the impeller at a very small point on the impeller. This energy is sometimes great enough to damage the impeller and is frequently enough to cause vibration and noisy pump operation. This process is called cavitation, and it must be avoided in the operation of any pump.

The damage caused by cavitation depends on several factors such as pump speed, impeller material, amount of cavitation, type of liquid, etc. The type of liquid is particularly important. For example, cavitation in water pumps is usually more serious than in hydrocarbon pumps. This is because water has a much higher latent heat of vaporization than hydrocarbons (say, three to eight times higher). As a result, when the bubbles collapse, far more energy is released causing more damage to the impeller.

Cavitation can be prevented by making sure that the pressure at the suction of the pump is sufficiently above the bubble-point of the liquid to prevent the liquid from boiling as it enters the impeller eye. Pump manufacturers publish NPSHr values for their pumps. It should be ensured that NPSHa is greater than NPSHr at all times.

NPSH Margin

It is necessary to have an operating NPSH margin that is sufficient at all possible flows—from the minimum continuous stable flow to the maximum expected operating flow—to protect the pump from damages caused by cavitation. A key concern is to provide a suitable margin for the maximum expected flow at the right side of the curve where NPSHr is higher compared to its value at the rated flow.

It is difficult to give general advice for required NPSH margin. As a very rough example, an NPSH margin of 2 meters (m) or 2.5 m might be used for ordinary pumps. As another rough guideline, the formula NPSHA = 1.2 × NPSHr + 2 m can be used for NPSH margins and the relation between NPSHa and NPSHr. NPSH margins of 2 m, 2.5 m or 3 m have widely been accepted for small/medium pumps or low-/medium-energy pumps. For high-energy pumps, higher factors and margins should be used. For example, for some high-pressure and high-energy pumps NPSHa = 1.5 × NPSHr + 3 m might be used.

Difficulties & Challenges

NPSH calculations should be done with great care. During the early stages of the development of a plant or facility, the layout is not yet firm. Hence, NPSHa for the pump(s) cannot yet be calculated with confidence. However, preliminary NPSH can be estimated using information from a preliminary layout and elevations. NPSH margins can be changed by later modifications to the layout and particularly the elevations. NPSH plays an important

role during the pump selection and could significantly impact the overall cost of the pump if a lower NPSHr pump is specified, since pumps with a lower NPSHr tend to be more expensive. At this stage, the goal usually is to calculate a preliminary NPSH value and provide it to pump manufacturers to get feedback, proposals and values of NPSHr. This allows all involved parties to determine whether a pump with the specified NPSHr can be selected or not. It can be achieved with some modifications to the pumping system layout (higher NPSHa), or it might be achieved by selecting a pump with lower NPSHr. Based on the manufacturer's feedback, the layout can be modified to have a suitable NPSH margin.

A Booster Pump: Last Solution

For high-speed pumps, such as boiler feed water pumps or high-pressure pumps, NPSHr can be high. High values for NPSHr, as high as 30 m or more, are not unusual for some applications. In these cases, there might not be a way to provide enough NPSH margin and a booster pump might be used to provide NPSHr. All other options should be considered before this expensive solution is employed. This might be the case in revamp, renovation or upgrading developments where elevations are fixed and cannot be increased. Booster pumps are typically low-speed centrifugal pumps with a low NPSHr. They are typically installed to provide 40 to 80 m of head to the liquid.

Considerations for Suction Piping

For pumps, the suction piping is almost always more critical and challenging than the discharge piping, even though the discharge piping operates at much higher pressure and temperature differences than the suction. The diameter of suction piping is more than the diameter of discharge piping. Also, the suction piping is relatively shorter and stiffer than the discharge piping. A discharge piping of a pump can be provided with different loops and flexibility provisions. However, this is not the case for the suction piping.

Often, a simple layout of preliminary suction piping is not adequate to reduce the piping load at the pump suction nozzle and bring them below allowable limits. In many cases, some flexibilities should be included in the suction piping, keeping an eye on pressure loss and NPSH margin. Flexibilities should be accounted for and the required piping length and added bends, loops, etc., should be minimized to keep pressure drop under control.

A Stop at Suction Piping

In some cases, the piping-imposed load on the pump can be reduced by placing stops at strategic locations. The exact location of the stop is determined by the configurations of the piping and nozzle load/piping stress analysis. There have been cases where a stop for the vertical direction was included to limit the reaction load on the vertical direction. This is effective as many pumps have suction piping with a relatively long vertical run.

A Loop in Suction Piping

In some cases, a loop might be needed in the suction piping to deal with extreme temperature differences. Such a loop on suction piping is only acceptable as the last resort. The location of the loop is very important. One may think to place a loop at a higher elevation due to better space and support structure availability. However, when handling near saturated liquid, the high elevation loop can be the cause of many operational problems.

The loop, as the last resort, should be placed at the low elevation section (bottom portion) of the suction piping. Although this portion of piping is generally more congested, the loop should still be placed at the bottom portion in combination with the original bends. Such a combination reduces the number of elbows required. This reduces the pressure loss of the loop. ■

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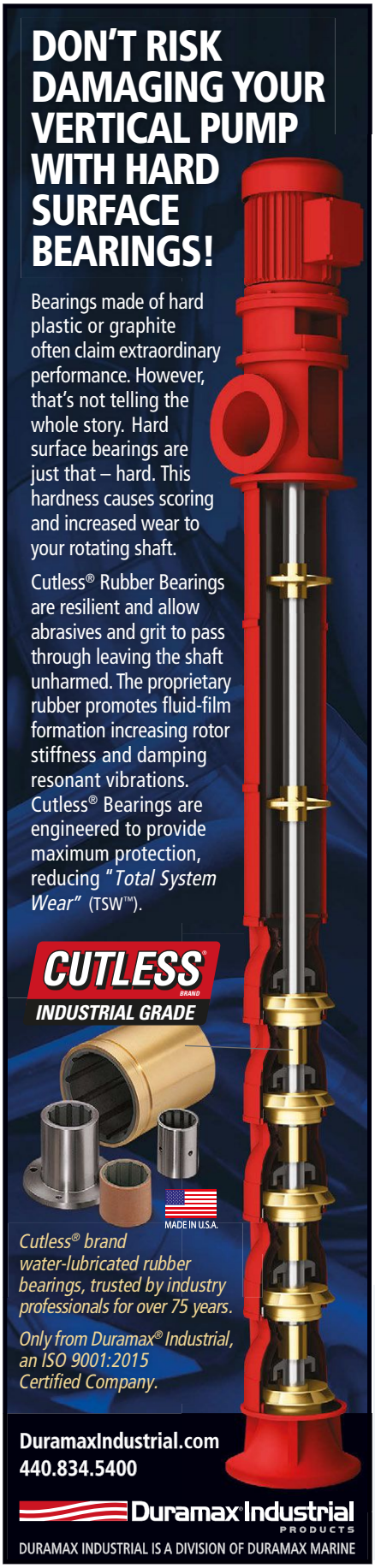


Check 119 on index.

Best Practices for Sealing High Pressure Boiler Circulating Pumps

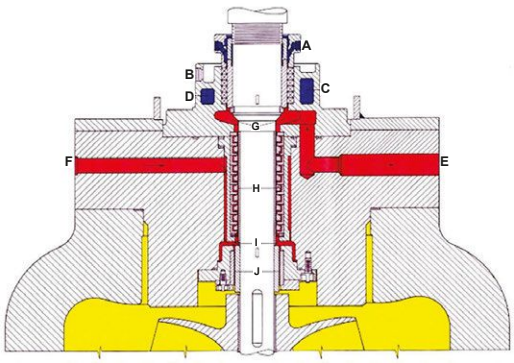
Making use of dual-stage mechanical seal systems.

TOPHER ROPP | FSA member

High pressure boiler circulating pumps found in medium to large (200 to 1,000+ megawatts [MW]) fossil-fueled power plants represent challenging application conditions for mechanical seals with seal chamber pressures in the range of 3,000 pounds per square inch gauge (psig), or 207 barg (gauge pressure), and process water temperatures of up to 700 F (371 C).

These pumps are typically single-stage vertical pumps designed to provide high flow rates with low pressure differentials, with two to five of these pumps being installed on a single boiler unit. The pumps are normally installed in a parallel configuration and are critical to maintaining an even temperature distribution in the boiler and do not typically have an installed spare pump. Therefore, the loss of one or more pumps from service requires a proportional reduction in power output of the affected boiler unit, likely resulting in large operating losses over a short period of time. In addition, the pump shaft seals on these pumps represent a safety hazard within the power plants, as catastrophic seal failures could result in the escape of large volumes of rapidly expanding super-heated steam.

Previous sealing solutions featured a controlled leak off system using either compression packing or a single mechanical seal coupled with a series of floating breakdown bushings and a Plan 32 external flush to provide high pressure cool water on the process side of the bushings to isolate the pump shaft seal from the hot process. Pumps fitted with these systems were found to have low thermal efficiency, higher energy costs, high water usage and higher maintenance costs.



A. Smothering water inlet
B. Gland spill ring drain
C. Cooling water inlet
D. Cooling water outlet
E. Leak-off outlet
F. Injection water inlet
G. Leak-off chamber
H. Upper seal ring clearance (pressure breakdown to leak-off)
I. Injection water chamber
J. Lower breakdown clearance (leakage to pump casing)

IMAGE 1: Stuffing box arrangement of controlled leak off systems (Images courtesy of Flowserve)

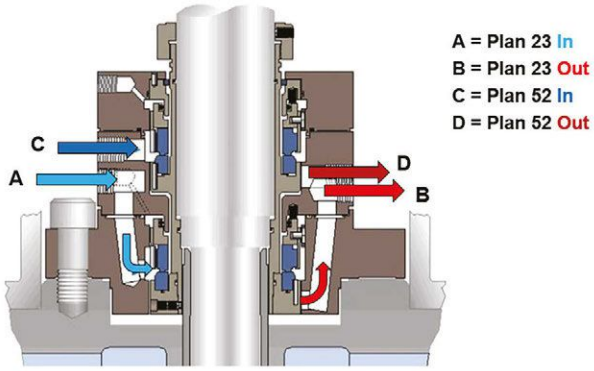


IMAGE 2: Typical dual-stage high pressure seal

Due to the application challenges, operating costs and risks involved, dual-stage mechanical seals using a Plan 23/52 auxiliary seal support system have largely replaced the costlier and less safe controlled leak off systems.

Dual-stage mechanical seal systems are designed with dual seals. These seals have a Plan 23 between the process and inboard (IB) seal to keep the seal chamber cool. They also have a partially pressurized Plan 52 between the IB and outboard (OB) seals to stage the pressure acting across both the IB and OB seals.

This is accomplished with the use of a pressure control valve (PCV) that can reduce the pressure in the Plan 52 to about half of the process pressure, lowering and equalizing the pressure differential acting on each set of mechanical seal faces to increase the seal reliability.

At its core, the dual-stage mechanical

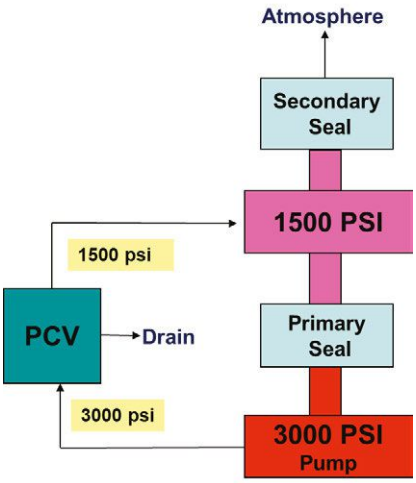


IMAGE 3: Simplified seal system panel with PCV valve

seal's auxiliary support system (the panel) is comprised of the Plan 23 seal cooler, Plan 52 seal cooler, and the PCV, which regulates the pressure within the system.

To increase reliability of the sealing system, the auxiliary support system often includes a magnetic separator, pressure sensors, temperature sensors, level switches, filters, accumulators and other items used to monitor and automate the auxiliary system.

In addition to the steady-state conditions described and designed above, upset conditions must also be considered. Upset conditions within boiler circulation pumping systems are likely to include dry run conditions from vapor accumulating in the vertical pumps, fluctuating pressures due to system temperature changes, high pressure startups and larger than normal temperature excursions. For maximum reliability in any of the above conditions, the seal face material pair is a metalized carbon running against a reaction bonded silicon carbide. Metalized carbon is chosen because it is the most durable of the self-lubricating face materials and is the most forgiving during upset conditions, particularly dry running. The seal faces are designed using finite element analysis (FEA) to ensure the seal faces remain stable during steady-state operation (when process pressure is staged between two seals) and in the event where the full process pressure is applied to one seal only.

To further improve safety, each mechanical seal is designed to handle the full process pressure if one of the two seals fails entirely. In the event of a single seal failure, the remaining seal is only intended to operate for a short duration (of up to one month), allowing for maintenance to be scheduled and implemented, and thus decreasing the need for load reduction on the boiler unit.

> Ensuring the seal coolers are properly vented is key to preventing vapor lock (loss of flow due to a gas bubble in the piping) from occurring.

Each seal requires internal circulating features to ensure that there is proper flow to the auxiliary seal coolers (Plan 23 and 52) in the seal panel. Ensuring the seal coolers are properly vented is key to preventing vapor lock (loss of flow due to a gas bubble in the piping) from occurring. Typically, a high-point gas accumulator with a level indicator is used to alert the operator that the system may need to be vented to prevent vapor lock occurring.

During steady state operation, the Plan 23 and 52 typically operate between 100 F and 140 F (38 C and 60 C). As a best practice, thermocouples (and local temperature gauges) should be placed at the inlet and outlet of the Plan 23 and 52 seal coolers to monitor system temperatures and to alert system operators of possible issues with flow through the panel that could cause increased temperatures and reduced seal life. Since boiler circulating water can collect contaminants, the Plan 23 is typically supplied with a magnetic separator to collect any iron oxide material that could cause mechanical blockage of the Plan 23

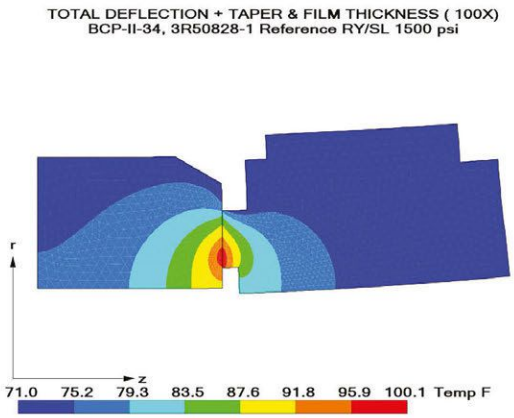


IMAGE 4: Typical FEA of optimized seal faces temperatures

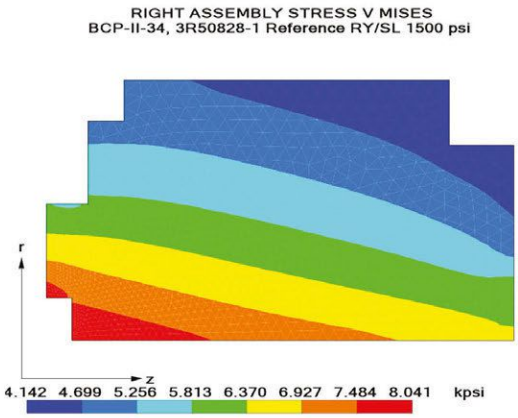


IMAGE 5: FEA of typical wear nose loading

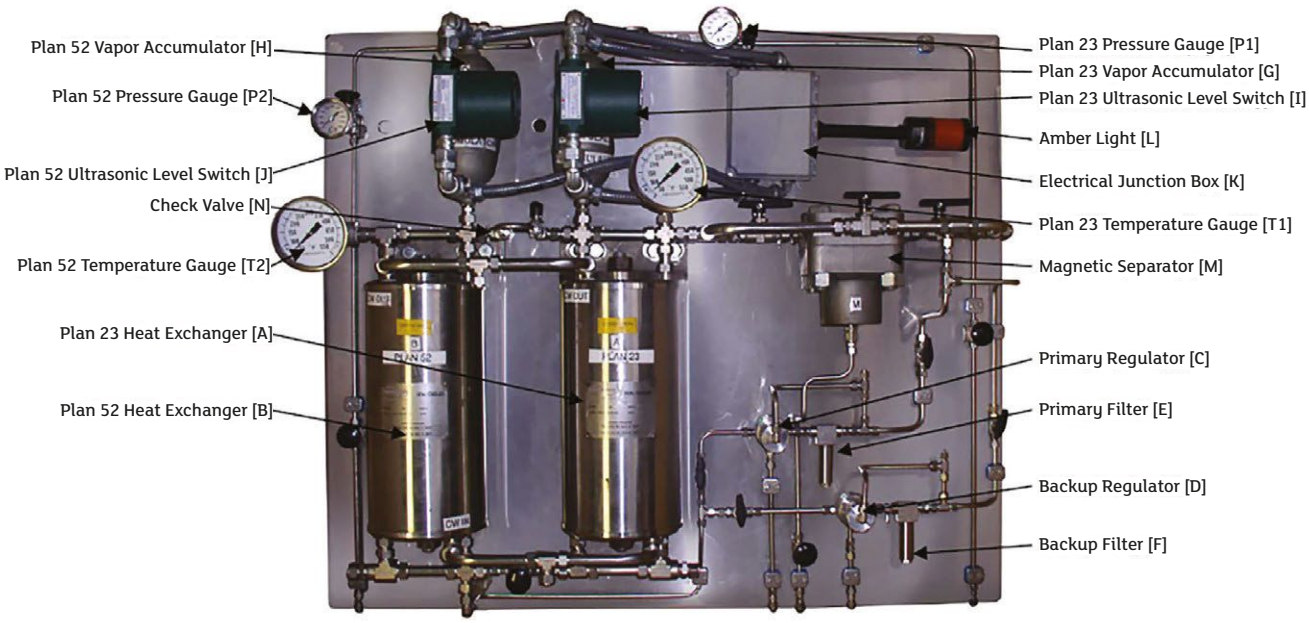


IMAGE 6: Typical auxiliary support system (panel) for Plan 23/52

or premature wear to the IB seal.

Pressure monitoring via pressure transducers with local readouts is also key to monitoring the health of the mechanical seals and support systems.

There should be a minimum of one pressure transducer located on each of the Plan 23 and 52 seal cooler systems, with placement logically selected to confirm proper operation of the PCV. Pressure monitoring will allow the system operators to track any PCV issues and monitor the health of the mechanical seals.

Case Study

A fossil fuel generation station in southern California was experiencing poorly performing sealing systems on their three boiler circulating pumps with recurring maintenance concerns and thermal efficiency problems. They originally used packing to seal the pump shaft and had changed to a single mechanical seal.

Both had used floating breakdown bushings with the Plan 32 external flush water injection system.

To upgrade the system, they installed a dual-stage mechanical seal and Plan 23/52 auxiliary seal support system that improved the equipment availability and plant efficiency. It improved operational flexibility and peak power generation by allowing operators to "bottle the boiler" (i.e., to efficiently keep the boiler water at elevated standby temperatures) without the need for seal cooling water injection or auxiliary boiler feed pumps.

The benefits of the upgrade to the dual-stage mechanical seal and auxiliary system resulted in improved efficiencies and equipment availability including:

- Reduced costs through thermal efficiency improvements by saving 15 to 25 gallons per minute (gpm), or 57 to 95 liters per minute (lpm), of feedwater leakage per pump, plus retention of heated water/steam during hot standby operation.
- Elimination of the Plan 32 seal cool water injection system piping and booster pumps, resulting in reduced operating and maintenance costs.
- Improved operational flexibility and unit ramp-up time by eliminating the cool water injection.
- Reduced effects of severe service duty and provided an installed backup seal with the staged dual seals.
- Optimized seal cooling and pressure control for low maintenance and reliable operations with separate Plan 23 and 52 piping loops.
- Virtually eliminated water and steam leakage-related safety issues.

The financial benefits and projected cost savings for the three boiler circulation pump upgrades were in the range of $110 million dollars with an expected return on investment of less than half a year.

Although the boiler circulating pumps can be a challenge to seal, upgrading to dual-stage mechanical seals and Plan 23/52 auxiliary support systems can provide improved safety, lower maintenance and operational costs, and increased meantime between planned maintenance. ■

We invite your suggestions for article topics as well as questions on sealing issues so we can better respond to the needs of the industry. Please direct your suggestions and questions to sealingsensequestions@fluidsealing.com.

Christopher "Topher" Ropp is a principal engineer for the Flowserve Seal Group. Ropp has been in the sealing industry for over 30 years. He holds a Bachelor of Science in mechanical engineering from Western Michigan University. He may be reached at chropp@flowserve.com. For more information, visit flowserve.com.

How a Power Monitor Aids a Plant in Times of Crisis

Remote monitoring features enable maintenance teams to track asset health from afar.

MICHAEL WATSON | Fluke

IMAGE 1: Three-phase power monitor (Image courtesy of Fluke Reliability)

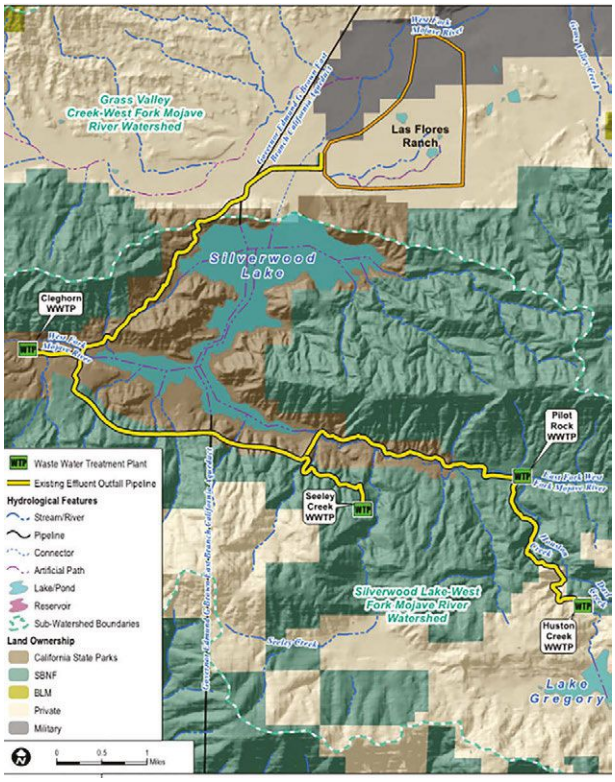


IMAGE 2: Topography of Crestline Sanitation District (Image courtesy of Crestline Sanitation District)

It might seem unusual to begin an article by talking about toilet paper, but the challenges of finding bathroom tissue during the COVID-19 pandemic are well-known. Because of the shortage, Crestline Sanitation District in California, a sewage collection, treatment and disposal services organization, encountered a trickle-down effect that could have caused asset failure.

Creative Alternatives Can Clog Up the Works

During a crisis, people tend to think outside the box. That is what Crestline customers did when, suddenly, toilet paper became one of the world's hottest commodities.

Unbeknownst to most people, the flushing of temporary toilet paper replacements, including wet wipes, paper towels and T-shirts, created unwieldy problems for many wastewater treatment plants across the globe. Even before COVID-19, wet wipes were costing facilities billions of dollars in damage annually, according to the National Association of Clean Water Agencies (NACWA).

Fortunately, Crestline had the right tool at the right time—a three-phase power monitor—to help them mitigate the issue.

This monitor helped the maintenance staff measure:

- single, split or three-phase loads
- voltage, current and frequency
- total harmonic distortion
- active power, nonactive power and power factor

The organization's Southern California headquarters are in Crestline, and its 100 miles of pipeline weave up and down the panoramic San Bernardino Mountains and Lake Gregory area. A 14-person team operates and maintains three wastewater treatment plants and three lift stations to serve 4,700-plus commercial and residential customers. Some of Crestline's coverage area is only accessible on foot because of its topography.

The facilities range from 45 to 65 years old. Similar to many other aging wastewater treatment plants, daily challenges include continuous maintenance of aging infrastructure systems and increasing compliance and regulatory requirements.

Isolating the Problem

Initially, the district purchased the power

IMAGE 3: Influent systems have experienced increased loads (Image courtesy of Enviro-Care)

monitor to help its maintenance team get to the root of a baffling problem and a potentially disastrous situation when the two lift pumps at Gregory station were exhibiting unusual activity.

The variations in the station's twin pumps caused high-level alarms to go off, signifying that it was on the verge of spilling raw sewage into a municipal lake.

"The problem with the site is that it's 10 feet from a public lake," said Jordan Dietz, electro-mechanical specialist for Crestline Sanitation District. "And if we spill, we go directly into the lake in seconds. So, it's a really critical location."

Fortunately, the alert provides the team with 30 minutes to respond, which gave them time to remediate the problem temporarily by running pumps by hand. However, the maintenance team still needed to figure out why the event occurred to prevent it from happening again.

Typically, the station's pumps run at 20-minute intervals to maintain a constant flow of wastewater. The team noticed that each pump was running differently than the other, even though the pumps were identical and installed at the same time. They could not determine why the motor variable frequency drive (VFDs) control system and some of the starters were showing different amperages.

"The fact that two identical pumps had two different trends was really the key that got us to see that something was wrong," Dietz said. "Even if the water level got to the same point, it wasn't starting the motors as quickly as it should."

Electrical Issues Discovered

After further troubleshooting, the maintenance team recognized it was not a mechanical problem and began focusing on possible electrical issues. Dietz knew the power monitor's capabilities and immediately put the tool to use.

"It was the three-phase power monitor that enabled us to see that the pumps, and ultimately the entire station, weren't grounding properly," Dietz said. "We isolated it down to harmonics and line voltage fluctuations that were causing varying amperages and VFD anomalies. We were able to diagnose, modify and mitigate the problem by using the power monitor."

The team continued to use the portable device regularly to monitor pumps, motors and entire systems to help identify plant energy inefficiencies and determine where to make upgrades.

Then the coronavirus hit, and many workers were required to work from home.

Remote Monitoring Alleviates COVID-19 Challenges

The maintenance team's ability to monitor power remotely has enabled them to manage and maintain assets continuously during the pandemic. The captured data is stored in the cloud and accessible to personnel working anywhere—in the field, at the plant and from home via a PC, laptop or mobile phone. When predetermined thresholds are breached, a notification is sent automatically to a maintenance worker's smart device, alerting them of the change in condition.

"Thanks to the necessity for remote work, the [power monitor] has been greatly instrumental for us," Dietz said. "My department got downsized for the pandemic, and since that time, the three-phase power monitor has been used for remote monitoring of our main plant, and specifically our influent bar screen. With the influx of wipes and paper towels being used in place of toilet paper, our influent systems have seen increased load."

A bar screen is a critical asset that captures trash before it can enter the system. If the screen experiences a substantial overload of wipes and rags, it can cause motor failure or other issues.

"As a safety measure, we added the power monitoring to ensure that we always have the correct power to our first line of defense against the rags—the bar screen," Dietz said.

Then, in early April 2020, the team needed a tool to assist when an unseasonably late snowstorm hit the area.

"We got a big storm that changed our weather from spring to winter and gave us 2 feet of snow," Dietz said.

"This caused a multitude of unplanned outages and weird voltage events. Because of the [power monitor], we were able to respond before anything negative happened and get the generator handling the issues."

Maintaining Connectivity

Due to the pandemic, Dietz's job has transitioned to remote connection management, electrical oversight and repair, and a sundry of other critical tasks. Although the change has forced some of Crestline's plans to take a backseat, the team carries on.

"Individually, we certainly have our weaknesses," Dietz said, "but we function incredibly as a team and persevere." ■

Michael Watson is a product application specialist for Fluke Reliability, focusing on the company's technician tools and condition monitoring product lines. Watson brings more than 25 years of experience in technician effectiveness, product service engineering and operations. He is a Certified Maintenance & Reliability Professional (CMRP), Certified Reliability Leader (CRL), and Certified Level 1 Thermography Analyst. For more information, visit fluke.com.

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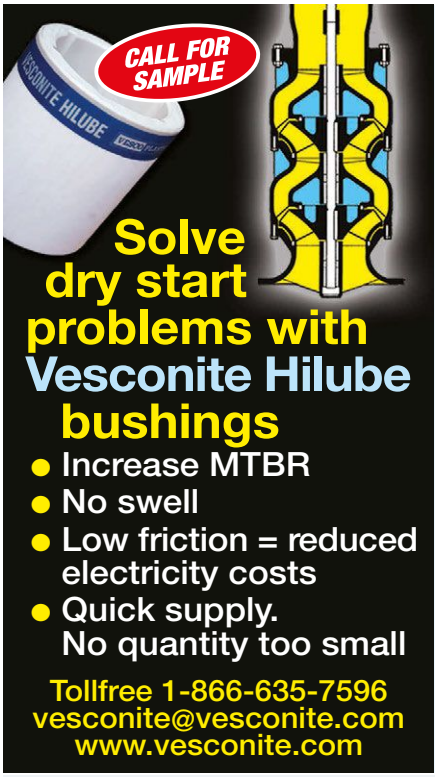

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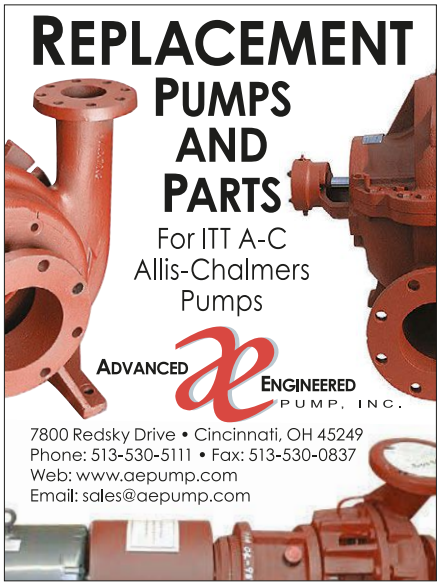

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Wall Street Pump & Valve Industry Watch

JORDAN, KNAUFF & COMPANY

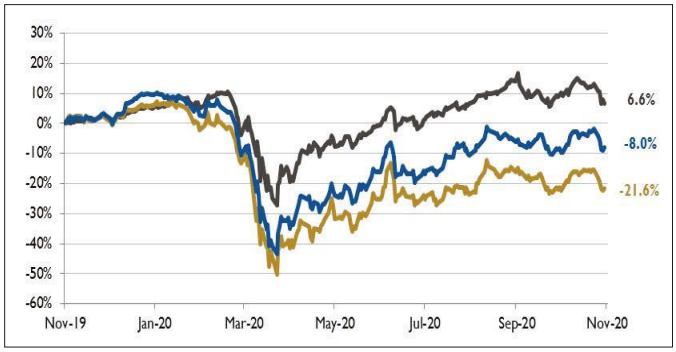

IMAGE 1: Stock Indices from Nov. 1, 2019 to Oct. 31, 2020. Local currency converted to USD using historical spot rates. The JKC Pump and Valve Stock Indices include a select list of publicly traded companies involved in the pump & valve industries, weighted by market capitalization. Source: Capital IQ and JKC research.

The Jordan Knauff & Company (JKC) Valve Stock Index was down 21.6 percent over the last 12 months. The S&P 500 Index was up 6.6 percent. The JKC Pump Stock Index fell 8.0 percent for the same period.[1]

The Institute for Supply Management's Purchasing Managers' Index (PMI) registered 59.3 percent in October, up 3.9 percentage points from the September reading, the highest since September 2018. The New Orders Index registered 67.9 percent, an increase of 7.7 percentage points from the September reading, the highest level since 2004. The Production Index registered 63 percent, an increase of 2 percentage points compared to September's reading of 61 percent. The Employment Index registered 53.2 percent, an increase of 3.6 percentage points from the September reading, in expansion territory for the first time since mid-2019. Inventories have been drawn down across wholesalers and retailers, with respondents characterizing customer inventories as too low by the widest margin in more than a decade.

The JPMorgan Global Manufacturing PMI rose from 52.4 percent in September to 53 percent in October, its highest level since May 2018. Expansion was seen across the world's major markets, led by the Eurozone. Of the PMI's five components, output rose in October at the fastest rate since February 2018, driven by the sharpest increase in new orders since January 2018. Growth was especially strong in Germany, reflecting a record inflow of new orders. Output growth also accelerated in the U.S., to the fastest for almost a year. While companies are optimistic that an end to the pandemic could come within a year, they seem to be taking precautions to avoid expanding capacity.

Month-over-month global consumption of crude oil rose by 1 million barrels per day (b/d) during August and September, compared with an increase of 4.1 million b/d from May through July. The U.S. Energy Information Administration (EIA) estimates that global oil markets have shifted from global liquid fuels inventories building at a rate of 7.3 million b/d in the second quarter to drawing down at a rate of 3.1 million b/d in the third quarter.

Global consumption of liquid fuels and petroleum averaged 95.3 million b/d in September. Liquid fuels consumption was down 6.4 million b/d from September 2019, but it was up from an average of 85.1 million b/d during the second quarter and 93.9 million b/d in August. EIA forecasts that global consumption of petroleum and liquid fuels will average 92.8 million b/d for 2020, down by 8.6 million b/d from 2019.

On Wall Street, the Dow Jones Industrial Average, the S&P 500 Index and the NASDAQ Composite dropped 4.6 percent, 2.8 percent and 2.3 percent, respectively, in October. Rising coronavirus cases, the presidential election and the stalled fiscal stimulus package contributed to the volatility. ■

Reference

1. The S&P Return figures are provided by Capital IQ.

Jordan, Knauff & Company is an investment bank based in Chicago that provides merger and acquisition advisory services to the pump, valve and filtration industries. Please visit jordanknauff.com for further information. Jordan, Knauff & Company is a member of FINRA.

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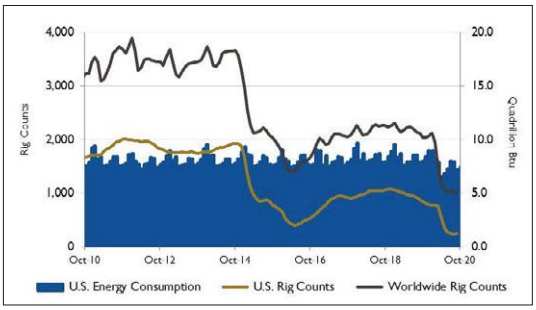

IMAGE 2: U.S. energy consumption and rig counts. Source: U.S. Energy Information Administration and Baker Hughes Inc.

IMAGE 3: U.S. PMI and manufacturing shipments. Source: Institute for Supply Management Manufacturing Report on Business and U.S. Census Bureau

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