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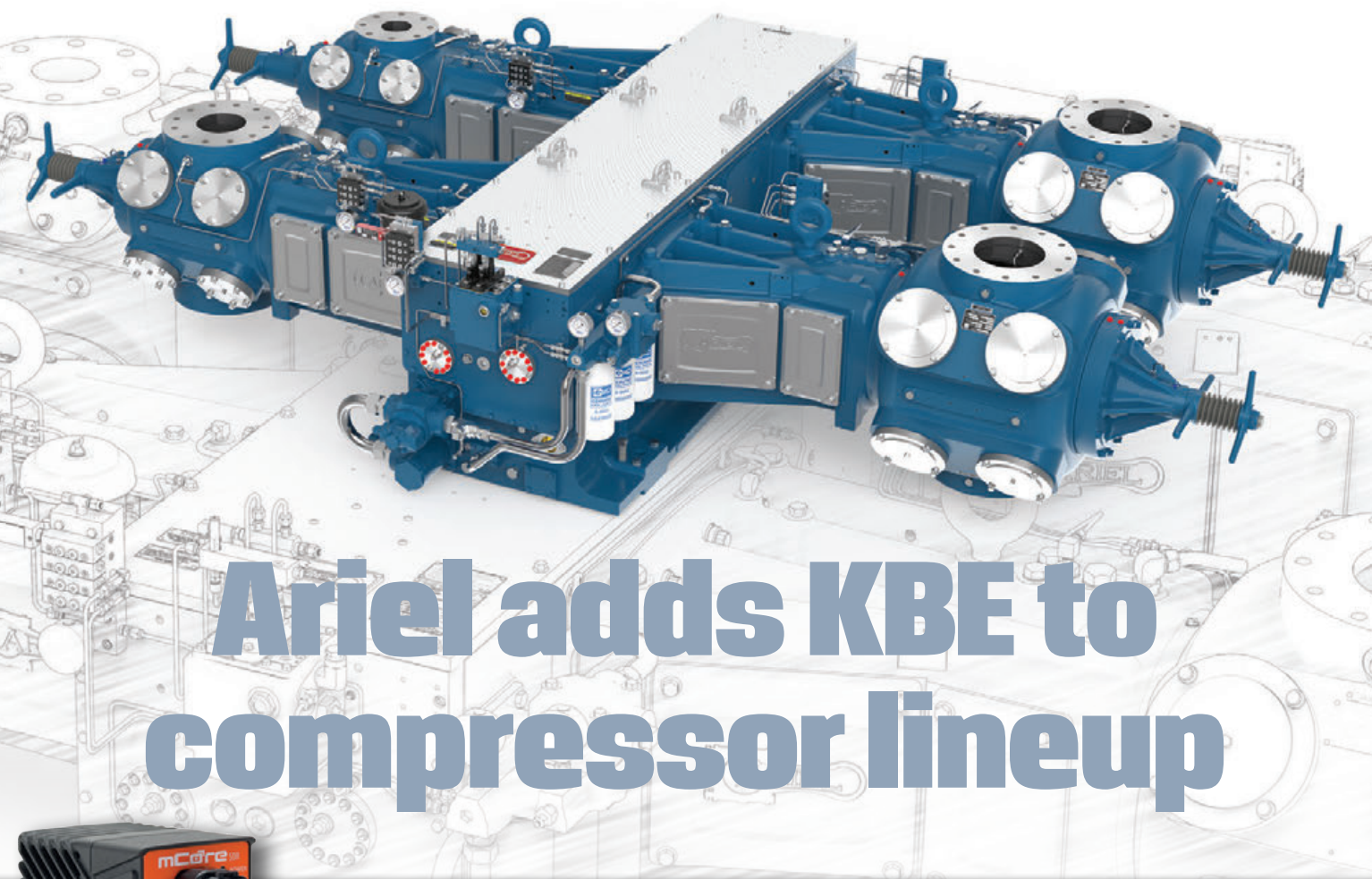
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Data to the rescue

Data is ingrained deeply in nearly every aspect of our lives. Our phones can pull up statistics on any topic in a few finger taps. A smart device can serve as a verbal encyclopedia. Even our watches can tell us how many steps we've taken or how hard our heart is working.

On the corporate side, data is a key element in measuring success. Companies leverage data every day to optimize their operations. Marketing firms tout metrics to determine the impact of a digital campaign. There are even jobs that didn't exist 20 years ago – social media managers – that thrive on using data to enhance a company's brand and reach.

The gas compression industry has also been shaped by all the technological advancements over the past two decades, especially in regard to monitoring and optimization devices. All of these devices have a commonality between them. They all provide data.

As I watched technology evolve from the 1980s on, I wondered what we'd see at the turn of the century and beyond. Those answers came slowly at first, but now everything seems to appear at a break-neck pace. Condition monitoring felt like an optional enhancement when my name started appearing in **COMPRESSORTECH²**. Now those devices are on nearly every compressor package.

The timing couldn't be more appropriate, now that the world and the gas compression industry have begun focusing more on climate change and how to be better inhabitants of this planet. Wherever I go, that topic seems to be at the forefront of most people's minds in this industry.

During Baker Hughes' Annual Meeting in Florence, Italy, the company's Chairman, President and CEO Lorenzo Simonelli summarized the situation the gas compression faces as we head into the next decade. The challenge is to supply more energy to a world with a ravenous appetite for it, all while reducing our environmental footprint. A clean energy future, he said, begins and ends with technology.

It's a good thing that the industry has the tools to meet this challenge. The latest devices, such as the Baker Hughes-C3. ai collaboration known as BHC3 Production Optimization, use machine-learning algorithms to gather and distribute information, all while learning about the performance of an operator's equipment and how to improve it in the process.

With this kind of data-driven technology, the gas compression industry appears poised to meet and exceed that challenge. How do I know? I've got the data to prove it.

CT2

DJ Slater

Senior Editor dj.slater@khl.com

GOOD NEWS



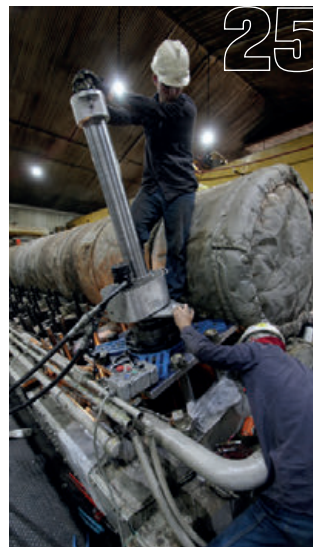


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Burckhardt introduces cost-saving supply method

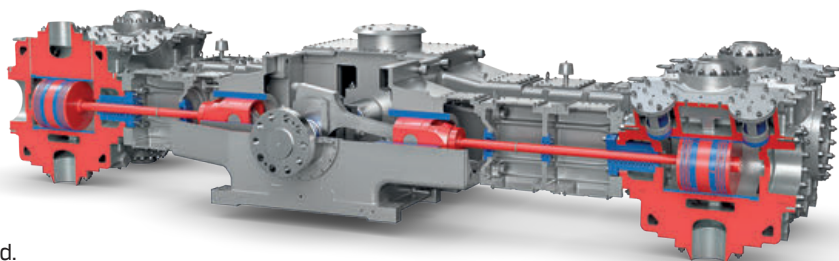
Burckhardt Compression has made internal changes to offer API Standard 618 compressor systems in a more cost-effective manner to its current and future customers. The changes allow Burckhardt to use its affiliates in other countries to supply compressor parts or the entire compressor, which helps customers save on the overall cost of the system.

The compressors feature a modular design that takes advantage of global processes, engineering and supply chain, the company said.

Hyundai Engineering Co. ordered the first two compressors through this method. The compressors, which will be driven by 5 MW electric motors, will be used for propane dehydrogenation in the production of propylene at a petrochemical plant in Poland.

"Burckhardt Compression has leveraged its global setup with locations around the world to offer this new, capex-optimized line of compressors," says Marcel Pawlicek, CEO of Burckhardt Compression. "It allows us to target and win over new groups of customers for our products."

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Big shale cutbacks by Chevron

Chevron Corp. announced a US\$20 billion capital and exploratory spending plan for 2020, but it wasn't especially good news for the company's natural gas businesses.

The company said it will reduce funding to various gas-related opportunities including its Appalachian shale holdings, the Kitimat LNG project and other international projects. Chevron said it is evaluating its strategic alternatives for those assets, including divestment. The company is reported to hold 750,000 acres (303,514 ha) of production leases in the Marcellus and Utica shale plays.

Petro-Canada Lubricants, a HollyFrontier Business, has launched Sentron SP 40, a stationary gas engine oil designed to meet the demands of next-generation stationary gas engines operating with steel pistons.

The company said Sentron SP 40's advanced additive technology is designed to prevent harmful deposits in the top ring grooves of steel piston engines to reduce wear in key engine parts and increase engine durability and life.



PEOPLE NEWS

■ **Burckhardt Compression** will nominate **TON BÜCHNER** to be the new chairman of the board at the company's annual general meeting on July 3. Valentin Vogt, the current chairman who has served as a director for 18 years — nine as chairman — will not stand for reelection.



Büchner, 54, was chairman and CEO of AkzoNobel, a Dutch multinational company, from 2012 to 2017. Prior to joining AkzoNobel, he worked for Sulzer for 18 years, ultimately serving as the company's CEO from 2007 to 2011. He has been a director at Novartis since 2016 and a member of the shareholders' committee of Voith since 2014.

"Ton Büchner is a business executive with exceptional qualifications who is deeply familiar with our products and targeted markets," said Vogt. "He brings a strong and well-established track record to Burckhardt Compression and lives the same values we do."



■ **Cooper Machinery Services**

hired **HANS MATHEWS** as its vice president of engineering. Mathews has 29 years of compression industry experience, which includes 20 years with Hoerbiger and nine years with Tenneco.

Mathews, who last served as Hoerbiger's

senior vice president of sales and engineering, is an expert of applying modern technology to legacy engine applications.

■ **Hoerbiger** announced two position changes within its organization. **DARREN SUDDUTH** has returned to the company as service sales manager for North America and **JASON ADKINS** will serve as head of operations for the company's North American Service business.

Sudduth will oversee all aspects of Hoerbiger's service sales, including solutions and upgrades, major projects and overhauls, and customer relations.

Adkins, who assumes a new position,

Hoerbiger acquires majority stake of Ragsol

The Hoerbiger Group acquired a majority stake in the Austrian oil and gas solutions provider Ragsol GmbH. No financial details were provided.

Ragsol, which had been wholly owned by RAG Austria AG, provides comprehensive solutions and products for mature oil and gas fields with the goal of producing oil and gas more efficiently at lower costs and in an environmentally friendly manner.

Ragsol has more than 80 years of experience in operating and optimizing mature wells. This acquisition is seen as a solid fit for Hoerbiger's Compression Technology Strategic Business Unit, complementing the present offerings in its Service Division.

"The unique products and smart brownfield approach of Ragsol let the customers increase the efficiency of mature oil fields, reducing operating costs by up to 40% and extending the life of the fields," said Wolfgang Sautter, head of the Service Division at Hoerbiger Compression Technology. "The Ragsol solutions help our customers to manage their valuable natural resources in a responsible and eco-friendly way."

is responsible for the continued transformation of Hoerbiger's service branch operations by managing a portfolio of local improvement projects.



■ **EMIT Technologies** appointed **MIKE PARIS**

as vice president of Engineering. Paris will

oversee design, applications, project and controls engineering teams for the Sheridan, Wyoming-headquartered specialist in emissions control technology for natural gas compression applications. »

MAN releases lube oil monitoring system

MAN Energy Solutions has launched a new lube oil monitoring system designed to meet the needs of the owners of industrial installations where lube oil quality is a critical setting.

The MAN fluid monitor is a light and robust system developed to enable owners to actively monitor – on an ongoing basis – the degradation and contamination of lube oil and protect their industrial assets. The fluid monitor is designed to immediately detect the tiniest anomalies in the lube-oil systems of four-stroke engines, turbomachinery and auxiliary equipment.

Used alongside laboratory analyses, the MAN fluid monitor alerts operators with alarms and stop recommendations as soon as it detects degradation in lube oil quality, thereby revealing minor wear of mechanical parts. Through the detection of anomalies, especially important during such sensitive engine phases as restarts where 50% of damage occurs, this product allows the operator to anticipate maintenance, protect major components, and identify part wear before a breakdown, thus maximizing machine availability, the company said.

MAN Energy Solutions said the fluid monitor has recorded over 18,000 test hours on pilot industrial sites, complies with CE standards and has been certified by Bureau Veritas marine applications. It has also received its very first order for third-party equipment in the Pacific region.

"We know that lube oil is the lifeblood of an engine and that 70% of major damage reveals lube oil contamination," said Arnaud Filancia, vice president within MAN Energy Solutions. "We wanted to develop a global monitoring solution capable of conforming to the demands of all rotating machines – such as four-stroke engines and turbomachinery – and whatever the application, whether it be marine, power plants or anything else." **CT2**



Detection releases enbase asset monitor

Detection Technologies, a global provider of condition monitoring products, has launched the Enbase asset monitor, a system for remotely monitoring the run status and location of natural gas and oilfield equipment.

The system, housed in a weatherproof and hazardous location-certified enclosure, determines an asset's run status using a built-in accelerometer to detect vibration. It also tracks GPS coordinates to determine when the asset is in motion and to send proactive location updates.

The Enbase asset monitor sends messages through a satellite network, which has coverage throughout the oilfield. The system reports back to the Enbase dashboard, which users can access data on their assets. The system runs on solar-power batteries, which have a 10-year life.

The system is part of a family of Enbase products. It is applicable for monitoring lower horsepower natural gas compressors, as well as rotating equipment.



Timken expands Philadelphia Gear repair facility in Alabama

Timken Co. announced that renovations are complete and new services are operational at the Philadelphia Gear Southeast Regional gear repair facility in Birmingham, Alabama. The expansion project included an isolated assembly bay, the addition of a retractable paint booth and a large industrial parts washer, all designed to facilitate a "clean assembly" environment.

"We evaluated our operation from the

ground up," said Jay Alexander, manager of the Philadelphia Gear manufacturing and service center. "Our renovated facility is streamlined to simplify production and improve efficiency, and more importantly, expand our service offering."

The newly renovated assembly bay features 3500 sq.ft. (325 m²) of isolated assembly space, new floors and a crane system capable of handling up to five

tons. The portable, retractable paint booth includes an integrated air filtration system that can expand to 400 sq.ft. (37.2 m²) to accommodate all gearbox sizes. The paint booth addition is an environmental and quality improvement in the painting process.

The other major investment was a large industrial parts washer that can hold gearboxes and components up to 7000 lb. (3175 kg). It incorporates a 72 in. (1829 mm) turntable, 150 psi (10.3 bar) of washing pressure and 180°F (82°C) washing temperature. This unit will reduce cleaning time by four hours per gearbox over manual methods and eliminate the need for outsourced sand or bead blasting, the company said.

Part of the Timken Co. since 2011, Philadelphia Gear Philadelphia Gear offers expertise in the service and manufacture of power transmission equipment, including gears, new and replacement low- and high-speed gearboxes and variable speed clutches for a range of industries such as oil & gas, power generation and petrochemical.

CT2



PEOPLE NEWS

Paris has extensive experience in the natural gas and energy industries. He previously was director of Engineering for Woodlands Energy Services for two-plus years and was COO at Sancus Energy and Power prior to that. Earlier, he spent 12 years as vice president of Compression for Valerus and more than 10 years as VP of Engineering for Hanover Co.



■ **TurboTides, Inc.**, a provider of turbomachinery design technology, announced the promotion of **SCOTT HANRATTY** to vice president of Global Sales. Hanratty is responsible for expanding global

sales, marketing and reseller recruitment and support, including directly overseeing sales activities in Europe and Asia.

Hanratty joined TurboTides as director of Sales - Americas in January 2019 and has since established the company's national sales channels in North, Central and South America. Most recently, he was a regional sales director for the Americas and East Asia at Concepts NREC.

■ **T.D. Williamson (TDW)**, the Tulsa-based global pipeline solutions provider, announced the appointments of **JEFF WILSON** to vice president, Eastern Hemisphere, and Rich Kehl to vice president, global engineering

solutions, effective Feb. 1.

Wilson has held a variety of positions since joining TDW in 2007. As vice president of global engineering solutions, he successfully launched numerous products and services and oversaw the TDW patent portfolio. He will relocate from TDW headquarters in Tulsa to the Global Solutions Center in Nivelles, Belgium.

Kehl was senior director of advanced isolation solutions. He has been instrumental in expanding the company's market position and portfolio offering. Before joining TDW, Kehl was a product manager in the power equipment industry, which included stints at GE and Alstom.

New methane emissions regulations enacted in BC

The BC Oil and Gas Commission enacted new regulations for British Columbia to reduce methane emissions from upstream oil and gas operations to meet or exceed federal and provincial methane emission reduction targets. The amendments to the Drilling and Production Regulation, which went into effect Jan. 1, are intended to address the primary sources of methane emissions from B.C.'s upstream oil and gas industry.

The impact of the new regulations is a reduction in methane emissions by 10.9 megatons of carbon dioxide equivalent over a 10-year period, according to the commission.

The changes include enhancements to requirements for leak detection and repair, which is intended to ensure leaks are detected and repaired quickly. Additionally, robust data management and reporting requirements to facilitate transparent reporting of industry actions are under development.

The new regulations and methane reduction measures align with the Province's CleanBC plan. The Government of B.C. has a methane emission reduction target of 45% by 2025 relative to 2014 levels, while the national government of Canada has set a reduction target of 40 to 45% by 2025 relative to 2012 levels.

To support ongoing progress on meeting targets, the Commission is involved in the BC Methane Research Collaborative (MERC), which was created to focus research efforts toward managing and reducing the release of methane from oil and gas operations. The initiative will make recommendations on the design and implementation of the key research deliverables critical to the identification, quantification and control of methane emissions to support reduction goals.

■ **Cooper Machinery Services** appointed two industry veterans to regional director positions. **MIKE BAUGHMAN** has been named regional director of the Permian Basin. Baughman began his career with Cooper as a high school student in 1979.

Baughman collectively spent 30 years with Cooper over the course of his career in Grove City and Odessa, Texas. He also spent time at Nickles Industries and Valerus Inc. More recently, Baughman had his own catalyst business. He returns as leader of Cooper's Midland-Odessa service, shop and sales operations.

The company also named **LANCE BRADFORD** as Northwest regional director for the U.S. He worked with Compressor Pump and Engine Inc. and has spent the last eight years as director of Mechanical Support for Kinder Morgan.

Bradford will be located at Cooper's Casper, Wyoming, service center.



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Natural gas prices drop to 2016 levels

This winter, natural gas prices have hit their lowest levels in decades. On Feb. 10, the near-month natural gas futures price at the New York Mercantile Exchange closed at US\$1.77 per MMBtu, according to the U.S. Energy Information Administration (EIA). This price was the lowest February closing price for the near-month contract since at least 2001, in real terms, and the lowest near-month futures price in any month since March 8, 2016, according to Bloomberg, L.P. and FRED data.

In addition, according to Natural Gas Intelligence data, the daily spot price at the Henry Hub national benchmark was US\$1.81 per MMBtu on Feb. 10, the lowest price in real terms since March 9, 2016. Henry Hub spot prices have ranged between US\$1.81 and US\$2.84 per MMBtu during the winter heating season, which began on Nov. 1, 2019.

Relatively warm winter weather has reduced the demand for natural gas for heating. Natural gas production growth has outpaced demand growth, reducing the need

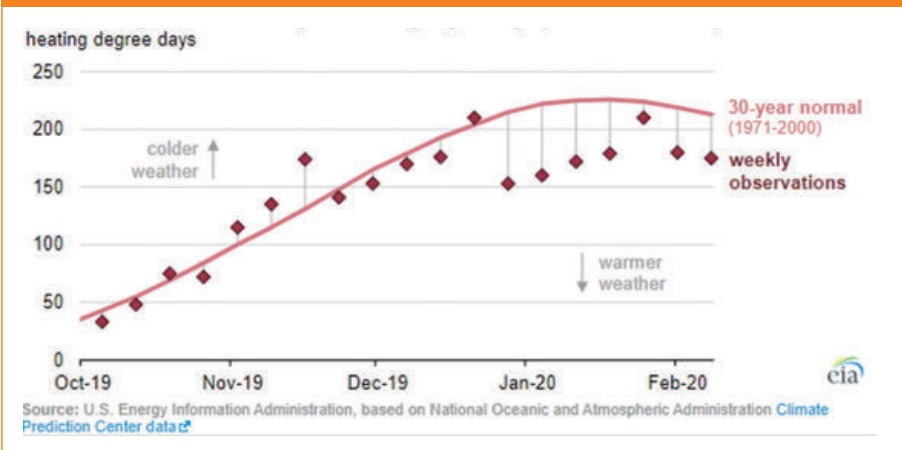
to withdraw natural gas from underground storage, according to the EIA.

Dry natural gas production in January 2020 averaged about 95 Bcfd (2.69×10^9 m³/d), according to IHS Markit data. IHS Markit also estimates that in January 2020, the United States saw the third-highest monthly

U.S. natural gas production on record, down slightly from the previous two months, the EIA said.

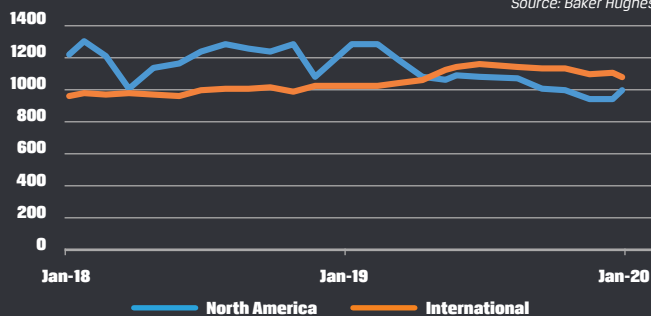
IHS Markit estimates that U.S. natural gas consumption by residential, commercial, industrial and electric power sectors averaged 96 Bcfd (2.7×10^9 m³/d) for January. **CT2**

U.S. NATURAL GAS CUSTOMER-WEIGHTED HEATING DEGREE DAYS (OCT 2019-FEB 2020)



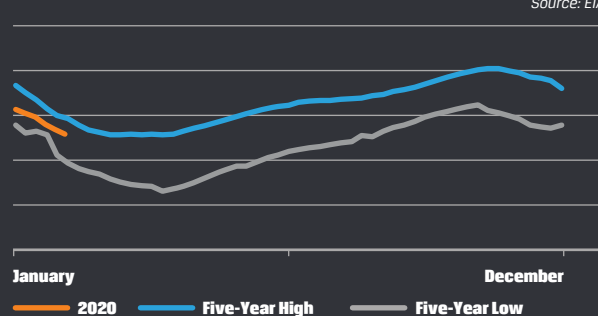
BAKER HUGHES RIG COUNT

Source: Baker Hughes



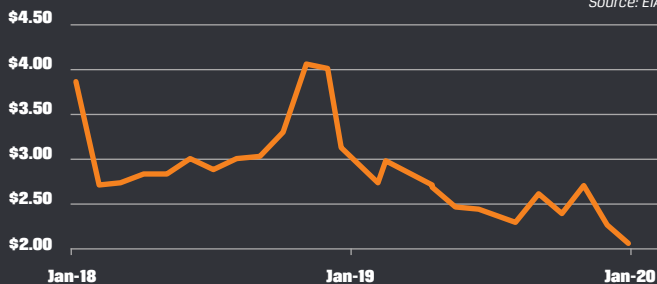
US NATURAL GAS STORAGE (Bcf)

Source: EIA



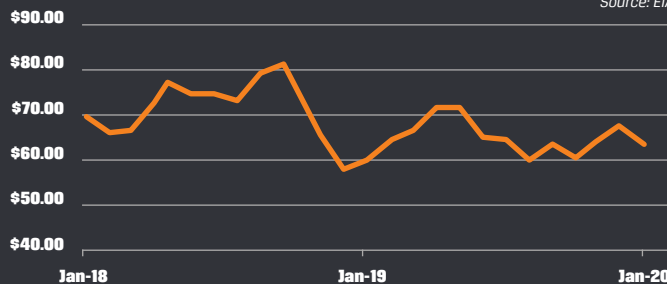
HENRY HUB NATURAL GAS SPOT PRICE (US\$/MMBtu)

Source: EIA



BRENT CRUDE OIL PRICE (US\$/Barrel)

Source: EIA



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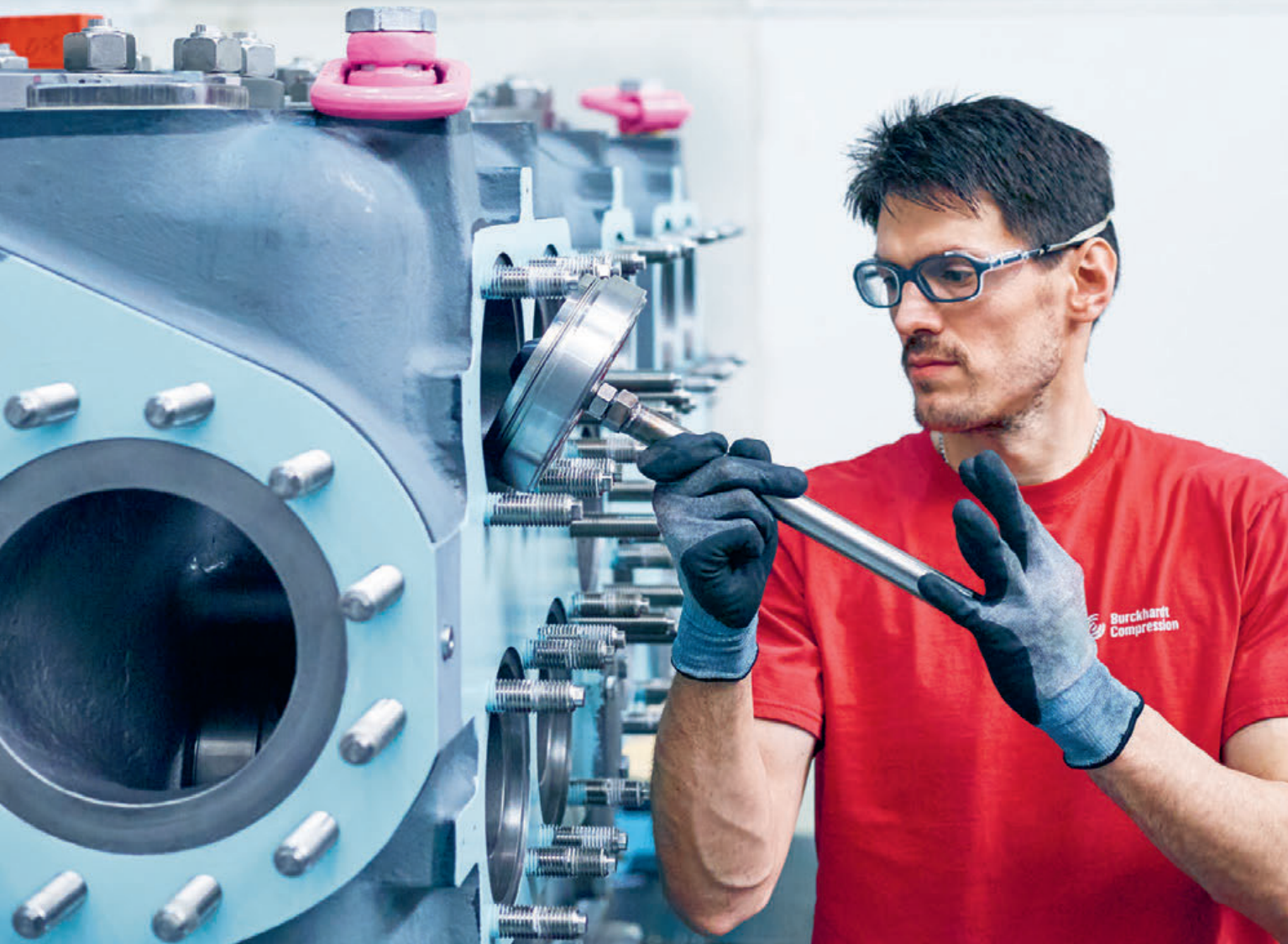
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Administration wants core environmental law updates

Changes would curb National Environmental Policy Act reviews. By **Patrick Crow**

The Trump Administration wants to revamp the application of the National Environmental Quality Act (NEPA), the legal framework for weighing the ecological impacts of proposed compressor stations, gas pipelines and other infrastructure.

The Council on Environmental Quality (CEQ), a White House office, oversees NEPA's administration. It has revised its guidelines only once before.

"Over the past 40 years, NEPA has been used as a tool to slow or completely kill important infrastructure projects across the country," said CEQ Chairman Mary Neumayr. Meanwhile, she said, NEPA implementation has become increasingly complex and time consuming: the average length of an environmental impact statement has grown to more than 600 pages and the average time for federal agencies to complete NEPA reviews is 4.5 years.

The new Secretary of Energy, Dan Brouillette, said NEPA regulations are quicksand for regulated entities. "The more they try to comply, the deeper into the regulatory muck they sink."

CEQ said its changes would clarify federal permit requirements, delete anachronisms and reduce paperwork. The office would mandate a one-year limit for environmental assessments and a two-year limit

for environmental impact statements (with possible extensions). Qualifying major infrastructure projects could proceed with limited federal oversight.

Very importantly – at a time when the Federal Energy Regulatory Commission and federal courts are being urged to consider the impact that interstate gas projects ultimately will have on greenhouse gas emissions – CEQ is providing some overdue guidance.

The office said regulators need only to consider environmental impacts that are "reasonably foreseeable and have a reasonably close causal relationship to a proposed action." For instance, greenhouse emissions from gas-fired power plants shouldn't count against the pipeline that supplies the fuel.

Analyzing NEPA

An analysis by ClearView Energy Partners has found that NEPA was the most frequent statutory basis for a legal challenge of oil and gas pipelines, with the most frequent argument alleging insufficient analysis of the effect of greenhouse gas from a project, both upstream and downstream.

Of course, green groups swore to fight the CEQ revisions tooth-and-nail.

Speaking for pipelines, the Interstate Natural Gas Association of America said NEPA may have been intended to ensure good public policy and informed decision-making, but it is outdated.

"The lack of clarity in the existing NEPA regulations has led courts to fill the gaps, spurring costly litigation, and has led to unclear expectations, which has caused significant and unnecessary delays for



"NEPA has been used as a tool to slow or completely kill important infrastructure projects."

MARY NEUMAYR, CEQ Chairman

infrastructure projects across the country," the association said.

Last December, the National Petroleum Council (NPC) discussed NEPA's flaws in a broader study, "America's Evolving Oil and Natural Gas Transportation Infrastructure." It said, "Overlapping and duplicative regulatory requirements, inconsistencies across multiple federal and state agencies, and unnecessarily lengthy administrative procedures have created a complex and unpredictable permitting process."

The Energy Secretary periodically asks the council, his industry advisory board, to analyze the hot topics of the day. The skeleton staff at NPC then recruits a task force, enlisting specialists from energy companies and representatives of academic, financial, research and public interest groups.

It usually takes the temporary committees a couple of years to compile their authoritative reports. They are always weighty in both senses of the word.

Worthwhile or not, CEQ's proposals seem somewhat quixotic. Like the Environmental Protection Agency's initiatives last year to relax Clean Water Act permitting and methane-leak limits, the NEPA changes can't be enacted during the dwindling days of the current administration.



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Shale play-by-play

James Willis highlights the latest news
from the major North American shale plays

APPALACHIA (MARCELLUS/UTICA)

Chevron leaving Marcellus

Chevron said it will write down the value for all its U.S. shale assets by US\$10 to US\$11 billion in the fourth quarter of 2019. More than half of the write down is the company's Marcellus/Utica assets. In addition, Chevron has listed all of its Marcellus/Utica assets, including 890,000 acres (360,170 ha) plus producing wells, for sale, signaling the company's exit from the plays. Chevron also has layoffs planned. According to the Wall Street Journal, some of the layoffs are likely to come from the company's unit in Appalachia where Chevron employs 400.

DEP fines ET \$30 million

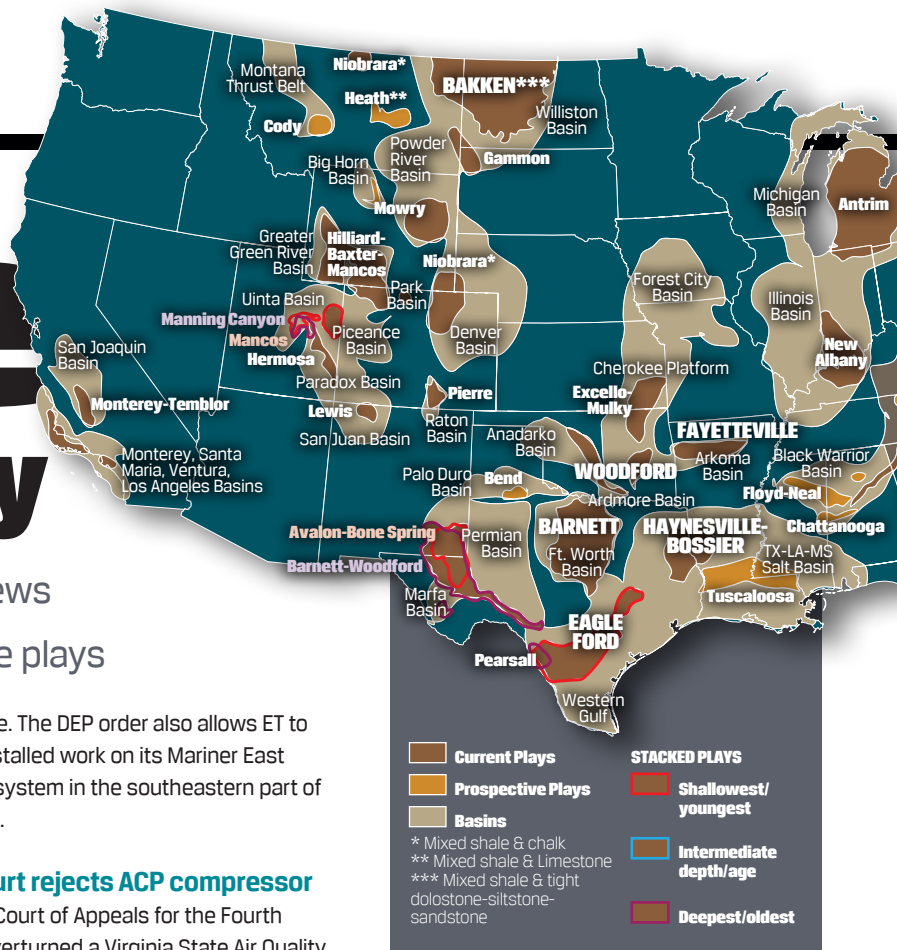
The Pennsylvania Dept. of Environmental Protection (DEP) issued the largest single fine in its history – US\$30.6 million – on Energy Transfer for the explosion of the Revolution Pipeline in southwestern Pennsylvania. The fine, along with revised plans and assurances by ET, means the company can finally, roughly 17 months after the explosion, fix the damaged gathering pipeline and return it

to service. The DEP order also allows ET to resume stalled work on its Mariner East Pipeline system in the southeastern part of the state.

Fed court rejects ACP compressor

The U.S. Court of Appeals for the Fourth Circuit overturned a Virginia State Air Quality Board permit for an Atlantic Coast Pipeline (ACP) compressor station planned for Buckingham County. The judges said the state agency did not consider environmental

justice and the potential use of electric turbines in siting the station. Work on the ACP project remains stalled pending the outcome



HAYNESVILLE

Castleton buys Shell's Haynesville acreage

Castleton Resources closed on the acquisition of the East Texas and North Louisiana Haynesville Shale assets of BG US Production Co., a subsidiary of Royal Dutch Shell. With the new acquisition, Castleton Resources now owns 222,400 net acres (90,002 ha) in the region and produces 334 MMcf/d ($9.5 \times 10^6 \text{ m}^3/\text{d}$).

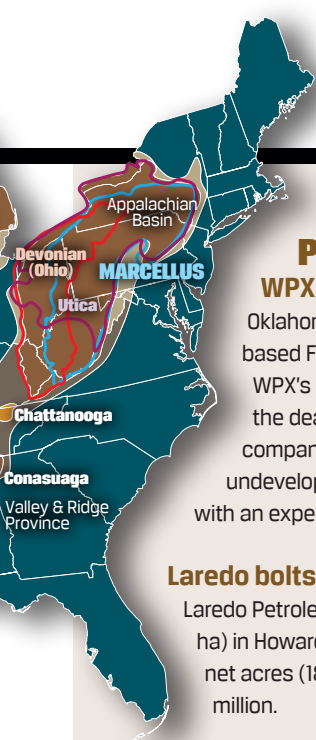
Sabine sells to Osaka Gas

Sabine Oil & Gas Holdings sold its subsidiary Sabine Oil & Gas Corp. to Osaka Gas USA, a subsidiary of Japan's Osaka Gas. As part of the sale, Osaka Gas USA will retain the current Sabine executive team and employees. With this sale, Sabine Holdings has completely divested of all its oil and gas assets since emerging from bankruptcy in August 2016.

Goodrich cuts budget 35%

Goodrich Petroleum's 2020 capital budget is US\$55 to US\$65 million, down 35% from 2019 spending. With natural gas and oil prices of US\$2.50 and US\$55, respectively, Goodrich expects to generate approximately US\$15 to US\$25 million of free cash flow. The company expects to grow production by 12.5% to 17.5% compared with 2019, producing 53 to 56 Bcfd (1.5 to $1.6 \times 10^9 \text{ m}^3/\text{d}$), or an average of 145 to 153 MMcf/d (4.1 to $4.3 \times 10^6 \text{ m}^3/\text{d}$) in 2020. Natural gas is expected to comprise 99% of total production. Goodrich plans to complete and bring to sale 13 gross (5.8 net) shale wells. The company drills mainly in the Bethany-Longstreet area of Caddo and DeSoto Parishes, Louisiana.





PERMIAN/DELAWARE

WPX buys Felix

Oklahoma-based WPX Energy is buying Denver-based Felix Energy in a US\$2.5 billion deal, adding to WPX's existing acreage in the Texas Permian. Calling the deal "opportunistic", WPX says Felix, a portfolio company of EnCap Investments, has 1500 gross undeveloped locations in the eastern part of the basin with an expected production of 60,000 b/d (70% oil).

Laredo bolts on acreage

Laredo Petroleum recently acquired 7360 net acres (2978 ha) in Howard County, Texas, for US\$130 million, and 4475 net acres (1811 ha) in Glasscock County, Texas, for US\$65 million.

Texas gas plant settles lawsuit

The James Lake Midstream natural gas processing plant near Odessa reached a settlement with the Sierra Club in federal court over allegations the plant released large amounts of sulfur dioxide pollution since 2014 (the year the plant was built), which violates the federal Clean Air Act. The owners agreed to pay a US\$100,000 fine and install new controls to reduce flaring.

Agua Blanca expanding

Joint venture partners WhiteWater Midstream, MPLX, and First Infrastructure Capital announced a final investment decision to expand the 1.4 Bcfd (39.6 X 10⁶ m³/d) Agua Blanca System in the Delaware Basin.

Summit gets Double E investment

Summit Midstream Partners signed a deal with investment firm TPG to fund US\$80 million of construction in the Double E Pipeline project. In return, TPG will receive preferred interests in a subsidiary holding company that indirectly owns a 70% interest in the project.

Permian Highway Pipe makes rapid progress

Construction on the western segment of Kinder Morgan's US\$2 billion, 430 mile (692 km) Permian Highway Pipeline (PHP) project is underway after beginning last summer. PHP will carry 2.1 Bcfd (59.4 X 10⁶ m³/d) of gas from the Waha Hub in Pecos County to the Gulf Coast.

Approach files for bankruptcy

Approach Resources has filed for Chapter 11 bankruptcy. The company says it is exploring "strategic alternatives" including a restructuring of its debt and possibly an outright sale.

CT2

of two other court cases, one of them at the U.S. Supreme Court. Dominion said it remains committed to the project, which will run 600 miles (966 km) from West Virginia to North Carolina.

New driller in central Pennsylvania

A new E&P is drilling in Lycoming County, Pennsylvania. Beech Resources, founded by John Fox (co-founder of MarkWest Energy) and business partner Charles Pollard, is actively drilling near Williamsport using a rig from Patterson-UTI Energy. Fox and Pollard have managed large oil and gas operations during their careers. The company's strategy is to target over-pressured, under-saturated Marcellus acreage in Northcentral Pennsylvania.

LOLA sues EQT again

LOLA Energy II filed a second lawsuit in Greene County, Pennsylvania against EQT, alleging the company trespassed (drilled under) land leased by LOLA. The original LOLA Energy, founded in 2015 by former EQT executives (including LOLA CEO Jim Crockard), sold to Rice Energy in 2017.



EAGLE FORD (AUSTIN CHALK, TUSCALOOSA MARINE SHALE) Ironwood II launches

Ironwood Midstream Energy Partners and EnCap Flatrock Midstream have formed Ironwood Midstream Energy Partners II. EnCap Flatrock is chipping in US\$400 million of initial funding. Ironwood II will focus on the development of midstream infrastructure for oil and gas producers working in shale plays across North America. Ironwood II will initially pursue greenfield projects and acquisition opportunities in Texas. The new company's very first acquisition was Twin Eagle's Gardendale and Asherton gathering systems, a cumulative 137 miles (220 km) of active crude oil gathering pipeline in the Eagle Ford with connections to multiple long-haul pipelines.

Williams sues RRC

Midstream giant Williams sued the Railroad Commission of Texas, the state regulatory body that oversees oil and gas drilling in the state, for its decision to grant a two-year extension of flaring permits to Exco Operating. Williams said it has gathering pipelines in the region where Exco wells have been drilled, and the Railroad Commission violated state law by granting Exco permission to continue flaring when a pipeline is present. Exco emerged from bankruptcy last July and said it does not have a contract with Williams.

Baytex investing further in Eagle Ford

Baytex Energy Corp. will spend US\$500 to US\$575 million to drill in 2020. Baytex drills in both Texas and Canada. The company will spend 30% of its budget (US\$150 to US\$172 million) on Eagle Ford drilling, with plans to drill 22 new wells. Baytex estimates production will be 84% liquids (oil, natural gas liquids (NGLs), condensate) and 16% natural gas. The company says its Eagle Ford assets will generate 37% of production and substantial free cash flow in 2020. CT2

Rice subsequently sold to EQT. Leases originally signed by LOLA ended up at EQT. Crockard discovered EQT had allowed some of the original LOLA acreage to slip out of the lease.

Following a non-compete period, Crockard

formed LOLA Energy II and subsequently re-leased some of the now-expired acreage. LOLA II maintains EQT drilled under some of the re-leased acreage that now belongs to them, and that EQT has refused to compensate LOLA II.



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Second look at Rogersville Shale

The State of Kentucky is spending US\$7.4 million to study the oil and gas potential of the Rogersville Shale in eastern Kentucky. The new project, called the Conasauga Shale Research Consortium, will evaluate the drilling potential of the Rogersville and other layers in the 8000 to 10,000 foot (2438 to 3048 m) range. Several E&Ps previously drilled test wells in the Rogersville and determined it was not economical to drill in the play.

New pipe in central Ohio

Columbia Gas of Ohio (a NiSource company) announced a new US\$135 million pipeline project to bring new supplies of Utica-sourced natural gas to homes and businesses located north and west of Columbus. The project, called the

BAKKEN/WILLISTON XTO selects Outrigger

XTO Energy signed a long-term gas gathering and processing agreement with Outrigger Energy II to service XTO's production in Williams County, North Dakota. Outrigger will build a 70 mile, 20 in. and 24 in. (113 km, 508 mm and 610 mm) diameter rich gas gathering system originating in eastern Williams County and terminating at a new 250 MMcfd ($7.1 \times 10^6 \text{ m}^3/\text{d}$) cryogenic gas processing plant located west of Williston, North Dakota. Outrigger plans to expand the plant an additional 200 MMcfd ($5.66 \times 10^6 \text{ m}^3/\text{d}$). The plant will feature ethane recovery and rejection capabilities and provide direct market access to the Northern Border Pipeline system for residue gas and the ONEOK NGL pipeline system for NGLs.

Bakken gas targets Midwest markets

The Northern Border Pipeline is a 1249 mile (2010 km) natural gas pipeline that links seven Midwestern U.S. states with natural gas reserves from Canada, the Williston (Bakken) in North Dakota and

Northern Loop Project, has filed for regulatory approval with the Ohio Power Siting Board, hoping OPSB will approve the project in 2020.

Antero selling \$1 billion in assets

Antero Resources is working to improve its financial performance by winning concessions from its midstream subsidiary and selling some of its Marcellus/Utica assets. The company asked for and received a break in midstream prices from Antero Midstream, which agreed to reduce Antero's costs by US\$350 million over the next four years.

Antero hopes to raise US\$750 million to US\$1 billion in 2020 selling its leased acreage, minerals, producing properties, hedge portfolio restructuring and Antero Midstream shares.

the Powder River Basin in Montana. The pipeline is owned 50/50 by TC Energy (TransCanada) and ONEOK. It is a major conduit for imported Canadian gas. However, there is serious talk about replacing Canadian and Powder River gas sources to have the pipeline flow North Dakota Bakken gas only. Bakken oil drillers need new markets for their associated gas. The problem, according to North Dakota Mineral Resources Director Lynn Helms, is ethane. More dethanization capacity and markets for the ethane produced will need to be developed before a Bakken-only Northern Border Pipeline becomes a reality.

SD pipe replacement

Northern Natural Gas of Omaha is looking to replace a 79 mile, 14 in. (127 km, 356 mm) diameter pipeline with an 84 mile, 12 in. (135 km, 305 mm) pipeline in South Dakota. The South Sioux City to Sioux Falls A-line Replacement project has been filed with FERC. Northern Natural Gas is conducting public outreach. Most of the new pipeline will be located 25 ft. (7.6 m) from the existing pipeline, which will be sold to a salvage company.

CT2

PennEast appeals to Supreme Court

The companies behind PennEast Pipeline, a US\$1.2 billion greenfield pipeline project from Luzerne County, Pennsylvania to Mercer County, New Jersey, have not abandoned the long-delayed project. In February, PennEast filed an appeal to the U.S. Supreme Court seeking to overturn a lower court ruling that prevents PennEast from using eminent domain in New Jersey for some of the planned route. Believing they have a least a possibility of getting the high court to review the decision, PennEast asked FERC to extend the deadline to build the project by an additional two years (January 2022).

Transco expansion online early

Williams' Transco Gateway Expansion Project, a US\$85 million project that flows an extra 65,000 dekatherms of gas per day to utility companies in New Jersey, went online 11 months early. The FERC-approved project includes a new compressor unit at Transco's existing compressor station 303 in Essex County, New Jersey; a new valve and electric

BARNETT

Devon sells to Thai company

Devon Energy has made a deal to sell its assets in the Barnett Shale to Banpu Kalnin Ventures (BKV) for US\$770 million. BKV is owned by Banpu, Thailand's largest energy company and coal producer. Banpu, via BKV, also owns Marcellus acreage in northeastern Pennsylvania. The Devon deal is expected to close in the second quarter of 2020. Net production from Devon's Barnett assets averaged 597 MMcf/d (16.9 X 10⁶ m³/d) in the third quarter of 2019, with proved reserves of 4 Tcf (0.11 X 10¹² m³). The Barnett transaction represents BKV's seventh transaction since 2016, with over US\$1.3 billion of capital invested into gas-weighted assets. With this acquisition, BKV will produce 780 MMcf/d (22.1 X 10⁶ m³/d) of production from its Pennsylvania Marcellus and Texas Barnett assets.

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transformer (also in Essex County); and equipment upgrades at a metering station in Passaic County, New Jersey.

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MIDCONTINENT (ANADARKO/SCOOP/STACK)

Jones merging with Revolution

Jones Energy II, an independent E&P targeting the Anadarko Basin in Oklahoma and Texas, announced it is selling itself to and merging with Revolution II WI Holding Co., an affiliate of Mountain Capital Partners. The all-cash transaction is valued at US\$201.5 million. The transaction is expected to close by the end of the first quarter of this year. Revolution, based in Oklahoma City, targets the Midcontinent region.

Dow funds Devon STACK

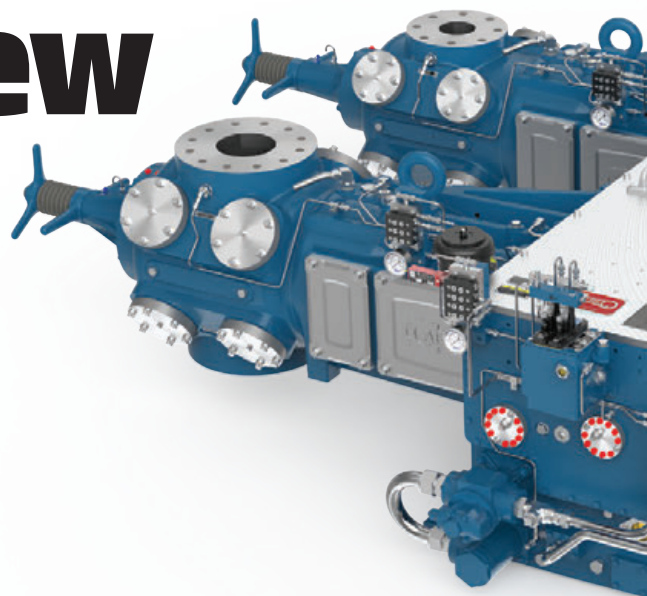
Devon Energy entered into an agreement with chemical giant Dow Inc. to jointly develop a portion of the company's STACK acreage in central Oklahoma. Under the deal, Devon will monetize half its working interest in 133 undrilled locations in exchange for a US\$100 million investment by Dow over the next four years. The average working interest is estimated at 60%. In addition to the benefits of Dow's investment, Devon expects to realize lower well costs from focused infill development drilling and midstream incentive rates that lower per-unit operating costs for each new well. Drilling in 2020 will begin mid-year with two units in northern Canadian County.

SandRidge CEO resigns

SandRidge Energy CEO Paul McKinney has resigned from the company. SandRidge COO John Suter is serving as interim CEO. The company is reevaluating its 2020 budget with plans to make cuts. Activist investor Carl Icahn pressured the company to pursue a sale last year, a move the board has rejected.

CT2

Ariel adds new compressor to KB lineup



KBE model designated for gas gathering, lease fleet applications. By **DJ Slater**

A trend appears to be rising out of Mount Vernon, Ohio in the form of new compressor models on a more frequent basis. Nearly two years after releasing two new compressor frames, Ariel Corp. has done it again with another model – the KBE.

The latest compressor adds another KB frame to Ariel's midline compressors – the heart of the company's lineup. In 2018, Ariel debuted the KBK:T frames, which also fall into the midline range. Unlike the KBK:T frames, which fell between two compressor models in the lineup, the KBE serves as an alternative for operators using Ariel's JGH:E:T compressors with ET cylinders.

"We've made a significant investment in compressor technology and will leverage that to bring new products to the marketplace," said Robert Drews, Ariel's director of marketing. "We are improving the value we provide to our customers."

Similar features

The KBE, available in two- and four-throw variations, is designed to meet the compression needs for many of the applications that use its JGH:E:K:T frames. It has the same features of other KB models, such as the KB style angled guide, which increases the structural stiffness substantially compared with the JG style frames, Drews said.

Like the JGT's two- and four-throw variations, the KBE boasts the same horsepower and rod load, but with a 5 in. (127 mm) stroke; the JGE, JGH and JGT all have a 4.5 in. (114.3 mm) stroke. The added stroke allows the KBE to fully load 1200 and 1400 rpm engines and improves operational flexibility.

The KBE frame is rated for 1300 to 2600 bhp (969 to 1939 kW) at 1400 rpm and a 1167 fpm (5.92 m/s) piston speed. It has a 74,000 lbs. (329,168 N) total rod load; 37,000 lbs. (164,584 N) tension rod load; and 40,000 lbs. (177,929 N) compression rod load.

The KB family

As part of the KB compressor family, the KBE incorporates redesigned and stronger piston and rod assemblies and connecting rods. Like the KBK:T, the crossheads, connecting rods and bearings are backward compatible with legacy JGE:K:T products.

"We hold ourselves accountable for supporting the equipment out in the field," Drews said. "We also strive to address any hurdles that could be encountered with our customers when introducing a new product."

"We feel that having backward compatibility helps demonstrate our interest in supporting our customers' existing equipment and our confidence in the product we are introducing," he said. "It minimizes the impact on a company's inventory to

adopt a new product because you can share components across both new and existing compressors."

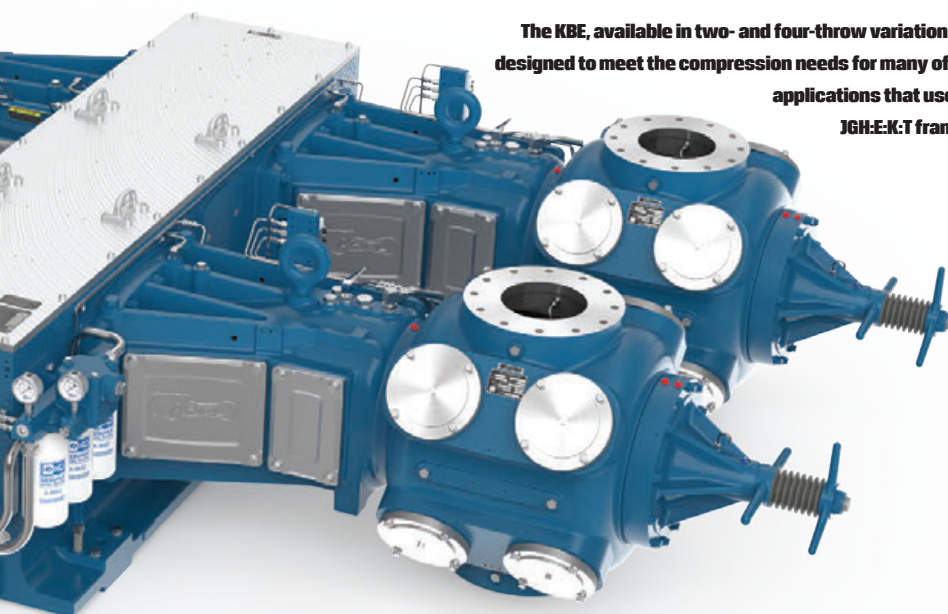
The KBE frame, which can accommodate an internal torsional vibration damper, has the same crankcase footprint as the KBK:T compressors and features a simplified auxiliary end that incorporates the frame oil thermostat into the oil filter header.

In terms of maintenance, Ariel designed the KBE for simplified access. The O-ring seals on the top cover and guide covers reduce the number of fasteners and eliminates the common challenges with paper gaskets.

New E cylinders

Another highlight of the KBE frame comes from its cylinders. The KBE uses Ariel's new E cylinders, a derivative of its common ET cylinders found in most of its compressor models. The E cylinders offer an extended service life through the use of the CP and CPs valves found in the majority of Ariel cylinders.

"The KBE combines our latest design features with enhanced operational capabilities, along with the extensive field experience and cost effectiveness of our ET cylinders", said Joe Fernandez, Ariel's manager of Application Engineering. "This product will be primarily focused in the 1000 to 1500 horsepower range, particularly popular for lease fleets."



The KBE, available in two- and four-throw variations, is designed to meet the compression needs for many of the applications that use its JGH-E-K-T frames.

"The longer stroke of the KBE matches well with 1200 and 1400 rpm engines, and also 1200 rpm electric motors," he said.

A future of KB frames

The KBE is another step in Ariel's long-range plans to incorporate the KB technology and its benefits across the compressor product line. The KB style frame first debuted in 2002 with the KBU and KBZ frames, designed for high-horsepower and high-compression capacity applications with horsepower

ratings up to 7800 bhp (5816 kW). The KBB and KBV frames followed four years later for pipeline transmission and high-pressure injection applications and are rated up to 10,000 bhp (7457 kW).

The gas compression world would not see another new KB frame until 2018, when Ariel debuted the KBK:T frames at the Gas Compressor Association (GCA) Expo and Conference in Galveston, Texas. Those frames featured a horsepower range from 1840 to 5520 bhp (1372 to 4116 kW) (see

COMPRESSORTECH², May 2018, p. 15).

"When we rolled out the KBK:T, that was a lengthy development program for us," Drews said. "We conducted a significant amount of testing on the components to improve them."

As of Jan. 1, 2020, Ariel has made its JGH (introduced in 1986) JGE (1987) and JGK (1988) frames inactive, meaning they are no longer being produced or sold for new unit business, filling that void with the KBE. The decision to move on from these frames, which will still receive Ariel support, is bittersweet for the company, especially given the history of these compressors. Ariel founder Jim Buchwald called the JGK compressor the catalyst to Ariel's ascension from a small compressor manufacturer into the "Big Time."

A new trend

The KBE won't be the last compressor with the KB style frame. Ariel expects to produce more KB style compressors in the coming years.

"It is a trend," Drews said. "It's our objective to adopt the KB style design across our product line where it works. We want to take the knowledge gained with the KB frames and leverage it across our product line to improve our customers' own and operate experience."

CT2

TABLE 1
ARIEL COMPRESSORS KB LINEUP SPECS

FRAME	KBE		KBK			KBT		
	KBE/2	KBE/4	KBK/2	KBK/2	KBK/4	KBT/2	KBT/4	KBT/6
Number of Throws	2	4	2	4	6	2	4	6
Rated Power (BHP)	1300	2600	1840	3680	5520	1840	3680	5520
Stroke (inch)	5		6			5		
Maximum RPM	1400		1200			1500		
Piston Speed (FPM)	1167		1200			1250		
Total Rod Load (lbs)	74,000		92,000					
Rod Load Tension (lbs)	37,000		46,000					
Rod Load Compression (lbs)	40,000		50,000					
Rod Diameter (inch)	2.0							
Crankshaft Centerline, from bottom (inch)	17							



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Cooper buys Hoerbiger's Engine Legacy Solutions

Purchase is the service company's fourth since late September 2019. By **DJ Slater**

Cooper Machinery Services, the former reciprocating compression division of Baker Hughes, has made another acquisition. This time, the company has purchased Hoerbiger's Engine Legacy Solutions business.

Hoerbiger's Engine Legacy Solutions business provides repairs, overhauls, upgrades and emissions advancements for large reciprocating, natural gas and dual-fuel engines. The Hoerbiger management team, as well as 30 employees from various locations, will be retained and join Cooper.

The acquisition follows Cooper CEO John Sargent's plans to incorporate companies that "are in the same space as us." Hoerbiger's services are in line with Cooper's, which manufactures and services reciprocating compressors, engines and turbochargers.



"We are very pleased to add the Engine Legacy Solutions business to our Cooper portfolio," Sargent said. "With this acquisition, the technical expertise of the Cooper organization, and our ability to assist our customers with the long-term preservation of their reciprocating horsepower, just took a giant step forward."

Swift growth

Hoerbiger's Engine Legacy Solutions business is the fourth acquisition for Cooper in the past five months. Sargent said in a prior interview with **COMPRESSORTECH²** that this many acquisitions in that time frame has not been overwhelming because each company integrates well with Cooper. Having commonalities with these companies has allowed Cooper to add them seamlessly, Sargent has said.

After Arcline purchased Baker Hughes, a GE Company's (BHGE's) reciprocating compression division in July 2019, Cooper surfaced from the former division and hired Sargent as its CEO. It also targeted its first two companies – Epic International and Reciprocating Technology Services (RTS).

Both companies provide services and parts in the gas compression landscape, which is why they caught Sargent's attention. Epic International provides parts, field services and repairs on engines and compressors and RTS specializes in field services and aftermarket parts for reciprocating engines and compressors. The acquisitions took place in late September.

Cooper field service technicians hone a power liner on a Cooper-Bessemer Z330 engine at a customer site.

"With this acquisition, the technical expertise of the Cooper organization just took a giant step forward."



**JOHN SARGENT, CEO,
Cooper Machinery
Services**

Complementary companies

Cooper rounded off 2019 with one more acquisition on Dec. 29 – Sinor Engine Co. Like the prior purchases, Sinor Engine complements Cooper as a service provider for Superior engines and compressors. Adding Sinor Engine to the mix gives Cooper additional resources and a centralized hub for all Superior-related services, including a designated center of excellence.

"We're adding companies that accomplish the same goals we have," Sargent said in an earlier interview with **COMPRESSORTECH²**. "We're trying to put all the pieces back together and be the best we can be."

It's unlikely this will be the last transaction for Cooper this year. While Sargent plans to focus on integrating these acquired companies under one roof soon, he said Cooper has letters of intent out with several companies and expects more acquisitions in the near future.

CT2

Euro gas report

Anna Kachkova
provides information
on the latest gas
compression news
from Europe

ALBANIA **TAP announces completion of Fier compressor station**

The Trans Adriatic Pipeline (TAP) consortium announced on Feb. 4 that construction was finished on its compressor station in Fier, Albania. The consortium began building the station in March 2017.

In a video posted on Twitter, the operator provided a few details of the work involved, noting that the footprint of the compressor station was 1.75 million sq.ft. (163,000 m²) and that the three compressor and gas turbine trains at the facility were the most technically complex parts of the station.

The compressors are of a centrifugal type of design, the consortium added, and able to compress gas up to 1378 psi (95 bar) from an inlet pressure of 856 psi (59 bar).

Siemens supplied the three STC-SV (08-4-A) compressors for the facility, which are driven by Siemens model SGT-400N gas turbines.

The pipeline will have an initial capacity of 353 Bcfy (10 X 10⁹ m/y) of natural gas. Its capacity could be doubled in the future, which would require additional compression facilities.

CROATIA **First compressor station on Croatia's gas system enters service**

The first compressor station on Croatia's gas system was put into service on Jan. 17. The compressor station is located at Velika Ludina, about 37 miles (60 km) east of Zagreb. It enables bi-directional flows

at an interconnection with Hungary and will allow gas to be transported in the future from the planned LNG terminal on Krk island to Hungary and other countries in 2021. Pipeline firm Plinacro, the compressor station's operator, invested 209.5 million kuna (US\$31.2 million) in the facility, construction on which began in August 2018.

The 4.5 MW compressor station has a capacity of 7.1 MMcfh (201,000 m³/h). It contains three compressor units that were manufactured by Romania-based Euro Gas Systems at a cost of €8.2 million (US\$9.1 million). Two of these are operating units and one is a standby unit, according to Plinacro's website.

GERMANY **Russian vessel movement prompts speculation on Nord Stream 2 completion**

A Russian pipe-laying vessel, the Akademik Cherskiy, left the port where it had been stationed in Nakhodka on Russia's Pacific Coast in early February. The vessel's movements have led to speculation that Russia's state-owned Gazprom is working out a way to circumvent U.S. sanctions that have stalled the completion of its Nord Stream 2 pipeline project connecting Russia and Germany.

According to Bloomberg ship-tracking data, the Akademik Cherskiy is expected to arrive in Singapore on Feb. 22. It remains unclear whether it will indeed then be deployed to work on Nord Stream 2, which is around 94% complete apart from a small section in Danish waters.

This comes after Russian Energy Minister Alexander Novak suggested in late 2019 that the Akademik Cherskiy could be an option for completing the remaining pipe laying on Nord Stream 2.

The work in Danish waters was previously being carried out by Swiss-based Allseas Group, but the company walked away at the end of December as a result of U.S. sanctions. Russia has since said it would complete the pipeline alone, without the help of foreign companies that would be affected by the sanctions.

It has been suggested that if Russia is able to restart work on the pipeline in the first half of 2020, it could realistically complete the project in the first quarter of 2021.

CYPRUS **Tensions mount over Mediterranean gas drilling**

Tensions have flared up between the island country of Cyprus and Turkey over drilling for natural gas in contested waters. In January, Cyprus claimed that Turkey had sent drillships into Cypriot territorial waters, directly in areas where it said it had leased mineral rights to Italy's Eni and France's Total.

Cyprus initially accused Turkey of being a "pirate state" that violates international law.



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LITHUANIA Welding begins on pipe for Gas Interconnection Poland-Lithuania

Welding has begun on the pipe that will be used for the Gas Interconnection Poland-

Lithuania (GIPL). In a Feb. 12 statement, Lithuanian gas transmission operator Amber Grid said that one-tenth of the pipe that is set to be constructed this year was due to be welded in February.

Preparations have also begun for horizontal-directed drilling under the Neris and Nemunas rivers as part of the project.

The GIPL is scheduled to enter service by the end of 2021. Amber Grid is planning to lay nearly two-thirds of the Lithuanian section of the pipeline in 2020 – or 62 miles (100 km) out of a total of 103 miles (165 km).

As well as connecting the Polish and Lithuanian gas transmission systems, the bi-directional pipeline will also connect the Baltic and Finnish networks with the European Union (EU) system. The GIPL will have a capacity to transmit up to 84.8 Bcfy ($2.4 \times 10^9 \text{ m}^3/\text{yr}$) of gas towards the Baltic countries, and up to 35.3 Bcfy ($1.0 \times 10^9 \text{ m}^3/\text{yr}$) towards Poland.

The pipeline will run from the 34.5 MW Jauniūnai compressor station in Lithuania's Širvintos district to the Hołowczyce compressor station in Poland. Also in Poland, a new compressor station will be constructed in Gustorzyn, which will enable transmission of gas from the Baltic Pipe system to the GIPL.

The country subsequently backtracked from these claims, but tensions between the two countries have remained high.

The situation played out not long after Greece, Cyprus and Israel signed a deal in early January to build an 1180 mile (1900 km) subsea pipeline to carry gas from the Eastern Mediterranean to Europe.

The EastMed pipeline project, estimated to cost US\$6 to US\$7 billion, would initially have the capacity to carry 353 Bcfy ($10 \times 10^9 \text{ m}^3/\text{yr}$) of gas from Israeli and Cypriot waters to the Greek island of Crete. From here, the gas would be sent on to the Greek mainland and into the European gas network via Italy.

The participating countries are aiming to reach a final

investment decision by 2022, with the pipeline set to be completed by 2025.

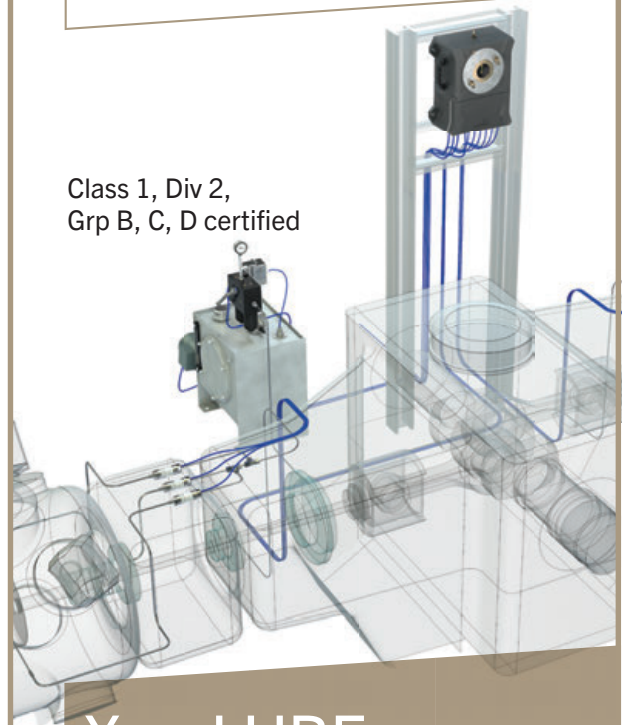
POLAND Gaz-System to expand Goleniów station

Poland's Gaz-System has received permits to expand the Goleniów and Odolanów compressor stations, as well as to build a new compressor station at Gustorzyn (see previous story). The three compressor stations are part of the Baltic Pipe project, which will carry Norwegian gas to Denmark, Poland and end users in neighboring countries. The Gustorzyn station will also enable gas to flow from Baltic Pipe to a future interconnection with Lithuania.

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Cloud-based product provides preventative analytics. **By DJ Slater**

INNIO Waukesha brings myPlant to compressors

INNIO Waukesha Gas Engine's myPlant isn't a new analytical platform, at least not in the power generation industry. For the past decade, myPlant has provided those operators with an inside look at the health and performance of their engines as well as their power plants.

But engines, especially those supplied by INNIO, can be used beyond the power generation sector, which is why the company has spent the last three years helping myPlant gain traction in the gas compression landscape.

Cloud-based platform

Today, myPlant serves as a data-gathering system for engines, compressors and other equipment, allowing users to monitor and optimize the performance of their operations.

"It's remarkable to be able to combine the engine and compressor analytics into one suite," said Jason Padilla, the vice president of marketing and business development for INNIO Waukesha. "Many other analytical platforms don't have the expertise on the engine, just the compressor. To have both gives the user significant total compressor package reliability. Bringing those two things

together (engine and compressor analytics) is a game changer."

myPlant is a cloud-based platform with analytical services. The data-collecting module connects to an operator's existing controls system. From here, the module obtains data from the operator's preestablished sensors and streams that information through a secure gateway – either a local internet connection or through an INNIO cell router – to the myPlant cloud. Once in the cloud, INNIO runs analytics on the data streams, which users can access through a mobile app or computer.

"The system is OEM agnostic," Padilla said. "Literally anything, including your washing machine at home, can be connected and viewed through myPlant."

myPlant data can be viewed on a mobile device using an app or a computer.

myPlant, which provides real-time monitoring, can collect any data imaginable from a piece of equipment, Padilla said. Applicable data for an engine or compressor includes temperature, pressure, vibration, oil and coolant reports, which allows for condition-based maintenance predictions.

Valve value

Additional analytics, especially those designed to resolve potential issues, include valve condition detection, bank-to-bank imbalance, remaining useful oil life and exhaust gas spread monitoring.

While having a detailed vantage point on any piece of equipment is useful, Padilla said one of the major benefits of having myPlant on a compressor package is its ability to detect the condition of the compressor's valves.

According to INNIO, undetected compressor valve conditions can cause operators to lose more than 12% of their available flow capacity. Through an





INNIO Waukesha Gas Engines
developed myPlant to give operators
a way to monitor and optimize their
engines and compressors.

INNIO analysis of more than 50 end-user compressor packages, more than 20,000 combined hours of run time were lost in 2017 due to compressor valve events. These hourly losses amounted to annual revenue hits from US\$8000 to US\$100,000 of gas flow per package.

With the ability to instantly detect the

condition of a compressor valve, an operator can avoid costly flow losses and unexpected shutdowns, Padilla said. Operators can also use myPlant to run condition-based maintenance schedules instead of daily infrared scans.

"The industry views the compressor as the revenue-generating tool in the package," he said. "We want them to improve the performance of their packages and reduce their overall costs."

Write-your-own analytics

Optimization is another aspect of myPlant. Operators can use the proprietary INNIO gas engine algorithms to estimate and adjust the load on their compression packages using existing sensors. With the ability to increase or decrease load instantly, operators can optimize their compression packages based on site operating conditions.

Another benefit of myPlant is the operator's ability to write their own analytics. Having this open-source capability means the user can shape the analytics to set personal parameters specific to their data-collecting needs.

"Users can write their own alerts and triggers that will go off when certain patterns are hit," Padilla said. "Everyone has their own ways of operating their equipment. This allows them to tweak and optimize their

performance.

"This feature is designed as a drag, drop, click feature so it is easy to use and requires no programming or data science experience," he said. "It allows the user to translate real-world knowledge into an analytic with minimal effort."

myPlant is also safeguarded against the speed of technology, which tends to outdate analytical platforms quickly. Updates for myPlant occur quarterly with new features released every three months. An example of this comes from a 2019 update that added automated compressor valve failure detection to the platform. This update, like the others preceding it, does not require new sensors or significant hardware upgrades, Padilla said.

"As we develop these new analytics, it makes myPlant fresh and up to date with all the new technology that we build," he said, adding that forthcoming 2020 updates include a new dashboard, fuel quality predictor, flow balance and a rod load calculator.

The wealth of updates allows myPlant to stay relevant in the industries it serves, Padilla said.

"You need all those analytics," he said. "The more data you're pulling in, the more you can refine and predict what will happen to your equipment in the future."

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Several companies will provide updates on new products at annual event in Galveston, Texas. By **DJ Slater**

GCA Expo & Conference technology roundup

For the past 25 years, the Gas Compressor Association has held the GCA Expo & Conference for professionals in the natural gas compression manufacturing, packaging and rental industries.

The association represents those industry professionals year-round, using the annual conference and exhibition as a means for networking opportunities and company updates. Those updates typically come during the exhibition's product innovation presentations.

As a service to our readers, here is a preview of those presentations.



EVENT DETAILS

WHAT?

Gas Compressor Association
25th Annual Expo & Conference

WHERE?

Moody Gardens Hotel, Galveston, Texas

WHEN?

March 24-27, 2020

PRODUCT INNOVATION PRESENTATIONS

2 p.m. - 3:30 p.m., March 25

www.gascompressor.org/meetings

FW Murphy

FW Murphy Production Controls will introduce its newest offering – the M-Link IoT Gateway, an integrated, tri-mode solution to deliver on complete connectivity. This device provides dual cellular (AT&T and Verizon) and satellite (Iridium) connectivity that auto-selects the best communication option. Installers no longer need to determine which signal is available and reliable; the M-Link does that for them.

M-Link provides access to fleet assets via a remote portal, mobile applications and over-the-air updates. Strong internal antennas provide double the signal strength of a cell phone, eliminating the need for high gain or directional antennas. Additionally, M-Link keeps the workforce connected by providing an onsite Wi-Fi hotspot.



FW Murphy's M-Link provides dual cellular and satellite connectivity, as well as an onsite Wi-Fi hotspot.

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Monico Monitoring, Inc.

Monico's Steve Neal will discuss the mCoreSDR product and MonicoLive service for remote monitoring of reciprocating compressors. The mCoreSDR device enables edge data acquisition from the engine and compressor controller for use in remote condition monitoring.

Monico's mCoreSDR can read multiple industrial protocols including Cat Data Link, J1939 and Modbus and push that data into other connected systems such as

outputting to a PLC, HMI, SCADA System or to an OSIsoft Data Infrastructure. With support for OSIsoft OMF and MQTT (SparkPlug B), the mCoreSDR can get the data into most systems. Additionally, the mCoreSDR provides onboard data buffering when transmitting data with the OMF or MQTT protocols, helping to minimize data loss when using inconsistent networks (cellular or satellite).

Coupled with the ability to run edge analytics and

The mCoreSDR device enables edge data acquisition from the engine and compressor controller for use in remote condition monitoring.



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Coupled with the ability to run edge analytics and



Siemens' presentation will discuss design considerations for compressors and compressor packages with CO₂ in mind.

Siemens

Siemens has a presentation titled Compressor & Package Design Considerations in a CO₂ Environment. The oil boom within the United States has mainly been attributed to shale and the technology involved in the shale extraction process. However, leveraging different tertiary oil recovery processes in revitalizing older oil fields has been significant in allowing for that growth, and CO₂ injection is playing a large part in that process.


Unlike other injection mediums used for tertiary oil recovery, such as water and natural gas, CO₂ has oil-soluble characteristics that enhance the recovery process, but there are challenges in injecting CO₂ that must be addressed in regards to equipment design.

Monico's partnership with ACI Services, running eRCM Express, compressor operators can reliably determine in real-time the safe operating parameters of their compressors. Operators can also gain increased visibility of compressor site operations through MonicoLive remote monitoring services, built on OSIsoft PI and hosted in the Microsoft Cloud.

This provides enhanced visibility and history to what the engine and compressor are doing in the form of data that is timestamped and stored in the cloud. The data can be accessed from any device with an internet browser, analyzed, trended, visualized and interpreted using the power of OSI Soft Pi.

Although CO₂ is neither toxic nor flammable, it is dense and corrosive (in the presence of water) and both these characteristics must be accounted for in compressor and

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compressor package design. This presentation will focus on those design considerations to ensure good performance and high reliability of that equipment. **CT2** 

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ACI Services

ACI Services will present its dynamic variable orifice (DVO), a device designed for controlling line pressure pulsations in reciprocating compressor systems, flow metering stations and other systems that require reduced pressure waves via damping.

The DVO works in a similar fashion as a standard orifice plate but has the capability to be adjusted in real time manually or through a programmable logic controller (PLC).

Typically, operators use orifice plates to control pulsations from reciprocating compressors and other sources. Standard orifice plates, however, have the drawback of being in a fixed position without any flexibility, said Roy Houston, the pulsation control products sales manager at ACI Services.

With the DVO, operators don't have to swap out anything. They can adjust the amount of restriction within the pipe by rotating a position indicator at the top of the device's adjustment shaft. The shaft engages the DVO's bevel gear, which manipulates the ring gear to open and close the DVO's internal ports. These adjustments to the beta ratio can take place while the compressor is pressurized and during operation (see **COMPRESSORTECH**², June 2018, p. 29)

The presentation will also detail how the DVO can be used for blowdown rate control.



ACI Services' dynamic variable orifice (DVO) can be adjust in real time to thwart pulsations.

Riverhawk

Riverhawk Co. will discuss the best practices to avoid dynamic torque overloads. Its presentation – Dissipation of Damaging Dynamic Torque Energy – evaluates the current practices for handling torque energy and why these methods don't always lead to the best results.

Operators must take steps to counter dynamic tolerance, such as strategically placed damping to reduce dynamic shaft loads. The presentation also covers the classes of vibration, such as transient excitation passing and infinite energy step torques.

Riverhawk will also provide an overview of its products that can aid in countering dynamic torque energy. Those products include its dynamic torque meter, rotational damper and peak shaver safety hub.

Riverhawk is an engineering-driven manufacturer specializing in hydraulic tensioning and bolting solutions. **CT2**



The Riverhawk dynamic torque meter can be used to set alarms and trip settings on amplitude. The meter can also be used to collect event data for later analysis.

Harvard Corp.

Harvard Corp.'s Otto Knottnerus will lead a presentation called How Ultra Clean Fluids Can Give High-Cost Reductions – How Best Practices Need To Be Managed. The company specializes in filtration products, such as filtration systems, coolant filtration systems, oil filter housings, oil and liquid filter elements, oil filter carts and hydraulic filter carts.

Harvard Corp., based in Evansville, Wisconsin, made its debut in April 1973 to provide filtration systems for several industries, including oil & gas, power and industrial plant. The company quickly outgrew its rented space and purchased a building with office, manufacturing and storage space, which became Harvard Corp.'s headquarters in 1977. The company added a new warehouse to help service its distributors in 1995.

According to the company, the Harvard brand filter removes contaminants as small as one micron, filters synthetic and petroleum-based fluids and removes the vast majority of silting particles. In addition, the filter absorbs water, antifreeze and other extraneous particles. Harvard Corp. also manufactures a line of filter elements to clean water-based fluids.

Waukesha Gas Engines

Ryan Krafcheck, senior product manager, Waukesha Gas Engines, will discuss the company's latest product and service offerings. From the VHP Series Five (7042GSIS5, 7044GSIS5 and 9394GSIS5) to the 275GL+ with ESM2 and VGF P48 with ESM2, Waukesha has developed new products for the compression and power generation industries.

The VHP Series Five will include an update on the fleet, including hours on leading units and reliability data. Attendees will also hear about the Series Five as an offering for rental and other midstream companies due to fuel flexibility, parts commonality across 800 to 2500 hp (596 to 1864 kW) engines, emissions performance and package mobility. Additionally, Waukesha is also offering myPlant Asset Performance Management software. **CT2**

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The link between rotating machine reliability and the hydrodynamic bearing

Proper component care pays dividends for equipment functionality. By **Lionel Pellevoisin**

The reliability of rotating machines

Since the invention of the wheel, and even, according to some experts, the potter's wheel that preceded it, the reliability of the machines has been a prime concern for operators.

The reliability of rotating machines is a major challenge for the industry. A process machine provides the expected production and therefore generates invoicing and customer satisfaction.

These positive results come from the adequacy of the machine, correct installation, proper operation, monitoring and maintenance. The majority of those factors put plenty of pressure on the maintenance managers of industrial sites.

One of the major components that provide proper functionality is the sliding bearing. The component's origins date back a few millennia before the Christian era when the potter's wheel and wheel became popular. It was necessary to control the friction and wear of an axle in its housing. The choice of materials, their sizing, the addition of a lubricant, are all problems that have appeared and accompanied the development of mechanics.

At first glance, we noticed the three technologies – the sliding bearing, the rolling bearing and, more recently, the magnetic levitation. We won't worry about the last two, which have their limits for functional, technical or economic reasons. Instead, we'll focus on the sliding bearing, which is a constant and essential component in high-power industrial machines.

Although it is the ancestor of bearings, the sliding bearing is the most advanced mechanical component since the industrial revolution, thanks to the materials used and the calculation capabilities made possible by computer technology. More precisely, this family is divided into two branches. The first is the friction bearing where only the friction coefficient controls the efficiency. The second is the hydrodynamic bearing. It is here that we enter an extraordinary, unknown and mysterious world.

The hydrodynamic bearing

The hydrodynamic bearing, as its name does not indicate, is a pump. A pump which, provided that a viscous fluid is made available to it, will create a pressure field between the shaft and its housing. It is the function of the hydrodynamic bearing that avoids solid-solid contact, limits heating, prohibits seizure, causes the coefficient of friction to drop, tolerates contaminants, dissipates vibration, and carries the load. Additionally, it is self-regulating. The power demand increases, the temperature increases, the viscosity decreases, the flow

rate increases, the calories are evacuated in proportion and a new balance is established. All of this occurs without human intervention or control.

Hydrodynamic bearing technology is not widely taught and remains the domain of a few rare experts. On-site in the middle of the machines, it is rarely talked about and easily forgotten. Under ideal conditions, it does not wear out and does not require any special

Bronze Babbitt bearings

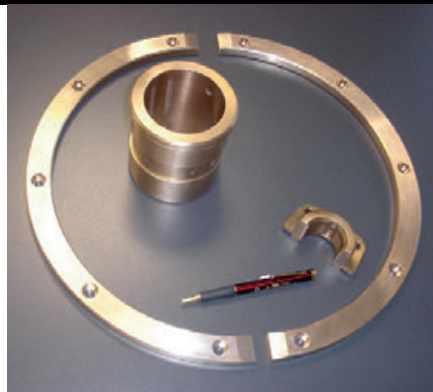




Main bearing

maintenance, aside from lubricant filtration and regular draining. In the best case, we follow its temperature, the position of the shaft and its accelerations, but as soon as we leave the instructions, it is urgent to stop everything.

All too often, a machine that has always run smoothly will one day burn a bearing. The damage is read on the spare part, the journal bearing in the bearing. The first reflex is to



Bronze parts

change it thinking the bearing has served its time. But a pad rarely has an intrinsic reason to fail. There is almost always an extrinsic motive. If it is not treated with the belief that replacing the bearing alone will be sufficient, then there is a high probability that the reliability of the machine will deteriorate and the bearing will be grilled again under the same conditions. When that happens, you have to unravel the mystery of its failure by checking all aspects of the machine.

Despite its discretion, the hydrodynamic bearing experiences all the power of the machine. Its successive improvements have led to the interposition of an intermediate part: the sliding bearing (or the bush). It is a critical piece, which, in the event of a problem, will sacrifice itself to preserve the noble organ that is the shaft. In nominal operation, its lifetime is infinite, there is no solid/solid contact but lamination of layers of molecules between them in the hydrodynamic film.

Moreover, if the bearing is guaranteed lubrication (the "gavage"), whether by splash, floating ring, gravity or pressure supply, the bearing itself pumps the fluid it needs to operate. A steady-state regime is therefore established in which the pressure is balanced with the loads at a given temperature and regulated by the lubricant flow rate and the thermal conductivity of the bearing. In this ideal state, our bearing – which allows energy, pressure and linear velocity levels to be reached that are beyond what would be possible with the best ball bearings – has excellent tolerance



Steel Copperlead Bearing

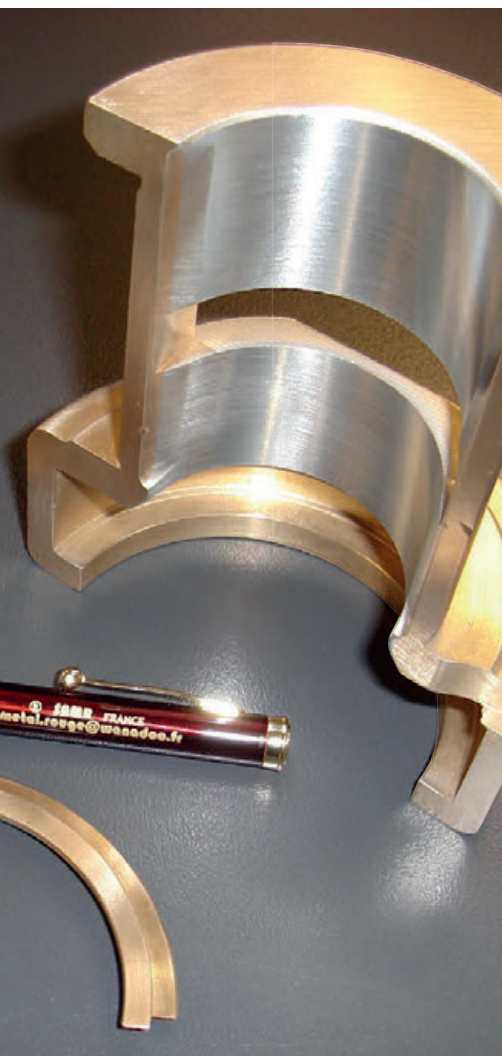
to external stresses. Its film of lubricant will behave like a shock absorber, with a stiffness and a damping coefficient very favorable to the attenuation of vibrations. Any particle contamination in the lubricant can be prevented by embedding it in the surface layer of the bearing. Other particles, compatible with the thickness of the hydrodynamic film, will simply be transported to the next filter. A calorific input will decrease the viscosity, increase the flow rate and regulate the temperature at the bearing. The clearances inherent in the mechanism will facilitate tolerance to misalignment. The accommodating power of the anti-friction material might, in some cases, help position the shaft and optimize its load-bearing capacity. The absence of metallurgical compatibility between the metals present will allow "touchette" without leading to seizure and its terrible consequences.

This is an idyllic picture that accurately describes what has been going on silently in most machine bearings in the industry for centuries. However, the person in charge of rotating machines at such a site is not so serene. This description goes hand in hand with the hazards associated with the operation of rotating machines.

Although the hydrodynamic bearing is generally auto stable, there are several situations that lead to its failure.

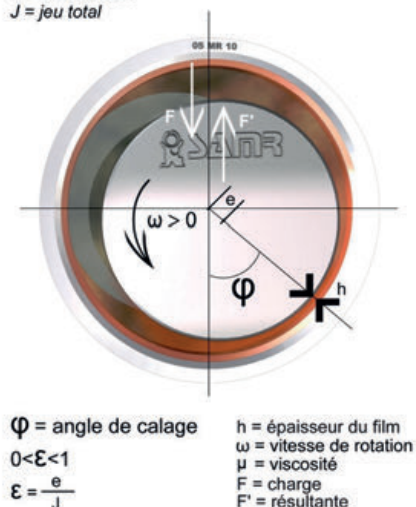
Hydrodynamic bearing technology

Its reliability, its tolerance to degraded operating modes and its safety in case of breakage make the hydrodynamic bearing an



Calage de l'arbre

ϵ = excentration relative
 e = excentration
 J = jeu total



Journal static position

essential technology found in all high-power machines (compressors, turbines, motors, alternators, gearboxes, pumps, rolling mills, crushers and so forth). Still, sometimes it fails.

Only three conditions govern the establishment of a hydrodynamic regime. It requires a viscous fluid at disposal, surface convergence and relative motion. It is the hydroplaning of the tire on the puddle or the skier's spatula on the water. These are examples of hydrodynamic regimes, which carry the load with little friction. But behind

this simplicity are a multitude of parameters that guarantee correct operation or, on the contrary, can lead to breakdowns.

A hydrodynamic bearing is dimensioned and designed for power; symbolized by the PV factor where P represents the load (more precisely the pressure) and V the relative linear speed. Under these conditions, the operating temperature, the position of the shaft in its housing, the fluid flow rate, the stiffness, and the damping of the lubricant cushion are determined and are compatible with proper operation.

These nominal operating conditions are not always met. Let's start with the viscous fluid. It must be available in sufficient quantities in the desired viscosity range, not contaminated beyond the absorption capacity of the bearing. Inadequate, missing or poorly maintained lubricant is a major cause of loss of the machine's reliability.

Next comes surface convergence. In a radial bearing, it results from the difference in diameter of the shaft and its housing. It can also be improved by specific lobes and/or bore geometries, such as lemon bore or offset bore. These geometries are guaranteed by the bearing manufacturers with levels of precision that are among the finest in industrial mechanics. The surface convergence, the clearance and the thickness of the oil film can be measured in hundredths of a millimeter. They are the result of a dimensional chain integrating at least three components, which are the body, the shaft and the bearing. The stacking of these dimensions and geometries, with their respective tolerances, will result in good surface convergence and operating clearances. Components taken one by one must remain in conformity under clamping, after assembly and in operation under

kinematic effects, thermal expansion, elastic deformation and misalignment.

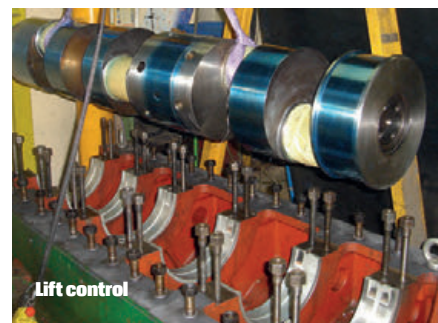
Finally, the relative speed is dictated by how the machine is driven. Stops, starts or reversals are critical phases, which cause the speed to drop to zero and deprive the bearing of its hydrodynamic speed with its oil cushion interposed between the solids. Special attention must be paid to temperature changes, cold starts, after a long stop or after disassembly/reassembly. These characteristics specific to hydrodynamic bearings mean that disassembly and reassembly cannot be treated as a standard operation where it would be sufficient to take new parts and reassemble the assembly for it to work. Numerous checks are necessary and are carried out by specialists trained and experienced in this technology.

Dismantling

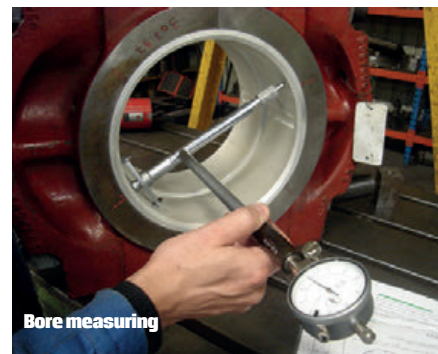
This phase is fundamental to the expertise of the bearing and must be entrusted to specialists. The parts must be marked and any stacks of shims correctly noted. Specialists will look for traces of molecular attrition, overheating, pollution or degradation of the lubricant, electric arcs, fatigue,



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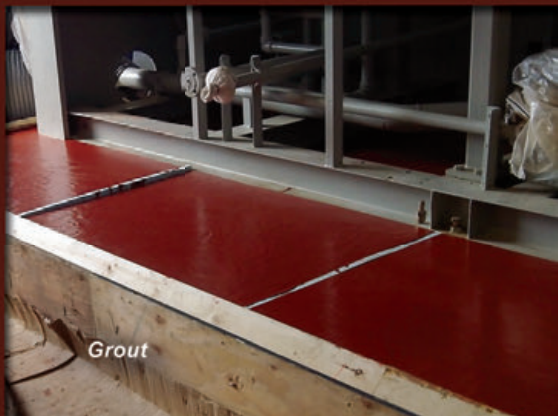
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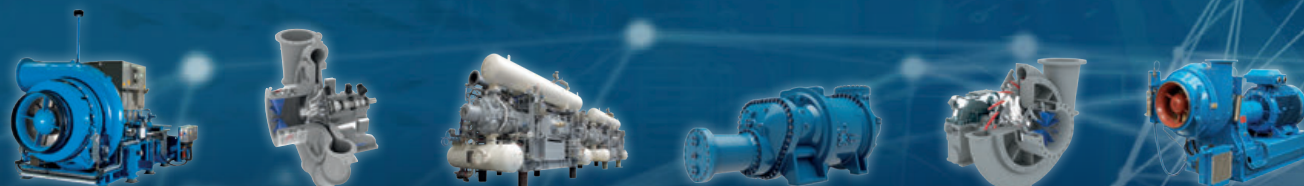
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interfere with the load-bearing capacity will be guaranteed. Lubricant supplies should be checked, as well as pinning and direction of rotation in the case of ramps or complex geometries (multi-center bores) or variable geometries. The quality of the lubricant will be controlled.

Starting the machine

This is a critical phase that reveals quickly whether an error has been made during the previous stages. A bearing instrumented with temperature sensors will check that the temperature stabilizes asymptotically at its nominal level. Lubricant pressure and/or flow rate are also good indicators. Noise and especially vibration measurements can reveal problems with alignment or balancing of moving parts. Depending on the machines, a starting protocol will be scrupulously followed (lubricant temperature setting, hydrostatic lift, progressive power loading). This means that in this field, more than any other, prior training and more than one evaluation is anything but superfluous and quickly pays for itself.

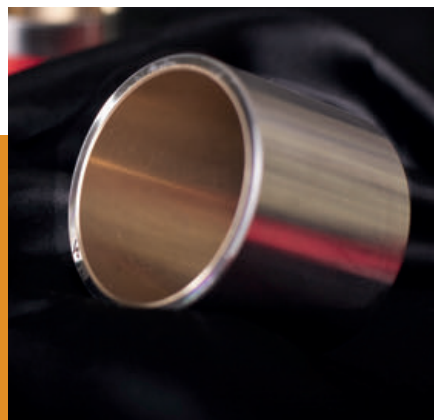
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cavitation, buttering, shocks, scratches, and wear. This may include incorrect assembly, incorrect tightening or contact, foreign bodies, excessive loads, cold starts or reversal of direction, poor lubrication, or oil film breakage. The clearances will be measured and compared to the nominal ones.

Reassembly

Specialists will also ensure that the bearing has been crafted by a professional able to guarantee the quality of the metals

used and their suitability – from the shell to the electrolytic coating, including the anti-friction alloy (white metal or red metal). Dimensional and geometrical qualities must be guaranteed. The same applies to the housing, which also must be evaluated. Specialists will check and adjust the lift, the clearances and the lineage. Tightness and the absence of particles that could



Proper care of components, such as the engine main bearing, connecting rods and crossheads, are key to the reliability of a rotating machine.



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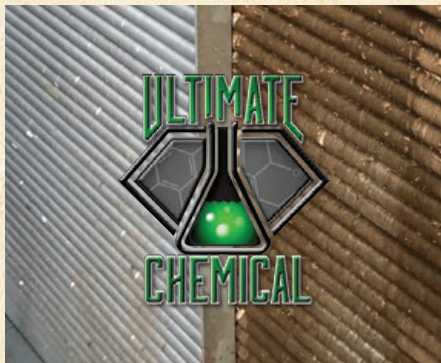


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TESCorp welcomes the "master" of vapor recovery

Ventmaster units designed to handle saturated gases.

By DJ Slater

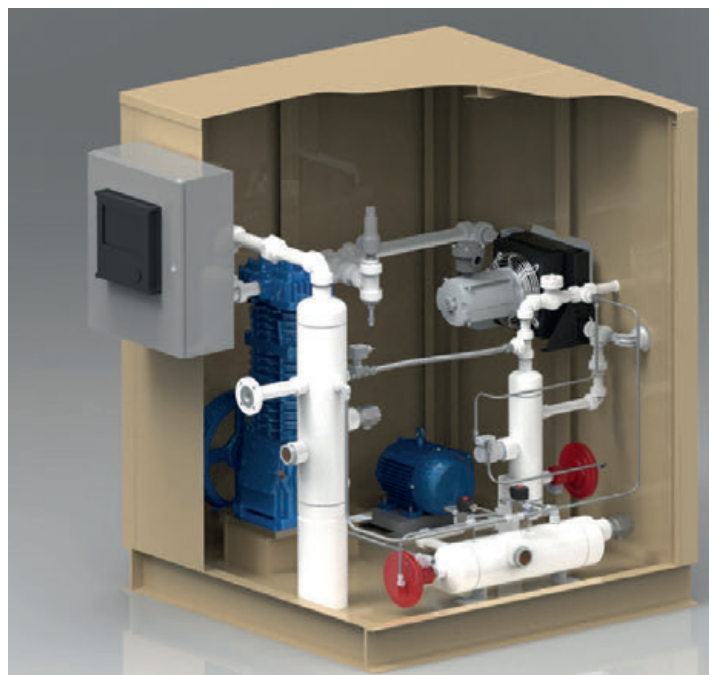
In the face of an industry norm, Thomas Energy Systems Corp. (TESCorp) is going in a different direction in hopes of giving compressor operators a better option to capture vent gas emissions in the oilfield and process industries.

The company has released its Ventmaster line of standardized vapor recovery units, designed to meet the U.S. Environmental Protection Agency's (EPA) performance standards for capturing vented gas emissions. The Ventmaster line is applicable to oilfield crude oil stock tanks and for recovering vented gases from gas compressors and process equipment found in the petrochemical industries.

Typically, these gases are heavy and in a saturated state. Applications of compressors to these gases must compensate for condensation within the compression cycle and the contamination of the seal oil during operation. Many operators rely on oil-flooded screw compressor units, even though such units are not able to handle these heavy "wet" gases that are being produced at near to "bubble point", said Vince Thomas, founder and president of TESC Corp.

"Maintenance is a big issue (with those units)," Thomas said. "One of the things I keep hearing over and over again is people that use oil-flooded screws are replacing them a lot.

"Application of this type of compressor is a balancing act in order to maintain conditions that do not allow the gases to achieve dewpoint in the compressor system," he said. "With pressures and temperatures changing throughout the day and seasons, this can



The Ventmaster line consists of four series – the BVR-M (1 & 2) and the CVR-M (1 & 2). The units are designed for saturated gases and adds "super heat" in the compression cycle to maintain temperatures in excess of dew point, eliminating any potential condensation within the compression process.

be a continuous problem and sometimes impossible."

A look inside

The Ventmaster line consists of four series – the BVR-M (1 & 2) and the CVR-M (1 & 2). The BVR-M series is a self-contained one- or two-staged system designed for handling low volume with moderate to high discharge pressures. It features an air-cooled, oil-free, one or two-stage reciprocating compressor with a double-distance piece shaft-packing box arrangement. The BVR-M, which handles saturated gas, has 13 model sizes available from 3 to 30 hp (2.2 to 22.4 kW); flows from 15 to 50 MMcfd (424,753 to 1.4×10^6 m³/d) at atmospheric conditions and flash gas flows up to 400 MMcfd (11.3×10^6 m³/d) with inlet pressures to 80 psig (5.5 bar) and discharge pressures up to 260 psig (17.9 bar).

The CVR-M is designed for medium to large quantity flows of saturated gases. It

features a liquid-cooled, oil-lubricated, one- and two-stage rotary vane compressor using mechanical seals and vapor recovery heads. The system comes in eight model sizes from 15 to 75 hp (11.2 to 55.9 kW); flows from 70 to 400 MMcfd (1.98 to 11.3×10^6 m³/d); and discharge pressures up to 140 psig (9.7 bar).

Common components

The Ventmaster line is an economical approach that utilizes a design with the units sharing a base core of common components, with the compressor size and horsepower being the primary variables.

"We designed the CVR from the ground up each time for each application," he said. "With the Ventmaster, we simplified the package with commonality of the components for both cost reduction and quick availability."

The Ventmaster line has gained popularity in the Denver Basin in Colorado, as well as North Dakota.

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Augmented reality makes it easier for novice employees to handle complicated problems.

An augmented approach to troubleshooting

Augmented reality capabilities allow Voith employees to pass on knowledge, provide access to the latest information for any employee in real time

Leveraging data from sensors, logs and third-party systems is nothing new. Visualizing data in 2D and 3D has been done for quite some time with CAD and other tools to make important decisions across many roles on a project team. It is said

that a picture is worth a thousand words, videos are worth thousands of thousands of words, and both increase the odds that everyone is on the same page.

Overlaid, real-time information

What is new, however, is integrating these tools and having the ability to see the data immediately and on-location. This allows experts to do their jobs as efficiently and safely as possible – making decisions based on all the available critical data in real time. A “central point of truth” is achievable with asset performance management systems that integrate the data from back-end corporate systems (ERP, LMS, HRMS); archived operational data; and real-time dynamic data streamed from key equipment and then delivered to any device – including augmented reality devices.

Many challenges currently faced in the

industry are driven by improvements in technology, increasing global competition and the tectonic shift in the workplace with an increasing number of experienced veterans retiring. In industries where equipment can run for decades, the spectrum of mechanical, electrical and digital machinery further complicates the challenges of capturing the knowledge of experts and quickly bringing up novice workers to fill in this widening gap in on-the-job expertise.

Many approaches have been attempted to address the issues noted above before they reach their flashpoint. Most solutions, however, have hit the wall when they failed to scale due to cost, access or speed.

■ **FAILURE DUE TO HIGH COSTS:** It has historically been too expensive to provide training to all employees across an organization to ensure that every part of

AUTHORS CORNER

JIM KOSALEK is the North American vice president of Service Sales for Voith Turbo. He has nearly 30 years of experience in the power and oil and gas industries. **BRENT WARD** is the Global Digitalization Business Development Manager for Voith Digital Ventures. His role includes focusing on industrial transformation enabled by advanced technologies at the equipment, plant and enterprise levels.





Documentation, training materials and assessment information can be accessed in real time through the use of augmented reality (AR) equipment.

a company is up to speed on the latest technologies and techniques.

FAILURE DUE TO LACK OF ACCESS: Typically, only specialized workers could attend classroom training sessions, participate in certification workshops or access expensive workstations and tools, all of which limit access to information and the understanding of new methodologies. Scheduling time with other experts, consultants or apprenticeships is also difficult, further limiting the availability of information and its transfer to new employees.

FAILURE TO ACCELERATE THE PACE: Today's industrial environments require more and more knowledge to be transferred "on the fly" so that workers have what they need, when and where they need it. This makes the timely transmission of data vital.

In the field, in the plant or on the go, an asset management system that allows data to be overlaid on real world assets (augmented reality) and integrates back-end systems, real-time data and computed signals can provide the workers at any level of the organization exactly what they need when they need it. An example might look like this:

A worker is on a ship that has one or more VoreconNXs driving main and gas lift compressors. The asset management system receives signals either 1) real-time raw; 2) real-time algorithmic or 3) planned (scheduled) creating an issue that needs to

be addressed before a deadline.

A filter needs to be replaced ahead of the typical preventative maintenance schedule because the performance of the machine has dropped. While the drop is almost imperceptible, calculations show that this will have a measurable impact on the efficiency of the production capability of the system and deadlines will likely be negatively impacted.

The work has been scheduled and all information required for the effort is connected automatically to the task. The information includes a service log, a list of previous work performed, inventory status and acceptable part numbers, diagrams, any updated manufacturer recommendations and expert videos on performing this task provided by the OEM with the VoreconNX, as well as videos from company experts showing best practices. Also attached is a checklist for the worker to assure compliance with corporate safety, regulatory

concerns, sustainability demands and other considerations (updated as recently as minutes before the task is performed).

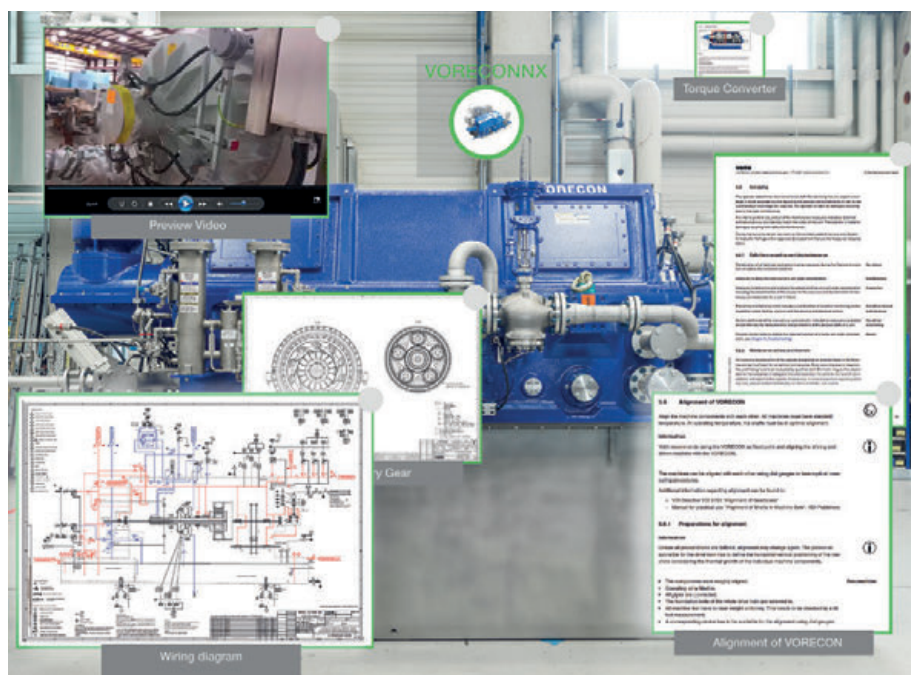
As the work occurs, the associate can capture photos or video and attach them to the checklist or the filter area to document the before and after appearance, critical steps for compliance or any other relevant data. The completed work then updates in the system and notifies anyone requiring the update. Algorithms are recalculated for predictive measures and the knowledge base enhanced for use by future workers at this or other facilities using the VoreconNX and the same or similar filter.

The above scenario seems too good to be true, especially when seasoned veterans can perform these types of tasks by memory. But larger operations and novice employees won't always have these experts at the ready. Having augmented reality capabilities ensures the information is captured, transferred and shared in real time. With this kind of system, internal workers and approved external parties will know everything they need to about the equipment whenever it is needed.

It is possible to achieve significant additional capacity in an operation through quality maintenance and digital asset management. With the right information centrally accessible, training can be done "on the fly", upskilling can be supported as people grow in their jobs and all the information is at their fingertips.

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This simulated image shows how augmented reality overlays important information on a real-life scene, allowing workers to access critical information while they are on-site and in the middle of an important process.





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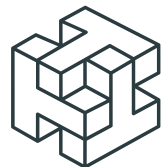
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Bacharach releases PCA 400 combustion analyzer

Device uses Bluetooth technology for enhanced data transfer. By **DJ Slater**

Bacharach has released a new handheld combustion and emissions analyzer with several features that make data extraction and analysis more seamless and accurate compared to similar devices.

With the PCA 400, Bacharach said it has a device that can analyze a variety of gases in several environments found in industrial applications. The PCA 400, which replaces Bacharach's PCA3 analyzer, is ideal for the midstream oil and gas industries, as well as power generation, chemical and industrial processing and other industrial combustion processes.

Real-time analysis

One of the PCA 400's prime features is the incorporation of Bluetooth technology, which allows operators to livestream collected data to any connected device, such as a smartphone, tablet, laptop or desktop. An iOS- and Android-supported mobile app provides an interface for operators to remotely operate the PCA 400, as well as offer expanded data storage, the ability to generate reports and send test results and reports electronically.

Having a Bluetooth-enabled device also cuts down on data transfer time and gives operators the flexibility to analyze data on more than one device in real-time, Kelly said. Data can also be stored directly on the PCA 400, which can hold up to 500 sets of

The PCA 400 uses Bluetooth technology to allow operators to access data in real-time from the device, as well as through an Android- or iOS-enabled mobile app.



Gas measurements are displayed on the PCA 400's 4.3 in. (109.2 mm) color touchscreen.

records.

"Our automatic data-logging feature, reporting software and mobile apps allow technicians to generate compliance reports accurately and efficiently," said Dan Kelly, a Bacharach engineer.

The PCA 400 also uses near field communication (NFC) technology, which is the same chip-based feature that allows people to pay for purchases by tapping their phone to a payment module or by transferring data from one device to another without an Internet connection.

Simultaneous measurements

The PCA 400 can simultaneously measure four gases, which include O₂, NO₂, SO₂, CO and NO. The measurement range for each gas is up to 500 ppm for NO₂, up to 3000 ppm for NO; up to 5000 ppm for SO₂; and up

to 10,000 ppm for CO. Oxygen measurements range from 0 to 20.9%, according to the company.

Users can view collected data on the PCA 400's 4.3 in. (109.2 mm) color touchscreen. The touchscreen also serves as a way for an operator to navigate the analyzer's functions.

A rechargeable lithium-ion battery pack or 4 AA batteries power the device, which can last up to 12 to 14 hours using the battery pack. The PCA 400's operating threshold ranges from 32° to 113°F (0° to 45°C). It also has a sample flow rate of 0.16 to 0.18 gpm (0.6 to 0.7 L/min) in standard mode and 0.26 gpm (1 L/min) in high flow mode.

The PCA 400 measures 10 in. high, 3.8 in. wide and 2.5 in. deep (254 X 96.5 X 63.5 mm). It weighs 1.5 lbs. (0.68 kg) with the lithium-ion battery pack.

"I'm very excited about the introduction of the PCA 400 to the marketplace," he said. "It offers unique and innovative features and technologies that benefit our customers in the field."

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Baker Hughes, C3.ai launch new AI application

BHC3 Production Optimization uses algorithms to predict problems, enhance operations. By **DJ Slater**

FLORENCE, ITALY – Baker Hughes and C3.ai have launched BHC3 Production Optimization, an artificial intelligence (AI)-based software application designed to improve oil and gas production rates. The application, revealed at Baker Hughes' Annual Meeting on Feb. 3, serves as an optimization product with the ability to learn from the data it collects and allows operators to use that information to make improvements to their upstream operations.

BHC3 Production Optimization uses machine-learning algorithms to gather and distribute real-time data for operators. The application creates a virtual blueprint of an upstream operation from individual and multiple wells to the pipeline, distribution and point-of-sale. The application can then use its AI capabilities to detect anomalies, provide production forecasts and offer actions to improve performance.

BHC3 Production Optimization is part of the BHC3 AI Suite, the platform for all of C3.ai's AI-based applications. Through the platform, BHC3 Production Optimization can pinpoint future problems and improvements. The application can also alert operators to under or overproduction problems in real-time and generate predictions and prescribed actions.

A single interface

The origin of BHC3 Production Optimization stems from the data gathering and software analysis shortcomings in the upstream field,



BHC3 Production Optimization's dashboard allows operators to view real-time data on their upstream assets.

said Philippe Wellens, product manager with C3.ai. Through its research, C3.ai discovered that most upstream data is fragmented and siloed, making it difficult for teams to work together as they use different information foundations. Additionally, many condition monitoring products are point solutions that don't interoperate or lack specific data points, such as having sensors across the entire production chain.

To remedy this, Wellens and C3.ai realized they needed a product that could gather data across the entire upstream production line, but also have the ability to learn from the data, provide a virtual metering network to enhance the data and distribute it to anyone within an operator's organization.

"The idea is to have a single interface, not 50 software applications, in which a user connects to and all the insights are shared and leveraged within that same interface that optimizes the full upstream value chain," Wellens said.

Virtual metering

BHC3 Production Optimization pools all data across the upstream operations to train

its AI models on the hydrocarbon flows in wells and surface production networks. These models are used to generate a virtual metering network by inferring hydrocarbon state estimations, such as flow rate, pressure and temperature from wells, pipelines, and network assets that are inaccurately or only periodically instrumented.

With continuous virtual metering estimations across the wells and surface networks, operators can back allocate production to individual wells, derive injection well optimization strategies, and recommend improvements to address production and sensor issues.

"The virtual metering layer is essentially the ability to create predictions. So where you don't have a physical sensor, you now have a virtual sensor," Wellens said.

BHC3 Production Optimization is the second AI software application developed out of the Baker Hughes and C3.ai partnership announced in June 2019. The first was an AI-based application – BHC3 Reliability – for compressor stations, onshore and offshore platforms, refineries and petrochemical plants.

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Moving at the speed

Pier Parisi embraces the brave new data-driven world

Pier Parisi's career path gave him a front-row seat to the technological advancements of the natural gas industry. He spent the earlier part of his career with Bently Nevada and GE before joining Dover and, currently, Apergy.

In September 2019, Compressor Product International (CPI) and Windrock, an Apergy company, began a commercial partnership, allowing the two companies to collaborate on monitoring and analytical technology (see **COMPRESSORTECH**², November 2019, p. 23).

The two companies have flagship devices built on the premise of monitoring, predicting and preventing equipment failures. CPI has Proflo EOS, a lubrication monitoring system for reciprocating compressors and Windrock has Spotlight, which monitors the health of compression equipment.

With the recent partnership and the plethora of technology around him, **COMPRESSORTECH**² spoke with Pier Parisi, vice president of business development, digital, Apergy, on how he views the rapid technological changes in the industry.

HOW IS THE NEW PARTNERSHIP WORKING OUT BETWEEN CPI AND WINDROCK?

We are off to a great start. There has been an immediate positive response from several customers, some of whom placed initial orders within weeks of the announced partnership. As a result, we've been able to provide some excellent insights to customers. In one case, we were able to detect a chronic problem in a compressor valve that is now being replaced with a better design by CPI. In another case, we were able to show a customer the different performance of two valves that were being



Pier Parisi

evaluated. CPI's commercial team is also very complementary to ours, giving us global service and sales coverage that will help expand the reach of our Spotlight Enterprise product lines.

ARE THERE ANY COLLABORATIVE EFFORTS OR PRODUCTS COMING IN THE NEAR FUTURE AS A RESULT OF THE PARTNERSHIP?

Absolutely. While we are working on linking our sales and service efforts, we are also combining product roadmaps so that CPI's product offering is more tightly integrated into our Enterprise platform and our AI predictive analytics offering.

HOW IMPACTFUL HAVE THE TECHNOLOGICAL ADVANCEMENTS IN THE PAST DECADE BEEN FOR THE GAS COMPRESSION INDUSTRY?

Quoting Victor Hugo, "nothing is more powerful than an idea whose time has come." This resonates a lot with us in regards to our Spotlight product line. Until just a couple of years ago, it was very difficult to install accurate dynamic pressure sensors in reciprocating compressors and have them last more than six months. The cloud was not as pervasive as it is now and data transmission via LTE was less secure,

less available and more costly than it is today. We now have a set of tools at our disposal that enables true IIoT Edge devices to provide great machinery insights at an affordable price. This enables AI analytics and expands access of machine health information to a much larger population. This concept is not necessarily new, but it is possible today due to technological advantages that surround us.

WHAT CHALLENGES DOES THE WEALTH OF DATA AND ADVANCED TECHNOLOGY BRING TO THE INDUSTRY?

I would say that the benefits far outweigh the challenges. We provide value by increasing the amount of data and insights exponentially. We have now surpassed one million hours of operation with Spotlight, which means that we've gone from data stranded in proprietary systems and reports to terabytes of smart data that enables predictions. In one swoosh, we've gone from having limited data such as temperatures and pressures from a PLC to true prediction of a valve-impending failure with a week's



of technology

notice. Just as Google maps predicts when you are going to get to your destination with increased precision, we are now able to do the same with machine data. Of course, there are some key qualifiers: you need clean data that is validated, time-stamped and available. And once you do, you need SMEs to train models so your AI knows how to find failures. It's not just data crunching. You need to guide your systems.

TECHNOLOGY SEEMS TO EVOLVE AT A SWIFTER PACE THE FURTHER WE GO INTO THE FUTURE. ANY THOUGHTS ON WHAT WE MIGHT SEE ON THE HORIZON IN TERMS OF TECHNOLOGICAL ENHANCEMENTS?

We honestly don't know what we don't know, so it's really difficult to come up with a long-term prediction. One constant is Moore's law, as our ability to deliver value doubles every year, with cost decreasing as well. I think that means more affordable edge devices and smart sensors, leveraging emerging technologies such as dust networks to provide even more data to AI engines. The days of complex and bulky electronics

in expensive cabinets are counted. Edge devices are clearly in the immediate future, let's say in the next five-year horizon.

IS THERE SUCH A THING AS TOO MUCH DATA?

I don't think so. Again, as long as data is reliable, our ability to store it, interpret it and transmit it is improving every day. Data analysts who design AI models love data. It wasn't too long ago that "data overload" was a favorite slogan in the industry, especially in the fast-paced environments of control rooms where operators need actionable information to make quick decisions during abnormal situations. But this is changing very quickly. We have been using traditional physics-based AI models of pattern recognition for the past 20 years, and today we are leveraging newer machine learning techniques to detect and predict at faster rates than ever. Data provides insights and transparency to operators. Some of the early adopters have embraced this and understand the value that is provided by good data. Conversely, data that is defective due to bad sensor calibration, poor time stamping or simply the wrong application can have opposite effects.

An example of this is our new partnership with DCP Midstream, which was announced in January. We will jointly develop new predictive models that are now possible



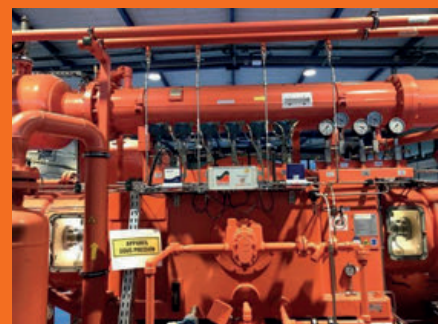
An Apergy employee works on a compressor.

because of the vast amount of data that is made available by our Spotlight system as well as their process historian. Several gigabytes of previously stranded and inaccessible data can be time stamped, contextualized and correlated to better predict future machine behavior that results from process changes. We are very excited about this partnership, which we believe will make an impact on our industry.

WHAT DO YOU ENJOY THE MOST ABOUT YOUR ROLE IN THE COMPANY?

I like solving problems that cannot be addressed by traditional commercial approaches. It is rewarding to find unsolved customer problems that are best addressed by a solution that involves more than one party. This gives us a chance to truly create new synergies, mostly by using technology you already have at your disposal, while also shrinking deployment cycle time. When you see this in action and a customer thanks you for the value they receive, it is truly rewarding.

CT2



Windrock's monitoring products have been installed on equipment at a CPI site in France.

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Ingersoll-Rand centrifugal compressors

Company was the first to introduce centrifugal compressors for natural gas pipelines. By **Norm Shade**

The Ingersoll-Rand (I-R) name has been synonymous with air compressors and equipment operated on compressed air. Its long history of innovation and leadership in compressor technology actually began with Ingersoll-Sargeant and Rand Drill, two predecessor companies that each introduced reciprocating air compressors in the early 1870s. Ingersoll-Rand formed from the merger of those two companies in 1905.

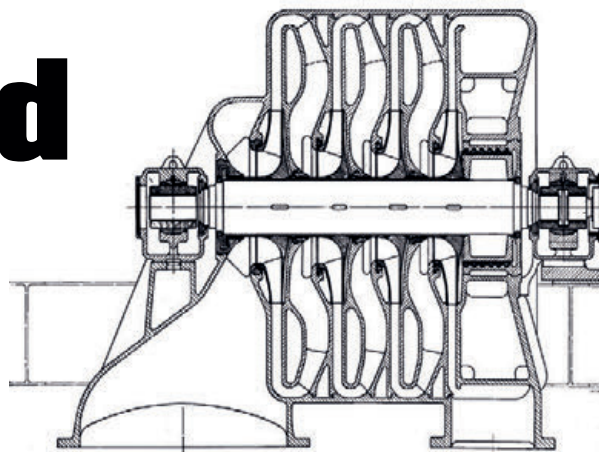
Reciprocating compressors would continue to dominate I-R's compressor production for several decades, but with the first practical centrifugal compressor appearing in France in 1899, I-R saw an opportunity for centrifugal technology in high-flow, low-pressure air compression applications. By 1912, I-R introduced the

first U.S.-built centrifugal air compressor, a tandem, steam turbine-driven unit that produced air at 90 psig (6.2 bar). A 1916 advertisement offered "turbo blowers and compressors for all industrial purposes". In 1917, I-R was building high-pressure centrifugal air compressors for marine services.

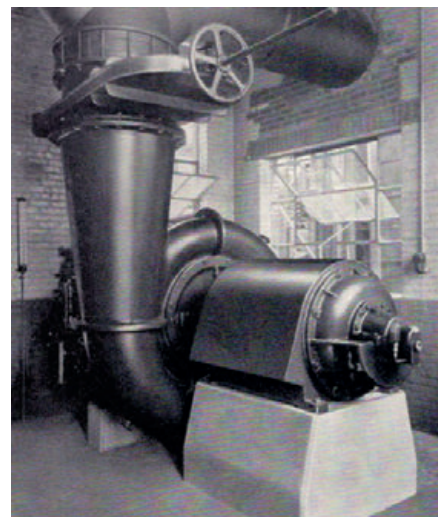
The first natgas centrifugals

I-R introduced the first centrifugal compressor for natural gas pipeline service in 1931. The six-stage "canned" unit, with an electric motor and compressor in the same casing, was installed directly in the pipeline to simplify sealing. Handling 140 MMcf/d ($3.9 \times 10^6 \text{ m}^3/\text{d}$) with a 1.4 pressure ratio at 400 psig (27.6 bar) inlet pressure, the compressor was successful, however, I-R took it out of service in 1932 because the electrical power cost made it too expensive to operate. It would be 16 years before centrifugal compressors again penetrated the gas pipeline industry. In 1933, I-R strengthened its centrifugal product line, by acquiring a comparable line from General Electric.

By 1936, I-R claimed more than 1,000,000 hp (745,712 kW) of centrifugal blowers, compressors and vacuum pumps installed for handling large volumes of air or gas at relatively low discharge pressures. Experience ranged from 5 to 12,000 hp (4 to 8949 kW) with applications in iron, steel, copper and lead furnaces, sewage



I-R single-stage centrifugal blowers (1936) were made for capacities from 350 to 40,000 cfm (9.9 to 1133 m³/min) for discharge pressure of 0.75 to 3.0 psig (0.05 to 0.21 bar).



A 1936 I-R multistage centrifugal blower cross-section. The fore-runner of I-R centrifugal compressors, multistage blowers ranged in size from 5000 to 12,000 hp (3729 to 8949 kW) for blast furnaces and other applications.

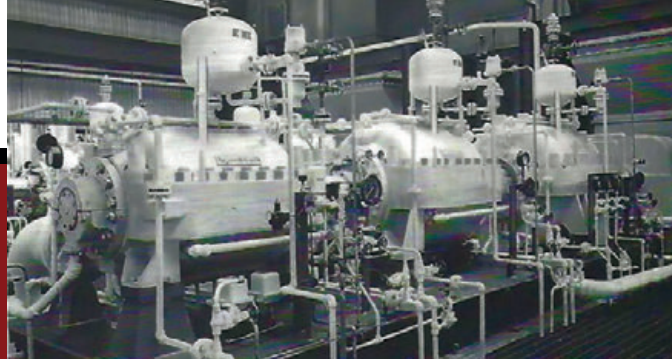
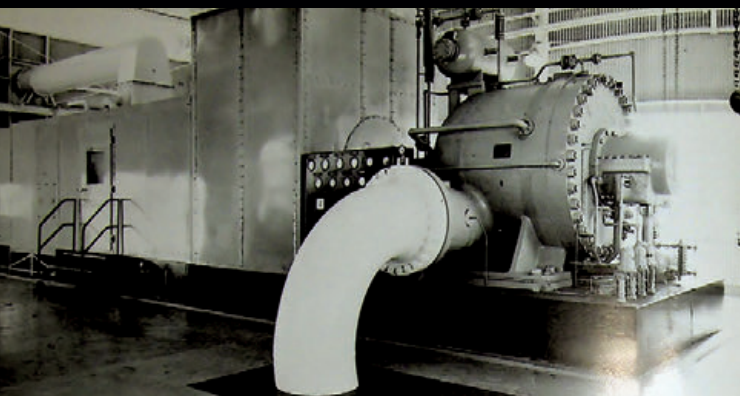
**This two-stage
I-R CPD-416
centrifugal
pipeline
compressor,
driven by a
4500 hp (3356
kW), 13,800
rpm I-R GT-22
gas turbine
was installed
in 1972 at Cities
Service Gas Co.
in Kansas.**



aeration, mine and tunnel ventilation and manufactured gas boosting and production.

More than 100 centrifugal machines were in service for blast furnace applications alone, ranging in size from 5000 to 12,000 hp (3729 to 8949 kW). A 1936 catalog described a line of 5 to 125 hp (4 to 93 kW) electric motor-driven air blowers, each combined in air-tight shells, built to handle 350 to 700 cfm (1 to 2 m³/min) at discharge pressures up to 5.5 psig (0.4 bar). An intermediate line produced flows from 10,000 to 20,000 cfm (283 to 566

CORNERSTONES OF COMPRESSION



This three-casing gas turbine-driven I-R centrifugal compressor train was applied to compress ethylene to 400 psig (27.6 bar) for a cascade refrigeration system, 1964.

This completely packaged I-R JP-125/CDP-230 gas turbine compressor set, rated at 12,500 hp (kW), was installed in a midstream pipeline station, 1965.

m³/min) with discharge pressures up to 110 psig (7.6 bar). And a line of large multistage blowers handled up to 110,000 cfm (3115 m³/min) at air pressures up to 60 psig (4.1 bar).

Many firsts for I-R

With ongoing innovation, I-R centrifugal compressors penetrated the rapidly growing chemical process and refining industries. Starting in 1940, I-R claimed many firsts, such as the first centrifugal hot gas circulator for hydrogen-forming and the first centrifugal air blower for fluid catalytic cracking service. In 1947, I-R built the first centrifugal gas compressor used for fluid catalytic cracking and introduced another centrifugal compressor into gas pipeline service. This 750 psig (51.7 bar) motor-driven, single-stage overhung design, with flanges opposite each other on the horizontal centerline, was a concept that soon became the pipeline industry's standard. Then, in 1949, I-R provided the first gas turbine-driven pipeline gas turbine. However, it was not fuel efficient and competitors Dresser-Clark, Delaval and Cooper-Bessemer would ultimately gain larger shares of this market.

Nevertheless, I-R continued advancing its centrifugal compressor product line in the chemical process and refinery markets. In 1953, it introduced the first 2000 psig (138 bar) centrifugal compressor and the first train

of multiple centrifugal compressors driven by a gas turbine. I-R's technical innovation continued through the next two decades, with either the first or the largest centrifugal compressors introduced into ethylene, ammonia synthesis, catalytic cracking air blowing, nitric acid, ethylene oxide and other gas services. This included a single train of four centrifugal compressors driven by a gas turbine in 1958, and many large units such as a 9000 hp (6711 kW) high-pressure recycle compressor for reforming, 11,000 hp (8203 kW) and 19,000 hp (14,169 kW) motor-driven air blowers for catalytic cracking, and a 187,500 cfm (5310 m³/min) blast furnace blower driven by a 23,829 hp (17,770 kW) I-R steam turbine.

By 1961, the I-R centrifugal line included horizontally split compressors up to 25,000 hp (18,643 kW) with up to nine impellers that could produce up to 200,000 cfm (5663 m³/min) and 800 psig (55.2 bar) discharge pressure. Vertically split compressors up to 15,000 hp (11,186 kW) were offered with four to seven impellers that could produce up to 20,000 cfm (566 m³/min) and 550 to 5500 psig (38 to 379 bar) discharge pressure. It also offered single-stage pipeline compressors up to 1000 psig (69 bar) discharge pressure. Through the 1960s and 1970s, sales of I-R's single- and two-stage model CDP pipeline compressors were

enhanced by the development of various I-R jet gas turbines ranging from about 4000 to 12,500 hp (2983 to 9321 kW).

The birth of Dresser-Rand

I-R continued to lead in industrial air compression with a broad range of reciprocating compressors. Although not first with centrifugals in the industrial air market, I-R introduced Type CVM multistage and CVS single-stage 100 psig (6.9 bar) intercooled centrifugal air compressors in 1958. Finally, in 1968, I-R introduced its Centac line of integral gear multistage air compressors, a concept that had been developed a decade earlier by Joy. I-R broadened this line over the years, adding a large capacity frame for process applications in 1984.

By 1980, I-R advertised "millions of installed turbocompressor horsepower" throughout the world, having built more types of centrifugal compressors for more applications and industries than any other manufacturer in the world. But on Dec. 31, 1986, after several years of declining sales and restructuring, Ingersoll-Rand and Dresser Industries formed Dresser-Rand, an equal partnership venture designed to handle the reciprocating compressor and turbomachinery products of both firms. Dresser-Rand operates today as a Siemens business unit.

CT2

1905

Ingersoll-Rand formed from the merger of Ingersoll-Sargeant and Rand Drill

1912

I-R introduces the first U.S.-built centrifugal air compressor.

1933

I-R strengthens product line by acquiring comparable line from GE.

1940s

With ongoing innovation, I-R claims many firsts in chemicals and refining.

1953

Introduction of the first 2000 psig (138 bar) centrifugal compressor.

1986

Ingersoll-Rand and Dresser Industries form Dresser-Rand, now part of Siemens.



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