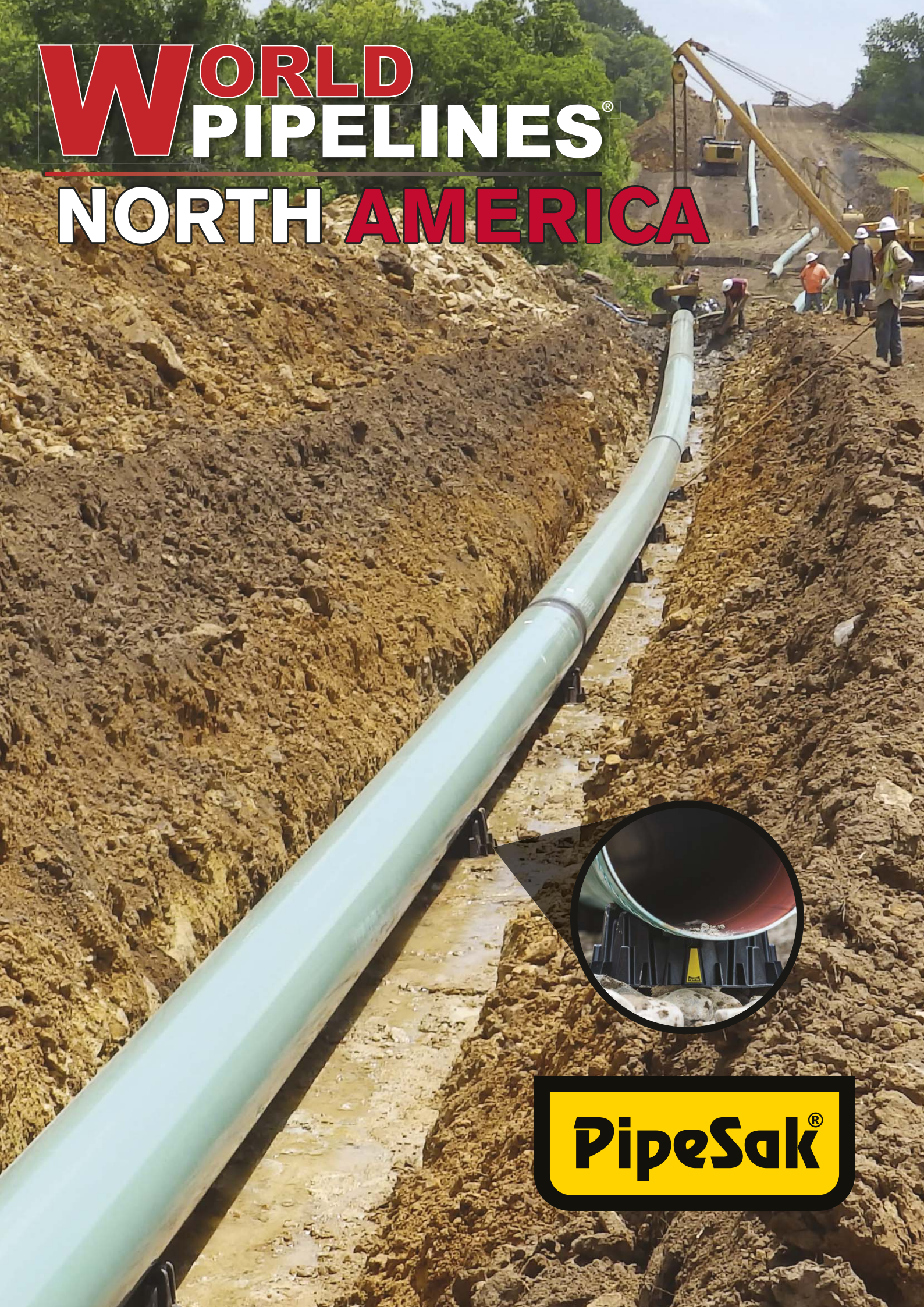


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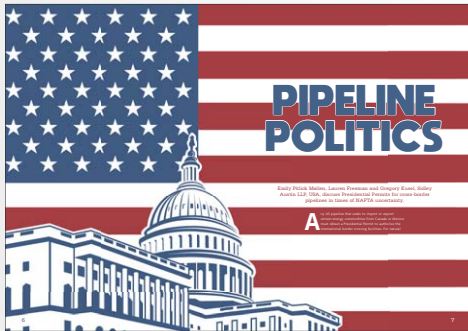
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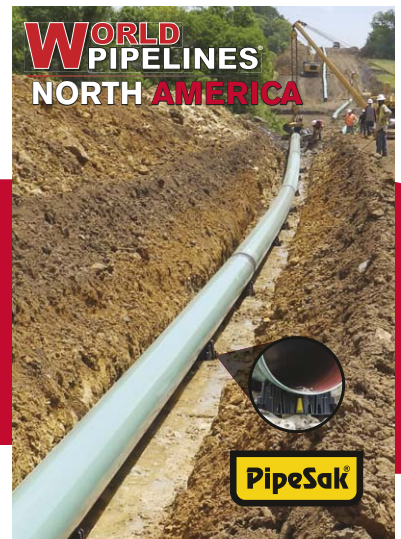
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Comment

PLAYING TRADE GAMES

The 2026 World Cup will be hosted by the United States, Canada and Mexico after their joint bid beat Morocco's rival proposal. The so-called 'United 2026' bid won 134 votes compared to Morocco's 65. Three vast nations will welcome the world's football teams and their supporters in eight years' time. Set to generate US\$14 billion in revenues and US\$11 billion in profit for football's governing body, Fédération Internationale de Football Association (FIFA), the 2026 World Cup will be played in 16 host cities across the US, Canada and Mexico. Edmonton, Montreal and Toronto will host matches, as will Monterrey, Guadalajara and Mexico City. The remaining ten locations will be in US cities such as Houston (NRG Stadium), Boston (Gillette Stadium), Miami (Hard Rock Stadium), Seattle (CenturyLink) and Kansas City (Arrowhead Stadium). A total of 17 US cities (including those listed above) have already begun their bids to be host to games: FIFA will pare down the list to 10 by 2021. A total of 60 matches will take place in the US, with Canada and Mexico hosting 10 each. The final is rumoured to be set for the 84 953 capacity MetLife Stadium, home to the New York Giants and New York Jets.

It is astonishing to learn about the power that FIFA wields, as I did when I read Taylor C. Noakes' opinion piece for CBC, published in August¹. To paraphrase Noakes: FIFA doesn't pay municipal taxes; it demands that host cities refrain from promoting any other major sporting event in the year preceding the World Cup; it stipulates that no major cultural events occur on the day of, after and before, a game; and it demands that FIFA's commercial partners have free and unrestricted access to the entire site of the matches and that none of their competitors advertise anywhere close to the site. FIFA also demands that each city be made as attractive as possible and even reserves the right to rename official venues.

The tournament marks the first time a World Cup has been shared by three host nations and it will require much administration, public spending and inter-nation co-operation.

The three nations are accustomed to working together, of course, in their capacity as partners in the North American free trade

agreement (NAFTA). However, recent moves by US President Trump to rewrite the terms of the 1994 accord, which Trump has referred to as the worst trade deal ever, have threatened the foundations of the trilateral trade bloc. Trump began moves last August to swiftly overhaul NAFTA, which he has long criticised for stealing American jobs (Trump has often blamed Mexico – among other countries that manufacture at cheaper prices and ship to the US – for the loss of manufacturing jobs at home following the implementation of NAFTA in the 90s. Mexico was free to import materials duty and tariff free for processing in factories near the border with the US, before re-exporting them back to their originating country).

At the beginning of August this year, representatives from Washington D.C. and Mexico City were getting closer to an agreement on how to reframe key portions of NAFTA,

including rules about whether imported automobiles will qualify for higher tariffs under the agreement. Canada has been conspicuous in its absence from recent talks, as Trump seems keener to sign a deal with Mexico than its neighbour to the north.

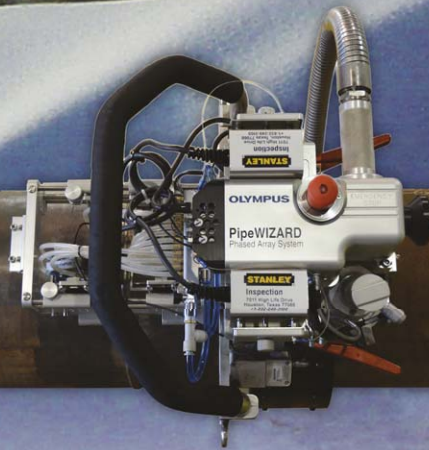
In another move to rebalance what it sees as unfavourable trade conditions, the Trump administration began to impose tariffs of 25% on imported steel and 10% on aluminium in February. The headache

this causes for the US pipeline industry is indescribable. The US is the largest steel importer in the world and, even if the tariffs bring about a welcome boost to domestic steel production, they will hit the pipeline industry hard, given that 77% of the steel used in US pipelines is imported – not to mention the speciality steels that are imported from all over the world to fulfil niche and complex large diameter, thick-walled steel pipe orders. Trump granted temporary exclusion from the tariffs to Canada and Mexico but he holds all the cards as NAFTA negotiations continue. Anti-import policies are likely to kick off a trade war, in which the pipeline steels industry is vulnerable to becoming a victim. 

“TRUMP BEGAN MOVES LAST AUGUST TO SWIFTLY OVERHAUL NAFTA, WHICH HE HAS LONG CRITICISED FOR STEALING AMERICAN JOBS”

1. 'Canada is poised to repeat its Olympics mistakes with a 2026 FIFA World Cup bonanza', <https://www.cbc.ca/news/opinion/canada-2026-1.4775528>

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Guest Comment

Don Santa

President of the INGAA Foundation Inc., USA

The expansion of the pipeline network in the US and Canada – brought about by new technology unlocking vast US shale oil and gas resources – is poised to continue. While infrastructure development will peak in the next few years, the midstream construction market remains robust through the forecast period, according to a new study conducted by ICF on behalf of the INGAA Foundation.

The study, *North American Midstream Infrastructure through 2035: Significant Development Continues*, finds that the US and Canada will require about US\$800 billion in oil and natural gas infrastructure investment through 2035. That is good news for both American and international consumers because sufficient pipeline capacity is key to consumers enjoying the benefits of US domestic oil and gas abundance.

Natural gas infrastructure makes up over half of the needed energy infrastructure identified in the report, with total natural gas investment of US\$417 billion, or an average of US\$23 billion annually, from 2018 through 2035. Natural gas infrastructure includes gathering and transmission pipelines, compressors, laterals, gas-lease equipment, processing, gas storage and LNG export facilities.

Meanwhile, US\$321 billion of new oil infrastructure (gathering pipeline, lease equipment, mainline pipeline and pumping, storage laterals and storage tanks) and US\$53 billion of new NGL infrastructure (transmission pipelines, pumping, fractionation and NGL export facilities) are forecast over the next 18 years. The study shows growth in total crude oil production for the US and Canada over the course of the projection period. This growing supply results in the need for new pipeline transport and oil handling capability. Not only do these new supplies increase US refinery input over time, but they also have the potential to cut crude oil imports in half. Moreover, growing US refinery input would increase oil product output and potentially boost US exports of refined products.

The primary drivers for robust midstream development are continued unconventional resource development and strong market demand, largely in response to the relatively low commodity prices fostered by these new oil and gas supplies.


For natural gas, exports are on the cusp of growing significantly, both to Mexico and as LNG to markets around the globe, the report forecasts. Furthermore, low gas prices have fostered growth in the power generation market as coal and nuclear plants continue to retire across the US. This trend seems irreversible considering state regulations that encourage clean power and the ways in which natural gas complements renewables. Regardless of policies, the relatively low gas price environment generally discourages additional investment to

upgrade or further limit emissions from coal plants, especially considering the threat of federal carbon control that still looms on the horizon. Low natural gas prices also have boosted gas demand for US manufacturing, particularly petrochemicals.

Overall, midstream investment will contribute about US\$1.3 trillion to the US and Canadian economies over the forecast period, or about US\$70 billion annually, with impacts to employment at an average 725 000 workers each year (including 242 000 directly employed) in the US.

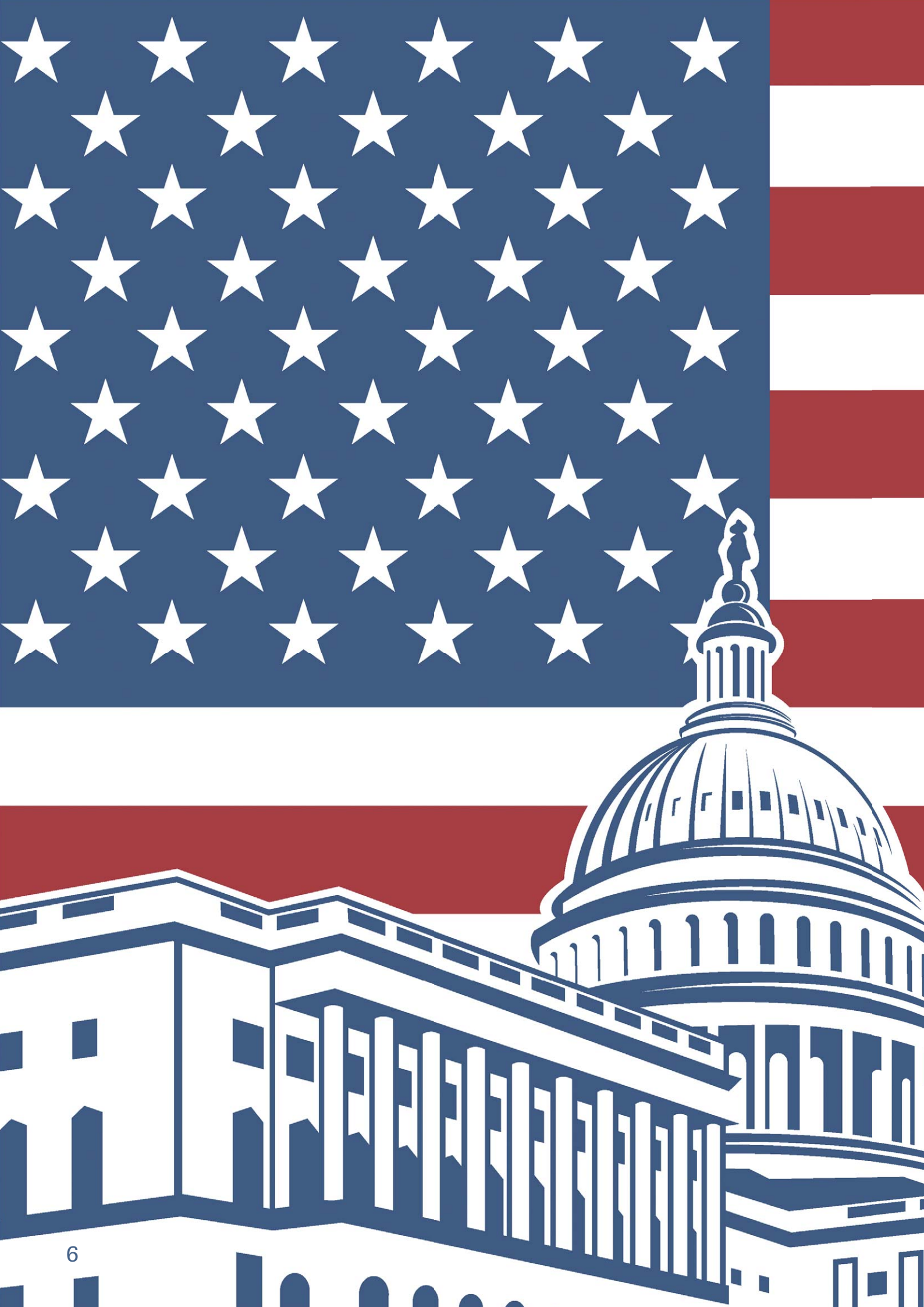
The bottom line is that the favourable economic environment for oil and gas infrastructure development has not yet run its course and is likely to continue for many years. This will have positive impacts on the US and Canadian economies, but also for global markets, which will have access to affordable US energy supplies.

INGAA is the North American association representing the interstate and interprovincial natural gas pipeline industry. INGAA's members operate approximately 200 000 miles of pipelines and serve as an indispensable link between natural gas producers and consumers.

Formed in 1990 by INGAA, the INGAA Foundation facilitates the safe, efficient, reliable and environmentally responsible design, construction, operation and maintenance of the North American natural gas transmission system to advance the delivery of natural gas for the benefit of the consuming public, the economy and the environment. 

You can learn more about the report here: <http://www.ingaa.org/midstream2035.aspx>

“THE FAVOURABLE ECONOMIC ENVIRONMENT FOR OIL AND GAS INFRASTRUCTURE DEVELOPMENT HAS NOT YET RUN ITS COURSE”



PIPELINE POLITICS

Emily Pitlick Mallen, Lauren Freeman and Gregory Kusel, Sidley Austin LLP, USA, discuss Presidential Permits for cross-border pipelines in times of NAFTA uncertainty.

Any US pipeline that seeks to import or export certain energy commodities from Canada or Mexico must obtain a Presidential Permit to authorise the international border crossing facilities. For natural



gas pipelines, the authorising entity is the US Federal Energy Regulatory Commission (FERC). For pipelines transporting crude oil, natural gas liquids or refined petroleum products, the regulator is the US Department of State (State Department). Historically, the process for obtaining Presidential Permits had been essentially apolitical and almost obscure – one of several regulatory authorisations necessary to build a pipeline project. But in recent years, the push to limit greenhouse gas emissions from fossil fuels engulfed higher profile pipeline projects in national political debates, making the Presidential Permit process more fraught with obstacles.

More recently, concerns over the future of the North American Free Trade Agreement (NAFTA) raise new challenges for cross-border pipelines. For a natural gas pipeline, FERC is required by statute to deem cross-border pipelines between the US and Canada and the US and Mexico “to be consistent with the public interest” because NAFTA requires the national treatment of natural gas from both of those countries.^{1,2} The State Department issues Presidential Permits to crude oil, natural gas liquids and petroleum products pipelines under authorities found in Executive Orders 11423 and 13337. If the State Department determines that the pipeline is in the US national interest (a ‘National Interest Determination’), the State Department will issue the permit.³ Although no specific mention is made in these executive orders to free trade agreements, these agreements are often taken into account in the State Department’s National Interest Determination and decision to grant a Presidential Permit.⁴

History of Presidential Permits

Presidential power over cross-border infrastructure can be traced back at least to the late 19th Century, when President Ulysses Grant approved a foreign telegraph cable between the US and Canada.⁵ Several attorney general opinions in the 1800s and 1900s confirmed the existence of presidential authority over specific cross-border infrastructure project approvals, but it was not until the 1950s that the practice of issuing Presidential Permits was formalised.⁶ This occurred via the issuance of several executive orders, including Executive Orders 10485 and 10530. Executive Order 10485, issued in 1953, empowered federal agencies to issue permits for the construction of cross-border electric transmission lines and natural gas pipelines.

With respect to cross-border petroleum infrastructure, in 1968, President Lyndon Johnson issued Executive Order 11423. This was the first executive order specifically related to cross-border petroleum infrastructure. Executive Order 11423 designated and empowered the Secretary of State to receive all applications and issue Presidential Permits for the “construction, connection, operation, or maintenance, at the borders of the United States, of: (i) pipelines, conveyor belts, and similar facilities for the exportation or importation of petroleum, petroleum products, coal, minerals, or other products

to or from a foreign country,” among other facilities. In 2004, George W. Bush issued Executive Order 13337, which amended Executive Order 11423 and provided specific procedures for the State Department’s review of Presidential Permit applications for oil pipelines.⁷ These procedures have also been applied to pipelines transporting natural gas liquids and refined petroleum products. The State Department must issue the permit if the project would “serve the national interest.”⁸

The authority to permit cross-border natural gas pipelines rests in a combination of statutory and executive order authorities. These are Section 3 of the Natural Gas Act (NGA), which provides the FERC with authority over the siting, construction, and operation of facilities to import or export natural gas, and Executive Order 10485, under which FERC must issue a Presidential Permit if doing so is found “consistent with the public interest.”⁹ Pursuant to the statute, applications for import or export facilities shall be granted without modification or delay unless FERC finds that the proposed exportation or importation will not be consistent with the public interest.¹⁰ In 1992, the same year NAFTA was signed, Congress amended NGA Section 3, adding Section 3(c), which created a different standard of review for applications to export natural gas to those countries with which the US has in effect a free trade agreement requiring the national treatment for trade in natural gas.¹¹ The added section deems the exportation and importation of natural gas between the US and those countries to be “consistent with the public interest” and requires that “applications for such importation or exportation shall be granted without modification or delay.”¹²

This statutory guidance has underpinned recent cross-border natural gas pipeline authorisations. For example, in a 2010 authorisation related to US-Canada facilities, FERC stated “granting the applicant’s request...will promote national economic policy by reducing barriers to foreign trade and stimulating the flow of goods and services between the United States and Canada, both of which are signatories to [NAFTA], providing for fewer restrictions on natural gas imports and exports.”¹³ And in a 2015 authorisation related to facilities between the US and Mexico, FERC stated “[t]he border-crossing facilities are needed to export gas that is being produced in the United States for sale to expanding energy and industrial markets in Mexico.”¹⁴ As part of the Presidential Permit review process, a cross-border natural gas pipeline must obtain favourable recommendations of the Secretaries of State and Defense.¹⁵

What happens next?

NAFTA took effect on 1 January 1994, and for nearly 25 years the presence of a free trade agreement between the US and Canada and Mexico has been taken as a given by the pipeline industry as its members planned projects to move commodities across the international borders and sought Presidential Permits to do so. Presidential Permits played a crucial role ten years ago when the US needed to

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import commodities to meet the country's energy needs. Pipelines brought natural gas from Canada while cargo ships brought liquefied natural gas (LNG) from Africa and northern Europe. Today, a thriving US energy sector requires Presidential Permits for export authorisation in order to access new markets for shale gas and oil production. According to the US Energy Information Administration, natural gas shipments to Mexico by pipeline are contributing to the US's emerging status as a net natural gas exporter, with pipeline exporting capacity expected to nearly double from historical levels by the end of 2018.¹⁶ To the north, Canada is no longer a large US supplier of natural gas. Instead, it now imports Marcellus and Utica shale production that is traded at the Dawn Hub in southwestern Ontario.

With respect to crude oil and petroleum-based products, US produced diluent moves by pipeline to Alberta where it is used in the production of crude oil, which then moves by pipeline back to the US. And on the southern side, there is a well-established circuit by which Mexico-produced crude oil is transported to the US for refining and is then exported back to Mexico as refined products like diesel and gasoline via pipeline.

The national treatment required by NAFTA makes it likely that pipeline import and export projects will obtain Presidential Permits. NAFTA also provides a platform to request relief if a permit application is rejected.¹⁷ If NAFTA disappears and there is no free trade agreement put in its place, Presidential Permits may be harder to obtain, particularly for natural gas pipelines.

An analogy for what a future without NAFTA or a replacement free trade agreement could look like may be found with the way Department of Energy (DOE) currently processes LNG export applications to non-free trade agreement countries. Per DOE guidance, such applications "shall be filed in hard copy format. DOE/FE will issue a Federal Register Notice of application seeking comments, protests, and motions to intervene in order to make a public interest finding for these types of applications."¹⁸ DOE reviews numerous factors in evaluating non-free trade agreement applications, including economic impacts in the US, international impacts, security of US natural gas supply and environmental impacts, among others. This can lead to extended review processes, lengthy export authorisation orders, and opportunities for appellate litigation.

As for projects already permitted, it is unclear what the disappearance of NAFTA would mean. Exports of natural gas would no longer be "deemed in the public interest" under the NGA, forcing DOE to make an independent determination with respect to the import/export of the molecules.¹⁹ This means that the molecules themselves may be subject to new regulation as they cross the border, which could impact the economics of already permitted projects if shippers want to avoid additional costs. Members of the environmentalist community already hostile to pipeline projects could seek to challenge the Presidential Permits as another front

in their opposition to fossil fuel development. Neither FERC nor the State Department could revoke or suspend the permits without complying with the Administrative Procedure Act's (APA) requirements for informal adjudications.²⁰ However, given that the permitting authority arises from executive orders, the President also could choose to revoke or grant permits individually on a case-by-case basis, which would not be subject to APA review. Either way, the process remains uncertain in this political climate. 

References

- 15 U.S.C. § 717b(c) (2012).
- North American Free Trade Agreement, Can.-Mex.-US, § 601, Dec. 17, 1992, 32 I.L.M. 289 (1993). FERC does not approve or disapprove imports or exports of natural gas molecules; rather that authority rests with the US Department of Energy (DOE) Office of Fossil Energy. However, DOE also deems the import and export of natural gas to NAFTA countries to be in the public interest.
- US Department of State, Public Notice 6590, "Inclusion of US Expiration Dates in Presidential Permits for International Border Crossings," 24 April 2009 (providing "Within the context of appropriate border security, safety, health, and environmental requirements, it is in the US national interest to facilitate the efficient movement of legitimate goods and travelers across US borders."
- Among the issues considered by the State Department in the past are the impact of the cross-border facility on the relations with the country to which it connects, and the impact of the proposal on broader foreign policy objectives. See US Department of State, Final Supplemental Environmental Impact Statement Keystone XL Project, p. 1.3 - 2.
- See Foreign Cables, 22 Opp. Att'y Gen. 13, 19 (1898).
- See, e.g., Granting of License for the Constr. Of a Gas Pipe Line, 38 Op. Att'y Gen. 163 (1935); Wireless Telegraph-Int'l Agreement, 24 Op. Att'y Gen. 100 (1902).
- Executive Order No. 13337, 69 Fed. Reg. 25299 (2004).
- Ibid.
- Executive Order No. 10485, 18 Fed. Reg. 5397 (1953); DOE Delegation Order No. 00-004.00A (available at <http://www.ferc.gov/industries/electric/indus-act/siting/doe-delegation.pdf>) (delegating to FERC authority to issue Presidential Permits for cross-border natural gas pipeline facilities).
- 15 U.S.C. § 717b(a).
- Energy Policy Act of 1992, Pub. L. No. 102-486, § 201, 106 Stat. 2776, 2866 (1992).
- 15 U.S.C. § 717b(c).
- Empire Pipeline, Inc., 132 FERC ¶ 61,229 at P 8 (2010) (citing North American Free Trade Agreement, Pub. L. No. 103-182 (December 8, 1993), 107 Stat. 2057; Implementation of the North American Free Trade Agreement Act, Executive Order No. 12889, 58 Fed. Reg. 69,681 (December 30, 1993)). <https://www.ferc.gov/whats-new/comm-meet/2010/091610/C-4.pdf>
- Impulsora Pipeline, LLC, 151 FERC ¶ 61,117 at P 14 (2015). <https://www.ferc.gov/whats-new/comm-meet/2015/051415/C-1.pdf>
- Executive Order No. 10485, 18 Fed. Reg. 5397 (1953).
- See <https://www.eia.gov/todayinenergy/detail.php?id=35332>.
- For example, TransCanada Corporation and TransCanada PipeLines Limited (TransCanada) requested arbitration under NAFTA Chapter 11 after the State Department rejected a Presidential Permit for the Keystone XL Pipeline.
- See <https://www.energy.gov/fe/downloads/information-submitting-Ing-export-application>.
- DOE recently provided guidance reaffirming its authority to rescind any order authorising LNG export to a non-free trade agreement country, but also "affirm[ing] its commitment to all export authorisations issued under the NGA, including long-term authorisations approving the export of LNG to non-FTA countries." Policy Statement Regarding Long-Term Authorisations to Export Natural Gas to Non-Free Trade Agreement Countries, 83 Fed. Reg. 28841, 28843 (2018). DOE added that "[t]he United States government takes very seriously the investment-based expectations of private parties subject to its regulatory jurisdiction." *Id.*
- 5 U.S.C. § 554.

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A CROSS-BORDER RELATIONSHIP

International Society for Mexico Energy founding members Mariel Juárez Olvera, IHS Markit Senior Analyst (Latin America) and James Fowler, ICIS Heren Senior Energy Analyst (Americas), discuss the status of the US-Mexico natural gas pipeline industry.



Members of the International Society for Mexico Energy (ISME), energy company executives, advisors, service providers, academics and journalists, gather regularly in Houston and in Mexico City to discuss the state of the energy market in Mexico. Founding members of ISME provide observations here specifically on the status of the gas pipeline industry.

Current status of Mexico gas pipeline industry

In 2013, Mexico's constitution was amended to open the country's entire energy industry to various degrees of private sector participation and competition. Although the gas industry had already gone through a reform process in the 1990s, the development of gas transportation infrastructure was still limited. One of the fundamental changes in the 2013 reform was the separation of gas sales from transportation services formerly provided primarily by Petróleos Mexicanos (Pemex)

to new private companies. In this sense, Mexico has opted to promote and incentivise the development of cross-border and interregional pipelines as a key tool for the development of the natural gas market, given the increasing importance of this energy source, not only for the energy industry but for the manufacturing, transportation, residential and commercial sectors as well. According to the Mexican Ministry of Energy (SENER), natural gas demand from those sectors grew by 62.3%, 40.0%, 46.3%, 12% and 56% respectively during the last 10 years ending in 2017. Natural gas consumption is projected to increase 26.8% to 2031, to reach a total volume of 9.65 billion ft³/d.¹

With this aim, the Mexican government has implemented two main policy mechanisms in order to promote entrance of new participants:

- ▶ Pemex's contract release programme, which forces the state production company to relinquish 70% of its gas sales related to merchandising activities.

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Table 1. CENAGAS' planned projects to expand the transportation and storage infrastructure according to the five year plan (2015 - 2019)

Project	States	Length (km)	Capacity (million ft ³ /d)	Commercial operation date
Strategic projects under development				
Tuxpan-Tula	Hidalgo, Puebla, Veracruz	283	886	2018
La Laguna-Aguascalientes	Aguascalientes, Zacatecas, Durango	600	1189	2018
Tula-Villa de Reyes	Hidalgo, San Luis Potosí	420	886	2018
Villa de Reyes-Guadalajara	Aguascalientes, Jalisco, San Luis Potosí	305	886	2018
Samalayuca-Sásabe	Chihuahua, Sonora	650	472	2018
Sur de Texas-Tuxpan	Tamaulipas, Veracruz	800	2600	2018
Other planned projects				
Nueva Era	Nuevo León	273	504	2018
Storage Strategic Project	To be defined	N/A	10 000	To be defined
Interconnection projects				
Monte Grande	SISTRANGAS to Sur de Texas-Tuxpan	N/A	500	2018
El Encino	SISTRANGAS to El Encino-La Laguna	N/A	70	2018
Guadalajara	Villa de Reyes-Aguascalientes-Guadalajara	N/A	200	2019
Oajaritos	FRSU	N/A	540	2018
Mayakán	SISTRANGAS to Mayakán	N/A	350	2019
Indicative projects to be considered by third parties				
Hub Kinder Morgan Monterrey	Nuevo León	N/A	200	2019
Libramiento Reynosa	Tamaulipas	N/A	350	2020
Libramiento Juárez	Chihuahua	N/A	35	2020
Expansión Arguelles	Tamaulipas	N/A	150	2019
Suministro a Quintana Roo	Quintana Roo	N/A	To be defined	2019 - 2020
Projects to be developed by CENAGAS				
Compression station Patzcuaro	Michoacan	N/A	N/A	2019 - 2020
Compression station Cempoala	Veracruz	N/A	N/A	2019

As well as cleaning up the energy matrix, natural gas also provides a cheaper fuel source, according to Santiago Garcia, Chief Executive Officer of Santa Fe Gas, the marketing arm of Mexican pipeline developer Fermaca.

“All this [new gas] will lower power prices. In the medium and long term, just with all the developments we are seeing in the power sector, we will see power prices come down because of market forces.”

For US producers, particularly in the booming Permian Basin, Mexico offers a market for their excess gas production, much of which comes from associated production. According

to Trey Greaney, Director of Commercial Optimisation at Oklahoma based pipeline company ONEOK, Mexican demand is becoming more of a focus for participants in the US market.


“Every time we go to an industry function or someone’s office, we always get asked the question ‘when is the Mexican infrastructure going to develop so that there will be more gas takeaway?’” Greaney said.

Mexican gas imports are likely to peak at 5 billion ft³/d or above this year, according to the estimates of price reporting agency ICIS. Further growth is also expected in the nearer term due to the continued deterioration in Mexican natural gas production, according to Madero.

“[In Mexico] we have a lot of E&P projects starting to be worked on, but they will not give us much gas by 2022. For the next few years we are still seeing a sad story in terms of decreasing domestic supply. At the same time, we are expecting to see demand continue growing by around 0.5 billion ft³/d every year for the next four or five years. That creates an even wider gap for imports,” Madero added.

New projects set to be completed within the next year, such as the South Texas-Tuxpan pipeline being constructed by TransCanada and Mexico’s IEnova, will be responsible for this continued growth. As US-Mexico export capacity continues to grow, new challenges will emerge.

“We are building a lot of capacity, so in the future we will have more rooms than kids in the house. For the first time in 2019, 2020 – when these projects start to come online – we will have more gas transport infrastructure capacity than actual demand. That’s great for gas security but it’s very challenging for those who own the capacity on the pipeline.”

Panelists predicted that this expansion in new pipeline capacity will therefore lead to a market developing south of the border, similar to that on the other side of the Rio Grande, with local pricing hubs emerging as well as secondary capacity markets and increased trade liquidity. 

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In the consumer world, markets virtually always take care of that through the process of sellers competing for business. There are, however, certain notable and well known exceptions, mostly consisting of natural monopolies. For example, while I may be able to buy a toothbrush or a car from a multitude of manufacturers (foreign and domestic) from any number of retail outlets, I cannot and would not expect 10 companies to run a natural gas pipeline to my back door to compete for my gas utility business. Hence these industries find themselves regulated by states and municipalities under the assumption that the market process cannot provide that regulation through competition.

Oil and gas producers sometimes find themselves in the same boat. Only a handful of companies may be operating oilfield pipelines, and in many cases only one or two. And even in those cases, it may not be that more than one company is willing or geographically structured to compete for the business of any one customer, leaving the producer with very limited options, and often just one option.

Pipelines could easily be thrown into that category, though we should not always be so hasty to do so. There has been a great deal of scholarly writing done on the subject and that is not at all the purpose of this article. But there is little doubt about the fact that oil and gas producers and pipelines sometimes have disagreements about the costs for the services provided – and that producers at times believe pipelines engage in monopolistic

behaviour (or monopsonistic, if the pipeline is the first purchaser of that product). At the same time, the pipes will counter that the cost of constructing, operating, and maintaining those lines is substantial, and that rate structures have not always kept up with those costs, particularly in a low-price environment as is presently the case for US natural gas.

An association for the oil and gas industry

The Texas Alliance of Energy Producers has approximately 2600 members, including representation from the larger publicly traded independent companies as well as the exploration and production (E&P) subsidiaries of some of the major integrated US oil companies. But the Alliance also represents a sizeable number of smaller independent companies and it is the charge from its board of directors to effectively represent those companies as well. Often it is the smaller independent companies who feel as though they lack the market power to engage with the pipelines and bargain for a better deal.

These companies and the production they represent are important, however. Independent oil and gas companies develop approximately 90% of the wells in the US, producing nearly 55% of US crude oil and 85% of US natural gas.

Regulators have not yet figured out how to come to grips with this dilemma. In Texas, the Texas Railroad Commission (the chief regulatory agency for the state's oil and gas industry) has yet to adjudicate a formal complaint that would help to settle the matter, but has indicated no desire to proactively treat the midstream industry and pipeline companies as regulated monopolies. And in fact, that is not the Alliance's preference either. But it does remain the case that producers with only one takeaway option face the untenable choice of either accepting the terms of the pipeline or shutting in the well, leaving them with virtually no bargaining power.

But here is the thing. We truly are all in this together. In most cases with regard to broad US energy policy, regulatory structure, tax and fiscal policy, environmental policy, and so on, the interests of US oil and gas producers and midstream companies are aligned. The upstream oil and gas industry in the US strongly supported the development of the Keystone XL pipeline, the Trans-Pecos pipeline, the Dakota Access Pipeline and other projects including future projects. Why? First and foremost because there is a market need, just as there is a market need for US-produced crude oil and natural gas. Further, the Alliance believes pipelines are the most efficient – and the safest – method of moving massive volumes of crude oil and natural gas from the field to the marketplace. Every barrel of oil or thousand ft³ of natural gas added to pipeline capacity represents the movement of raw petroleum products into critical markets including refineries, chemical plants, processing facilities, export terminals, and the country of Mexico. And of increasing importance, every addition to pipeline capacity reduces the number of crude oil hauling trucks on horribly congested and deteriorating roads in Texas and US oilfields.

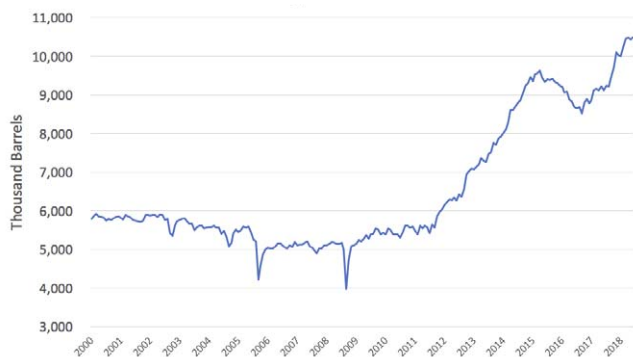


Figure 1. US daily crude oil production, January 2000 - June 2018.

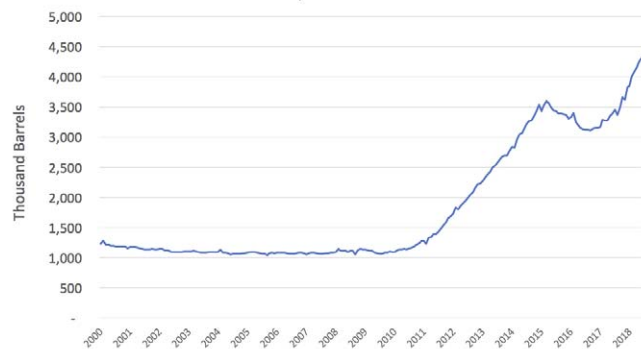
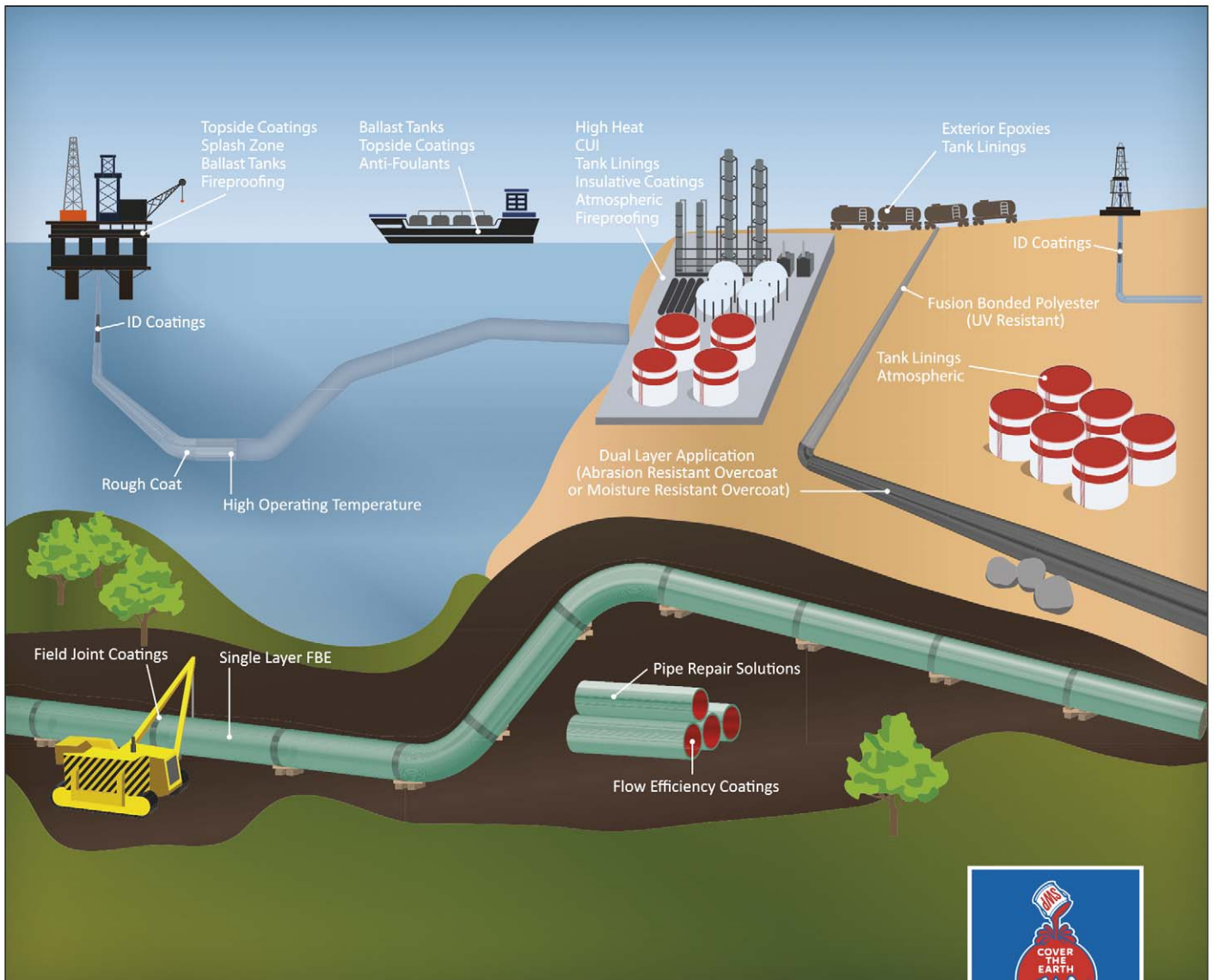


Figure 2. Texas daily crude oil production, January 2000 - June 2018.



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Figure 3. US monthly natural gas production, January 2000 - June 2018.



Figure 4. Texas monthly natural gas production, January 2000 - June 2018.

US oil and gas production history

The US oil and gas story in recent years is a remarkable one, demonstrating the power of markets and prices to meet the energy needs of America's household and business consumers. For nearly 40 years, from 1970 - 2009, US crude oil production declined steadily, and the prevailing consensus even through 2008 was that the market system simply would not work – it does not matter how high prices go if the geology will not permit additional production in response to those rising prices. And that was simply the most recent after decades of 'peak oil' fears, proclamations that the US is 'running out of natural gas', and so on.

As new production techniques – most notably horizontal drilling and hydraulic fracturing – were broadly employed in natural gas production with the Texas Barnett Shale as the laboratory, natural gas production exploded in the US and has increased by over 50% since 2002. These techniques were then expanded to crude oil production and the turnaround has been even more dramatic. Daily crude oil production in the US has increased by 150% since its low point in 2008 and continues to climb. In late 2017/early 2018, production surpassed 10 million bpd for the first time since 1970 and moved into all-time record territory in the process. US crude oil production in 2018 will easily break the annual record from 1970. Texas crude oil production began to rise in 2008 and has more than quadrupled since then with brand new production from

the Eagle Ford play in South Texas and the massive Permian Basin leading the way.

Natural gas production growth in Texas is largely 'accidental' at this point, meaning most of the rigs in the state are drilling for crude oil with natural gas production as a by-product of crude oil wells. Up to and including 2008, over 80% of the rigs in Texas were actively drilling for natural gas. Gas production continued to grow through the crude oil-driven expansion of 2009 - 2014. When crude oil prices collapsed beginning in the second half of 2014, natural gas production finally declined. But it is on the rise once again with monthly state-wide production volumes approaching the peak levels achieved in 2014 - 2015. US natural gas production by every measure will set new records in 2018.

The extraordinary growth in crude oil and natural gas production has logically swelled the volumes that must be moved by pipeline. In Texas more so than nationally – and in the Permian most specifically – the markets are screaming for additional pipeline takeaway capacity and it cannot arrive fast enough. Calculating takeaway capacity relative to current and future production is telling enough, but commodity markets tell the real story. Permian Basin crude oil pricing is currently discounted compared to benchmark posted prices for West Texas Intermediate crude oil by more than US\$15/bbl due to the rising inability to move that crude out of the region. Natural gas prices at Permian hubs are now as much as US\$1/thousand ft³ lower compared to benchmark pricing at other locations.

Pipeline development

Crude oil pipeline projects are underway, and this is the most welcome of news. But little relief is expected until the second half of 2019. Further, by some estimates, Permian Basin crude oil production is expected to roughly double over the next five years, and the implications for additional pipeline needs are staggering.

While crude oil is the production focus in the Permian and always has been (100% of the working rigs in the Permian are crude oil directed), natural gas production is high and climbing, again as 'associated' production – gas production from crude oil wells. The sheer volume of natural gas production relative to Permian pipeline capacity is a rising threat to regional crude oil production. Something has to happen to that produced gas, and broadly speaking there are only two options: market it or flare it (burn it in the field). Only so much gas can be flared by law, and even a pending decision to expand flaring volumes will not nearly solve the problem. Absent the ability to market or flare that gas, the well must be shut in – again, a well that was drilled to produce crude oil.

These are the reasons crude oil and natural gas producers support additional pipeline development in the Permian, in Texas, and all across the US. Upstream production cannot make it to downstream without midstream.

The crude oil export ban, in place since 1975, was lifted in late 2015. In 2018, the volume of crude oil exports

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exceeded 3 million bpd and continues to rise. That amounts to some 28% of total daily US crude oil production. Export markets are increasingly critical to Texas and US crude oil and natural gas producers, and once again pipelines are the preferred method for moving oil and gas to coastal export facilities. Or in the case of Mexico, directly into the country itself. US natural gas exports to Mexico are up by a whopping 450% since 2010, virtually all by pipeline, with the majority of that crossing the border in Texas. Mexico is an increasingly important outlet for Texas and US-produced natural gas, and it simply will not happen absent the pipeline investment to carry it from here to there.

For this host of reasons, US and Texas petroleum producers understand the important relationship between production and pipelines, and the critical nature of continued pipeline development unfettered by onerous federal regulation, inappropriate local and state governmental barriers, protests and the like. The concurrent development of petroleum production and midstream infrastructure has rapidly moved the US and North America toward North American energy independence, and that trend continues in 2018.

The Trump administration has done a lot to loosen the shackles on US oil and gas producers, and on the pipeline development necessary to support continued oilfield development. These include tax and regulatory reform, removing federal road blocks to permitting, and the simple recognition that the market-driven development of America's energy resources is of extraordinary benefit to the US economy. In short, it was a welcome relief that oil and gas producers and pipeline companies no longer had a big target on their backs at which their own federal government was taking aim.

Steel tariffs are a setback in that process.

A tariff on imported steel

On 8 March 2018, the Trump administration announced a global 25% tariff on imports of steel articles under Section 232 of the Trade Expansion Act of 1962. Section 232 is the 'national defence' clause ostensibly aimed at protecting domestic steel industry manufacturing and supplies for national security purposes. The rhetoric both from the administration and from protected primary steel-producing industries, strongly suggests rent-seeking protectionist motivations and the Section 232 language is broad enough to accommodate these motivations. Canada, Mexico, and the EU were originally exempted from the tariffs, but on June 1 those exemptions were lifted and the tariffs were applied to supplies from those countries as well.


Steel-consuming industries are clearly harmed by these tariffs, including the US domestic oil and gas, pipeline transportation, and oilfield pipeline construction industries. As of June 2018, an estimated 422 000 jobs exist in the US upstream (oil and gas exploration and production) sector in the 'oil and gas extraction' and 'support activities for oil and gas operations' (drilling and oilfield service companies), compared to 146 000 jobs in the primary steel and aluminium manufacturing industries (the tariffs

also included a 10% tariff on imported aluminium). The estimated number of oil and gas pipeline construction jobs alone outnumbers primary steel and aluminium jobs at an estimated 155 000 in June, and 'pipeline transportation' adds another 48 000 jobs. Jobs in these important sectors of the US economy will be lost as a result of tariffs imposed to protect primary steel and aluminium manufacturing jobs.

Steel prices began to rise in early 2018 based simply on the threat of imposed tariffs, and have continued to rise since the tariffs were put into place. And as is typically the case, the cost increases have already significantly outpaced the 25% steel tariff rate, rising by as much as 40 - 45% in some cases for oilfield steel goods. In a few cases, countries opted to negotiate quotas with the US rather than be subject to the 25% tariff on steel – South Korea in particular. Quotas are even more insidious in terms of raising domestic steel prices because a hard limit is imposed on the volume of imported steel, creating an even greater artificial shortage. In the case of South Korea, they agreed to a quota of 70% of the average volume of steel goods shipped to the US over the last three years for each of nearly 60 different products. In recent years, oil country tubular goods (OCTG) have comprised approximately one third of South Korean steel imports into the US, while nearly 700 000 t of line pipe has been imported.

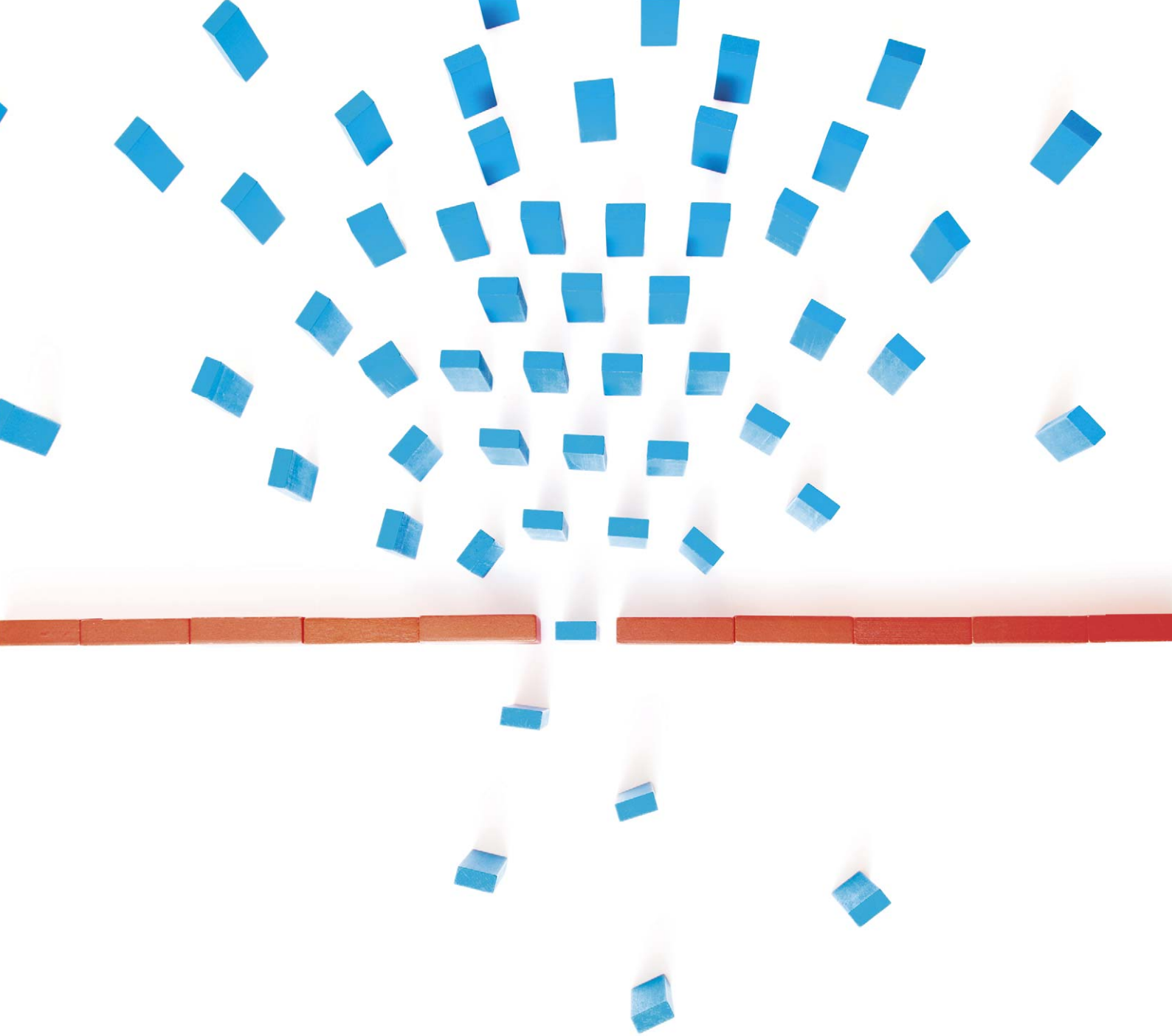
The oilfield simply does not run without steel – OCTG and line pipe in particular – and steel comprises some 10 - 20% of the upstream oilfield cost structure. Prices are rapidly on the rise for those products and availability is dwindling, especially to the smaller producers who were not in a position to purchase huge volumes on the front end of the tariff discussion to make sure their needs were met for the balance of the year or longer. Further, retaliatory tariffs by China and other countries now pose an increasing threat to US exports of crude oil and natural gas (LNG, primarily).

Of at least equal concern is the impact of the tariffs on the continued expansion of pipeline takeaway capacity from the production regions. Dramatic shortages in takeaway capacity were becoming apparent even before the tariffs became an immediate concern. Now that they are in place, the cost of the projects is almost certain to be staggeringly higher, which may mean at least some of those projects may be delayed or shelved entirely. The increased cost of constructing those lines may also change the economics of the rate structures to which oil and gas producers may be subjected.

The oil and gas community and the pipelines stand shoulder-to-shoulder in opposition to steel tariffs and quotas, one of a host of issues about which that is true. Neither of us can survive without the other. 

Note

The sources for the graphics are the US Energy Information Administration, the Texas Railroad Commission and the Texas Alliance of Energy Producers.



The Permian's lose-lose situation

Jamie Brick, McKinsey Energy Insights, USA, explores the gas problems in the Permian related to insufficient pipeline capacity and market repercussions.

The Permian is experiencing its first natural gas problem. Gas production is starting to exceed pipeline capacity exiting the Permian, and in-basin prices are falling as a result. Paradoxically, the second problem is a potential overreaction to the first problem: market fundamentals could attract too many pipelines, and the Permian runs the risk of having underutilised pipelines.

Introduction

Permian gas prices will remain weak for the next few years despite nearly 2 billion ft³/d of additional pipeline capacity coming online by 2020. This is because the Permian, predominantly a shale oil play, has large quantities of associated gas production. Permian crude and NGL production is expected to grow from 3.3 million bpd in 2017 to 8.8 million bpd by 2025 – which in turn is expected to cause natural gas production to rise from 7.1 billion ft³/d to 16.0 billion ft³/d over the same time frame.

The Texas Gulf Coast and, to a lesser extent, Mexico are the most likely destinations for incremental Permian gas volumes. While the fundamentals support additional pipelines (i.e. large quantities of new gas being produced), there is a real risk that the Permian will become over-piped in the medium to long-term. As private equity looks to fund the next major pipeline project, they will

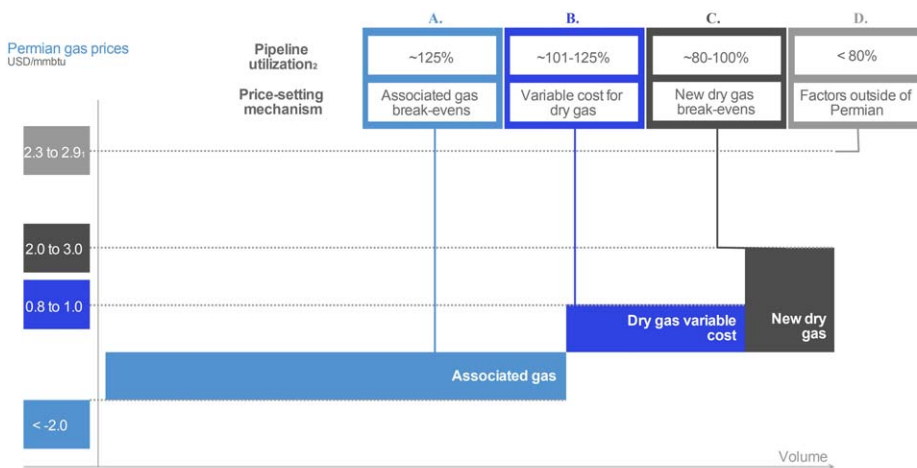
be increasingly drawn to projects linking the Permian to the demand centres in the US Gulf Coast. This is because pipelines typically offer stable revenue, and the regulatory risk is minimal in an oil and gas friendly state like Texas. Combining favourable fundamentals, minimal regulatory risk and private equity, there is a real risk that too much capacity will be developed in the long-term.

Conventional economics do not apply to unconventional associated gas

For all the excitement the Permian basin enjoys, it poses a major problem to gas markets. Depending on the year, an increase in oil production due to oil prices rising US\$10/bbl would also cause associated gas production from the Permian to increase by 1 - 2.5 billion ft³/d. With sufficient gas pipeline capacity, this inexpensive associated gas would displace gas from other basins, causing US gas prices to drop by approximately US\$0.10/million btu.

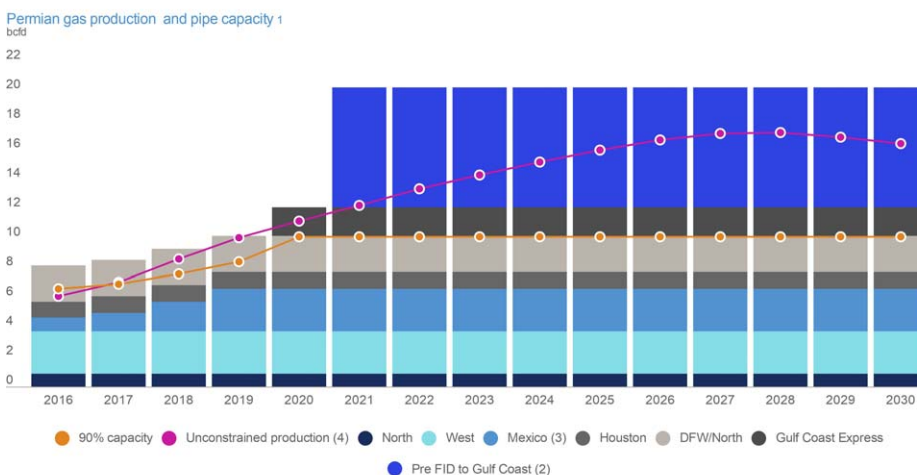
If pipeline utilisation exiting the Permian remains below 80%, in-basin gas prices are expected to be approximately US\$0.10/million btu cheaper than on the Texas Gulf Coast, because of the variable cost of transporting the gas (D, Figure 1). Once pipeline utilisation exceeds 80%, in-basin prices start to decrease as Permian gas competes with other gas for access to this limited pipeline capacity, causing in-basin prices to fall further. The Permian has already crossed that 80% threshold, and prices are starting to show the effects.

This scenario would usually result in operators reducing drilling for gas, but only approximately one quarter of Permian gas production is not associated with oil and is sensitive to in-basin gas prices. If in-basin gas prices fall, the first to be affected will be the <5% of production that comes from new gas wells, which have a breakeven of between approximately US\$2 - 3/million btu (C, Figure 1). Next would be the roughly 25% of Permian production from gas wells that have already been drilled, which break even at approximately US\$0.80 - 1.00/million btu (B, Figure 1). The remaining 75% of gas production is associated with



1) Assumes Gulf Coast price of 3.00/mmbtu 2) When utilization is greater than 100% it means unconstrained gas production would exceed pipeline capacity and implying gas production is shut-in
SOURCE: McKinsey Energy Insights, team analysis, press release

Figure 1. Illustrative Permian gas cost curves, US\$/million btu.



1 Capacity shown at 100% 2 not an exhaustive list of proposed pipelines 3 Includes constraints within Mexico 4 Subtracts in basin demand assumed to be ~500 mmcfd
SOURCE: McKinsey Energy Insights, team analysis, press release

Figure 2. Permian gas production and pipeline capacity, billion ft³/d.

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oil, and can even have a negative value, as oil revenue is what drives investment decisions for those wells (A, Figure 1). Since this associated gas is largely unaffected by in-basin gas prices, one can expect to see Permian gas production continue to increase even as the takeaway capacity approaches 100%.

Where will incremental Permian gas production go?

There are two primary destinations for incremental Permian gas: Mexico and the Gulf Coast. Once bottlenecks are resolved, new pipelines to Mexico should add an effective export capacity of approximately 2.9 billion ft³/d, a much-needed outlet until new pipelines to the Gulf Coast come online from 2020 (Figure 2). The other destinations for Permian gas are to the west and north. However, both routes face problems. Building additional pipelines to the west is difficult, especially in California, while western gas demand is uncertain due to higher solar generation. Meanwhile, competing volumes from the Marcellus and SCOOP/STACK, as well as higher pipeline development costs for long distance interstate pipelines, makes building a pipeline to the north less attractive.


Too much of a good thing?

In other areas, we have seen anecdotal evidence indicating private equity money competes against itself, causing the required returns to fall. Additionally, Appalachia provides

a good example of how excess pipeline can develop in response to wide basis differentials (McKinsey Energy Insights models indicate there is more pipeline capacity exiting Appalachia than production until after 2026.)

Most of the proposed new pipelines linking the Permian to the Gulf Coast would be regulated as an intrastate (i.e. within Texas) pipeline and are generally easier to permit and build compared to interstate, or even north-eastern interstate pipelines. Furthermore, private equity companies are increasingly attracted to stable pipeline revenues – especially when those pipelines are in an energy-friendly state like Texas, where a pipeline can be expected to come online 12 - 18 months after FID. As a result, it is more likely in the long-term that excess new pipeline capacity will be built from the Permian to the Gulf Coast, rather than too little.

Conclusion

The Permian is in a unique position. High oil prices lead to additional gas production and put downward prices on in-basin gas prices. The Permian's gas problem can be divided into two phases. The first phase is from now until around 2020 where there is insufficient pipeline capacity and in-basin prices are low. Despite building nearly 2 billion ft³/d of additional pipeline capacity by 2020, further additional capacity is needed. This leads to the second phase. Market fundamentals may attract too many pipelines, and the Permian is at risk of becoming over piped. 



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UNCONVENTIONAL GAS PRODUCTION PROBLEMS

Alick MacGillivray, TÜV SÜD NEL, UK, examines the growth of unconventional gas production and the factors that may limit further expansion.

In the last few years, the US has experienced something akin to a revolution in its natural gas production. This is largely due to the introduction of new technologies allowing greatly improved extraction of gas from shale rock deposits. This type of 'unconventional' gas production has increased in the US by a factor of 12 over the last decade and now comprises a quarter of all gas production in the country. This has elevated the US to be the largest gas producer in the world, having recently surpassed Russia.

Large shale gas reserves are not confined to the US. It is estimated that globally there are more than 7500 trillion ft³ of recoverable shale gas – equivalent to 60 years of the

world's natural gas demand. Countries such as China and Canada have large reserves but have yet to attain the production volumes achieved in the US. European countries generally have less potential in this area, due to less favourable geological conditions and reticence by the public due to environmental concerns. Despite this, the UK government, in an effort to diversify the country's energy supply, has supported exploration for shale gas reserves, although no production has yet (June 2018) taken place. This article will briefly describe some of the technologies being used to extract and transport the gas and discusses some of the main issues arising from it.



The use of hydraulic fracturing

Hydraulic fracturing, commonly referred to as 'fracking' is one of the methods that has been used to stimulate and ultimately extract gas trapped within shale deposits. This is a well-proven technology, which has been in use since the 1960s. It involves injecting large amounts of water, mixed with sand and small traces of chemicals at high pressures to break up the rock and release the gas. This gas flows back to the surface along with large amounts of water and chemicals from the fracking fluid and other deposits flushed up from underground, making up what is called flowback. This happens over a short period of time (days) after which the well will reach its natural gas production level with little amount of water.

Fracking can also release produced water, which is naturally occurring water trapped in the shale formation. It also carries minerals and naturally radioactive materials. This technique is capable of producing recovery factors of up to 20% of the trapped gas.

Horizontal drilling of shale wells

Most wells that are drilled for water, oil and natural gas are vertical wells – drilled straight down into the earth. However, drilling at an angle other than the vertical can hit targets and stimulate reservoirs in ways that cannot be achieved with a vertical well. In drilling horizontal wells, the drill bit is steered from its downward trajectory to the horizontal for 1 - 2 km, thereby exposing the wellbore to as much reservoir as possible. By drilling horizontally, the wellbore may intersect a greater number of naturally existing fractures in the reservoir. When combined with hydraulic fracturing, a well can cost as much as 3× per metre compared with drilling a vertical well. However, costs are currently declining rapidly in this area.

Managing the flow streams in unconventional gas production

The water used in hydraulic fracturing is often sourced from surface water (such as lakes and rivers), ground water (wells and aquifers), municipal supplies, and from wastewater from previous fracking processes. Once collected, it is transported or piped to the site, where it is stored in tanks until it is used in the drilling or fracking processes. As much as 20% of this



Figure 1. Shale is potentially a significant source of energy.

water can return to the surface via flowback and produced water. Having a piped supply is a great advantage as it removes the need for road tankers – which increase pressure on the local transport infrastructure.

Flowback water, produced after fracking is completed, is generally collected in metal tanks or open pools, lagoons or pits lined with layers of plastic. These are then pumped dry and the water is usually recycled from fracking additional wells, or transported in trucks off site to a waste disposal facility. Increasingly, operating companies are using closed loop systems as the preferred method of handling flowback water. When multiple wells are in close proximity to each other, then recycling the water is the most cost-effective solution.

A few weeks after drilling and fracturing a well, water may appear from it, along with the natural gas. This water is often disposed of by evaporation in large ponds, due to the high salinity of the water. However, the solution applied should be customised for the specific site conditions. The amount of equipment, materials and water required to support shale gas operations presents a significant logistics challenge. The type of issues encountered include road transportation, due to the high volume of traffic associated with shale gas production – principally in the movement of water, sand and chemicals.

Flow measurement in unconventional gas production

Flow monitoring of the various streams plays an important role in unconventional oil and gas production. It involves measuring fracture water, flowback and produced water, as well as monitoring the produced fluids at different stages of the production process.

Prior to the injection of fracturing fluid into the well, flowmeters are employed to monitor supply water by measuring the flowrate into pressurised tanks. The type of flow measurement device used here depends on the company involved and the legislation that is in place. Some are using indirect methods of measurement, including measurement of the pressure drop across a valve to infer the flow. It is also possible to simply count the number of tankers that are being used to inject the water. Another basic option is to use a single-phase flow measurement technology such as an electromagnetic meter. These meters electrically measure conductive fluids such as water and are unaffected by density and viscosity. Other simple technologies such as orifice plates also have been used for this purpose.

Flowmeters are also used to measure the quantity of the chemical solution that is combined with the water and sand to form the frack fluid. These chemicals are often corrosive and so should be measured by a non-invasive device such as an ultrasonic meter.

The measurement of flowback water is important and can be challenging. After the shaker process (which removes as much as possible of the solid proppant), the collected liquids will need to be measured by means of a flowmeter prior to decanting to storage vessels and transportation trucks. The final stage, during which flowmeters are used, is to measure



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the amount of chemicals needed to treat the collected flowback water.

Note that the costs of transporting flowback liquids are high. Every vehicle leaving a fracking site requires an accurate estimate of the weight that it is carrying. To do this, the operator should not only know the volume the vehicle is carrying, but also the density of the fluid (which can vary between sites). The density should be measured during the loading operation.

To measure the gas for export purposes, non-invasive technologies, such as ultrasonic and Coriolis meters, are often used. These are very accurate technologies and can measure a very wide range of flows.

Although many operating companies use simple single-phase technologies for the predominantly water-flow stages of the shale gas production process, this only delivers a limited amount of information. The information acquired and used by operators can be used to optimise the measurement process. For example, the use of inline multiphase meters can allow operators to determine the amount of sand being returned from a fracked reservoir. These meters can still be costly and currently are employed only in a limited number of wells.


The situation in the UK

The UK has been a net importer of gas since 2004 and its production in the North Sea has declined ever since.

Currently, approximately half of the gas is imported from overseas. Exploration for shale gas in the UK is still at a very early stage with only a modest level of exploration activity.

The largest shale formation in the UK is the Bowland Shale Formation in the north of England, which has the potential to form a resource analogous to the shale producing provinces of North America. This formation could play an important role in energy production in the UK.

The main barriers to production have been environmental concerns stemming from the potential effects of fracking, such as the pollution of ground water, seismic activity and pressures on local traffic infrastructure. Because of this lack of production, the regulation surrounding shale oil and gas production requires to be further developed.

To address these issues, the UK industry should look to developments in the US to guide future development in this area. This includes introducing strategies to optimise production and monitoring of waste and production flow streams. In terms of wastewater management this means reuse and treatment of wastewater, treatment of production chemicals, monitoring for leaks of methane, and the use of alternative fracturing methods. The industry in the UK still has many obstacles to overcome but shale gas is potentially a significant source of energy that can be exploited in the future. 

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STEP INTO DIGITAL TRANSITION

Mark Zuniga, UniversalPegasus International, USA,
presents a firsthand view of designing and implementing
digital inspection systems for the pipeline industry.

I am a member of an industry undergoing transformational change. I vacillate from week to week as to whether I count this as a blessing or a curse. Change on this level presents great opportunities, but not without a good measure of pain.

To say the oil and gas industry is cyclical is something of an understatement. However, those cycles have tended to come in the form of rolling hills and wandering valleys. Today's point in that cycle came on like a sheer cliff drop after scaling a mountain of the order of Everest. The industry was riding high at US\$150/bbl one minute, to costing less than bottled water the next. I have been in the industry long enough to go through a cycle or two, but not to have been there in the 1980s. That was a period of transformation too, I am told.

What happens to an industry during step change? Forces are brought to bear on it that had not been felt before, and likely from angles never seen. Most often there are two likely outcomes: demise (been to a Blockbuster lately?), or evolution. Rarely is the status quo maintained. During

this period businesses are ripe for mergers, acquisitions, closures, etc. Businesses at every level of the industry struggle to adjust to a new normal. For the oil and gas industry, that meant learning how to be profitable at US\$40/bbl crude oil prices. For an engineering and field services firm it meant doing more for our projects with fewer resources and less cost. The market downturn also happened to coincide with years of significant increases in regulatory requirements and scrutiny on the industry.

This perfect storm of shrinking profits, increased workload, increased regulation, fewer resources and a drive to reduce costs led our firm to explore how technology could better serve our projects. One area in particular that stands out is our application of mobile technology to field services. My firm provides field inspection to monitor the construction of pipelines on the owner's behalf. The inspection is performed by experienced, qualified inspectors monitoring a wide array of pipeline construction activities. Monitoring can begin at the mill where the pipe is made and continue to a

coating facility, to transport of the pipes, to receiving at a marshalling yard and ultimately to the ditch-side where the pipe will be buried. In addition to monitoring material, inspectors report on the construction firm's activities, including: clearing, grading, hauling/stringing, bending, welding, coating, ditching, lowering, back-filling, clean-up, seeding, fencing and finally hydrostatic testing the pipeline. For construction purposes, pipelines are broken into 'spreads' typically no shorter than 50 miles in length. For pipelines that extend hundreds of miles, each spread can have any of the previously described activities occurring simultaneously. Each spread is assigned a team of inspectors and they may come on and off, or be reassigned to another spread, based on the activity occurring in the pipeline construction cycle. While inspector headcount varies, it is not uncommon to have between 40 - 60 inspectors on a 50+ mile pipeline spread at peak.

How pipeline inspection is traditionally performed

The goal of pipeline inspection is to ensure the highest quality asset is being constructed. The inspector is tasked with identifying multiple issues such as material damage, defective welding, improper material usage, deviation from design, etc. The actual list is extensive and more than I could describe here, yet we expect our inspectors to catch all non-conformance. In order to do so, the inspectors must start with a baseline from which to compare. This baseline is established by the construction drawings, specifications, procedures and regulatory permits (with guidelines) typically prepared by an engineering firm. The inspector records his findings on pipeline inspection forms for which there is no industry standard, although most track similar information.

Pipeline inspection has historically been driven using paper. The entire construction documentation package previously described is printed and issued to nearly every inspector and/or housed at construction trailers/offices.

The inspection forms themselves are handwritten on paper forms. The completed paper form is individually reviewed manually for completeness and compliance, and then validated as complete. The paper form is scanned and placed in a project file. There are at least six steps in the traditional manual form process: printing, delivery to inspector, completion, review, approval, clerical form handling for data consolidation, scanning for project records, and lastly physical placement in a project repository. On any given day a single spread can generate 50 - 100 paper forms. As an example, a 200 mile pipeline project could generate between 200 - 400 handwritten paper forms per day, or between 1200 - 2400 forms during the typical six day construction week. Depending on geographic location, weather and other factors, a 200 mile pipeline project could take between four to six months to construct and yield nearly 100 000 forms. This typical approach generates a mountain of paper that must be reviewed and sorted for conformance, with issues identified to be addressed. The management of this process is typically tracked in spreadsheets. The timeframe in which all of this is done is also critical, as ideally issues are to be addressed prior to the pipe being buried. This paper process presents numerous challenges, from illegible writing, erroneous entries, paper handling, transposition errors (retyping in spreadsheets), lack of transparency, inability to properly audit, delayed reporting (due to volume), etc.

Mobile technology

My team leveraged mobile technology to replace the existing paper based process. While this may not sound groundbreaking to most readers, I can assure you we are mapping uncharted territory for the industry. Mobile devices and solutions are slowly being used in materials management, field survey, construction inspection, construction and overall project co-ordination efforts. These devices provide near real-time access to data for construction and compliance activities via digital data

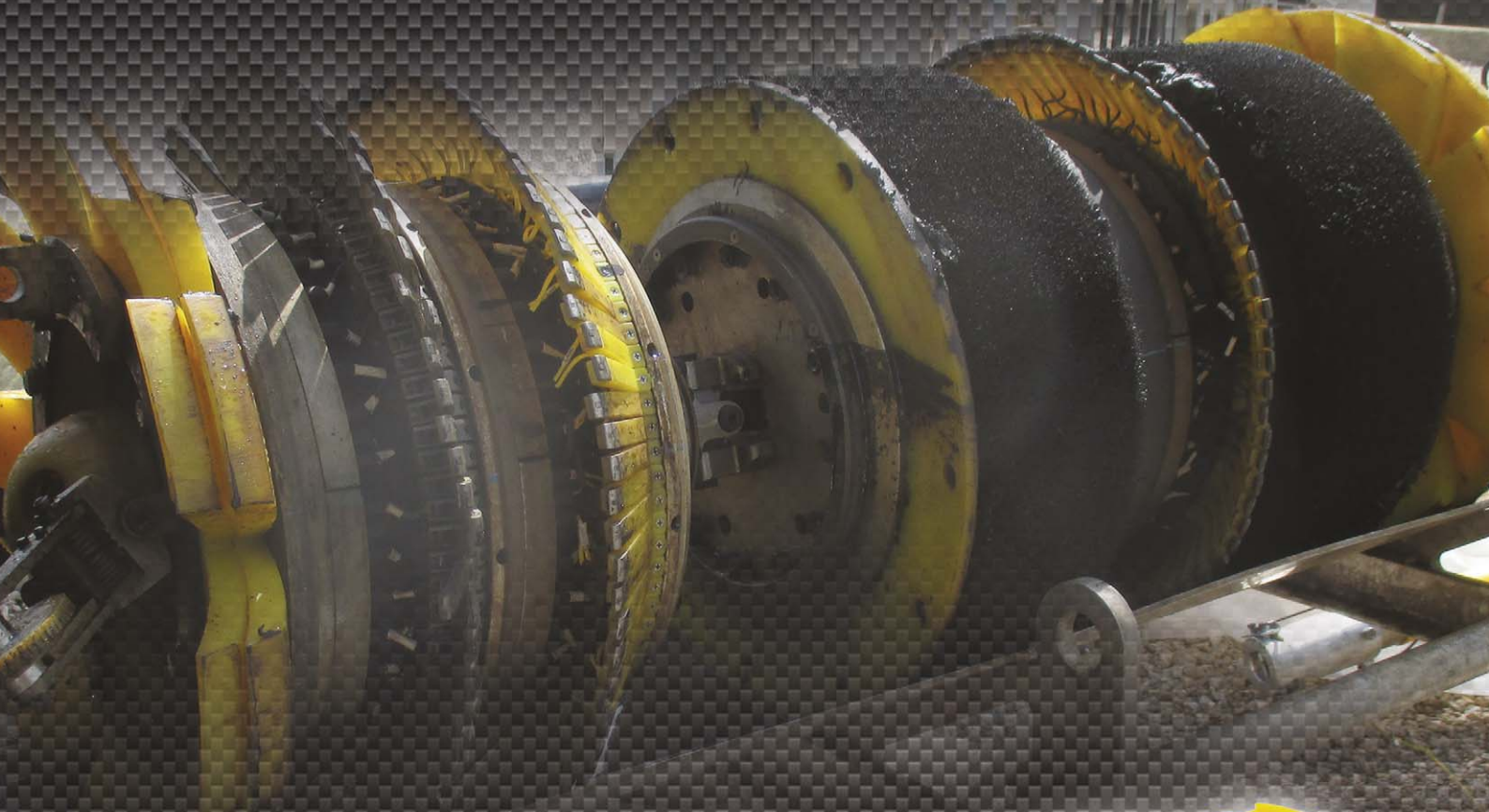
capture, data reporting and distribution. The information managed includes: construction drawings and specifications, requests for information (FRI), reports on issues, quality verification documents, non-conformance issues or other project specific information.

The mobile inspection platform (MIP) integrated several pieces of commercial off the shelf (COTS) software, a geographic information system, an enterprise database, a compliance engine/framework and tablet hardware to create a mobile inspection platform. This mobile platform delivers



Figure 1. The mobile inspection platform is highly configurable and can be rapidly deployed to meet unique requirements.

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a digital construction quality management system that provides streamlined project workflows, near real-time verification of regulatory and design requirements and field construction progress reporting all at significant cost savings to our clients.

The platform is highly configurable and can be rapidly deployed to meet unique field inspection forms, workflows and project requirements. Key components of the mobile inspection platform are its ability to collect information online or offline, mine large volumes of data in near real-time and provide flexible, advanced reporting. Our solution provides those capabilities via a ruggedised, field hardened tablet supported with training and processes that ensures data collected by nearly any means is ingested into the system. The system supports viewing and redlining of critical field documents such as engineering bulletins, drawings, environmental, construction drawings and specifications via the tablet. The application supports the document revision process using push technology, which ensures that the most current documents and drawings are available in the field at all times.

The advantages of going digital

The use of a digitally based data collection approach in lieu of a printed form presents many advantages. Digital data collection and verification provides controlled input, managed workflows defined by the project and audit-ready records for project completion. Controlled input improves the quality of data captured through the use of required fields, predefined options (i.e. dropdown lists), prepopulated fields (i.e. date, time, etc.), automated calculations and standardised fields (i.e. alpha, numeric, etc.). A digital platform offers multiple inherent advantages such as:

- Significant cost savings.
- The ability to process and manage large volumes of information.
- Near real-time verification of regulatory and design requirements.
- Supports a traceable, verified and complete (TVC) project.

- The ability to generate reports based on the information in a wide variety for formats (i.e. maps, charts, dashboards, tabular, etc.).
- A superior repository to maintain records for ongoing use.

Regulatory compliance is critical to the success of a project's execution and completion. Based on recent experience in federal regulatory compliance audits, there is a clear need for all information to be traceable, verified and complete (or 'TVC' – as it has come to be known in the industry). In addition, the information must be readily available throughout the duration of the project and in particular for audits. Our solution has a proven track record of supporting federal regulatory compliance audits and even proactively works to identify issues prior to an audit. The system is capable of reporting and alerting when exceptions are introduced into the system. Exceptions such as a blank (required) field on a form, data that falls outside of predefined parameters or a missing/unsubmitted form can all be highlighted daily. This is achieved via the platform's compliance engine. The compliance engine is a key technology element of the system that results in the largest benefit to the client. The compliance engine is an automated verification system that evaluates predefined engineering criteria, flags exceptions and routes the issue via a project defined workflow to classify and mitigate. The workflow tracking system provides status tracking and commenting capabilities for auditing and traceability purposes. For perspective, a recent 200 mile, 5 spread pipeline using MIP yielded the following results:

- 455 project team users including inspectors.
- 235 compliance rules established.
- 91 000 forms submitted.
- 500 000 data elements (from forms) analysed.
- 56 000 exceptions found.
- Savings of more than US\$1 000 000 in reprographics/printing costs.


We set out to survive and evolve in our small part of the oil and gas industry, but we ended up proving technological innovation can be a good thing for all involved. We will seek to make better use of technology. We will learn to apply that technology in practical, efficient and cost effective ways. We will train our workforce to adapt so that we all have a longer future in an industry that is so vital to our country. We will adjust to the new normal. And who knows, as the market returns the new normal may include a totally digital world in pipeline construction. 



Figure 2. Advantages of the mobile platform.

Note

This article is based on an article published on the Forbes website: <https://www.forbes.com/sites/forbestechcouncil/2018/06/01/how-to-disrupt-an-industry-with-an-app/>

Pipelines



GETTING

A GRIP

Andy Neuberger, CRC-Evans, USA, explains the challenges of pipe stringing operations and the methods designed to overcome them.

As Eddie Weatherford toured the right-of-way (ROW) of Pipeline Contractors LLC's jobsites in Louisiana and Mississippi, he noted locations that would pose significant challenges to the upcoming stringing operations. With restricted work areas and the congestion posed by directional drilling rigs, precise control of each pipe joint as it was offloaded from trucks was going to be critical to the overall success and safety of the project. Weatherford, of CRC-Evans International, recommended the use of the safest, most effective pipe handling product available – DECKHAND® by LaValley Industries.

Pipe stringing has been an important part of the pipeline construction process since the earliest days of pipelining. It was in those days that the traditional method of pipe stringing was first established. Workers using cranes and, later, excavators equipped with chains and straps would unload trucks and position pipe along the trench in preparation of bending, welding and lowering in. The pipe joints needed to be lifted dead centre, and workers would position the pipe on the cradle by hand or with the use of tag lines. Despite this method being established so many years ago, it is nevertheless still employed on jobsites throughout the world. Although effective, this method has proven to have several significant drawbacks. First, field personnel are often placed in danger zones as they must manually guide the pipe joint into place. Second, chains and straps can fail or be secured improperly causing the pipe joint to free fall during lifting. Lastly, straps and chains create a free-swinging load which can be very hard to control, especially in poor weather conditions such as snow, rain or high winds.





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Figure 1. Total load control with the DECKHAND.



Figure 2. Safely, precisely and efficiently stringing the ROW.



Figure 3. Out of harm's way, the DECKHAND eliminates the risk in any environment.

Vacuum lifters

Approximately 25 years ago, a new tool was introduced to pipe stringing operations – vacuum lifters. Vacuum lifters immediately changed pipe stringing operations. As vacuum lifters were designed as an excavator attachment, they allowed the industry to move away from utilising labour intensive cranes towards more efficient excavator based lifting. Vacuum lift attachments are typically designed with their own on-board diesel motor powering a vacuum pump that creates the suction necessary to lift pipe joints through vacuum. The vacuum attachment then typically utilises the excavator's crowd function to power a hydraulic motor that allows the excavator operator to rotate the pipe joint 360°. Although the vacuum lift method brought improved labour efficiencies to the pipe stringing process, it did not fully address many of the existing drawbacks found in the traditional method. Pipe joints still needed to be lifted dead centre and workers still needed to position the pipe on the cradle by hand or with the use of tag lines. Additionally, vacuum lifters still created a free-swinging load, making total load control and precise pipe placement a continuing challenge. Vacuum lifters also brought with them certain additional operational challenges. First, as pipe is being lifted solely using vacuum, the safety of the lift is fully contingent on the suction being generated by the vacuum lift. Should the suction be compromised in any way, the pipe joint is no longer secured to the attachment and can free fall. Second, the vacuum lifter requires a clean surface on the pipe joint in order for the suction pad to properly seal. This meant that the pipe joint needed to be cleaned of mud, snow or any other debris that could compromise the vacuum seal. This requirement often caused workers to climb on pipe racks to clean each pipe segment prior to lifting, which creates its own potential hazard. Lastly, as the vacuum lift typically utilises a separate internal combustion engine, it must be continually maintained and fuelled – increasing jobsite maintenance costs.

Pipe grapple method

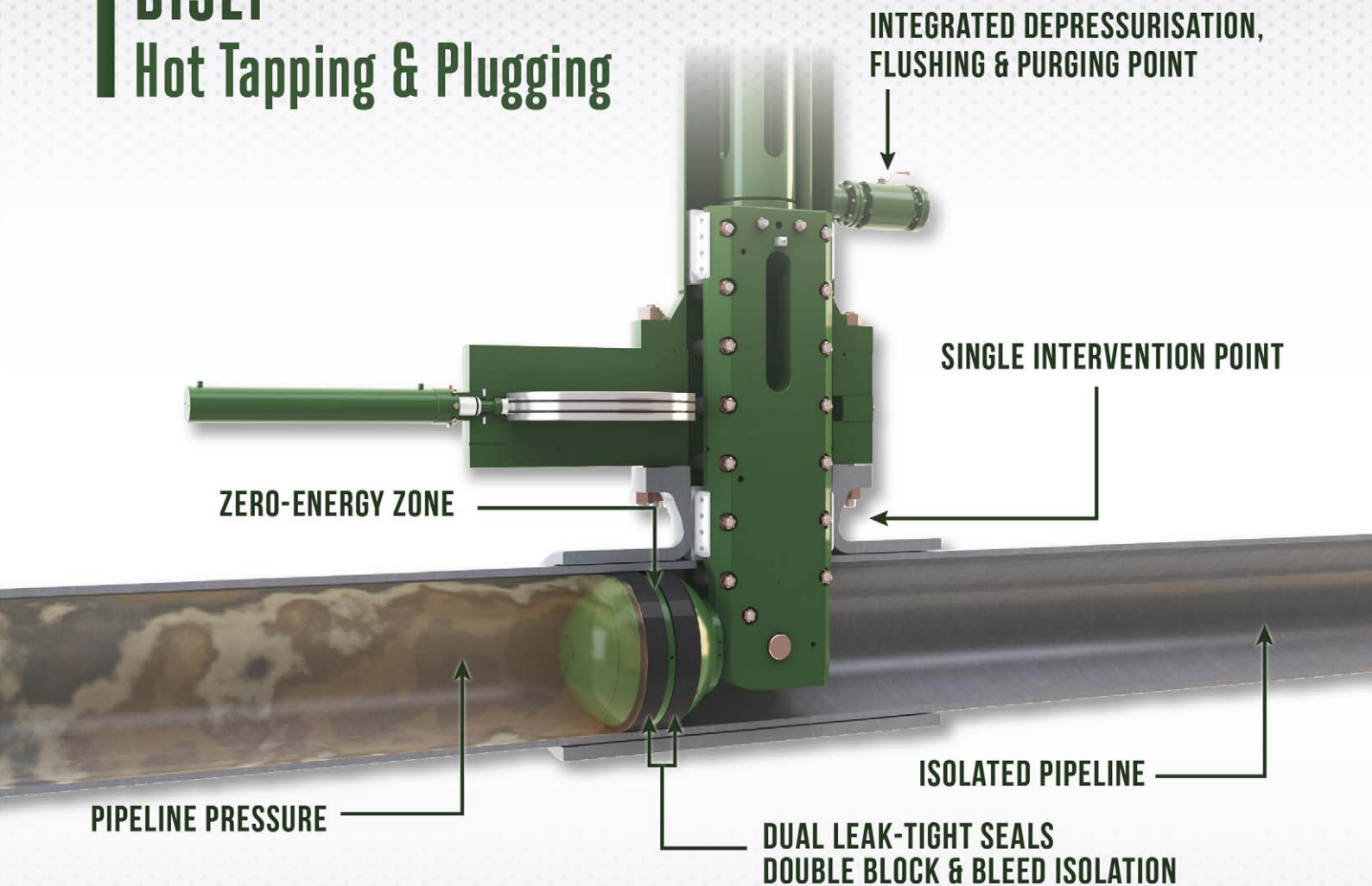
In 2005, LaValley Industries surveyed the pipeline construction landscape and saw an unmet need for a new pipe stringing method that could provide total control, positive grip, improved safety and precision pipe placement during pipe stringing operations. This analysis led to their design of the DECKHAND pipe handling system and the creation of the mechanical grapple method of pipe stringing. In the mechanical grapple method, a single operator utilises the DECKHAND excavator attachment from the comfort and safety of the excavator cab to unload trucks and position pipe along the trench during pipe stringing operations. The DECKHAND is pinned to the excavator and powered by the excavator's auxiliary hydraulic circuit. Its mechanical design allows it to securely hold the pipe joint and its load locking hydraulic valve design ensures that the pipe joint is gripped securely during lifting, regardless of hydraulic pressure. The protective wear pads on its arms protects coated pipe from damage. Further, its slew ring and pinion rotational



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design guarantees that the load is always under control and never free swinging. Additionally, its hydraulic tilt and shift functions allow the operator to navigate uneven terrain with ease and place pipe joints with absolute precision. These features combined with its robust construction allow the operator to lift pipe joints from an off-centre position, lending additional versatility to the pipe stringing process.


Using the mechanical grapple method, pipe is lowered into position solely by the excavator operator without need of additional personnel or taglines – thereby removing workers from danger zones and reducing operational costs. The load is always under total control and never free swinging, which allows contractors to work in inclement weather, including high winds, with ease. As the pipe is mechanically gripped, working in conditions with heavy dirt, mud or snow is simple without requiring workers to prepare the pipe joint surface in preparation of lifting.

Pipe stringing operations

As Weatherford considered the aforementioned pipe stringing methods and equipment, it became very clear that the requirements of Pipeline Contractor jobsites were ideally suited for deploying the DECKHAND. With 360° controlled rotation, tilt and shift functions, the mechanical grapple method would allow Pipeline Contractors to string pipe on the crowded jobsite with precision and safety. “I knew that Pipeline Contractors LLC has a well-earned reputation for successfully completing difficult pipe stringing jobs and I wanted to give them a tool they could use with great confidence in this application. Without a doubt, I had a lot of confidence that the DECKHAND was the best choice to overcome the challenges on the right-of-way.”

Pipeline Contractors took delivery of several DECKHAND units and immediately deployed them on the ROWs and pipe yards to complete the project. Pipeline Contractors’ stringing crews strung in excess of 5000 joints, handling each joint three times as each pipe joint was loaded from rail car to pipe yard, pipe yard to truck and finally stringing along the ROW. “The stringing crews were extremely impressed with the DECKHAND”, stated Weatherford. “The DECKHAND’s total control and positive grip allowed the crews to successfully navigate amongst the drill rigs and improved overall jobsite safety by removing labourers from danger zones. Its tilt and off-centre lift capabilities were especially important as well. 15 000 lifts without incident and a job completed on-time makes for a happy customer.”

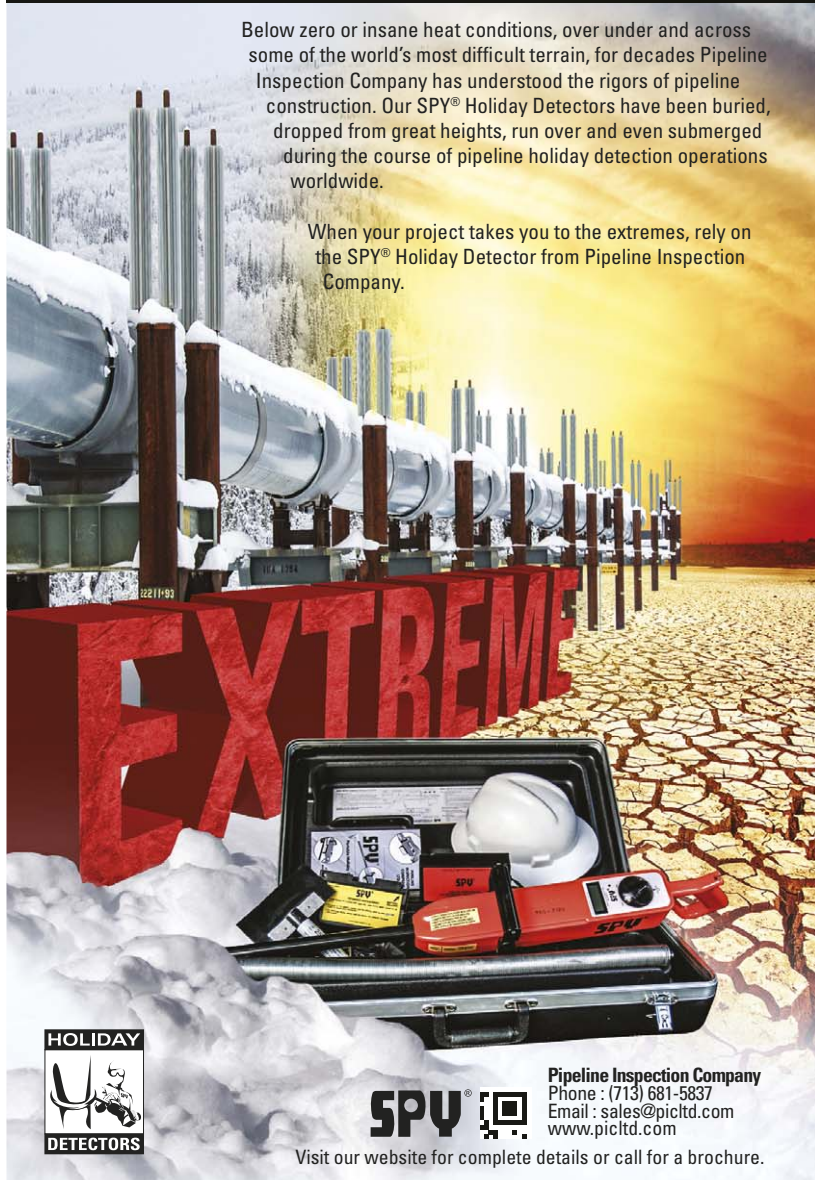
“I created the DECKHAND for projects such as this” states LaValley Industries’ CEO and Founder, Jason LaValley. “Improving jobsite safety while increasing operational effectiveness is what our industry strives for and the DECKHAND was created with those goals in mind. It brings me and my team great satisfaction when we see someone like Pipeline Contractors using our tool to complete even the most difficult jobs.

The combination of LaValley Industries’ innovative equipment and CRC-Evans’ customer centric approach continues to help clients like Pipeline Contractors build better pipelines through intelligent start-to-finish solutions. “Our goal is to help our customers overcome whatever challenges their project presents them, says Weatherford. Staying at the forefront of technology and bringing innovative solutions to problems are the keys to helping customers like Pipeline Contractors accomplish even the most challenging projects.” 

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LEARNING TO ACCEPT YOUR WRINKLES

Christopher Holliday and Alasdair Clyne, ROSEN Group, Canada, outline an integrated approach applied to a pipeline to demonstrate the acceptability of non-compliant wrinkles.

Improvements in inline inspection (ILI) technology have led to an improvement in the probability of detection and ability to characterise geometric features such as wrinkles. Guidance and limits for the assessment of wrinkles were introduced into CSA Z662, 'Oil & Gas Pipeline Systems', in the 2015 version.

The CSA wrinkle acceptance limits are largely based on fatigue assessment criteria; part of the assessment process is

confirmation that associated cracking is absent. In practice, this can restrict the assessment to wrinkles where the absence of cracking has been confirmed by non-destructive examination (NDE).

This article describes an approach that was applied to a Canadian pipeline in order to demonstrate the acceptability of non-compliant wrinkles, i.e. peak-to-trough heights that exceeded the acceptance limits detailed in CSA.

A wrinkle (Figure 1) is defined as a localised deformation of the pipe wall, usually characterised by a dominant outward bulge. They can be purposely introduced to the pipe to shorten the intrados of a pipeline bend but can also be unintentionally formed during field bending, which is a particular challenge for pipe that is thermally insulated, where it is not readily possible to visually inspect the pipe bend for wrinkles.





Figure 1. Exposed wrinkle bend¹.

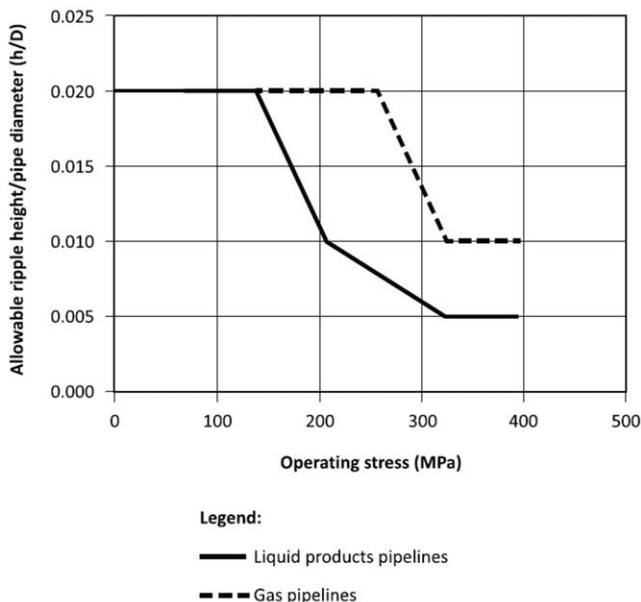


Figure 2. Recommended maximum allowable ripples, wrinkles and buckles for steel pipe.

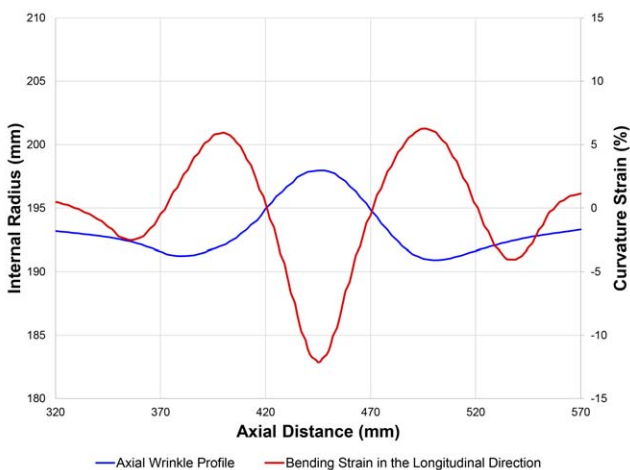


Figure 3. Axial wrinkle profile vs bending strain in the longitudinal direction.

To demonstrate an acceptable fatigue life, CSA Z662-15 Clause 10.10.8.3 stipulates an allowable peak-to-trough height that would be associated with a design fatigue life of 100 years, based on the generally conservative assumption that the pipeline is pressure cycled from the maximum operating pressure (MOP) to 0 psi every other day for liquid product pipelines and cycled once a month for gas pipelines (Figure 2).

If a wrinkle or ripple is not acceptable according to the criteria defined in CSA, then an engineering assessment can be used to demonstrate the acceptability of the anomaly.

The engineering assessment must address CSA Z662-15 Clause 10.10.8.3, which defines two assessment criteria:

- Demonstrate that the wrinkle is free from other interacting anomalies such as corrosion, gouges, cracks, etc.
- Demonstrate an acceptable fatigue life of the wrinkle.

Furthermore, CSA states that wrinkles that are expected to grow in size over time (e.g. due to ground instability), if not removed or repaired, shall be periodically monitored.

A Canadian crude oil pipeline was inspected with an axially orientated MFL and high-resolution caliper dual technology ILI tool. 20 wrinkles were reported that were non-compliant (the peak-to-trough height was too large) according to the acceptance limits (Figure 2) given in CSA for the MOP. Therefore, to establish the acceptability of these wrinkles, an engineering assessment that included a strain check and stress-based fatigue was performed. Strain-based analysis was used to imply the likelihood of cracking, allowing for a fatigue life to be established on the basis of a crack-free wrinkle.

Static strain-based assessment

ASME B31.8 (2016)² offers the option of using strain-based methods to assess the severity of mechanical damage. This method is primarily intended for dents; however, it is reasonable to apply a consistent methodology to wrinkles if the individual effect of the three strain components is considered.

The three strain components considered by ASME B31.8 are two bending strains (longitudinal and circumferential) and one membrane strain (axial extensional strain).

Extensional strain is the component of elongation experienced by a material that is pinned at both ends when plastically deformed by bending. This definition is appropriate for dents, but it is not wholly valid for wrinkles. In the case of wrinkles, the extensional strain component is considered to be negligible, relative to strain due to bending.

There are no standard industry-wide critical strain limits for wrinkles. However, the strain acceptance criteria in ASME B31.8-2016 and referenced in CSA Z662-15 are based partly upon the strain at which cracking initiates in buckles and includes an element of safety; therefore, these limits are reasonable for the strain-based assessment of wrinkles, i.e. 6% strain limit for wrinkles in the pipe body and 4% for wrinkles associated with welds. If wrinkles can be shown to



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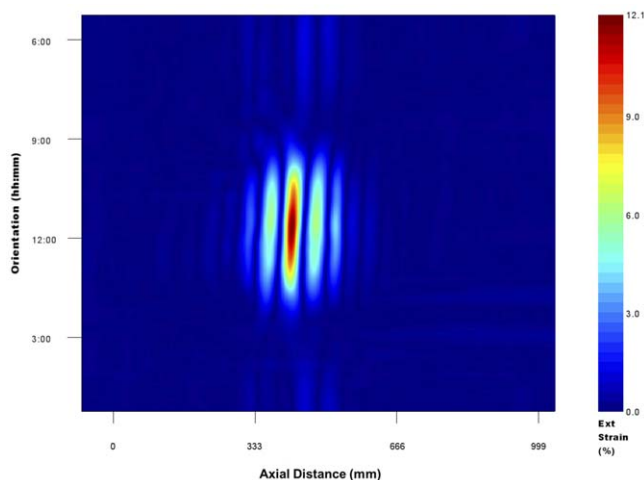


Figure 4. Orientation vs log distance and total effective strain on the outside of the pipe.



Figure 5. Example of excavated wrinkle.

be associated with curvature strains less than a critical limit, then it can be implicitly concluded that they are at a low likelihood of associated cracking.

Of the 20 wrinkles identified for further assessment, 13 within seven field bends had calculated curvature strains greater than the 6% critical limit (maximum of 12.1%, shown in Figures 3 and 4); they were therefore considered to have an increased risk of associated cracking.

The operator made the decision to investigate a bend containing seven wrinkles, including the wrinkle with the maximum strain of 12.1%. The objective of the excavation was to confirm the absence of cracking, maximum wrinkle height (peak-to-trough) and length (trough-to-trough), and to measure the shape (in particular the minimum radius of curvature), enabling a comparison with the ILI data and, therefore, the drawing of conclusions regarding the accuracy of the ILI.

No wrinkles were apparent initially, however, upon removal of the insulation, the wrinkles were clearly visible (Figure 5).

The wrinkle profiles were recorded using a portable 3D imaging system, and the strain associated with each wrinkle

was calculated based on the radii of curvature measured by the 3D imaging. The wrinkles were also inspected using 0° and 45° UT probes and magnetic particle inspection (MPI); no wall thinning, metal loss or crack-like indications were identified.

Unity plots comparing wrinkle height (peak-to-trough) and strain were produced to visualise the differences between the in-field and ILI measurements (Figures 6 and 7).

The comparisons between the ILI and in-field measurements displayed good correlations for both dimensions and strain, demonstrating the accuracy of measurement that can be achieved by using the appropriate ILI tools combined with the necessary data evaluation. The wrinkle data evaluation exploited an optimisation process based on known limitations of caliper measurements.³ The absence of cracking associated with all seven wrinkles, including the wrinkle with a calculated curvature strain of 12.1%, suggests that a critical strain limit of 6% for this particular vintage of pipe contains an element of conservatism.

Of the 13 wrinkles not yet excavated, five had estimated strains >6%. Three of these (maximum strain of 8.0%) were located in the same vintage of pipe as the excavated bend, where the maximum strain of 12.1% was observed to be free of cracking. Therefore, the likelihood of cracking associated with these three wrinkles was considered low.

Two wrinkles were located in another bend with calculated strains of 10.6% and 6.5% – they were present in a different pipe vintage. For that reason, a low likelihood of cracking could not be implicitly demonstrated based on the findings of the excavated bend, which led to the NDE being recommended to confirm the absence of cracking.

Therefore, with the exception of the two wrinkles where the absence of cracking could not be implicitly concluded, the findings of the strain-based assessment allowed for a fatigue life to be established on the basis of a crack-free wrinkle.

Stress-based fatigue assessment

If a wrinkle can be demonstrated to be free from interaction with other defects such as cracking, then CSA Z662-15 stipulates reviewing the wrinkle peak-to-trough against the wrinkle acceptance criteria derived from research undertaken by Kiefner & Associates.⁴ As all 20 wrinkles exceeded the CSA peak-to-trough height criteria, a more detailed fatigue assessment was conducted in accordance with the work performed by Kiefner & Associates, utilising cyclic pressure and temperature data representative of historical and anticipated future pipeline operation.

A stress concentration factor (SCF) associated with wrinkles can be determined by finite element analysis (FEA) based on the wrinkle geometry. An example of an FEA model is shown in Figure 8. Detailed FEA can also include corroded areas within the model.

It is possible to estimate the design fatigue life due to cyclic internal pressure by using the calculated SCF, an appropriate S-N curve, and historical and future pressure and temperature operating regime information.

The maximum cyclic stresses in the wrinkles were estimated based on the calculated SCFs and the cyclic

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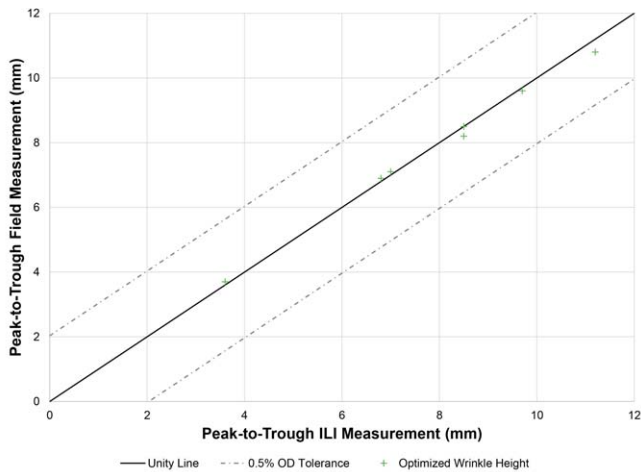


Figure 6. Unity plot showing ILI wrinkle height vs in-field wrinkle height.

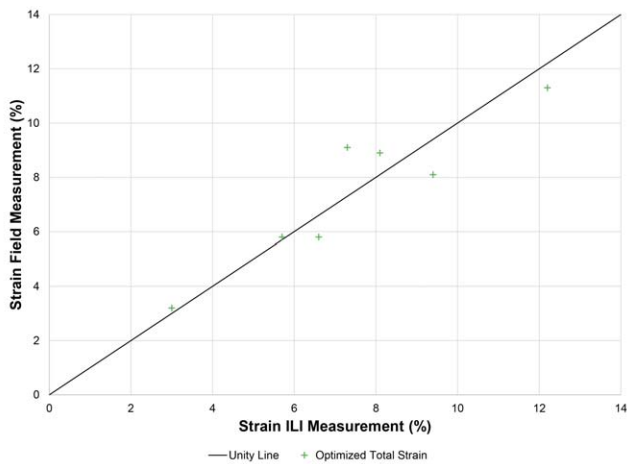


Figure 7. Unity plot showing ILI calculated total effective strain vs in-field calculated strain.

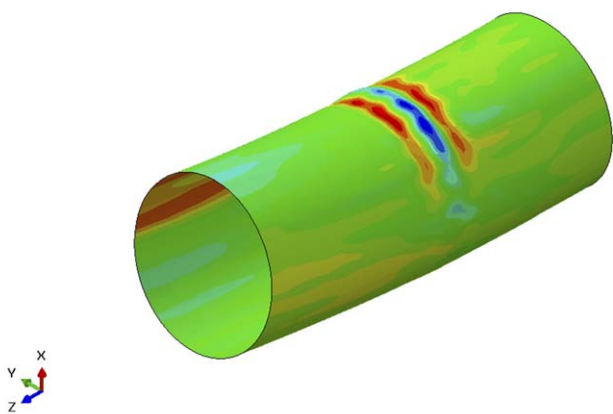


Figure 8. Finite element model of wrinkle on intrados of field bend.

pressure and temperature data. The wrinkle fatigue lives were subsequently estimated using a conservative stress-based S-N curve provided in BS 7608-2014.⁵

The fatigue assessment resulted in estimated fatigue lives (due to internal pressure and temperature cycling) in


excess of 100 years for all 20 wrinkles. Therefore, having shown cracking to be unlikely by strain assessment, and evaluation of MFL data for the wrinkled areas showing no evidence of metal loss, and hence no corrosion, the fatigue lives of all the wrinkles were demonstrated to be acceptable.

CSA Z662-15 Clause 10.10.8.2 states that wrinkles that are expected to grow in size over time, if not removed or repaired, shall be periodically monitored. In practice, bends containing wrinkles can be monitored by routinely comparing repeat geometry inspections to monitor for changes in wrinkle dimensions. Geospatial data recorded by an inertial mapping unit (IMU) gives the curvature of the wrinkled section. An increase in curvature would likely be accompanied by an increase in wrinkle severity and a need for re-assessment. The pipe curvature data from the IMU can also be used to calculate bending strain. The bending strain assessment can be supported by a pipe movement assessment that compares bending strain estimated from repeat inspections. An increase (or reduction) in bending strain is generally associated with movement of the pipe. An area of pipe movement raises a number of integrity concerns: is the area stable? Is further movement a possibility? Have wrinkles or a buckle been introduced or made worse? What level of bending can the pipeline tolerate? How imminent is loss of containment, or loss of serviceability?

The findings of the bending strain and pipeline movement assessment can be reviewed alongside detailed geohazard surveys or slope analyses to make an engineering judgement on the likelihood of future ground movement.

Conclusions

In conclusion, the approach adopted as part of the case study described in this article applies the codified strain assessment of dents to wrinkles. Furthermore, it facilitates the refinement of existing conservative height-based methods with more accurate stress analysis-based methods of assessing wrinkles to determine their significance for the integrity of the pipeline and the need to remediate.

The fatigue assessment presented as part of this paper primarily considers cyclic loading based on pressure history data. However, some studies suggest that another failure mode of wrinkles is high-strain low-cycle fatigue, a mechanism which is particularly challenging to predict but was outside of the scope of this case study. 

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A lifetime of attention

Vivian Kwok, Tulsa Inspection Resources, LLC, USA, details the spectrum of services required during a pipeline's lifetime.

Tulsa Inspection Resources, LLC (TIR) is an affiliate of Cypress Energy Partners, L.P. (Cypress), providing services in one of Cypress's three business lines. TIR offers a full spectrum of pipeline services – ranging from pipeline related surveys, inspection, integrity support services, pipeline and facility mechanical non-destructive examination (NDE) and non-destructive testing (NDT). From surveys to NDE, TIR's mission is to provide quality services in a safe, ethical and cost-effective manner. TIR provides an array of expert pipeline services to the oil, gas and public utility industries for all stages of pipeline and plant construction and asset management.

Environmental, health and safety

Cypress is fully committed to – and ensures that its employees and services maintain – the highest level of environmental, health and safety (EHS) excellence.

Beyond providing quality services, environmental stewardship is a fundamental value for Cypress and its affiliates. The company has implemented an EHS management system (EHSMS) based in part on the requirements and guidelines of OSHA, the EPA and various state agencies. The EHSMS is supported by the company's senior leadership and was designed to provide its employees with guidance on accident prevention and alleviating pollution causes; maintaining compliance with all relevant local, state, and federal rules and regulations; and applying relevant industry best practices.

Just as Cypress provides its services in a manner that protects the environment and the safety of its employees and customers, it is a moral and professional priority. TIR is driven by providing services safely and performing tasks the right way, for the right reason, the first time.

The company views its employees as an extension of the safety management team. The EHS department understands safety as ‘a judgement of the acceptability of risk associated with a work process in a given situation.’ That is, TIR believes it is everyone’s duty to identify, communicate, and minimise the overall risk in all activities. All employees are empowered to stop any work they believe is being performed with compromised safety, which establishes both employee wellbeing and field-wide responsibility for the safety of the company’s operations.

Each employee must be operator qualified (OQ), certified by TIR’s subject matter experts (SME) through a combination of classroom and computer-based training (CBT) evaluations. These evaluations include written and hands-on scenarios to validate the employees’ technical knowledge and skills. Moreover, TIR is a strong advocate of API 1169 Training and Certification. One of the company’s goals for 2019 is



Figure 1. Pipeline split tee repair option. TIR supports with AWS certified Weld Inspector, NACE coating inspection and utility inspectors. API 1169 certified options available.



Figure 2. Mechanical integrity field data collection being gathered for TIR’s data management team to analyse and process.

to have 100% of all applicable inspectors, based on client requirements, with API 1169 certification. TIR also has the facilities, training aids, and the availability of qualified instructors to provide additional training that may be needed by its clients. Trusted third party entities, such as JJ-Keller and the National Safety Council, may also provide training for TIR’s employees.

TIR uses an in-house database and learning management system (LMS) to record training. In addition, the company utilises ISNetwork’s training database for easy client access and confirmation of each employee’s records, including OQ records. TIR is a premier member of ISNetwork, PEC, Avetta, Browz, and CCS risk assessment agencies.

TIR’s EHS metrics demonstrate the company’s concern for making health and safety an utmost priority; TIR continually exceeds industry standards. Cypress’ US and Canadian EHS policies hold a 100% compliance rating in ISNetwork for both review and verification services (RAVs) and RAVs+. In 2016, ISNetwork recognised TIR as an ‘ISN Featured Contractor’ because of the company’s performance and efforts to ensure compliance.

Cypress seeks to enrich the trust and respect of its clients to form long-term relationships. Company personnel are highly qualified professionals who are conscientious about their responsibility to represent TIR and the best interests of its clients.

Capabilities and services

TIR’s duty and diligence extends to exceeding the expectations of its clients and satisfying their needs. TIR provides a full spectrum of pipeline services – from birth to recommission or decommission – and delivers them in a cost-effective, tailored and meticulous manner. TIR is more than an inspection company, it is a support provider for its clients for the lifetime of their assets.

Serving the North America pipeline industry

TIR’s Pipeline New Construction Survey Group serves the North American pipeline industry by providing the highest quality survey through teamwork, experience and professionalism. The services include:

- Pipeline routing and design:
 - Preliminary survey, centreline and ROW layout.
 - Alignment sheet generation.
 - Aerial surveys.
 - Permit drawings.
- Construction staking and as-builts:
 - Stakeout centreline and workspace.
 - Complete as-built of pipeline and related facilities.
- Post construction:
 - Above ground markers (AGMs) and anomaly staking.
 - Hydrotest elevation data.

➤ Additional services:

- River crossings.
- Depth of cover (DOC) surveys.
- Pipeline relocations.

TIR is capable of staffing large survey projects with its bank of field technicians. Management reviews each job and matches the best surveyor(s) for the job.

Each technician is trained and proficient with the highest quality of Trimble survey gear. TIR field technicians have years of experience gathering data, laying out pipeline centrelines and performing topographic surveys. All data is run through a vigorous QA/QC process to ensure the accuracy and completeness of the data. TIR field crews also utilise a job hazard analysis (JHA) each day to identify any risks or hazards specific to their job.

Communication plays a key role in TIR's success. Each field member is required to submit a nightly job progress report to all managers associated with the work. These reports include progress notes and identifies any issues they may have encountered.

Inspection

In addition to its surveyors, TIR partners with highly experienced third-party inspectors. The company's extensive database with more than 16 000 resumes, enables TIR to track and identify the best available candidates for its clients, and all inspectors and related staff are subject to TIR's rigid training standards.

TIR dedicates an Account Manager for its clients who serves as a central contact point for both the customers and inspection staff. The Account Manager is supported by specifically assigned account co-ordinators in addition to contracting, compliance, payroll, invoicing, and training staff who travel to a site for individual or group training.

Some of TIR's inspector classifications and qualifications include but are not limited to:

- Material Inspector.
- Construction Manager.
- Project Managers.
- Chief Inspector.
- Utility Inspector.
- Certified Welding Inspector (CWI).
- Depth of cover (DOC) surveys.
- Environmental Inspector.
- Coating (NACE certified).
- Electrical Inspectors.

All individuals of TIR's inspection teams are essential in ensuring that the pipeline is constructed to the client's specifications, while adhering to local, state and federal laws.

Partnership

TIR partners with CF Inspection Management, LLC (CF), a woman-owned business enterprise (WBE), to support the company's supplier diversity

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programme. CF provides a full array of pipeline inspection and integrity management programmes and services to the oil and gas industry. CF's values, service offerings and capabilities reflect those of TIR.

CF's personnel are capable of delivering full project management for pipeline in-line inspection (ILI) projects. CF's programmes encompass all levels of programme planning,

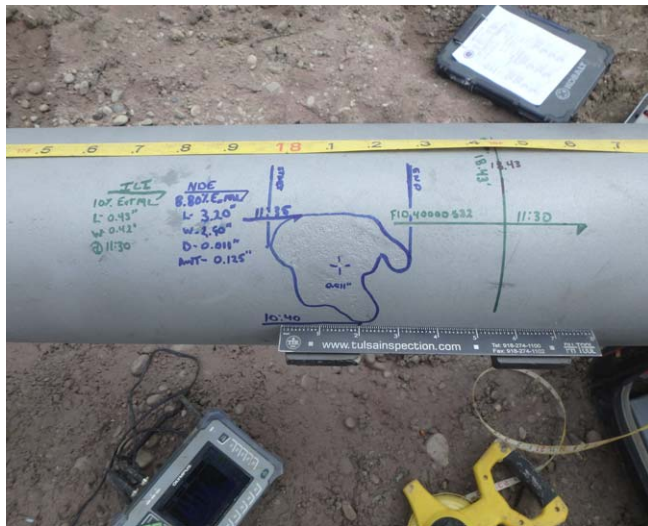


Figure 3. Example of photographic documentation of ILI vs NDE correlation information.

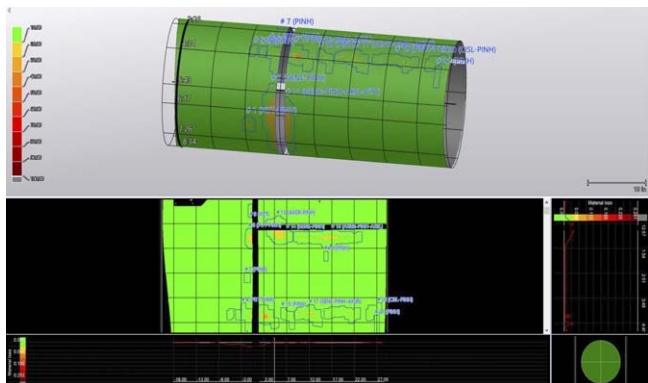


Figure 4. TIR-NDE utilises a combination of the Creaform™ HandyScan 700 and PipeCheck software for the evaluation of corrosion and mechanical damage for pipeline integrity assessment. These combined tools allow TIR-NDE technicians to produce accurate and repeatable fitness for service calculation/data to its clients.



Figure 5. Regional bottlenecks and construction demands have pushed seasonal limits.

including services that TIR offers. Some additional pipeline maintenance activities that CF specialises in include, among others, the design of pipeline batching projects for ILI and Department of Transportation ILI assessment and remediation documentation.

CF's maintenance inspection professionals are the foundation of its programme offerings. CF's experienced, qualified (CWI, API 653, API 510, API 570, NACE, etc.) personnel are capable of serving all aspects of construction inspection. The company's database has approximately 6000 professionals. CF also thoroughly screens each individual, and the company employs particular individuals according to its clients' preferences. Their resumes are also available for client review. CF's inspectors also work closely with the CF Integrity personnel, who specialise in make-ready maintenance activities in preparation for ILI.

Together with TIR, CF seeks to serve its clients for the full span of their pipeline as a WBE in the oil and gas industry.

Integrity services

TIR's Integrity Services Group partners with asset owners to ensure the successful completion and continual maintenance of their pipeline and facilities. TIR is a leading full-service provider within the pipeline integrity field, skilfully serving its clients' projects throughout their lifetime – beyond completion of construction.

Hydrotesting services

Hydrotesting is one integrity service that the company employs. This strength test helps ensure the initial integrity of the asset, is a key data point in substantiating the maximum allowable operating pressure (MAOP), and can be used as an integrity test as the asset ages, to meet PHMSA requirements.

Brown Integrity, LLC, another affiliate of Cypress, is a trusted leader in the pipeline industry with more than 40 years of hydrostatic testing experience. Its crews have worked in nearly every oil and gas producing and transmission region in the US and have successfully completed projects in all types of terrain and environments.

Brown Integrity utilise a range of fill and pressure equipment to accommodate any size project, including some of the largest fill pumps in the industry. These units are 1500 hp, three stage centrifugal pumps, three stage fill pumps, high volume test pumps for mainline, and other

smaller fill and pressure pumps. Brown Integrity also owns specially designed test trailers with state-of-the-art testing equipment. The company's test trailers are equipped with lights and HVAC for all-season operations.

Brown Integrity has worked with many recognised contractors

and energy providers. The company partners with construction, exploration, pipeline, refining, and processing companies to help ensure safe and high integrity operations of pipelines and facilities.

Pipeline integrity support services

TIR provides other pipeline integrity services. These services range from project management to AGM site survey to make-ready maintenance, and all the way through to anomaly remediation and PHMSA reporting.

TIR's provision of integrity services first requires its Integrity Project Management personnel who are capable of full project control. TIR project managers work in conjunction with pipeline operators and other contractors and vendors to deliver high quality inspection programmes that encompass all levels of programme planning.

TIR also provides data management, which is a key differentiator between TIR and its competitors. The company's data managing services include providing its clients with detailed project reports, cost tracking, pipeline data analysis and data storage.

TIR's Pipeline Integrity Group can further capitalise on a large pool of proficient field personnel and decades of pipeline integrity experience to provide quality services. The company's integrity support service offerings include but are not limited to:

- Above ground marker (AGM) – GPS survey.
- Pig tracking: cleaning, gauging, and other types of pigging projects.
- Turnkey ILI inspection support: tool transport, lifting and loading of ILI tools, pig cleaning and decontamination.
- Anomaly dig staking and as-builts.
- Depth of cover (DOC) and GPS centreline surveys.
- Complete project management.
- Pipeline marker placement and installation.
- Hydrotesting for non-piggable pipelines.

From management to field personnel, TIR confidently serves its clients and their assets with expertise, depth and precision.

Non-destructive examination (NDE)

TIR's NDE mission is to provide its clients with the most accurate data acquisition methods available in NDE through a combination of innovation, reliability and experience. Innovation through applications to resolve traditional NDE limitations. Reliability by doing the job right the first time. Experience from years in the field of NDE and inspection performed on thousands of anomaly investigations. TIR's organisation utilises the latest in NDE methods to verify the existence of potential threats to a pipeline operators' assets through ILI validation and Direct Assessment methods. The company employed a three-step process – scan, analyse, and report – to increase the accuracy and reliability of the data. All data is thoroughly processed by QA/QC analysts who have physically performed NDE on pipelines and possess a minimum of 5 years' experience. Technology that TRI's technicians utilise include:

- Flaw analysis and sizing technique (FAST).
- Phased array (PAUT).
- Time of flight diffraction (TOFD).

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TIR's innovative NDE tool belt and inspectors allow the company to accomplish jobs with a high level of accuracy and reliability while maintaining its clients' assets, even after decades of operation.

Beyond the pipeline: mechanical integrity

A pipeline's storage and processing facility do not escape TIR's concern. Established in 2017 and staffed with seasoned industry personnel, TIR's Mechanical Integrity Group (MI) provides a broad range of services focused on stationary equipment in all segments of the oil and gas industry. TIR is prepared to support its customers' existing programme or develop a customised programme plan to meet their needs.

TIR MI professionals oversee mechanical integrity or API inspection projects and work in conjunction with client personnel and other service providers to deliver a variety of high quality, cost-effective inspection services. TIR inspectors are API and/or AWS certified with experience in all areas of the energy industry. Likewise, TIR's field NDE technicians are certified per ASNT for various disciplines. Once the field data or existing historical data is gathered, TIR's data management team analyses and processes the information within the Inspection Data Management System (IDMS) the client prefers. Lastly, TIR can provide vessel engineering evaluation and analysis support on an as-needed basis. TIR MI offerings include:

- API 510, 570, and 653.
- CWI inspection.
- Inspection planning.
- Turnaround inspection.
- On-stream inspection.
- Vendor surveillance.
- Field QA/QC.
- P&ID walk down.
- Sketching/drawing.
- Gap analysis.
- QA/QC data review.

TIR MI celebrated its first anniversary in July 2018. Within a year, the company has exceeded its business expectations by more than double.

The success of TIR's MI department relies on the relationships among its business development team and with its customers. TIR MI is about providing support and expertise with a servant attitude to its customers.

Most of TIR's clients had been interested in establishing baseline inspections for their pressure vessels, process piping and storage tanks. Demand from TIR's customers inspired the VP of Integrity Services, Richard Grogan, to develop TIR's mechanical integrity line of business in 2017.

Grogan assembled MI experts he knew would build TIR's reliability and ensure that the company serves its clients with the highest standard. Grogan recognised that Dawna Fretwell, Operations/Business Development Manager, would be a key player. She stepped on as the first and only employee for TIR MI.

Fretwell first sought partnerships with non-TIR customers to expand TIR's network and relationships. The customer relationships she drew in from previous employment experiences strengthened TIR's reputation as a full provider of mechanical integrity services.

However, TIR MI's rapid expansion and TIR's customers' high demand was too great for a single-person department. Fretwell recruited old colleagues with whom she has worked well to join the TIR MI team.


Moreover, just as field inspections progressed, the data gathered from them also called for management. TIR's data analysis services became a significant portion of developing the company's robust MI programme. Today, TIR MI employs more than 30 data analysts (DA), and the company anticipate having 50 total DAs on its team by the end of the year.

TIR MI continued to grow when the company recruited Bob Brewer, MI Technical Services Specialist/Business Development Manager. Brewer further expanded the TIR's network. His high level of expertise and deep concern for the client's needs ensure their positive customer experience.

"It's about listening. What can we help you with?" Brewer said. TIR MI strives for effective and valuable results without frivolous spending. TIR has a responsibility to be good stewards of its clients' investments. The MI team also actively seeks new tools to add to its service offerings and avenues to bring support for its customers.

TIR MI is about being a servant to its customers. It's the company's desire to partner with its clients as they move forward, investing in the reliability and efficiency of their assets. TIR's business development aims to sustain its growth while preserving current customer relationships, all the while reaching out to help new customers as well.

"We're not just a contractor. We're partnering with somebody. I'm looking for that relationship," Fretwell said.

TIR celebrates its 15th anniversary this year, and the company strives to continually express its company values in 2018 and beyond. Safety, integrity, quality, compliance, customer service, and long-term relationships are fundamental core values of Cypress and its affiliates. TIR takes pride in emphasising the environment, health and safety with its EHSMS and training services, while also providing unparalleled services and experience to serve its clients and their assets. 



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WELCOME TO CYBERIA

Gordon Cope investigates how enemies of western civilisation are actively seeking ways to disrupt and impair vital infrastructure through cyber warfare.

In 2016, the US Department of Homeland Security's Industrial Control Systems Computer Emergency Response Team (ICS-CERT) responded to 256 specific cyber incidents related to critical infrastructure. 59%, or 151 of these incidents, took place in the energy sector.

And it has since gotten worse. "Computer-based attacks are one of the fastest-growing threats to American businesses and infrastructure," noted Kyle Isakower, Vice President of the American Petroleum Institute (API).

Recent cyberattacks

In a major public release in March 2018, the Department of Homeland Security (DHS) and the FBI specifically accused Russian hackers of conducting co-ordinated cyberattacks against critical infrastructure, including the energy, nuclear, aviation and water sectors.

The cyberattacks, which were attributed to the 'Dragonfly' and 'Energetic Bear' cyber espionage groups associated with the Russian government, involved a series of tools, including malware, spearfishing and watering-hole domains (see definitions). The goal was to compromise third party service companies so that the hackers could move laterally into Industrial Control Systems (ICSs), in order to collect information about the operation of critical infrastructure.

“The initial victims are peripheral organisations such as trusted third party suppliers with less secure networks, referred to as ‘staging targets,’” the alert says. “The threat actors used the staging targets’ networks as pivot points and malware repositories when targeting their final intended victims.”

Within that same month, the pipeline sector was given a rude wake up call. In March and April 2018, four US pipeline companies suffered shutdowns to their systems for communicating with their customers. Oneok Inc., which operates gas pipeline networks in the Rocky Mountains and Texas, disabled its system after determining that a third party service provider was the “target of an apparent cyberattack.”

Oneok’s announcement came after Energy Transfer Partners, Boardwalk Pipeline Partners and Chesapeake Utilities reported similar shutdowns. The third party provider was identified as Latitude Technologies, a unit of Energy Services Group. The compromised service is a computer-to-computer electronic data interchange (EDI) system that allows customers to communicate their natural gas needs to operators. The shutdowns did not

impede the flow of gas, but forced the companies to temporarily use workarounds to conduct business.

Vulnerabilities

Corporate functions for utilities and pipeline networks can be divided into two general areas: business and operations. The business side – client billing, commodity trading, financial planning – involves interaction with a large number of counter parties and services. As such, a company is exposed to a variety of potential breach points, such as the above incident where a third party service provider was the initial source of infection.

The other side, operations, is where the nuts and bolts of a company – the compressors, valves, commodity processing and shipping – reside. Typically, this infrastructure is operated by ICSs, which are traditionally separated from business functions by physical isolation and computer firewalls, making them relatively impervious to cyberattack.

Since the early 2000s, however, ICSs (which are also often referred to as operational technology, or OT), have gradually evolved toward supervisory control and data acquisition (SCADA). The latter allows greater operational efficiency by allowing staff to remotely control infrastructure, but it also requires the use of the internet to connect smart valves and monitors to HQ, which potentially exposes once-internal systems to outside penetration.

How hackers cause problems

Cyberattackers come in all shapes, sizes and motivations. The classic ‘hacker’, a savvy techie acting alone to create mischief for the sheer challenge, is still a major headache for companies. Using readily-available software, they can create ‘denial-of-service’ events, in which a company server is flooded with requests to the point of overload.


Hackers searching for illicit profits can also interfere with companies. A common tactic is to infiltrate ‘ransomware’, which is malware that encrypts data and documents on a PC. The hacker then extorts money from the victim in exchange for a decryption key. Ransomware attacks gained recent notoriety when it caused massive disruptions to the civic computer system of Atlanta, Georgia.

PC users can protect themselves against ransomware by subscribing to a reputable software security service, like Symantec, and running regular virus updates. In addition, frequent backups to a cloud-based folder like Google Drive or Dropbox allows victims to overwrite encrypted files if an infection occurs.

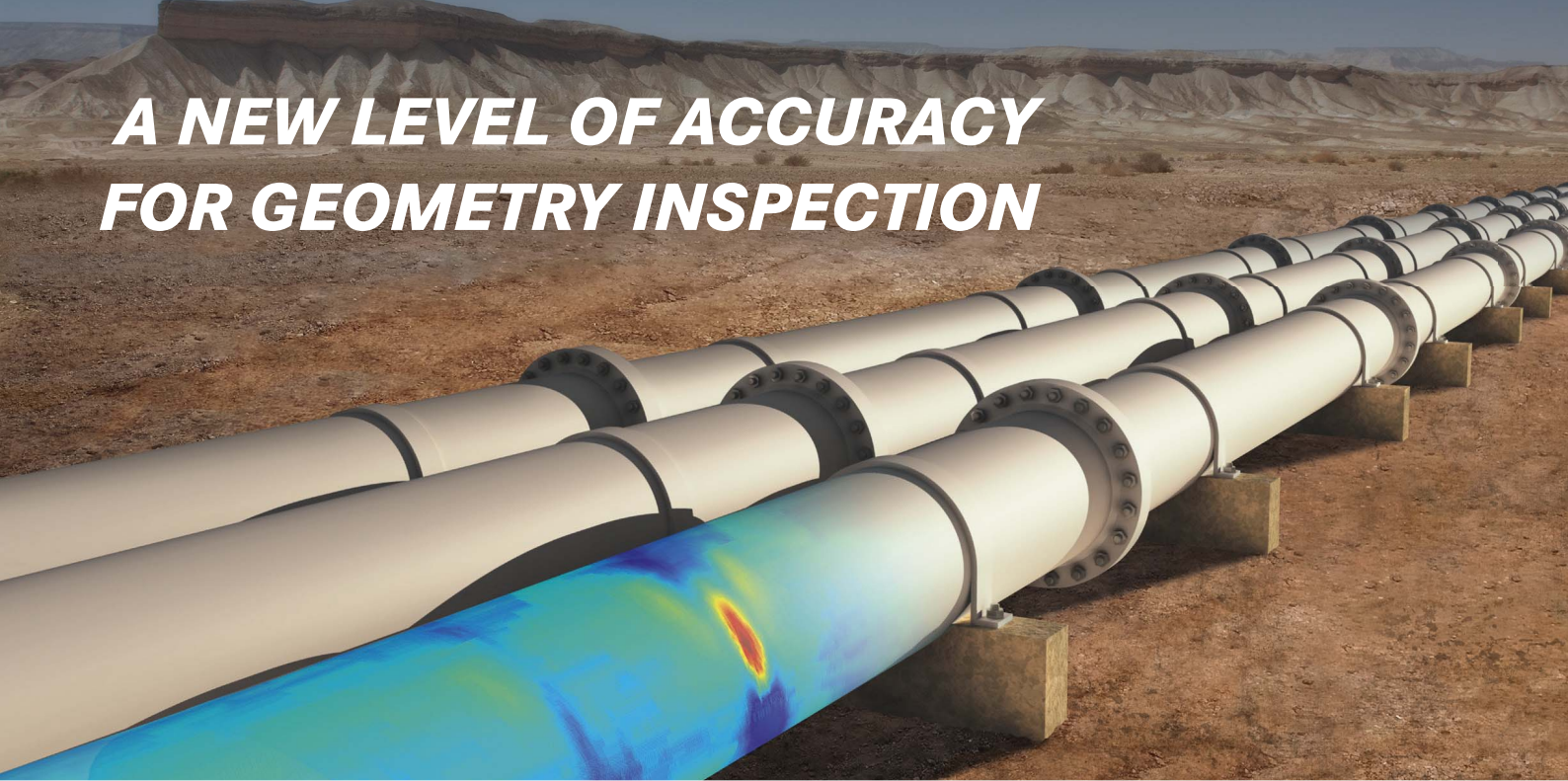
Criminal hacker gangs can also attempt to penetrate a company’s business unit seeking insider information. Seven Generations Energy, an oil and gas company based in Calgary, noticed suspicious activity attacking its firewall. Prior to quarterly and annual earnings statements, their system would get millions of scanning attempts from China, Eastern Europe and Vietnam. They suspected that someone was trying to infiltrate their system with the intent of leveraging confidential financial results. In order to protect their system, they hired a cyber security consultant and conducted comprehensive penetration testing to identify potential weak spots, then spent over a year plugging them up.

While the number of hacking events is growing in public awareness, they still do not present the major threat to the oil and gas sector. John Harbaugh is COO of root9B, LLC (R9B), a

Definitions

- ▶ ‘Threat actors’ is a term used by the DHS and other government agencies to categorise enemy agents actively seeking to infiltrate and/or disrupt valuable infrastructure assets through cyberattacks.
- ▶ ‘Malware’ is malicious software that is intended to damage or disable computers and computer systems.
- ▶ ‘Phishing’ is a blanket bogus email soliciting victims’ sensitive information, like credit card details.
- ▶ ‘Spear phishing’ is directed at a specific target, such as a company’s financial dealings or intellectual property.
- ▶ ‘Whaling’ targets CEOs or CFOs, often using fake emails crafted to resemble legal documents such as subpoenas, customer complaints and executive issues.
- ▶ ‘Watering-hole domain’ is a computer attack strategy aimed at victims who belong to a profession or organisation associated with the target. For instance, the threat actors observe that pipeline engineers commonly frequent a certain industry website. The threat actor sets up an identical site (with a slightly different domain name), in which they have installed malware. Eventually, members of the targeted group inadvertently visit the site and become infected.
- ▶ ‘Ransomware’ is malware that encrypts data and documents on a PC, then extorts money from the victim in exchange for a decryption key. 

A NEW LEVEL OF ACCURACY FOR GEOMETRY INSPECTION

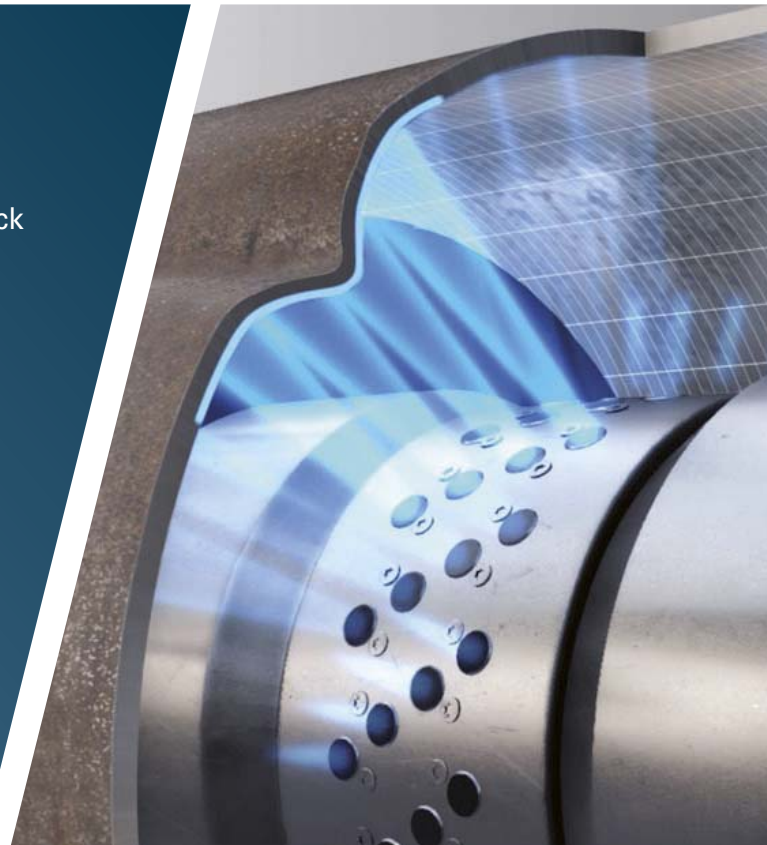


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Six easy steps to better cyber security

Facilities that employ Industrial Control Systems – such as refineries, petrochemical plants and pipelines – can increase their cyber security with a number of inexpensive steps:

- Change passwords frequently.
- Do not use the same password for different applications.
- Make passwords more complex.
- Change hardware and vendor systems default passwords.
- Separate critical operation controls from non-critical functions.
- Employ dual factor authentication systems, where every log-on requires a subsequent password generated by a third party authenticator. 

cyber security consultancy based in Colorado Springs, Colorado. Over the last 25 years, he has led cyber operations capability for the US Air Force, operated cyber defence for the Department of Defense, and been a senior participant in cyber operations and threat intelligence organisations at the Nation Security Agency. “Hackers are not getting more sophisticated, they’re not upping their game,” he notes. “There is more awareness, so it appears to be more common, but it’s been around for a while.”

Nation states that practice cyber warfare, however, are a different matter entirely. “For a country with limited resources, it is difficult to project military power globally,” says Harbaugh. “Cyberattacks are relatively inexpensive and can have global reach through the internet. A nation state may not have the capabilities to counter embargoes and sanctions, but it can hurt an enemy through cyber warfare.”

For the last several years, oil and gas facilities in Saudi Arabia have been under persistent cyberattack by a foe with nation state capabilities. In 2012, Saudi Aramco offices were infected with the ‘Shamoon’ virus, wiping out data on tens of thousands of computers. A similar virus resurfaced in Saudi government offices and a private Saudi petrochemical company in 2016 and 2017.

The attacks have since escalated into much more dangerous territory. In August 2017, a privately-run Saudi petrochemical company had its OT compromised by a virus that was designed to trigger an explosion. The virus had been specially designed to be remotely installed and sit undetected in the Schneider Triconex control system, which is employed in over 18 000 nuclear, water treatment and chemical plants, and oil and gas facilities worldwide. Fortunately, a coding bug in the virus inadvertently shut down the plant’s production systems prior to its activation, leading to its discovery.

While experts around the world have been investigating the attacks in Saudi Arabia, they have found it difficult to pin the blame on any one state. US government officials and cyber security experts have long suspected Iran as being the perpetrator

of the cyberattacks, however. The Middle East country has a long-standing policy of aggression and animosity toward Saudi Arabia (the two countries are currently conducting a proxy war in Yemen). Cyber analysts speculate that Iran’s motivation for the attacks is to financially and socially destabilise Saudi Arabia, which is currently undergoing massive political, social and economic modernisations under King Salman.

What can be done?

Many ICS systems were never devised to prevent the type of cyberattacks occurring today. New systems, however, can be strengthened prior to deployment. Wurdtech, a subsidiary of GE, devised a certification programme called Achilles Certification that allows oil and gas companies to ensure that new-purchased equipment meets baseline levels of cyber security. Best practices have also been codified into ISO standards, creating security requirement guidelines for industrial automation and control system providers. The result has been OT systems that are far more robust and resistant against cyberattacks.

Thousands of legacy systems remain in operation, however. In order to protect them, companies like Wurdtech provide Industrial next generation firewalls (NGFWs). These are hardware devices loaded with cyber security software that sit at the perimeter of a control system and/or in front of a critical asset (e.g. vibration monitor, distributed control system, safety programmable logic controller, etc.), to identify attacks and mitigate risks. It protects industrial and SCADA networks with OT-specific security and threat intelligence, simplifies centralised management, and offers a full security view of the industrial network.

In addition to new hardware and software applications, the oil and gas sector is taking steps to co-ordinate industry responses. In mid 2014, with the help of the API, the sector launched the Oil and Natural Gas Information Sharing and Analysis Center (ONG-ISAC) to protect critical energy information from cyberattacks. Based in Washington, D.C., the volunteer-led organisation facilitates the exchange of information, evaluates risks and provides up-to-date security guidance to oil companies.

Challenges

Regardless of the hardware and software defences put in place, a determined cyberattacker is bound to eventually succeed. “The buyer community is interested in an automated solution, but an automated solution can never defend itself 100% against an attacker,” says Harbaugh. “You can install a 15 ft wall around your home, and a burglar will bring a 16 ft ladder. You have nation states, hacktivists, terrorists and criminal organisations that understand how automated systems work. If you rely on them exclusively, then you are conceding an advantage to your adversary because they know how they work, and how to evade them.”

All too often, Harbaugh and his team are called in by a company when they suspect they have a problem. “229 days – that’s the average time a cyber intruder spends in a network before detection.”

R9B approaches security breaches not as an IT issue, but as a physical threat, the same way the military or police deal with a foreign army or a criminal. “There is a lot of knowledge and



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technology that defines and indicates how to interact with such physical threats in order to solve them,” says Harbaugh. “There is a lot of knowledge and technology to deal with warfare, defence and bad people. We offer a platform to enable a defender to take back control of their network from intruders.”

R9B created the HUNT ORION platform and other apps that allow a user to manoeuvre in the network space, seeking to defend it. “It looks for the most likely path an intruder might take once the system is breached, and then locates them,” says Harbaugh. “The platform has automated processes that detect suspicious activity, then allows the tip to be elevated to the human level of intervention so that the operator can take back control of the network.”

The future

Clearly, governments must work with the oil and gas industry to create an infrastructure and environment that are more resistant to cyberattacks. In August 2018, the Department of Homeland Security announced that it would launch a new cyber security effort, the National Risk Management Centre. The centre will help government and the private sector better co-ordinate efforts to protect critical infrastructure (including energy pipelines), by reducing risks and responding to attacks.


But there is also a great deal of valuable work that could be done within the sector itself. “There are two communities directly involved in the problem, the vendors (who create cyber security systems and processes), and the buyer or victim community (who suffer cyberattacks),” says Harbaugh.

Even though it is obviously in their best interests to co-operate, the two communities are often poles apart. As an

illustration, Harbaugh recounts the massive 2017 data breach that occurred at Equifax, a credit-rating agency. The breach occurred through an unpatched flaw in a website software tool called Apache Struts. The flaw, which had been identified and disclosed by DHS months earlier, allowed hackers to take control of Equifax’s website and download names, driver’s licence numbers, Social Security numbers, addresses and birth dates.

“When news of the Equifax breach became public, the vendor community blamed the victim; Equifax should have patched a server with a known vulnerability,” says Harbaugh. “OK, maybe there was a reason the server wasn’t patched, but the vendor and buyer communities aren’t treating each other as partners.

“It’s disingenuous to take pot shots at each other,” says Harbaugh. “It may take a catastrophic event to make everyone accountable, but I am optimistic that, over the next few years, the vendor community will treat the buyer community as a partner, and work together to find solutions.”

In the meantime, oil and gas companies in all sectors of the industry need to keep abreast of the latest developments, seeking outside expert help if necessary. When a cyber emergency emerges in your corporation, Harbaugh offers the top three attributes for hiring a good cyber consultant in order to deal with it. “They should have a team that understands the real problems, and don’t just offer you a generic vacuum cleaner,” he notes. “Secondly, they should be talking to you as a partner, learning what you really want to protect. And, finally, they should never say that they can give you 100% protection. If they do, they’re lying.” 

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Are you ready for the new security threats?

Kirk Theige, Spartan Security International, USA, discusses the continued security of North American pipeline infrastructure.

For those pipeliners who started their careers a couple decades (or more) ago, pipeline security was not something that crossed anyone's radar screens. Maybe it conjured up fenced valve settings with locked gates or something along those lines. Today, like back then, there are still valves settings sitting in fields with nothing around them. However, pipelines across open ranchlands, skirting suburbia and through cities are, for the most part, buried and because of that design parameter alone, they are quite secure. Historically, pipelines just did not garner much attention. Then, as now, unintentional third party strikes were the most pressing physical security issues.

Physical security issues

September 11, 2001, changed things, bringing terrorism into focus. Al Qaeda and ISIS have called for attacks against North America's oil pipelines. Jihadists planned and attempted to attack various pipelines, including an attack on

the jet fuel pipeline and storage tanks at JFK International Airport. Fortunately, these plans were broken up by the Federal Bureau of Investigation and the Department of Homeland Security before they could be implemented. Sadly, domestic environmental activists sometimes succeeded where the jihadis did not. In the ten months spanning 2008 and 2009, several natural gas pipelines in British Columbia (Canada) were bombed by environmentalists. In 2011 and 2012 there were two failed attempted pipeline bombings in Oklahoma and Texas (USA), where, fortunately, the bombs failed to go off. In 2016, homegrown ecological radicals organised and synchronised simultaneous attacks on, and caused the subsequent shutdown of, five different crude oil pipelines in four states. These enviro-terrorists broke into fenced and locked pipeline facilities, cutting off valve locks and shutting manual mainline pipeline valves. Their goal was to stop and disrupt the flow of crude oil from Canada to the US. Those terrorists, who were associated with the protesters against the Dakota Access Pipeline (#NODAPL), caused extended delays and brought additional financial costs to the construction project, not to mention damage to land and clean-up costs.

Now here we are in 2018 and the threat matrix has changed again. Rest assured that the jihadists and the environmental terrorists are still out there, looking and planning. But now bad actors come in various new guises: hackers with keyboards; nation states looking to harm America; activists trying to disrupt pipelines for environmental reasons; and hackers wanting to manipulate individual stock pricing for financial gain. They have created a new dimension for pipeline security professionals and operators alike.

Cyber security

Today, the media often reports on major corporations being hacked, data being stolen and privacy invaded, with stories on JP Morgan, Home Depot, Equifax, Ebay, Sony, the US Office of Personnel Management and the biggest data breach in history, Yahoo. Here, some three billion private user accounts were compromised and Yahoo lost US\$350 million from its sale price to Verizon because of the breach.

And now, the cyber terrorists and criminals have got around to targeting pipeline infrastructure. From 2011 to 2015, approximately 350 cyber security attacks on US energy companies were reported to the Department of Homeland Security (presumably some went unreported). This number is miniscule in comparison to the attacks in today's cyberwar. For example, the Alaska Pipeline reports that this year alone it has been fending off an average of 22 million botnet attacks per day. Of course, that doesn't mean that 22 million hackers have their sights lined up on the Alaskan Pipeline every day. Alyeska's Chief Information Officer has been quoted as saying, "It can be six or seven million some days and 45 million the next, I wish I could tell you why it changes that way, but I really don't know." One thing is for certain, these cyber terrorists have sent thundering herds of bots to attack the gates of Alyeska.

Other pipeline companies have been attacked this year as well. In April 2018, four major US pipeline operator networks were penetrated. In each of the four cases, SCADA systems

and other pipeline operating systems were not targeted or affected, which may indicate that the attacks weren't initiated by jihadis. These attacks may have been financially motivated – something of the corporate espionage ilk. These attacks did, however, from the best we can tell, originate from outside North America. Perhaps the perpetrators were searching for ways to intercept and redirect banking transactions, trading strategies and technology advancements or access pricing structures and contractual agreements in order to take the competitive advantage. Could those attacks be originated by bad actors in foreign lands including nation states? Of course. Or they could be privateers, looking to sell ill-gotten data or to make stock market gains. Whatever the motivation, these bad actors hacked into shared data network systems, obligating some of the nation's largest natural gas pipeline operators to interrupt and temporarily close computer communications with their clients. All of the attacks mentioned above, and the many more that have gone unreported, shine a light on the security weaknesses inherent in US energy networks. Today's pipeline infrastructure is evermore reliant on internet and intranet systems, which unfortunately exposes not only financial data but critical operating systems. Cyberterrorists do continually target pipeline operations. During the last half of 2017, an oil and gas facility in Saudi Arabia was infected by an unknown virus – now named TRISIS – developed most probably by nation state-backed hackers. It attacked, took over and shutdown the facility. The TRISIS virus targets the safety systems and rotational equipment with an intent of failing the systems, seeking to cause physical harm and death.

Ultimately, the cyber security risk to North American energy infrastructure is its highest point in history: from the wells upstream, to midstream operations, to downstream refining and right up to the doorstep of the residential market.

There are over a half a million miles of energy and chemical pipelines all across the US and Canada. Cyber invasions into pipeline and facility control systems could do more than interrupt deliveries. The risks are high. If the jihadis, nation states and eco-terrorists have their way, they will shut down our systems through catastrophic failures by explosions, fire and spills that will certainly threaten lives, not to mention the environment and property.

Security measures

Physical security systems

The pipeline industry is a high-profile industry at risk to criminal and terrorist attacks. Knowing that, we need to remain vigilant and proactive for the foreseeable future. Here in the US and Canada the threat of terrorist acts on our pipeline infrastructure is low but very real. As mentioned earlier, the majority of our pipeline mileage is below ground and, in the most part, safe. With that said, as we saw in all the examples above, pipelines can be attacked at valve locations. There are various security systems that can be installed, including surveillance camera monitoring systems, security guards (both static and dynamic), monitored area fence and ground disturbance systems and of course

monitored access control systems. Network-based monitored systems blended with security manpower are without doubt the best types of security systems to be deployed. Spartan Security International and its sister company, the TigerSix Corporation, as EPC firms, have long been advocates of these types of systems. As a construction manager I managed my first fibre optic line laid alongside of 225 miles of pipeline in 1996. The company has been blending fibre optics and security systems for 15 years with great success. The company highly recommends a security risk analysis conducted by a third-party, to be conducted on pipeline systems and IT systems.

The company motto of Deter-Delay-Detect-Respond is simple. For example, a chain-link fence is a deterrent; helical rolls of NATO standard razor wire laid in front of and on top of the fence acts as a delay; automated alarm camera or fence disturbance systems are a detection tactic; and, of course, sending a security guard or police personnel would be a response. Physical security works hand in hand with cyber security by 1) controlling access to the network hardware and 2) operating the security surveillance and detection systems.

Cyber security issues

Recently the FBI obtained an Al Qaeda video calling for “electronic jihad” against the US’ critical pipeline infrastructure.

Enter the technology growth in our industry. In recent years, technology has made it possible to add increasing amounts of instrumentation and other monitoring systems to track data from hundreds of thousands of oil and gas wells and several million miles of pipeline infrastructure, all communicating electronically to their respective control centres. Complex algorithms throughout the infrastructure are continuously adjusting pipeline flow, automatic valves, sales point transactions, sales and storage volume tracking, pressure relief and emergency shutdown systems, to name a few. Cyber security should be at the front of each operator’s to-do-immediately list. So the motto of Deter-Delay-Detect-Respond applies here as well. A simple

example would be: installing a physical firewall and running vulnerability scanning software is the deterrent; a password, PIN or dongle is the delay; running intrusion detection software is the detection; and the response – depending on the goals or requirements of each unique or individual system – could vary from the removal of the malware, or shutting down and air gapping the systems, or notifying authorities.

Today’s advanced cyber criminals and terrorists however are very good at covering their tracks, making the detection part difficult. To begin developing or enhancing your network security countermeasures, perhaps start with a risk assessment,

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determining what is the most important or critical part of your company and work down from there with “what if” scenarios. What if we lose “this” or what if “that” is compromised? This type of brainstorming will help you prioritise new ways to protect your infrastructure. Each pipeline operating company has its own individual needs and should work with a third-party cyber security expert to develop its own security architecture.

Regulations

Though it is difficult to establish how much we spend on pipeline physical security, fences and cameras, it has been determined that our energy industry spends less than 0.02% of its revenues on cyber security. This is substantially lower than the banking and financial institutions. Cybersecurity experts realise that pipeline equipment is vulnerable to hacking and wide open from a security perspective. To put it bluntly, we are in the embryonic stage of cybersecurity. Why did I mention this? So far the TSA believes that the pipeline industry has done a “good job taking their (TSA) guidance seriously”. To me, saying that we have done a “good job”, doesn’t instill that warm fuzzy feeling. One Congress member remarked that the TSA isn’t doing enough to “address pipeline security”. The agencies in charge of pipeline security regulations may want to pass through congress and mandate even more regulations, as happened in Canada. In 2010, the Energy Board of Canada mandated security regulations for jurisdictional Canadian petroleum and natural gas pipelines. The Canadian decision mandates and enforces security regulations and raises questions here in the US as to the comparative evidence of voluntary security vs a regulated security approach.

As mentioned above, not everyone in government is keen on letting pipeline operators determine their security needs. In 2008 the Department of Homeland Security Inspector General (DHS IG) office report stated that “the TSA’s current security guidance is not mandatory and remains unenforceable unless a regulation is issued to require industry compliance.” Additionally, “DOT and TSA will need to conduct covert tests of pipeline systems’ vulnerabilities to assess the current guidance as well as each operators’ compliance”.

Then again, in September 2016, the DHS IG submitted a report that determined that the quality of information and specificity of federal threat data has been an issue for some time. The report concluded that “TSA lacks an intelligence driven, risk-based security strategy that informs security and resource decisions across all transportation modes.” Regardless of regulations, pipeline operators should perform third-party risk assessments and penetration tests annually.

Homeland Security Presidential Directive 7 (HSPD 7) maintains that the DHS – as the lead agency for pipeline security – and the DOT collaborate in regulating pipeline security. However, there is a plethora of government agencies that have their hands in this, trying to do the right thing. Historically, government agencies like to spread their wings and regulate corporations. Agencies and programmes such as: the Information Analysis and Protection directorate; TSA’s Pipeline Security Division; Implementing Recommendations

of the 911 Commission Act of 2007; the Transportation Government Co-ordinating Council; the Office of Pipeline Security (OPS); the Corporate Security Review (CSR) programme; Energy Government Co-ordinating Council; Control System Security Programme (CSSP) and many more are all competing for more authority. The potential of overlap by these agencies and programmes is huge. It’s difficult when one hand doesn’t know what the other hand is doing: it makes interpreting the regulations and negotiating the rule book tricky. For example, what part of your system is a critical part of the overall nation’s infrastructure? Well, you must determine that. It isn’t clear even to the DHS, and they have admitted that. TSA’s Pipeline Security Guidelines is a good place to start.

The TSA is already authorised by federal statute to enforce pipeline physical and cyber security regulations if it becomes necessary. However, they are more inclined to continue with the voluntary approach. The TSA believes that setting regulations may set the bar too low for some pipeline operators that have already taken their risk seriously and elevated it to a higher level of security. Also, the TSA and DOT do not have the expertise or manpower to enforce the regulations. I am a firm believer in protecting our assets and the nation’s infrastructure as good corporate citizens, keeping the government from injecting itself into a project it is not prepared to undertake. By protecting our assets with vigilance and vigour, we will by default protect our country from major or catastrophic disruptions in service.


If our pipeline infrastructure is hit by a physical or cyberattack that results in a catastrophic failure and major disruption, rest assured that the DHS’s voluntary security approach will turn into government mandated security regulations, which may or may not turn out to be effective.

Closing observations

Over the years as a consultant, I have been inside many companies: I have seen both strong security and safety cultures and lip service to the cause. I have seen organisations where the third parties and contractors are held to a higher standard than company employees.

In my travels I have seen companies with non-existent security policies and enforcement. I’ve encountered companies that resist even basic security and safety parameters until forced by the withholding of building permits or fines by local government.

Most companies have at least a vague grasp of security issues, but I have seen operators with vast holdings across the country where the security team consists of one person and almost zero budget. Which of course effectively ties their hands and does nothing to prompt the security culture from within.

Whether a breach is physical or cyber in nature, brand, market value and business integrity can be significantly impacted by a security event. Just as we had to develop a corporate safety culture many years ago, we must now develop a corporate security culture. Pipeline operators need to develop a security culture within and to invest more to be prepared for today’s threats. 

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Digitalisation of the pipeline lifecycle

Raul Lema, Technical Toolboxes, USA, and Brad Raabis, Metegrity, Canada, describe a new working platform that will both manage valuable pipeline data and generate actionable information.

The pipeline lifecycle can be defined by four key phases: design, construction, operations and integrity. The underlying catalyst for success in each of these phases is the speed in which owner operators can gather accurate, actionable intelligence on their assets and deliver bottom line results that impact the operational cost and revenue of their business. Complex pipeline engineering calculations are needed at every stage.

Figure 1. Digital data capture and standardised engineering calculations at the inspector's fingertips can be used to reduce the risk of failures in the future.



In the current climate, too many pipeline owner operators are relying on outdated methods to curate and analyse the information they need to drive bottom line results. Relying on spreadsheets, physical reports, paper processes and manual calculations, they face significant hurdles when trying to acquire actionable data during pipeline construction. These challenges are compounded over the long-term integrity of the asset's life. An excessive amount of engineering and man-hours are required to garner any actionable information. This impedes construction efficiency, progress and overall quality – raising the potential for lost profitability, or worse, asset failure.

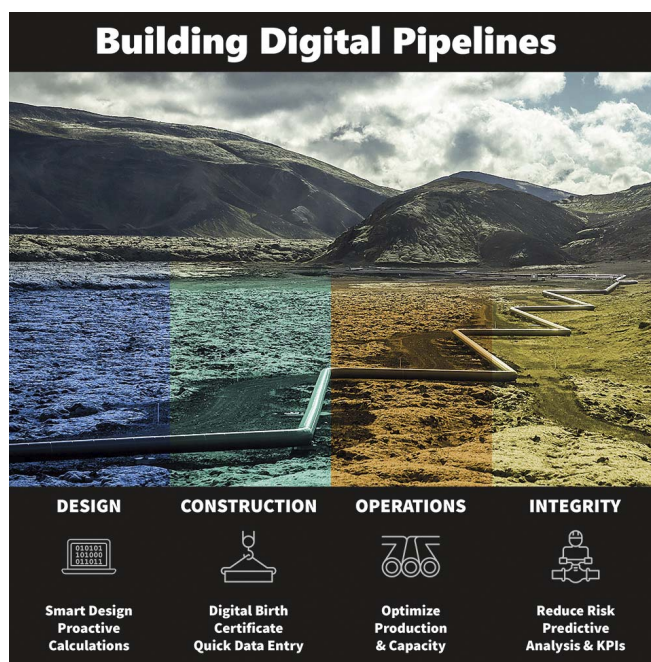


Figure 2. True value can be realised in each stage of the pipeline lifecycle when information can be quickly processed, driving key decisions that improve asset efficiencies and reduce asset risks and costs.



Figure 3. Empowering inspectors with the latest technology improves project data capture, efficiency and reliability from the field to the boardroom.

The solution

To address these industry challenges, pipeline software service providers Technical Toolboxes (TT) and Metegrity are combining forces. They recognise a need for new technological innovation – specifically, a platform that not only manages valuable pipeline data but also generates actionable information, offering pipeline owner operators full digitalisation of processes.

Each company brings technology to the table that solves portions of this digitalisation equation. With Pipeline Toolbox from TT, more than 230 different pipeline-specific engineering calculations are automated. With Pipeline Enterprise from Metegrity, the data needed to perform those calculations is collected automatically in real-time and curated onto a single, robust platform. TT can then utilise that data to auto fill values required to determine actionable business intelligence on the pipeline. Together, each of the two services completes the other for full digitalisation. Together, they represent an innovation in pipeline quality management technology.

The ability to fully digitalise processes along all four phases of the pipeline lifecycle translates into a substantially reduced likelihood of asset failure, considerable increase in profitability and increased efficiency and accuracy during projects.

Methodology

With these combined services, standardised calculations can be delivered to field personnel right at the work face to drive quicker decisions on construction-related issues. This reduces the overhead required to gather data from files and paper-based long-term record systems to complete calculations. It enables predictive capabilities when calculations are captured and analysed over time. This transition enables machine learning and artificial intelligence systems.

For an example of how this might work in real life scenarios, consider this: judging cover is required for an engineered crossing (if the crossing is outside of designed recommendations). On the fly, hydrotest filling requirements can be accessed by field personnel without requesting calculations from head office. Hydro horizontal directional drilling (HDD) pressure calculations would be standardised among all inspectors. This in turn would eliminate HDD inspectors having to manage conflicting calculating spreadsheets. Average frac-outs can cost up to US\$3 - 4 million in clean up, fines and lost construction production. By digitalising all processes and data collection, the combined pipeline offering from TT and Metegrity helps avoid millions of dollars of expenditure while radically improving the efficiency and accuracy of the project.

Further down the phases of the pipeline lifecycle, this combined offering will substantially improve pipeline integrity management. Pipeline integrity models can be fed with relational database values that normally would have to be extracted through manual processes at engineering rates. Being able to access this data (and pertinent calculation) will provide the foundation for new models of pipeline degradation that are more quantifiable than anecdotal. This can increase maximum operating pressures that are defined by regulators. Ultimately, this will improve understanding and reduce catastrophic events in pipeline health and operations.


The design phase is both the starting point of any project and the impetus of all future development. Future pipeline design will benefit from improved understanding of pipeline health and integrity models derived from this partnership. New digital insight will be gained and provide potential benefits that cannot yet be quantified. Innovation begets innovation, and the sheer increase in actionable intelligence will facilitate a myriad of uses and benefits. In turn, new methods will be engineered to capitalise on this new partnership and industry solution.

Expanding potential for pipeline digitalisation

Metegrity delivers data capture and creation of a digital twin with thousands of data points in a relational database. TT's Pipeline Toolbox is a vast calculation engine with more than 230 standard calculations that address the pipeline lifecycle; design, construction, operations and integrity. By combining the services, TT's Pipeline Toolbox facilitates the calculation of actionable tasks, while Metegrity's Pipeline Enterprise automates the data collection and entry required for those equations. Combined, both products create a new solution that will enable seamless integration of data points and calculations. This will deliver significant reduction in overhead costs incurred by midstream companies throughout the pipeline lifecycle. Reduction of these costs provides increased profitability of current and future pipelines and enhanced financial feasibility of future pipeline projects. Pipeline operators

can expect immediate, tangible reductions in cost and increases to profitability. These include improvements to production, capacity, cost control, safety, risk management and overall efficiency.

The future of digitalisation

Pipeline companies around the world are all moving toward digitalising their processes. With increased competition from renewables and margins tightening, digitalisation of pipelines will be more competitive, driving cost and risk down and improving bottom line production and revenues. With the increased availability of digital technologies for the pipeline sector, it is more affordable than ever to invest. The return on investment is apparent during construction but more so over the 50 - 100 year lifecycle of the pipeline, when production, integrity and operational costs are scrutinised daily. 



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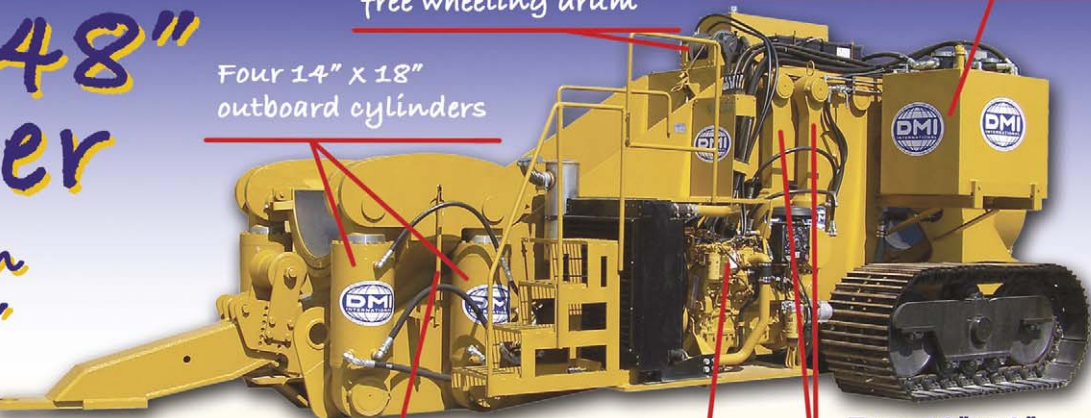
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THE TALE OF TWO CONTROLLERS

Vinai Misra, Woodward, Inc., USA, outlines the role of load sharing to prevent conflict between parallel controllers.

Roughly 1500 gas compressor stations are located throughout North America, with many of these stations utilising multiple compressor sets in parallel for capacity and redundancy reasons. The controllers for these parallel compressors are often tasked to control a common process variable such as suction or discharge pipeline pressure. However, if these controllers are not designed to work together, they will independently try to control the process variable, resulting in each controller 'fighting' with the other controllers. This fight causes overall unstable and poor compressor station performance.

In these types of parallel compressor applications where multiple controllers are tasked to control the same process variable, each controller acts independently and tries to control the process variable, not knowing that

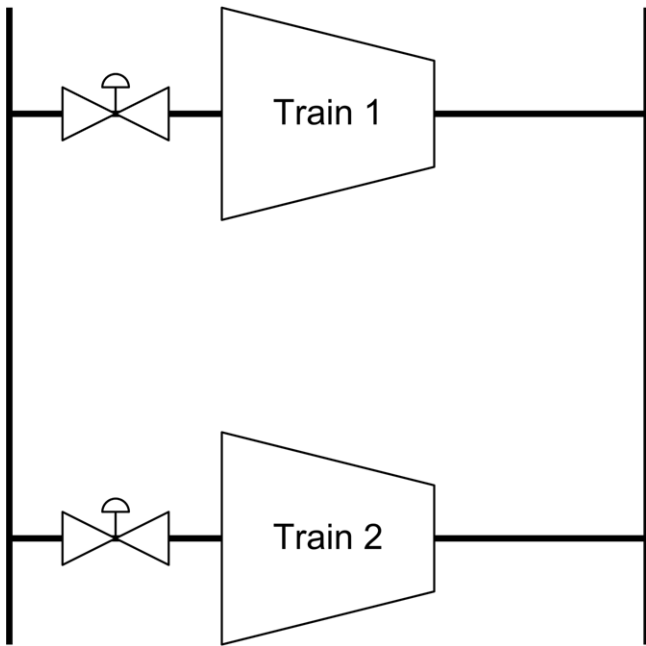


Figure 1. Two compressors supplied by a common suction header.

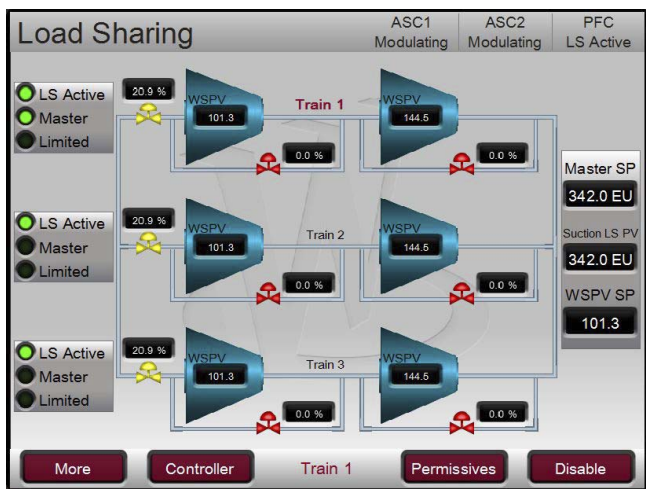


Figure 2. Load sharing among multiple compressor trains.

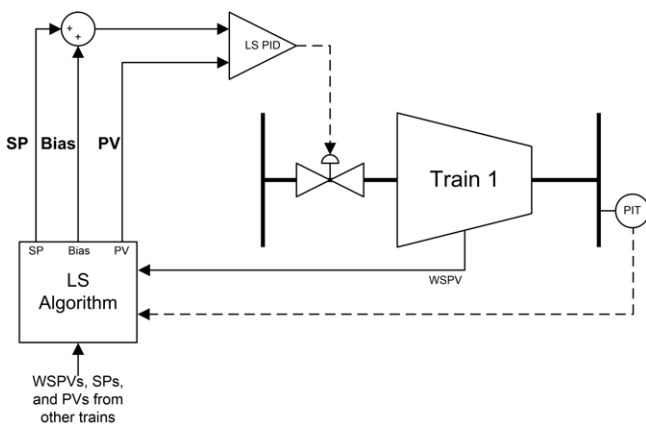


Figure 3. Load sharing core generates set point bias for performance controller.

another controller is trying to do the same thing. This violates a fundamental control axiom; a process variable can only be controlled by one thing at a time. The controller may be influenced by other variables or may relinquish control to another controller, but that one-to-one correspondence between the controller and the controlled variable must be maintained. Otherwise the various controllers will ‘fight’ each other for control and chaos can ensue.

“This simple concept can easily be overlooked when trying to accommodate all the possible interactions surrounding a complex control system,” says Rich Kamphaus, Global Sales Director for steam turbine and compressor markets at Woodward. “Some means must be employed to assure that multiple controllers act in concert with each other. This is best accomplished by allowing each compressor controller to communicate with the other parallel controllers in the system and share their individual sensed process parameters.”

Woodward’s goal to develop a controller that enables this type of communication between multiple compressors culminated in the release of its new Vertex compressor controller. The Vertex controller was specifically designed to allow compressor trains to load each compressor proportionally – also commonly known as load sharing.

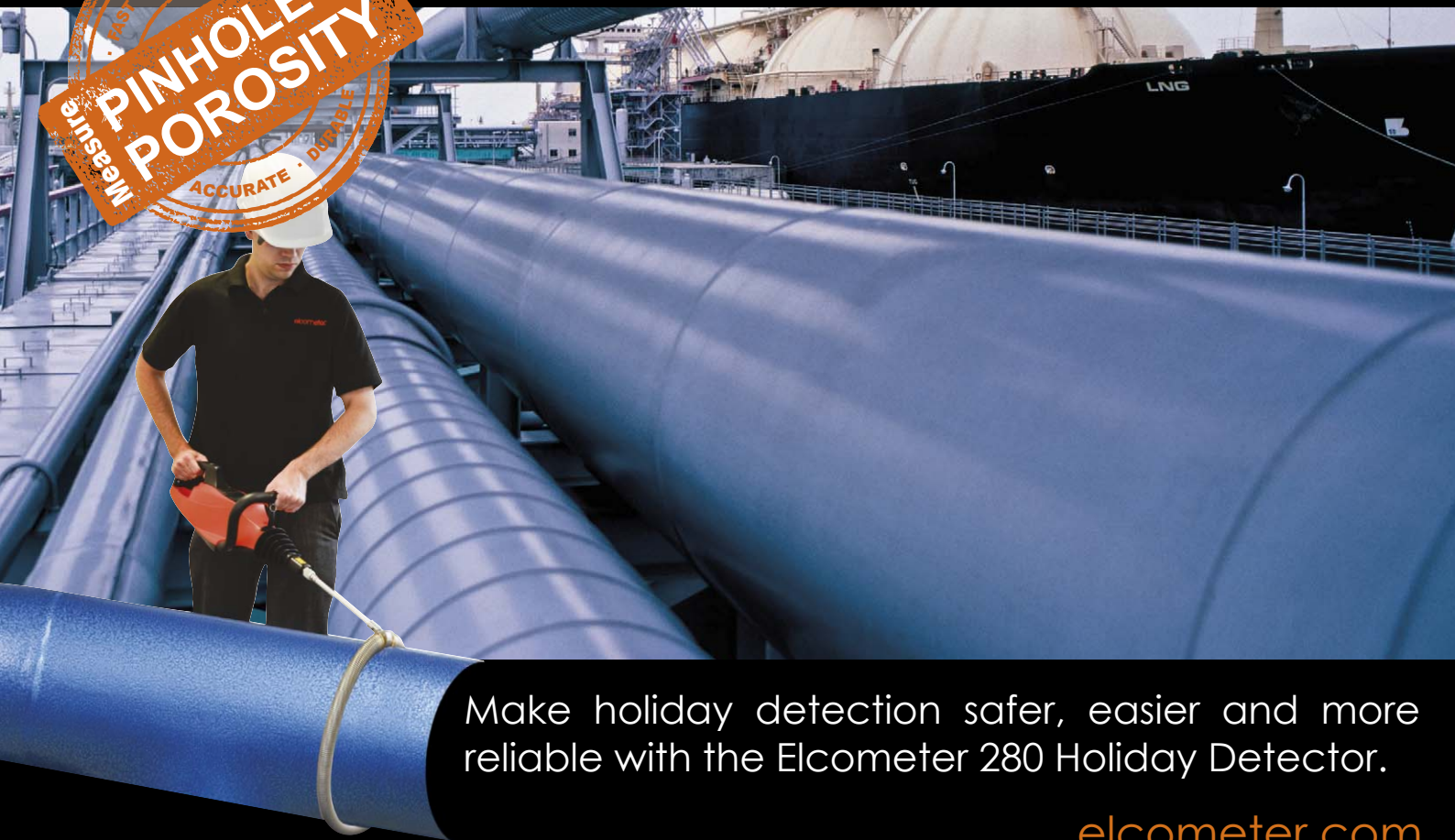
Figure 1 illustrates the need for proportional load sharing using the example of multiple compressors connected in parallel to a common suction header. In this example, the performance controller for each compressor controls the suction header pressure with a throttle valve. Each compressor’s controller tries to control its own throttle valve without knowing what the other controller is doing, resulting in each trying to control the header and fighting the other to maintain its set point.

If load sharing is not employed, one controller may drive its throttle valve fully open while the other controller drives its throttle valve fully closed – resulting in loading one steam turbine at maximum load and another steam turbine at minimum load. While the suction pressure might be maintained at the set point, the load is not shared between the two compressors.

The Vertex controller’s proportional, integral, derivative (PID) architecture provides a good example of how load sharing can be achieved among multiple controllers while jointly maintaining a common process variable – such as flow, suction pressure or discharge pressure. Its parallel load sharing algorithm works with the system performance controller to both maintain the common process variable and to balance the load between the compressors. Multiple process variables can be designated as the parameter to be shared between compressors. “Again, only one parameter can be in control at a time.” Kamphaus explains. For the parallel load sharing application, the load sharing core (LSC) generates a bias signal that can be applied to either the set point or the common process variable of the performance controllers.

The Vertex controller’s integrated load sharing functionality allows multiple compressor trains to work

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together to control a common suction or discharge header pressure to the desired set point, while distributing a shared parameter equally across all trains, as shown in Figure 2.

Load sharing control logic

The primary function of the Vertex's parallel load sharing (LS) algorithm is to generate a bias signal for the performance controller. The LS algorithm works with the performance controller output to maintain the common process variable (suction or discharge header pressure) and

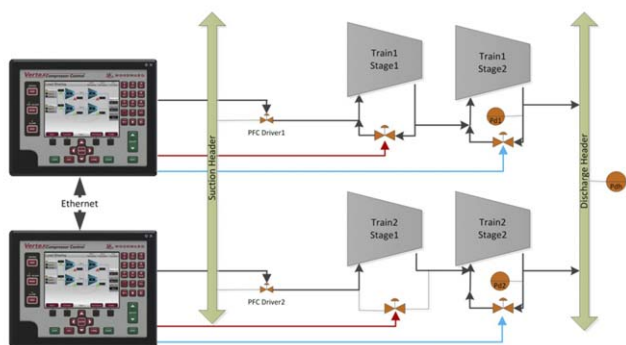


Figure 4. Typical load sharing schematic.

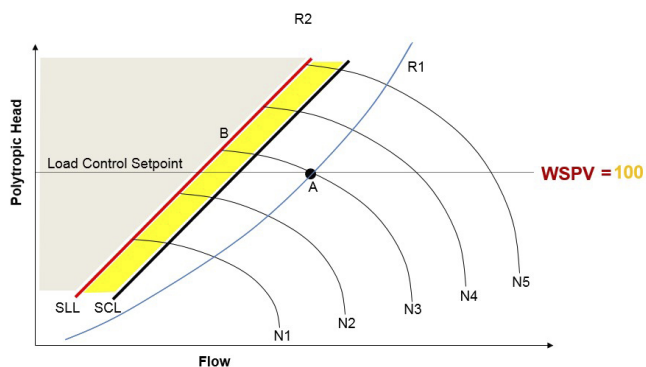


Figure 5. Woodward surge process variable (WSPV).

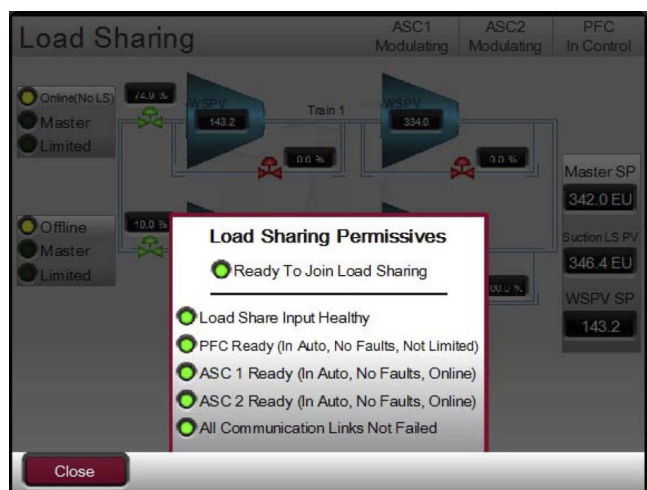


Figure 6. Permissives for load sharing.

to balance the load – typically Woodward surge process variable (WSPV) – between the compressors.

A block diagram of this implementation is shown in Figure 3.

In this example, a set of parallel trains (only the first train is shown) control a common discharge header pressure. The shared parameter is the flow through each compressor. The LSC using the LS algorithm compares the flow through the first train with the flow through the other trains. The difference between the first train's flow and the average flow is used to generate the bias signal. The bias signal adds to the compressor's set point (SP) and compares to the measured process variable (PV). The LS PID controller responds to the bias such that the flow through the first train moves toward the average flow through all trains. The bias signal is applied to the set point instead of the process variable.

The LSC will change the sign of the bias signal based on application to the PV or the SP. In addition to the shared parameter, the position of the anti-surge valve can also affect the bias calculation in compressor applications. As shown in Figure 5, if distance from surge (WSPV) is the shared parameter, all trains will reach the surge control line at the same time. Distance from surge will be fixed at the surge control line and will no longer be a valid shared parameter. The anti-surge valve position of each train then affects the bias calculation so that all trains open their anti-surge valves in a balanced manner.

The primary function of the parallel LS algorithm within each controller is to generate a bias signal for the LS PID that works to move the load share parameter towards the average of all trains in the load sharing group, represented by the equation: Bias = (average WSPV - my WSPV) × gain.

Enabling load sharing

To enable load sharing, all parallel compressor controllers must comply with minimum requirements, such as the performance controller of each unit must be active and not have any faults. Figure 6 shows a list of permissives that allow the load sharing control to be enabled.

Once enabled, if the respective compressor train is the first to be enabled in the load sharing group, it immediately transitions to an active state. If the compressor train is not the first one to be activated, it will remain in a 'joining' state until the load share parameter (i.e. WSPV) deviation is within the 'joining window'. While in this joining state, the load share parameter deviation 'kick out' function is disabled and the load share bias attempts to bring the joining Vertex into the joining window. This action assures that an added compressor will transition smoothly into load sharing with the other units.

Disabling load sharing

Once in the load sharing mode, 'kick out' conditions will cause the unit to leave the load sharing mode and go back to performance control of the local variable. If auto re-join is enabled in the service menu, load sharing control is automatically re-enabled after the kick out condition has

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been resolved and the permissives to enable are met within the auto re-join delay time.

If a sensor failure is detected (flow, pressure, temperature) at any point and backup strategies are unreliable (last good value, default value, calculated from other parameters, etc.), the affected compressor must be removed from the load sharing scheme. It may remain active for other process control such as compressor

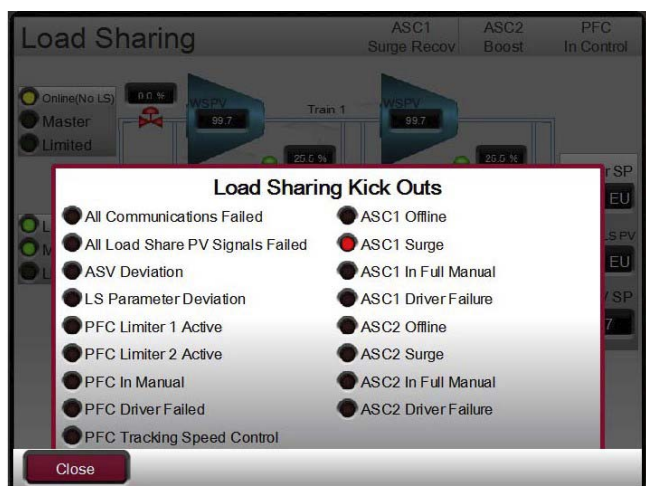


Figure 7. Kick out conditions for load sharing.

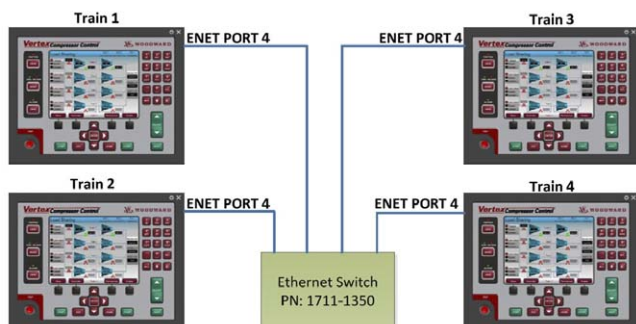


Figure 8. Load sharing network.



Figure 9. Vertex compressor control.

suction or discharge pressure. However, its WSPV cannot be accurately determined if a critical process signal is unavailable. Similarly, disabling or inhibiting individual units in this manner is allowed if the operator determines that unit operation could be dangerous or unstable, or simply unnecessary.

“If the required flow drops below the compression capability of the compressor set, one or more of the compressors can be taken off line,” Kamphaus adds. “You want to be able to bring on compressors as demand increases and take compressors offline as demand drops.”

While maximising load sharing efficiency is preferred, traditional anti-surge protection and control along with start-up/shutdown sequencing are always active on each individual compressor’s recycle valves. When it is enabled, the traditional performance control remains active and acts as a cascaded control to influence the unit’s speed control of the individual compressor motor/turbine drives.


Communication setup among load sharing devices

It is crucial for participating load sharing controllers to exchange control state information between each other in order for them to function smoothly. Figure 8 shows the Vertex’s communication lines that allow load sharing to occur with easy plug and play setup.

“Essentially, Vertex controllers communicate between each other so they know what portion of the load each compressor needs to carry,” Kamphaus says. “If one compressor set is half the size of the other, you don’t split the load in half. Instead, one has to carry more than the other to compensate for the size inequality.”

Designed to function as a plant DCS node or as a standalone compressor controller, the Vertex controller is a cost-effective compressor control and protection device. Used as a replacement for old or obsolete anti-surge controllers, it can be configured to function like those controllers, but with faster scan rates and improved surge anticipation logic. It comes in one integrated package for all control functions (anti-surge control loop 1, anti-surge control loop 2 and performance control). Also, for load sharing function, there is no need for additional master controller hardware.

The communication information shared between each controller for load sharing purpose is selectable, and is performed via a simplex communication network.

Packaged in an industrially hardened enclosure, the Vertex control is designed to be mounted within a system control panel located in a plant control room or next to the compressor. The control’s user-friendly front panel serves as both a programming station and operator control panel. It allows plant engineers with password authority to access and program the unit to the specific plant’s requirements. It allows operators to easily start/stop the compressor and enable/disable any control mode. The Vertex’s 8 in. graphical display allows operators to view actual and set point values from the same screen, simplifying compressor operation. 

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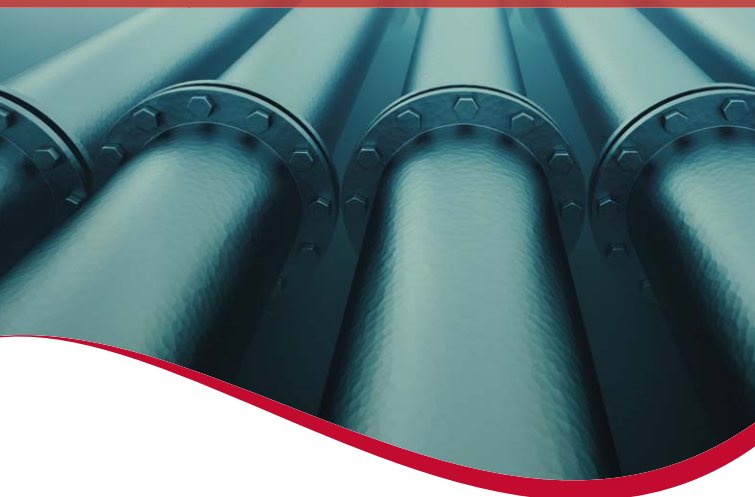
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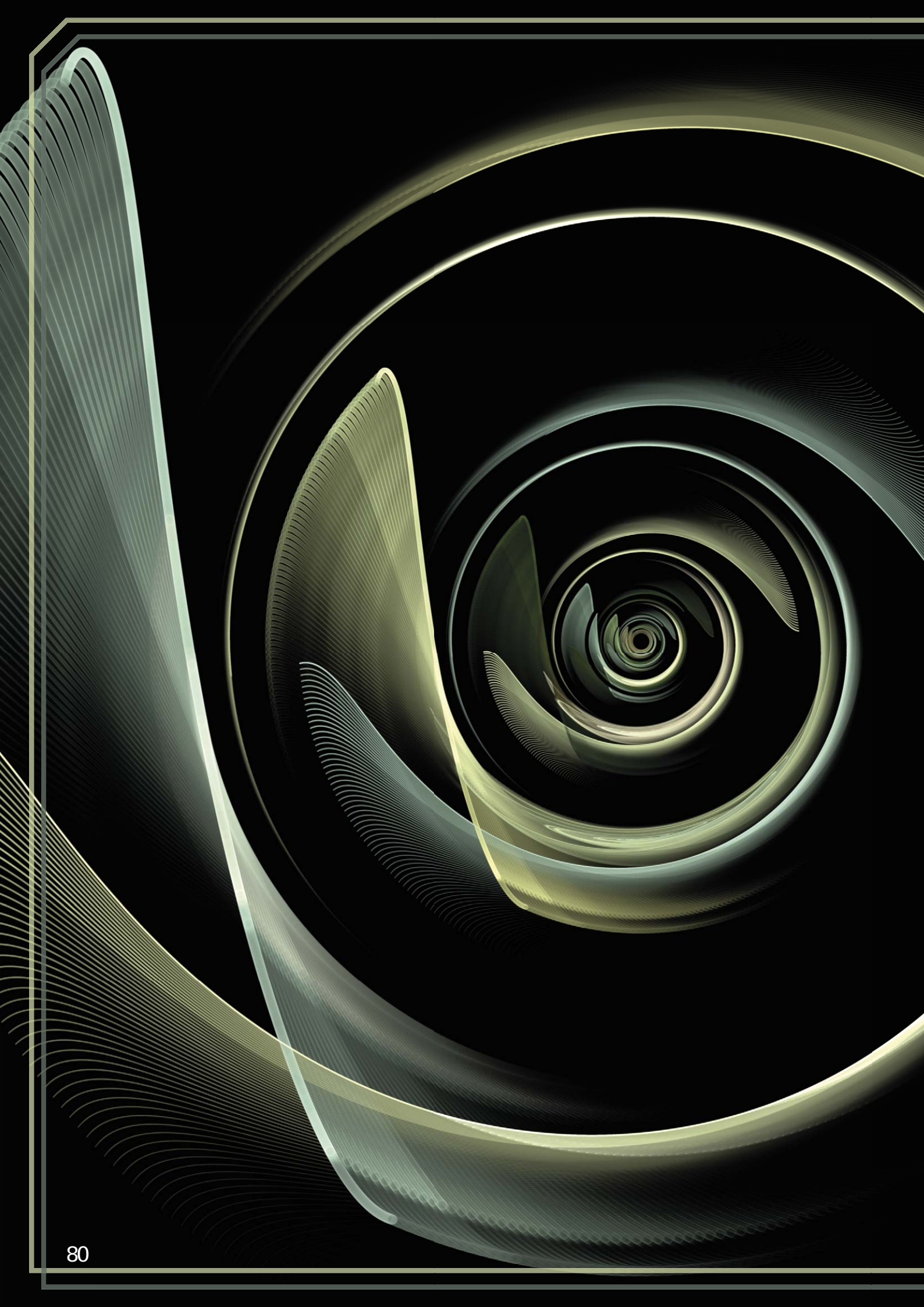
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Turbines are driving the future

Corie Allemand, Director Pipeline Solutions Americas and Matthew Moriarty, Regional Account Manager, Siemens, USA, detail the next wave of compression and pumping solutions for North American pipeline projects.

Oil and gas production from both conventional and unconventional plays across North America continues to rise to record levels. However, in order for the US, Canada and Mexico to fully capitalise on the vast economic benefits afforded by these resources, pipeline networks and their associated infrastructure will have to grow immensely.

The American Petroleum Institute (API) estimates that in the US alone,

an additional 27 000 - 45 000 miles of transmission and distribution infrastructure with 10 - 12 million hp of compression will be needed by 2035 to keep pace with production growth. API also forecasts that in that time period, between 218 000 - 240 000 miles of gathering lines with 22 - 29 million hp of compression will be required.¹

In light of this, midstream operators must find new and innovative ways to simplify and streamline bringing new transmission capacity online, while at

the same time shortening construction schedules, reducing costs and mitigating risk. Once the new infrastructure becomes operational, operators are faced with the challenges of maximising utilisation and reducing total cost of ownership in order to generate returns on these enormous capital investments.

With an extensive portfolio of products and technologies that spans the entire midstream value chain, Siemens is helping pipeline operators (both in the US and internationally) address these challenges and forge ahead with capital-intensive pipeline projects.

Teaming up

One example of how Siemens is helping to meet the evolving needs of North America midstream operators can be seen in its work with Fermaca, a Mexican private company focused on the transportation of natural gas and the second energy infrastructure operator in the country. In 2013, in the midst of extensive energy reform, the Mexican government opened up its oil and gas sector to private investment. One of the results



Figure 1. Siemens has sold more than a dozen SGT-400 turbines to customers in Mexico over the last three years and more than 60 worldwide.



Figure 2. El Encino is the largest natural gas compression station in Mexico territory with a total of 155 000 hp of mechanical power installed on site.

of this was significant expansion of the country's pipeline network, which transports natural gas from northern Mexico to the country's interior. Fermaca builds and operates large sections of the extensive new pipeline network and teamed up with Siemens on two critical projects.

The first project is a 476 km (295 miles) connection between El Encino in the state of Chihuahua and La Laguna in the state of Durango. This link transports natural gas from Waha, Texas, to power plants owned by the Mexican energy provider, Comisión Federal de Electricidad de Mexico (CFE), in the states of Chihuahua and Durango, as well as to central and western Mexico. A compressor station in El Encino uses three turbo-compressor trains with an installed rated power output totalling 155 000 hp and a gas transport capacity of 1.3 billion ft³/d to generate the pressure needed to ensure that the gas arrives safely in La Laguna. Each of the three compressors is driven by a Siemens SGT-750 industrial gas turbine.

The project with Fermaca marked the first instance worldwide in which an SGT-750 was used as a mechanical driver. The turbine model provides a 13 stage compressor with a pressure ratio of 24:1, mechanical efficiency of 40% and a two-stage power turbine with a rotational speed of 6100 rpm. The SGT-750 minimises starting power requirements, but delivers a high starting torque and variable compressor speeds, from 50 - 105%. The turbine exhibits 99% availability for maximum uptime and requires minimal maintenance (designed for 17 maintenance days in 17 years of service). A clean, fourth-generation dry low emission (DLE) combustion system minimises the turbine's impact on the environment, making it one of the world's most eco-friendly turbines.

The second and third projects in Mexico, which are expected to go into operation in 2019, include an approximately 850 km (528 miles) pipeline in two sections that runs from La Laguna to Aguascalientes and from Villa de Reyes to Aguascalientes, and then to Guadalajara in the Mexican states of San Luis Potosí and Jalisco. For these two sections of pipeline, Siemens supplied Fermaca with a total of five compressor trains. Each train consists of one, single shaft compressor with a vertical joint and will be driven by an industrial SGT-400 gas turbine. In addition, there is also a long-term service agreement with Fermaca for a period of 25 years. Two of the compressor trains will be used in the pipeline station in La Laguna. The other three units ensure the necessary pipeline pressure in the station in Villa de Reyes.

The project teams for Fermaca and Siemens collaborated closely to determine the optimal train solution. This collaborative approach resulted in a competitive CAPEX and OPEX offering, due in part to a standardised solution. Siemens designed identical packages for both La Laguna and Villa de Reyes compressor stations, including all auxiliary systems, to maximise common parts and streamline operations and maintenance teams.

The proven gas turbines and compressor packages supplied by Siemens are designed for safe and efficient operation with low maintenance and high reliability. This will make it possible to transport gas smoothly, efficiently and

without harming the environment, thus enabling Fermaca to make a significant contribution to Mexico's energy reform for many years to come.

North of the border

Siemens is also helping midstream operators build out pipeline infrastructure in Canada.

In February, Siemens received an order from North American pipeline operator, Nova Gas Transmission Ltd (NGTL), a wholly owned subsidiary of TransCanada Corporation, to supply a gas turbine-driven compressor train for the Winchell Lake Compressor Station in Alberta, Canada. The turbo-compressor train will be a critical part of the NGTL pipeline expansion to transport natural gas to export markets. Commercial operation is expected to begin in 4Q19. TransCanada's Winchell Lake Compressor Station re-pressurises natural gas along the NGTL's Western Alberta System Mainline. This line, via the Gas Transmission Northwest (GTN) System that begins at the Kingsgate compressor station located at the British Columbia-Idaho border, exports natural gas into Washington, Oregon, California and Nevada.

The scope of supply for the compressor train includes an RFBB36 pipeline compressor driven by Siemens' aero derivative SGT-A35 gas turbine (formerly the Industrial RB211), and associated auxiliary systems. The SGT-A35 gas turbine configuration incorporates a variety of proprietary technical features that have positioned the turbine as the engine of choice for reliability and lowest total cost of operation in the gas transmission market.

The RFBB36 compressor met all project specifications and offers some of the highest compression efficiency in the midstream market with the lowest CO₂ and methane gas emissions compared to other pipeline compressors. Siemens also provides TransCanada with customer care services supporting approximately 160 aero derivative gas turbines operating today.

Overall, the combination of efficiency, reliability, and Siemens' focus on low CO₂ and methane emissions helps Siemens' customers – like TransCanada – reduce capital and operational expenditures on major infrastructure projects that span thousands of miles across rugged terrain and harsh weather conditions.

How it fits into Pipelines 4.0

The gas-driven compressor packages supplied to Fermaca and TransCanada are just one of many solutions that comprise Pipelines 4.0 – Siemens' integrated approach to the engineering, supply and lifecycle optimisation of midstream assets. Tailored to meet the evolving needs of North American operators, Pipelines 4.0 combines equipment and turnkey packages for pipeline

stations with data analytics, lifecycle services and cyber security.

The approach draws on the company's extensive midstream track record of supporting large-scale liquids and natural gas pipeline projects, with a focus on pump and compressor stations, as well as tank farms, terminals and storage facilities. With the industry's largest installed base of rotating equipment, Siemens also provides motors and drives, automation, electrification (including e-shelters), digitalisation and SCADA solutions.

In addition to gas-driven compressor packages, the Pipelines 4.0 portfolio includes integrated electric motor-driven (EMD) compressor packages. The EMDs are pre-engineered for efficient installation and start-up, thereby allowing operators to significantly reduce project lead times. Its options extend to an electrification package that includes

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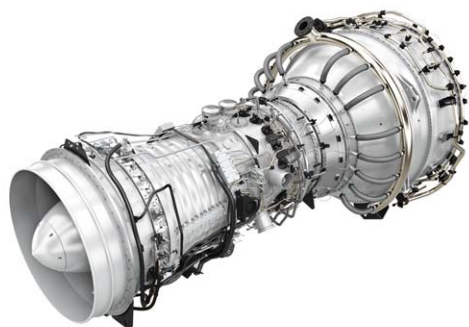


Figure 3. Siemens SGT-A35 gas turbine incorporates a variety of proprietary technical features that offer excellent reliability and one of the lowest total costs of operation in the gas transmission market.



Figure 4. The power capacity, performance and asked reliability of Siemens' SGT-750 compression equipment will be supported by the company's local service organisation, together with technical personnel located in Siemens' Swedish equipment factory.

compressor drives, motor skids, automation, substations and transformers, enabling operators to further streamline interfaces and reduce risk.

On the data analytics front, Siemens recently developed 'Smart Pump' to optimise the power consumption of pipeline pump stations. Software-based solutions include the use of digital twins and the company's IoT platform, MindSphere, to optimise pipeline asset performance, from pre-FEED through the entire asset lifecycle.

Use cases for SmartPumping applications show the potential to help operators cut their utility charges by up to 5%, which translates into millions of dollars of cost savings over multiple years of operation. By deploying sophisticated software technologies – including artificial intelligence and machine learning (among others) – operators are able to improve and optimise pumping operations in terms of load management, power consumption and scheduling.

Creative financing solutions

Siemens offers Pipelines 4.0 through several business and financing models, including leasing, debt financing and equity

investments. This takes advantage of not only the company's financial strength but also its confidence in the future of midstream operators across North America.

From equity and mezzanine solutions to public-private partnerships, tailored project financing, asset-based lending, and construction and permanent facility financing, Pipelines 4.0 provides midstream operators with the flexibility to lead, arrange, or participate in projects according to their needs. Whether a pipeline project is new construction or an upgrade to existing capacity, the integrated solution is designed to help customers develop creative, competitive debt and equity financing solutions with both floating and fixed rate options, off-balance sheet, and long-term payment options.

Real-world benefits


The overall goal of Pipelines 4.0 is to help North American midstream operators accelerate deployment of the next generation of pipeline infrastructure and achieve returns on their investment more rapidly. This fully integrated, pre-tested, ready-to-install approach to building the physical plant of new pipelines can simplify and reduce procurement costs, time and risks. One major sole-sourcing advantage of Pipelines 4.0 is that it can help eliminate time consuming cycles of troubleshooting and potential vendor finger pointing during commissioning. These cycles can add weeks, if not months to project completions.

Recently, for example, Siemens used the Pipelines 4.0 approach to provide 64 ready-to-install pump stations for the build-out of a pipeline network by one of North America's largest midstream operators. The integrated approach saved months of time in bringing new capacity online and enables the operator to continuously optimise its pumping operations to reduce lifecycle costs.

Overcoming future challenges

While unconventional resource development has enhanced production in North America, it has also strained transportation infrastructure, namely pipelines – the most efficient means to move oil and gas to market. The resulting 'bottleneck' poses an obstacle to the entire industry.

In the midst of the pressing demand for pipelines, operators face a number of challenges. Some of these include a potentially 'lower for longer' price environment, intense competition, the need to reduce CAPEX and OPEX, ageing assets, the effective management of large amounts of data, cyber security concerns, tightening legislation, and the looming retirement of highly experienced personnel.

Pipelines 4.0 is Siemens' answer to this complex conundrum. It comprises highly integrated offerings and turnkey solutions for pump and compressor stations to enhance efficiency; data analytics and lifecycle services to optimise critical asset performance; cyber security services to protect information and 'smart' equipment; and dedicated support teams to facilitate inter-company communications. 

References

1. 'US Oil and Gas Infrastructure Investment Through 2035' (American Petroleum Institute, April 2017), p3. <http://www.api.org/-/media/Files/Policy/Infrastructure/API-Infrastructure-Study-2017.pdf>



PURGED BY PAPER

Ryan Robb, Aquasol Corporation, USA, examines the solutions for planned pipeline shutdowns and the ramifications of a poorly executed shutdown.

Between the US, Canada and Mexico, nearly three million miles of pipeline snake their way across North America, supplying the continent with the oil and gas that power the myriad of industries which comprise a modern economy. The US alone accounts for approximately 2.4 million miles of North America's energy pipelines, making it the largest network in the world. Russia, with the second largest network, only boasts one-tenth of what is found in the US. Much of the oil and gas flowing through these pipes is bound for refineries and power plants spread across the country.

In the strictly regulated environment of the energy industry, it is crucial for oil refineries and natural gas fired



Figure 1. Insertion of the EZ Purge® in pipe.

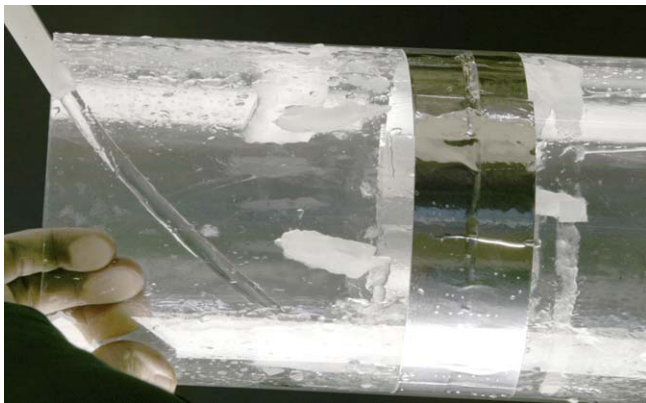


Figure 2. Simulation of Aquasol® Water Soluble Dam hydrotest.



Figure 3. Insertion of handmade dam, made with Aquasol Water Soluble Paper.

plants to execute well planned and in-budget turnarounds. Turnarounds, also known as planned shutdowns, are carried out for preventive maintenance and inspection of a facility to ensure it is operating safely and efficiently. Shutdowns are extremely costly, often employing thousands of skilled labourers while ceasing all profitable operations. The loss of refined petroleum products or generated power can raise the costs of fuel in many of the local communities surrounding a facility during its turnaround.

Shutdown maintenance

Despite the negative aspects of a shutdown, the ramifications can be far worse if it is avoided. Without a proper shutdown, equipment in the facility will begin to degrade and break down. Breakdowns will lead to inefficient, ineffective operations and potentially cause the release of more environmental toxins than expected, leading to an unplanned shutdown. An unplanned shutdown will suffer from a lack of the careful planning and co-ordination undertaken when preparing for a turnaround. Skilled labourers, materials, and even funds will not be readily available on short notice. Preventive maintenance is always a better option than breakdown maintenance, and the comparatively short time a refinery is shut down for a turnaround is well worth it. Shutdown maintenance is not only critical for the many refineries and power plants dotting North America, it also serves the millions of miles of pipelines that supply them. With the facilities operating in optimum conditions, oil and natural gas will continue to flow and satisfy their demand.

Shutdown maintenance can also be an economic boon for some. Contractors receive multi-million dollar contracts for which they create numerous temporary jobs and purchase a wide array of materials from numerous suppliers. Purchasing agents give careful consideration to find the products most suited for the job, seeking out new technologies that satisfy the ever-expanding government regulations while making the job safer, faster and more cost-efficient. Manufacturers are driven to constantly innovate and improve to satisfy the stringent demands of these contractors, the facility operators which hire them, and the regulatory bodies which oversee them.

Welding during shutdown

Much of the work undertaken during shutdown maintenance involves welding to repair and replace the considerable pipework found in refineries and power plants; as such, one of the key processes the contractors must routinely perform is weld purging, a common yet specialised process many welders will be very familiar with. Purging is the process of evacuating oxygen from the weld zone before welding begins. Oxygen is forced out of the zone by introducing an inert gas such as argon or nitrogen. Without a proper purge, oxygen will enter the weld – causing premature corrosion and making the weld susceptible to cracking. Replacing or repairing piping in an unpurged environment would do more harm than good, requiring the work to be redone, otherwise there could be

significant equipment failure soon after the facility returns to normal operations.

Welders create a purge chamber, blocking each side of the weld joint with some form of purge dam or device that retains the inert gas flooding the weld zone. This reduces the amount of gas that needs to be used as well as the time it takes for the purge to finish. Purge dams have become exceedingly more technologically advanced over time to accommodate the many different pipe schedules, situations, and other factors that may be encountered while working with pipe. In the past, weld purging would often be performed with homemade, jerry-rigged contraptions constructed out of dubious materials such as cardboard, masking tape and foam. Handmade purge devices will usually suffer from inefficient gas retention and can contaminate the weld, as well as be a fire hazard in the weld zone. In modern turnarounds, most facilities will not allow the use of such handmade equipment for their shutdown maintenance. It is in the best interest of the contractor to use purging equipment specifically manufactured for the job, providing for the highest standards of gas retention, quality welds and safety as possible.

Purging technology

Aquasol Corporation has been assisting refineries to ensure smooth and efficient turnarounds since its founding in 2003. Aquasol is dedicated to advancing purging technology, and its products have been selected for turnaround projects across the globe. The company is headquartered in the US, where it manufactures all of its products. Aquasol began as a one product company with its rolls of water soluble paper and tape, which can be used to create purge dams of infinite sizes. The paper is composed of sodium carboxymethyl cellulose and wood pulp, which allows it to dissolve almost instantaneously in water. The welder simply cuts the paper to one-third larger than the size of the pipe to be welded and affixes it to the interior of the pipe with Aquasol® Water Soluble Tape. The adhesive of the tape is also constructed from soluble materials and will not leave any sticky residue in the pipe. The adhesive is mildly tacky until activated by brushing a damp sponge over it; it is designed this way to allow for proper positioning of the dam before it fully adheres to the pipe. Once all welds are completed, the dams will be flushed out of the pipe with a water or steam hydrotest. The water soluble dams are

especially useful for closing welds or bends in the pipe where retrieving the equipment may be difficult or even impossible. Aquasol's soluble paper is also versatile, being produced in multiple sizes and grades, as well as being available in both rolls and reams – this allows the paper to suit the needs of nearly any job.

Aquasol's paper benefits from being 100% biodegradable and EPA approved. Facilities such as oil refineries and natural gas fired power plants can draw significant attention for the environmental impact they have on the local communities. Owners are encouraged to be proactive in limiting the negative effects products used can have on the environment and choosing products with regulations and community concerns in mind. Use of Aquasol Water Soluble Paper, or the other products manufactured from it such as



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EZ Purge, can help to show a strong track record of care for the environment.

Aquasol Water Soluble Paper has seen extensive use for turnarounds around the world. In the past ten years, the paper has been used for shutdown maintenance for over 70 facilities in North America alone. The welders on these projects have employed hundreds of thousands of feet of soluble paper to perform upwards of 20 000 tie-in welds. The versatility of the paper has allowed welders to use the same product on many different sizes and layouts of pipe for these tie-in welds, making it a preferred product for jobs that will have significant variation between the pipes.

The engineering team at Aquasol felt that they could improve on the success of water soluble paper and make the purging process even simpler and faster. This motivation led to the EZ Purge® Water Soluble dam being developed over the course of two years. EZ Purge is a pre-formed dam constructed from Aquasol Water Soluble Paper. The dam is already shaped to be effortlessly inserted into any schedule pipe and attached using the pre-applied water soluble adhesive along the edge of the dam. This adhesive is the same material that is found in the water soluble tape, allowing the welder to be certain the dam is optimally positioned prior to activation. The dams save welders time they would have spent constructing them, so they can get back to doing what they do best – this saves money for the contractor, facility owners and the consumer. EZ Purge also features ZAP Technology as an additional improvement over the standard water soluble paper. ZAP stands for zero air permeability and is a proprietary coating which enhances the gas retentive properties of the paper; with ZAP, no gas is able to transfer through the dam. ZAP maintains the same environmental standards as the paper it is constructed from as it is still 100% biodegradable. EZ Purge will perform admirably in almost any size pipe, with possible sizes ranging from as low as 0.5 in. to as large as 84 in.

The convenience of EZ Purge has seen it increasingly used for shutdown maintenance since its development. The standard pre-formed sizes mean there is little opportunity for error and makes tie-in welds a cinch. This ease of use has led it to be the go-to product for over 50 turnarounds in North America, where more than 50 000 dams have been utilised in their tie-in welds. A Welding Engineer for a major contractor that has had involvement with hundreds of turnarounds, claims that he uses EZ Purge for all of his final tie-in welds. His crew will install dams into all the pipes destined for tie-ins ahead of time. The welders can begin immediately purging once the pipes arrive where they are needed and are set in place. With this method, the company was able to ensure that all of the tie-ins would be properly purged for a high-quality weld.

Pipe purging may be only one aspect of the turnaround process but it is crucial to keep refineries and power plants in peak condition. Aquasol will continue to push purging technology forward to help make shutdown maintenance simpler and more cost-effective. 

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Our wide range of rugged and reliable CLAMPMASTER® internal line-up clamps provide accurate internal line-up and dependable root pass copper backing for pipeline welding. Clamps can be optionally configured for your most demanding requirements including remote, self-propelled and vertical operation, purge dams for TIG welding.



Coating Removal Systems

Tri Tool produces both form tool and end mill type Coating Removal Systems for the rapid, precise removal of tough pipe coating materials. Practical designs give you total control of depth of cut and lead-out angle. Our systems can be custom configured for your specific project, for any material or cut geometry. Call us today for proven coating removal solutions.

See us at **FABTECH Booth C12152, Nov 6 - 8, Atlanta, GA**

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