MARCH 2024
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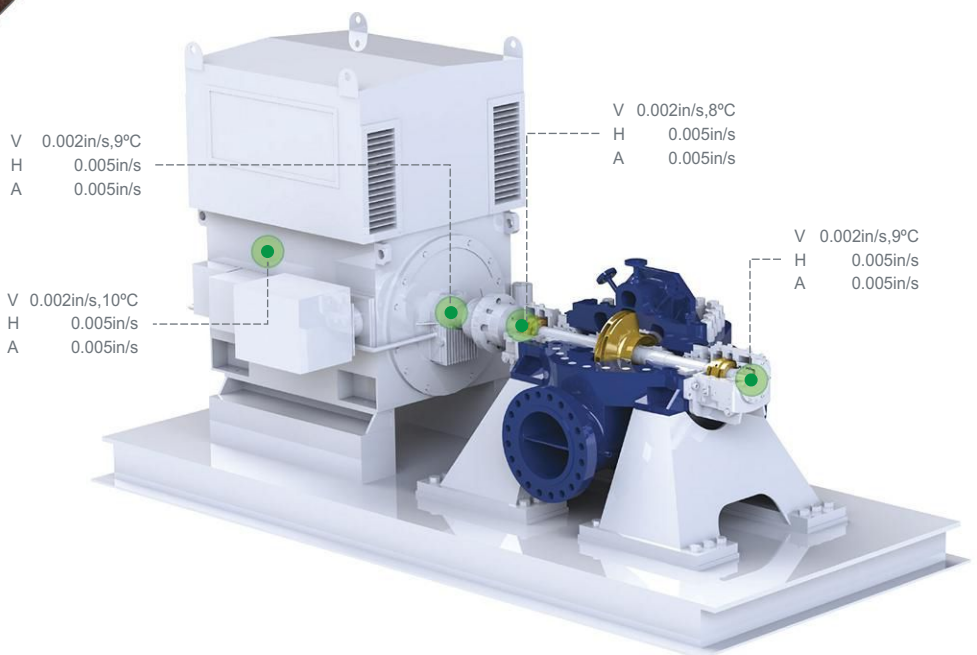

I recently had the opportunity to attend AHR Expo, and this year's show was conveniently held in my adopted hometown and current place of residence, Chicago. The day was cold and rainy, a fact I overheard many out-of-town visitors lamenting as we trudged en masse to the sprawling facilities of McCormick Place. (Little did they know, it had been -30 F with wind chill the week before.)

A glimpse of the crowd at AHR Expo 2024 (Image courtesy of AHR Creative)

No one was complaining of cold inside the building, however, where a whopping 48,000-plus attendees mingled, networked and strolled among 1,875 exhibitor booths. As a first-time attendee, I hadn't been expecting a crowd size akin to a Beyoncé concert, but it was wonderful to see so many professionals gathering to learn about the latest innovations in the world of heating, ventilation and air conditioning (HVAC). I definitely left the experience having learned a thing or two about HVAC, as well as the valuable lesson that comfortable shoes are a must at any trade show, particularly one this large.

If you'd like to learn more about AHR Expo beyond just one editor's footwear recommendations, be sure to visit page 10 for a full write-up of the event. If stories about aftermarket are more your style, our cover series delves into such topics as navigating resonance challenges in refurbished pumps (page 28), detecting motor faults (page 31) and routine maintenance for multistage pumps (page 34). In honor of Women's History Month, this issue's On the Curve (page 12) celebrates two remarkable women in history who made equally remarkable contributions to the world of pumps and systems. Finally, if you've ever asked yourself the question, "What do dolphins have to do with flange sealing?" you can find the answer in this month's Sealing Sense on page 58.

As always, thanks for reading.

Thomas Baer, Managing Editor
tbaer@cahabamedia.com

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EDITORIAL

EDITOR: Amy Hyde
ahyde@cahabamedia.com • 205-314-8274

MANAGING EDITOR: Melody Manasco
mmanasco@cahabamedia.com • 659-202-6637

MANAGING EDITOR: Thomas Baer
tbaer@cahabamedia.com • 205-216-5624

ASSOCIATE EDITOR: Dillan Wright
dwright@cahabamedia.com • 205-961-3390

CONTRIBUTING EDITORS: Lev Nelik, Jim Elsey, Amin Almasi

CREATIVE SERVICES

ART DIRECTOR: Elizabeth Chick

DIGITAL PROJECT MANAGER: Greg Ragsdale

WEB DEVELOPER: Greg Caudle

CIRCULATION

SUBSCRIPTION CHANGES & INQUIRIES:
pumpsandsystems@omeda.com

ADVERTISING

NATIONAL SALES MANAGER:

Derrell Moody
dmoody@pump-zone.com • 205-961-3379

SENIOR ACCOUNT EXECUTIVES:

Mark Goins
mgoins@pump-zone.com • 205-310-7081

Garrick Stone
gstone@pump-zone.com • 205-212-9406

SALES DEVELOPMENT REPRESENTATIVE:

Jacob Greene
jgreene@cahabamedia.com • 205-602-8102

CLIENT SERVICES REPRESENTATIVE:

Susan Powell
spowell@cahabamedia.com

CAHABA MEDIA GROUP

PUBLISHER: Matthew G. Conroy
VP OF SALES: Greg Meineke
VP OF FINANCE: Brandon Whittemore
DIRECTOR OF CONTENT: Elizabeth Manning
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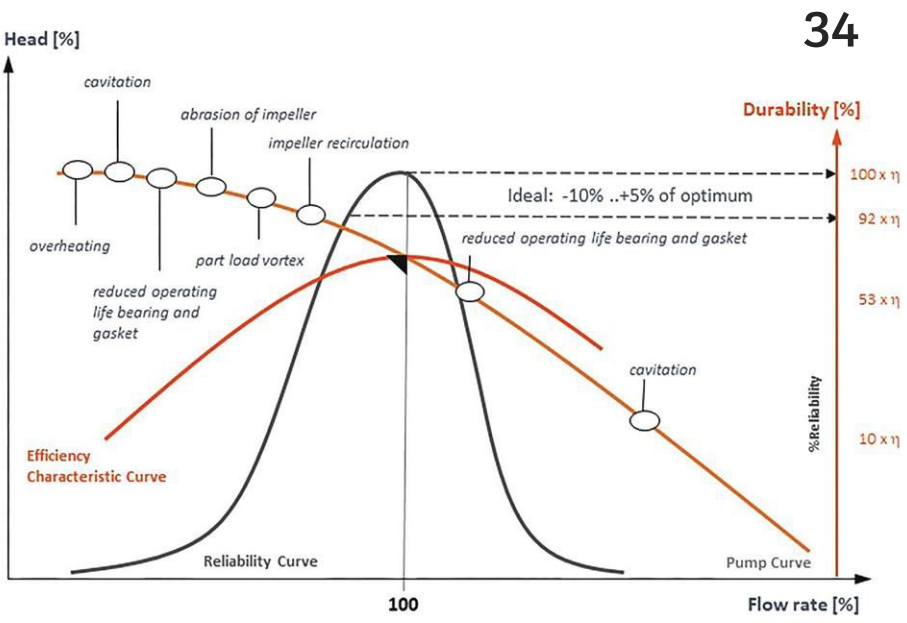

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NEW HIRES, PROMOTIONS & RECOGNITIONS

VAGNER REGO,
ATLAS COPCO GROUP
NACKA, Sweden – The board of directors of Atlas Copco AB appointed Vagner Rego as the new president and CEO of Atlas Copco Group, effective May 1. He will replace Mats Rahmström who has, as previously communicated, requested to leave his position after successfully leading the Group since 2017.

Rego, currently senior executive vice president and president of the compressor technique business area, joined the Group in 1996 as a trainee engineer in his native country, Brazil. In 2006, he was appointed business line manager for compressor technique service in Brazil and in 2010, he became vice president marketing and sales for the Compressor Technique Service division, based in Belgium. He has also been general manager for Power Technique's customer center in Brazil. Before he took on his current position in 2017, he was president for the Compressor Technique Service division. ■
atlascopcogroup.com

OLIVIER LEONETTI,

EATON
DUBLIN – Intelligent power management company Eaton announced Olivier Leonetti has been named executive vice president and chief financial officer, effective Feb. 5. He succeeds Thomas B. Okray, who is leaving the company for personal reasons.

Leonetti joins Eaton from Johnson Controls, where he served as executive vice president and chief financial officer. Before joining Johnson Controls in 2020, he served as chief financial officer of Zebra Technologies Corporation and Western Digital Corporation and held senior finance leadership roles at Global Commercial Organization, Amgen, Inc., and Dell, Inc. He also serves on the board of All-In Milwaukee and has been a member of Eaton's board of directors since 2019, a role he will step down from.

Leonetti is a certified accountant. He holds a master's degree in internal audit from the Graduate School of Management, Marseille, France; an MBA from Ecole Supérieure des Affaires, Grenoble, France; and a master's degree in economics and accountancy from the University of Aix-Marseille, France. ■
eaton.com

HEATHER COLLINS,

AWWA
DENVER – The American Water Works Association (AWWA) selected Heather Collins as the association's next president-elect. Collins will begin her term as president-elect in June at the conclusion of AWWA's Annual Conference & Exposition (ACE24). Her term as president begins in June 2025 following that of current president-elect Cheryl Porter.

Collins is assistant chief of operations for the Metropolitan Water District of Southern California, where she has worked since 2011. She currently sits on AWWA's board and is a member of the Water Utility Council. She previously served as an AWWA vice president and member of the Technical and Educational Council.

She holds a master's degree in civil engineering from Loyola Marymount University and a bachelor's degree in civil engineering, environmental option, from California State Polytechnic University in Pomona. ■
awwa.org

SHARON SZAFRANSKI,
ITT INC.
STAMFORD, Conn. – ITT Inc. announced the election of Sharon Szafranski to its Board of Directors. Szafranski currently serves as executive vice president of the welding segment at Illinois Tool Works (ITW). Szafranski began her career at ITW in 1994.

Szafranski currently serves as executive vice president of the Welding segment at ITW, where she has full P&L responsibility for an approximately $1.9 billion business with approximately 3,500 employees. She has spent nearly 30 years with ITW and has held 11 different roles of increasing responsibility in the organization, beginning as a sales trainee in 1994.

ITW operates across seven segments, including automotive OEM, construction products and food equipment and is based in Glenview, Illinois. ■
itt.com

HANNES LEICHTFRIED,

DANFOSS DRIVES
BALTIMORE – Danfoss Drives announced that Hannes

Upcoming Events

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NRG Park
Houston, Texas
2024.otcnet.org

AWWA/ACE
June 10-13
Anaheim Convention Center
Anaheim, Calif.
awwa.org/ace

NFPA
June 17-20
Orange County Convention Center
Orlando, Fla.
nfpa.org/events/conference

EASA
June 24-26
Caesars Forum & Harrah's Las Vegas
Las Vegas, Nev.
easa.com

Mergers & Acquisitions

Concepts NREC Acquired RBTS, Inc.
January 19, 2024

ITT Completes Acquisition of Svanehøj
January 19, 2024

Control Devices Acquires Gilmore
January 29, 2024


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NEW HIRES, PROMOTIONS & RECOGNITIONS (CONT.)

Leichtfried has been appointed head of sales and marketing for the drives business segment in North America. With nearly 30 years of experience at Danfoss in Austria and Germany, Leichtfried, an Austrian native, is excited to continue to build the North America Drives business.

Leichtfried began his career at Danfoss in 1994 as a technical support engineer, then moved into sales and marketing roles. He was most recently the head of sales and marketing for Danfoss Drives in the Central European region. In his new role, he will be based at the Danfoss Drives' Loves Park, Illinois, office. ■

danfoss.com

AROUND THE INDUSTRY

AHR Expo Returned to Chicago With Energy, Excitement & a Focus on Decarbonization

WESTPORT, Conn. – The AHR Expo (International Air-Conditioning, Heating, Refrigerating Exposition) returned to Chicago for a lively week of learning, reconnecting, perusing and demoing everything new coming to market in HVACR. Notable topics included all things decarbonization—from equipment on the floor to discussions in education programming, refrigerant regulation updates, the heat pump resurgence and the unveiling of many new products that are shaping the path forward for HVACR.

"The industry showed up for business in Chicago," said Show Manager Mark Stevens. "Throughout the year we've followed discussions regarding regulation rollouts, decarbonization trends and various other tracks about the way we conduct business as an industry. It was evident in the halls that the professionals in attendance are primed to create solutions and drive business forward."

It was clear to anyone filling the halls on Monday morning of the show that attendance was strong, welcoming 48,034 attendees there to interact with the 1,875 exhibitors spread across North and South Halls. Maximizing 527,520 square footage of space for booth displays, attendees gained access to all the latest the industry has to offer, including new products, technology, skill learning and demonstration.

Inside exhibitor booths, industry professionals and influencers hosted events, competitions and meet-ups, opening exciting channels of content creation and networking opportunities.

"The network transformation is resulting in incredible visibility and partnership for professionals," said Nicole Bush, director of marketing. "There is a true line of two-way communication between the professionals in the field and the manufacturers creating products and technology. Having an in-person forum like AHR Expo to strengthen the social relationships formed online is proving to be immensely beneficial to our industry."

The 2024 Education Program highlighted topics within the industry with the goal of addressing pain points, opportunities and applications to increase efficiencies, business and relationships.

"It's encouraging to see the growth in our education programming, not only with topic variety but also with the expertise signing on to provide insight," said Special Projects Manager Kimberly Pires. "There is a deepened connection between what's being discussed in sessions and what's being applied on the show floor, and this continues to benefit attendees with a true understanding of current information in the industry."

In 2024, the education program featured 120 free sessions, 153 new product presentations in New Product Theaters located in South Hall and seven panels in the AHR Panel Series.

In the 2024 State of the Industry Panel, topics included decarbonization, including gas bans, grid capacity, heat pumps and dual-fuel options; building automation and AI as it relates to energy conservation and future planning; refrigerant updates, including sell-through periods, EPA regulation, recovery and reclamation, etc.; workforce development, virtual training, bridge programs and more.

In the panel titled, "How Do We Address the Workforce Development, Recruitment and Retention Gap?" representatives from Lincoln Tech, a postsecondary vocational institute with locations across the U.S., joined a discussion featuring Jose De La Portilla of Rheem Manufacturing, Alison Neuman of Johnson Controls, Bryan Orr of HVAC School & Kalos Services and Dominick Guarino of National Comfort Institute, Inc. to delve into creating programming and bridge opportunities to attract professionals to the skilled trades and prepare them for a lifelong career in HVACR. The group discussed how to promote the industry and build a successful culture to retain, train and onboard, allowing for better preparation for fieldwork, supportive technology and the ability to identify weaknesses, gaps and opportunities.

Other popular sessions included topics featuring heat pumps, business strategy and growth, emotional intelligence adeptness, building automation, controls and AI, social media and industry growth, smart solutions, A2Ls, compliance, codes and standards, as well as various other niche topics, providing something for every job role represented in the industry.

In 2025, AHR will head south to Orlando. Save the date for Feb. 10-12, 2025, at the Orange County Convention Center. Hotel blocks are expected to open for attendees in late spring and registration will go live in early summer. ■

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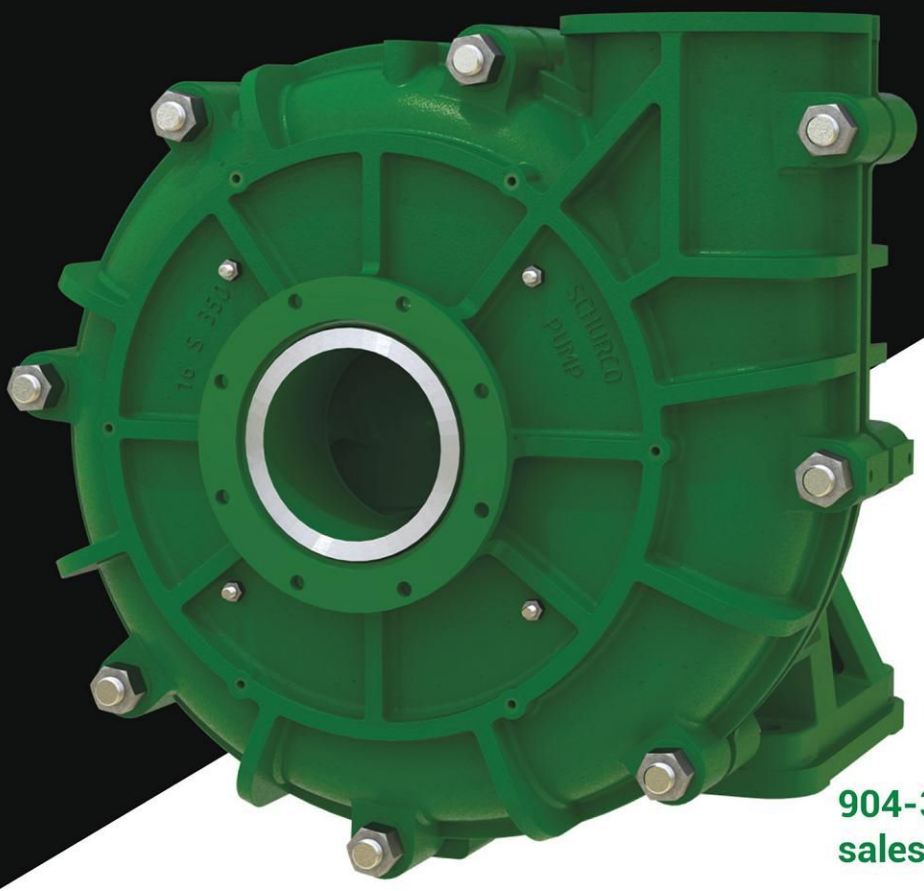

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MARCH IS WOMEN'S HISTORY MONTH

Ellen H. Swallow Richards

Photo courtesy of the MIT Museum

Ellen H. Swallow Richards was admitted into the Massachusetts Institute of Technology (MIT) in 1871, making her the first woman to attend the university. In 1876, she helped establish the Women's Laboratory at MIT, which helped further women's scientific education and remained open until MIT started awarding undergraduate degrees to women on a regular basis in 1883. MIT opened the nation's first laboratory of sanitary chemistry in 1884, and Richards was appointed as assistant chemist, aiding in sewage treatment research. Richards and her assistants performed a survey of the quality of bodies of water in Massachusetts in 1887, many of which were polluted with industrial waste and sewage. The scale of the survey was unprecedented for the time and led to the first state water-quality standards in the country and the first modern municipal sewage treatment plant in Lowell, Massachusetts.

Harriet Williams Russell Strong

Harriet Williams Russell Strong became interested in finding ways to better irrigate dry land while living on a ranch in southern California. She designed and patented a flood control/storage dam system in 1887 that used a series of ascending dams to help store water while also acting as reinforcement for the dam above it, allowing for controlled and uniform regulation of water flow. She was an advocate for the Los Angeles Flood Control Act of 1915 and held public office on the flood control board before women had the right to vote in California. During World War I, she presented a plan to Congress to dam the Colorado River at the low end of the Grand Canyon to control floods, conserve water, generate electricity and provide irrigation to farms in the area that would allow the country to send food abroad to Allied armies and victims of war. This plan was rejected by Congress as the war ended, but some of her ideas would later become a reality years after her death in 1926 with the completion of the Hoover Dam in 1935 and the All-American Canal in 1942.

Photo courtesy of the United States Patent and Trademark Office

Quiz: What Makes the Meter Turn?

LEV NELIK, PH.D., P.E. | Pumping Machinery LLC

IMAGE 1: The main water supply pipe comes from under the ground (Images courtesy of the author)

A residential home had a nice garden with a new watering system recently added by a contractor.

The main water (at 60 pounds per square inch gauge [psig]) supply pipe comes from under the ground, as shown in Image 1 (on the right). The water can go to the right (to the house) and/or to the left and under the ground, coming out further to the garden watering control valve system, which is also shown in Image 1 (at the corner of the property).

Image 2 shows when there is usage of water (red line) by people in the house while the garden system is not active. Meter M1 (on the right) measures water usage for the house, and meter M2 measures water usage for the garden. The M1 dial shows the movement of the digits registering the usage, while the digits of M2 are not in motion, as the garden is not being watered.

When the garden watering system kicks in, water flows to the garden as shown in Image 3, and the garden water meter M2 digits move, confirming the water is flowing to the garden. However, when the owner received the water bill, it showed higher water usage than anticipated. When he observed the system during the watering cycle, he noticed the house water supply meter M1 dial was also moving even when no water was consumed in the house. Why?

The owner called the contractor to find out what was going on. What do you think he found?

What do you think happened, and how did the contractor solve the problem?

The best answer will be published in an upcoming issue of P&S.

Note: Dr. Nelik conducts a periodic Pumps Live Troubleshooting Course focused on learning pump theory and applications by solving similar actual pump problems, which are solved in class by the attendees. To register or schedule, email drpump@pumpingmachinery.com. Solution to your pump problem is guaranteed. ■

Lev Nelik (aka "Dr. Pump") is president of Pumping Machinery LLC, an Atlanta-based firm specializing in pump consulting, training, equipment troubleshooting and pump repairs. Nelik has 30 years of experience in pumps and pumping equipment. He may be reached at drpump@pumpingmachinery.com. For more information, visit pumpingmachinery.com/pump_school/pump_school.htm.

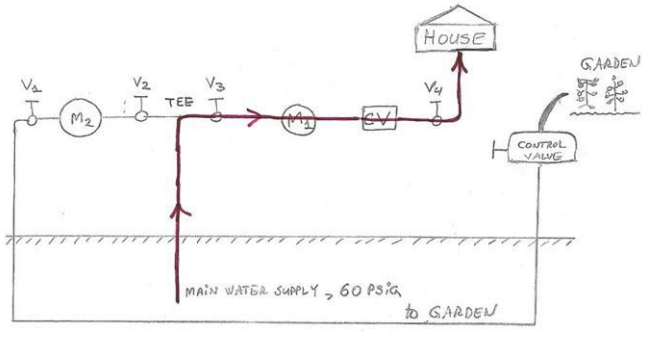

IMAGE 2: Usage of water by the house only

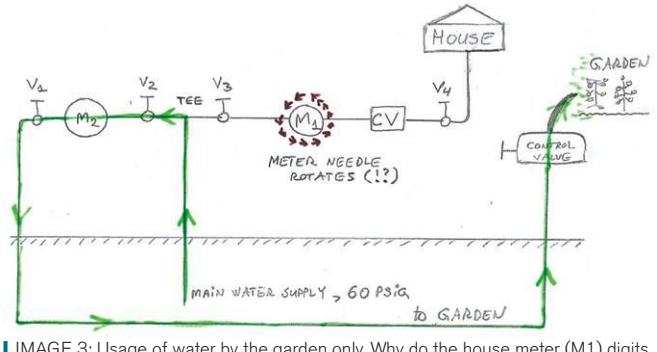

IMAGE 3: Usage of water by the garden only. Why do the house meter (M1) digits also move?

Packaged Wastewater Systems: Residential & Light Commercial, Part 1

MICHAEL KELLEY | Zoeller Company

Flushing the toilet is a pleasantry of modern civilization that is taken for granted. The public rarely concerns itself with what happens to the water, nor does it want to. If wastewater professionals do their jobs well, that will continue to be a mystery. There are many stages, components and processes to take that waste and return it to the environment, but this series will focus on residential and light commercial sewage pump package systems and how to provide trouble-free operation. This is not a pump sizing course, but a list of questions will appear in Part 2 for convenience. Whether you're a pro or a newbie, gathering the proper information is the most critical step, and the list of questions should provide enough information to make a proper selection. Let's start by explaining the various components of a packaged system.

Pump: This is the heart of the system and typically a submersible, automatic pump. The pump allows us a way to convey waste where gravity flow is not feasible. It needs to be capable of moving enough water to prevent overflows or backups and be able to overcome the elevation, friction loss and any other pressure requirements between the pump and outfall of the system.

Basin: This is the container that collects the sewage and houses the pump and level monitoring devices. It is typically polyethylene or fiberglass. It can be installed indoors or outdoors.

Controls/alarm: These will monitor the liquid levels within the tank, turning the pump on and off or notifying the owner of a potential backup or system issue.

Piping and fittings: The proper valves, pipes and diameters are critical for installation.

Pump

There are two options when selecting a sewage pump: solids handling pumps and grinder pumps. Solids handling pumps are designed to pass the solids through the pump. They typically have a recessed, vortex or semi-open impeller with enough spacing to pass a minimum 2-inch spherical solid through the pump. Recessed vortex impellers allow the solids to pass beneath the impeller and tend to be more reliable against clogging. Solids handling pumps tend to produce higher flows but lower head, or pressure.

Alternatively, there is the grinder pump. Rather than passing the solids through the pump, grinder pumps grind the sewage into a fine slurry, allowing for tighter tolerances within the pump and thus different performance characteristics. Centrifugal grinder pumps generally produce 30 to 50 gallons per minute (gpm), which is sufficient for most residential and light commercial applications. These pumps are also capable of much higher heads than solids handling pumps.

Ultimately, either option that can meet the hydraulic requirements will be acceptable. Given the sufficient flow, higher heads and ability to chew through domestic waste, grinder pumps are generally the more robust option in a packaged system when pumping to municipal sewer. If pumping to a septic tank, grinders should not be used. Septic tanks are designed to separate the fats, oils, greases and solids from the water and grinder pumps make this far more difficult. Therefore, if you are pumping to a septic tank, be sure to use a solids-handling pump.

Basin

Location is one of the most important aspects for a residential package system, as it will dictate the size and type of basin used. It is important to consider if the basin will be installed indoors or outdoors, the inlet depth and location (the inlet is the primary drainpipe that brings the waste to the basin) and the frost depth (to prevent freezing pipes). Indoor basins will typically be protected from the environment, which minimizes the chance for freezing. For this reason, indoor basins better fit the one-

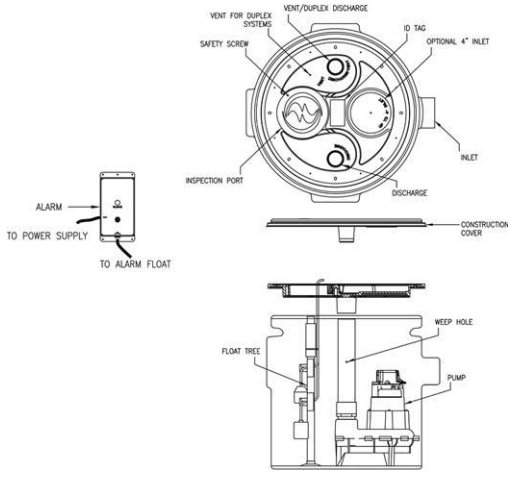

IMAGE 1: Typical simplex indoor package system with pump switch and alarm float (Images courtesy of Zoeller Company)

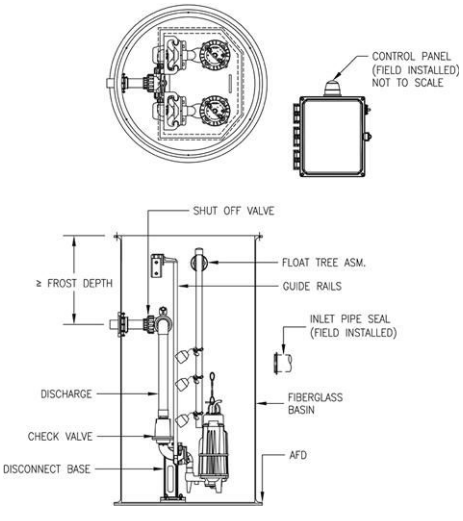

IMAGE 2: Typical duplex outdoor package system with control panel and off, on and lag/high water control switches

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size-fits-all approach. Most manufacturers will pair their pumps with an appropriate basin for an off-the-shelf solution, and as such, sizing the basin is typically not a requirement.

Image 1 shows a typical simplex indoor packaged system. Outdoor installations will vary from region to region, and possibly home to home, where the one-size-fits-all approach is not as applicable. The primary differences are due to the inlet level below grade and frost depth, which directly impacts the depth of the basin. As you move further north, the frost depths get deeper and ultimately require deeper basins. Deep inlets will also require deeper basins and are typical with homes that have plumbing fixtures in the basement. If the stub out from your home is 9 inches below grade, you will likely need an 11- or 12-inch deep basin. Therefore, it is beneficial to locate the stub out at a location that minimizes the depth below the finished grade outside of the home. Image 2 shows a typical duplex outdoor package system.

Controls/Alarm

It is not ideal for pumps to run continuously, nor is it ideal for an owner to have to plug their pump in every time they flush a toilet. Most package systems are paired with an appropriate means of automating the system. Typical options are automatic pumps, pump switches or control panels. Automatic pumps have a float switch built into the pump. As the water rises, the float rises, switching the pump on. As the water level drops, the float drops and will eventually switch the pump off. Automatic pumps will have a limited range of operation but are typical in residential applications.

Pump switches can be paired with pumps that do not have a float switch built in. The pump switch is typically plugged into the outlet and the pump plugged into the back of the switch, as seen in Image 3.

When the pump switch is in the down position, it creates an open circuit and will interrupt power from the outlet to the pump. When the float rises, the contact inside the float will close, allowing power to flow through the switch and into the pump. At that point, the pump is activated, the water level and float drop, the contact opens and the pump stops. Since the full electrical load of the pump passes through the switch, the pump switch needs to be rated for the volt and amps of the pump. Switches allow for more variable on and off points by varying the tether length of the float or using a double float switch that has a separate float for the on and off points.

For installations with automatic pumps or pump switches, an alarm should always be used. The alarm is generally contained in a small box that connects to a float inside the basin located a few inches above the pump activation point. In the event of pump failure, the alarm float will raise and sound an alarm notifying the owner of an issue. Some alarms offer remote monitoring, allowing the owners to receive text, email and/or push notifications in the event of an alarm condition. Be sure to check with manufacturers to see what remote monitoring options they offer and if the service is free or requires a monthly fee.

Control panels offer the greatest flexibility and are more commonly used on outdoor installations. They are typically comprised of a weatherproof enclosure and require three to four floats to monitor the liquid levels: off, on, high water and a lag float for duplex applications. Control panels offer greater variability of set points, ease of troubleshooting and additional monitoring, and they are configurable to job-specific requirements.

Fittings & Valves

The site and location will dictate which fittings are needed to get from the pump to the outfall, but there are some considerations that should be taken for each installation. At a minimum, every installation should include a check valve and shut-off valve.

The check valve protects the pump from backflow, which could lead to short cycling, overflows and impeller backspin. For indoor installations, spring-loaded check valves are recommended to help eliminate water hammer and offer a quiet operation. The shut-off valve allows service providers to isolate the pump from the discharge to remove, service and replace the pump as needed. If not already done by the manufacturer, weep holes should be drilled in the discharge pipe, below the check valve and inside the basin. Air can get trapped inside a pump as the basin fills with water, and when the pump activates, no water is pumped out because the impeller is spinning in the air. This is typically referred to as air-lock and can be easily avoided with a weep hole that allows air to escape the pump as the water rises.

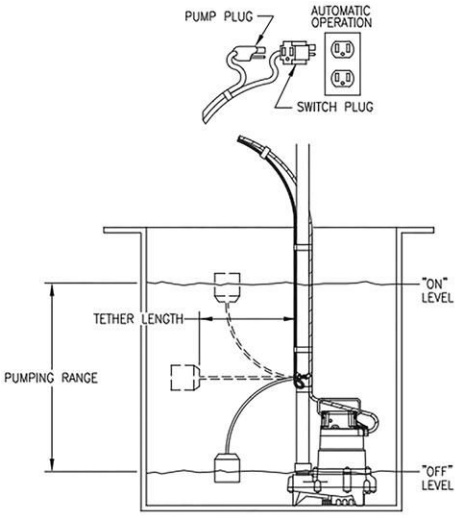

IMAGE 3: Typical pump switch installation

If pumping is being done to a pressure sewer system, often referred to as a low-pressure sewer system, a curb stop must be installed. A curb stop is an additional, redundant check and isolation valve installed at the curb of the home prior to the connection to the pressure main. This is critical to isolate the on-lot components from backflow or air in the common main and provide isolation in the event any components need to be serviced. An access riser should be included with the curb stop so the isolation valve can be accessed. ■

Michael Kelley is a professional engineer with a Bachelor of Science in mechanical engineering and a Master of Business Administration. He has spent the last six years as a senior application engineer for Zoeller Company. He works with customers on design and troubleshooting in applications including pressure sewer, pump and basin sizing, on-site wastewater treatment and other specialty applications. For more, visit zoellerpumps.com.

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A Recipe for Aftermarket Excellence

CRYSTAL BRISTOW | Jenkins Electric

The industrial parts aftermarket is centered around the ability, tenacity and urgency to recreate obsolete or hard to find parts. It's like trying to recreate your favorite dish from your favorite restaurant. You know what it looks and tastes like. While you may have all the information necessary to recreate it, the execution and practice will likely prove more difficult. However, if the chef shared his recipe, the task would be easier. It wouldn't mean you'd nail it on the first try, but you'd be much further ahead than if you went it alone. As an aftermarket industrial parts supplier and manufacturer, the recipe is relatively simple, but like all recipes, the quality of the ingredients makes all the difference.

STEP 1 A Heaping Amount of Application Understanding

To begin the recreation process, you need a heaping amount of application understanding. When your aftermarket part is finished, what's the application, environment and life cycle that will be expected? Does it need to be perfectly polished and fine dining ready, or is functional, delicious and repeatable okay?

In looking for an aftermarket solution, look to a partner with years of experience in the industry or related to the application. No matter how detailed the recipe is, technique and experience can never be replaced by detail.

STEP 2 A Dash of Problem-Solving Mindset

Next, don't forget to add in a dash of problem-solving mindset and company culture. Chances are, if you're looking for aftermarket parts, you're a problem solver already. Look to like minds—those willing to experiment and who have the staff, tools and processes conducive to that shared mindset.

STEP 3 Blend of Complementary Flavors

Salty and sweet is my favorite blend of complementary flavors, and finding a similar blend is the next step in your recipe for aftermarket excellence.

This is where old school meets new school, and knowing what works well together through experience shines. By utilizing old school techniques such as foundry castings, pattern making and repair and refurbishment skills blended with new school tools like 3D printing, computer-aided design (CAD) drawings and waterjet capabilities, you're left with complementary flavors that deliver a well-balanced solution. While new school techniques may seem like the easiest solution, they can be cost prohibitive or limiting when working with small quantities and the need to experiment. Utilizing both old school and new school techniques, you can get the best of both worlds.

STEP 4 A Pinch of Experimentation

Once your core ingredients are ready, it's time to start combining them, which means you'll need the time and partnership to experiment. Discover what works. What order gives you the best results? Do you work with lower cost ingredients during the experimentation phase and then once you've locked in your ingredient order, shift to a more permanent and repeatable list of ingredients and process?

Remanufacturing aftermarket parts works similarly, but finding a partner who can and will work with you during the experimentation phase is critical. Perfecting a recipe takes repetition and patience but not always a large investment. Look for a partner who can and will work with you and is comfortable experimenting to find solutions. They should also be skilled in helping you move from an idea all the way to remanufacturing.

STEP 5 A Drop of Remanufacturing (To Taste)

Remanufacturing is the final step in bringing our recipe together. We've nailed the ingredients, the order and the techniques, but can we make a significant quantity and solve our original problem?

There are two ways to look at remanufacturing: partial and turnkey. Do you want to receive an unfinished part that you put the finishing touches on, or do you want to receive the final, beautiful, ready-to-use part that is the result of all your hard-earned experimentation? The choice is yours. Selecting a partner or resource who can walk through the whole recipe with you and be there to "taste test" is ultimately going to make you as successful as possible throughout this process.

When preparing for this article, I asked a technical team questions about the "what," "why" and "how" of remanufacturing parts for aftermarket sales. I was given a healthy amount of technical advice that all led back to one central theme—finding a partner who has these four qualities. ■

Crystal Bristow is the executive vice president at Jenkins, where she steers the design and implementation of the organization's strategic and marketing master plans in an effort to continue the legacy of the over 115-year-old organization. In her personal time, she clearly watches too much Great British Bake Off. If you'd like to connect with Bristow, you can find her on LinkedIn at linkedin.com/in/crystalbristow.

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P24010 (02-01-24)

Sealing Oil Mist: Choosing the Proper Bearing Isolators

Two types of technology function best in challenging sealing environments.

CHRIS SOLFELT |
Inpro/Seal

IMAGE 1: Bearing isolator designed to create an ideal oil mist seal (Images courtesy of Inpro/Seal)

IMAGE 2: Magnetic-type seal designed to be a great solution for oil mist lubricated pumps

Pumps are routinely placed into severe duty applications where durability and reliability are critical. But even the most expertly designed and stout pieces of equipment can be vulnerable to downtime, or even failure, in these challenging conditions if not maintained properly.

Proper lubrication and protection of the bearings are key factors supporting pump longevity. Without proper lubrication, failure is inevitable and leads to high-cost repairs, replacements and downtime.

While there are many lubrication methods, there is one that has gained popularity and relevance for pumps in downstream applications, such as refining and petrochemical, and that is oil mist. This lubrication method uses an aerosol mixture of fine oil droplets suspended in air. A secondary system takes oil from a supply tank and atomizes it into finer particles. That particulate mixture is then distributed to the bearings.

Oil mist has gained traction in downstream applications because it provides precise lubrication, which means less power consumption, less lubrication excess and waste, fresher lubrication coverage on the bearings and better pump mean time between failures (MTBF).

Oil Mist Challenges

While oil mist use continues to grow favorably among pump operators, it presents sealing challenges. The main difficulty associated with oil mist is keeping it contained within the equipment. Because the lubrication particles are very fine, minuscule openings or leak paths can allow the oil mist to escape, impacting bearing life and operator safety. A leading cause of equipment downtime and lost production is bearing failure, and failed bearings occur predominantly due to lubrication loss and contamination. Additionally, stray hydrocarbons can be inhaled or pool on surfaces to create potential fall hazards. Proper sealing selection is important to operator safety and equipment reliability.

The American Petroleum Institute (API) recognizes the benefits and prominence of oil mist, which is why most API pumps are oil mist-lubricated equipment. Meeting the API standard—specifically API 610—means having bearing housings with one of two specific sealing solutions. It states that "bearing housings shall be equipped with replaceable labyrinth-type or magnetic-type end seals and deflectors where the shaft passes through the housing. Lip-type seals shall not be used. The seals and deflectors shall be made of spark-resistant materials."

Additionally, the U.S. Environmental Protection Agency (EPA) has tightened regulations on emissions and other particulates. While regulation development is ongoing, operators are continually pressed to reduce carbon emissions and eliminate hydrocarbon leakage. As oil mist is an aerosol mixture, it is not always possible to detect leaks with the naked eye. Preventing leakage starts with having the right bearing seal technology in place.

Durable Sealing Protection

Bearing isolators are two-part compound labyrinth or magnetic seals consisting of a rotor and stator working in conjunction to protect rotating equipment from lubrication loss and contamination ingress. However, not all of them are the same. For oil mist, operators must be aware that bearing isolators are engineered to order, utilizing specialized materials, design concepts and features to provide their application the right protection. The technology is not general or plug-and-play with any piece of rotating equipment. In the case of oil mist lubrication, the proper design of the bearing isolator will determine if the equipment is protected. There are several design criteria to consider when selecting a bearing isolator for oil mist applications.

Labyrinth-type bearing isolator: In this type of bearing isolator, operators should make sure there is a coalescing ring that blocks mist from escaping through the labyrinth, where it is collected and deposited back into the bearing housing through the lube return. Another essential component is a vapor-blocking (VBX) ring. Bearing isolators depend on centrifugal force to operate; however, there are times when equipment needs to be shut down. The VBX ring ensures the labyrinth path is shut off and no oil mist can escape while the equipment is at rest. During operation,

centrifugal force provides lift so it is still operating with a non-contact design.

The stator/rotor interface is another key piece of internal technology. Properly designed interfaces provide permanent IP66-rated protection against contamination ingress. A contamination chamber should also be a part of the bearing isolator's design to collect contaminants trying to enter the bearing housing and expel them through the expulsion port using centrifugal force and gravity. Another important design element is the D Groove. As the name suggests, it is a D-shaped groove built into the rotor that captures oil on the shaft. The oil runs along the groove and is returned to the bearing housing.

Aside from its sealing and protection benefits, labyrinth-type bearing isolators are also known for their longevity. Because they do not depend on contact as a sealing mechanism, this technology can last as long as the equipment.

Magnetic-type bearing isolator: This technology works differently but is still an effective choice for oil mist-lubricated environments. Magnetic-type seals utilize two precision-lapped faces that are magnetically energized to create a liquid-tight seal. The critical element is ensuring the seal is designed so the faces maintain proper lubrication and the face loading is distributed equally around the rotor and tuned specifically for oil mist. Additionally, operators must take extra care while installing magnetic-type seals so the faces are not damaged. Flat faces are critical to maintaining a quality seal. Magnetic-type seals are a great choice for oil mist, as positive contact seals effectively seal fine mist particles.

Both labyrinth- and magnetic-type bearing isolators do not cause shaft wear, a common problem tied to elastomeric lip seals, which can wear quickly at the contact point and damage the shaft. ■

Chris Solfelt is product manager for Inpro/Seal and may be reached at csolfelt@doverprecision.com. He has nine years of experience in the bearings and seals industry for rotating equipment, including five years at Inpro/Seal. For more, visit inpro-seal.com.

Advantages & Disadvantages of Diaphragm Seals for Pumps

Diaphragm seals offer benefits that may be worth the initial investment.

TRICIA LEWIN | Colonial Seal

Diaphragm seals are devices used to protect pressure instruments, such as pressure gauges, transmitters and switches from the process media they are measuring. They are commonly used in various industries to prevent the process fluid from directly contacting and potentially damaging the sensitive components of the pressure instrument. Diaphragm seals come in different types, and the choice of seal depends on the specific application and requirements. Here are some common types of diaphragm seals used for pumps:

1. Metallic diaphragm seals

Metal diaphragms: Metal diaphragms of stainless steel (several grades), Carpenter 20, Hastelloy, Monel, Inconel, tantalum, titanium and several other metals are in common use where high-pressure ratings and specific chemical compatibility are required. Flanged assemblies or flush welded versions are available.

2. Elastomeric diaphragm seals

Rubber diaphragms: These are diaphragms made from materials like rubber or elastomers. They are flexible and are used in applications where a lower pressure range is expected.

Polytetrafluoroethylene (PTFE) diaphragms: PTFE is a nonreactive and chemically resistant material. PTFE diaphragm seals are suitable for corrosive and aggressive media.

3. Composite diaphragm seals

Used in toxic environments: Composite diaphragms are used everywhere toxic and chemically aggressive agents are conveyed.

4. Sanitary diaphragm seals

Designed for hygienic applications: These diaphragm seals are specifically designed for industries like pharmaceuticals, food and beverage and biotechnology where cleanliness and hygiene are critical.

5. Flush diaphragm seals

Designed for cleanability: Flush diaphragm seals have a smooth, flush surface that is easy to clean. They are commonly used in applications where hygiene is essential, such as in the food and pharmaceutical industries.

6. Extended diaphragm seals

Used in high-temperature applications: These seals have an extended diaphragm to isolate the pressure instrument from high temperatures.

7. Specialty diaphragm seals

Some diaphragm seals are designed for specific applications, such as high-purity applications, cryogenic applications or applications with aggressive chemicals.

These seals can be produced to meet Food and Drug Administration (FDA), United States Pharmacopeia (USP) Class VI, National Sanitation Foundation (NSF) 51 or 3-A Sanitary Standards. Standard materials include nitrile butadiene rubber (NBR), neoprene (CR), silicone rubber (VMQ) and ethylene propylene diene monomer (EPDM). High-performance, high-temperature resistant elastomers such as fluoroelastomers (FKM), hydrogenated nitrile butadiene rubber (HNBR), fluoro vinyl methyl silicone rubber (FVMQ) and perfluoroelastomer (FFKM) can be utilized.

In the processing industry, diaphragm seals are mostly found in actuators, fittings, hydraulic accumulators, pumps, compressors, valves and regulators. When incorporated into a pump system, a diaphragm seal can offer several advantages:

Chemical compatibility

Diaphragm seals are available in a variety of materials, allowing for compatibility with different types of process fluids. This is especially important when dealing with corrosive or abrasive substances, as it protects the pressure-measuring instrument from direct contact with the fluid.

Corrosion resistance

In applications where the process fluid may be corrosive, a diaphragm seal acts as a barrier, preventing direct contact between the corrosive fluid and the sensitive components of the pressure-measuring instrument. This helps extend the life span of the instrument and reduces maintenance requirements.

Hygienic applications

In industries such as pharmaceuticals or food and beverage where hygiene is crucial, diaphragm seals can be made from materials that comply with sanitary standards. This ensures the

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Diaphragm seals are often designed for easy removal and replacement.

pressure-measuring instrument remains uncontaminated and suitable for use in sensitive environments.

Temperature extremes
Diaphragm seals can be designed to withstand extreme temperatures. This is particularly useful in applications where the process fluid is at high or low temperatures, as it helps protect the pressure-measuring instrument from thermal damage.

Pressure pulsation damping
In pump systems, pressure pulsations can occur, leading to inaccurate pressure readings. Diaphragm seals can act as a buffer, dampening pressure fluctuations and providing a more stable and accurate measurement.

Easy maintenance
Diaphragm seals are often designed for easy removal and replacement. This simplifies maintenance and reduces downtime, as the pressure-measuring instrument can be replaced or serviced without interrupting the entire system.

Extended instrument life
By protecting the pressure-measuring instrument from harsh process conditions, diaphragm seals contribute to the longevity and reliability of the instrument, resulting in reduced replacement and maintenance costs over time.

Versatility
Diaphragm seals can be used in various applications and industries, making them a versatile solution for different pressure measurement needs.

While diaphragm seals can offer advantages in certain applications, they also come with some disadvantages when used in pumps. Here are some potential drawbacks:

Cost
Diaphragm seals can be relatively expensive compared to other types of pressure measurement instruments. The initial investment and installation costs may be higher, which can be a significant factor in budget-conscious projects.

Maintenance
Diaphragm seals require regular maintenance to ensure they are properly functioning. Over time, the diaphragm can wear out or become damaged, leading to leaks and inaccurate pressure readings. Maintenance can be time-consuming and may result in downtime for the system.

Compatibility issues
Diaphragm seals may not be suitable for use with certain types of fluids or aggressive chemicals. Incompatibility with the process media can lead to chemical reactions, corrosion or degradation of the diaphragm seal, affecting its performance and life span.

Temperature limitations
Diaphragm seals may have temperature limitations, and exposure to extreme temperatures can impact their integrity and reliability. High temperatures can lead to thermal expansion or degradation of the diaphragm material, while low temperatures may cause the material to become brittle and prone to cracking.

Response time
The presence of a diaphragm seal can introduce a delay in pressure measurement response time. This delay may be acceptable in some applications, but in processes where rapid pressure changes occur, the response time of the diaphragm seal may be a limiting factor.

Potential for clogging
In applications with particulate-laden fluids, there is a risk of the diaphragm seal becoming clogged, which can affect its performance and accuracy. Regular cleaning or filtration may be required to prevent clogging issues.

Installation complexity
Installing diaphragm seals correctly can be more complex than installing direct-mount pressure instruments. Proper installation is crucial to ensure accurate pressure readings, and improper installation may lead to leaks or other issues.

Size and weight
Diaphragm seals can add bulk and weight to the overall pressure measurement system. In some applications, especially those with space or weight constraints, this may be a disadvantage.

Despite these potential issues, diaphragm seals remain a viable option in many industrial applications where they can provide reliable and accurate pressure measurements in challenging conditions. The decision to use a diaphragm seal should be based on a thorough understanding of the specific requirements and constraints of the application. ■

Tricia Lewin is a member of the Independent Sealing Distributors Association and has five years of experience meeting the sealing design and sourcing requirements for a variety of pump manufacturers and distributors. Visit colonialseal.com.

Streamlining Quality Assurance

The benefits of in-house validation testing in expansion joint manufacturing.

LINDSAY HORNBECK, NICHOLAS WHEELER & MING-HANG YANG |
Garlock

IMAGE 2: Center for advanced materials research and testing

There are several diverse ways to design expansion joints. As the design evolves, each variation requires testing and validation to ensure the expansion joint is performing in the targeted range. Validation testing could take a long time and cost a lot of money if every variation is sent to a third-party testing facility. That is why it is crucial to have in-house testing capabilities when manufacturing performance expansion joints. Eliminating factors such as lead times and shipping allows designers to receive test results quickly.

This grants more time for design, development and making necessary alterations to the expansion joint based on said results. The financial savings of in-house testing capabilities allow for more resources to be invested into the design. These savings will also benefit potential buyers, as the cost of the expansion joint remains unaffected by third-party testing prices. The most beneficial aspect of in-house testing is the freedom to customize testing. Without testing constraints, expansion joints can undergo testing in unique real life application states opposed to standardized methodology.

1 Burst Test

During burst testing, an expansion joint is pressurized until failure occurs. Failure takes place either in the material or at the sealing flange. This test simulates the effects of pressure surges in a pressurized piping system. The results from the burst testing will determine the expansion joint's safety factor rating. The industry standard safety rating is 3:1, but for a performance expansion joint, the performance rating should exceed all standardized values. Developing a performance expansion joint with the highest pressure rating in the industry and backed by an atypical 4:1 safety factor results in the safest, most reliable expansion joint in the market. To claim a statement as such, the expansion joint should endure several functional tests simulating actual field conditions. The ability to perform this testing in-house during the design and development phase generates accurate results in a timely manner. Using engineering resources in creating in-house testing capabilities allows users to test outside the normal standard size range. Additionally, this provides the performance expansion joint with another advantage to the standard expansion joint. Generally, larger-sized expansion joints have burst ratings generated by stress calculations. Designing in-house burst testing capabilities allows the joint to be designed and rated to its highest potential. This will allow the performance expansion joint to be marketed with confidence and backed by validation testing throughout the entire size offering. Utilizing electromechanical components such as pressure transducers and a data acquisition box will provide test data throughout the entire process and display the exact pressure value upon burst failure.

IMAGE 3: 72-inch performance expansion joint during burst testing

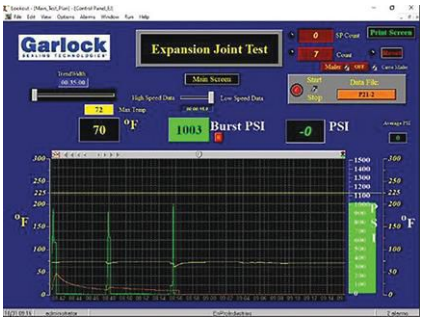

IMAGE 1: Performance expansion joint during burst testing with digital data acquisition (Images courtesy of Garlock)

2 Spring Rate Test

In "Expansion Joints – Piping Technical Handbook," the Fluid Sealing Association (FSA) defines the spring rate as the force required to move the expansion joint a certain distance in compression, extension or laterally. It is most often expressed in pounds (lb)/inches (in). In the real world, a tensile tester with properly designed tooling and fixture is used to measure the spring rate of an expansion joint (Image 4[a] and [b]). In the case of a compression spring rate test, an expansion joint is compressed at a specified deformation rate from its neutral position to achieve a given compression deformation (inch). The force (lb) to deform the joint would be measured and recorded throughout the test. The spring rate in compression direction can then be calculated through the following equation. The same test principle also applies to spring rate tests in elongation and lateral direction.

Spring Rate (lb/in)=(Force (lb))/(Deformation (in))

Equation 1

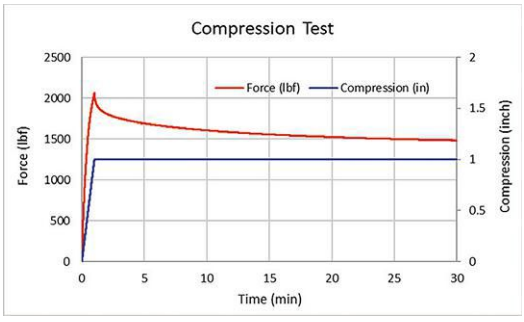

IMAGE 4: (a) Setup for spring rate test in compression and elongation direction; (b) setup for spring rate test in lateral direction; (c) force-time chart for the compression spring rate test: compression rate = 1 inch/minute and compression deformation = 1 inch

3 Vacuum Test

During a standard vacuum test (FSA-PSJ-701-19), negative pressure is pulled up to 26 inches of mercury for 10 minutes to ensure the layers of the joint do not delaminate and pull apart. The standard method of testing for vacuum only ensures a joint will withstand this negative pressure in a neutral state. In application, a joint is unlikely to only see a neutral state—elongation and compression are typical deformation states of an expansion joint.

IMAGE 5: Vacuum test at neutral state

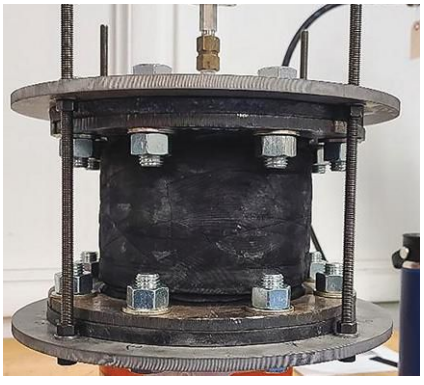

IMAGE 6: Vacuum test at elongated state

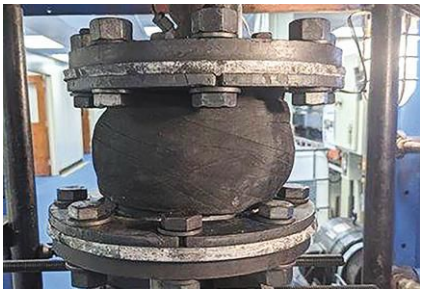

IMAGE 7: Laterally displaced joint for movement testing

These deformed states apply different stresses on the layers of material within the joint. To this effect, a modified vacuum test was developed to simulate this worst case application. This test was developed following FSA-PSJ-701-19 standards with the addition of a gradual elongation of the joint and requiring 29 inches of mercury. A full 10-minute vacuum cycle is performed at four equal elongation intervals, with the first interval being a neutral state (Image 5) and the final a fully elongated state (Image 6). This elongation puts the joint under maximum rated conditions during vacuum testing to ensure optimal performance.

4 Movement Test

To best simulate end user applications, a nondestructive, modified hydrotest was recently developed. This new testing involves simulating the movement and pressures a joint could experience in the field. Performance expansion joints have an established maximum service pressure along with a maximum elongation or compression movement.

These variables are tested in tandem by displacing the joint to the maximum ratings, pressurizing and holding for 10 minutes. The acceptance criteria for this test are an absence of visible deformation and no leakage from the joint. Many expansion joints also have a specification for lateral movement, prompting the need to test this additional variable. To mimic this variable, the joint is installed in a modified movement test stand, deflected to the maximum rated lateral movement and pressurized to maximum rated pressure for 10 minutes.

Major consideration has gone into the development of vacuum, spring rate, movement and burst testing to best simulate end user applications of expansion joints. Achieving all these criteria in-house provides users with reliable results and the highest quality expansion joint possible at a reasonable price. ■

Lindsay Hornbeck is a product engineer for Garlock Sealing Technologies. Hornbeck graduated from Rochester Institute of Technology with a bachelor's degree in mechanical engineering. Hornbeck has been a product engineer at Garlock for five years and specializes in product development of rubber expansion joints.

Nicholas Wheeler is a mechanical engineer for Garlock Sealing Technologies. Wheeler graduated from Rochester Institute of Technology with a bachelor's degree in mechanical engineering. He has five years of experience with Garlock and specializes in the creation of new testing equipment and HMI software.

Ming-Hang Yang is a senior materials engineer with over 10 years of experience in polymer composite. He is also an engineering group lead at Garlock Sealing Technologies, working with his team on product and technology innovations For more information, visit garlock.com.

Navigating Resonance Challenges in Refurbished Pumps

A case study in diagnostic testing and innovative solutions.

KYLE BOWLIN | Hydro, Inc.

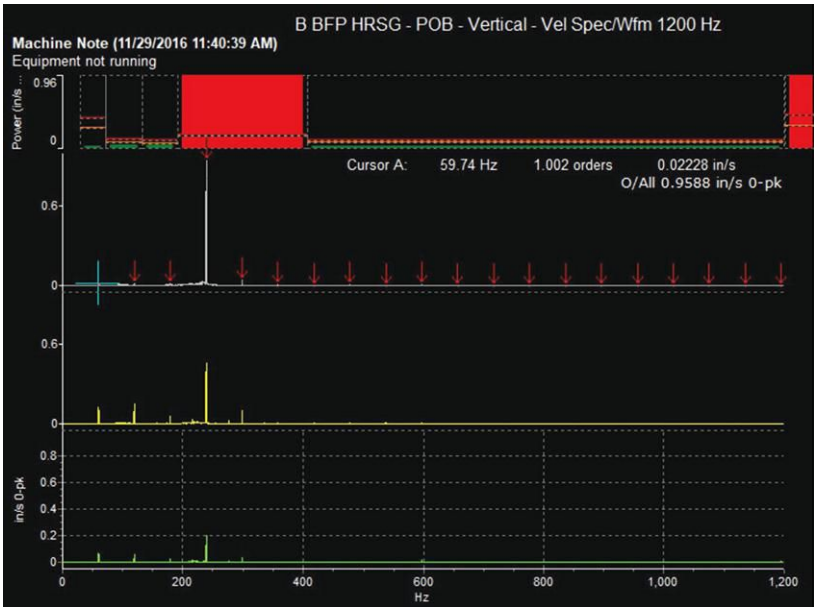

IMAGE 1: Vibration data collected by end user after commissioning (Images courtesy of Hydro, Inc.)

When equipment is sent out for refurbishment, the expectation is that mechanical and hydraulic performance upon reinstallation will be better than what was experienced in the worn condition. This assumption holds true in most cases; however, unexpected behavior can occur after a pump is remanufactured and reinstalled. While it is easy to jump to the conclusion these performance changes were caused by errors made during the repair or installation of the equipment, sometimes the problem is more complex and related to latent weaknesses in the design that had lain dormant until refurbishment.

No pump can be returned to the same condition as when it was first purchased. Although equipment can be returned to "like new" condition, there will always be slight changes in the stiffness and mass induced by the machining and welding processes performed when returning the equipment to optimal operating conditions. While under most circumstances these changes will not have any impact, in a design that is operating on a razor's edge between acceptable performance and the excitation of a resonant condition, these changes can make a world of difference.

It is important to understand a newly refurbished, poorly performing pump may not actually indicate there was a problem with the repair. It is natural to assume the pump should be returned to the repair vendor as a warranty, but this could lead to taking the equipment out of service unnecessarily and not addressing the underlying problem. Taking the time to collect comprehensive field data and perform a robust causal analysis will provide significant long-term benefits by effectively diagnosing the problem and preventing its recurrence.

This scenario was experienced by a power utility in the southeastern United States when they ran into significant vibration increases after one of their boiler feed pumps was refurbished by a local repair shop. Concerned by the level of vibration, the utility reached out to an independent aftermarket service company they had worked with frequently and knew had extensive experience with this application. The aftermarket company had a division dedicated to performing field testing and troubleshooting, which could collect data on the problematic equipment and use advanced modeling tools to understand the nature of the vibration. The field testing and analysis revealed the pump had been operating with a small margin between a structural resonance and one of the pump forcing frequencies. Armed with this information, solutions were developed to increase this margin and return to stable operation.

Initial Testing & Installation Adjustments

The pump in question is a 10-stage axially split opposed impeller boiler feed pump. The first stage impeller has four vanes, and the series stage impellers have five vanes, resulting in two vane pass frequencies—4X rotations per minute (rpm) and 5X rpm. The vibration was measured at 1.0 inches per second (IPS) 0-Peak, with a dominant peak at the 4X frequency (1X vane pass frequency for the first stage impeller). The pump was installed on Unit 2 of the plant and operated as a 100% pump. The sister pump installed on Unit 1 did not exhibit the same high vibration.

Common root causes for high vibration at vane pass for this pump configuration include impact loading of the fluid exiting the impeller and striking the stationary volute cutwater, acoustic resonance in the crossover passage and excitation of a structural resonant frequency. Because the heightened vibration did not exist prior to refurbishment and reinstallation, the most likely cause was a structural resonance. Additionally, the 4X rpm frequency exhibited a body of energy at

the base of the peak and was highly directional, which are both characteristic of a resonant excitation.

The aftermarket service provider's reliability division determined impact testing was the best first step in diagnosing and resolving the vibration issue. Impact testing, or an operational deflection shape (ODS), is typically performed on equipment while it is not running. A calibrated modal hammer is used to impact the structure, providing a quick pulse of broadly based energy. The calibrated modal hammer provides force in, while accelerometers read response out, allowing the field engineer to obtain a frequency response function (FRF). Through this process, the structural natural frequencies can be identified.

Prior to arrival on-site, they were informed all four feet of the boiler feed pump had been torqued to the full torque value during installation. No thermal expansion gib blocks were found on either the Unit 1 or Unit 2 boiler feed pumps. This goes against common practice, where the thrust-end feet are typically allowed to move axially, allowing for thermal expansion as the pump comes up to temperature. The decision was made to impact test the equipment both with the feet fully torqued and with the feet released. Releasing the thrust-end feet would decrease the stiffness of the installation and shift the natural frequencies. The intent of this plan was to determine how much of a softening effect releasing the feet would have on the installation, with the hope it would move operation out of the suspected natural frequency excitation range.

With all four pump feet torqued to the full value, the collected FRFs identified a structural resonance at the outboard bearing housing at 217 hertz (Hz), which has a -9.28% margin of separation from the first stage 4X vane pass frequency of 239 Hz. Best practices maintain a minimum +/-15% margin between forcing functions and natural frequencies to avoid excitation of a resonance. Testing with the thrust-end pump feet released revealed the identified resonant mode shifted to a slightly lower frequency of 207 Hz; this provided a -13.46% margin of separation, which was an improvement, but still not within the recommended +/-15% margin. Comparison impact testing was performed on the Unit 1 boiler feed pump. The correlating resonant mode on this pump was identified at 197 Hz. At a -17.64% margin of separation, this meets acceptable margin criteria and explains why the high vibration condition was not being experienced on the other unit.

The plant decided to install thermal expansion gib blocks and collect vibration data while the pump was running to see how the increase in margin from -9.28% to -13.46% affected pump vibration. This change would have the collateral benefit of ensuring the casing was able to expand as it came up to temperature, mitigating any risk of warping.

After the gib blocks were installed, vibration was recorded as the unit came online. The vibration at the outboard vertical location reduced significantly from approximately 1.0 IPS 0-Peak to approximately 0.35 IPS 0-Peak. While this was a substantial decrease in amplitude, the vibration still marginally exceeded the 0.3 IPS 0-Peak recommended alarm for this size pump.

Modal Analysis & Solution Development

After it was determined that releasing the thrust-end feet did not provide sufficient reduction in overall vibration, the site and aftermarket service company decided

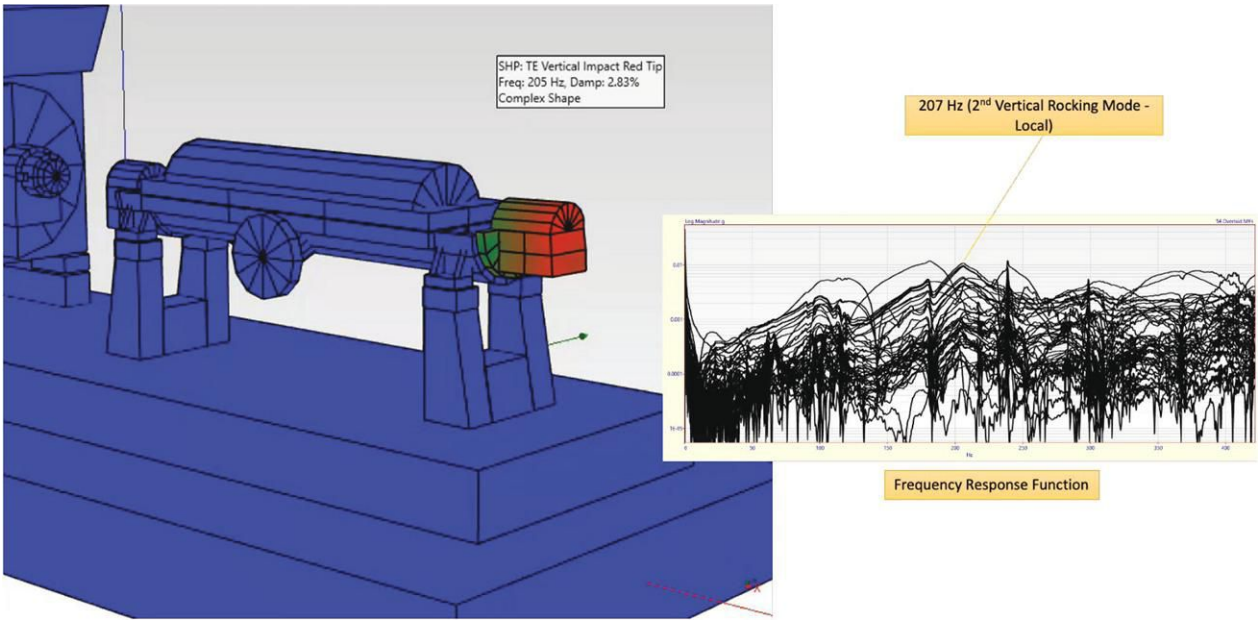

IMAGE 2: Second vertical rocking mode

IMAGE 3: Dynamic vibration absorber with two masses

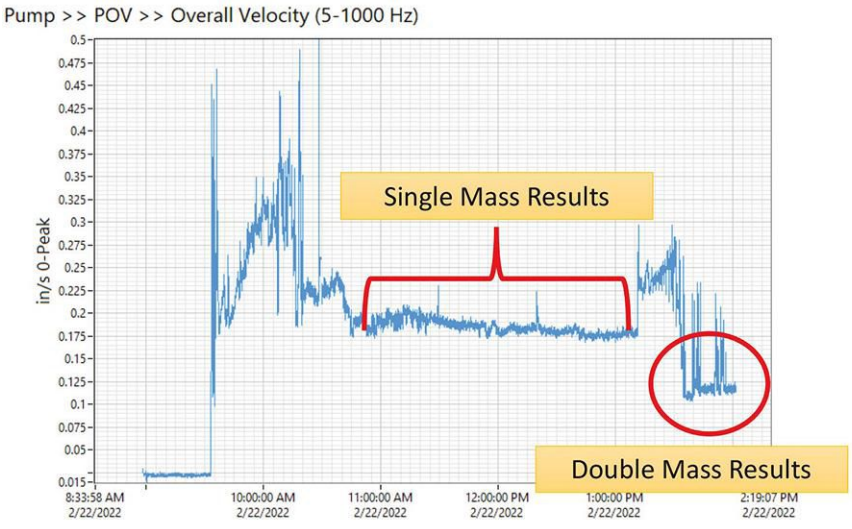

IMAGE 4: Vibration reduction with single mass and double mass DVA

performing an offline modal analysis was the next necessary step. The purpose of this test is to identify the natural frequencies present below 800 Hz and their associated mode shapes, determine each mode's proximity to excitation and understand the damping and amplification properties. The testing was performed by attaching a total of 18 tri-axial accelerometers to the pump casing and bearing housings and impacting the structure with a 3-pound (lb.) modal hammer equipped with a 5,000 pound of force (lbf.) force transducer. The captured FRFs were imported into MEScope Visual Modal software for curve fitting and animation.

Understanding the mode shape of the resonance supports creating the most effective design changes to resolve the problem. In this case, the mode at 207 Hz was an isolated rocking mode, which indicated changes needed to be made directly to the bearing housing, as the entire structure was not participating in the resonant excitation.

Armed with more information on the offending mode, four proposed courses of action were developed. Two of these four options would require removing the equipment from the field. The first of these was to complete a finite element analysis (FEA). Theoretic structural modifications would be applied to the FEA software model to determine what modifications would shift the frequencies out of excitation range without exciting a secondary resonance.

Another option was to redesign the first stage impeller to have a different vane count, removing the 4X rpm forcing function. Neither of these options were pursued, as the site had a strong preference not to remove the equipment unless there were no other viable alternatives.

The options available that did not require removing the pump from the field were to modify the pump in the field by adding mass and designing a dynamic vibration absorber (DVA). It was determined the best course of action was to design and manufacture a DVA.

A DVA works by having an identical natural frequency as the system to which it is mounted but vibrating in an opposing phase. The opposing motions cancel out the resonant amplification. DVAs do require periodic resetting, as the mass attached may move over time and change its natural frequency; however, the successful installation of a DVA would allow the pump to be placed back in service quickly and operate with reduced vibration while a more permanent solution is developed.

The DVA was initially designed and mounted with a single mass. This DVA was able to reduce vibration to 0.2 IPS 0-Peak from 0.35 IPS 0-Peak. A second mass was added to the DVA, which was successful in reducing the vibration down to 0.11 IPS 0-Peak. The DVA was designed to allow removal without having to readjust the mass, facilitating seal and bearing maintenance.

Resonance is a complex problem and can often be overlooked as the cause of vibration problems in cases where an otherwise unproblematic refurbishment or installation shifts equipment into an excitation range. Resolving resonance can be equally complex, as efforts to change the dynamics of an installation or change the forcing function through a new vane combination are expensive and would likely require the equipment to be out of service for a considerable amount of time.

By using a combination of field testing and analytical modeling, a clear picture of the nature of the vibration can be developed and any dormant risks identified. This allows a solution to be developed that is both effective and cost effective, minimizing the investment in time, labor and money to resolve the problem and ensuring the equipment is returned to a safe and reliable operating condition. ■

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Kyle Bowlin is the general manager of Hydro Reliability Services. He is a Level IV vibration analyst with 25 years of experience in troubleshooting rotating equipment. Bowlin may be reached at kbowlin@hydroinc.com. For more, visit hydroinc.com.

Detecting Motor Faults

Learn when it's best to call an expert.

AMY FREY | EDE Electric Motor Testing

Periodic motor testing is a regular occurrence for many plant electricians and electrical and instrumentation (E&I) departments across a multitude of industries. Like many departments within these corporations, the electrical departments have endured staff shortages along with the ever-present business cycle of contracting out maintenance and then bringing it back in-house due to cost constraints.

It is always a balancing act of how much well-trained and capable engineering talent is employed within a maintenance department, along with owning the necessary technology versus what specialized testing companies can offer at a price. As facilities age, motor failures become more frequent, making this issue even harder to balance.

The balance is usually reached with maintenance staff troubleshooting the outage. If their attempts do not eliminate the issue, an expert is called in with more technology to adequately evaluate the motor system and offer guidance on next steps. The example below is an actual case study of the process followed when both plant staff and local contract companies are brought in to solve a critical problem.

IMAGE 1: Variable frequency drive (Images courtesy of EDE Electric Motor Testing)

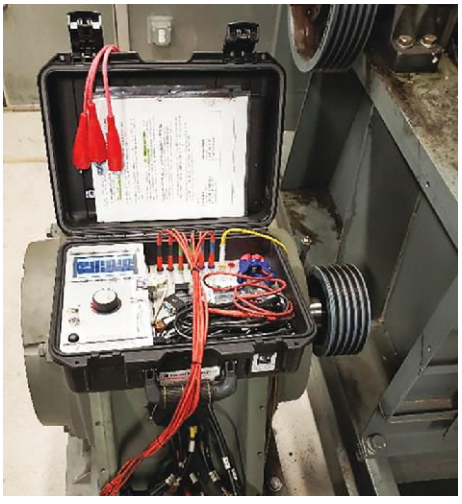


IMAGE 2: Motor test set inside motor room behind pressure doors

Critical Air Handling in a Colorado Medical Campus

In medical facilities, electric motors play a vital role in the inner workings of many departments. From heating, ventilation and air conditioning (HVAC) and lighting to elevators and patient care apparatus, electric motors keep the facilities' main objective—patient care—operating. So, what happens when a problem develops in a system that is vital to the objective? Since the continuous operation of medical facilities is necessary, staff maintenance and electricians are employed to troubleshoot and repair.

In the summer of 2023, a 100 horsepower (hp) motor in the HVAC system at a large medical campus in a major metropolitan area in Colorado developed an issue. This motor was one of four variable frequency drive (VFD) operated motors that drive separate fans for air handling to the pulmonary clinic, allowing for cooling and heating during different times of the year. The VFD tripped off for one of these motors and showed various errors such as ground fault and overcurrent.

Since medical campuses operate 24/7, they have outage windows for maintenance to perform testing and troubleshooting. In July, this outage window is between 5 a.m. and 7 a.m., as this is the coolest part of the day. Since the motors run in a pressurized environment, these two hours are the only time the other three units can be taken offline to allow safe access to the air handling unit by personnel. While three motors can provide cooling to the building, it is not an optimal situation for certain areas such as surgical suites that need to be kept at a low temperature for patient safety.

The morning following the motor trip, an HVAC technician came in with standard electrical tools, including a multimeter and megohmmeter. The motor passed the megohm test, and the multimeter showed balanced continuity and resistance readings. Since the motor seemed to be okay, the culprit appeared to be a faulty VFD. This VFD was replaced, and the system started. The motor and drive once again tripped with the same faults.

At this point, the facility's electricians knew more testing with specialized equipment was necessary. A local testing company came in during the approved time

window and performed diagnostic electrical testing on the motor. This included digital low ohm resistance (DLRO), megohms, direct current (DC) high potential (HiPot), inductance and a surge test.

Electrical Diagnostic Tests & What They Target

Digital Low Ohm Resistance (DLRO): The DLRO, also known as the micro-ohm meter, measures resistance values in micro-ohms at specified currents. Precision DLROs use the four-wire Kelvin resistance method that helps eliminate contact resistance and reduce errors caused by lead resistance.

Megohms: The simplest of motor tests is the megohm test. Also known as insulation resistance (IR), it is used to diagnose breakdown in wire insulation integrity. In the trade, it looks for "grounded" or defective insulation to ground.

DC High Potential (HiPot): Using DC voltage, the DC HiPot tests the dielectric strength of the insulation to ground. This is used to determine if the ground wall insulation is capable of handling an overvoltage situation. It impresses a significantly higher and therefore more rigorous test than the megohm test.

Inductance: A low voltage excitation frequency (and the resulting electromotive force [EMF] measurement) is applied to the electric coils inside the electric motor. It can be used as a reference value, or in the case of three-phase industrial motors, each phase should exhibit relatively similar readings. Large differences between the three readings can be an indication of a "hard" short circuit in a coil or phase-phase.

Surge: The surge test focuses on the copper windings in the motor. Surge testing is a technique to test the dielectric strength of the insulation in windings. It finds voltage dependent faults in turn-to-turn and phase-to-phase insulation. It is depicted on the tester screen by a shift to the left of the waveform.

Testing Results From Fan Motor

DLRO: Showed detectable deviation.

Resistance test 1-2	20.0 °C	25.5 °C	0 … ∞	60.950 mΩ	9.0 s	GO
Resistance test 3-1	20.0 °C	25.5 °C	0 … ∞	53.379 mΩ	9.0 s	GO
Resistance test 2-3	20.0 °C	25.5 °C	0 … ∞	53.830 mΩ	9.0 s	GO
Resistance test deviation	20.0 °C	25.5 °C	0 … 3.0 %	13.2 %	9.0 s	NO GO

Megohm: Passed

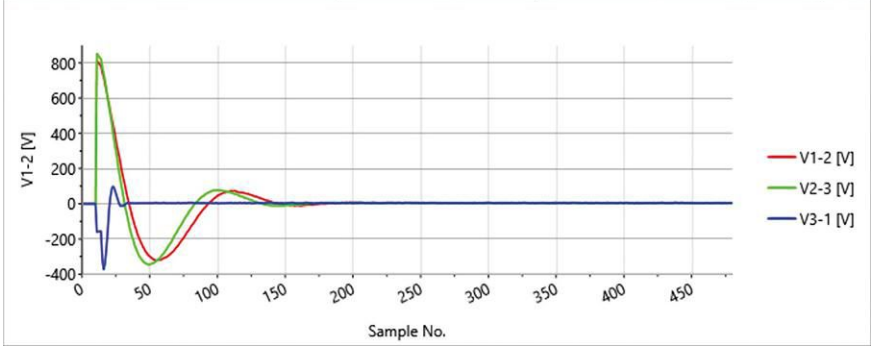
DC High Potential: Passed

Inductance: Showed Deviation

Inductance test 1-2	50 Hz	50 Hz	0 … ∞	18.726 mH	25.0 s	GO
Inductance test 3-1	50 Hz	50 Hz	0 … ∞	342.366 µH	25.0 s	GO
Inductance test 2-3	50 Hz	50 Hz	0 … ∞	16.986 mH	25.0 s	GO
Inductance test deviation	50 Hz	50 Hz	0 … 10.0 %	98.0 %	25.0 s	NO GO

Surge: 100% deviation

Surge voltage phase-to-phase 1-2 <> 3-1	1000 V	813 V	0 … 15.00 %	100.00 %	01:04 m	NO GO
Surge voltage phase-to-phase 1-2 <> 2-3	1000 V	853 V	0 … 15.00 %	100.00 %	01:04 m	NO GO
Surge voltage phase-to-phase 2-3 <> 3-1	1000 V	100 V	0 … 15.00 %	30.41 %	01:04 m	NO GO



Test Results

Three of the five tests showed detectable or high-level deviation. The two tests that passed also provided useful information on the insulation to ground. It allowed the testing engineer to focus on the turn or phase insulation and feel comfortable in the integrity of the ground wall insulation.

At this point, the investigation shifted to the turn insulation and determining the likelihood of a turn-to-turn short in one phase of the motor. Because of the protection programming of the VFD, the fault did not propagate into a hard ground fault. Turn-to-turn shorts cause a circulating current inside induction motors, which can cause a hot spot and has the potential to catastrophically burn down the motor.

Higher quality VFDs have two little-known capabilities. One is they protect themselves from the motor when an issue such as a turn-to-turn short happens, and the second is the VFD will protect the motor from the circulating current that happens when shorts within the windings occur. It does this by tripping the motor off and then gives information to the

The critical nature of some systems will dictate the need to move quickly and fix the issue.

maintenance engineer on what occurred at the time of the trip.

The three tests that showed deviation narrowed down the possible issue significantly and allowed the test engineer to quickly pinpoint the problem. While the DLRO showed a 13.2% deviation within phases, specifically 1-2, the inductance test showed the possibility of a hard short in phase 3-1. The surge test showed issues on all phases but shifted to the left, verifying a shorted 3-1 phase at 100 volts. This information showed the turn-to-turn short in one phase was indeed the cause of the service interruption.

Moving Forward

After all the tests were completed and the results analyzed and reported to the plant electricians, it was decided the motor would be pulled and replaced. After this was completed, the new motor operated according to specifications and allowed the set of four fan motors tasked with keeping the pulmonary clinic cool on hot Colorado summer days to work without incident and without overtaxing any of them.

So, when is it truly the time to call in an expert? Is it when something initially happens or when the equipment owned by the facility or plant is exhausted of capabilities and the problem still exists? Sometimes it might even be better to get a second opinion on work done by plant technicians to verify results that have been accumulated. It simply depends on the situation. The critical nature of some systems will dictate the need to move quickly and fix the issue.

No matter what, the E&I department is tasked with keeping a corporate balance and getting the job done in a timely and cost-effective manner. It is not a one-size-fits-all problem that can be taken lightly or easily solved. Users must balance the needs of the future with the costs associated with keeping critical plant operations running smoothly when it comes to electric motors. ■

Amy J. Frey, MS, is co-owner and president of EDE Electric Motor Testing. With 20 years of experience in working with maintenance professionals through new and existing equipment and services, she uses that base of knowledge to make EDE one of the leaders in electrical testing and equipment repair and maintenance. For more, visit edeinst.com.

A Health Check for Multistage Pumps

Routine maintenance is a critical factor in avoiding pump downtime.

LOYAL FISCHER | KSB

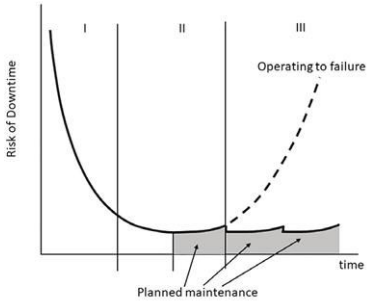


IMAGE 1: Risk of downtime (Images courtesy of KSB)

The Importance of Maintenance

Routine maintenance is critical for rotating equipment and makes economic sense. For most pump applications, running a pump to failure leads to expensive repairs that require more time at the repair shop. If the pump service is critical, like a boiler feed pump, the failed pump may leave the plant at risk for reduced production or complete shutdown. In the case of a power plant, this lost production could result in hundreds of thousands of dollars in lost earnings. Knowing the condition of the plant's pumps allows users to anticipate what pump maintenance is required for optimal operation. If the risk of failure over the life of a pump is considered, the initial installation is the period with the highest risk (phase I in Image 1). However, after successfully commissioning the pump and the system, the risk of failure drops to a low and reasonable level unless the pump is not maintained. In that case, the risk of failure increases with time, putting operations at risk for a pump failure.

Routine Maintenance & Monitoring

Reading and following the OEM's operating and maintenance manual

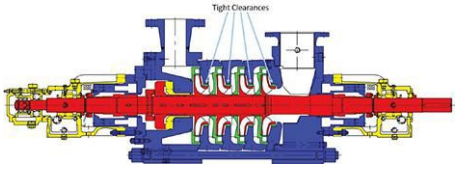


IMAGE 2: Clearances affected by nozzle loads

IMAGE 3: Wireless vibration and temperature monitoring

recommendations is best practice. Proper installation and routine maintenance requirements can be found in a good manual. Manual details include installation requirements for the pump baseplate and systems that support the pump operation, such as forced oil lubrication systems and cooling water requirements. Support for the suction and discharge piping connections is also critical. Loads on the pump nozzle distort the pump casing and can affect alignment. Inside a pump, there are tight clearances between rotating and stationary parts, and nozzle load-induced casing distortion will reduce those clearances even further (Image 2). Even for a pump that has been installed for years, the installation needs to be checked to ensure the piping nozzles still align with the pump nozzles.

Monitoring bearing temperatures and bearing housing vibration level is more than enough for most installations. While shaft position monitoring with proximity probes is great, a simple seismic vibration sensor is sufficient for many installations. Fortunately, many wireless monitoring systems are available if users do not have monitoring systems in place (Image 3).

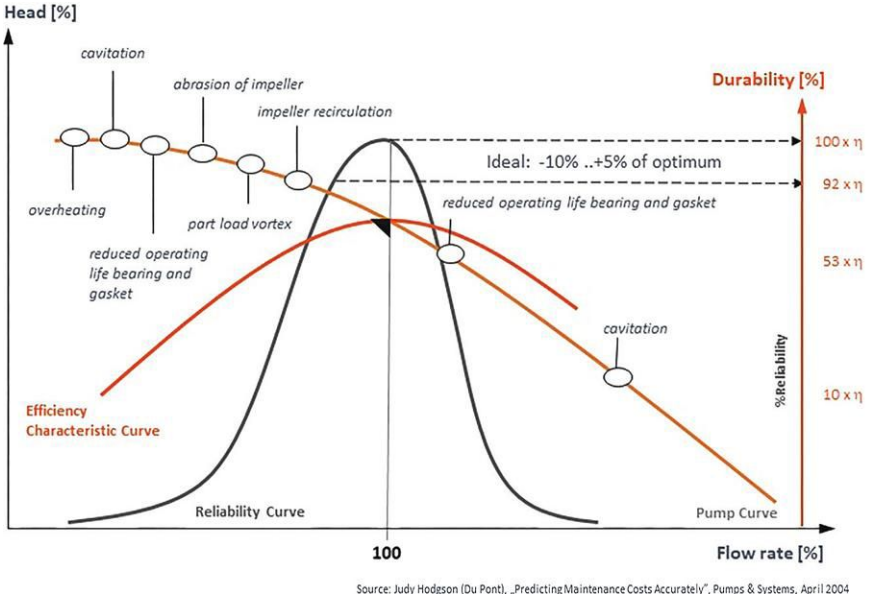


IMAGE 4: Pump risks depending on operating point

Recommendations for routine maintenance are an essential part of the OEM's manual. Maintenance recommendations will often include recommended intervals for checking or changing lubrication. They also include the expected intervals for checking wear parts such as bearings and shaft seals. The manual provides guidelines on the number of hours the pump can be expected to operate before users need to plan scheduled maintenance. However, this recommendation is an estimate for many clean liquid applications. The intervals between needed repairs at a plant will depend greatly on how the pump is operated. Pumps operating continuously at a flow rate close to their best efficiency point may not require a rebuild until well beyond the OEM rebuild interval, which is a conservative average. The other extreme is a pump that operates intermittently at an extremely low flow rate. When pumps operate at these low flow rates, a large percentage of the pump's absorbed power does nothing but create heat and vibrations, which accelerates pump wear and requires more frequent pump rebuilds.

IMAGE 5: Pump data logger

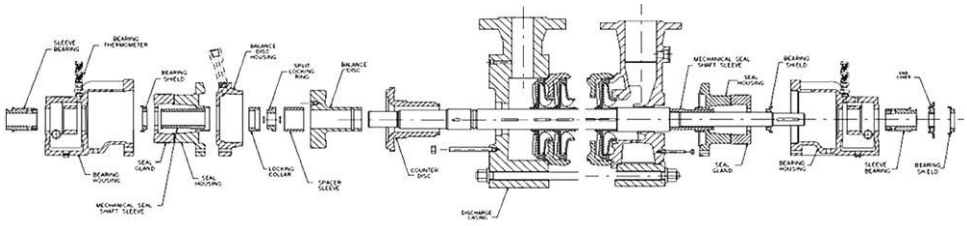


IMAGE 6: Exploded view of a multistage pump

For example, if a pump operates at 50% efficiency, half of the pump input power only generates heat and creates vibrations.

Pump Efficiency & System Interaction

If users have a pump that is operating at extreme part load or suspect that the pump operation may not be ideal, then it is important to understand how the pump is operating in the system.

To see if the pump is being operated in a way that might shorten its life, the key pump performance parameters need to be monitored and compared to the pump

performance curve. This would include pump flow, suction and discharge pressure, inlet temperature and rotating speed. Plotting the actual pump operating points on the pump curve will tell a user where the pump is operating relative to its best efficiency point. This will allow users to determine if the pump's operation is ideal or harsh (Image 4).

Operations with limited pump and system instrumentation or limited pump expertise can look to certain companies for assistance. Some companies have portable dataloggers and personnel who can monitor a system for a period of time, generate a comprehensive report outlining how the pump is functioning and provide possible solutions for optimization.

The Pump Health Check

Monitoring the bearing temperatures and vibration levels is helpful and recommended, but how can users determine when to plan a pump rebuild without sending the pump to a repair shop?

For some pump designs, there is a solution referred to as a pump health check.

The following multistage boiler feed pump serves as an example (Image 6).

A pump health check is a partial disassembly of a pump to check key wear parts, including bearings, shaft seals, balancing devices and the internal wear ring clearance at the impellers (Image 6). The main casing is not disassembled, and it remains installed on the baseplate with the suction and discharge piping connected but isolated from the system. The pump health check is an inspection of the bearings, seal, balancing device and casing wear rings, as well as alignment verification.

Bearings inspection:

The first wear part to be removed in the disassembly are the bearings. Important checks for a sleeve bearing include examining the surface condition of the bearing babbitt. Wiping or adhesion is probably the most common problem for a pump sleeve bearing. Minor wear might be repaired at the site, but it is good to have a replacement bearing available to minimize pump downtime. There may also be side loading concentrations due to shaft misalignment with the driver.

Erosion and abrasion due to oil contamination is also possible. Collecting an oil sample and sending it for analysis is recommended. However, for the health check, the visual examination will tell users if they need to install a new bearing.

In addition to inspecting the bearing, be sure the oil supply and return connections are clean and not blocked by debris.

Seal inspection:

A shaft seal examination should be conducted following the bearings inspection. A visual inspection of the mechanical seal sliding ring faces is important. Seal faces with pitting or groves warrant replacement. Hard particulates can imbed in the softer ring material and score the surface of the hard ring material. Dry running causes adhesion wear. Proper air purging during commission is important to remove air from the seal cavity.

Cavitation wear may occur if the fluid of the seal cavity is too hot. For cavitation damage, users will find the pitting at the atmosphere side of the seal faces. Inspect the cooling or injection systems that keep the seals cool and/or clean.

These systems can sometimes foul or become obstructed and may need cleaning. Lastly, elastomers should always be replaced during a seal inspection.

Balancing device inspection:

The function of the balancing device is critical for a multistage pump. There are two key items that must be checked on a balancing device.

First, the surfaces of the parts that form the clearance between the rotating and stationary parts need to be checked. Light scoring is fine on the flat wearing surface of a balance disc, but deep scoring would necessitate its replacement. Second, the dimensions of the part at the wearing surfaces must be measured. A balancing device is a wear part; the dimensional check will indicate if it must be replaced.

Casing wear rings:

With the partial pump disassembly, users are able to inspect and replace, if needed, most of the important wear parts. However, there is still one important clearance that affects the efficiency, performance and reliability of the pump. That clearance is between the impeller eye and the casing wear ring (S1 in Image 7).

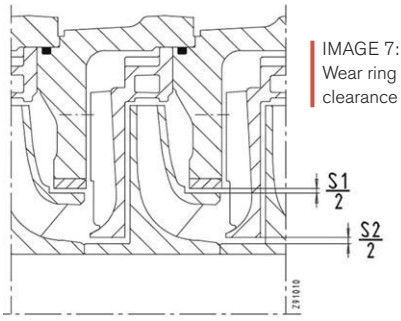


IMAGE 7: Wear ring clearance S1

This clearance has two main functions. The first function is in regard to pump efficiency. This clearance separates the higher pressure discharge side of an impeller from the lower pressure suction side. If an impeller does not have the clearance S1, then there is recirculation flow back to the suction of the impeller, resulting in poor pump efficiency and performance (see Image 8).

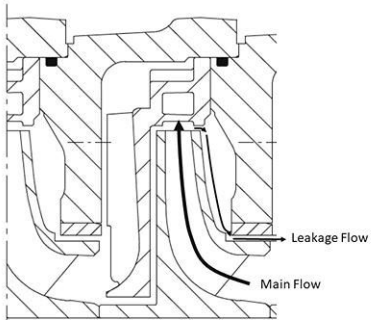
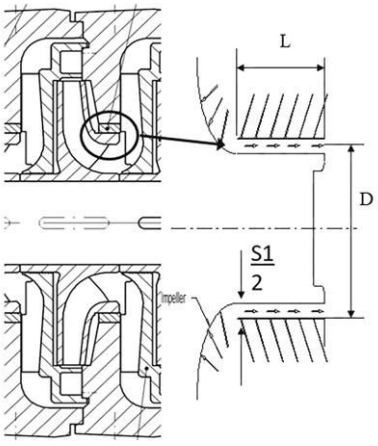


IMAGE 8: Leakage path through the pump wear ring

The second function involves rotor support. This clearance with a pressure differential across it acts like a hydrostatic bearing. For multistage pumps, this can be particularly useful for supporting the rotor against hydraulic and gravitational forces. Known as the Lomakin effect, small increases in the S1 clearance reduce the



$F = K * D * \Delta P * e * (L^2/S1^2)$
e = displacement of impeller from center
K = boundary flow factor
S1 = gap clearance
ΔP = pressure differential across clearance

IMAGE 9: Lomakin Effect

stiffness of these bearings.

Knowing the value of S1 is important for the timing of the pump's rebuild. Although this clearance is inside of the pump, there is a way to check it without disassembling the pump casing. An average indication of this clearance can be determined when

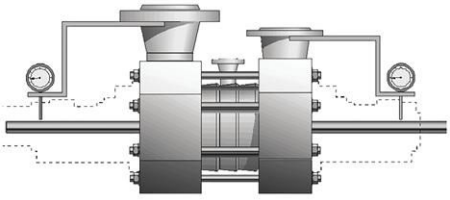


IMAGE 10: Rotor lift to measure wear ring clearance

the bearings, shaft seals and balancing device are removed. S1 is the next tightest clearance within the pump, and it can be measured with a simple rotor lift, as shown in Image 10.

Alignment verification:

Upon reassembly, the pump should be realigned with its driver. The radial bearings are removed for inspection, and when reinstalled, the rotor should be recentered. When this is done, realignment of the pump with its driver should be completed.

Unfortunately, a rotor lift check does not work for every multistage pump, but it works for a good percentage, and it is a great way to help monitor the condition of a pump and plan for its next overhaul.

The time needed for this process depends on the pump. On average, three to four days from the time pump disassembly begins is a good estimate. It is also important to plan ahead and have replacements for the parts being removed and inspected just in case they need to be replaced.

How often should a pump health check be performed? It depends on the operating conditions. If the pump is running in good to ideal conditions, then maybe every two to three years. Operating conditions less than ideal require more frequent inspections. ■

Loyal Fischer is an expert in engineered pumps with more than 30 years of engineering and sales experience. He currently utilizes his industry knowledge and expertise to train through the KSB SupremeServ Academy, in addition to continuing to serve the nuclear power industry and lead pump retrofit projects. Fischer began his career in 1989 at Ingersoll-Rand as an application engineer transitioning to a sales engineer before joining KSB in 1995. Visit ksb.com.

Fighting Corrosion Every Step of the Way

Corrosion will always pose a threat, but it is a threat that can be overcome.

TERRY REYBURN | Rebuild-it, a Sentry Equipment Service

IMAGE 1: Corroded skimmer blade before repair and retrofit services (Images courtesy of Rebuild-it)

Water + metal + oxygen = corrosion. It is an inevitable natural process, especially in wastewater treatment facilities, that threatens the structural integrity and operating efficiency of equipment. When refined metal is in contact with both air and moisture, the combination oxidizes the refined metal, converting it to a more chemically stable form. Unfortunately, for refined metal, a more chemically stable form means deterioration.

No matter how hard users may try, it is impossible to completely prevent corrosion. It is possible to slow the rate at which metal corrodes by considering relevant external influences such as the water's pH level, conductivity, oxygen concentration and temperature, which all play a role in corrosion. However, at some point, equipment will corrode beyond repair.

Just because equipment is corroded does not mean it needs to be replaced. Most of the time, corroded equipment can be repaired and retrofitted, returning it to its best operating state and, in some cases, making it better than before. When corrosion strikes, a repair and retrofit service is often more cost effective and efficient than a brand new purchase.

Understanding Corrosion

A common impact on corrosion is the pH level of the water. pH is a measurement of the activity of free hydrogen and hydroxyl ions in a solution and is measured on a scale of 0 to 14. In acidic conditions (a pH level below 7), certain metals like iron, steel and copper are more prone to corrosion. In highly alkaline environments (pH above 7), corrosion can affect materials such as aluminum and some stainless steels.

Weather conditions also influence local pH levels, like in Florida. Florida's climate is extremely humid and has high water table acidity and high levels of alkali and gases, making projects in the state highly susceptible to rapid corrosion. Knowing the climate and local pH levels can help determine construction protocols. According to experts, wastewater treatment facilities that experience high rates of corrosion should look to install equipment that is manufactured with stainless steel, as opposed to steel, due to its chromium content.

Water conductivity is another important factor that affects corrosion rates. Electrical conductivity, a measure of how well water can conduct electricity, is influenced by the presence of dissolved ions, salts and minerals. In an industry like wastewater treatment, where water has a high concentration of the aforementioned elements, rapid rates of corrosion threaten operation. When metals are exposed to water with high conductivity, ions can move more freely. Corrosion of metals involves electrochemical processes, where metals lose electrons, leading to oxidation. This process can occur more rapidly in a conductive environment because ions can easily transfer between the metal surface and the surrounding solution.

Galvanic Corrosion

Of the many ways corrosion manifests, wastewater treatment facilities are most susceptible to galvanic corrosion. Galvanic corrosion can be defined as corrosion that occurs because of one metal being in electrical contact with another in a conducting corrosive environment. Because wastewater treatment facilities are filled with metal equipment like pumps, valves, drives, skimmers, etc., structural steel treatment tanks serve as prime breeding grounds for corrosion. Although it can manifest anywhere, there are

IMAGE 2: Strengthened and refurbished skimmer blade after repair and retrofit

certain parts of the tank that have a higher probability for galvanic corrosion than the rest of the tank.

The highest corrosion risk in any wastewater treatment plant is the point near the top of the clarifier where air and water meet. The combination of constantly moving metal and oxidation rapidly increases the rate of corrosion, and without proper maintenance, clarifiers could fail at a moment's notice.

To help reduce the rate of corrosion, plant managers should look for clarifiers that are manufactured with corrosion-resistant metals such as stainless steel and aluminum and/or are treated with corrosion-resistant coatings. Another corrosion hot spot is where the skimming device attaches to the metal attached to the feedwell. Again, the constantly moving metal increases the rate of galvanic corrosion and can lead to clarifier failure.

Although corrosion is impossible to prevent, plant operators need to be aware of its effects on operation. Being proactive is imperative, and apathy during routine checks of this equipment can lead to complete plant shutdowns and cost thousands of dollars in fines and repairs.

IMAGE 3: Empty wastewater treatment tank in Bonita Springs, Florida, awaiting treatment upgrades

Repair & Retrofitting

Routine maintenance and proper project planning can extend the life span of operational equipment, but unfortunately, proper planning only lasts so long. If an operations manager finds themselves with a faulty piece of equipment or notices the plant is not operating at peak efficiency, they have some options. The first option available is the purchase of new equipment. This can be an easy process, but it is also the most expensive. Because technology has exponentially sped up the process of innovation, there is always a new product that is better and has more features. Although these innovations promise increased efficiency and smoother operation, they can

often have the opposite effect on plant operations, as they are not catered to the plant's unique functions. Additionally, any new technology comes with new problems to solve, and more training is required. The steep cost of new equipment is compounded with the cost of the time and training required to maximize its potential.

Instead of purchasing new equipment, plant operators can turn to repair and retrofit services for a cheaper, and oftentimes more effective, solution to their equipment woes. Retrofitting is more cost effective than buying new equipment and has the potential to make old equipment function even better than before. Through the benefits of corrosion-resistant coatings, increased welding integrity and technology upgrades, these kinds of services can help plants keep their original infrastructure intact, leading to fewer complications and compatibility issues.

Emergency

Sometimes preventative measures are not enough, and corrosion can spell disaster for wastewater treatment facilities. Treatment facilities are essential to community infrastructure, and without them, millions of gallons of water would pollute local water systems. The Environmental Protection Agency (EPA) imposes heavy fines for plants that are shut down for any number of reasons. In November 2023, the city of Lynnwood, Washington, was fined a total of $550,259 by the EPA for shutting down a sewage incinerator. Plant operators and municipalities want to avoid these types of shutdowns, but should an unfortunate circumstance strike, there are companies that can help get plants back up and running in no time.

Comprehending Corrosion

Corrosion poses some of the largest threats to efficient operation in wastewater treatment facilities, and although it is impossible to completely prevent, understanding how it manifests and how to slow its spread can exponentially extend the life span of equipment. When equipment corrodes beyond function, a new purchase is rarely the only option available. To save time, money and energy, plant operators can look to repair and retrofitting services to help revive their equipment. ■

Terry Reyburn is the founder of Rebuild-it, a Sentry Equipment Service. In his first career job at EIMCO, Reyburn immediately proved himself as a leader and a bar-setter in the aftermarket parts, rebuilds and repairs sector. Eager to take on the next big project, he started Rebuild-it in 2015 to provide comprehensive repair and retrofit services to wastewater treatment facilities across the U.S. Always looking upward, Reyburn continues to assemble a team of exceptional engineers in the market to ensure that Rebuild-it maintains its reputation of efficiency and excellence. For more, visit rebuild-it.com.

Combined Cycle Power Plants, Pump Applications & Boiler Feed Pump Design

An overview of common technologies found in combined cycle power plants.

PETE GAYDON | Hydraulic Institute

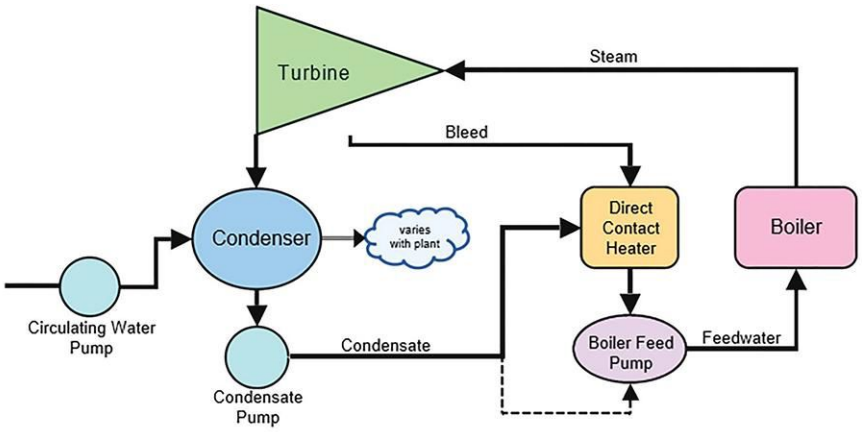


IMAGE 1: Diagram of simple steam power cycle with condensing turbine (Images courtesy of the Hydraulic Institute)

Application	Typical Pump Types (not exclusive)	Fluid	Applications Consideration
High-Pressure Boiler Feed	Multistage: • between bearing axially split • between bearing radially split ☆ single casing ☆ double casing	Treated water up to 350 F	• supplies high pressure and temperature water to boiler • high head, flow and power • load swings • net positive suction head (NPSH) margin considerations
Boiler Circulating Water	• overhung centerline mounted • overhung sealless • between bearings radially	Treated water up to 675 F	• circulate water within the boiler to increase efficiency • high suction pressure and sealing
Boiler Fill Pump	• vertically suspended double casing diffuser	Treated water up to 300 F	• moves collected condensate from heaters back into feedwater cycle • low NPSHa/NPSH margin • high temperature and pressure
Condensate	• vertically suspended double casing diffuser or volute	Treated water up to 120 F	• supplies condensate to heaters or boiler feed pump • low NPSHa/NPSH margin • vacuum suction pressure • load swings
Circulating Water	• vertically suspended single casing diffuser ☆ mixed or axial flow • between bearings axially split • overhung vertical end suction	Cooling tower, river or lake, salt or brackish water	• circulates large quantities of water through the condenser • high flow and low head • abrasives depending on source • corrosion depending on source • proper intake design

The demand for electricity is increasing due to the growing population and the electrification of motor vehicles and home heating. Renewable energy is a growing share of the power generation pie, accounting for about 22% of all U.S. production in 2022, according to the U.S. Energy Information Administration. This leaves about 60% of U.S. electricity being generated in fossil power plants and 18% in nuclear power plants, which will continue to serve a large percentage of demand for the foreseeable future.

Legislation has imposed stringent emission controls; therefore, many coal-fired power plants have been retired due to the cost of complying, and newly constructed fossil plants are overwhelmingly combined cycle power plants (CCPPs). CCPPs primarily use natural gas as fuel and can better meet emissions requirements. To keep up with increasing demand and reduced emissions targets, improving power plant efficiency is a very relevant issue, which is supported by applying the appropriate pumps and optimizing pump systems within these plants.

Combined Cycle Power Plant Overview

CCPPs generally consist of multiple gas turbines, which burn natural gas. The gas turbines drive electric generators serving as a portion of the plant's megawatt (MW) generation. CCPPs also include steam turbine generators that utilize heat recovery from the gas turbine combustion to generate steam. The heat recovery steam cycle increases the efficiency of CCPPs and reduces the emissions compared to other fossil generation plants.

Other than combustion, pumps are the primary source of energy in the steam cycle. Image 1 illustrates a simple steam

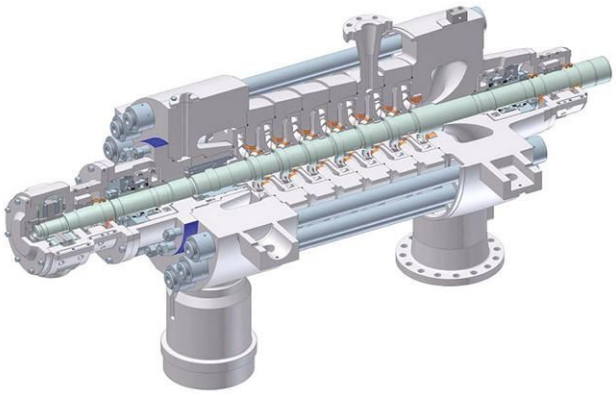


IMAGE 2: Between bearings, multistage, radially split, single casing pump (BB4)

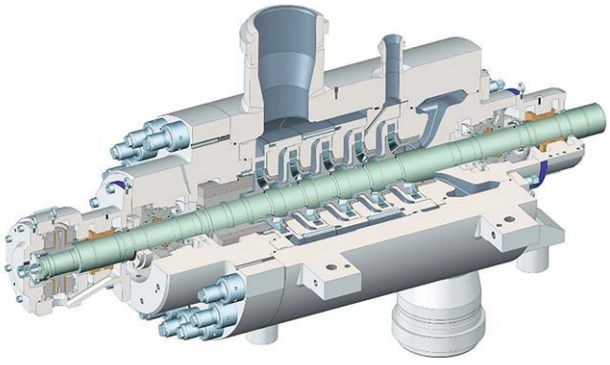


IMAGE 3: Between bearings, multistage, radially split, double casing pump (BB5)

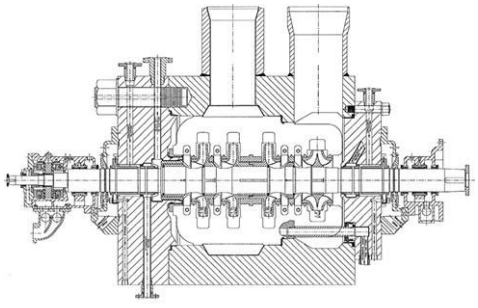


IMAGE 4: Between bearings, multistage, radially split, double casing, volute type pump with opposing impellers.

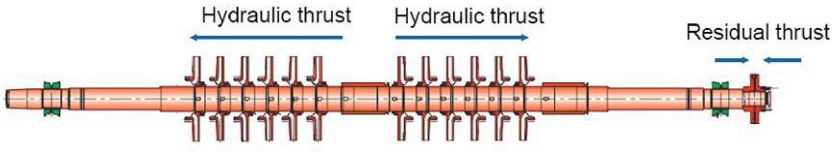


IMAGE 5: Depiction of thrust offsetting with opposing impellers

generation cycle. Condensate is pumped to a heater, and then the boiler feed pump (BFP) forces the water into the boiler at high pressure, where it transitions to high-pressure steam. The steam then drives a steam turbine generator, and finally, the circulating water pump forces large quantities of water through the condenser, which condenses the steam back to water so the cycle can continue.

Pump Application Overview in Combined Cycle Power Plants

A CCPP will typically operate at several load points throughout a 24-hour cycle and may be called on to change load rapidly. When the plant operates at less than full load, the pumping systems will be impacted. Pumps should be selected/specified and controlled to meet the different load points while maintaining optimum plant efficiency and reliability. For operation at reduced load, speed control should be used, when possible, to maintain operation of the pump within the preferred operating region. If load swings are such that the flow rate to the boiler goes below the pump's minimum flow, a minimum flow bypass line of sufficient size is required to allow the pump to operate reliably.

The pump applications within a CCPP can be divided into main service pumps and auxiliary service pumps. There are up to seven pump applications in the main service category and up to 12 pump applications in the auxiliary service category. It should be noted that Image 1 provides a narrow view of pump applications.

Applications within the main service category are listed below with some basic application information and considerations. As noted, the application considerations vary; therefore, the pump types, sizes and configurations will be application specific. The Hydraulic Institute's Guidebook Power Plant Pumps: Guidelines for Application and Operation goes into full details on all the applications listed, as well as the auxiliary service applications. Within this article, the high-pressure boiler feed application is further discussed.

Boiler Feed Pump Types & Select Design Features

BFPs are the largest pump type with respect to energy used in a power plant. This is due to the high boiler pressure and the large volume of steam that must be generated in the boiler. The boiler pressure can be 3,000 pounds per square inch (psi) or more, which requires a heavy-duty multistage pump that has been designed for this challenging service. In larger CCPPs with higher pressure boilers, the BB4 and BB5 pump types are typically used.

Illustrated in Image 2, the BB4 type is a between bearing, multistage, ring section pump. In this pump type, the sections include an impeller, diffuser and crossover to direct the flow to the next impeller stage. Sealing is accomplished radially by compressing the sections with tie rods under tension. The number of impellers can be increased within limits to accommodate higher pressure requirements.

Illustrated in Image 3, the BB5 pump is like the BB4, but it is a double casing design and is often referred to as a barrel pump. Note there is a similar impeller, diffuser and crossover to the next stage, but in the BB5 these hydraulic components are within an outer casing (barrel). This results in pressure containment with a single high pressure radially split sealing joint, which enables the BB5 to be used in the highest-pressure applications.

The BB4 and BB5, shown in Images 2 and 3, are both multistage pumps with in-line impellers configuration. The in-line

configuration results in additive axial thrust from each impeller. To deal with the axial thrust, a balance drum or disk is used to offset the load, and a thrust bearing supports the residual load. An alternate design to offset the axial load includes opposing impellers, and is available in the BB5 volute type pump in Image 4. In this pump, flow enters on the right side before going through the first two in-line stages. Then, flow crosses over to the third stage on the left side before entering the fourth stage prior to discharging. The offsetting of the axial thrust is depicted in Image 5, which shows the residual load being carried by a thrust bearing. When a rotor is configured with the opposed impeller design, changes in axial thrust overdue to wear in clearances results in smaller residual thrust changes, allowing a smaller thrust bearing to be selected.

Another important design consideration is the pump's net positive suction head requirement (NPSHr). NPSHr is specific to the first stage impeller, so it is common for the first stage impeller to be a different design than the rest, optimized for NPSHr. The volute type BB5 pump in Image 4 depicts this the clearest, where the first stage impeller is a double suction type that splits the flow to each eye resulting in lower NPSHr.

There are no fixed rules for selecting the pump type for the specific power plant application, and the length of this article only allowed room to highlight a single application and cover limited design considerations. Other important design considerations include materials of construction, shaft sealing, bearing design, lube oil systems, coupling, driver and the pump base and support. For additional information and guidance on pump applications in power generation, applicable pump types and design and application considerations, users are encouraged to refer to Power Plant Pumps: Guidelines for Application and Operation. ■

Pete Gaydon is deputy executive director of the Hydraulic Institute. He may be reached at pgaydon@pumps.org. For more information, visit pumps.org.

How to Improve Cooling Tower Efficiency

Considerations in fan design and mechanical drive systems.

SCOTT SMITH | Motion

Cooling towers are some of the most cost-effective cooling systems today. They remove unwanted heat from water by bringing cool air and warm water into contact, transferring or rejecting the heat via evaporation.

Wet and dry cooling towers differ in how they remove heat. Most cooling towers are wet, while air-cooled heat exchangers are dry. However, both designs use an axial fan to move air inside the tower, feature a covering to contain the fan and funnel the air into the fan and have plenums (specific spaces) to direct the air, allowing the heat to be transferred by direct or indirect contact.

Cooling towers are categorized as either crossflow or counterflow towers. In crossflow towers, the water and the air move almost perpendicular to each other, while in counterflow towers, the water and air move in opposite directions. In addition, cooling towers can be classified as induced-draft or forced-draft towers. In induced-draft towers, the fan, commonly at the top of the tower, pulls the air through the tower's fills. Conversely, in forced-draft towers, the air is pushed toward the fill media from the tower's base.

Cooling tower mechanical upgrades can significantly improve efficiency while increasing reliability and performance. Investing in fan and drive system upgrades can lead to major energy savings, reduce maintenance costs and extend the cooling tower's life span. In this discussion, we will focus on three mechanical improvements:

1. Energy reduction through fan efficiency
2. Gearbox drive efficiency
3. Extended equipment life

Energy Reduction Through Fan Efficiency

System efficiency is one of the best ways to reduce energy costs and increase airflow for the cooling system to run at its best. Fan design should not be based on a "one size fits all" concept but rather a carefully designed airfoil custom-built for the cooling tower's specific duty conditions. A low-drag airfoil shape designed with features such as high-blade twist, wide-chord width and superior finish will result in high efficiency levels.

The most efficient blade designs feature a seamless, hollow construction to ensure durability. They are made from lightweight, corrosion-resistant materials such as fiberglass-reinforced plastics from polyester or epoxy resin, depending on the application. The lightweight designs ensure a low moment of inertia, reducing wear and stress on the cooling tower's motor, bearings and drive system.

Ultimately, a properly designed cooling tower fan with the design features outlined above will provide more air flow with less power consumption than the typical metallic fan blades supplied by many cooling tower manufacturers. It is common to realize power savings of 10%-40% with custom-designed blades.

Improved Drive Efficiency

Cooling towers come in all shapes and sizes and can utilize several forms of power transmission, including gear, belt and direct drives. Our focus will be on large-capacity cooling towers that require lower fan speeds and higher torque.

The most common method used in these larger towers is a mechanical gearbox, with a high-speed input from an electric motor that sits outside the turret and is connected via a drive shaft to the gearbox input shaft. The gearbox's output shaft, which sits vertically, is directly coupled to the fan blade. These gearbox systems are supplied in various frame sizes in primarily single- and double-reduction configurations. Horsepower (hp) and reduction ratios vary depending on the drive size. Typical horsepower capacities range from 7.5 to 150 hp, with ratios varying from 5:1 to 70:1.

Cooling towers come in all shapes and sizes and can utilize several forms of power transmission, including gear, belt and direct drives.

Cooling tower gearboxes are needed to drive the cooling tower fan blade, which develops airflow through the tower—introducing an exchange of heat. The fan drive application is often exposed to extreme environmental conditions with large temperature swings, moisture, chlorine and chemical exposures—depending on the tower's design.

In the fan drive application, the gearbox's output shaft is connected to the fan blade, typically in a vertical position. This creates a heavy thrust load on the shaft and increases the exposure of the output shaft seal to moisture and contamination. Heat loads on these gearboxes can be large, often requiring cooling fins in the gearbox housing to dissipate heat faster.

Key features improving drive efficiency

- Robust gearbox design with:
  - » Pumpless lubrication in which oil is delivered to all locations using an oil slinger with an oil management system
  - » Heavy casting to reduce noise and vibration
  - » Vertical cooling fins in the housing to maximize thermal performance
  - » Quality bearings—roller or tapered—sized to exceed minimum L10 life as the American Gear Manufacturers Association specifies
  - » Double radial lip seals or mechanical seals to prevent oil leaks and reduce contamination
  - » Marine-grade or epoxy paints to withstand moisture and chemical exposure to the housing
- Proper gearbox mounting to eliminate vibration that can lead to bearing and gear tooth damage
- Proper coupling and shaft alignment to reduce vibration and shaft loading, which can lead to premature bearing failure
- Proper lubrication to reduce scaling, galling and high temperatures that can lead to gear and bearing failure

Extended Equipment Life

As is the case in most mechanical drive systems, there are plenty of opportunities to extend drive life and reduce downtime by paying attention to the simple things. One challenge with cooling tower fan drives is that the drive is not easily accessible, resulting in an "out of sight, out of mind" mentality. A preventive maintenance plan is the best way to mitigate unscheduled downtime and cooling tower failure.

Here are some proactive steps that can prevent unnecessary downtime costs:

- ***Vibration analysis:*** Consider installing permanent vibration sensors that provide real-time, remote vibration data. Monitoring for trends can identify issues before failure occurs.
- ***Regular lubrication and oil analysis during scheduled outages:*** Check for leaking seals, ensure proper lubrication levels and periodically analyze fluid for contaminants and wearing of internal materials.
- ***Proper choice of lubrication:*** Consider synthetic lube oil over petroleum-based lube oil for longer changeout intervals and higher heat loads. Work with your gearbox supplier for the optimum lubrication choice.
- ***Proper repair:*** Partner with an experienced repair provider to ensure that quality bearings, seals, materials and craftsmanship are used.

Other factors can affect overall cooling tower efficiency, such as feed water quality, water circulation and chemical usage. However, focusing on fan design and the drive system will provide the largest increase in efficiency and the quickest return on improvement investment. ■

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For more on making your system more efficient, visit **pumpsandsystems.com/tags/efficiency.**

Scott Smith is division manager – West Shops at Motion. A certified fluid power specialist, he has over 35 years of experience in the fluid power and industrial distribution business, including more than 12 years with Motion. Smith holds a degree in manufacturing engineering from the Oregon Institute of Technology. For more information, visit motion.com.

Binder Transfer in Paint & Coatings

Sealless eccentric disc pumps provide low shear, CIP and high volumetric efficiency for binder transfer.

PAUL CARDON | Mouvex

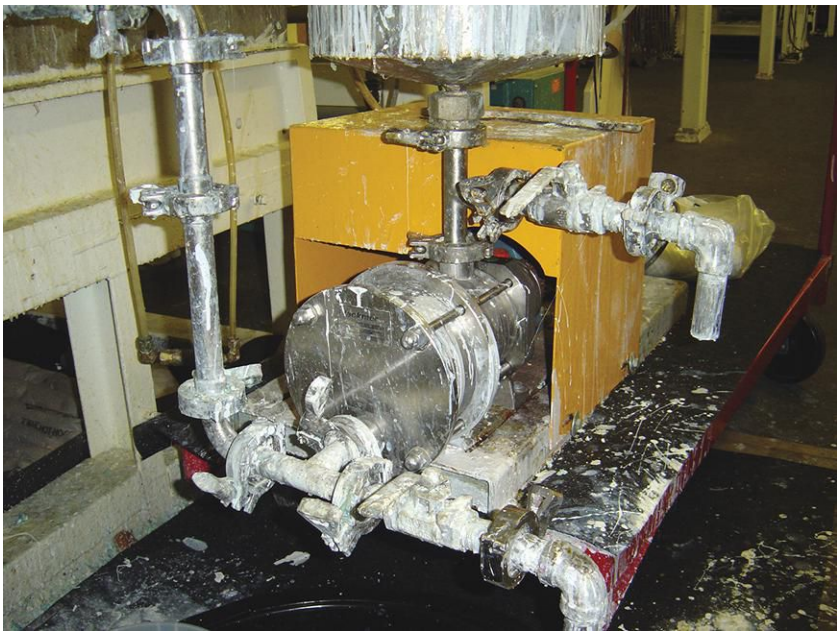

IMAGE 1: An eccentric disc pump in use (Images courtesy of Mouvex)

The Challenge

A paint and coatings plant that produces both cationic paste with pigments and cationic binders without pigments for truck shipment to automotive OEMs experienced difficulties when transferring the compounds from mobile tanks to trucks.

In particular, the types of pumps that were being used were incapable of totally draining the pipes, hoses and mobile tanks used in the process, leading to wasted time and materials, as well as an increase in the probability of leakage occurring.

The trucks are loaded with cationic binders from mobile tanks, meaning frequent human involvement, so the plant operators were looking to upgrade to a style of pump that would make the overall operation cleaner and more efficient.

Because of the specific types of binders that are handled, as well as the operators' requirements for clean, time-sensitive performance, a versatile pump needed to be incorporated—one that is sealless, provides low shear, clean-in-place (CIP) capabilities and high volumetric efficiencies.

The Solution

The plant selected a new pump that featured eccentric disc technology. Four years after installation, the pump continues to optimally operate. The key to its operation is the pump's ability to drain the inlet hose, mobile tank and outlet pipe completely at the end of the loading process. Additionally, this pump does not have a mechanical seal, so product leakage does not occur.

A sealless eccentric disc pump proved ideal for this application because of these important design benefits:

- Sealless design in which there are no mechanical seals, magnets, rubber or polytetrafluoroethylene (PTFE) diaphragms
- Low-shear handling of products with low slip, lower internal velocities and ultra-low agitation
- CIP capability that allows the pump to be completely drained, flushed and cleaned without disassembly
- High volumetric efficiency that is able to maintain a constant flow rate at a given viscosity throughout its pressure range
- Good compression performance and the ability to run dry (up to 10 seconds) enabling excellent self-priming capabilities and complete line stripping of suction and discharge lines
- Self-adjusting operation that maintains delivery/pressure performance over time through the use of a self-adjusting disc/cylinder

Because of the last characteristic, eccentric disc pumps can also be used as dosing pumps (Image 1). Since the pump is automatically self-adjusting, it maintains great efficiency and repeatability over time.

The Technology

Eccentric disc pumps consist of a cylinder and pumping element mounted on an eccentric shaft. As the eccentric shaft is rotated, the pumping element forms chambers within the cylinder, which increase in size at the intake port, drawing fluid into the pumping chamber. The fluid is transported to the discharge port where the pumping chamber size is decreased. This action squeezes the fluid out into the discharge piping.

Operating Principle

Eccentric disc pumps typically have a shear rate of sec-1 = 0.9 rotations per minute (rpm), which is lower than other types of pumps used in paint and coatings applications. This is due in part to the gentle, low-velocity action of the disc and cylinder and the extremely low slip rate of the pump.

Eccentric disc pumps do not have required clearances that can cause slip, which is the portion of the pumped

product that is forced back to the suction side of the pump due to pressure through the clearances.

In these pumps, the discharge pressure exerts itself against the eccentric disc in a way that assists in maintaining axial contact with the cylinder, thus mitigating the usual effect that discharge pressure has on slip in pumps. It is this low slip between the disc and cylinder that gives the pump the ability to self-prime and line strip.

Eccentric disc pumps are typically capable of handling viscosities of up to 10,000 centipoise (Cp), working pressures up to 130 pounds per square inch (psi) (9 bar), capacities of 4 to 158 gallons per minute, operating temperatures up to 176 F and a particle-size range of 1 to 3 millimeters.

Regarding CIP technology, some eccentric disc pumps hold 3A Approval Certification and are designed per European Hygienic Equipment Design Group (EHEDG) specifications to be flushed and cleaned in place.

When installed for CIP operation, eccentric disc pumps experience no loss of performance due to vertical drain porting. When cleaning, pressure is introduced to the back of the eccentric disc through the pump chamber (Image 2). When the flush pressure overcomes the spring, the disc moves away from the cylinder, allowing the cleaning solution to pass through the pumping chamber. This feature allows a relatively large volume of cleaning fluid to sweep through the pump, providing a thorough cleaning and often eliminating the need for bypass piping for the CIP mode.

Regarding maintenance, eccentric disc pumps consist of few parts. The cylinder-disc assembly can be replaced without disturbing the suction piping or drive components.

Eccentric Disc Technology vs. Others

Because of these characteristics, eccentric disc pumps are able to supply important benefits that pumps traditionally utilized in the paint and coatings market sector may not be able to provide.

- *Air-operated diaphragm (AOD) pumps:* AODs have traditionally been the pump of choice in the paint and coatings market because of their low initial purchase cost. However, some types of AOD pumps are inefficient and require high maintenance, increasing their total cost of ownership.
- *Gear pumps:* These are the second-most popular pump choice behind AODs due to their capability of handling higher viscosity ranges. The weaknesses of gear pumps include excessive seal leakage, inability to self-prime, a flow rate that is jeopardized when wear begins and high internal velocities that affect fluid dynamics. This leads to shear and clearances that result in slip as pressures increase and viscosities decrease.
- *Centrifugal pumps:* The primary drawback of centrifugal pumps is their high rate of slippage. Centrifugal pumps typically have lower efficiencies than eccentric disc pumps.
- *Lobe pumps:* Lobe-type pumps perform like gear pumps, meaning they have many of the same drawbacks that gear pumps have. Also, the need to seal two shafts doubles the expense of seals and the potential for leakage.

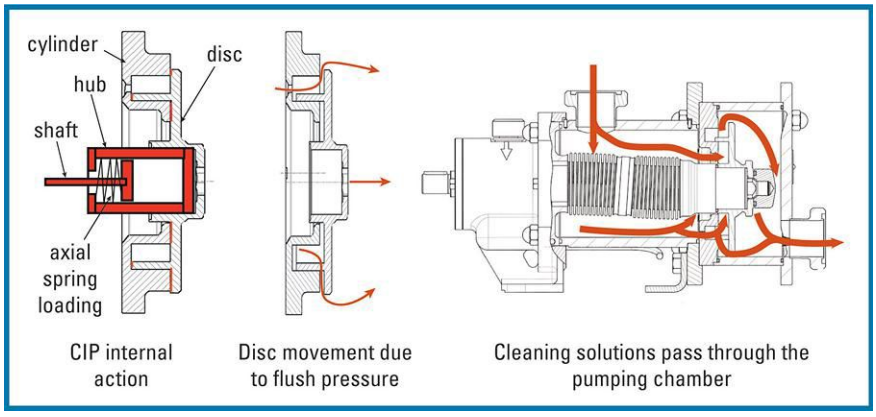

IMAGE 2: Movement and flow for CIP

A final benefit of the eccentric disc pump is its ability to be used in many applications. In the paint and coatings industry, that could include the pumping of pigments, resins, solvents and additives. These capabilities help make eccentric-disc technology a great solution to addressing pump seal, suction, product shear and volumetric efficiency concerns.

Through the incorporation of such benefits as leak-free operation and line-stripping capabilities, the eccentric-disc principle makes the pump extremely flexible, allowing the pumping of low-viscosity, high-viscosity and highly abrasive materials within a single process, all with the same pump. This makes the eccentric disc pump not only a longer-lasting, more efficient piece of equipment, but a multitasking one as well—and possibly the answer for many difficult pumping applications in the paint and coatings industry. ■

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For more on coatings, visit pumpsandsystems.com/tags/coatings.

Paul Cardon is the product manager for Mouvex and PSG. He may be reached at paul.cardon@psgdover.com. Mouvex is a product brand of PSG, a Dover company. For additional information on PSG, please visit psgdover.com.

Pumping Liquid Hydrogen for Industrial & Transportation Applications

Liquid hydrogen will play a pivotal role in the ongoing energy transition.

RICHARD LONG |
Flowserve

As the world accelerates toward an energy transition, it has become clear hydrogen will play a key role in decarbonizing hard to abate industrial and transportation applications.

Hydrogen is the most abundant element in the universe and, when produced from water by electrolysis using green electricity, is a totally clean energy source. While batteries have the potential to be the new gasoline, hydrogen could well become the next diesel. Unlike carbon-based fuels, hydrogen produces no harmful byproducts upon combustion. Only power, heat and clean water are produced when hydrogen is combined with oxygen in a fuel cell.

As liquid hydrogen is much denser than gaseous hydrogen, it allows for more hydrogen molecules, i.e. energy, to be stored by volume. Pumping liquid hydrogen is also more efficient than compressing gaseous hydrogen for several reasons, the most significant being the reduced energy losses due to density changes during the heat of compression.

However, the gains from using liquid hydrogen do come with their own set of challenges, particularly the energy costs and inefficiencies associated with liquefying the hydrogen in the first place and then turning it back to electricity while maintaining the low temperatures needed to keep the hydrogen in a liquid state.

1 Safety

Liquid hydrogen leaks easily, is inflammable but vaporizes easily and when combined with the oxygen in the air, it ignites easily and burns with a near invisible flame. As gaseous hydrogen is lighter than air, it will rise quickly and disperse and does not pollute the ground or groundwater. Due to the deep cryogenic temperatures (-253 C/-423 F) involved in handling liquid hydrogen, care must be taken to ensure there is no direct skin exposure to any uninsulated equipment. Liquid hydrogen must be stored in well-insulated, double-walled containers to maintain low temperatures and prevent boil-off, reducing the risk of leaks or explosions associated with high-pressure gas storage.

2 Materials

Hydrogen can cause embrittlement in common industrial pump materials like carbon steel, leading to cracking and reduced mechanical integrity over time. As such, it is recommended to use 300 series stainless steels or more noble alloys for liquid hydrogen applications for all the wetted parts. In certain applications, aluminum can be used but requires special care due to its potential susceptibility to hydrogen embrittlement at high temperatures and pressures. It is important to consult with materials engineers and experts familiar with hydrogen-related challenges when considering both metallic and non-metallic parts for these applications.

3 Rotor Dynamics

Liquid hydrogen is light, with a relative density of only 7% that of water. It has low viscosity and, as a result, low pressure drop across any close clearances within the pump offering limited “Lomakin” support.

Designing centrifugal pump rotors for service in liquid hydrogen presents unique challenges, primarily due to the specific properties of liquid hydrogen. One of the primary concerns is the relatively low stiffness developed in the close clearance seals, commonly referred to as the Lomakin Effect. The Lomakin Effect arises when there is a hydrodynamic force in the thin film of fluid between the rotor and the stator. In the context of liquid hydrogen, the low viscosity and density of the fluid create high fluid velocity and relatively low-pressure drops, minimizing the Lomakin Effect and making the rotor more susceptible to vibrations and potential damage.

4 Pump Selections

Low- and medium-pressure applications will most often utilize specially

The Lomakin Effect arises when there is a hydrodynamic force in the thin film of fluid between the rotor and the stator.

designed single or multistage cryogenic submerged motor pumps like those serving the liquified natural gas industry.

The anticipated release of new modular axial field integral motor pumping systems with individual stage speed control and no axial thrust compensation requirement will offer significant potential benefits as the technology matures. As with any centrifugal pumping application, ensuring operation at or near best efficiency point (BEP) is key to ensure reliability and optimum total cost of ownership.

As liquid hydrogen has such a low mass, it requires pumps to generate high heads to create any significant pressure. In practical terms, this will necessitate positive displacement pumps or high speed multistage centrifugal pumps above approximately 10 bar.

For higher pressures, positive displacement piston pumps specially adapted to seal the ultra-cold cryogenic liquid hydrogen are used. These pumps can be driven by motor/crank or hydraulic actuation.

5 Heat Generation

A primary concern in liquid hydrogen applications is the addition of heat to the fluid and consequential vaporization, leading to boil-off gas losses and higher potential for rotor instability and leakage.

Centrifugal pumps, when used for liquid hydrogen, present thermal challenges. Compared to positive displacement pumps, centrifugal pumps are generally less hydraulically efficient. This reduced efficiency translates to energy being imparted to the hydrogen in the form of heat. Additionally, the compression of the fluid inherently generates heat, elevating the temperature of the liquid hydrogen being pumped.

These thermal effects are cumulative, and given the proximity of operation to the vapor dome, there is a tangible risk of the liquid hydrogen vaporizing. Such vaporization not only introduces rotodynamic instability in the pump, but also impacts the economic viability of the process. The resultant boil-off gas collected and vented represents a loss in efficiency and profitability. As the fluid is compressible, the application engineer will also have to consider the potential increase in temperature through the pump due to the heat of compression.

6 Net Positive Suction Pressure

With its low density, liquid hydrogen has a reluctance to flow into the eye of the first stage or through the suction valve of a reciprocating pump. As such, the application will always require a sufficient net positive suction pressure to ensure reliable operation and no vapor locking. As the fluid is compressible, the application engineer will also have to consider the potential increase in temperature through the pump due to the heat of compression.

7 Sealing

Polytetrafluoroethylene (PTFE) elastomers are used to prevent leaks at joints and static connections. For sliding surfaces, resilient metal seals or specialty seals pre-loaded by metal springs will provide both reliable static and dynamic sealing under cryogenic conditions. At higher pressures, suitably rated cone and thread fittings should be utilized.

8 Testing

Due to the relative lack of equipment experience in new liquid hydrogen pumping applications, it is critical that equipment be thoroughly cryogenically tested for safety, performance and reliability in the liquid hydrogen environment.

Liquid hydrogen can be safely and efficiently pumped to support the growing list of use cases in the ongoing energy transition. Special care and attention need to be taken on pump design, selections, materials, operating conditions and sealing to ensure safe and reliable operation. ■

Get More Info

P&S

For more on pump selection, visit **pumpsandsystems.com/tags/pump-selection.**

Richard Long is a pump industry veteran with over 30 years of experience with Flowserve and its heritage companies. Long is currently the director of hydrogen pumping systems for Flowserve. For more information, visit flowserve.com.

Lessons From the Space Shuttle Challenger Disaster, Part 2

The importance of valve packing loading precision.

RON FRISARD |
Fluid Sealing Association member

IMAGE 1: Space shuttle Challenger takeoff (Images courtesy of Fluid Sealing Association)

Part 1 of this article ran in the February 2024 issue of Pumps & Systems.

The Importance of Valve Packing Loading Precision

Excessive gland load on valve packing bolts gives rise to three primary issues:

- *Bending of glands*
  Stress on the bolts can cause the gland to bend and distort, compromising its perpendicular alignment to the stuffing box. This distortion impedes the gland follower's free movement into the stuffing box, resulting in load loss and failure.

- *Bent stems*
  Excess gland forces increase packing friction, rendering the handwheel ineffective in operating the valve. The use of cheater bars to enhance force may exert loads so strong they exceed the yield strength of the stem, causing it to bend. A bent stem introduces serious valve operability issues and leakage.

- *Seat leakage*
  Applying a cheater bar on the handwheel can often exert more force on the seat to close the valve than initially calculated by design engineers. This added force can exceed the limits of the seat material, resulting in cracks and internal leakage.

In the 1980s, the Electric Power Research Institute (EPRI) undertook the formidable task of reducing unscheduled maintenance in nuclear power plants. A significant issue flagged was a high percentage of lost power generation due to leaking valves. EPRI, through meticulous research, underscored the critical role of correct packing loading in ensuring longer packing service life. They discovered that relying solely on the "skill of the craft" method resulted in a substantial scatter in loading accuracy.

A pivotal change following the landmark EPRI report was the adoption of a torque wrench as the correct way to apply gland load. Torqued valves became the norm and were integrated into packing procedures, training manuals and textbooks. While torque brought about an industry shift, it also brought its own set of challenges. Studies revealed the accuracy of applying load using a torque wrench hovered around a modest 30%. These studies often utilized bolts in good condition and adhered to ideal bolting practices, conditions not always mirrored in real-world situations. The absence of these practices led to false positives in torque wrench readings, resulting in inaccurate load application. Bolt condition emerged as another critical factor, necessitating the replacement of studs during field repacking to ensure proper loading. Simple issues like a bent thread on a new or old bolt could create an illusion of tightness without any load being applied to the gland.

Valve packing, functioning as a wearing part in a valve, undergoes volume reduction over time through the repeated actuation of opening and closing. This reduction in shape prompts the gland to move into the stuffing box to compensate for the loss. Stretched by a small distance, the bolts loosen, lowering the gland force on the packing.

This phenomenon occurs with every valve actuation, and the loss of load remains concealed. An innovation sparked by the EPRI report was the adoption of Belville springs sets, which were introduced to the bolting on a valve to enable live loading. This technology, involving more travel in the joint, sought to reduce the loss of load over time compared to valves without springs, extending their service life.

However, live loading technologies, including Belville springs, grapple with the challenge of not addressing precise gland loads. The inherent inaccuracy of torque still contributes to premature packing failure, even with the implementation of live loading. Another seldom discussed yet well-known issue in bolting circles pertains to reapplying a torque value in the field, introducing drastic errors. Dried anti-seize lacks the same K factor as when applied in a wet state, resulting in a wide and unpredictable scatter in

IMAGE 2: Valve cartridge live loading

torque readings. Despite the illusion of reenergizing a valve, reapplying the same torque value while in service often results in a 50% reduction in load.

A modern technology that has revolutionized the landscape of correct packing loading is a cartridge live loading. This innovative approach utilizes Belville springs but in an outer cup design, cut to a precise height based on calculated gland load. This design ensures accurate packing load application when the flat washer on top of the springs aligns with the cup.

This simple yet effective design marks the next generation of accurate valve loading, moving away from reliance on torque wrenches and embracing spring compression. In addition to providing spring travel and extending the duration of bolt load loss, this technology offers a visual aid of actual valve loading while in service.

A plant manager walking through their plant with their team once pondered, "When is this valve going to fail and cause me a headache?" With cartridge live loading technology, valves can be routinely checked for correct assembly loading before any signs of leakage emerge. A simple box wrench can be employed to reload the valve to the correct load, bypassing the need for torque measurements.

While spring assemblies, like all live loading technologies, must be sized according to valve dimensions (stem diameter, stuffing box OD, stud diameter and clearances), they also factor in the valve's operating conditions, including system pressure and temperature.

A modern technology that has revolutionized the landscape of correct packing loading is a cartridge live loading.

In embracing cartridge live loading, plant maintenance teams now possess a consistent and reliable method to ensure accurate packing loads, resulting in fewer failures and extended reliability. This technological advancement symbolizes our commitment to learning from past challenges, adapting and evolving to create a safer, more reliable future in the intricate realm of industrial operations. ■

FLUIDSEALING ASSOCIATION

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.

Ron Frisard is packing and gasketing global product line director for AW Chesterton and chair of the gasketing division of the Fluid Sealing Association and past chair of the packing division.

What Users Should Know About the Department of Energy's Latest Motor Rules

Understanding the implications of these new rules will allow users to better prepare for the future.

TIM ALBERS | Nidec Motor Corporation

In an ongoing effort to reduce energy consumption, greenhouse gas emissions and energy costs, the United States Department of Energy (DOE) is implementing two new motor efficiency and test rules and proposing a third that broadly impact motors from .25 horsepower (hp) to 750 hp.

Those who do not live and breathe DOE regulations as part of their daily jobs may find it challenging to understand the nuances of the DOE's new electric motor rules and which of their motors are covered in each category.

This article provides a high-level summary of each of the new rules, as well as their implementation dates, so users are aware of what lies ahead and can begin planning now for the changes.

Updated Test Rule for Electric Motors

Following a six-month extension, requested by motor manufacturers, to its original implementation date, the DOE's updated test rule for electric motors took effect in October 2023.

Key changes include:

1 ***Motor nameplates must now list only the voltage at which a motor meets the listed efficiency*** – Formerly, motor nameplates often listed a spread of voltages at which a motor can run. For example, a 230 volt (V) motor's nameplate might previously have listed a voltage spread of 208 V to 230 V.

With this new rule, the DOE seeks to ensure that motors achieve the efficiency level designated on the nameplate at each voltage rating listed on the nameplate. While a 230 V motor may continue to operate when the voltage drops to 208, the motor must work harder, reducing its efficiency. The certified efficiency, therefore, is only achieved at 230 V.

This rule applies only to listing voltage on a nameplate. The DOE continues to permit manufacturers to include voltage range information in their catalogs and other literature.

2 ***The updated test rule covers a broader range of motors*** – The former test rule regulated only three-phase motors ranging from 1 to 500 hp. The updated test rule covers both single- and three-phase motors from .25 hp to 750 hp. For the first time, the test rule also includes a test procedure for both the open and enclosed air-over electric motors commonly used for fans and blowers. Keep in mind that not every motor is required to meet a designated efficiency standard. With this test rule, the DOE requires manufacturers that are voluntarily listing the efficiency of these motors on the nameplates to certify the motor meets the stated value. Certification is accomplished through the same verification process required of motors whose efficiency is regulated and must be certified.

3 ***Synchronous and inverter-only motors*** – While synchronous and inverter-only motors are not yet impacted by the efficiency standards, work is ongoing by the National Electrical Manufacturer Association (NEMA) and energy advocacy groups to create test methods, labeling requirements and other standards for these motors that satisfy the test rule's efficiency labeling requirements.

Medium Electric Motor Rule

The DOE's updated medium electric motor (MEM) rule expands the types and sizes of motors that must comply with NEMA Premium and Super Premium efficiency standards, which formerly affected only 1 hp to 500 hp three-phase motors.

Implemented by the DOE as a direct final rule in June 2023, the updated MEM rule was created based on recommendations from the Motor Coalition, a group consisting of NEMA and a consortium of utility, energy efficiency and environmental organizations. When it takes effect in June 2027, new requirements for motors that must comply with MEM rule standards include:

- ***100 hp to 250 hp motors*** – A majority of 100 hp to 250 hp motors will be required to meet NEMA Super Premium Efficiency (similar to IE4) standards. The exception is open drip proof (ODP) motors. Some NEMA ODP motors match IE4 values, but others are slightly lower because their frame sizes are smaller than the totally enclosed fan cooled (TEFC), which are the basis of the IEC IE4 values. The NEMA Premium table to be

The sooner users understand the implications of the rules, the better prepared they can be for the changes that are already here and those that are coming in the years ahead.

published later this spring (and which matches the DOE-published values) lists the TEFC IE4 values.

- *1 hp to 250 hp air-over electric motors* – Air-over motors that are built in a standard NEMA frame size will have to meet NEMA Premium efficiency standards from 1 hp to 75 hp and Super Premium standards from 100 hp to 250 hp. Air-over motors from 1 hp to 20 hp that are down-framed from standard NEMA size will be required to meet the same efficiency as current fire pump motors, which is equivalent to NEMA Energy Efficient levels.

- *500 hp to 750 hp motors* – These previously unregulated motors will be required to meet NEMA Premium Efficiency standards.

Notice of Proposed Rule for Expanded Scope Electric Motors

In November 2023, the DOE issued a notice of a proposed rule (NOPR) that aims to prescribe energy conservation standards for expanded scope electric motors (ESEM), a subset of motors used in various commercial and industrial equipment. The primary motors covered by this rule are single-phase and three-phase motors rated .25 hp to 3 hp.

Like the MEM rule, the proposed ESEM rule is based, in large part, on recommendations made to the DOE by the Motor Coalition. The comment period for this rule has ended, and the proposed implementation date for the new rule is January 2029.

Important Takeaways

- *It expands upon the small motor rule enacted by the DOE in 2015* – The original fractional motor rule, which covered .25 hp to 3 hp motors, was written in a way that limited the DOE from expanding its scope. The proposed new rule modifies the MEM rule described above, expanding it to include single-phase and other smaller motors. This overlap with the small motor rule makes some components of this new ESEM rule confusing. In general, almost all induction single-speed motors over .25 hp will be covered by a motor efficiency rule once this rule is implemented.

- *The proposed rule covers motors not currently required to comply with DOE efficiency standards* – These include both open and totally enclosed fractional hp motors as well as air-over motors.

- *Some, but not all, motor technologies are covered by this proposed rule* – While single-speed permanent split capacitor (PSC) motors will be required to comply with the proposed rule, multispeed and synchronous motors will not. That includes electronically commutated motors (ECM) and brushless DC motors, which are starting to gain traction as an energy-efficient alternative to PSC motors. Other types of single-phase motors included are induction start-capacitor run, capacitor start-capacitor run, split phase and shaded pole. Fractional hp three-phase motors are also broadly covered as well.

- *The proposed rule's January 2029 implementation date coincides with the date that new heating, ventilation and air conditioning (HVAC) and other manufacturing equipment rules are set to take effect* – The DOE is coordinating rule implementation so manufacturers can redesign their HVAC equipment and motors once to comply with all pending regulatory changes.

- *Input from the Motor Coalition validated the technical and economic feasibility of the proposed changes* – The proposed design efficiencies have already been tested and implemented on a small scale in equipment now available on the market. While the proposed changes will require the redesign of many motor models, the Motor Coalition found the necessary efficiencies can mostly be achieved with current manufacturing technologies and frame sizes. With literally tens of thousands of active custom models being utilized in the United States, the mechanical and electrical characteristics of each design must be resolved at the unique model level to fit the requirements of the OEM or end-use application.

How These Changes Impact Operations

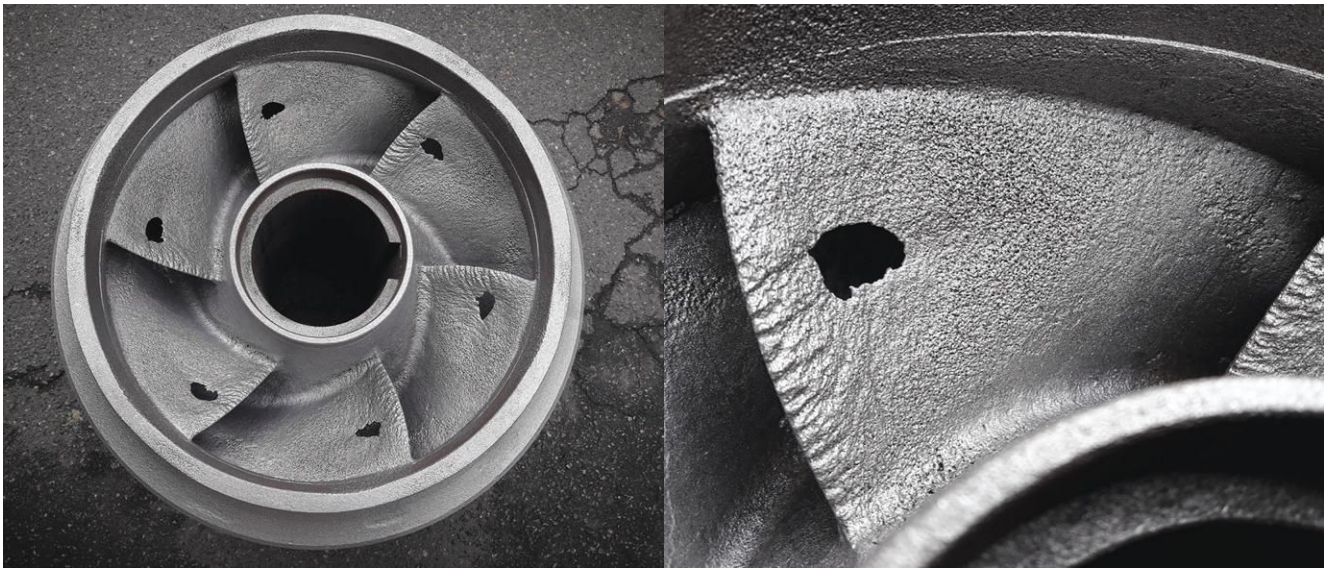
OEMS and end users seeking a more detailed understanding of how these changing rules will impact their motor fleet should consult their motor manufacturer. The sooner users understand the implications of the rules, the better prepared they can be for the changes that are already here and those that are coming in the years ahead. ■

Tim Albers is senior director of product management for Nidec Motor Corporation/U.S. Motors. For more information, visit nidec.com.

Cavitation 101

Understanding and mitigating cavitation in pumps.

GEOFF MORRIS & DANIEL GUTIERREZ | ABB



IMAGES 1&2: Pitting that results from the shockwaves generated by the vapor bubbles imploding can even put holes in the pump blades. (Images courtesy of ABB)

In this Pumps 101 article, learn what cavitation is, the causes and timing behind why it happens, the damage it can inflict on pumps and ways to avoid it. The 201 article will more comprehensively discuss the scientific factors triggering cavitation, methods for detection and multiple effective strategies to mitigate its effects, including using a drive to control the pump.

What Is Cavitation & Why Does It Occur?

Cavitation can occur in centrifugal pumps for various reasons. One of those reasons is when the inlet pressure to a pump is low. Low inlet pressure can occur due to a low level of liquid in a tank that supplies the liquid to a pumping system or due to a leakage in the pipes causing the inlet pressure to drop. Typical instances where this occurs include when a liquid is pumped from location to location in water/wastewater treatment and in food and beverage applications.

Cavitation comes from vapor bubbles collapsing inside a liquid, sending shockwaves throughout the liquid. The vapor bubbles are created when there is a local pressure drop below the vapor pressure. This can happen inside the pump or in the pipes and valves containing the liquid. In fact, any obstruction that can create a local low-pressure zone can lead to the creation of vapor bubbles.

The collapse of a vapor bubble is like a small, rapid explosion where a great deal of energy is released locally, creating damage. The implosion of the bubble leads to surface erosion when the shockwaves hit the impeller blades or the pump housing. This results in tremendous noise and noticeable vibrations. These common symptoms of cavitation are often some of the first signs of an issue.

Water can turn into vapor at room temperature if the local pressure in the pipe or pump gets below the vapor pressure. It is essential to understand the bubbles are created due to a local pressure drop and not due to a temperature rise. It is only at certain local spots in the system that the pressure gets low and bubbles are then formed.

Cavitation can negatively impact pump operation and lifespan. The creation of vapor bubbles may not be a problem, but a problem can occur when the bubbles in the liquid move in the pipe or pump and enter an area with normal pressure, typically only a short distance from where they were created. In the normal pressure area, the bubbles then implode, sending shockwaves into the liquid. The shockwaves can cause such severe pitting that they can ruin the impeller blades or the pump housing, as seen in Images 1 and 2. But even before

that, the efficiency of the pump begins to decrease. Typically, this is followed by unplanned maintenance or a costly pump replacement.

How Can Cavitation Be Avoided?

Centrifugal pumps have a characteristic called net positive suction head (NPSH). This parameter defines how high the pressure must be at the inlet of the pump to avoid cavitation. The NPSH value is dependent on the liquid flow (volume) under specific conditions, as shown in Image 3. When pumping high volumes, a high pressure at the inlet of the pump is needed. Going below the NPSH value will increase the risk of cavitation. The information of NPSH for a specific pump is used during the design phase of the complete system to ensure there is enough pre-pressure in most applications.

In an application where a tank is being emptied, the inlet pressure to the pump may decrease as the tank level decreases. This increases the risk of experiencing cavitation and measures must be implemented to avoid damage to the pump.

Since cavitation is linked to the inlet pressure of the pump, consider measuring the inlet pressure and using that information to stop the pump if the pressure becomes too low. This is how traditional cavitation protection is implemented. A low tank level can also be used as an indicator. With these ways to avoid cavitation, stopping the pump also means stopping the flow of liquid, and there might still be some liquid left in the pipes that needs to be pumped out.

NPSH is also dependent on the flow of the liquid. Reducing the speed of a pump will also reduce the flow and head/pressure the pump produces. Therefore, the risk of cavitation can be reduced by slowing the speed of the pump when the inlet pressure starts to drop or by just stopping the pump.

What Additional Problems Can Be Caused by Cavitation?

When experiencing cavitation, the expected resulting cost is normally related to service and repair of the pump. However, other costs must also be considered, like the added cost of unplanned downtime and lost production. A considerable cost can also be the production of inferior quality liquid due to cavitation.

When cavitation occurs, it can cause contamination, such as metal or plastic from inside the pump. Additionally, the material can get stuck inside valves or sensors, damaging them as well.

There is no loss of quality when treating water except for the unwanted contamination in the liquid, as the water first turns to vapor when the bubbles are created and then turns back to water when the bubbles collapse. However, in food and beverage applications, the quality of the liquid being pumped is critical. For example, when milk that is pumped starts to foam because of cavitation, the foaming is irreversible, and the quality of the milk is lost.

Any kind of irreversible process triggered by cavitation means loss of quality, loss of revenues and a higher cost due to additional processing. In some cases, the loss can be 100%, and in other cases, the liquid can be used for other purposes but with the added cost of having to use filtering or some other kind of treatment. Therefore, it is important to consider where the material that was removed by the implosions will end up, and whether it can be removed in a way that makes it possible to use the liquid, or if it will result in a 100% loss.

It is important to note that cavitation is a problem in all pump systems. A good system design with correct pump selection where the NPSH requirements are considered will reduce the risk of creating cavitation.

The next article will dive deeper into the causes of cavitation and its effects and will go into greater detail of how it can be detected and mitigated. ■

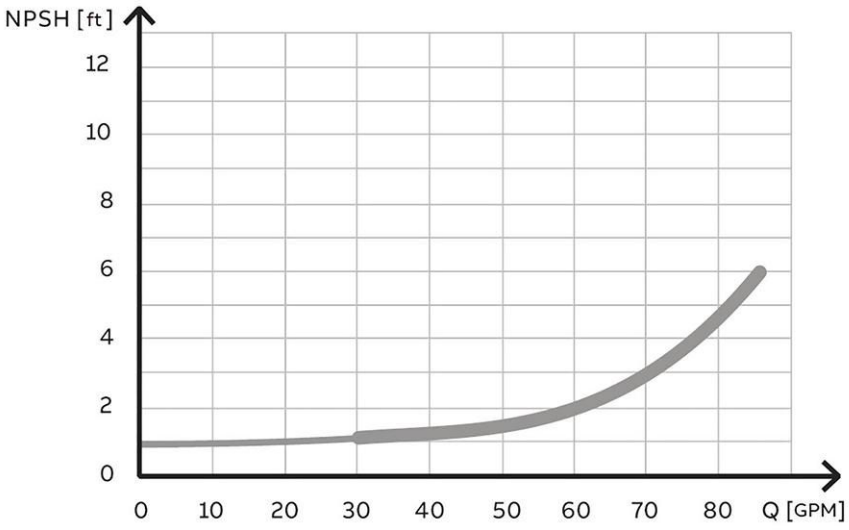


IMAGE 3: As the pumping volume increases, the inlet pressure must also increase to avoid cavitation.

Geoff Morris has worked in the automation and control industry for over 20 years, starting as a drives product manager and managing product lines that include industrial controls and motor control centers, sensors and safety and automation services, as well as selling automation products like PLCs and HMIs. As the OEM business development manager for pumps and water in the U.S., Morris helps pump OEMs build better systems by demonstrating the value of using ABB drives, PLCs and HMIs.

Daniel Gutierrez has worked in industrial automation and motor control for over 20 years. His experience includes working as a sales engineer of industrial automation products and as an applications engineer in industrial automation, including motors, variable speed drives, PLCs and HMIs. As an OEM applications engineer, Gutierrez helps pumping and water system OEMs update and upgrade the design of their control systems. For more, visit new.abb.com/drives.

Benevolent Dolphins, Flange Sealing Wisdom & the Art of Maintenance Mastery

Comprehensive training is imperative to ensuring quality and safety.

RON FRISARD | Fluid Sealing Association Member

In the tales of the mid-18th century, sailors spun a captivating narrative about dolphins—the mariners' supposed best friends. Stories echoed of men falling overboard and being saved by dolphins who guided them toward the shore. Dolphins became revered as benevolent protectors of the sea, always looking out for their human companions. Little did these sailors know that centuries later their tales would serve as an allegory for the perils of selective data analysis, echoing through discussions about the quality of scientific data.

In the realm of scientific inquiry, the story of benevolent dolphins illuminates the danger of cherry-picking data clusters, such as only considering cases of people who survived falling overboard. Imagine a scenario where a dolphin inadvertently pushed someone out to sea—a tale lost to the depths, its data excluded. Such selective analysis can lead to misguided conclusions, much like assuming dolphins are protectors when they may actually harbor a disdain for humans. This tendency to focus solely on positive data while excluding the negative is pervasive in various aspects of our lives. This is sometimes referred to as the survivorship bias.

This phenomenon of benevolent dolphins can also be observed in the field of flange sealing maintenance practices, where results are often based on only half the data. In our data-driven world, it is crucial to scrutinize maintenance training, ensuring it is grounded in facts rather than fallacies. Many plants lack specific training on effective bolting practices, an oversight that could significantly enhance overall plant performance and safety by minimizing leaks.

To navigate these waters successfully, it is essential to review a plant's training program meticulously, ensuring it considers a comprehensive dataset when evaluating effectiveness. Treating training as a continuous improvement process is the key to staying afloat in the ever-evolving sea of industry standards.

Embarking on the journey to enhance a flange sealing training program requires navigating through good sources of technical information. The Fluid Sealing Association (FSA) is an international trade association founded in 1933. Its member companies are deeply involved in the production and marketing of fluid sealing devices, primarily targeted to the industrial market, making them a trusted technical resource for the industry (the knowledgebase site can be found at fsaknowledgebase.org).

Consider this case in which a hundred gasket failures were meticulously reviewed. A root cause analysis revealed that 68% of these failures were due to under-compression of the gasket, while 15% occurred because the wrong product was used in the wrong application. With these facts, it becomes evident that including bolt tightening skills in maintenance training is imperative. Yet, in the field, bolt loading training often does not receive the attention it deserves.

Take, for example, the absence of a standard anti-seize used uniformly by all employees and contractors. This oversight leads to inconsistent torque calculations, as many journeymen at a plant resort to outdated "torque tables" without adjusting for the coefficient of friction (K Factor) of the anti-seize used. This can result in inaccurate gasket loading and lead to

gasket failure. This seemingly simple assumption that all anti-seizes and thread lubricants are the same underscores the critical importance of comprehensive training programs.

Another critical aspect is assessing the condition of bolting in a bolted connection. The absence of under-compression often stems from poor load transmission, emphasizing the pivotal role of bolt condition. Understanding torque is not tension is essential. Far too often, these terms are used interchangeably, but they have distinct meanings. Torque represents the force applied to the bolt, ideally resulting in a specific amount of stretch (tension) on the bolt. This relationship involves various factors, including bolt condition, coefficient of friction and torque wrench accuracy.

A real-life incident serves as a stark reminder of the consequences of using incorrect materials. In 2018, on Thanksgiving weekend, an ethylene oxide (EO) plant in Delaware accidentally released EO into the air. The Delaware Memorial Bridge had to be closed for five hours due to the potentially hazardous nature of EO. While no injuries were reported, the inconvenience caused to thousands highlighted the severity of the situation. Investigations determined a failed flange gasket, made of a material unsuitable for the operation, was the cause. This incident underscores how critical gasket selections are in hazardous service.

The Gasket Handbook, a 138-page document available for download from the FSA webpage, offers comprehensive technical information on gaskets in bolted flange connections. It serves as a valuable resource for plant engineers, maintenance operators and purchasing personnel, guiding them on specifying gaskets, troubleshooting leaks and understanding the functional distinctions between various gasket types.

Lifelong learning and training are indispensable for maintenance workers, engineers and planners. Ensuring training incorporates the latest methods and techniques not only reduces the risk of accidents, but also contributes to the longevity of plant operations. So, let's navigate the seas of maintenance wisdom with the diligence of sailors, avoiding the pitfalls of cherry-picked data and embracing the full spectrum of knowledge for a safer and more efficient future. ■

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Ron Frisard is packing and gasketing global product line director for AW Chesterton and chair of the gasketing division of the Fluid Sealing Association.

Determining Pump Materials & Choosing the Right Pump for Condensate

HYDRAULIC INSTITUTE

Q | How do I determine the materials of construction for my pump?

The selection of materials for wetted pump components requires many considerations but often comes down to user and manufacturer experience and requirements in regulations and standards. The experience and regulatory requirements and standards consider items like the required pump life, how often the pump is operated, corrosive and erosive properties of the fluid, hazardous nature and toxicity of the fluid and the potential for cavitation damage. In addition, the corrosive and erosive properties of the fluid may vary with temperature, concentration of chemicals or solids, liquid velocity and entrained gases, which reinforces the fact that standards and experience should be followed.

Standards and organizations that can be referenced for recommendations on materials of construction are as follows:

Hydraulic Institute:

- ANSI/HI 9.1-9.5 Pumps General Guidelines for Materials, Sound Testing and Decontamination
- ANIS/HI 3.1-3.5 Rotary Pumps
- ANSI/HI 5.1-5.6 Rotodynamic Sealless Pumps
- HI 6.1-6.5 – Reciprocating Power Pumps
- ANSI/HI 7.1-7.5 – Controlled Volume Metering Pumps
- ANSI/HI 10.1-10.5 – Air-Operated Pumps
- ANSI/HI 12.1-12.6 Rotodynamic Centrifugal Slurry Pumps
- ANSI/HI 14.3 Rotodynamic Pumps for Design & Application
- HI 30.1 Specification for General Purpose OH1 Rotodynamic Pumps (Free)
- Pump Application Guidebooks for: Water Treatment Plant Pumps, Wastewater Treatment Plant Pumps, Power Plant Pumps and Commercial Building Services

American Society of Mechanical Engineers

- Chemical Process Pumps – ANSI/ASME B73.1, B73.2 and B73.3

American Water Works Association

- Water and Wastewater Pumps – ANSI/AWWA E102, E103 and E110

American Petroleum Institute

- Petroleum Handling Pumps – API 610, 674, 675 and 676

National Fire Protection Agency

- Fire Water Pumps – NFPA 20

Lastly, refer to the National Association of Corrosion Engineers (NACE) for additional materials selection guidelines based on corrosiveness.

For more information on the topic of materials used in pumping applications, refer to ANSI/HI 9.1-9.5 at pumps.org.

Q | What pump should I use for condensate?

Condensate is a term that describes a liquid that has been condensed from vapor back to a liquid. Pumping condensate comes with the challenge that it has little margin to vapor. In pumping applications, this relates to a low net positive suction head available (NPSHa). The low NPSHa is an important pump design consideration because the pump will have to be designed with a relatively low net positive suction head required (NPSHr) so it can operate in the application with acceptable levels of cavitation. Rotodynamic pumps are commonly used in condensate applications. Some strategies included in their design to achieve a low NPSHr include low operating speed, double suction impellers and higher suction specific speed designs. Another strategy that may be employed is to use materials of construction that are better at withstanding erosion due to cavitation. Note that cavitation resistant materials do not limit cavitation and associated performance reduction, but they may result in longer life.

IMAGE 1: Vertically suspended, multistage, diffuser type can pump (VS6 type) (Image courtesy of the Hydraulic Institute)

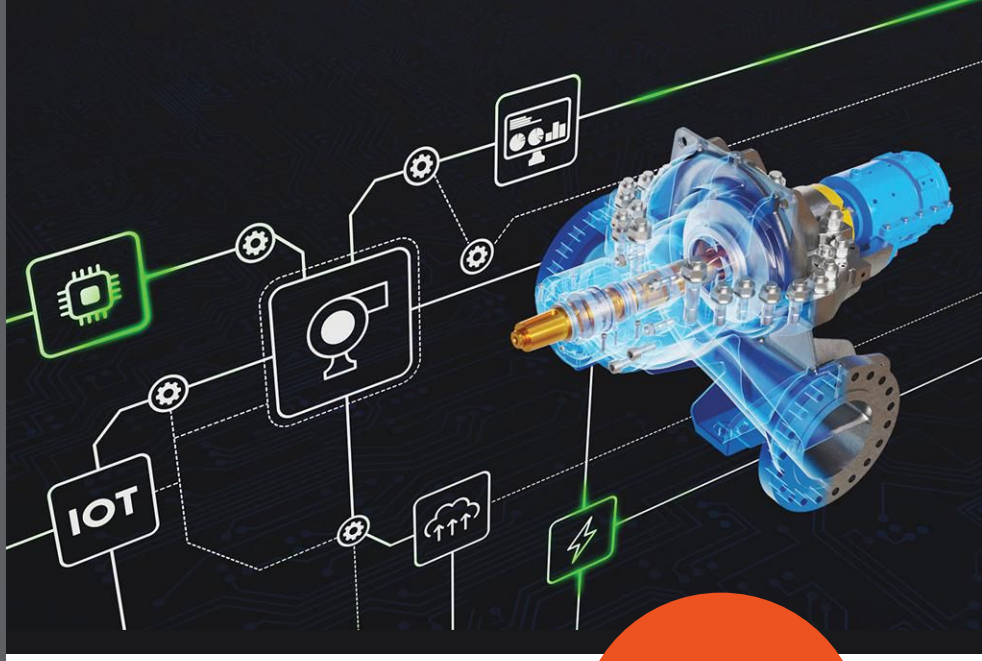
In power plants, condensate is the first pumping application in the steam cycle. Exhaust steam that has driven a steam turbine generator then flows through a condenser where it is condensed to liquid and collects in a hot well. Due to the low vapor pressure margin and the cost of elevating the hotwell, it is common to excavate deep enough to provide the required NPSH and use a vertically suspended can pump, as illustrated in Image 1. This design allows the vertical pump to take inlet from closed-suction piping that is under vacuum, and the depth of the can and length of the column and bowl assembly provide the required NPSH. Image 1 illustrates a bowl diffuser configuration, but a VS7 volute design could also be used, which enables the use of a double-suction, first-stage impeller to lower the NPSHr.

For more information on condensate pumping, refer to Pump Application Guidebook for Power Plant Pumps at pumps.org. ■

HI Pump FAQs® is produced by the Hydraulic Institute as a service to pump users, contractors, distributors, reps and OEMs. For more information, visit pumps.org.

HYDRAULIC INSTITUTE

Unlocking Hidden Opportunities for Pump Energy Efficiency



In the wake of ongoing concerns over security of supply, heightened supply chain and energy costs and increased pressure on businesses to improve sustainability, the demand for energy efficiency in industrial equipment and assets has been accelerated.

The call for pump operators to act now has never been greater, and the risk to operators who fail to do so has never been higher. However, the savings from **improving pump efficiency** are all too often **overshadowed** by those afforded by increasing heavy equipment efficiency such as turbines.

According to the Hydraulic Institute, energy is the largest single expense over a centrifugal pump's life cycle cost, and there remains substantial opportunities to reduce energy costs and decarbonize. In our upcoming webinar, Sulzer's retrofit experts will discuss and explore the following:

- Top five root-causes for energy losses in centrifugal pumps
- Holistic end-to-end energy efficiency solution possibilities comprising of audits, retrofits, machine learning based monitoring and more
- Proprietary calculator: identify and visualize pumps' best efficiency point (BEP) gaps and energy savings potential in a matter of minutes
- Real-world energy efficiency case studies via targeted retrofit with tangible outcomes such as $200k of energy savings and more than 450 kilograms of carbon reduction

March 20, 2024
10 p.m. CST,
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FREE

PUMPS& SYSTEMS webinar

Radhika Bajpai
Retrofit Speciaist
(Southeast Asia)

As the pump retrofit experts for Southeast Asian, Japanese and Korean markets, Bajpai is the go-to expert for pump retrofits and application engineering. With more than 12 years of technical experience for pumps in major pump OEMs, she was involved in more than 200 projects, including end-to-end advisory and project engineering for the retrofit of 60 high-energy pumps for critical applications for energy majors such as PTTEP Bongkot Thailand, Bangchak Refienery, Perfchem Malaysia and Brunei Shell Petroleum. Some notable projects include those of BW Adolo FPSO, KG-DWN-98/3 (KG-D6) MJ Field, DEEPWATER TANO PROJECT and Sea Lion project etc.

Kevin Peacock
Solution Engineer

With close to 30 years of mechanical engineering experience under his belt, Kevin Peacock has held senior technical and engineering leadership positions for one of the leading global EPCs for 20 years. A rotating equipment functional expert, he was involved in technical oversight for projects owned by energy majors across the Americas and APAC. In Sulzer, he combines his flair for rotary and field engineering with delivering expedited solutions for critical rotating equipment and enhancing reliability and efficiency. Peacock was involved in high impact projects such as PO/TBA expansion, JG Summit OSBL/PMC expansion and Petronas Rapid UIO, just to name a few.

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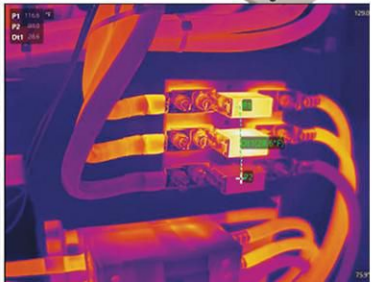

2

1

1 DROP-IN REPLACEMENT PROGRAM

Elevate industrial efficiency with **WEG** Electric Machinery's new Drop-In Replacement Program. Seamlessly integrate advanced electric machinery solutions to enhance performance and reliability while minimizing downtime. WEG Electric Machinery's solutions are meticulously designed to seamlessly integrate with your current systems, operate with heightened efficiency and reduce operational costs.

■ *weg.net*

2 INDUSTRIAL INFRARED SERVICES

EDE ELECTRIC MOTOR TESTING now offers industrial infrared services. Find hidden problems in plant equipment with definitive answers to avoid costly downtime. This cost-effective service coupled with the company's expertise in predictive motor testing programs will provide comprehensive information on the state of plant operations and electric motor and infrastructure health. The company also offers complete reports to provide answers on heat-related issues.

■ *edeinst.com*

3 WEAR RINGS & BUSHINGS

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■ *graphalloy.com*

4 CAST VALVES

TRILLIUM FLOW TECHNOLOGIES has expanded its Red Point valve brand with new cast valve offerings. Red Point, known for its forged products, has expanded into cast valves to address industry challenges like long delivery times and limited options for valves made from exotic materials for critical services. This move, led by the experience of the Trillium team, targets quality-centric applications and includes high-quality castings for gate, globe and check valves larger than 6 inches—part of Trillium's commitment to providing high-end, dependable valve solutions.

■ *trilliumflow.com*

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■ *schenck-usa.com*

6 SUBMERSIBLE PUMP

PENTAIR announces the release of its new line of next-generation submersible solids handling pumps. Featuring an innovative hydraulic design built to protect wastewater systems from the clogging challenges presented by modern flushables, this new range of pumps provides superior clog resistance while reducing energy consumption and the need for regular maintenance. Designed to prevent clogs, these pumps feature a semi-open impeller and cutter plate combination that provides superior clog resistance. An all-new hydraulic design requires less horsepower to meet specific duty points. Built with servicing in mind, the pumps require no regular maintenance.

■ *pentair.com*

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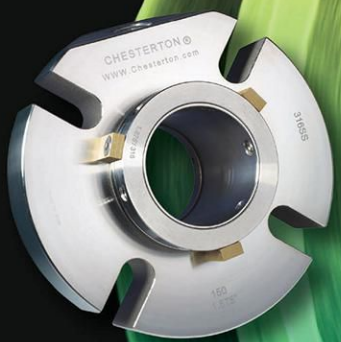

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