MARCH 2021

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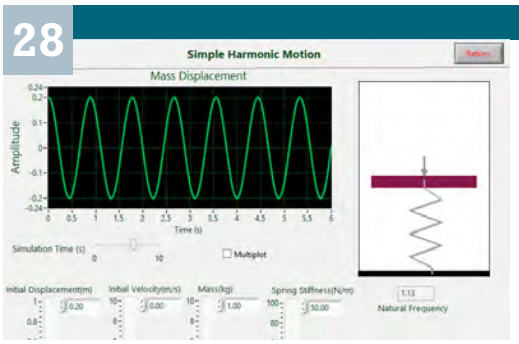

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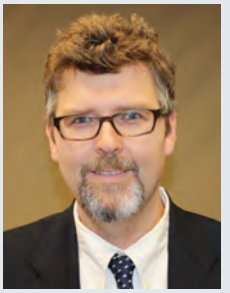

J. Campbell, Editor
Modern Pumping Today

Welcome to the March edition of MPT! In our opening case study, Chris Brand shares how Oman Cement Company has built on a long-term ABB relationship with the installation of state-of-the-art digital solutions to modernize a major cement plant (pg. 12). See how ABB delivers the latest digital control systems to boost operational efficiency, increase availability, lower costs, and drive sustainability.

Just a few years ago, it was extremely difficult to monitor and maintain distributed stations. Today, all installations in remote distribution and collection systems must be connected to a central control system. Dave Eifert and Eike Wedekind of Phoenix Contact offer "The Water/Wastewater System Manager's Guide to Remote Telemetry and Remote Maintenance" (pg. 14) in our Water/Wastewater Solution section.

In our Maintenance & Reliability section, Talmage Wagstaff encourages plant operators to "Take a Serious Look at Your CIP Pump Maintenance Program" (pg. 18). A CIP, or clean-in-place, system is vital to the daily operations of any food manufacturing facility as these critical systems could mean the difference between success and shutdown. Enjoy!

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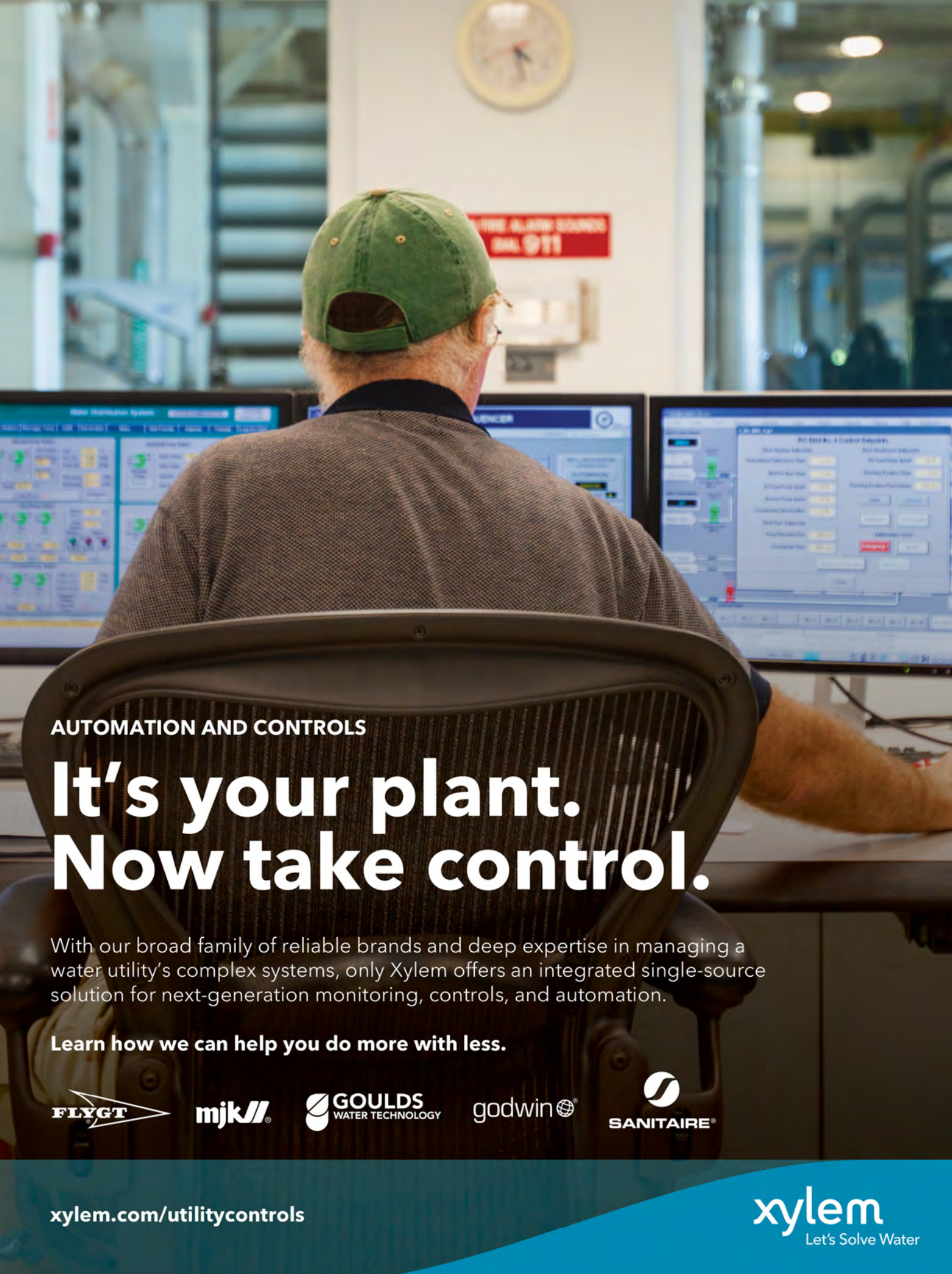

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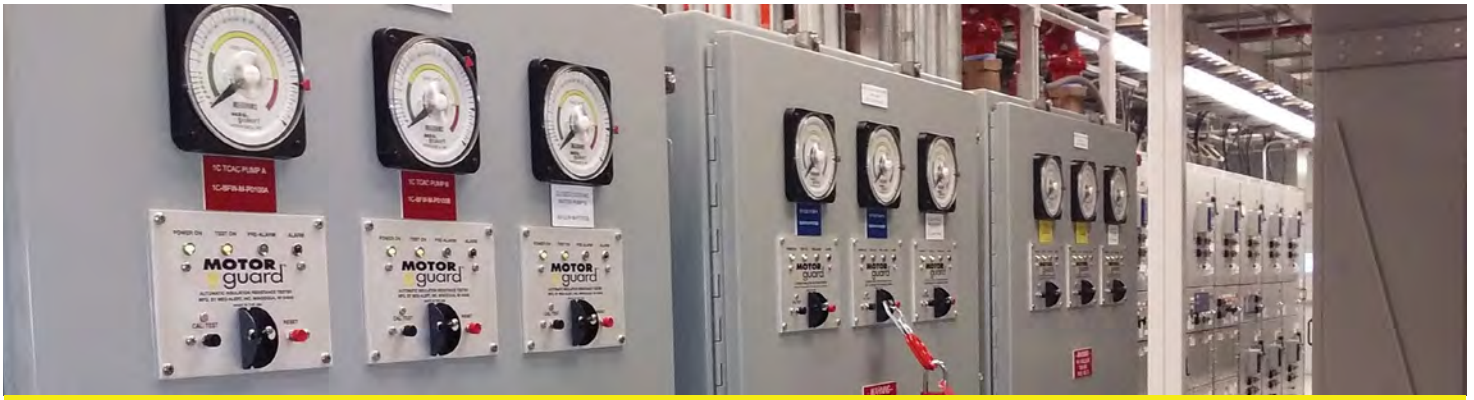

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INFOSIGHT NAMES NEW TECHNICAL SALES SPECIALIST FOR THE NORTHEAST

InfoSight Corporation announces the expansion of its sales team. Eric LaChapelle has joined the team as a regional technical sales specialist and will bring identification solutions to the industries of the upper northeast United States.

Infosight is the creator of unique metal barcoding tag solutions for all industries, including the steel industry.

SCHENCK USA EXPANDS PROPERTY ACQUISITION IN HUDSON, MASSACHUSETTS

Schenck USA Corp. announces its continued commitment to the One Schenck USA strategy by its acquisition of the building and property site of Schenck's business unit Test Devices, located at 571 Main Street, just 30 miles west of Boston.

The acquisition of the building, situated on 6.8 acres, provides a state-of-the-art 57,000 square-foot facility with 5,500 square feet of office space strengthening the footprint for growth in support of increased activities with local and global markets in the e-mobility and aerospace industries.

The successful business unit is an integral part of Schenck business, with continued focus on offering spin testing (pre-spinning and development testing), semi-finish machining, and balancing services, as well as supplying specialized spin testers to the aerospace industry.

Test Devices by Schenck incorporates advanced capabilities at test services facility utilizing two advanced spin testers and a subscale jet-engine test cell with fortified cells and state-of-the-art control rooms, and highly sophisticated data acquisition systems. Our production services facility is comprised of three spin testers, a pre-spin assembly area, a computerized inspection room, four balancing machines, and CNC lathes and mills for precision machining and drilling. The rig assembly floor for building and testing completed spin testers and spin tester modules for the local and global market, includes sufficient floor space to simultaneously build several rigs.

CUDD WELL CONTROL SIGNS ALLIANCE AGREEMENT WITH WORLDWIDE FACILITIES, LLC

Cudd Well Control, a global onshore and offshore well control emergency response and critical well intervention provider, has entered into an alliance agreement with Worldwide Facilities, LLC, a national wholesale insurance broker, managing general agent, and program underwriter.

For more than forty years, Cudd Well Control has provided rapid well control response and engineering services to onshore and offshore oil and gas operations

worldwide. Cudd Well Control is strategically located to quickly respond, prevent and mitigate critical well control events and reduce non-productive time.

Through this alliance and the insurance product administered by Worldwide Facilities, Cudd Well Control will be the preferred well control provider to the global oil and gas industry, giving companies immediate access to its experienced team of well control specialists, engineers, and critical well intervention services. The alliance will actively support traditional energy insurance products, in addition to the recently launched "Increased Costs of Drilling and/or Completion Insurance" (ICDC) Program.

Andy Ferguson, president of Cudd Well Control, states, "Being the 'first call' well control services provider under Worldwide Facilities' upstream energy insurance policies is very exciting."

ATLAS COPCO EMPLOYEES SUPPORT TEXAS RELIEF EFFORTS

Atlas Copco USA's employee-driven Water for All program announces it will provide support to the state of Texas with fresh, clean drinking water in partnership with Can'd Aid. This support responds to the recent ice and snowstorms that have caused widespread power outages, resulting in resident's inability to obtaining heat, water, food, and medicine.

Can'd Aid will use the $13,000 donation from Atlas Copco to send 50,400 cans to Texans in need within the Houston and Austin areas. A truckload of 50,400 cans will support about 8,400 individuals or approximately 2,100 families.

"We have hundreds of colleagues, their families, and multiple locations across Texas," says Aaron Prato, vice-president of Atlas Copco North America LLC. "We see the devastation, and our hearts go out to everybody affected. This is just one way that we will play a part in the work to get the area back on its feet."

SKF ANNOUNCES NEW EXECUTIVES FOR NORTH AMERICA

SKF announces two key additions to the executive leadership team of SKF USA, its U.S. subsidiary. Fal Dieso joins SKF as vice president of marketing in North America, and Amy Sliwinski has been promoted to vice president of human resources for SKF in North America.

Dieso will lead the planning, development, and execution of all SKF strategic marketing initiatives in North America. Sliwinski will lead human resources for SKF North America and become a member of the company's executive leadership team. ◆

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2021 WQA Convention & Exposition

Imagine more people with access to quality water

In an uncertain world, the WQA dares to "imagine" a better world, a call-out that serves both as the central theme for this year's convention and exposition and as a hopeful summons to the water industry attempting to reconvene in-person events throughout the summer.

A steady increase in COVID-19 cases and continued or increased restrictions on large gatherings and travel were making it less likely the WQA could host a live event as originally planned for April 27 through 29. For the 2021 WQA Convention and Exposition, education sessions will be offered July 28 and 29, and the trade show will be open July 29 and 30. The event will take place in the Las Vegas Convention Center in Nevada, the same space originally reserved for WQA to host an April event.

2021 WQA CONVENTION AND EXPOSITION AT A GLANCE

When: July 28-30, 2021

Where: Las Vegas Convention Center, Las Vegas, Nevada

Website: www.imagine.wqa.org

IN-PERSON CONVENTION IS GO

Postponing the event for three months greatly increases the likelihood of having an in-person event, and WQA believes its members, exhibitors, and sponsors would all benefit greatly from being able to gather in person. Additionally, event planners are encouraged by news that COVID-19 vaccines could be available to tens of millions of U.S. residents in coming weeks, with the expectation that it could be available for more widespread use before the convention dates.

Over 140 leading exhibitors of the water treatment industry have already signed on to take part of the in-person Las Vegas event, with more coming by the day. As always, attendees will find leading exhibitors, a stellar education lineup, top experts, and opportunities to connect and network with like-minded water treatment professionals.

VIRTUAL OPTIONS STILL AVAILABLE

WQA is planning some virtual access to the 2021 WQA Convention and Exposition so that those who cannot travel to Las Vegas will be able to attend some of the scheduled education sessions, events and exhibits online. Only exhibitors already signed up for the live event will be able to exhibit virtually. More information on these options will be available as the event date approaches.

For existing WQA members, there's no delay for annual business, as the business meeting will be conducted virtually this spring. WQA by-laws require an annual business meeting to elect a board of directors, hear reports, and conduct other association business to ensure the smooth transition of WQA leadership into the following year.

WQA BUSINESS BOOT CAMP

An annual tradition all attendees look forward to—WQA presents its Business Boot Camp opportunities! WQA offers

COVID-19 GUIDANCE

The Water Quality Association is excited to plan for the upcoming WQA Convention & Exposition at the Las Vegas Convention Center, July 28-30, 2021. WQA is committed to hosting the safest possible event for attendees and exhibitors in the wake of the COVID-19 pandemic and will follow all safety measures based on the latest guidance from the Centers for Disease Control and Prevention (CDC) and World Health Organization (WHO) as well as local government requirements and guidance.

this intensive seminar focused on topics such as strategic planning, succession planning, and team management, tending to the needs of members seeking help in growing their business and tackling the everyday challenges that face all companies.

Topics at the Boot Camp traditionally include both advice from experts that attendees can implement as well as a panel discussion on obstacles to avoid. Some of the presenters and panelists are WQA members, themselves, who have years of business experience. Attendees do not have to be WQA members to attend, but members will receive a discount on registration.

WQA CENTRAL RETURNS

Meet the team at WQA Central! The hub of the exhibition, WQA Central is at the center of the trade show floor at the WQA Convention and Exposition. Attendees are welcome to stop by during regular trade show hours to meet WQA staff, board members, and guests. At WQA Central, attendees can check the status of their Continuing Professional Development (CPD) credits or renew their WQA membership. Attendees can also inquire about Gold Seal and Sustainability Product Certification or learn more about the Water Quality Research Foundation. ◆

Modernizing a Major Cement Plant in Oman

ABB digital control systems transform a core industry for the future

By Chris Brand, ABB

Oman Cement Company (OCC) has built on a long-term ABB relationship with the installation of state-of-the-art digital solutions. ABB Ability™ System 800xA will optimize performance on all three process lines as OCC continues to supply the country's construction industry. ABB has built on a forty-year relationship with leading cement producer Oman Cement Company SAOG in delivering the latest digital control systems to boost operational efficiency, increase availability, lower costs, and drive sustainability.

HEAVY WORK

The Muscat-based cement factory, which has an annual cement production of 3.8 million tons, now has the latest version of ABB Ability System 800xA, which integrates its three process lines into the single digital platform.

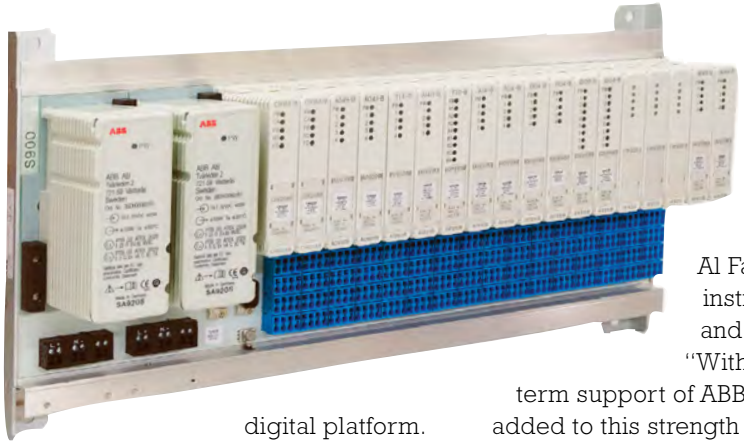

ABB has also replaced older controllers in their final lifecycle phase with AC800M models.

Teams from Oman Cement Company and ABB Switzerland collaborated to complete the engineering, supply, installation, and commissioning of the ABB systems. ABB secured two separate contracts for the work with OCC, a company that has been a customer since 1978.

"Cement production is a core industry for Oman, serving and enabling a self-sufficient construction industry," says Bashar Al Farsi, head of instrumentation and control, OCC. "With the long-term support of ABB, we have added to this strength and look forward to continued success, now with the latest digital control system across our three process lines. We have already identified time and cost savings, and will drive towards greater efficiencies and sustainability targets as we aim to be the number one cement manufacturing company in the Sultanate."

RANKED THE BEST

ABB Ability System 800xA, ranked by the ARC advisory group as the

world's top distributed control system (DCS) platform over the last twenty years, can implement advanced process control methods.

"Connecting all three lines on one platform from a single partner versus multiple deliveries from different parties harmonizes the engineering and technology standards across the plant. This also helps gain synergies for operations and maintenance teams by ensuring overall interoperability and consistency as well as reducing complexity," says Max Tschurtschenthaler, global cement lead, ABB Process Industries.

BUILT FOR THE FUTURE

ABB's new system also has a solid foundation to build up digital applications and integrate other process areas of the OCC plant on the same single platform.

"Deep domain knowledge and long-term customer relationships remain key factors of our performance and this was shown with our recent project with Oman Cement Company," says Ramzi Akkawi, regional sales manager North Africa and Middle East for mining, aluminum, and cement, ABB.

"Clear technical know-how, upfront transparency and the ability to highlight and eliminate potential risks based on past execution experience was highly regarded by our customer. We had a strategic approach to execute these projects with minimal production downtime." ◆

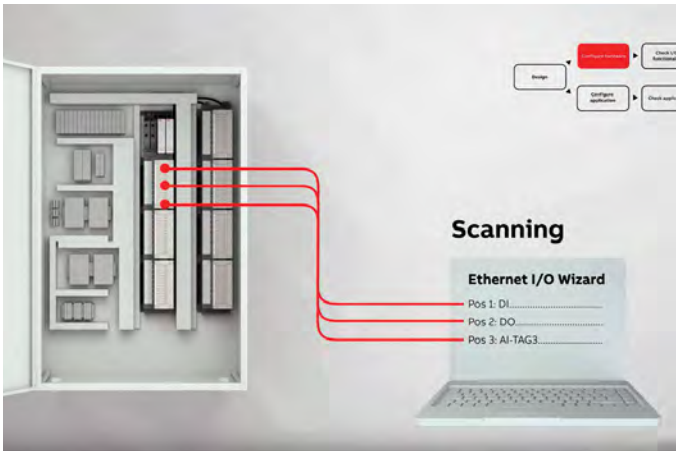

ABB is a leading global technology company that energizes the transformation of society and industry to achieve a more productive, sustainable future. By connecting software to its electrification, robotics, automation and motion portfolio, ABB pushes the boundaries of technology to drive performance to new levels. With a history of excellence stretching back more than 130 years, ABB's success is driven by about 110,000 talented employees in over 100 countries For more information, visit **www.ability.abb.com**.

The Water/Wastewater System Manager's Guide to Remote Telemetry and Remote Maintenance

Part 1 of 2

By Dave Eifert and Eike Wedekind, Phoenix Contact

Just a few years ago, it was extremely difficult to monitor and maintain distributed stations. The reason for this was that the remote systems were either unable to communicate with a control center, or communication involved a great deal of effort and expense.

Today, all installations in remote distribution and collection systems, such as water, gas, or electricity supply pipelines or even transportation technology applications, must be connected to a central control system. This allows smaller installations such as pumping stations, transformer stations, or transformer substations to be monitored and controlled remotely. This connection presents new challenges for the technology.

Remote control and remote maintenance have since become the established standard in communication. Remote systems or external stations can be easily connected to the control center using a wide range of telemetry methods. Standardized transmission is made easier thanks to defined, standardized protocols. The predictive maintenance, made possible as a result of this, enables huge cost savings.

But which communication method is best suited to the relevant application?

This article will provide the reader with a practical selection guide to the communication mechanisms and media for remote maintenance and remote control technology that are relevant to them.

DIFFERENCE BETWEEN REMOTE CONTROL AND REMOTE MAINTENANCE

In industrial communication, there is a vast difference between remote control and remote maintenance, even when using identical technology. This often leads to confusion when it comes to selecting the right communication media. The particular features of the different applications are described below.

Even predating all the talk about the industrial internet of things (IIoT), central control systems have been used to operate systems and machines in ever-more distant locations. In addition, the installed systems are constantly growing in complexity. This often leads to problems when needing to diagnose and correct errors in the event of a fault. In the event of a fault, there is much more to it than just remote maintenance. Thanks to developments in recent years, complete support and monitoring of the production process are now possible.

REMOTE CONTROL TECHNOLOGY

Continuous monitoring of important process data can be realized by using suitable remote control technology. System status is continuously displayed in the control center. The required logging of flow rates or liquid levels, for example, can be stored centrally for many years, in compliance with regulatory requirements. Thanks to special protocols, process data can be transmitted securely over wide area networks, even with low bandwidth and with poor transmission quality.

Communication used to be performed via dedicated wiring with discrete digital and analog signals. As processes became more complex, more information was needed from the process, and it was possible to process this information in control systems, the discrete lines were, in many cases, replaced by serial connections via permanent line modems.

WHAT IS MEANT BY REMOTE CONTROL TECHNOLOGY?

Remote control technology describes the remote monitoring and control of physically separate system parts by means of data transmission. Measured values and control commands are transmitted over long distances and visualized, processed, and stored in a control center. In contrast to remote maintenance, remote control requires a permanent connection to a remote station in the vast majority of cases.

Stations that did not have dedicated permanent line connections were connected via analog dial-up connections, leased permanent lines, or wireless systems. More recently, cellular communication connections have been used. One of the disadvantages of dial-up connections is that there is no permanent connection to the control system and, as with voice telephony, connection establishment takes some time. Recently there has been a clear move away from serial transmission paths toward IP-based communication. Modern communication options such as Internet, VPN, cellular up to 5G are also integrated in remote control technology.

COMMUNICATION PROTOCOLS

There are specific protocols for every type of industrial communication. In factory automation, fieldbuses with defined transmission paths utilize one of several specific protocols optimized for the applications found in discrete manufacturing. Even the cables are often specified, and process information is usually exchanged cyclically, with very high determinism between the controller and I/O station, HMIs, and other nodes.

Another group of industrial protocols originates from the time of serial communication via permanent lines. These are mostly what are referred to as polling protocols. One example is the Modbus protocol, which is used worldwide.

A typical feature of this form of data exchange is that the control system polls each external station in a round-robin fashion. These communications are not deterministic—that is, it is not possible to predict how long it will take to poll any particular remote node, nor the entire system. Polling either only identifies changes or transmits all data points to the control system. However, in the event of a lost connection, it is impossible to later determine what happened at the external station during this time, or whether specific threshold values were exceeded. The advantage of these protocols is their easy parameterization. The disadvantage is the setup of time dependencies, which can be labor-intensive.

With the introduction of remote control technology and the associated expansion of systems, a new type of industrial protocol was needed. Previously, a physical connection was required between the control system and the external station, which limited the amount of data that could be sent. Over time, cellular communication networks have become more commonly used to connect external stations to the control system. As a result, it was no longer possible to use time-critical polling protocols.

Cellular communication networks are storage networks that can retain the individual data packets, which are then only reassembled again at the receiver. Once a connection has been established, the user no longer has to deal with data transmission. It is controlled by using TCP/IP, for example.

In certain geographic areas, cellular networks can experience intermittent outages. This behavior places new demands on a transmission protocol. It must provide internal security mechanisms to prevent data loss in the network.

BASIC REQUIREMENTS

A remote control protocol must feature the following in order to satisfy current requirements:

Bidirectional, Event-Oriented Transmission

It must be possible to send data to the external station and receive data from the external station simultaneously. For example, an external station must not be hindered

REMOTE MAINTENANCE DISTINCT FROM REMOTE CONTROL

Remote maintenance describes remote access to a station for fault diagnostics or for maintenance purposes. This saves costs, as a technician does not have to be on site or travel long distances in order to return the system to operation. It also reduces downtime.

by control system polling if it is transmitting an alarm message.

Storage of Process Information (In the Event of Connection Interruptions)
Some of the data in the processes is relevant for billing. Other data is just as critical for regulatory compliance. The data must not be lost as a result of a connection interruption and must be stored by the external station as historical data until it has been received by the control system.

Time Stamping of Process Information
For the control system to be able to reconstruct the data trend, the historical data must at least have an exact time stamp.

Time Synchronization
In order to reconstruct data trends using the time stamp, all of the system's external stations must use the same time as the control system. A remote control protocol must therefore offer the option of synchronizing all devices in the system.

Serial Communication via Dedicated Permanent Cabling
In some systems, distributed system nodes are connected via the supplier's dedicated permanent lines. One example is the connection of the remote pumping station to the central process control system. Serial communication is possible here because copper cables are traditionally installed along with the supply pipelines. With protocols according to IEC 60870-5-101 or IEEE 1815 (DNP3), for example, the system is equipped with communication standards that are established in remote control technology. This satisfies all requirements for secure remote control technology. In the event that the permanent line fails, the selected remote control protocol ensures that the data for a pumping station is stored in the remote control device.

Communication via TCP/IP (or UDP/IP) or Cables
If no dedicated cables are present, communication via a TCP protocol for networking distributed systems to the control system is a reliable method for data transmission. Protocols according to IEC 60870-5-104 or IEEE 1815 (DNP3) support standardized connections for remote communications, including storm water overflow tanks, pumping stations, or well shafts—via the cellular communication network or wired communication, depending on the application. If such interfaces already exist at the control system, the remote control devices used can reliably communicate with the control system.

Depending on the protocol used, communication is event-oriented and prepared for the use of cellular-based hardware. In the event the communication infrastructure fails, the remote control protocol ensures that data is stored locally and automatically uploaded to the central control system once communications have been re-established.

Online Data
The process image data is read cyclically from the PLC and displayed in the control system via the OPC interface. Switching operations can also be performed from the control center.

Historical Data
Historical data is retrieved cyclically or in a user-controlled way. The time-stamped historical data is sorted in chronological order into *.csv files by the AX ODP server. The memory capacity in the PLC depends on the number of variables and the corresponding memory cycle.

Malfunctions, Alarms, and Messages
Malfunctions, alarms, and messages are transmitted to the control system by the substation in an event-oriented way. These can then be stored in chronological order and evaluated in the control system.

If the external stations are connected via the ODP server by means of GPRS, they can communicate with virtually any control system. In order to do this, the AX ODP server must be installed in the control center. The ODP server developed specifically for GPRS communication makes data for connection to the control system available via OPC. They are manufacturer-neutral and can communicate with every OPC-based control system.

A LOOK AHEAD

In next month's conclusion, we'll examine the differing protocols for remote control as well as those not for remote control. Also, as cellular communication network and the Internet provide a solution for transmission over long distances and on a global scale, we'll look over the history and future of these continuous connections. ◆

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Take a Serious Look at Your CIP Pump Maintenance Program

These critical systems could mean the difference between success and shutdown

By Talmage Wagstaff

A CIP, or clean-in-place, system is vital to the daily operations of any food manufacturing facility. Without a CIP system in place that is performing to specification, the facility risks fines, shutdown, and contamination of all products coming off the production floor. It is absolutely not the area to have a mechanical failure, because we can manufacture nothing else until the CIP system does its job.

What does a CIP system do, exactly? It pumps cleaning, rinsing, and sanitizing solutions through the product piping to clean and sanitize the lines for the next product to flow through it. This is done by CIP pumps pushing fluid through the lines to remove the debris and trash, while maintaining the turbulence throughout the system's entire circuit. It is critical that the CIP pump provide adequate pressure for the job, because the cleaners and caustic need proper fluid speed velocity in order to rid the lines of the debris.

This means that proper pump size is imperative, and its operation needs to be completely to manufacturer's specification so that they properly perform the cleaning, and there is no risk of any residual material in the lines causing a contaminated product. In a food manufacturing facility, contaminated product could cause food-borne illnesses, product recalls, and FDA mandated shutdowns while they investigate the contamination. These are all consequences that a manufacturing facility will have a hard time dealing with, and it has put food manufacturers out of business in the past.

WHAT IS THE CIP PROCESS IN A MANUFACTURING FACILITY?

The CIP process is closely monitored in food manufacturing. This is again due to the risk of food-borne illnesses, and federal guidelines specify the depth of cleanliness that they expect to be performed prior to a product being manufactured

that will be available for human consumption. This process will be automated into the control software in most cases, which removes the element of human error.

The CIP process begins with what is known as the "push out" phase. This is where the CIP pumps use pressure to blow the residual product in the lines out, usually into a rework or scrap tank or drum-off line. Then, a pre-wash cycle will begin, which typically includes a non-chemical pressure test prior to any caustic or chemicals being introduced into the line. Next, the caustic wash will take place, followed by the first rinse cycle.

An acid wash will then begin, using nitric acid, or sometimes phosphoric acid. A final rinse will be administered, and then the sanitizing cycle will be performed to disinfect the product lines prior to the introduction of another food product or ingredient running through the material line. Sodium hypochlorite is typically the chemical used to sanitize the lines. As one can imagine, all of these highly corrosive chemicals running through lines, pumps, and valves can be incredibly taxing on the machinery, and a CIP pump has to be built to withstand some of the harshest conditions a manufacturing facility can deliver.

Between the heat, chemicals, and pressure that is necessary to clean and sanitize the facilities product lines, the strain that the CIP pumps are handling can lead to the complete exhaustion of the equipment if it isn't maintained thoroughly, and in a timely fashion. Fortunately, like most pumps in manufacturing facilities, CIP pumps can be rebuilt to manufacturers specification and run like the day that they were purchased, given that they're properly cared for.

PROPERLY MAINTAINING THE CIP PUMP

CIP pumps take a brutal beating in the normal course of pumping hot chemicals throughout the production line circuit, and they need to be cared regularly. Caustic materials and high

temperatures aren't forgiving, so the proper preventative maintenance is critical for the life of the pump. A self priming pump must be used so that pump cavitation doesn't occur, which will damage the impeller blades, or force the pump to run dry, which will burn up the pump seals.

A thorough preventative maintenance program for the CIP pumps in the facility should include the following:

- Ensuring that food grade lubrication is properly applied to all of the pump's lubrication points.
- The rotor wing tips should routinely be inspected for metal to metal contact.
- The pump needs to routinely be checked for shaft spline wear and rotor spline wear.
- The pump should be inspected to ensure that there are no loose or worn gears.
- The gear teeth need to be inspected for improper wear.
- The front and rear pump seals should regularly be serviced and replaced.
- Check the bearings for shaft radial play.

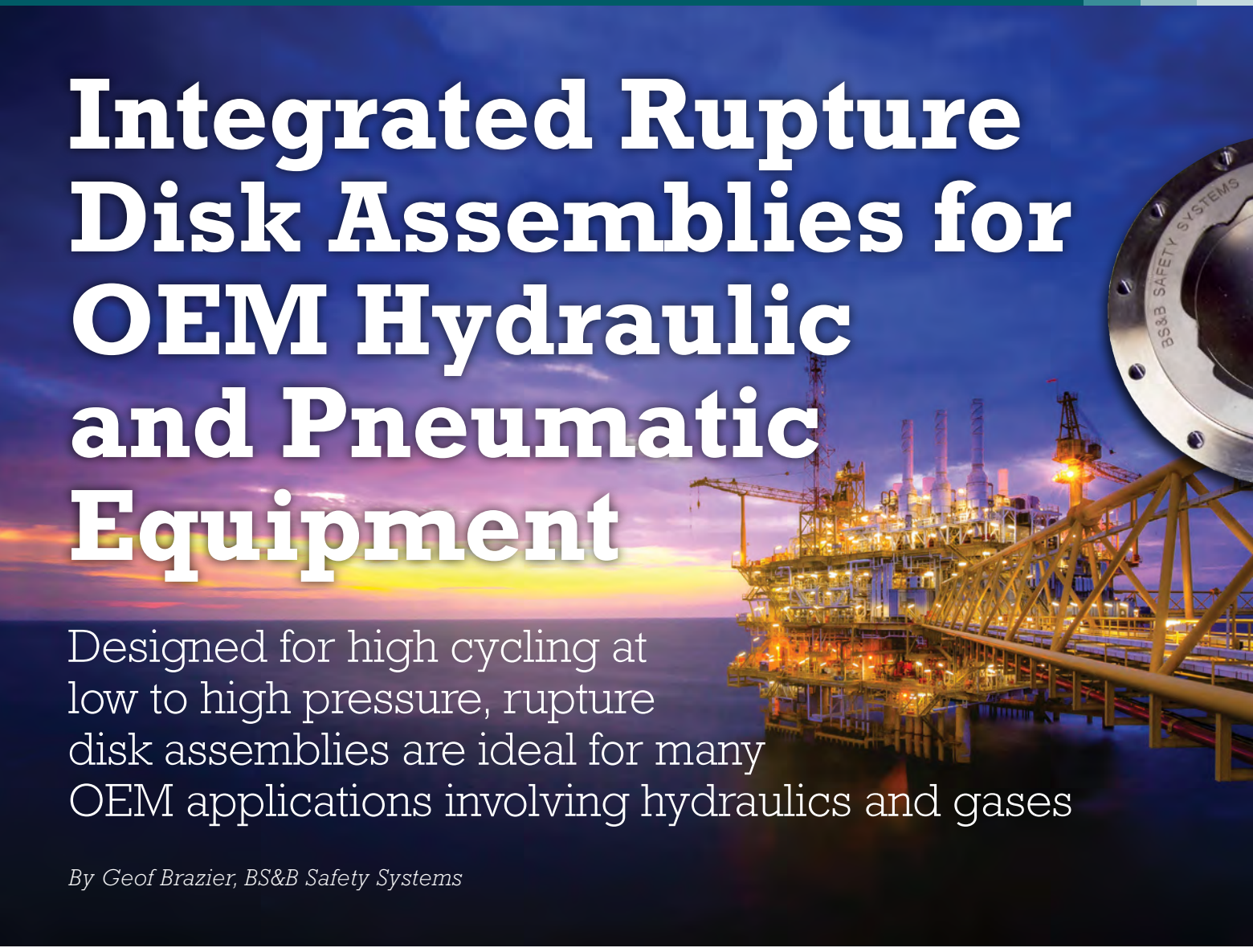
PREVENTATIVE MAINTENANCE FOR CIP PUMPS IS COST EFFECTIVE

By performing these routine pump inspections, the majority of pump failures can be prevented. Replacing any and all worn components of the pump prior to failure helps to prolong the life of the pump, and to prevent critical breakdowns from taking place. This type of preventative maintenance requires a maintenance department to watch the pump in action, and to fully inspect the components regularly, in order to ensure that wear is spotted immediately.

The fact is that when pumps are properly maintained and run at the manufacturer's specifications, the pump can often be rebuilt three or four times before it must be scrapped. That is an incredible amount of savings over a period of time, with the cost of the pump, production downtime to replace the pump, and the labor dollars required to perform the pump replacement. By properly maintaining the CIP pump in your facility, you're preventing costly downtime, replacement costs, and the overall trouble that comes with critical part failure. ◆

Talmage Wagstaff is co-founder and CEO of RedList. Raised in a construction environment, Wagstaff has been involved in heavy equipment since he was a toddler. He has degrees and extensive experience in civil, mechanical, and industrial engineering. Wagstaff worked for several years as a field engineer with ExxonMobil servicing many of the largest industrial production facilities in the country. For more information, visit **www.yourredlist.com**.

Integrated Rupture Disk Assemblies for OEM Hydraulic and Pneumatic Equipment



Designed for high cycling at low to high pressure, rupture disk assemblies are ideal for many OEM applications involving hydraulics and gases

By Geof Brazier, BS&B Safety Systems

For more than eighty-five years, rupture disks have served as an effective passive safety mechanism to protect against overpressure or potentially damaging vacuum conditions. The disk, which is a one-time-use membrane made of various metals including exotic alloys, is designed to activate within milliseconds when a pre-determined differential pressure is achieved.

Equipment reliability in operation is essential for its owner, and this demands high integrity from the pressure relief technology used to protect low- and high-pressure OEM systems. As a result, OEMs are increasingly turning to integrated rupture disk assemblies with all components combined by the manufacturer, as opposed to loose rupture disk and holder devices that leave much to chance. These assemblies are being tailored to the application, miniaturized, and utilize a wide range of standard and exotic materials, as required. This approach ensures the rupture disk device performs as expected, enhancing equipment safety, reliability, and longevity while simplifying installation and replacement.

SEPARATE COMPONENTS VERSUS INTEGRATED ASSEMBLIES

Traditionally, rupture disks began as standalone components that are combined with the manufacturer's separate holder device at the point of use. The installation actions of the user contribute significantly to the function of the rupture disk device. When installed improperly, the rupture disk may not burst at the expected set pressure. There is a delicate balance between the rupture disk membrane, its supporting holder, and the flanged, threaded, or other fastening arrangement used to locate the safety device on the protected equipment.

For this reason, an integrated rupture disk assembly is often a better choice than separable parts. Available ready-to-use and with no assembly required, integrated units are certified as a device to perform at the desired set pressure. The one-piece design allows for easier installation and quick removal if the rupture disk is activated.

The assembly includes the rupture disk and housing and is custom engineered to work with the user's desired interface

to the pressurized equipment. The devices are typically threaded or flanged, or even configured for industry specific connections such as CF/KF/ Biotech/VCR couplings. The rupture disk and holder are combined by the manufacturer by welding, bolting, tube stub, adhesive bonding, or crimping based on the application conditions and leak tightness requirements.

There are additional advantages to this approach. Integrated assemblies prevent personnel from utilizing unsafe or jury-rigged solutions to replace an activated rupture disk to save a few dollars or rush equipment back online. The physical characteristics of increasingly miniaturized rupture disks as small as 1/8 inches can also make it challenging for personnel to pick up the disk and place it into a separate holder.

OEMs are driven to deliver the longest life and lowest cost of ownership to their customers. The use of an integral assembly maximizes the longevity, proper function, and trouble-free service of the pressure relief technology.

HYDRAULIC AND PNEUMATIC APPLICATIONS BENEFIT

The integrated assembly is ideal for numerous hydraulic, pneumatic, and other low-, medium-, and high-pressure applications including pumps, piston-and-bladder accumulators, engines, pressure vessels, and piping. Additional markets include OEM equipment for onshore/offshore oil and gas applications, pressure washers, refrigeration systems, fire protection, and breathing equipment.

As one example, the oil and gas industry utilizes rupture disks on triplex pumps for many field applications including oil extraction and well servicing operations. Triplex pumps are positive-displacement pumps configured with three plungers. Commonly referred to as "mud pumps," the devices typically can handle a wide range of fluid types, including corrosive fluids, abrasive fluids, and slurries containing relatively large particulates.

The pressures the pump must endure depend on the depth of the drilling hole and the resistance of flushing fluid, as well as the nature of the conveying drilling fluid, although application specific, hydraulic operating pressures are typically in the 5,000 to 20,000 psi range. A three-plunger pump is continuously cycling, so the disk must be able to withstand high pressures with 1,000,000 pressure cycles or more easily experienced.

In oil and gas and other industries that depend on hydraulic systems to store energy and smooth out pulsations, standard system components like accumulators require rupture disks. By definition, accumulators hold hydraulic fluid under pressure. If the pressure spikes too high, there is a risk that without a rupture disk the system, or even accumulator, could experience a catastrophic failure.

Both medical devices and fire rescue breathing equipment depend on integrated application specific rupture disk solutions for critical life safety reliability. Medical devices in particular often must be very compact and low profile, and integral assemblies can help to provide such capability with streamlined design.

In aerospace, from satellites to aircraft to drones, tailoring integrated rupture disk applications for use with lightweight, compact materials like titanium and aluminum are also important, since it takes more energy to get heavier vehicles off the ground.

When tremendous corrosion resistance is required as well in very aggressive conditions, titanium is often the material of choice. For such applications, BS&B can weld titanium rupture disks to titanium housings and provide a titanium assembly. Where less weight and economy are required, an aluminum welded assembly may be the right solution.

INTEGRATED ASSEMBLIES: RUPTURE DISK DESIGN

The most important considerations in rupture disk device design are having the right operating pressure and temperature information along with the expected service life, which is often expressed as a number of cycles the device is expected to endure during its lifetime. Since pressure and cycling varies depending on the application, each requires a specific engineering solution.

Coming up with a good, high reliability, cost-effective, and application-specific solution for an OEM involves selecting the right disk technology, the correct interface (weld, screw threads, compression fittings, single machined part) and the right options as dictated by the codes and standards.

Because user material selection can also determine the longevity of rupture disks, the devices can be manufactured from metals and alloys such as stainless steel, nickel, Monel, Inconel, and Hastelloy. For a wide range of industries, it can be important for rupture disks to have a miniaturized reverse buckling capability in both standard and exotic materials.

Where economics is the driver, reverse buckling disks are typically made from materials such as nickel, aluminum, and stainless steel. Where aggressive conditions are required, more exotic materials like Monel, Inconel, Hastelloy, Titanium, and even Tantalum can be used. In almost all cases, "reverse buckling" rupture disks are utilized because they outperform the alternatives with respect to service life.

In a reverse buckling design, the dome of the rupture disk is inverted toward the pressure source. Burst pressure is accurately controlled by a combination of material properties and the shape of the domed structure. By loading the reverse buckling disk in compression, it can resist operating pressures up to 95 percent of minimum burst pressure even under pressure cycling or pulsating conditions. The result is greater longevity, accuracy, and reliability over time.

The process industry has relied on reverse buckling disks for decades. Now the technology is available to OEMs in miniature form as small as 1/8 inches burst diameter from BS&B. Until recently, obtaining disks of that size and performance was impossible.

However, miniaturization of reverse buckling technology presents its own unique challenges. To resolve this issue, BS&B created novel structures that control the reversal of the rupture disk to always activate in a predictable manner. In this type of design, a line of weakness is also typically placed into the rupture disk structure to define a specific opening flow area when the reverse type disk activates and also prevents fragmentation of the disk "petal."

Reverse buckling and therefore having the material in compression does a few things. First, the cyclability is much greater. Second, it allows you to obtain a lower burst pressure from thicker materials, which contributes to enhanced accuracy as well as durability.

Small nominal size rupture disks are sensitive to the detailed characteristics of the orifice through which they burst. This requires strict control of normal variations in the disk holder. With small size pressure relief devices, the influence of every feature of both the rupture disk and its holder is amplified. With the correct design of the holder and the correct rupture disk selection, the customer's expectations will be achieved and exceeded.

TAILORED SOLUTIONS EVEN FOR EXTREME CONDITIONS

Due to cost, weight, and other considerations, BS&B has increasingly received more requests for housings that are made out of plastics and composites. Because customers are often accustomed to certain types of fittings to integrate into a piping scheme, different connections can be used on the housing. Threading is popular, but BS&B is increasingly utilizing several other connection types to attach the rupture disk assembly to the application. Once the integral assembly leaves the factory, the goal is that the set pressure cannot be altered.

If you rely on someone to put a loose disk in a system and then capture it by threading over the top of it, unless they follow the installation instructions and apply the correct torque value, there is still potential for a leak or the disk may not activate at the designed burst pressure. When welded into an assembly, the rupture disk is intrinsically leak tight and the set-burst pressure fixed.

While OEMs have long relied on rupture disks in their hydraulic and pneumatic equipment, high-pressure, high-cycling environments have been particularly challenging. Fortunately, with the availability of integrated, miniaturized rupture disk solutions tailored to the application in a variety of standard and exotic materials, OEMs can significantly enhance equipment safety, compliance, and reliability even in extreme work conditions. ◆

Geof Brazier is managing director of BS&B Safety Systems custom engineered products division. Since designing the first rupture disk in 1931, BS&B Safety Systems continues to set the standard. Our commitment to technology, high-quality manufacturing, and quality by design has earned us the ISO 9001 Quality System Certification. BS&B Safety Systems offers a worldwide network of engineering, manufacturing, and support services. For more information, call 918.622.5950, email sales@bsbsystems.com, or visit **www.bsbsystems.com**.

An Almost Everlasting Evaporator Circulation Pump

Egyptian fertilizer processor finds the right pump for caustic chemicals and high temperatures

By Annette Wirén, Sulzer

PROJECT DATA

The pump is installed in an evaporation / concentration loop. It is located between the evaporator and the heat exchanger and takes care of the continuous circulation of the phosphoric acid through the heat exchanger and the evaporator.

ITEM	DESCRIPTION
APPLICATION	Evaporator circulation pump
LIQUID	54% phosphoric acid at 187 degrees Fahrenheit (86 degrees Celsius)
PUMP TYPE	CAHRM750K
CONSTRUCTION MATERIAL	Casing/wearing/shaft in WN 1.4539 Propeller in WN 1.4584
NOMINAL SPEED	520 (rpm)
LUBRICATION	Grease
INSTALLATION	Pump/motor side mounting on common baseplate
MOTOR	Siemens 250 kW – 3,300 V - 50 Hz
TRANSMISSION	Pulleys/belts (ten belts)
MECHANICAL SEALS	John Crane P32+FA33

El-Nasr Company for Intermediate Chemicals (NCIC) is the largest fertilizer company in Egypt and a leading company in the North African market. Its Al-Fayoum fertilizer complex was started in 2011 and includes a phosphoric acid plant (150 tons per day P_2O_5). Sulzer was the selected vendor for the supply of the axial flow pumps, and many other pumps.

THE CHALLENGE

The phosphoric acid is produced in a dihydrate (DH) process. The phosphate rock is attacked by phosphoric and sulfuric acid in a reactor. The 28 percent P_2O_5 acid produced is filtrated and then evaporated to a concentration of 54 percent P_2O_5.

The constraints of the evaporator circulator are as follows:

- 54 percent P_2O_5 acid with contaminants (HF, H_2SiF_6, H_2SO_4,≈ 3 percent solids).
- maximum operating temperature of 203 degrees Fahrenheit (95 degrees Celsius).
- manufacturer standard design (high flow, low head, and limited NPSHa).
- no speed variation.
- heavy duty and nominal bearing duration more than 25,000 hours of operation.

Evaporator circulation pump type CAHRM750K running at site.

THE SOLUTION

Sulzer selected the best pump size and propeller design for optimum benefits to the customer:

- propeller specifically designed for the project, with high efficiency and lasting performance in a corrosive and erosive application.
- optimal selection of the operating point with regard to the BEP and inherent hydraulic constraints of axial flow pump.
- adapted mechanism for pulleys/belts assembly, guaranteeing perfect performance and long lifetime of the mechanical seals as well as trouble-free operation of the bearings.

FOR FURTHER READING

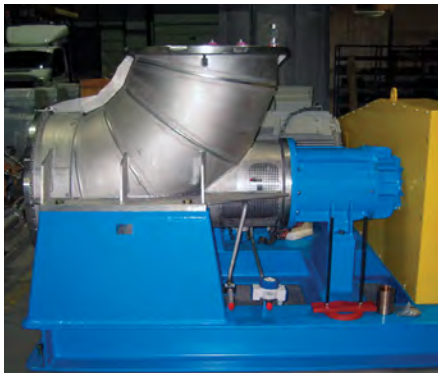
For further information on the selection and operation of axial flow pumps in an evaporation loop, consult the article "***Optimizing Axial Flow Pumps in Evaporator Circuit***" by D. Krebs (43rd Annual International Phosphate Fertilizer and Sulfuric Acid Technology Conference, AIChE, Clearwater convention 2019) or read his article "**Optimizing the Performance of Axial Flow Pumps in Evaporator Circuits.**"

The construction material proposed by the engineering company was SS904L, which is a common material for such applications. Its advantage is good corrosion resistance in most low-temperature P_2O_5 applications.

CUSTOMER BENEFIT

An axial flow pump with a state-of-the-art design, adequately selected to meet exact production needs and properly serviced, proved to be highly beneficial to our customer. The pump was operated for eight years with no repairs needed. After that, the customer decided to replace the main wear parts: propeller, shaft, wear ring and mechanical seals. Although many of the parts could have been reused, the customer chose to replace them with genuine new parts. Reusing worn components would not have guaranteed a similar lifetime after restart.

Despite an apparently low solids content in the fluid, the total weight of solids passing through the pump during one hour of operation can be estimated to be about 180 tons. These solids are mainly gypsum and precipitates. The traces of erosion visible on the propeller did not reveal abnormal patterns. The hydraulic design tailored for the project turned out to be successful and highly reliable.



Evaporator circulation pump type CAHRM750K in the workshop prior to packing.

During these eight years, the total cost of ownership (TCO) was kept to a minimum, with no added costs for commissioning, no down-time costs, no removal and disposal costs. The only costs incurred were related to operation, i.e. energy and consumables, and routine maintenance.

"The Sulzer axial flow pump type CAHRM750K we use in the evaporator circulation loop has been running perfectly since start-up and we are very satisfied. We only had to replace some parts after eight years of operation, which is remarkable," adds Yasser Ahmed, production manager at NCIC. ◆

Sulzer is a global leader in fluid engineering. We specialize in pumping, agitation, mixing, separation, and application technologies for fluids of all types. Our customers benefit from our commitment to innovation, performance, and quality and from our responsive network of 180 world-class production facilities and service centers across the globe. We provide pumps, agitators, compressors, grinders, and screens developed through intensive research and development in fluid dynamics and advanced materials. We are a market leader in pumping solutions for water, oil and gas, power, chemicals, and most industrial segments. For more information, visit **www.sulzer.com**.

Protect Large Motors from Bearing Damage

The larger the motor, the more expensive the repairs and downtime

Large electric motors controlled by VFDs are prone to high shaft voltages that can damage bearings through electrical discharge machining. Generators can also experience current surges and electrical arcing that destroy bearings.

And since larger motors are typically used in critical processes involving high volumes, downtime is very expensive.

Protect large motors with AEGIS® PRO Rings

AEGIS® PRO Rings are specially designed to protect large motors, generators, and turbines against bearing damage due to bearing currents. With 6 rows of conductive microfibers for high current-carrying capacity, AEGIS® PRO Rings bleed down shaft voltages to safe levels, protecting both motors and coupled equipment.

So, when repairing large motors, protect their bearings with AEGIS® PRO Rings. For information, visit: est-aegis.com/pro.

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Innovative Vibration Learning System

Part 2 of 2

See Part 1 www.mptmag.com

By Dr. Budhaditya Hazra, Liang Xu, and Dr. Suri Ganeriwala, SpectraQuest

In last month's introduction, we touched on how SpectraQuest has introduced a new innovative and modular bench scale experimental set-up called vibration fundamentals training system. The Vibration Fundamentals Training System (alias VFT) is a turn-key integrated educational package for teaching/learning the fundamental principles of mechanical vibration as well as engineering mechanics. The VFT provides an ideal tool for damping free vibration experiments using the wireless sensors without affected by the damping associated with the sensor cables. It is a perfect tool for teaching mechanical vibration courses both at under graduate and graduate levels.

EXPERIMENT 2: FREE VIBRATION OF SPRING MASS DAMPER SYSTEM

In general, vibratory systems consist basically of potential energy storing element (stiffness), kinetic energy storing element (mass or inertia), and energy dissipation element (damping). Damping effect in vibratory systems may be caused by friction between moving parts (dry friction), or material deformation and internal friction between layers of a part (structural action), or the use of mechanical viscous dampers. The first two may never be completely eliminated but can be, generally, ignored under certain conditions.

However, the third can be used to achieve a required damping effect. In the first part of this series, we introduced some experiments that can be easily performed as a part of the vibration teaching curriculum, and we conclude with experiments showing that the damping contribution from dry friction and structural action is indeed negligible.

OBJECTIVES

In this experiment, a simple spring-mass-damper system is to be studied, in order to determine the damping coefficient C by logarithmic decrement method.

SYSTEM DESCRIPTION

Figure 4 shows the system to be studied, which consists of a solid disc of mass M (sum of the disc mass, springs effective mass and the load career), that moves vertically up and down, while attached from its upper side by a spring of stiffness K, and from its lower side by a dashpot damper with damping coefficient C; the spring and the damper are fixed to the main frame.

The dashpot used consists of a cylindrical disk immersed in a container filled with oil. Figure 6 shows the details of the cylinder piston type arrangement. The coefficient of damping of the dashpot varies according to the spacing between the disc and the wall of the container. All the calculations are performed based on the acceleration measurement carried out using the wireless accelerometer.

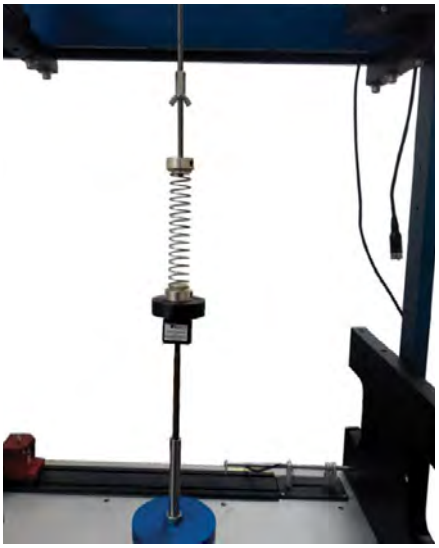

Figure 4: Setup for free vibration test.

GOVERNING EQUATIONS

By giving the system shown schematically in figure 4 an initial vertical displacement Y, it will vibrate freely with a time-varying function y(t), and the resulting equation of motion will be:

$$M\ddot{y} + C\dot{y} + Ky = 0$$

To solve for y(t); let $y(t) = Ye^{st}$, then the auxiliary equation and its solutions are:

$$Ms^2 + Cs + K = 0$$

$$\Rightarrow s = -\frac{C}{2M} \pm \sqrt{\frac{C^2}{4M^2} - \frac{K}{M}}$$

Substitute in y(t), to get:

$$y(t) = Y_1 e^{S_1 t} + Y_2 e^{S_2 t}$$

$$\Rightarrow \qquad y(t) = e^{-\frac{C}{M}t}\left[A_1 \sin\left(\sqrt{\frac{K}{M} - \frac{C^2}{4M^2}}\right)t + A_2 \cos\left(\sqrt{\frac{K}{M} - \frac{C^2}{4M^2}}\right)t\right]$$

But:

$$\zeta = \frac{C}{C_{Critical}} = \frac{C}{2\sqrt{KM}} = \frac{C}{2M\omega_n}$$

Then, the linear spring equation following Hooke's law becomes:

$$y(t) = e^{-\zeta\omega_n t}\left(A_1 \sin\left(\omega_n\sqrt{1-\zeta^2}\right)t + A_2 \cos\left(\omega_n\sqrt{1-\zeta^2}\right)t\right)$$

LOGARITHMIC DECREMENT METHOD

Considering a typical decaying curve as the one shown in figure 5, then the ratio of the amplitude Y_o corresponding to the time $t = t_o$, t_o the amplitude Y_n at time $t = t_o + n^T$, is given by:

$$\frac{Y_o}{Y_n} = \frac{e^{-\zeta\omega_n t_o}}{e^{-\zeta\omega_n (t_o + n\tau_d)}} = e^{n\zeta\omega_n\tau_d}$$

Define the logarithmic decrement as:

$$\delta = \frac{1}{n}\ln\left(\frac{Y_o}{Y_n}\right)$$

Eliminate a portion of the logarithmic decrement from the previous two equations to obtain the following:

$$\delta = \zeta\omega_n\tau_d = \frac{2\pi\zeta}{\sqrt{1-\zeta^2}}$$

$$\Rightarrow \zeta = \frac{\delta}{\sqrt{\delta^2 + 4\pi^2}}$$

Then find the damping coefficient, where:

$$\omega_n = \sqrt{\frac{K}{M}}$$

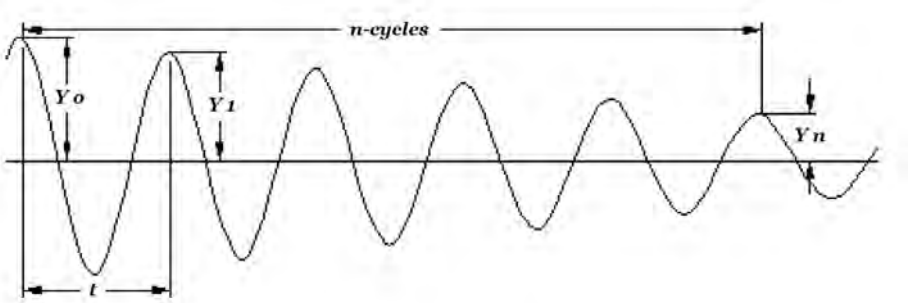

Figure 5: Logarithmic decrement of the spring mass system for under-damping case.

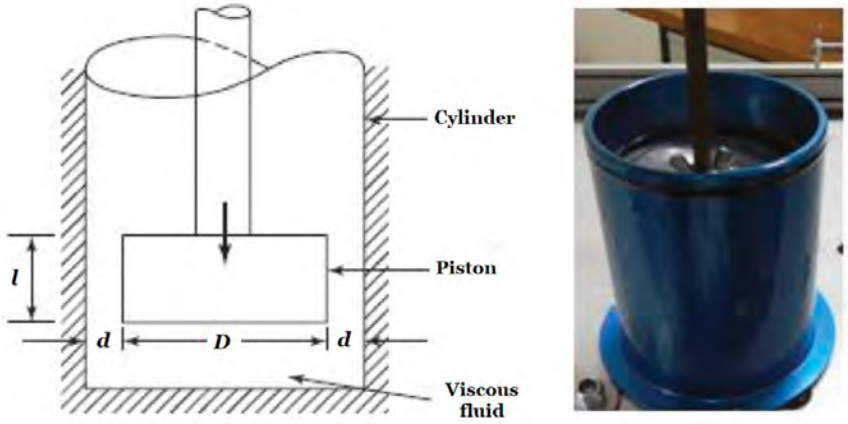

Figure 6: Cylinder piston type viscous damper.

$$K = \frac{Gd^4}{8ND^3}$$

THEORETICAL VALUES OF DAMPING RATIO

The theoretical expression for viscous damping coefficient for the piston cylinder arrangement as shown in figure 6 is given by the following formula

$$c = \mu\left[\frac{3\pi D^3 l}{4d^3}\left(1+\frac{2d}{D}\right)\right]$$

Where u is the coefficient of kinematic viscosity in micro-reyns (or centistokes). The damping coefficient is expressed in Ns / m^2. Once c is known, the theoretical value of damping ratio can be calculated using the following expression:

$$\zeta = \frac{\mu\left[\frac{3\pi D^3 l}{4d^3}\left(1+\frac{2d}{D}\right)\right]}{2M\omega_n}$$

To arrive at the theoretical values of damping ratio using equation the following values of the parameters are used: l = 6.5 mm; d = 4.15 mm; = 3 micro-reyns. The diameter of the cylindrical cup containing the damping fluid is 73 mm.

EXPERIMENTAL PROCEDURES

1. Start with the system shown in figure 4.
2. Pull the mass down and then release it to let it oscillate freely.
3. The accelerometer gathers the acceleration data.
4. Use the software to calculate natural frequency and damping using Fourier spectra and logarithmic decrement respectively.
5. Perform two sets of experiments for two situations: with the damper attached and no damper attached.

From the results in tables 3 and 4, it can be observed that even the undamped system possesses some damping although negligibly small. The theoretical value of damping ratio is calculated. It can be observed that there is significant error between the actual and the estimated values of damping. This is attributed to the fact that there are many unobservable sources of damping which is not practically easy to determine. For example, the movement of the cylindrical rod that connects the vibration mass to the piston, generates friction between the rod and the guide through which it slides. Figures 7 and 8 further provides the screen capture for the damping and frequency estimates of the spring-mass-damper system using the customized VFT software.

Thus, it is safe to conclude that accurate estimation of damping is practically difficult. The problem gets mitigated to a large extent by increasing the mass of the vibrating body keeping the stiffness fixed.

VIRTUAL EXPERIMENTATION

One of the key aspects of the VFT system is virtual experimentation. The key philosophy behind virtual experimentation is that the students should be able to perform all the experiments on a simulation setting before performing the actual experiment. The VFT package offers a simulation software is designed to teach basic concepts using a new interactive and visual simulation technique. Users can perform virtual experiments on various topics

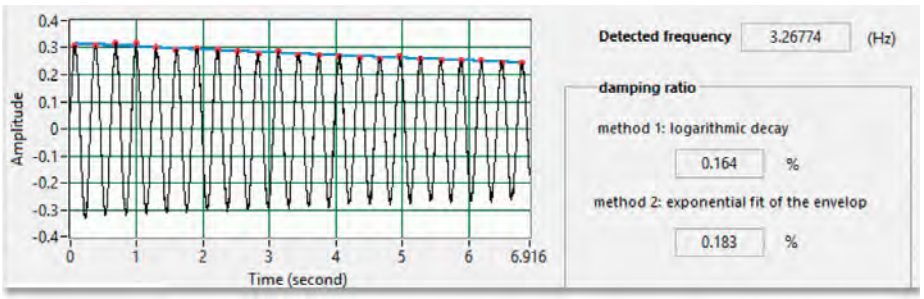

Figure 7: Estimated w_n and the theoretical values of damping ratio using the custom software for the undamped case.

TRIAL	m (kg)	w_n (Hz)	ζ ESTIMATED (%)	ζ THEORETICAL
1	0.35	4.02	0.141	0
2	0.57	3.26	0.2	0
3	0.784	2.75	0.18	0
4	0.920	2.55	0.19	0

Table 3: Results for spring mass damper system in absence of viscous damping.

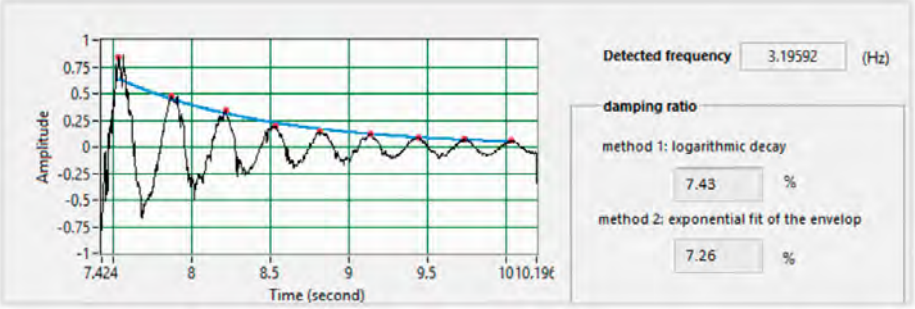

Figure 8: Estimated w_n and the theoretical values of damping ratio using the custom software for the damped case.

TRIAL	m (kg)	w_D (Hz)	ζ ESTIMATED (%)	ζ THEORETICAL	ERROR (%)
1	0.35	3.98	11.0	7.66	46.6
2	0.57	3.20	7.4	5.8	28.48
3	0.784	2.74	6.6	5	32.0
4	0.920	2.54	5.8	4.59	26.36

Table 4: Results for spring mass damper system in presence of viscous damping.

by changing the parameters of a vibratory system and see how the system behavior is affected. The effect is displayed dynamically. The vivid visualization enhances the learning and clarification. A spring-mass-damper system is used to animate the vibration response. It is important to observe that the speed of animation is proportional to the natural frequency of the spring mass system: the higher the frequency, the faster it moves.

One of the attractive features of the software is the multi-plot option. A multi-plot can be used to compare their effects on vibration response. Therefore, instead of deriving the equations, the user can go one step further, ''play and see'' the vibration behavior. The software includes the most common topics of a typical vibration course. This is particularly u seful, for example, to demonstrate resonance of a SDOF vibrating system. Users can set the frequency of the forcing function close to the natural frequency of the SDOF system and compare the response amplitudes as the forcing function frequency is perturbed to values slightly higher and lower than the natural frequency.

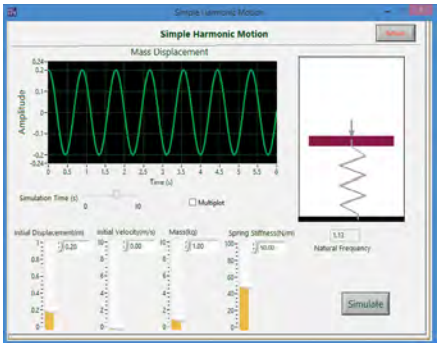

Figure 9: Simulation software showing a SDOF system vibration.

Figure 10: Simulation software demonstrating resonance using the multiplot feature.

CONCLUSION

We have presented a very innovative Vibration Learning System; SpectraQuest's vibration fundamental training (VFT) system. VFT is a modular, attractive, hands on vibration training system that supplements textbook learning with very easy, convenient and effective bench scale experiments. The system facilitates different levels of modularization to perform wide gamut of vibration experiments. The results from some of the experiments clearly prove this point. It is well supplemented by a wonderful virtual experimental package in the form of a simulation software which clearly demonstrates its efficacy in providing a preparatory guidance before performing the actual laboratory tests. ◆

SpectraQuest, Inc. is a leading developer and manufacturer of complete turn-key Systems for training and diagnosis in machine vibration analysis, rotor balancing, and shaft/coupling alignment. System includes machinery fault simulators, interactive training program, data acquisition hardware/software, and accessories. To accelerate the learning and design process SpectraQuest offers a series of interactive software CDs on vibration fundamentals and calculations, signal processing, alignment, and balancing. For more information, visit **www.spectraquest.com**.

Robots Tackle Infrastru

Automated solutions provide safer, more efficient method for dangerous task of repairing hydropower pipes

By Dan Thompson, igus

The durability of the igus products to perform in rugged, dirty environments was critical to their inclusion on the robot.

cture Challenge

Crumbling global infrastructure has reached a critical point. In 2019, the American Society of Civil Engineers estimated the nation needed to spend $4.5 trillion to fix roads, bridges, dams, and other infrastructure. A report in 2017 from the ASCE gave the United States a D+ grade—the same as in 2013. The next report, due in 2021, does not figure to be markedly improved. Canada faces similar issues. A 2019 report found nearly 40 percent of the roads and bridges were in fair, poor or very poor condition. About 30 percent of the nation's water infrastructure are in the same condition. A report in 2019 from the World Economic Forum said the world is facing a $15 trillion infrastructure gap by 2040.

"We're talking about roads, bridges, libraries, arenas and more—things Canadians rely on every day," says Bill Karsten, president of the Federation of Canadian Municipalities (FCM). "Good, reliable infrastructure supports our quality of life in communities across the country, so Canadians should find these results concerning."

A newly developed robotic device from Remote Orbital Installations LLC (ROI) and Big Sky Engineering in Wisconsin, delivers a faster and safer alternative to manual labor for pipeline rehabilitation. A robotic platform, which ROI/Big Sky calls the "Crawler," can both surface-blast and line medium to large diameter pipe internals. Current projects involve penstocks, large diameter pipes at hydro-electric installations that transfer water from mountain lakes down to generating turbines at a lower elevation.

ROI/Big Sky developed the robot for contractors looking to satisfy stringent specifications required to perform work for BC Hydro in British Columbia, Canada. More than 95 percent of electricity comes from hydropower in this region. The penstocks that channel water through the turbine generators have been in place for decades. The original internal coatings are degrading and need to be removed and replaced with a new lining system to prevent further corrosion.

DANGEROUS WORK

The death of five people in a 2007 accident in Colorado demonstrates the danger of confined space pipe repair. The victims were applying an epoxy lining in a penstock at the Cabin Creek Station about thirty miles west of Denver when a fire broke out. Trapped in an access tunnel filled with noxious fumes and smoke, the workers died from asphyxiation.

In response, BC Hydro sought a new solution from the industry to address their rehabilitation needs. "Their ultimate intent is to ta ke man-entry out of these jobs," says Mike Kronz, who helped design the unit for ROI/Big Sky. "Canada is pretty tight on restrictions for human safety. Their regulations and standards sometimes make the Occupational Safety and Health Administration in the United States look like child's play."

"We're always up for a challenge. We knew what needed to be done, we proved it, and we came up with the solution," adds Paul Garvoille, who also helped design the unit for ROI/Big Sky.

ROI/Big Sky first generated and tested model prototypes but would not know for certain how the full-scale automated unit would perform until it was tested under actual project conditions. To understand this, a full-scale mock-up of an 8-foot diameter pipe, 59 feet long with a 45-degree incline was constructed at the Big Sky facility for testing.

The primary advantage of the Crawler is minimizing the amount of time workers spend inside the pipe structures, thereby reducing the risk that was inherent in the Cabin Creek tragedy. "This not only reduces the amount of manual labor, but it also is quicker, safer and performs the work more consistently," Kronz says.

The device is operated from a modified shipping container referred to as the command center. "There is all kinds of feedback that can be read in the command center," Kronz says. "There's an umbilical cord attached to the Crawler that allows for remote operation up to 2,000 feet from the command center."

A Wisconsin company has designed an automated unit, called the "Crawler," that can surface-blast and line medium to large diameter pipe internals.

The unit can travel up to 150 feet per hour during the internal lining process. The Crawler's blasting rate in a 10-foot penstock is about 500 to 600 square feet per hour.

TECHNICAL DETAILS

The Crawler is a technical marvel, with many of the components provided by igus, a German-based manufacturer of motion plastics. The company runs its North American operations out of Providence, Rhode Island.

The most critical products in the application are energy chains, which are used to manage and protect electrical cables going from the lower control cabinets to the upper cabinets. They are used in the main boom raise, which allows the boom to extend and contract as it works within the pipe.

An igus energy chain also allows the wheel width of the Crawler to be adjusted as it moves within the penstock. Diameters vary from 5 to 13 feet, and the automated unit is adjusted through the umbilical cord that is controlled by the operator.

The device also includes a slewing ring from igus which allows the boom to pivot from side to side, servo motor cables that direct boom movement, and a 1,640-foot umbilical cord that contains power and control cables along with fiber optic cables.

"It's a dirty, rugged environment with a lot of dust and abrasive material," Garvoille says. "Everything has to be extremely durable. In layman's terms, it is sandblasting."

The durability of the igus products was critical to the success of the Crawler. "We've done several projects and we haven't had a single failure with the igus components," Kronz says. "Other materials have failed, but not the igus products. The slewing ring, for instance, is comparable to a ball bearing. That would have been a real problem with all the dirt that the device experiences. The igus materials don't require any seals to protect the ball bearing."

PROVING WORTHY

The first project occurred in BC Hydro's Bridge River Facility in 2018, a facility that opened in 1961 in British Columbia.

The Crawler navigated through nearly 4,500 feet, adjusting to the different angles while moving along descents as steep as 45 degrees. A second repair project occurred in 2019 at BC Hydro's Cheakamus Facility, where the Crawler completed over 1,600 feet of pipe repair. The Crawler's blasting rate in a 10-foot penstock is about 500 to 600 square feet hour, and travels about 15 feet per hour. During the internal lining process, the unit travels at 150 feet per hour. For contractors, the lining material cost is about $200 per minute.

With infrastructure in such dire need of repair, the Crawler will play an important role in providing such critical work.

"There's a global market for this," Garvoille says. "If there is a pipe that transfers water, it's not going to last forever. They have to be protected and repaired from time to time."

Kronz adds, "This equipment could basically be used in any pipe or similar structure that needs repair." While one design cannot satisfy all of the global needs for infrastructure, it is a big step toward solving some long-term and critical infrastructure issues.

"We've been hearing how infrastructure is falling apart around us," Kronz says. "In British Columbia, 95 percent of its energy comes from hydropower and BC Hydro alone has twenty-seven generating stations. We're just getting started." ◆

The Crawler includes several components from igus, including energy chains that protect electrical cables and also allow for the wheel width of the unit to adjust as it moves within the penstock.

Dan Thompson is the product manager of energy chains for igus. Igus uses its innovative polymer materials to develop products that provide creative solutions and exceed our customers' expectations while delivering fast, accurate service. For more information, visit **www.igus.com**.

Featured Product

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Gardner Denver High Pressure Solutions (HPS), a leading total solutions provider for the drilling, well servicing, and frac pumps market, introduces the new GD 2500Q Heavy Duty Frame (HDF) quintuplex pump, designed to extend pump service life through an optimized power end frame design. The frame upgrade has been developed to increase component thickness and allow for larger, stronger welds, to boost structural integrity. Today's pumping conditions have pushed power end frames of all makes to their limits. The upgrade was designed with the aim of reducing stress in vulnerable areas. For more information, visit www.gardnerdenverpumps.com.

The Real-time Data Revolution Is Here

OSIsoft's Jim O'Rourke and Gary Wong talk digital transformation

The use of real-time data has become a major leap forward in both efficiency and management decisions. Jim O'Rourke is an academic principal with OSIsoft and, along with his coauthor Dr. Osvaldo Bascur, has recently released the book "Digital Transformation for the Process Industries: A Roadmap," which provides readers with a blueprint to digitally transform their facilities and entire enterprises. He and Gary Wong, OSIsoft's industry principal for water, recently joined MPT's podcast to discuss this technology's bright future. An excerpt of that conversation appears below.

MPT: **What are some of the ways industries can effectively integrate operational technology with information technology to become more predictive?**

Jim O'Rourke: The first thing that any company that wants to go through its digital transformation and become more efficient, it is to consolidate their operations, data, all of it into a system of record that people in the enterprise, whether it be operations people, subject management, or subject matter experts like maintenance and process and safety. And all those people can have the data at their fingertips the way they want to consume it, to make sure their assets are running at peak performance, make sure that they're running sustainably, and make sure that that safety is enabled. And then really to minimize controllable costs, whether that be any off-spec product, you make unscheduled downtime because equipment not performing the way it was supposed to, or simply just wasted energy because the process or the equipment is inefficient.

MPT: **What are some of the more creative ways you've seen companies use real-time data infrastructure to improve their performance?**

Gary Wong: I would say in the early days of the twenty-first century, the paper business went through a pretty traumatic downturn, as communications went from paper to electronic communication. And for so many of these paper mills, the demand went way down; however, they had their own ways of making power. So they said, "Well, how about if we sell this excess power back to the grid to have another revenue stream?" With the data that they had in the plant of the operations when things were scheduled, how much power was being used, then they could focus on selling excess power back to the grid and increasing the revenue streams.

MPT: **In many cases, that raw sensor data was already there, so how has OT become more useful and adaptable in modern infrastructure?**

Gary Wong: Yeah, when you hear about "big data," for example, like before that was coined, all these automation and SCADA systems have been, like you say, generating a lot of data from the OT side of things. So having that context available is critical, and in terms of how, for example, we have templates set up, and we've got some customers, say Water Corporation in Australia, they've got over 1,000 pumping stations. They can easily create a single template for all these various pumps. And as that raw data comes in, context is automatically put beside it, in terms of the type, the location, the manufacturer, when it was last serviced, and so on.

Jim O'Rourke: Gary's right on the money there regarding the sensor data. What our approach has been for many years is to contextualize the data as it's collected. And more importantly, we have tools that can send this data with the context up to corporate analytics, and also the data scientists so that they can use it quicker and decrease time to value for their findings. ◆

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

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