

# WORLD PIPELINES<sup>®</sup>

Volume 24 Number 1 - January 2024



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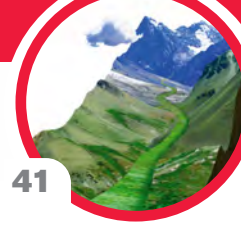
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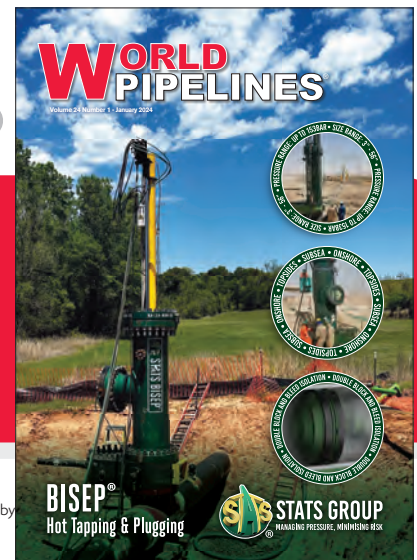
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Annual subscription £60 UK including postage/£75 overseas (postage airmail). Special two year discounted rate: £96 UK including postage/£120 overseas (postage airmail). Claims for non receipt of issues must be made within three months of publication of the issue or they will not be honoured without charge.

### Applicable only to USA & Canada:

World Pipelines (ISSN No: 1472-7390, USPS No: 020-988) is published monthly by Palladian Publications Ltd, GBR and distributed in the USA by Asendia USA, 701C Ashland Avenue, Folcroft, PA 19032. Periodicals postage paid at Philadelphia, PA & additional mailing offices. POSTMASTER: send address changes to World Pipelines, 701C Ashland Avenue, Folcroft, PA 19032.

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### SENIOR EDITOR **Elizabeth Corner**

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On p. 13, ABB Energy Industries discusses asset performance management using Industry 4.0 technology, and how this is the key to driving operational efficiencies. Read it to see how the ability to digitally visualise your pipeline asset can reap rewards (there's also a compressor station case study to get your teeth into).

Rockwell Automation (p. 18) helps us to understand edge computing and how it can eliminate the scale and capacity constraints that arise from running a remote, decentralised pipeline network. The article explains how collecting and managing industrial data using edge devices will enable digital transformation across the pipeline sector.

Digitalisation, as described in these keynote articles, works to the benefit of many desirable outcomes, including increased safety, operational efficiencies, improved decision-making, and greater profitability. Digitalisation can also contribute to a lower carbon footprint, helping to reduce emissions across value chains and maintain the health of assets, thereby safeguarding environments.

In her article starting on p. 23, Vicki Knott from CruxOCM writes about the environmental impact of improving pipeline operations, with a focus on reducing latency in human processes, and advancing automation. An integrated supply chain, in which live data streams can unlock the true value of AI, could bring about real sustainable progress, argues Knott. She urges pipeline operators to pull the levers to achieve increased utilisation of pipeline networks, therefore reducing emissions per barrel.

The band Coldplay released its first sustainability report last year, outlining its efforts to address the sustainability issues that affect the band and its stakeholders, including fans, suppliers and venues. This type of reporting is not required by law, nor is it governed by set standards, so the band's proactivity sets them apart as trailblazers. Coldplay uses digital technology such as kinetic dancefloors and electricity-generating bikes to power shows.

Whilst digital tools can lead us to decarbonisation wins, they also produce their own carbon footprint. Season two of the Palladian Energy Podcast has focused on sustainability in oil and gas, and for a recent episode I spoke to Gareth Edwards from GoCodeGreen (an Earthshot Prize-nominated climate technology company). He talked about the importance of accurately measuring the carbon impact of digital products and services, to support action to reduce the footprint of software and the technology value chain. Edwards enlightened me about the impact of music streaming services: the most streamed song on Spotify in 2023 was Miley Cyrus's 'Flowers' – sorry Coldplay – and the streaming activity “has an equivalent impact to 77 000 lb of carbon, about the same as 15 000 cars”.

Almost everything we do has an environmental impact, so we must analyse digital tools on the basis of operational and environmental wins and losses. 

**T**o kick off 2024, we're running a keynote feature on the digitalisation journey for pipeline companies. Articles from AVEVA, ABB and Rockwell Automation provide a close look at how digitalisation can benefit pipeline operations.

Stuart Parker from AVEVA offers insight into the six ways that forward-looking pipeline companies are installing intelligent pipeline frameworks through the use of digital systems (p. 8). Read the piece to learn about digitising liquid and gas pipeline operations, along with processes such as leak detection, training, fiscal measurement and autonomous control.

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# WORLD NEWS

## Trans Mountain pipeline: line fill planned for March or May

Trans Mountain Corp plans to begin line fill in March or May on its long-delayed Canadian oil pipeline expansion, depending on the diameter of pipe it uses and assuming no new problems, the Canadian government-owned company said in a filing in early January (Reuters reports).


The company is awaiting a regulatory decision on its request for a construction change.

Line fill is a final step before the expanded Alberta-to-British Columbia pipeline begins service, providing crucial additional access for Canadian oil to refineries on the US West Coast and in Asia.

The project will nearly triple the pipeline's shipments to

890 000 bpd.

Trans Mountain said the new schedules assume that it faces no delays caused by challenges drilling into hard rock, such as tool damage. Trans Mountain continues to target the end of 1Q24 to begin shipping crude and is developing contingency plans to address any challenges to that schedule, a spokesperson said in an email.

Trans Mountain had asked the Canada Energy Regulator (CER) to allow it to install smaller-diameter pipe in a 1.4 mile (2.3 km) section of the oil pipeline's route after encountering challenging drilling conditions in a mountainous area between Hope and Chilliwack, British Columbia. 

## Kinder Morgan closes on acquisition of NextEra Energy Partners' South Texas assets

Kinder Morgan, Inc. on 28 December 2023, closed on its previously announced US\$1.815 billion acquisition of NextEra Energy Partners' South Texas assets (STX Midstream), which includes a set of integrated, large diameter high pressure natural gas pipeline systems that connect the Eagle Ford basin to key growing Mexico and Gulf Coast demand markets.

The acquisition includes a 90% interest in the NET Mexico pipeline (MGI Enterprises, a PEMEX affiliate, owns the other 10%), Eagle Ford Midstream and a 50% interest in Dos Caminos LLC (Howard Energy Partners (HEP) owns the remaining 50% and will continue to operate the pipeline).

Dos Caminos recently placed in service a 62 mile pipeline connecting HEP's existing midstream pipeline and facilities in

Webb County, Texas to KMI's new Eagle Ford pipeline, which was placed in service on 1 November 2023. This portfolio of assets is highly contracted, with an average contract length of over eight years. Approximately 75% of the business is supported by take-or-pay contracts.


"We are pleased to add these assets to our natural gas portfolio to serve growing LNG, industrial, Mexico export and power generation demand markets on the US Gulf Coast," said KMI President of Natural Gas Pipelines Sital Mody. "These assets integrate well with our existing South Texas footprint and extend our direct connectivity in the lean area of the Eagle Ford Basin, allowing us to offer LNG customers greater access to desirable low-nitrogen natural gas supply." 

## Serbia completes interconnector to gas pipeline in Bulgaria

Serbia has completed the interconnector to a pipeline in Bulgaria, which would allow the Balkan country to diversify its gas supplies and reduce its dependence on Russia.

The launch of the interconnector will make operational the pipeline from the town of Novi Iskar in Bulgaria to the Serbian city of Nis, allowing Belgrade to access gas from Azerbaijan and LNG terminal in the Greek port of Alexandroupolis.

The capacity of the pipeline on the Serbian side is 1.8 billion m<sup>3</sup>/yr, which accounts for 60% of the country's annual gas needs.

The European Commission donated €49.6 million (US\$53.37 million) for construction of the interconnector. Another €25 million was secured in a single loan from the European Investment Bank while €22.5 million was provided by Serbia. 

## TotalEnergies hires former Benin PM to assess East Africa land purchases for EACOP

France's TotalEnergies has hired former Prime Minister of Benin Lionel Zinsou to assess land purchases in Uganda and Tanzania as part of the Tilenga oil and East African Crude Oil Pipeline (EACOP) projects (Reuters reports).

TotalEnergies said that as the land acquisition process draws to a close, Zinsou will evaluate the procedures used, the conditions for consultation, the compensation and relocation of people affected, and grievance handling.

Zinsou's consulting firm will also assess actions taken by TotalEnergies EP Uganda and EACOP to improve living conditions for those affected. It will submit a report by April 2024.

TotalEnergies said the Tilenga and EACOP projects include a land acquisition programme covering 6400 hectares (15 815 acres), carried out on behalf of the Ugandan and Tanzanian governments.


The programme concerns 19 140 households and communities

owning or using plots of land, and includes the relocation of 775 primary residences.

To date, 98% of the households concerned have signed compensation agreements, 97% have received compensation, and 98% of households to be relocated have taken possession of their new homes, TotalEnergies said.

The Tilenga project in Uganda is being carried out by TotalEnergies (56.67%, operator), CNOOC (28.33%) and UNOC (15%).

Ugandan oil will be transported to the port of Tanga, Tanzania through EACOP, whose shareholders are TotalEnergies (62%), UNOC (15%), TPDC (15%) and CNOOC (8%).

Zinsou, Prime Minister of Benin from 2015 - 2016, is founder of consulting firm SouthBridge, with which TotalEnergies has collaborated in the past. 



# CONTRACT NEWS

## EVENTS DIARY

30 January - 3 February 2024  
**76<sup>th</sup> annual PLCA Convention 2024**

Nassau, Bahamas  
<https://www.plca.org/annual-convention-events>

12 - 16 February 2024  
**PPIM 2024**

Houston, USA  
<https://ppimconference.com/exhibition/>

13 - 15 February 2024  
**AMI Pipeline Coating**

Vienna, Austria  
<https://www.ami-events.com/>

3 - 7 March 2024  
**AMPP Annual Conference + Expo 2024**

New Orleans, USA  
<https://www.ampp.org/>

8 - 11 April 2024  
**Pipeline Technology Conference (ptc) 2024**

Berlin, Germany  
<https://www.pipeline-conference.com/>

15 - 19 April 2024  
**TUBE Düsseldorf 2024**

Düsseldorf, Germany  
<https://www.tube-tradefair.com/>

6 - 9 May 2024  
**Offshore Technology Conference (OTC) 2024**

Houston, USA  
<https://2024.otcnet.org/>

11 - 13 June 2024  
**Global Energy Show 2024**

Calgary, Canada  
[www.globalenergyshow.com](http://www.globalenergyshow.com)

26 - 29 August 2024  
**ONS 2024**

Stavanger, Norway  
[www.ons.no](http://www.ons.no)

## Tracerco announces contract win in Gulf of Mexico

Tracerco has announced it has secured a million-dollar contract in the Gulf of Mexico which will see the business deploy its inspection technology across multiple oil and gas platforms.


The contract will see Tracerco deploy its pipeline inspection technology – Discovery™ – as part of an agreement between three of America's largest oil and gas companies, all of whom operate different riser pipes on multiple platforms in the Gulf. The project also comes as part of the first life extension permit granted for these assets.

Speaking about the contract win, Jim Bramlett, Tracerco's Commercial Manager for North America said: "This is a fantastic win for us and is the first time we've experienced the collaboration of multiple oil and gas companies on a riser life

extension project.

"Discovery is an obvious choice and natural fit for many operators, as real-time, highly accurate data can be gathered with a non-intrusive approach meaning no need for any downtime.

"The fact that three of the largest American oil and gas companies have joined forces to do this gives them not only economies of scale but also enables us to get standardisation on these risers as we work with these operators to maintain pipeline integrity and extend the lifespan of their assets."


Discovery has been designed to allow owner operators to gain enhanced understanding of a pipeline, its coating and process fluid, all whilst being fully operational. 

## Fugro wins ultra-deepwater contract offshore Namibia

Galp, a Portuguese energy corporation, has awarded Fugro a contract to conduct an environmental and geophysical survey offshore Namibia.

Known for its remote location, challenging conditions and ultra-deepwater, this site is key to future energy operations in the region. Fugro's advanced technology and expertise in marine geophysical and environmental surveys ensured efficient and accurate data collection, enabling Galp to make informed decisions for safe energy operations in the region.

With fieldwork completed earlier this month, the survey reached depths of 2000 m. The *Fugro Venturer*, a geophysical vessel, collected sediment samples for environmental and chemical analysis before an autonomous underwater vehicle (AUV) captured seabed video footage. Additionally, Fugro acquired in-situ full ocean depth water profiles and water samples to measure the current biodiversity. The geo-data collected through this survey will support the identification of potentially sensitive habitats, advance knowledge of remote seamounts, and contribute to informed project planning and resource management.

Furthermore, the geophysical survey will provide insights into the underwater landscape, ensuring the safe movement and operation of offshore assets within the designated area. 

## ON OUR WEBSITE

- Vallourec to sell its Mülheim site
- EACOP announces the delivery of first 100 km of line pipe
- TC Energy's Coastal GasLink seeks damages from contractor
- Schneider Electric report: digitalisation will create new OT jobs
- Rystad Energy: impact of fluctuating weather in northern hemisphere

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**Stuart Parker, Oil and Gas Industry Principal, AVEVA, discusses six ways digitisation can optimise pipeline operations.**

**T**he global pipeline market picture is more nuanced and unpredictable than at any other time in history. The industry is presented with complex new challenges, as well as vast opportunities. A heightened demand for energy security is driving demand for expanded oil and gas pipeline infrastructure. Now, industry executives must balance stakeholder expectations, including affordable and flexible energy, profitability, and environmental sustainability – particularly mandated decarbonisation targets. What's more, companies must strive to reduce operational costs and their carbon footprints across complex value chains, including a growing and ecosystem of business partners.

As a result, more companies are looking to digital transformation to drive effective capacity, not only through CAPEX, but also OPEX investments. By using analytics to augment and empower the workforce, pipeline operators can optimise operations and improve asset availability, creating scalable business models with shorter lead time, all while swiftly responding to market changes.

Today's forward-looking oil and gas companies are installing intelligent pipeline frameworks to quickly turn massive amounts of data into wisdom that generates business value. By using existing operational data as well as new data sources, companies can take a model-focused approach that puts them on the path to operational excellence.

When organisations successfully execute these digital transformation strategies, teams can uncover opportunities to significantly improve equipment reliability, operational efficiency, safety, and overall business performance.

# THE INTELLIGENT FUTURE OF PIPELINES



## Not all data is equal

Oil and gas pipeline companies were collecting huge amounts of operational data long before the term 'Industrial Internet of Things' (IIoT) was coined. However, turning vast amounts of raw data from SCADA, pipeline applications, ERP systems, and more, into contextualised information around equipment and processes is often challenging. Contextualising this data ultimately enables operational improvement.

Not only does a wealth of raw data, devoid of context, structure, or quality, rarely pay dividends, those tasked with utilising that data often find it difficult and cumbersome to extract insights. If users are too slow to develop and implement sustainable solutions, the company will accrue significant lost opportunity costs. When unstructured operational data builds up in data lakes, traditional IT technologies can create more problems than they solve, as businesses must spend more time wrangling data than using it to deliver business value.

Unfortunately, many companies are rushing to layer in new technologies and solutions, such as cloud, machine learning, edge, IIoT, and predictive analytics before building the right data and analytics foundation. Adopting these new solutions can potentially deliver new and valuable insights, but pipeline companies must first enact solid data management and analytics strategies. Deploying an enterprise-level, real-time data management platform lays the foundation for future technology success.

## Know your data

To produce actionable intelligence, data must be structured and accessible to those who can best use it, particularly subject matter experts who have the knowledge and experience to put data insights into action.

Digital transformation success hinges on having a single source of truth. Operations data must first be standardised and contextualised before it can be analysed and visualised. Comprehensive data management systems can lay the foundation for operations data integration, data validation, and analytics. AVEVA's PI System, for an example, is an agnostic data management platform that combines, abstracts, and normalises disparate data sources from multiple control systems and information silos into one centralised location.

A centralised operations data management platform then uses standardised and templatised tag-naming conventions and assets are cataloged in a flexible hierarchy. This platform becomes an operational system of record, creating the foundation to democratise insights across any pipeline business model.

Using the data model, companies can accelerate digital transformation by combining operational data into a digital replica of physical assets. This can be enabled by developing a 'digital twin' of the entire system using information such as drawings, 3D models, materials, engineering analysis, dimensional analysis, real-time pipeline data, and operational history.

During the operational life cycle, the digital twin is updated automatically, in real time, with current data, work records, and engineering information, to optimise maintenance

and operational activities. Engineers and operators can easily search the asset tags to access critical up-to-date engineering and work information in order to diagnose the health of a particular asset.

Previously, such tasks would take considerable time and effort, and issues were often missed, leading to failures or pipeline outages. With the digital twin, operational and asset issues are flagged and addressed early-on and the workflow becomes proactive instead of reactive. Pipeline companies can easily benchmark operational performance, such as pipeline throughput and energy consumption, to uncover gaps and improve pipeline efficiencies.

## Digitising the pipeline

A pipeline management system enables advanced analytics and simulation capabilities to deliver safe and efficient pipeline operations, leak detection, and operator training software.

The real-time process data from the pipeline management system can be fed into analytics and simulation modules with the ultimate goals of optimising overall pipeline throughput, process conditions, and even predicting equipment failures. These analytics use advanced pattern recognition, statistical models, and machine learning technology to model an asset's operating profile and processes.

Below are six use-case scenarios where Intelligent Pipeline companies can use data analytics on top of an enterprise pipeline management system.

### Liquid pipeline operations

Advanced simulation and analytics tools can be used to model and predict fluid flows in pipelines. This not only allows product and batch tracking and line pack, but also helps uncover improvement of throughput in existing assets. This improved visibility into operations enables pipeline operators to optimise throughput. What's more, they can plan for future infrastructure expansion to increase efficiencies and throughput to improve competitive advantage.

### Gas pipeline operations

Advanced simulation tools can be used to model gas flow behaviours and predict loads for current and future gas days in near real time. These insights enable pipeline operators to better balance supply and demand, optimise capacity, and better adhere to gas contracts.

### Pipeline leak detection

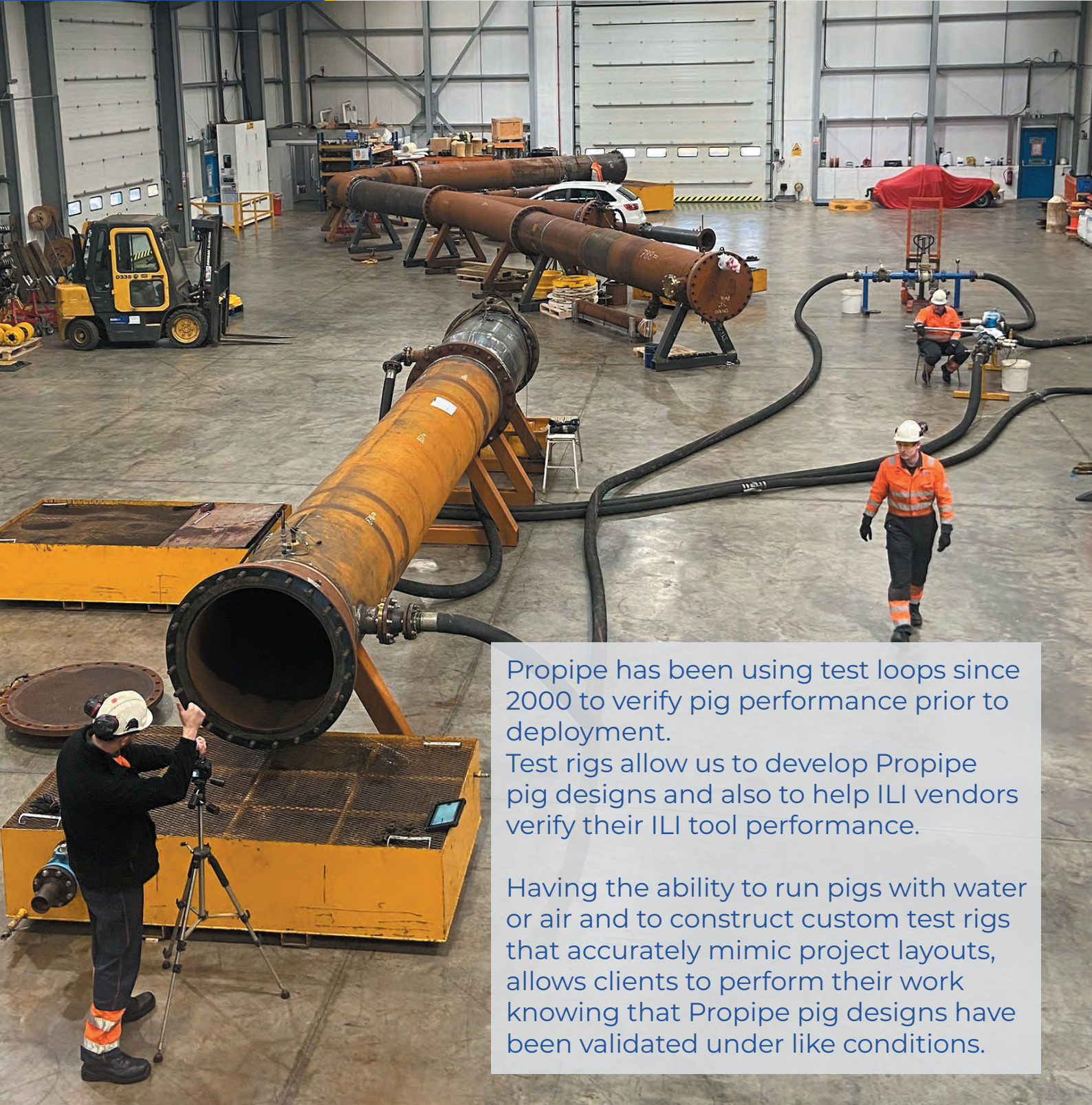
Quickly identifying pipeline leaks is key to minimising risks and preventing major spill overs, and many leaks go undetected by a single solution. There's no one-size-fits-all solution, and multiple detection technologies are often needed to detect different types of leaks that exhibit dissimilar flow patterns. Analytics can simulate liquids and gas flow and detect any subtle changes that could point to a pipeline leak.

### Pipeline training simulator

Training controllers are critical for ensuring operational safety and integrity while making sure all operations are adhering to a pipeline operators' safety and compliance programme. The



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pipeline training simulator is an operator training system that allows pipeline controllers to train on normal and abnormal operating scenarios in a safe and realistic environment. Operators can navigate actual pipeline operations and receive certifications before they assume the roles and responsibilities as a controller in a live operating environment. Major oil and gas operators have significantly reduced training costs and time to proficiency by using simulators as part of enterprise-wide training programmes.

### Fiscal measurement

The accurate measurement of volumes is extremely important to ensure correct and timely accounting, both internally and at custody transfer points, and pipeline companies must use available data to improve accuracy.

While SCADA and production measurement software provide features to identify issues with measurement, there are opportunities to perform analytics on measurement and raw data to provide earlier indications of issues.

### Autonomous control


Through analytics, expert systems, and artificial intelligence (AI), future operational systems will become even more automated – from the scheduling through to product delivery. This level of autonomous control will be enabled by better data for operator decision making, followed by recommendations and what-if scenarios, and will gradually result in automated control during normal, and eventually abnormal, operations.

Pipeline companies are starting to make use of action sequences which allow ‘canned’ sets of commands chained together with pre-and post-action verification to ensure the commands are executed safely and correctly. Utilising pipeline data analysis to drive actions using a rule-based approach can enable pipeline companies to improve outcomes when performing operations where timing of the actions is critical.

For example, when changing the mode of operation for liquids pipelines with sharp changes in elevation, the timing of pump and valve changes avoid problems, such as cavitation. Rather than relying on operator reaction to the data being presented, system analysis of the data can trigger the next action sequence more efficiently and effectively.

### The future of pipeline is undeniably intelligent

The oil and gas pipeline industries are under tremendous pressure to adhere to constantly changing regulatory requirements, increase agility to succeed in a rapidly changing business climate, protect cybersecurity concerns, and meet global sustainability goals.

An intelligent pipeline strategy enables companies to create new capabilities, new business models, and innovate ahead of the competition. By deploying information management systems, powerful analytics, automation of workflows, and driving behavioural change in workforce, oil and gas companies can evolve and change how work is performed to build a sustainable, profitable organisation. 

# THE PALLADIAN ENERGY PODCAST



## SERIES 2: SUSTAINABILITY IN THE OIL AND GAS SECTOR

### EPISODE 4

CHEMISTRY AT WORK: SUSTAINABILITY IN THE OILFIELD

### EPISODE 5

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Ryan Conger, Technical Sales Manager for APM at ABB Energy Industries, discusses taking asset performance management to the next level using industry 4.0 technology, and how these digital solutions can help pipeline operators drive efficiency, predict failures, and reduce downtime.

**T**ransferring hydrocarbons safely, efficiently, with no unexpected failures or shutdowns, and with minimal impact on the environment remains the overarching goal of pipeline projects worldwide. To achieve these aims, operators have at their disposal a range of digital and automation

# THE POWER OF PREDICTION

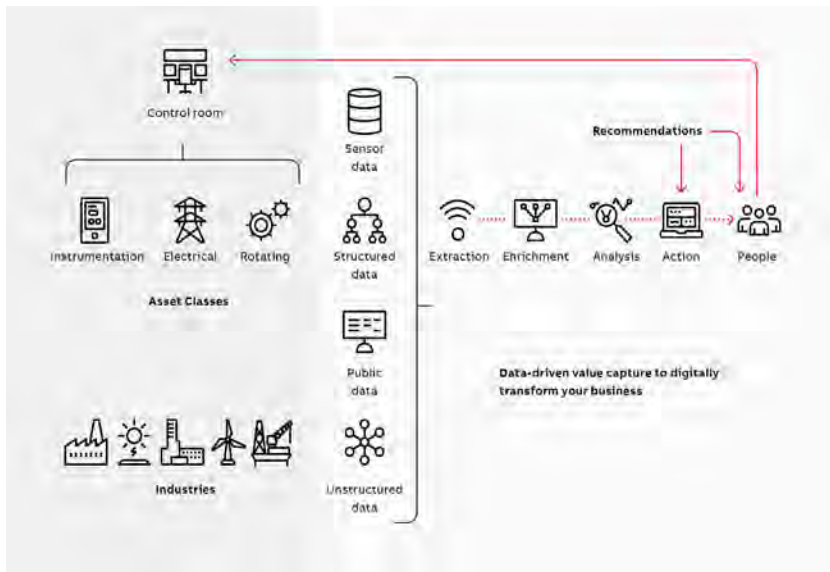


Figure 1. APM is a key element in the digital revolution.

solutions such as pipeline modelling, augmented operations, and compressor and pump station simulations – all of them enabled by rapid, secure, high-availability communications and dedicated fibre optic backbones – that offer visualisation along the entire pipeline network, often from a single location.<sup>1</sup>

From a technology perspective, artificial intelligence (AI), machine learning (ML) and data analytics are increasingly becoming embedded in pipeline operations, gathering vast amounts of real-time data on cathodic protection and leak detection systems<sup>1</sup> using wireless sensors, and making that information available quickly and securely to personnel via a distributed control system (DCS).

Asset performance management (APM) is a key element of this digital revolution. Monitoring the health and efficiency of critical pipeline assets with ‘APM 4.0’ enables operators to identify and address process upsets before they incur damage. Using quantitative risk analysis and the current state of machine health solutions, customers can leverage the data available to them to optimise operations, reduce energy consumption and emissions – and maintain competitive advantage.

In this article we will explore how APM has evolved from traditional run to failure or time-based modelling to today’s data-driven solutions, how ABB’s portfolio of ‘vendor agnostic’ APM tools can help pipeline customers monitor and enhance the physical integrity of their systems and take a closer look at APM 4.0 in action at a compressor station in Poland.

### The brave new world of data driven APM

First, a brief history of APM illustrating how it has evolved over the few decades, driven by technology. Taking a bottom-up approach, most enterprises began by simply fixing equipment when it broke, which has obvious drawbacks in terms of unscheduled downtime and maintenance costs.

Then, using an automotive analogy, industry began to think ‘rather than running out of gas on the side of the road, we’ll fill up with gas each week,’ which led to a time or calendar-based perspective on APM. The drawbacks of using a schedule to assess a potential failure is that it treats every piece of machinery as being of the same importance, rather than prioritising critical assets and also uses time as the only ageing parameter.

Manufacturers began to deduce that ‘maybe breakdowns are dependent on how many kilometers or miles I drive,’ which constituted a significant leap forward into usage-based maintenance, whereby failure modes and effects analysis (FMEA) and reliability-centred maintenance (RCM) were also used to prioritise critical assets. However, this too had its shortcomings, in

that it failed to leverage real-time data, instead basing maintenance on how and when an asset has broken down in the past. In real-world operations, research has shown that 82% of asset failures happen at random intervals.<sup>2</sup>

Advanced condition monitoring, therefore, became much more about closely monitoring how specific pieces of equipment operate and behave – the equivalent of medical screening, where a physician takes the patient’s blood pressure, weight, etc. – leading to the use of rotation and vibration sensors to more accurately monitor the health of critical assets in real-time, leading to predictive maintenance. To revisit the car analogy, it’s the inclusion of measuring the fuel tank level as well as using the fuel economy to calculate a time to empty. The benefits are obvious: maintaining industrial assets efficiently (i.e. only when needed) has been shown to decrease maintenance costs by 20 – 30%, and machine downtime by as much as 20 – 50%.<sup>3</sup>

So, we have arrived at what can be described as a more top-down approach to APM, where industry 4.0 innovations such as AI and ML are informing predictive maintenance of critical plant assets. The aim is to take a more holistic view of the operational ecosystem to try and not only assess the risk or probability of a failure occurring, but also the severity. Using this predictive approach, operators can then make the call on which specific piece of equipment – gas turbines, compressors, switchgear, instrument, etc. – should we prioritise with a view to maximising uptime, production efficiency and profitability. This form of monitoring can also be expanded to encompass multiple facilities for maximum benefits.

### ABB’s vendor agnostic APM strategy

Earlier on, we mentioned ‘vendor agnostic’ APM solutions. What do we mean by this? Well, with solutions such as ABB’s Genix APM Suite, adding advanced asset condition monitoring to existing operational technology (OT) landscapes is easy. ABB has a key advantage in this regard in

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that the company is a technology leader in the automation space, meaning many of our customers already employ our automation solutions. As a result, our engineers can often get their systems up and running faster and help them close the loop in terms of getting the information back down to that control layer.

Another differentiator is that the majority of OEMs are adding some sort of condition monitoring and even AI solution to their equipment, but they have their own proprietary software that you have to use to get at it. ABB's strategy of being data agnostic and combining all assets – electrical rotating instrumentation, IT equipment, fixed equipment – in one place seems to really be resonating in the market. This agnostic approach uses adapters to convert data from non-ABB CMMS systems into a format that can be understood by ABB technology and collated in a single location, where ML/AI and 'first principles' models (based on the engineering design and physics behind the way a piece of equipment operates) can be utilised to evaluate the status of assets and detect any potential issues.

ABB's Genix APM Suite, for example, drives significant improvements in operational sustainability. By assessing the remaining useful life of industrial assets, the platform generates a preventive maintenance plan that can extend equipment uptime by up to 50% and asset life by up to 40%.<sup>4</sup>

The company's strategy of combining the 'big three' APM solutions – proven experience as an OEM of electrical, rotating and wireless sensor instrumentation; advanced digital, automation and data analytics software; and finally, the ability to either move APM to the Edge (on premise, next to the asset) or run it in the cloud – into a single, unified offering is fairly unique in the market right now.

Say a customer wants to use real-time data to predict vibration failures, and that it must be closed loop and integrated back into the safety system which are not cloud accessible. With a click of a mouse, wired and wireless sensor data on the Edge can be integrated into the existing OT system. The data can then be analysed, with outputs/alarms sent via email or common dashboards.

### Case study: APM in action in Poland

Let's look at how these technologies can be applied in a real-life industrial project – in this instance a pipeline tank farm and pumping station – and how they offer personnel insight and control over key processes, enabling managers to make more informed, data-driven decisions to add business value.

The customer in question is a leader in crude oil logistics in Poland, and as such operates crude oil and gasoline product pipelines, storage facilities and terminals throughout the country. The client reported unplanned stops at a redundant pumping station, used to relieve primary systems in the event of a failure. The lost redundancy was leading to reduced transfer of gasoline product and a higher risk of second failure during repair time. Manual site inspections were both costly and time

intensive, an issue compounded by the fact that the customer had limited maintenance capacity.

ABB was tasked with installing an on-premises solution that enabled personnel to remotely monitor vibration levels and predict deterioration trends. The strategic importance of the business meant a non-cloud offering from ABB was necessary due to cyber security and data privacy concerns.

Following a pilot deployment, ABB's APM advanced condition monitoring system was deployed along with Smart Sensors for Bearings and Next Generation Smart Sensor for Hazardous Areas.

The combined offering enabling automatic, wireless monitoring of electric motors and rotating equipment, helping to detect both machine vibration and temperature anomalies that could potentially lead to equipment failure and production downtime, with remote access for maintenance and management staff.

The results? The customer benefited from continuous data collection, transparency around asset health, improved fleet management and better failure prediction thanks to remote monitoring of the customer's internal network. Wireless condition monitoring infrastructure via Bluetooth proved to be more cost-effective than some traditional wired solutions (typically up to 50% cost savings).<sup>5</sup>

### Investment in human capital

There is another important dimension to the discussion – that of talent attraction and retention. The technology transition must be supported by the transformation of processes and people to reskill current workers, ensure that invaluable industry experience is not lost as people retire, and, of course, to attract the new generation of qualified, digitally literate talent to process industries.

One way of approaching this is to make sure the knowledge of APM theory and practice is templated and then used to inform R&D around failure modes and effects libraries; in other words, automate that knowledge into present and future APM applications as much as is possible. This will not only make APM technologies more efficient, but it will also reduce the time needed for new industry recruits to get up to speed. Experience informs technology, and people will remain the most important asset.

In conclusion, time-consuming reactive maintenance is becoming a thing of the past, to be replaced by APM 4.0 solutions that give pipeline operators unprecedented visualisation over their operations, enabling them to predict and avert downtime and keep the hydrocarbons flowing. 🌐

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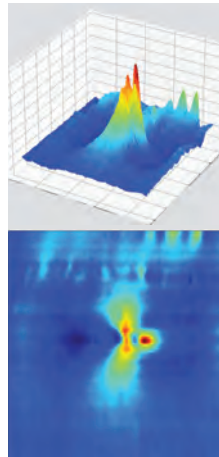
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**Sheeraz Ahamed Khateeb,  
Rockwell Automation, USA,  
explains how adopting  
edge solutions is pivotal  
for pipeline operators  
looking to extract  
value from data.**

In the current highly volatile market, midstream oil and gas companies are under pressure to ensure their operations run at maximum efficiency. For pipeline operators, this is made more challenging by the remote, decentralised assets and infrastructure of their operations. To effectively collect, manage and utilise data from their widely distributed networks, edge solutions are playing an increasingly important role. For these organisations, operational excellence begins at the operational edge.

These assets and equipment must be managed in real-time with limited resources and personnel. According to a recent Gartner report, most new data will be generated at these remote assets. To unlock its value and usefulness, midstream operators must deploy new computing architectures that eliminate the scale and capacity constraints currently existing at the operational edge, due to legacy infrastructure and standard computing resources.

As pipeline operators continue to digitalise their operations, many have turned to edge computing to modernise and optimise processes, improving the efficiency and effectiveness of their critical automation and control solutions. Edge computing is an innovative approach that can overcome the challenges of conventional architectures, including islands of automation, unplanned application downtime and data loss, and the lack of a simple way to manage solutions.

According to the World Economic Forum's report '*Digital Transformation Initiative: Oil and Gas Industry*', digital technologies can unlock up to US\$1.6 trillion of value for oil and gas companies, their customers, and society by 2025. To gain the value of these new digital technologies, particularly advanced Industry 4.0 capabilities, pipeline operators must overcome the unique challenge of applying solutions across geographically dispersed and often remote assets.

Renowned analyst firm, IDC, predicts a strong outlook for edge solutions as they attract the attention of C-suite executives. According to an IDC survey, 73% of senior IT and line-of-business decision-makers view edge as a strategic investment. These organisations are looking to edge as a way of increasing productivity and improving security, leading to faster, more informed decision-making. IDC also predicts that by 2023, more than 50% of new enterprise IT infrastructure will be deployed at the edge rather than corporate infrastructure; by 2024, there will be an 800% increase in the number of applications at the edge.



**MOVING**

**TOWARDS**

**THE**

**EDGE**

## To the edge or into the cloud

Edge computing can benefit various verticals, including discrete, process, and hybrid manufacturing. This technology helps companies that generate substantial amounts of data daily and need actionable insights to optimise their operations and enhance business outcomes.

As organisations adopt digital transformation (DX) initiatives to improve operational efficiency, success depends heavily on putting industrial data to work. Industrial organisations usually operate in a distributed manner, sometimes with plants worldwide. A mid-size manufacturer often has several or many manufacturing models, hundreds of different types of equipment, a variety of suppliers, and vastly different cultures or nationalities throughout the workforce. As organisations attempt to achieve the IT/OT convergence goals, they must make substantive shifts using the prevalent technology paradigms, namely the mature cloud computing solution and the less mature edge computing option.

With cloud computing, organisations can transmit voluminous industrial data from plants, equipment, machines, vehicles, and controllers to IT/OT applications through an internet connection, but the infrastructure details behind the scenes are hidden from the end user. With edge, the computing resources are placed closer to the user or the device at the network's edge. Edge computing can enhance OT solutions by addressing cloud computing issues such as performance, latency, bandwidth, security, and proximity. Through these, it can power the next industrial revolution, transform manufacturing, and promote an agile business ecosystem that is more efficient and easier to manage.

The edge approach emphasises reduced latency and provides more processing of data close to the source, eliminating a lot of round-trip data movement. This means that edge computing is helpful for use cases that involve time-sensitive and data-intensive applications. These applications can deliver near real-time performance by computing resources closer to the source of data generation. Moreover, these applications help prevent overloading of the network backhaul by processing more data locally and being selective about the amount and frequency of data sent to the cloud. By keeping data local, you also achieve better security, privacy, and data sovereignty.

## Advantages of edge computing

There are four significant advantages that edge technology offers to pipeline operators. These are: lower latency, lower bandwidth limitations, higher performance, and more robust compliance. The most common motivator for edge solutions is attributed to network latency, which represents a delay between an application request and the resulting response. For real-time applications, even milliseconds matter. In an OT environment, unpredictable latency could mean increased defect rates or safety issues.

With the proliferation of IoT devices and other connected equipment at the edge, such as controllers – RIO, PLC/DCS – or RTU, data generation is growing exponentially. Depending on the location, high-speed network connections may not be available or could be prohibitively expensive. Thus, to address AI use cases requiring large data volumes at the edge, organisations are

using edge computing to reduce data transmission requirements by filtering and processing data locally. Higher performance is a direct advantage of achieving lower latency and bandwidth. By placing infrastructure and applications closer to data generation and consumption, the overall performance is optimised – leading to a better user experience.

Another advantage is that edge computing also limits the movement of data – helping address corporate governance policies or other regulations that require sensitive information to remain onsite. In Europe, the General Data Protection Regulation (GDPR) dictates data sovereignty rules regarding where data can be communicated and stored. Other jurisdictions are following suit, with legislation such as the California Consumer Privacy Act (CCPA). Edge provides more control over such compliance.

Lastly, edge computing improves business continuity. As more organisations automate operations, it is imperative that the underlying systems remain available even if the network or cloud is not. That said, cloud is highly reliable with very high up time, in the region of 99.9999%. Every primary cloud provider has had an unforeseen service outage over the past year – and will most probably continue to do so. However, applications running on edge infrastructure can continue to function until network services are restored, limiting the impact on business operations.

## Challenges around the edge

The move to the edge comes with its challenges. When it comes to security, edge locations are often remote and have relatively limited resources, unlike a corporate headquarters location, where there may be an on-premises datacentre, high-speed internet connectivity for access to the cloud, and onsite IT staff. Few organisations can afford to install redundant high-end servers, storage, and networking equipment in all their remote locations. Instead, they may install critical applications on commodity servers or even desktop PCs that do not have redundant components. Even more dangerous is that edge locations may not have a server room or other environmentally controlled spaces for IT equipment. The lack of redundancy, adequate power, cooling, or ventilation can introduce a single point of failure.

Many remote locations today are connected to the corporate datacentre and the cloud by a broadband Internet connection from a local Internet service provider (ISP) with minimal service level agreements (SLAs). Suppose broadband Internet is unavailable in specific remote locations. In that case, more expensive private circuits may need to be installed, or the site may need to use 4G or 5G cellular connections with relatively costly and limited data plans. For organisations that do not deploy any infrastructure at their remote locations, an Internet outage can mean a complete work stoppage at a remote location.

Finally, specialised IT staff are generally located at the corporate headquarters. Remote locations may have little or no onsite IT staff, which means a complete stop when systems are down. For sites that have no onsite IT staff, remote access from the corporate headquarters to commodity IT equipment in the edge location can be challenging, with limited remote management tools and no hands-on capabilities.

## Edge solutions

FactoryTalk® Edge Manager™ software from Rockwell Automation provides the intelligent, centralised edge management infrastructure necessary to leverage edge computing across the enterprise. It addresses the edge management and orchestration challenges while empowering OT administrators to centrally configure and manage fleets of edge devices at the enterprise level. These capabilities will enable faster software deployment and create affordable access to data and a future-ready analytics platform.


The software can be accessed from anywhere with an internet connection, and the IT/OT administrators do not need to be physically present next to the managed devices. The solution is exceptionally secure. Customers can shorten the exposure time due to any vulnerability and maintain the most robust security posture on their physical assets.

These compelling capabilities position Rockwell Automation to excel at the edge, now and in the future. As Rockwell Automation keeps innovating across business units, more and more applications will require a place at the edge. By building a managed edge with a marketplace of trusted applications, they are confirming that we will continue to deliver positive business outcomes as operational technology evolves to include more analytics software. With the orchestration capabilities of FactoryTalk Energy Manager software across VMs, the majority of the existing software portfolio can be deployed and managed at the edge, including FactoryTalk ProductionCentre® (MES),

FactoryTalk Analytics™, FactoryTalk Remote Access™, and FactoryTalk DataMosaix™ and Plex solutions.

FactoryTalk Edge Manager is technology agnostic, and can manage and work for any make of edge device. It is also very agile any can easily be updated to incorporate future additions or modifications for brands available today as edge suppliers. This is achieved by FactoryTalk Edge Gateway™, which has a marketplace to accommodate updates and revisions.

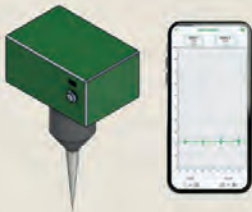
As the Rockwell Automation software footprint becomes more optimised for containers and clusters in the runtime environment, more software can be deployed on each edge device within the compute, network, and memory constraints. Notably, the application marketplace in FactoryTalk Edge Manager can support deploying applications inside a virtual machine, a container application, or a Kubernetes cluster application on the same computer – providing maximum deployment flexibility and futureproofing to customers.

Edge computing is the ideal foundation for pipeline operators to accelerate digital transformation and enable equipment reliability, application availability, and new operational insight by capturing data at the point of origin. Rockwell Automation also has edge devices from the ASEM™ range. In doing so, pipeline operators can achieve the results that matter most: increased employee safety, improved decision-making and visibility, operational excellence, lower carbon footprint, and increased customer satisfaction for greater profitability. 

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# A SUSTAINABLE FUTURE WITH AUTOMATION

**Vicki Knott, CEO, CruxOCM, explains the environmental impact of improving pipeline operations.**

**F**undamentally, the pipeline business is about moving energy products safely and efficiently. The product of the energy industry itself is, of course, the Joule and our customers are consumers of energy, which is all of us.

If we think about the word ‘product’ like we think about apps that we use on our phones, or items that we purchase on Amazon, then the ‘product’ of our pipeline businesses is moving that Joule, safely and efficiently. The industry has been rightly focused on safety and now with our consumers of energy demanding a lower carbon Joule, we have to find ways to get as efficient as possible. What’s better than safe reliable energy? Consumers are demanding that the products we provide be safe, reliable, and clean.

Crude, refined products, and NGL pipelines (hence forth known as ‘liquids pipelines’) are my personal bread and butter from an operational perspective, so I will focus this article on what sustainability and the environmental impact of working towards optimally efficient pipeline operations looks like from my experience. Then I will follow up with what folks can do to maximise efficiency. Efficiency, after all, reduces environmental impact and the first necessary step towards energy sustainability.

The liquid pipelines business is both simultaneously complex and simple. The physical composition of batches of product, combined with the elevation profile, results in a continuous real time, time series dynamic system – i.e. steady state operation really is never actually steady state operation. These are the complexities that are managed every minute of every day by control room operators. These complexities in operations are exactly where the opportunity is for us to have a positive impact on the path to energy sustainability and mitigating any potential for environmental impact for our liquid pipeline operations.

To think about liquid pipeline operations simply, many folks will think of pipeline operations as a logistics problem, like train cars or trucking. This is also true; however, the devil is in the details of course. There are many times I have heard folk’s rebuttal to the fact that their pipeline is underutilised with “we meet 100% of our contracts, there isn’t any opportunity for improvement”. That is so far from the truth. Most pipeline operators we speak with are between 80% and 90% utilisation of their pipelines, meaning that increasing the utilisation of the asset by 5% or more is very realistic. Increasing utilisation of our existing assets means that we are increasing the volume of petroleum products that are moving. Some folks may interpret that as not a positive move towards sustainability; however, I firmly disagree.

Moving more product in an intelligent way by minimising the energy required to do so results in a reduction in emissions per barrel – which is exactly what we need in the near-term energy transition. We do not know if we will ever get to 100% renewables globally, but it is our responsibility to provide our customers with a product that they want to purchase. Joules that are safe, reliable, and clean. Reducing emissions per bbl is a massive impact that can be made today for not much more than software installations and commissioning. Capital projects to add new pump stations are not necessary. Electrification is also required for full decarbonisation; however, in this article I am highlighting the nuance and effectiveness of a broad and solid digital/automation strategy.

Levers to achieve increased utilisation, reducing emissions per barrel:

1. Digitalisation.
2. Reduce latency in human processes.
3. Automation.

### **Digitalisation**

Digitalisation of our pipeline operations has been underway for over a decade with amazing progress to date. It is more common than not for pipeline operations teams to have already migrated operations from field only to a central control room with digital data feeds and visualisations for pipeline operations. Since there is a fantastic playbook to get ourselves that far I will not spend any additional time on this first step. I mention it because it is crucial to steps number 2 and 3.

### **Reduce latency in human processes**

Once operations are digital, there needs to be connectivity to the business unit that needs production data to make decisions on how to run the business. In a typical monthly nominations cycle (yes, even for simple systems) it can be multiple times a week that product batches are diverted to other locations, they do not arrive, there are new maintenance requests, and/or unplanned outages happen, all of which result in a change to the nominations plan that was set at the beginning of the month and must be managed/communicated to all of the correct parties.

If you are one of the employees on the sharp end of that, whether that be in hydraulics engineering, maintenance planning, scheduling, and the control room, you are well aware that the data pulling, teams messages, flurry of emails, phone calls, can probably be done better. Latency in human decision making as a result of inefficient human processes results in lost value capture. When it comes to running a business, its mission critical that all decision makers have timely access to accurate information. In the current business operations between these various stakeholders, the interactions internally are all via antiquated human process, like email, phone calls and attaching excel files. What I believe needs to happen here is access to real time dashboards that show the correct information for the correct stakeholder. This sounds straight forward and like something that should already exist – but it doesn’t.

I think there is a massive opportunity to surface the right data, to the right people, at the right time in our midstream operations to minimise latency in decision making, ultimately capturing more value.

### **Automation**

Once everything is digital, and we are surfacing the right data to the right people at the right time, then there is opportunity for advanced automation at the business level as it pertains to the exchange of information. By way of example, automated push of an unplanned pipeline outage to the scheduling team, hydraulics engineering, and maintenance planning. That automated push alone may

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save hours of decision making time, ultimately increasing asset utilisation.


I feel strongly that this concept can be then abstracted to the energy supply chain as a whole. Imagine being an employee at a very large department store like say Wal-Mart and not having a real-time inventory tracking system that is accessible to all employees that need the information to make critical business decisions as quickly as possible. It simply would not fly in this day and age since the technology is available to us, yet, our energy supply chain does not yet have that visibility, likely due to the magnitude of the industry as a whole. At this time that

is understandably so, because as an industry we have not yet felt existential pressures that other industries have experienced, like video rentals, or newspaper, but some folks say it is coming and I agree; the only constant in this world is change. What we do have though is a playbook for this level of visibility into businesses from other industries that we can use – we just have to collectively zoom out to see the forest for the trees. I of course understand that there is commercially sensitive information and so opening up the coffers and sharing all data with everyone is not an option; however, if folks truly understand their business, they will know exactly which live data streams they need

where and when to be effective, without compromising security.

Regarding the energy supply chain concept, the most impact that digitalisation and modern human processes can have I believe is in the pipeline sector. Pipelines do not typically get the same fan fare as refining, drilling or production. Our piece of the industry may be boring but it is crucial to unlocking the system as a whole and is conveniently located between production and refining, meaning that any value that is unlocked will have a trickle effect up and downstream, enabling more production and additional refined products (assuming capacity is available of course).

Once this level of data is available, then the power of AI can truly be unlocked. Until then, we may be incorrectly focused on what I call 'point optimisations' with AI that look great for sustainability and emissions reduction in a silo, but do not have an actual impact across a midstream organisation or supply chain as a whole.

As folks in the energy sector, we live firmly in the physical world but to bring our operations to the next level of sustainability and environmental impact reduction in what may be becoming an existential time for our industry, we will need to think in the abstract. The energy sector has the brightest minds in the world, I believe that if any group of folks could achieve an integrated supply chain to make an immediate impact on decarbonisation and increased efficiency at the scale of the energy sector, it will be us as a collective. 

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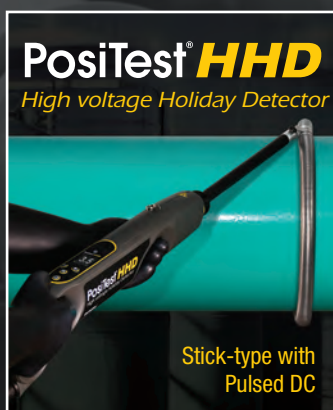
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# Coatings



## **Dr. Jeffrey David Rogozinski, Global Product Director, Sherwin-Williams**

Dr. Jeffrey David Rogozinski has more than 30 years' experience in coatings and academia and is responsible for developing protective coatings, powder coatings, resins and additives for the oil and gas, pipeline, and bridge and highway markets. He is a member of several coatings associations and a consultant for global specification writing for CSA Group, the International Organisation for Standardisation (ISO), ASTM International, NACE International and others.

## **Justin Hair, Global Energy Midstream Market Manager, Sherwin-Williams**

With more than 30 years of service dedicated to the oil and gas coatings industry – both as an industrial painting contractor and a Sherwin-Williams global energy team member – he has specialised in multiple subject matters related to challenges facing the aboveground petroleum storage tank industry, with additional focus on pipeline construction, pipeline coating rehabilitation and pipeline repair. He is an AMPP Certified Coating Inspector and also serves as a committee member with the American Petroleum Institute.

## **Eric Stark, USA Technical Director, Denso, Inc., a member of Winn & Coales International Ltd**

Eric Stark has a PhD in Chemistry from the University of Washington and has worked for Denso, Inc. for the last 12 years managing the research and development of Denso's liquid coatings. In 2018 he helped design and build a state-of-the-art laboratory at Denso's new Telge facility in Houston (USA). With his extensive technical knowledge, Eric oversees a team of chemists that work on future developments for Protal™, Archco™ and Viscotaq™ coatings.

## **Julie Holmquist, Content Writer, Cortec® Corporation**

Julie Holmquist has been the Content Writer at Cortec Corporation since November 2015. Over the last eight years she has gathered a wealth of knowledge about corrosion protection in a variety of industries. In particular, she has had the privilege of learning from several subject matter experts who have worked with corrosion protection and preservation in the oil and gas industries.



## What type of coatings does your company provide and how do they meet the challenges faced by pipeline operators and owners? What are the primary performance characteristics of your coatings products?

**Dr Rogozinski, Sherwin-Williams:** Sherwin-Williams Protective & Marine provides liquid and powder coating solutions for pipelines and related assets. That includes both shop-and field-applied coatings that support the full stream of oil and gas development and use – from exploration to consumption.

Our solutions exceed the industry's most stringent performance requirements for preventing corrosion on and inside pipelines and associated assets. That includes meeting today's complex operational challenges related to higher temperature substances with harsher chemical moieties coming out of the earth. It also includes protecting pipes from damage and moisture in terrains that are rockier, wetter and more varied than ever before.

To effectively fight corrosion, our coatings offer intrinsic barrier properties that stop moisture and electrolytes from working their way into and underneath them to threaten the steel substrates below. They have excellent adhesion to ensure a strong, lasting bond with pipelines and other assets. In addition, our coatings prevent damage from both chemical and physical attacks. We're able to attain this array of properties because we control the molecule, and therefore, we control the paint.

**Eric Stark, Denso, Inc.:** Denso, Inc. – a member of Winn & Coales International Ltd – supplies protective coating solutions for a wide range of field-applied pipeline applications. To address the many application types utilised in the field, Denso supplies an extensive range of products using numerous materials such as liquid epoxy, vinyl ester, and urethane coatings, petrolatum tapes, viscoelastic coatings, fibreglass wraps, bitumen tapes, and butyl tapes. Primary among the liquid coatings are epoxy-based coatings used for coating weld seams, elbows and tees, etc. during construction, as well as replacement of damaged or defective coatings on existing pipelines. Protal 7200™ is the preferred liquid coating for this type of application due to its excellent balance of cathodic protection, fast return to service, ability to be applied using a variety of methods, adhesion, and abrasion resistance. Other Protal™ liquid coating options are also available to handle sweating pipe, directional drill pipe, high temperature pipe, and cold application conditions.

Our petrolatum, viscoelastic, fibreglass, bitumen and butyl tapes provide outstanding corrosion protection in combination with ease of application and minimal surface preparation. Once applied, they can provide corrosion protection over a wide temperature range. Our petrolatum tapes have a long history of over 90 years of successful service, and our Viscotag™ viscoelastic coatings have the added benefit of exhibiting self-healing behaviour if a holiday develops. Fibreglass wraps are used to provide additional protection for external forces on the petrolatum and viscoelastic tapes. Denso manufactures a heavy-duty fibreglass wrap (Denso Bore-Wrap™) that has been specifically designed for use on the weld seams and full lengths of directional drill pipe as an abrasion/gouge

resistant wrap. Finally, our bitumen and butyl tapes provide exceptional adhesion to pipe surfaces along with excellent corrosion protection.

**Julie Holmquist, Cortec Corporation:** Cortec® provides a variety of solvent-based and water-based anticorrosion coatings for metal. Water-based coatings are of special interest in these days when almost everyone is looking for ways to have a lower impact on the environment. They also are much more user-friendly than solvent-based coatings because of easier cleanup without the need for mineral spirits.

Cortec offers both permanent and removable coatings. Some of these are so inconspicuous that they can be applied on flanged or bevelled pipe ends and weld joints of pipeline segments, which often remain exposed until pipeline assembly. This can provide critical corrosion protection during the sensitive times of shipping and outdoor storage.

One especially suitable coating for weld joints is VpCI®-391. This is also one of Cortec's most popular removable coatings for manufacturers in general, as it leaves behind a dry non-tacky film that is barely noticeable and sometimes does not even need to be removed. It offers worker and environmental advantages of being water-based and having a low VOC of 0.4 lb/gal. (48 g/L). It can be brushed onto the end of the pipeline segment for approximately two years of protection during the shipping and storage stages of the construction project. Workers can rinse the coating off before pipeline assembly, if desired. VpCI-391 has also passed API 1104 weld strength testing when welded through without removal. In either case, VpCI-391 offers a convenient means of corrosion protection while the pipe segment ends remain exposed.

## How do you define correctly applied, fit-for-purpose pipeline coatings? Which standards do you hold up as the gold standard?

**Justin Hair, Sherwin-Williams:** Sherwin-Williams follows specifications based on guidelines from a variety of notable standards organisations, including ASTM International, ISO, AMPP, the CSA Group and the American Petroleum Institute (API). Company representatives have seats on committees with each of these organisations, including some serving in leadership roles.

Every industry specification written has relied on one or more of these global gold standards. Therefore, we develop fit-for-purpose pipeline coatings that meet and exceed the most stringent association-defined guidelines for field and shop applications. We also go further by meeting even stricter guidelines from asset owners that develop their own protocols that exceed global standards.

Importantly, we offer a breadth of material capabilities via our varied portfolio of coating solutions. This enables asset owners to use the right materials based on the specific project needs. For example, pipes meant for installation in Alaska can use coatings with cold weather flexibility, while pipes to be used in the Middle East can feature a different coating that meets higher temperature requirements.

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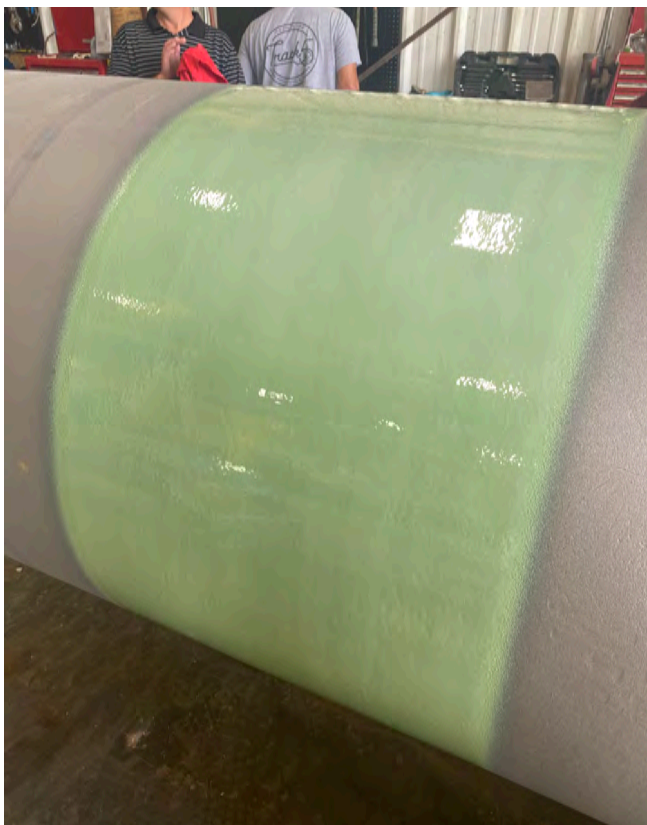
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**Eric Stark, Denso, Inc.:** Correctly applied, fit-for-purpose pipeline coatings are defined by proper surface preparation; mix ratio and thorough mixing (if applicable); lack of defects (holidays); and cured or applied performance properties, such as cathodic disbondment, adhesion, and hardness. There are several standards which apply to field-applied pipeline coatings regarding correct application and fit-for-purpose characteristics – these include AMPP SP-0105, ISO 21809-3 and CSA Z245.30 for field-applied liquid coatings. In North America, the AMPP and CSA standards are both highly regarded, but since a large



**Sherwin-Williams.** A moisture- and abrasion-resistant overcoat fusion-bonded epoxy (FBE) layer of Pipeclad® 2060 MRO is applied immediately after a base anti-corrosion FBE layer of Pipeclad 2000, allowing the two powdered coatings to crosslink before curing to form an extremely durable protective coating system for buried pipelines.



**Sherwin-Williams.** To protect girth welds from corrosion, Pipeclad 5000 can be applied in the field using automated liquid girth weld coating equipment.

percentage of pipelines are owned by Canadian companies the CSA standard is probably the 'gold standard'.

### **Can you talk about coatings in terms of innovation and advancements?**

**Dr Rogozinski, Sherwin-Williams:** When we think about innovation, we look at the market space and anticipate where the coatings will need to go and what exposures they will encounter. We think about the potential problems our customers may have when they explore new formations deeper in the earth and traverse new regions and unfamiliar terrain. In doing so, we are highly focused on the concept of purposeful design – controlling the molecule and controlling the paint – so we can give our customers an advantage.

To meet the needs of pipeline owners crossing undulated, rocky terrain with a heavy moisture content, our product development team created a new coating category called moisture-resistant overcoats (MROs). These robust abrasion-resistant overcoats (AROs) on steroids, including Pipeclad® 2060 MRO, not only offer excellent gouge, impact and damage resistance like a traditional ARO, but also reduce the rate of moisture ingress into the coatings. Reducing this absorption is critical, as any moisture that works its way to the pipe substrate can increase the potential for the coatings to delaminate due to fundamental adhesion loss and/or cathodic disbondment. The MROs are also highly flexible, enabling installations in difficult areas without worry of adhesion loss.

**Eric Stark, Denso, Inc.:** In terms of innovation and advancements, there continues to be effort placed on developing new coatings that can be applied at cold temperatures to broaden the window during which liquid coatings can be applied in the field. This is particularly important in Canada, the northern US, and other cold climate countries.

At all of our sites we have research and development teams who are continuously researching and developing our products and systems to meet these new demands.


### **How environmentally-friendly can pipeline coatings be?**

**Eric Stark, Denso, Inc.:** Pipeline coatings such as Protal 7200 are typically 100% solids – meaning virtually no solvent, which limits the contribution to airborne pollutants. In addition, once cured, the level of extraction of harmful compounds is minimal due to the inert nature of the cured coating. There has been considerable effort by suppliers to the pipeline coatings industry to offer materials that are sustainable and even recyclable, but these normally come at a cost. The extent to which the pipeline industry accepts these new materials, and the associated costs, will determine how environmentally friendly pipeline coatings can be.

Tape products are typically more environmentally friendly than liquid coatings due to the lack of reactive chemicals but are not suitable for all applications.

**Justin Hair, Sherwin-Williams:** All pipeline coatings are a necessary component to preserve and protect the integrity of

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buried pipes and, in turn, our environment. That's a sustainable aspect itself, but we go much further by carefully formulating our materials to limit emissions on the production and application end, while delivering the long-term performance needed to minimise future coating applications on the service side.

We're highly focused on removing any unnecessary volatile organic compounds (VOCs) from our formulations. Our liquid pipeline coatings are predominantly 100% solids materials featuring very little to no VOCs. In addition, our powder coatings are 99% efficient and have zero emissions.

The coatings themselves can also enable greater sustainability for pipeline installations. For example, ARO and MRO coatings offer the damage-resistance properties to enable the use of native backfill when laying pipe. This allows installers to minimise the trucking in of tonnes of softer fill material, which greatly reduces diesel fuel emissions.



Winn & Coales International Ltd. Protal 7200™ can be easily applied by brush, roller or spray in high and low temperature environments.



Winn & Coales International Ltd. Application of Protal 7200 in the field.

On the pipeline operation side, our interior pipeline coatings also help to reduce emissions. The coatings smooth out pipe interiors, enabling natural gas to flow more efficiently. That means less diesel fuel and power needed to run compressor stations, thereby reducing carbon dioxide emissions.

### What does application and training look like for your product?

**Julie Holmquist, Cortec Corporation:** Application of VpCI-391 is basically the same as for any other paint. Workers should make sure the surface is clean before applying the coating by brush. If the pipeline workers do not want to weld through the coating, they can use an alkaline cleaner such as those in the VpCI®-41x Series to rinse it off.

**Eric Stark, Denso, Inc.:** It's important to us that our customers feel confident in applying our systems and we take great pride in training teams to the highest standard in application methods. Denso provides free virtual training via Zoom and Teams using our dedicated in-house training facilities where we can physically demonstrate how to properly apply any of our pipeline products. We can also provide on-site training as needed.

As mentioned earlier, Protal 7200 can be applied using a variety of methods. These include manual application using an applicator pad or paint brush and spray application using a plural airless spray apparatus, an automated spray ring, or a spray gun using cartridges. After successfully attending the training on these application methods, the applicators receive a certificate card to carry with them to prove they have been trained on how to properly apply our products.

**Justin Hair, Sherwin-Williams:** Owners' specifications require documented product training for both shop and field applications of liquid and powder coatings. Based on the applicable standards for a product, we provide owners with a Manufacturer's Qualified Application Procedure (MQAP). This MQAP offers written documentation of application methods. We'll review that with an owner's training staff at a minimum, so they can train the individuals on the pipeline. We'll also perform that broader training ourselves at the owner's request.

Our application specialists are experts in both shop and field applications and can often deliver on-site training within a couple of days of a request depending on where it's needed.

### Can your coatings be customised or tailored to specific project requirements?

**Julie Holmquist, Cortec Corporation:** Cortec often works with the customer to customise coatings to specific project requirements. One example was the case of a tube steel manufacturer who needed a clear water-based coating to protect the outer diameter (OD) of tube steel pipes. The coating was required to have a 1 mil (25 µm) application thickness, zero VOC, and force-dry compatibility while protecting the oil and gas industry piping until end user commissioning. Cortec adapted by developing EcoShield® 386 FD, a permanent force-dry coating with only

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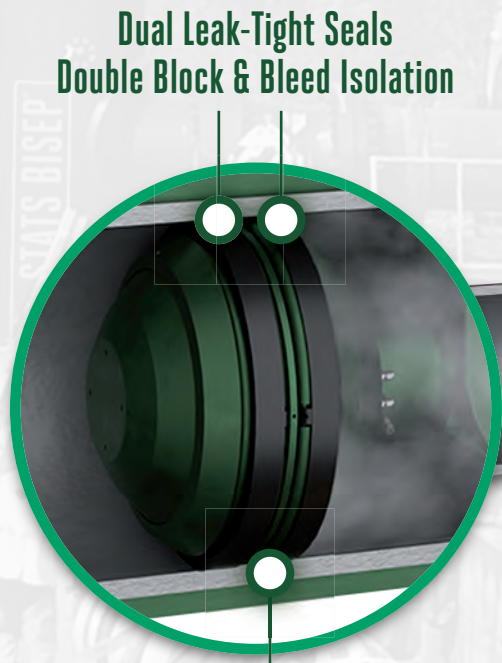
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0.04 lb/gal. (5 g/L) of VOC. A trial in which several hundred pipes were coated with EcoShield 386 FD and left outside for a year in a yard near the Gulf of Mexico proved successful and left the client very satisfied. Cortec can also adjust to various other performance and application needs such as adhesion, viscosity, foaming, and dry time to meet the customer specs.

**Dr Rogozinski, Sherwin-Williams:** With our tight control over the molecule and therefore the paint, we can carefully manipulate coatings to deliver the precise properties for an application – with some acceptable property trade-offs. For example, as we enable greater temperature resistance for a coating used in subsea drilling pipelines by sequentially


increasing its glass transition temperature, we may need to sacrifice a little flexibility or damage resistance in favour of that enhanced heat performance. We're able to carefully dial in those properties to arrive at the best formulation for the circumstances.

Sherwin-Williams had projects like the Whistler Pipeline in Texas in mind when developing Pipeclad 2060 MRO. The extremely durable coating allowed the pipeline installer to eliminate the time-consuming and costly step of wrapping pipes in a polymeric protective wrap to protect applied coatings from damage during trench backfilling operations. The coatings were able to withstand the force of rocks and debris raining down on the pipes during backfilling without

a protective wrap. The installer was also able to use native backfill in rocky terrain, saving significant time and money for the project.

Among our damage-resistant coatings, we have created molecular level composites that dissipate energy from impacts, so the coatings do not crack and therefore compromise the substrate underneath. This alone enhances corrosion protection for pipelines. However, should a pipe become damaged during horizontal directional drilling, for example, those same coatings are purposely designed to work synergistically with cathodic protection systems to enable continued robust corrosion protection.

**Eric Stark, Denso, Inc.:** Denso offers tailor-made solutions and is able to develop new products customised to specific project requirements when an existing product (or products) is not appropriate or approved for the application.

Typically, existing pipeline formulations are not changed in any way as they are normally qualified by owners and would require requalification if modified. However, Denso does have the capability to package coatings per customer or project requirements, and can also customise the width and length of tape products should this be required. 

**Notes**

Julie Holmquist, Cortec Corporation, would like to give special thanks to Eric Uutala, Technical Sales and Product Manager, and Luke Stone, Technical Service Engineer, Cortec Corporation, for their technical consultation.



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## A TRANSFORMATIVE FIBRE OPTIC PARTNERSHIP

**Hifi (Canada) discusses partnering with Trans Mountain to complete the world's longest fibre optic sensing deployment on a liquids pipeline, while ensuring comprehensive pipeline integrity.**

**H**ifi's engagement with the Trans Mountain Expansion Project provides high fidelity distributed sensing (HDS™) using specialised fibre optic technology for comprehensive pipeline monitoring along the full project length, which involves twinning of the existing 1150 km (715 mile) pipeline from Edmonton, Alberta to the Canadian West Coast in Burnaby, British Columbia. The new pipeline

will feature an extensive hybrid fibre optic network deployed during construction inclusive of a fully distributed fibre sensing architecture to monitor for leaks, integrity risks, and other operational applications, while also providing surveillance capability for both the existing and new pipelines. Once completed, this continuous HDS system will represent the world's longest fully distributed fibre optic sensing deployment

on a liquids pipeline. The project represents a significant achievement for both industries, as recognised by the Fibre Optic Sensing Association (FOSA) in awarding Project of the Year honours to Hifi and Trans Mountain for this initiative.

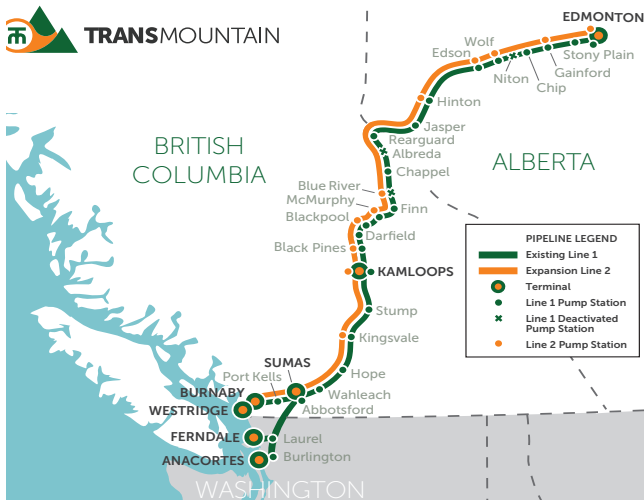


Figure 1. Trans Mountain expansion project map.



Figure 2. Pipeline Conduit Clips for expedited deployment.



Figure 3. Trenchless Crossings – Horizontal Directional Drills (HDD).



Figure 4. Burnaby tunnel deployment and concrete casing preparation.

Trans Mountain (formerly Kinder Morgan Canada) is in the process of twinning its existing 1150 km (715 mile) pipeline which extends from Alberta to British Columbia, Canada (Figure 1). The original 24 in. Trans Mountain pipeline was constructed in 1953. The Trans Mountain Expansion Project represents a major undertaking and consists of adding a combination of 36 in. and 42 in. pipeline along with 12 pump stations, 3 berths, and the addition of 19 petroleum storage tanks.

Hifi is a fibre optic sensing technology service provider based in Calgary, Canada which is partially owned by Cenovus, Enbridge and BDC. With these stakeholders it should come as no surprise that Hifi is exclusively focused on supporting the HDS technology for turnkey, preventative pipeline monitoring, with a primary focus on energy sector assets.

As part of the project design, Trans Mountain partnered with Hifi to incorporate the ambitious deployment of an extensive hybrid fibre optic network consisting of a large telecommunications fibre cable coupled with Hifi’s specialised optical sensing fibre via dual micro duct conduit secured to the pipe. Upon project completion, a state-of-the-art monitoring and communication system will span the full length of the pipeline and monitor every inch of the asset, making it the largest fibre-on-the-pipe liquids pipeline monitoring system of its kind in the world.

### Project challenges

The sheer scope and scale of the project created an impetus for process and technology innovation. Some of the more significant developments related to the project included employing custom-designed clips to secure conduit and sensing fibre to the new pipe during construction (Figure 2), as well as designing complex conduit and fibre cable redundancy strategies for hundreds of trenchless crossings (Figure 3). The challenges posed by such crossings are anything but trivial, with many exceeding 2000 m (1.25 miles) in length. Perhaps the most daunting of these features was a 2600 m (1.86 mile) tunnel in Burnaby, British Columbia where the main pipeline was split into three separate pipes stacked in a vertical configuration (Figure 4), requiring independent optical monitoring of each different pipe. Other unique milestones achieved during project execution related to the variety of construction methods employed in addition to open trench, including Direct Pipe, auger bore/ guided horizontal auger bore, micro tunnelling, pipe ramming, as well as retrofit trenching of conduit across 200 km (125 mile) of existing pipeline segments (these were twinned several years earlier). These different deployment techniques were combined over multiple construction spreads operating in parallel and proved very challenging for pipeline construction, let alone for the subsequent installation of conduits for the fibre cables where it was critical to maintain both continuity and proximity to the pipe at all times. Overcoming these – and many other – challenges allowed for continuous fibre deployment across both the greenfield and brownfield elements of this vast project.

The retrofitting of approximately 200 km (125 mile) of existing pipe represented yet another unique challenge in the context of the overall Trans Mountain deployment. Two sections of the expansion pipeline traversing a national park were already twinned a number of years ago as illustrated



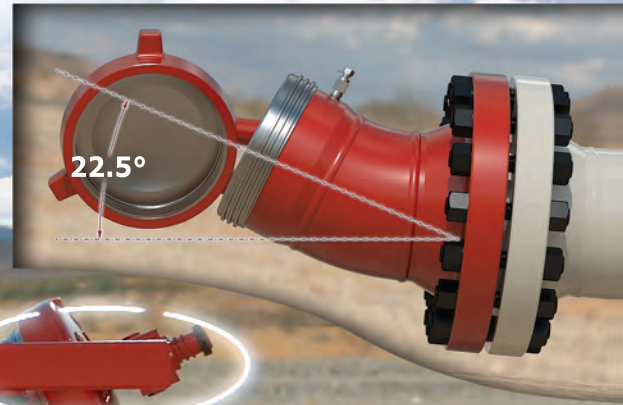
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Figure 5. Trench-based retrofitting of existing pipeline segment.

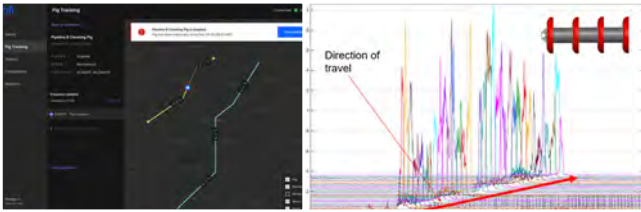


Figure 6. Pig detection, tracking and analysis.

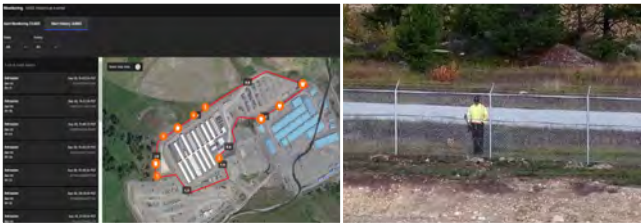


Figure 7. Perimeter security – Trans Mountain expansion project camp communities.

in Figure 1. Advancements in vibratory plowing technology, as well as in the technologies and processes governing pipeline locating, were leveraged by 3C Information Solutions Incorporated (3CIS) to enable accurate and cost-effective deployment of the fibre optic conduit at a precise clock position next to the pipe while maintaining a specified distance of 1 m (3.3 ft) within a tight allowable offset (+/- 0.2 m). Plowing machines were augmented by 3CIS with complementary technologies such as high accuracy GPS and inertial compensation to provide confidence for the desired conduit deployment position, resulting in successful retrofitting of the existing pipe segments within the stated offset interval regardless of the often extreme nature of the terrain involved (Figure 5).

Some of the valuable applications being supported by Hifi's HDS platform and the associated hybrid fibre optic network deployed for the Trans Mountain Expansion Project will include a next-generation Gigabit SCADA network enabling robust supervisory controls, fibre multiplexing of pipeline programmable logic controllers (PLCs), as well as the potential provision of surplus bandwidth to support underserved rural communities along the pipeline corridor through delivery of enhanced telecom services. On this last item, Hifi and Trans Mountain hope that this project will serve as a ground-breaking example of how traditional pipeline infrastructure (notably the heavily regulated and thoroughly scrutinised governing rights-of-way) can be leveraged to combine improved pipeline

safety with low-cost telecommunications access for remote communities previously considered 'unconnectable'.

It is also worth highlighting the significant due diligence conducted by the project proponents, most of which occurred long before ground was broken on the pipeline right of way. For example, before Hifi was selected as a partner, a rigorous third-party blind testing programme was managed involving multiple week-long 'true blind' leak testing of a variety of different technologies and suppliers. This independent testing was complemented by extensive field-based leak simulation and ground disturbance testing initiatives conducted collaboratively between Hifi and Trans Mountain. Results of this testing have been used to establish various specifications pertaining to sensitivity, accuracy, reliability and robustness. These specifications have recently been used for information exchange with the Canada Energy Regulator (CER) to support improved understanding and effective oversight for fibre optic monitoring systems.

### Hardware and software standards

Hifi's turnkey HDS pipeline monitoring system, which is backed by more than 100 patents (pending and approved) will leverage robust edge-to-cloud communication protocols that can alternate seamlessly between the high-speed Gigabit network and high latency/low speed backup satellite networks. Security is of the highest priority, and Hifi has recognised this by being fully compliant with the SOC 2 Type II standard. Developed by the American Institute of CPAs (AICPA), SOC 2 or Service Organisation Control Type II, is a cybersecurity compliance framework with the primary purpose to ensure that third-party service providers store and process client data in a secure manner. It defines criteria for managing customer data based on five 'trust service principles' – security, availability, processing integrity, confidentiality and privacy. There are two levels of SOC compliance: Type I describes an operator's systems and whether their design is suitable to meet relevant trust principles and Type II details the operational effectiveness of those systems. In addition to the utilisation of resilient cybersecurity practices, the conformance of Hifi's hardware and software development and implementation processes to the highest industry standards have been attested to in multiple annual external audit reports. Some examples of these processes include rigorous management of change programmes and comprehensive and regularly tested backup and recovery mechanisms. The SOC2 Type II compliance enables the secure application of Hifi's advanced supervised and unsupervised machine learning-based algorithms specifically designed for the project such as automated baselining and tuning, sophisticated management of very large sensing data sets encompassing distributed measurements of high-definition acoustics, temperature, and vibration/strain, along every centimeter of the pipeline asset. The project will support the full breadth of Hifi's event detection portfolio, including pinhole leak detection, slope stability and geotechnical monitoring for events such as earthquakes and landslides, ground disturbance and security intrusion detection, thermal anomalies, as well as end-to-end pig detection/tracking/analysis, inclusive of moving status, speed, strain, and estimated time of arrival (Figure 6). Given the

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integrity management support offered by these applications, the HDS platform enables operators with preventative leak detection by focusing on anomaly conditions such as geohazards and third-party interference or intrusion, which if not remedied, could ultimately result in a pipeline leak.


Hifi's recently unveiled digital validation and verification service offering (Deep Fake) will also be a very useful tool for the Trans Mountain Expansion project. This capability provides for system health confirmation through advanced machine learning software which mimics signatures of various events and alarm conditions, such as pipeline leaks detected by Hifi's HDS optical sensing technology, to test system effectiveness. Deep Fake can be used for on-demand generation of simulated events that are effectively indistinguishable from real operating anomalies, thereby allowing operators to conveniently audit system performance at any time or place without the requirement for costly field simulations. This digital event simulation capability also provides operators with great utility in regard to system orientation and control room operator training.

### Looking to the future

Hifi expects that the Trans Mountain Expansion Project will also benefit from future HDS applications currently under development. Perhaps the most notable of these focuses on Hifi's patented use of high-fidelity optical sensing to establish distributed flow monitoring. The technique leverages historical acoustic and strain data to construct an energy propagation algorithm capable of estimating flowrates with a high degree

of accuracy, promising substantial benefits in the areas of batch tracking, custody transfer and operations support. All applications will be utilising Hifi's HDS Monitor control room user interface software for visualisation and data presentation to ensure that the Trans Mountain operating team is able to use the preventative monitoring service in real time inclusive of leveraging Hifi's 24/7 monitoring engineer team.

Moving beyond the right-of-way, Trans Mountain also leveraged the HDS technology for non-pipeline applications over the course of the project, specifically deployment of a high-fidelity sensing fibre architecture during the construction period to support perimeter security at four separate remote camp community environments. This included the innovative use of multiple fibre sensing arrays to determine and differentiate ground-based vs fence-based security intrusions, as well as a customised application programming interface (API) to support automated pan/zoom/tilt (PZT) camera integration for security zone isolation (Figure 7).

By the time this article is published, the fibre optic infrastructure will have been installed, spliced and tested to support the planned commercial in-service date for the Trans Mountain Expansion Project. And once operational commissioning is completed shortly thereafter, this continuous HDS system for the twinned pipeline will represent the world's longest fully distributed fibre optic sensing deployment on a liquids pipeline. The project represents a significant achievement for both industries, and Hifi and Trans Mountain are very proud to have been recognised by the Fibre Optic Sensing Association (FOSA) in awarding Project of the Year for this initiative. 

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# A perfect match

**Fabrizio Buccheri, Prysmian EOSS Product Manager Optical Sensing and Cristian Grecco, Oil and Gas Sales Manager, Omnisens S.A., Switzerland, outline how adopting distributed fibre optic monitoring ensures the safe and efficient transportation of carbon dioxide through pipelines.**

In recent years, the transportation of carbon dioxide (CO<sub>2</sub>) via pipelines has gained prominence as a key component of carbon capture and storage (CCS) initiatives to combat climate change. Ensuring the safe and efficient transport of CO<sub>2</sub> over long distances is paramount, and advancements in monitoring technologies play a pivotal role in achieving safe pipeline transportation. One such technology that has revolutionised pipeline monitoring is distributed

fibre optic monitoring. The use of distributed temperature sensing (DTS) system is more reliable, accurate and has better resolution compared to other leak detection technologies like computational pipeline monitoring (CPM) or distributed acoustic sensing and can help CO<sub>2</sub> pipeline operators to implement a robust pipeline integrity programme.

The DTS monitoring system is composed of a DTS interrogator and fibre optic cable which runs the entire length



Figure 1. Fibre optic cable laying for CO<sub>2</sub> pipelines.

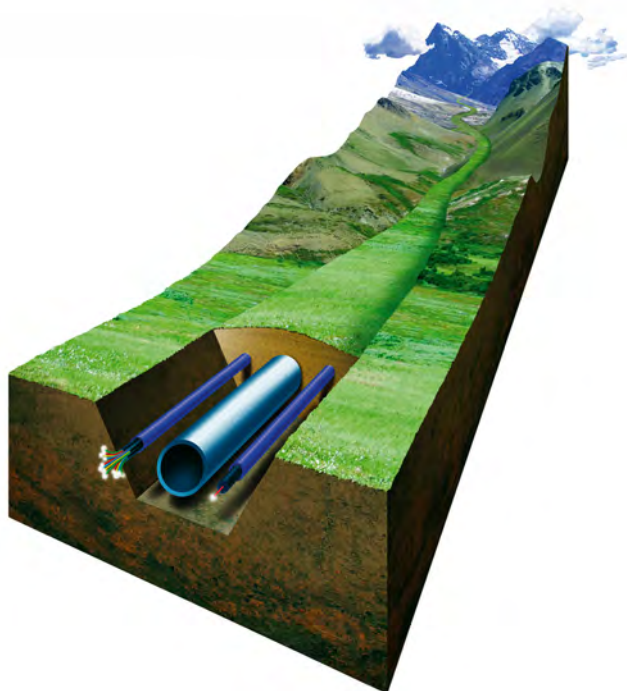


Figure 2. Fibre optic pipeline monitoring.

of the pipeline. The cable is a non-intrusive ‘SENSOR’ and it is immune from Electromagnetic interference (EMI). The system enables the operator to measure the pipeline temperature almost in real time 24/7 at 3 m increments or less on the entire length of the pipeline. DTSs have a very long range, up to 100 km, and can detect a leak event in minutes.

In terms of regulations, the API 1175 Recommended Practice, focusing on pipeline leak detection (PLD) programme management, encompasses various components of PLD programmes. It delves into key aspects such as primary leak detection system (LDS) technologies, the methodology for selection processes, and their relevance within the broader LDS programme, among other programme elements. Due to the positive experience during the past two decades, its 2022 edition incorporated distributed fibre optic sensing (DFOS). According to this recommended practice, DFOS-LDS has been acknowledged as having the capacity to serve as the primary LDS, complementary LDS, or alternative LDS (in instances where the Primary LDS is unavailable) within the pipeline leak detection programme. Additionally, DFOS-PLDS may function as a redundant LDS, ensuring identical functions to the primary LDS. Being now an industry recognised method that is technologically able to detect much smaller leaks, DFOS-LDS should contribute to increase confidence in CO<sub>2</sub> pipeline projects and increase their chances of being implemented.

### The need for advanced monitoring in CO<sub>2</sub> transportation

As the world transitions towards a more sustainable future, the demand for CO<sub>2</sub> transportation through pipelines has surged. These pipelines are critical components of CCS projects, facilitating the movement of captured CO<sub>2</sub> from industrial sources to secure storage sites. However, the inherent risks associated with transporting CO<sub>2</sub>, a high-pressure and potentially hazardous substance, underscore the importance of robust monitoring systems to detect and locate potential leaks promptly. Especially, because CO<sub>2</sub> is heavier than air, the former replaces the available oxygen, and the surroundings of the leak suddenly become a highly hazardous area.

Traditional Raman DTS monitoring systems, have been the go-to choice for many industries. However, the limitations of Raman-based systems, such as lower sensitivity and shorter range, have led to the development of more advanced technologies such as Brillouin-based DTS.

### Advantages of distributed temperature sensing in CO<sub>2</sub> pipelines

DTS is a cutting-edge technology that utilises fibre optic cables running the entire length of a pipeline measuring temperature in almost real-time at 3 m increments or less. This 24/7 monitoring allows for the FAST detection and location of leaks, providing a crucial advantage in preventing environmental damage and ensuring the safety of surrounding communities.

During a CO<sub>2</sub> leak, due to the Joule-Thomson effect, the exiting gas has a considerably lower temperature than the gas inside the pipeline. This temperature change is a result of the conversion of internal energy into kinetic energy as the gas molecules move more freely due to reduced pressure. The sudden expansion of the gas results in a significant temperature drop and may lead to the formation of solid CO<sub>2</sub> (dry ice) or the freezing of moisture close to the pipeline. This phenomenon can be detected and located in a few minutes by DTS systems.

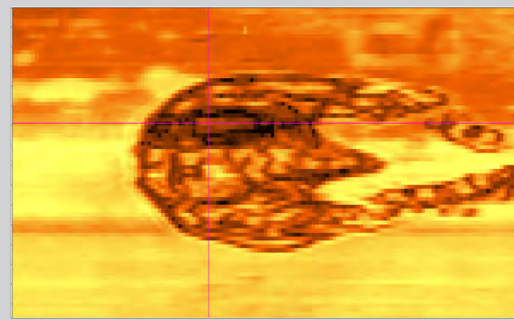
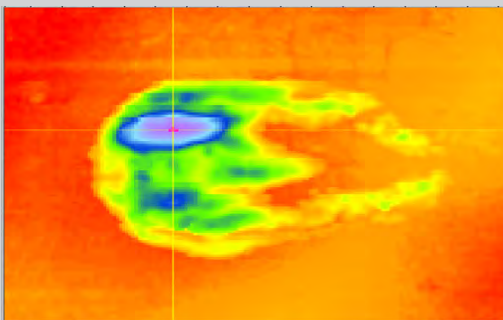
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Figure 3. Omnisens LYNX system telecommunication rack cabinet.



Figure 4. Omnisens Brillouin DITEST DTS interrogator.

### 1. Continuous 24 hours/7 day real-time monitoring

One of the primary advantages of DTS is its ability to offer continuous monitoring along the entire length of the pipeline. Traditional point sensors can only provide information at specific locations, leaving gaps in coverage. DTS, on the other hand, offers a comprehensive and continuous view, ensuring that no potential leak goes unnoticed.

### 2. Quick detection and response

The high sensitivity of DTS enables rapid detection of temperature changes, which can be indicative of a leak or a developing issue. This swift response time is essential in minimising the impact of leaks, allowing operators to take immediate corrective actions and prevent further escalation. The DTS systems utilise a MAP view that shows the colour-coded temperature over the entire length of the pipeline.

### 3. Cost-effective installation

Installing DTS systems along existing fibre optic cables in the pipeline infrastructure is a cost-effective solution compared to retrofitting traditional monitoring systems. The ability to utilise the existing infrastructure minimises installation costs

and downtime, making DTS an attractive option for pipeline operators.

## DTS for leak detection in high-pressure gas pipelines

The unique challenges associated with monitoring high-pressure gas pipelines, such as those used for CO<sub>2</sub> transportation, necessitate advanced technologies capable of providing accurate and real-time data. DTS, with its ability to detect temperature changes along the entire length of the pipeline, offers a powerful solution for leak detection in high-pressure environments.

### 1. Pressure-induced temperature changes

High-pressure gas pipelines are susceptible to temperature changes caused by variations in pressure. When a leak occurs, the escaping gas undergoes a rapid expansion, leading to a drop in temperature in the vicinity of the leak. DTS can accurately capture these subtle temperature changes, serving as an early warning system for potential leaks.

### 2. Spatial resolution for pinpointing leaks

DTS Systems acts like a series of thermocouples distributed along the pipeline. Brillouin-based DTS excels in providing high spatial resolution and temperature accuracy at long distances. This capability is crucial for pinpointing the exact location of a leak along the pipeline. Detailed spatial information enables operators to respond swiftly and efficiently, minimising the potential consequences of a gas leak.

### 3. Detecting small leaks

Traditional monitoring systems may struggle to detect small leaks in high-pressure gas pipelines due to their limited sensitivity. Brillouin-based DTS, with its enhanced sensitivity, can identify even minor temperature variations, allowing operators to address potential issues before they escalate into larger, more critical problems.

### 4. 24/7 real-time monitoring for dynamic conditions

Gas pipelines often operate under dynamic conditions, with fluctuating pressures and temperatures. DTS provides real-time monitoring, allowing operators to adapt quickly to changing conditions and respond promptly to any anomalies detected. This dynamic monitoring capability enhances the overall safety and reliability of high-pressure gas transportation systems.

## Lower false alarm rate: DTS vs DAS

In addition to the aforementioned advantages, it's crucial to highlight the lower false alarm rate associated with Brillouin-based DTS systems compared to DAS systems. False alarms can lead to unnecessary shutdowns, operational disruptions, and increased costs. Here's how DTS outperforms DAS in this aspect:

### 1. Sensitivity to temperature changes

DTS, with its focus on temperature sensing, is inherently less prone to false alarms caused by non-leak-related acoustic events. DAS systems, which rely on acoustic signals, may be more susceptible to false positives triggered by external factors such as vibrations from nearby machinery or environmental noise.

## 2. Specificity in leak detection

Brillouin-based DTS offers high specificity in detecting temperature changes associated with leaks, minimising the likelihood of false alarms. DAS systems, while effective in certain applications, may struggle to differentiate between genuine leak-related signals and other sources of acoustic disturbances.

## 3. Improved signal processing algorithms

DTS systems, especially those utilising Brillouin scattering, often employ sophisticated signal processing algorithms that enhance the accuracy of leak detection. These algorithms can filter out noise and non-relevant signals, contributing to a lower false alarm rate compared to DAS systems.

## 4. Technology validation


The validation of the technology in DTS is straight forward, as nowadays finite element algorithm models can simulate the temperature distribution and evolution during a leak event at various conditions. It can even help to optimise the positioning of the fibre optic cable, its design and the decision to install the cable inside conduits or not. When implementing DAS systems, the validation of the technology is challenging as computer simulation is not possible and there are no international standards developed to perform a leak test.

## Conclusion

The adoption of distributed fibre optic monitoring, particularly Brillouin-based DTS, marks a significant step forward in ensuring

the safe and efficient transportation of CO<sub>2</sub> through pipelines. The advantages are: 24/7 real-time monitoring, leaks are located FAST and within metres, and cost-effective installation is complemented by the ability of DTS to address the unique challenges posed by high-pressure gas pipelines.

As the world continues to prioritise sustainable practices, investing in advanced monitoring technologies becomes imperative. Brillouin-based DTS not only addresses the limitations of traditional Raman systems but also offers enhanced sensitivity, spatial resolution, and signal integrity, making it the technology of choice for safeguarding the environment and communities along CO<sub>2</sub> transportation routes, specifically high-pressure gas pipelines. The marriage of Brillouin-based DTS with CO<sub>2</sub> pipelines exemplifies the synergy between innovation and environmental responsibility, paving the way for a safer and more sustainable future, with the added benefit of a lower false alarm rate compared to DAS systems.

Omnisens, since 2021 part of Prysmian Group, has been manufacturing and supplying Brillouin DTS Leak Detection Systems for over 20 years. Its incorporation to Prysmian Group allowed Omnisens to become a player with presence in all continents, which is fundamental to provide timely technical and commercial support before, during and after the implementation of LDS to complex pipeline projects. Being Prysmian, a world leader on cable solutions, now allows Omnisens the possibility to provide technical advice also on the selection of the best fibre optic cable for the project. 



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# INNOVATIONS IN PIGGING STATIONS

**Nicolaas Ainsworth, Argus, Canada, discusses advances in equipment used to introduce and remove gear from pipelines.**

Pipelines are essential to our modern energy infrastructure as one of the safest, most economical, and environmentally friendly means of transporting fluids today.<sup>1</sup> But the infrastructure that stands as a cornerstone to our way of life is not invulnerable. Without proper corrosion and material build-up maintenance, leaks, blockages, and complete operation shutdowns can happen.<sup>2,3</sup> The resulting consequences are inefficient flowrates, profit loss, environmental damages, infrastructure death, regulatory compromise, safety risks, and heightened dangers of fires and explosions.<sup>1,2,3</sup> Midstream operators commonly introduce pipeline pigging into their maintenance programmes to avoid these risks and ensure a healthy line.

By sending 'pigs', through a line section, operators can purge the line of harmful materials that would corrode or build up and block the line if left unchecked.<sup>2,3</sup> Additionally, by sending inline inspection tools or 'smart' pigs through a line, operators can survey the state of their infrastructure and be proactive in facilitating its integrity.<sup>4</sup> The advancements in pigs and the continuously improving support to line integrity are stupendous and much acclaimed. Less talked about, though, is the advances in the equipment we use to introduce and remove the gear from our pipelines.

## **Pig barrel trap: the traditional method**

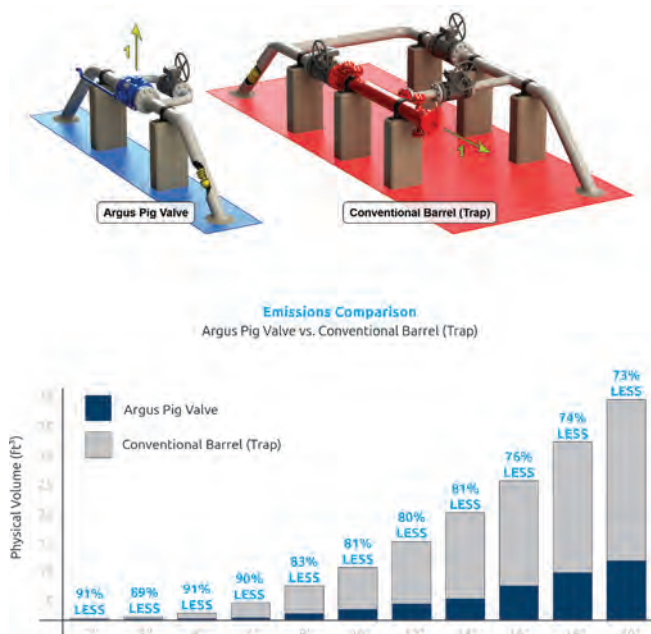
The benefits that sending a pig through a pipeline has on its integrity may be apparent; however, introducing and removing that pig from a pipeline can be less intuitive. Pigging requires implementing pig launching and receiving stations on opposing ends of a line segment. At the launching station, the operator inserts the pig into the station and sends it through the line to be captured and removed at the receiver station. Traditionally, these stations use a complex barrel set-up with multiple isolation, drain and kick valves to complete the process. This type of station is known as a pig barrel trap or pig barrel station. While barrel traps will allow you to pig a pipeline, the system has many severe limitations and risks, reducing its effectiveness at improving infrastructure integrity.

The innate design of the pig barrel trap requires the infrastructure to take up a significant amount of space. The





**Figure 1. A 10 in. Argus pig valve receiver station in Haynesville Shale Gas, Louisiana (USA).**



**Figure 2. Comparison of an Argus pig valve to a conventional barrel trap in size and emissions release.**

footprint and weight of the barrel trap can make introducing the station challenging, if not possible or practical, for many lines. Numerous pipelines can become considered ‘unpiggable’ simply because the barrel traps cannot be introduced, and the operator may be unaware of the alternative.<sup>4</sup> The inability to run pigging operations on these pipelines compromises the integrity of the infrastructure, leaving midstream operators with few choices.

The design of a barrel trap additionally poses an increased risk to the operator’s safety. Due to the horizontal alignment of the barrel, operators may be at risk of being struck by pigs propelled at high speeds from the gas pressurisation in the line if a mistake is made during the procedure.<sup>5,6</sup> When these mistakes happen, the force and forward-facing direction the equipment launches can lead to severe injury or death if struck. Unfortunately, the occurrence of these incidents and their corresponding consequences are well documented<sup>7</sup>. The complexity of the pig barrel trap only adds to the danger. The complexity of the station requires numerous

complex systematic steps to operate safely, providing more opportunities for human error.<sup>8</sup> These innate design features explain why pigging is considered a significantly dangerous operation.

### Pig valves: modern method to pigging stations

Higher standards for environmental friendliness and operational safety, increased offshore operations, and the increasing desire for maintenance on more lines exasperate pig barrel traps’ issues and limitations. Pipeline operators need a better alternative to launch, receive and maintain pigs. Fortunately, technology has grown, and there is a better choice. A modern solution to the traditional pig barrel stations is an alternative trap structure known as a pig or scraper valve. The concept of a pig valve is to use a trunnion-mounted, quarter-turn valve with an entry point to allow the sending and receiving of pigs. The design, typically accompanied by piping bypass and block valves, enables operators to achieve double block and bleed positive shut-off upstream and downstream while sending or receiving a pig.<sup>9</sup> The design of the pig valve overcomes the pig barrel trap’s safety, operational complexity, and size issues with the added benefits of higher environmental friendliness and more straightforward maintenance.

The Argus pig valve is one of the best examples of a pig valve or scraper. Argus is renowned globally for its innovative pigging stations, especially its pig valve. Its design eliminates the projectile risk operators face when pigging with a barrel. The Argus pig valve uses top-entry loading mechanisms that keep operators out of harm’s way when loading or removing.<sup>9</sup> If a mistake does occur in depressurisation, the pig will not launch toward the operator as it is not horizontally facing. However, that risk is more or less moot, as the valve design makes it nearly impossible to actually open with pressurisation, as by the time the cap is fully open, and the pig exposed, all pressure would have likely escaped. Furthermore, pig valves have substantially smaller configurations with much fewer valves and infrastructural components than barrel traps.<sup>9</sup> Thanks to its simplification, pig valves often require fewer steps, reducing the opportunity for human failure and any of this occurring.

In addition to removing operational safety risks, the pig valve also extends the number of pipelines that can undergo pigging operations. The pig valve has a much smaller footprint than a traditional barrel trap and is far lighter.<sup>9</sup> The compact size of the valve station infrastructure makes pigging possible in previously impossible areas and more practical in others. The lighter weight of the pig valve station infrastructure also makes it more suitable to use where this is a significant concern, such as on offshore platforms. By providing more opportunities to implement pigging operations, the pig valve enables operators to elevate the efficiency of the flow rates of their pipelines and reduce the need for costly replacements, leading to higher revenue generation.

As noted, in addition to overcoming the issues of the barrel system, the pig valve has the benefit of reducing maintenance difficulties and significantly lowering GHG emissions.<sup>9</sup> The simplification of its configuration means fewer components need upkeep, and there are fewer points for potential failure, improving maintenance. The pig valve also requires much less physical volume to vent than a barrel. The Argus pig valve, for example, reduces the amount of emissions by up to 91% compared to a barrel trap.<sup>9</sup> The drop in emissions makes the pig valve ideal for companies searching for ways to help decarbonise their operation.



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**Figure 3. Example of an Argus Multi-Pig Launcher station in the field.**

### Automated and MPL valves: further optimisation of pigging stations

The pig valve is not the only advancement in pigging stations. An issue plaguing many operators is what to do if their pipeline needs frequent purging of corrosive or damaging residues. The problem is quite common in wet gas pipelines. Pipelines carrying wet natural gas, sour gas, and others are susceptible to the gas slowing down and liquifying in areas through a phenomenon known as liquid loading.<sup>3</sup> The puddles of the liquified gas sit and slowly eat away at the walls, creating leaks and cracks. In addition, the puddles can block gas from running through the line, leading to profit loss.<sup>3</sup>


Pipeline pigging is the only realistic solution to mitigate the pooling. However, the pigging frequency necessary to make it effective can be problematic. Sometimes, operators must purge their line through pigging operations multiple times a day to stay ahead of the problem. Operating a barrel trap station numerous times a day is time-consuming and expensive. A pig valve is a better solution but still has limitations in needing to be reloaded per operation. An alternative innovation to pigging stations built to overcome this problem is automated pig launchers such as the Argus Multi-Pig Launcher (MPL). The Argus MPL takes a pig valve and applies a vertical barrel to the top entry. (There are alternative automated launchers that use horizontal barrels, but these stations fight gravity and can be prone to failure.)

The operator can preload their station with several pigs using a vertical barrel. Preloading the pigs allows operators to consolidate up to eleven operations (in the instance of the Argus MPL) into one. The operator can manually send the pigs through the line, but the station usually has an actuator allowing remote launching. The clear benefit of having the actuator is midstream and upstream owners

need to send only one team every eleven launches to load the MPL. Consolidating the operations cuts travel and operation costs while removing safety risks and emissions associated with travel. These benefits also make the station ideal for pigging in locations that are difficult, or periodically impossible, to reach.

### Conclusion

Pipeline pigging is vital to ensure the integrity and longevity of pipeline infrastructure by allowing operators to remove build-up that reduces flow efficiency while purging the line of harmful debris that can cause corrosion and rust, leading to leaks and failures<sup>12,3</sup>. Pigging is also crucial in enabling operators to inspect their infrastructure and be pre-emptive in mitigating failures.<sup>4</sup> The incredible advancements in pipeline maintenance and ILLI pigs have been a hot industry topic; interestingly, the advances in the stations necessary to use the gear are less spoken about. There appears to be some misconception of what modern alternatives to the traditional pig barrel trap or station are available. As many of the pain points of running pigging operations stem from the stations you use to pig, it is interesting why the alternatives are less spoken about.

Entering a pipeline with a pig has traditionally been a complex, costly, and often dangerous activity due to the innate design features of the pig barrel traps or stations necessary to introduce and remove pigs from the line.<sup>5,6</sup> Innovations in the system for launching and receiving pigs are helping solve the issues of the traditional stations while providing additional benefits to GHG emission reduction and more. Pig valves such as the Argus pig valve eliminate the safety risks associated with the conventional barrel trap using a vertical loading mechanism and an entry cap.<sup>9</sup> Additionally, the compact size and smaller infrastructure footprint extend the number of pipelines operators can maintain by pigging. Innovations in automated pigging stations like the Argus Multi-Pig Launcher also support operators who require high-frequency pigging or pigging in remote areas by consolidating operations and utilising actuation technology. Both these systems also massively reduce GHG emissions and operational complexity. In summary, the innovations in pigging stations are helping pipeline operators increase revenue, save infrastructure, reduce GHG emissions and extend operator safety. 

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**P**igging plays a key role in the pre-commissioning, inspection and maintenance of pipelines and pig signallers are crucial to confirming the successful launch of pigs, ensuring they navigate critical or challenging sections of the pipeline and ultimately verifying they have been received. In recent years, the industry has been shifting towards the adoption of non-intrusive pig signallers over intrusive models but despite the obvious benefits of non-intrusive, intrusive signallers are still widely used. This article will explore these benefits and the different technologies on the market and how they operate as well as providing recommendations on selecting the correct technology for the application at hand.

### Understanding pig signallers

Pig signallers, sometimes known as pig detectors, are devices designed to identify and signal the passage of pigs. Their primary purpose is to alert the operator when the pig has been launched and received and when it passes specific locations or conversely, a lack of signal can indicate that a pig has stalled in the pipeline. If this happens, pig signallers can be used to narrow down the search area before employing the use of a pig locating system. For example, if a signaller does not trigger but the previous one does, the operator can conclude that the pig is located between these two signallers.

There are two types of pig signallers; Intrusive signallers are mechanical devices that indicate the passage of a pig when

it pushes against the trigger inside the pipeline as it moves through. In contrast, non-intrusive devices detect pigs without penetrating the pipeline. They utilise technologies, such as acoustic and magnetic, to identify the pig as it passes. Non-intrusive signallers can be easily strapped to the pipeline using ratchet straps or stainless-steel banding.

### Technology overview

Before diving further into the many smart features and advantages of non-intrusive signallers, an overview of the technologies and their principle of detection will be presented.

While each technology has a unique detection method, there are some common features. Upon pig detection, the signallers activate an alert, utilising

# NON-INTRUSIVE LEADING THE WAY



Carey Aiken, Online Electronics, UK, describes the many smart features and advantages of non-intrusive pig signallers.



**Figure 1. Dual-functionality ultrasonic pig signaller with locating function.**



**Figure 2. Online Electronics 4003 magnetic pig signaller.**

visual signals like flashing LEDs or remote notification to a control room or handheld device. The passage data, including date and time is logged for future reference with up to 100 events being stored. After alerting the detection locally or remotely, the signallers reset after a predetermined time, ensuring readiness for the next pig. Manual reset options via a push button or control room are also available.

### Magnetic

Magnetic pig signallers, while not a novel technology, have undergone a significant evolution, becoming more reliable, customisable and intelligent over the years. These signallers operate with any pipeline medium – the only requirement is that the pig is carrying magnets.

A magnetic sensor is integrated within the unit housing or provided on a cable for buried or restricted access pipelines. As the pig approaches, the sensor detects the rising magnetic field and if it reaches the set threshold, an 'Approach' is registered on the signaller. As the pig moves past the signaller along the pipeline, the magnetic signal decreases, triggering the pig passage.

The sensitivity to magnetic changes ensures precise and timely detection, making magnetic signallers a preferred choice for many pipeline operators.

### Ultrasonic

Ultrasonic pig signallers provide a sophisticated approach to pig detection in liquid lines, distinguishing themselves from other

models by detecting both the passage of a moving pig and the position of a stationary one, without the need for magnets or transmitters.

Equipped with an ultrasonic transducer on a cable, the signaller uses the pulse-echo method to detect the time of flight of ultrasonic pulses through the pipe. A pulse is sent through the pipe wall and if the line is filled with liquid the unit can detect a reflection from the other side. When a pig passes, disturbing the fluid path, the interruption of the reflection is identified, and pig passage detected. Calibration of the detection algorithm allows the signaller to identify and ignore smaller objects, further enhancing the accuracy. An ultrasonic pig signaller is unique in its ability to precisely locate a stationary pig by moving the ultrasonic sensor along the pipeline and measuring the reflection. This prevents delays in establishing position especially after the mainline tee but before the pig receiver isolation valve where the pig can lose momentum and stall.

### Acoustic

Acoustic pig signallers, operating on sound detection, offer versatility in any pipeline medium without requiring magnets or transmitters. They monitor the acoustic emissions from the vibrational and acoustic noise produced by a moving pig in the pipeline and advanced detection algorithms filter out irrelevant noise. To avoid false positives, it is preferable not to install these units near pipeline features that could potentially have a noise profile similar to that of a pig such as a valve, however all valve line up activities should be completed before the pig is launched. Upon identifying the sound of a pig approaching, the unit signals 'Pig Approach' and as the sound level decreases it signals 'Pig Passage'.

### The application at hand

Meaningful understanding of the application and types of pigs the operator will use and why should be considered. On paper, acoustic signallers appear to be the obvious choice due to their versatility in any medium and with any pig. This may be true when considering a pipeline away from background noise but a relatively 'noisy' area could contribute to false positives or a missed pig if this is not managed appropriately.

If the pigs used are metal-bodied pigs, they can be fitted with magnets. Measuring a physical element such as magnetic field, provides a more direct response and minimises the risk of false positives and missed pigs. If the system is liquid, an ultrasonic signaller can be used with any type of pig. As mentioned previously, an ultrasonic sensor can be moved to locations where there is a high probability of a stuck pig such as at the receipt location. You can also inspect the launcher to ensure that the pig has left without needing to open the quick launch closure. Acoustic signallers may be an appropriate solution in cases involving foam pigs being used in wet gas systems for liquid management since it is not generally recommended to fit magnets to foam pigs.

### Why choose non-intrusive?

Converting to non-intrusive pig signallers brings with it a range of benefits that positively affect operations, the environment, and the safety of personnel and the wider community.


Although non-intrusive signallers may involve a higher initial investment, the long-term economic advantages are apparent. For new installations, the total cost of ownership (TCO) for intrusive signallers includes costs emerging from cutting a fitting, procurement, welding, signaller purchase, installation, and regular maintenance. Repair TCOs, often indicated by missed pig passages, combines costs incurred because of missed events, repair part acquisitions and installation. The TCO of a non-intrusive signaller comprises the purchase price, installation accessories, potential remote signal interface and occasional battery replacements. With non-intrusive there are reduced maintenance needs, minimised downtime, a decreased workforce requirement thanks to automatic reset and remote communication options, and an extended equipment lifespan resulting in substantial cost savings over time.

Unlike intrusive pig signallers, non-intrusive alternatives eliminate the need for cutting nozzle holes into pipelines and welding pipe fittings, thereby reducing emissions risks associated with welds. Additionally, non-intrusive signallers eliminate multiple potential leak paths found in pressurised mechanical instruments. By eliminating the necessity for direct physical contact and interventions, non-intrusive signallers minimise the risks associated with equipment failures, ensuring safer operational environments.

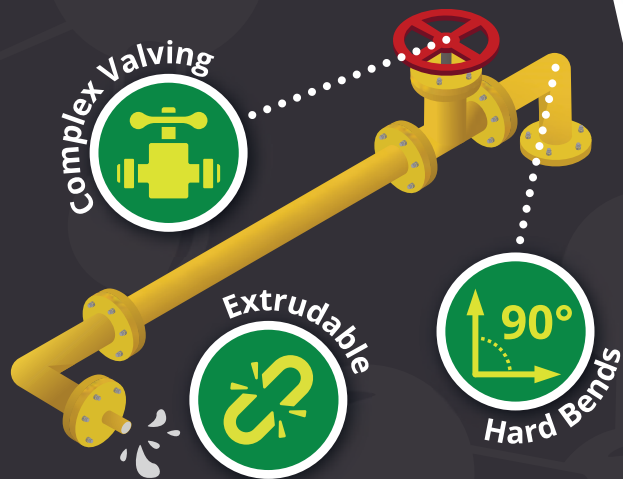
Modern non-intrusive pig signallers are equipped with a range of advanced features such as data logging and accompanying apps that allow operators to receive data and adjust parameters on a handheld device. Their flexibility ensures

operators have a versatile tool tailored to specific operational needs.

The transition to non-intrusive signallers signifies more than an equipment upgrade; it represents a comprehensive shift in industry norms. With global regulatory frameworks tightening and a growing preference for eco-friendly practices, industries need to adapt. The adoption of technologies like non-intrusive signallers goes beyond compliance – it can position a company as a leader in sustainable practices, leading to increased confidence and trust among customers. As pipelines and control systems lean heavily into digitalisation, non-intrusive signallers prove they are more than ready for the challenge. Seamlessly integrating with SCADA control systems, their compatibility with modern technological frameworks ensures they remain relevant, not just today, but well into the future. The industry can also benefit from collaborative efforts and knowledge-sharing. Companies that successfully carried out this transition can serve as valuable case studies, offering guidance to others.

While intrusive signallers remain, non-intrusive signallers are starting to emerge as the preferred choice, offering economic advantages, reduced environmental impact and enhanced safety. Selecting the right technology based on application specifics, such as pig design and pipeline medium will lead to optimised operation and should take precedence over datasheet review and system standardisation. The transition to non-intrusive signallers signifies a shift towards sustainable practices. This, combined with their advanced features, positions them as a future-ready solution. 

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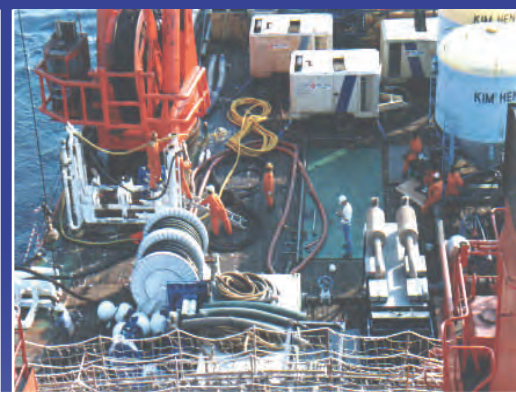
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Brasil Post Trenching Rough Shore Approach (Lead Keel Machine)



Typical Deck Layout On DP Vessel for Deep Water Trenching 80 to 400 meters



Typical Dynamic Positioned Vessel during Trenching (Lead Keel Machine)



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Floating Jet Sled across mud flats too shallow for barge



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- Trenching Deepest trench 7 meters 2000 Indonesia
- Trenching in strongest water current 11 knots China 2004
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- Also laid 7 kilometers of 150 NS 110,000 Volt cables including directional drilling shore approach through rock cliffs
- Salvaged six projects where pre dredging, directional drilling and jet sleds failed

**Equipment Includes:** 45 20 ft sea freight containers with 8 x 1600 hp 350 psi pumps, 2 x 1000 psi booster pumps, 3 hydraulic hose reels with 90 to 120 meters of 4 x 4 inch hose, interconnecting piping and suction strainers, 6 x subsea pipeline lead keel type jet machines for 6 inch to 52 inch pipelines, 1 Tiger Shark cuts 600 mm deep trench per pass x 1200 mm wide in 30 mpa ucs rock, 2 cable trenchers that simultaneously backfill to 1.5/3 meters cover. An eight point mooring system 20 tonne, 20 tonne heave compensator, 3 Hydraulic power packs including 1 300 HP for tiger Shark, 1 Tiger Shark Hose reel with 2 x 500 meters of 5000 psi hydraulic hose and a 10 tonne clump weight and deployment system. A 10 tonne hydraulic cable tensioner.

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Figure 1. 48 in. Subsea BISEP deployment, (Arabian Gulf).

# A BIG ROLE FOR LINE STOPPING

**Darran Pledger, STATS Group, UK, discusses the critical importance of pipeline maintenance and its direct impact on the reliability, safety and efficiency of pipelines.**

technological solutions of the present day. Historically, pipeline maintenance challenges were often addressed reactively, with limited understanding of the long-term consequences of neglect. Early pipelines faced issues such as corrosion, material degradation, and leaks, leading to environmental concerns and operational disruptions.

As pipelines expanded globally to meet the escalating demand for energy transport, the industry encountered challenges magnified by the scale and complexity of these extensive networks. Traditional maintenance methods, relying on manual inspections and periodic interventions, struggled to keep pace with the increasing demands and risks associated with ageing infrastructure.

The transformative shift began with the integration of technology into pipeline maintenance practices. The advent of advanced materials, inspection tools, and monitoring systems heralded a new era. This evolution allowed for proactive identification of potential issues, reducing the likelihood of catastrophic failures, and enhancing the overall reliability of pipeline networks.

## **Advanced solutions for critical maintenance**

Today, the need for advanced solutions in critical repair and maintenance has never been more pressing. Large-diameter midstream pipelines, vital for global energy transportation, require innovative technologies to address challenges unique to their scale. The introduction of intelligent pigging, robotic systems, and



**P**ipelines serve as the arteries of the energy network, facilitating the transportation of crude oil, natural gas, and refined products from extraction points to processing facilities, refineries, and end-users. The critical importance of pipeline maintenance lies in its direct impact on the reliability, safety, and efficiency of this essential infrastructure.

Effective maintenance ensures the integrity of pipelines, preventing leaks, corrosion, and structural failures that could lead to environmental hazards and significant economic losses. In an industry where operational continuity is paramount, routine maintenance activities become a proactive measure to identify and rectify potential issues before they escalate. This includes inspection, testing, and repair procedures that adhere to stringent safety standards and regulatory requirements.

The complexity and scale of midstream oil and gas pipelines demand sophisticated maintenance strategies. Large diameter pipelines traverse challenging terrains and diverse environmental conditions, adding layers of complexity to maintenance activities. To address these unique challenges, innovative technologies and advanced methodologies become essential in maintaining these extensive networks.

As the demand for energy continues to rise globally, the effective and reliable maintenance of pipelines remains fundamental to ensuring a safe, cost-effective, and uninterrupted supply of energy to the world.

## **The evolution of pipeline maintenance technology**

The evolution of pipeline maintenance follows the industry's journey from rudimentary practices to the sophisticated

advanced sensing technologies has revolutionised the inspection and maintenance processes.

These advanced solutions offer real-time monitoring, data analytics, and predictive maintenance capabilities. They enable operators to identify anomalies, assess structural integrity, and plan targeted interventions, mitigating the risk of unplanned shutdowns and environmental incidents.

STATS Group's industry leading pipeline isolation technology exemplifies the industry's commitment to pushing boundaries and



**Figure 2. 24 in. Dual BISEP and integrated bypass, gas pipeline tie-in (Northern Ireland, UK).**



**Figure 3. 40 in. BISEP deployment for AKT Oil Services, (Basra, Iraq).**

ensuring the highest standards of safety and efficiency in critical repair scenarios. Safety is paramount and the importance of high-integrity pipeline isolation is significant to address the many key challenges posed by their scale and risks associated with pipelines operating at high pressures and large volumes.

### High integrity isolation

For more than 25 years, STATS has been pushing the boundaries of pipeline isolation technology featuring leak-tight, dual elastomer seals. Clients often approach STATS to develop engineered solutions and innovative technologies to solve their complex pipeline integrity challenges. An extensive history of providing robust solutions has led to the development of many patented technologies, which are now standard products.

STATS BISEP® technology provides operators pioneering hot tap installed line stopping capabilities to enable the safe and effective repair and modification of pipeline infrastructure. The BISEP was developed following extensive engineering, research and development in the early 2000s, specifically to address a client challenge to engineer a solution to deploy a hot tap installed double block and bleed isolation.

STATS were awarded the contract by Shell to isolate for removal and replacement 32, 10 in. cell fill lines situated within the utility shafts of the Brent Bravo and Delta platforms in the North Sea. During its execution, it was the single largest project undertaken by Shell in the North Sea.

However, the first BISEP was deployed in 2006 for Petrofac in the North Sea, providing leak-tight isolation of a 16 in. pipeline for more than 12 months.

The patented BISEP provides a fail-safe double block and bleed isolation deployed through a single full bore hot tap intervention and is the only DNV Type Approved line stop tool. This verifies that the design criteria satisfy the requirements for pipeline isolation plugs to provide dual seal and isolation in accordance with; DNV-OS-F101 (Submarine Pipeline Systems) and recommended Practices; DNV-RP-F113 (Subsea Pipeline Repair) and in compliance with code ASME BPVC Section VIII, Division 2.

### Seal testing sequence

The BISEP offers significant safety advantages over traditional line stop technologies, with the hydraulically activated dual seals providing leak-tight isolation of pressurised pipelines. The dual seal isolation barrier is confirmed once each seal is independently tested with full pipeline pressure in the correct direction and the pressure between the seals is vented, creating a zero-energy zone. The zero-energy zone between the seals is monitored throughout the work scope, confirming the isolation integrity with zero leakage, a crucial factor in the energy industry where any compromise in integrity can have severe consequences.

The BISEP, when configured with an integrated bypass, ensures maintenance of critical pipelines can be conducted without the need for pipeline shutdown. This is a critical advantage in midstream operations where continuous flow is essential for maintaining productivity. By avoiding shutdowns, the BISEP tool minimises downtime and associated financial losses.

The BISEP tool is versatile and compatible with a wide range of pipeline medium offering a solution for pipelines up to 56 in. and pressures up to 153 bar. In addition to leak-tight isolation of

traditional hydrocarbons pipelines, STATS BISEP has been deployed and successfully isolated hydrogen, high pressure liquid CO<sub>2</sub> and high temperature steam, up to 381 °C. This adaptability makes it a practical choice for a wide range of applications, providing a comprehensive solution for pipeline repair and maintenance challenges.

### Global deployment

Demand for large diameter BISEP's has grown significantly in recent years for both onshore and subsea applications, allowing sectional replacement, valve change out and re-routing of pipelines, whilst production continues uninterrupted.

Notable awards in the Middle East include a major workscope which involves the hot tapping and BISEP isolation of 8 pipelines, performing a total of 69 hot taps and 32 BISEP isolation deployments ranging from 10 - 40 in. Also in the Arabian Gulf, STATS were commissioned by UAE-headquartered Oil & Gas EPC Contractor National Petroleum Construction Company (NPCC), to isolate multiple 48 in. oil lines. The scope of work involved subsea hot tapping and BISEP line stopping to install a bypass system.

Mark Gault, General Manager, Middle East said, "This is a landmark project for STATS Group and reinforces our credentials for providing innovative subsea hot tapping and high integrity isolation solutions which can address diverse and technical challenges.

"Additional work scopes in the region have included an award in the UAE for 42 in. hot tapping and BISEP with integrated bypass deployment to remove a 4 in. drain line, plus a 42 in. and



Figure 4. 48 in. fitting and completion plug manufacture (Edmonton, Canada).

52 in. BISEP deployment in Kuwait for a fuel line upgrade project.

In addition, STATS have also increased its track record in Iraq, with a pig trap replacement project in Basra involving multiple deployments of both 40 in. and 48 in. BISEP's with AKT Oil Services.

"Our strategy of putting in the hard yards in terms of investing in localisation in the Gulf region and in employing and training locally based staff has put us in a strong position to expand further in the region", added Gault.

Jamie Frederick, President and General Manager of STATS Group's US business said: "We are experiencing significant growth



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**Figure 5. 48 in. SureTap hot tap of crude oil line for BISEP deployment (Saudi Arabia).**

which is due to market acceptance of our innovative double block and bleed technology while at the same time we are establishing a reputation as ‘big diameter specialists’.

“We have recently completed a multi-site high pressure double BISEP isolation with integral bypass to replace a section of 42 in. pipeline in the southern US. Our isolation allowed the client to upgrade their compression while not impacting their customers. During isolation, the 36 in. bypass diverted flow around the isolated section to maintain product. The workscope was then repeated at a further three locations. This ability to take on larger diameters with industry leading double block and bleed technology is undoubtedly a market differentiator.”

In the UK, a new 48 in. BISEP and split tee fitting is currently in manufacture for a project in early 2024 near Swansea, South Wales. Neil Mackay, Senior Business Development Manager at STATS Group, commented, “This landmark project will be the largest and highest-pressure double block and bleed line stopping scope ever completed onshore in the UK, with the BISEP rated to 102 barg.”

### Hot tapping

To support hot tapping and line stopping activities, particularly in larger diameter pipelines, significant product development and investment has been made to extend the company’s range of SureTap® hot tapping machines with the introduction of the STI530-90 XL. Three new SureTap STI530-90 XL hot tapping machines have been manufactured and distributed to

key regions to meet demand which can cater for up to 60 in. diameter cuts and offers an extended reach of 180 in.

### Reducing venting and flaring

As pipeline operators deal with the challenges associated with eliminating greenhouse gas emissions during pipeline maintenance and facility upgrades, double block and bleed pipeline isolation technologies enable localised repair and maintenance worksites to be safely isolated without the need to depressurise large sections of the pipeline. This avoids the need to discharge significant quantities of greenhouse gases into the atmosphere. In the case of large-diameter gas pipelines, this can prevent the potential discharge of thousands of tonnes of methane emissions into the atmosphere.

The United Nations Environment Programme global methane emissions report states that existing technologies can reduce methane emissions by 30% by 2030. The greatest potential for cost saving is in the oil and gas sector, where captured methane adds to revenue instead of being discharged to atmosphere.<sup>1</sup> The technologies the UN refer to don’t require innovation funding or development, technologies like the BISEP can have a real impact, and are available now with an extensive global track record.

STATS continue to support its customers to reduce emissions, recognising the pivotal role that natural gas is playing, as the world seeks to first reduce carbon emissions ahead of a longer-term transition to more sustainable sources of energy.

Jamie Frederick, President and General Manager of STATS Group’s US business commented: “There’s a growing market awareness of the integrity of our patented equipment and the sustainability features offered by our technologies, particularly in helping reduce carbon emissions for our clients.

“One example of this approach is that we recently completed one of the industry’s first leak tight double block and bleed isolations with a BISEP tool which achieved emission-less venting. This prevented methane emissions into the atmosphere, and in this project alone we estimated that more than 1.6 million ft<sup>3</sup> of methane was not vented – which is the equivalent of 913 t of CO<sub>2</sub>e saved or taking 197 motor vehicles off the road for one year.”

### Future

The evolution towards advanced solutions signifies a proactive approach to ensuring the integrity of pipeline infrastructure, emphasising the indispensable role of technology in safeguarding the energy networks that power our world.

The BISEP double block and bleed line stop tool offers a comprehensive and efficient solution for the repair and maintenance of midstream oil and gas pipelines. Its ability to perform operations without shutting down the pipeline, dual leak-tight seals for enhanced safety and real-time seal monitoring capabilities, position it as a valuable asset in the industry.

Mr Frederick concluded: “We’re excited about the future energy transition and the role STATS is playing in supporting our customers to achieve their net-zero goals.”

### References

1. United Nations Environment Programme and Climate and Clean Air Coalition (2021). Global Methane Assessment: Benefits and Costs of Mitigating Methane Emissions. Nairobi: United Nations Environment Programme.

# UPDATING PIPELINE BUCKLING

Ismael Ripoll, Advanced Analysis Lead, Xodus Group, discusses the approaches to managing pipeline lateral buckling, proposing an updated methodology.

**F**or the designers, installers and operators of surface-laid subsea pipelines, the risk of lateral buckling must always be taken into account.

Lateral buckling refers to the sudden change in shape of a subsea pipeline, usually caused by external forces and changing conditions.

While it is not just an oil and gas problem – and can occur in the transportation of water or chemicals – given the labyrinthine network that carries fossil fuels across the globe, it is something the industry should be acutely aware of. Pipeline buckling can have serious consequences, including structural damage, disruptions to flows and, in the worst cases, the potential release of hazardous substances.

The reasons for a pipeline buckling can be many and varied, differing across regions and conditions. The most common reasons are temperature changes that cause pipes to expand and internal pressures from whatever is being transported, as well as the potential impact of fishing gear.

Engineers and operators put numerous measures in place to reduce the risk of a pipeline buckling, such as undertaking proper design work and installing engineered buckle triggers such as sleepers to control movement. The pipeline is also monitored extensively to check for any

signs of buckling, while regular maintenance work is carried out.

In carrying out lateral buckling design, the subsea pipeline industry typically uses a combination of Monte-Carlo simulations and finite element analysis (FEA). The Monte-Carlo simulations are used to determine the longest virtual anchor spacing (VAS) that can be reliably implemented (characteristic VAS), while FEA is used to determine the longest VAS with acceptable mechanical conditions (tolerable VAS). Designers must then ensure the characteristic VAS is less than the tolerable VAS along the whole pipeline.

As it stands the use of the VAS concept as alternative for the actual limit introduces an inconsistency, whereby the full range of frictions that can cause buckling aren't considered. This results in an incorrect measurement of uncertainty and a certain level of conservatism, resulting in more engineered buckle triggers than may be needed. Industry has been aware of this limitation for some time and alternative methods have been put forward, but guidelines around these aren't publicly available and findings aren't adopted. Without widely available tools and a common, available methodology, it is difficult for operators to optimise the lateral buckling design of their pipeline projects.

### **An updated methodology**

To better inform the understanding around pipeline buckling, Xodus has produced a technical paper in partnership with TotalEnergies entitled '*Lateral buckling design using the friction distributions at the expected buckles*'. It puts forward an updated methodology that can be implemented with minimal changes to the recommendations of DNV-RP-F110, a recommended practice that gives design methodology and criteria to allow pipelines to buckle in a safe and controlled manner.

Our method is based on Monte-Carlo simulations that determine the soil friction distributions of the expected buckles, and then an approach in which the tolerable VAS is determined using these soil friction distributions of the buckles.

As such our paper empirically addresses some of the limitations of the F110 approach and puts forward several modifications. In the probabilistic buckle formation algorithm, instead of sampling a distribution of critical buckling force, the breakout lateral friction and the out-of-straightness (OOS) factor is sampled separately and combined to calculate the critical buckling force. This allows the distribution of VAS lengths to be extracted alongside the distribution of the lateral frictions at which buckles form.

But the separate sampling of lateral friction and OOS, rather than critical buckling force, posits the question of how many times the lateral friction should be sampled over a certain length of pipeline. In carrying out our research we settled on two options: sampling at each element or sampling at each OOS reference length. These two choices demonstrate the two types of uncertainty in lateral friction – general epistemic uncertainty and spatial variability.

General epistemic uncertainty refers to the doubt on the properties of the soil type covering a certain area, while

spatial variability would be the changes in soil properties along the pipeline.

The paper shows the significant impact this approach can have on the overall lateral buckling design, demonstrated through a case study. To demonstrate the merits of our proposed approach on the lateral buckling design of a pipeline we came up with a case study, based on a 25 km long, 12 in. deep water pipeline with five curves along its length. The pipeline operates at high pressure (360 bar) and moderate temperature (55°C inlet), and is divided into 100 m long segments.

### **Results**

Probabilistic results are presented for two different sets of simulations: one where the lateral friction distribution is sampled once per element (typically 100 m long) and another where it is sampled once per out-of-straightness (OOS) (typically 1000 m long).


Results indicate that the pipeline buckles in all simulations, regardless of which of the lateral friction sampling approach is used. The total number of warps along the pipeline remains reasonably stable, with between five and six buckles per stretch of pipeline. Across all the simulations the total number of buckles varies between two and 16.

However, when results from the tests are grouped in 1 km intervals along the pipeline route, visible variations develop between the two sampling approaches, both in terms of probabilities of a buckle and the longest VAS that can be safely implemented, or characteristic VAS.

As anticipated, the likelihoods of buckling are larger when the lateral friction is sampled per element, rather than per OOS reference length. Equally, the characteristic VAS tends to be shorter in the former case.

After drawing out and analysing the data from the simulations, one crucial conclusion emerged. When the F110 approach is used to determine how a pipeline should be installed, lateral buckling mitigations would need to be introduced over 17 km of this pipeline. But with the approach proposed in this paper no mitigations are required at all, an improvement that would lead to significant cost savings without impacting the integrity of the pipeline.

Crucially the modifications laid out in our paper can be rolled out with minimal changes to the approach set out by the F110 standard. Moreover, the Python code used to perform the probabilistic buckle formation runs, with the changes detailed above, has been released under an open-source licence, meaning pipeline operators across the globe can use the code together with the methodology presented in our paper.

In preparing our findings we have identified a number of aspects of the current methodologies that could be updated to better enhance results. Some of these facets are addressed through small modifications, but other aspects remain and we recommend that they are dealt with before more complex approaches for lateral buckling design are considered. The OOS distributions should be reviewed and updated to take into account additional operational experience, something that is particularly necessary for route curves and sleepers. 

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- ✓ Ability to inspect pipelines up to 50 feet (15 meters) under water



## Ana Paula Gomes and Marco Marino, Enivibes, Italy, describe how to enhance pipeline leak detection and integrity monitoring through an innovative and integrated approach.

**P**ipelines represent an efficient and economical solution for fluid transportation. It is crucial to maintain continuous and meticulous monitoring of asset integrity to prevent harm to facilities, the environment, and human safety. At the forefront of monitoring priorities is leak detection and third-party interference (TPI) detection, making a comprehensive detection system mandatory to ensure the safety of these assets.

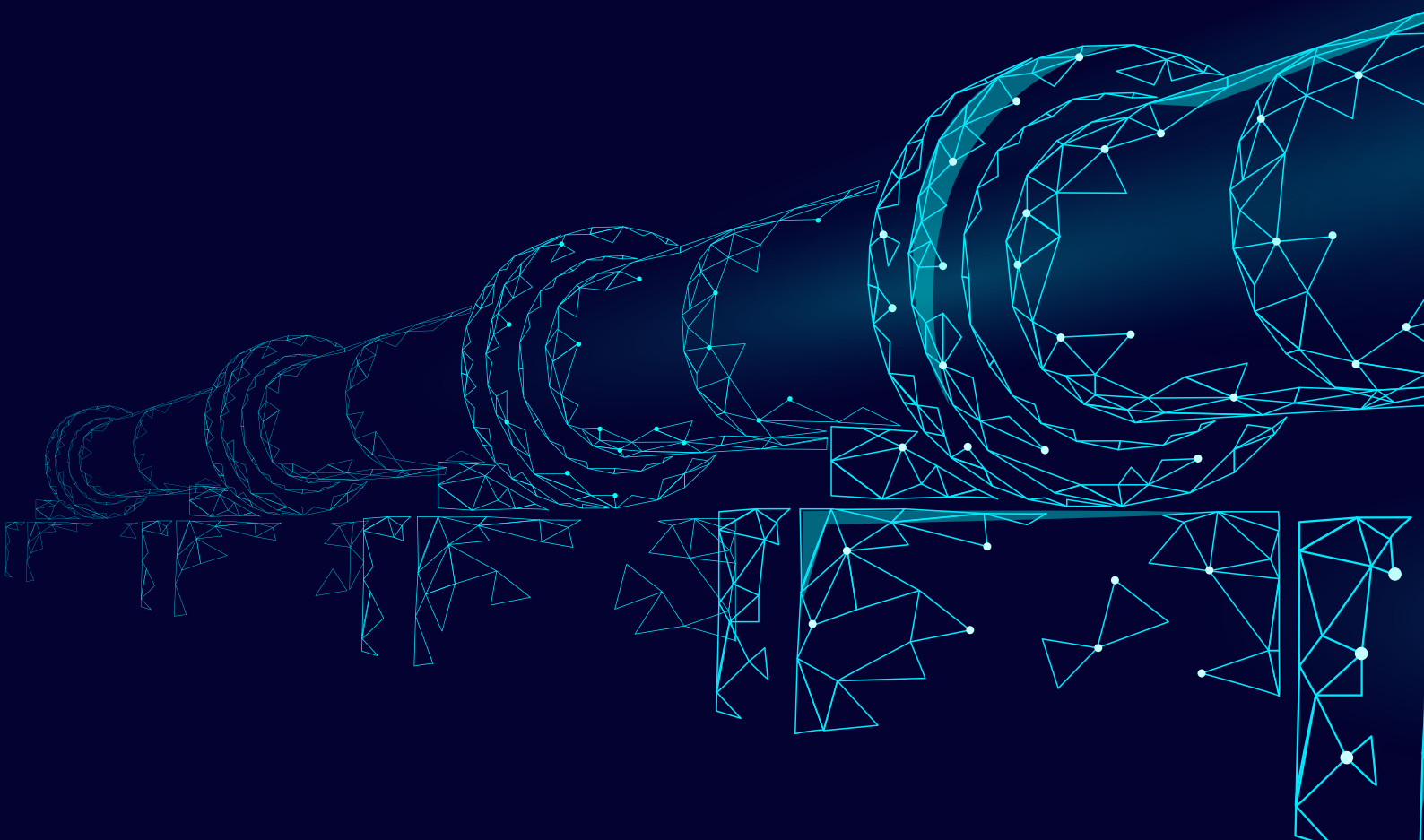
The Eni Vibroacoustic Pipeline Monitoring System, e-vpms<sup>®</sup>, emerges as a strong candidate for pipeline monitoring due to its many applications and easy deployment. This technology is currently deployed in thousands

of kilometers worldwide, providing real-time monitoring of oil and gas pipelines, offering advantages such as non-invasiveness, cost-effectiveness, and ease of installation for retrofitting existing pipelines. Remarkably, with only a few sensors, this system can safeguard hundreds of kilometers against leaks, unauthorised activities, or accidental events, e.g. digging, impact or illegal tapping that may harm pipeline integrity.

Enivibes, the first venture established as part of the activities of Eniverse (Eni's Corporate Venture Builder), and proprietary of the e-vpms technology, and SLB (formerly known as Schlumberger) recently announced a global alliance that covers the

deployment for pipelines transporting liquid hydrocarbons and produced water. As the latest addition to SLB's Midstream Production Systems portfolio, this global alliance will bring the e-vpms technology to onshore and offshore pipelines, and with it, the ability to monitor the integrity of even the oldest assets. Operators worldwide will have access to reliable and specific real-time information, allowing for focused and timely responses, particularly in cases of environmental nature.

The e-vpms platform encompasses a wide range of integrity management technologies. These include various leak detection methods, recognition of TPI, pig tracking, assessment of valve-sealing



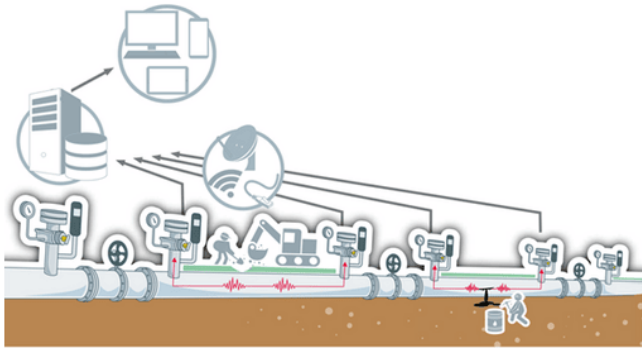
# STRATEGIC SENSORS AT WORK



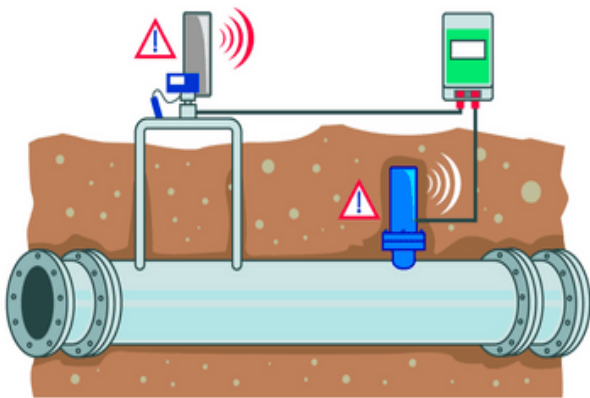
quality, detection of corrosion micro-vents, and localisation of existing leaks during pressure tests.

### Understanding the system

The e-vpms technology consists of a multi-point array of vibroacoustic sensors strategically positioned along a pipeline, a telecommunication system for data transfer, and a central



**Figure 1. e-vpms® hardware schema. Mechanical perturbations (e.g. leakages, impacts, or digging operations) interact with the pipeline, generating vibroacoustic waves that propagate along the pipeline. These anomalies reach the sensors, and the recorded data are then transmitted to a central processing unit.**



**Figure 2. e-vpms sensor blocks: Regular Sensor (upper left, grey). Shallow Water Sensor (bottom right, blue). Acquisition Station (top right, green).**



**Figure 3. Illegal hot tap detected and localised by the e-vpms waveleak®.**

processing server. These sensor groups are dedicated to capturing the entire elastic-dynamic wave field: they record micro-vibrations, total and acoustic pressures, which together provide in-depth insights into the physical phenomena responsible for generating elastic perturbations, i.e. leakages and TPIs.

This combined information enables the identification and precise localisation of abnormal noise sources, carrying second-order event information. To detect such subtle yet informative vibrations, the equipment is highly sensitive, and the signal processing algorithms are exceptionally advanced.

Acoustic and elastic waves are generated from a localised source whenever an event occurs and propagate in both directions at the speed of sound in the respective media. Vibroacoustic sensors record these waves, and a remote-control unit continuously transmits data segments to the processing server. This central server oversees advanced digital processing chains, including non-linear filters, real-time noise estimation, detection, and multi-channel localisation (Figure 1).

From a wave physics perspective, a pipeline acts as a highly efficient wave-guide system. The acoustic pressure field can travel for kilometers within the fluid, while vibrations propagate through the solid shell following elastic-dynamic laws. These characteristics grant e-vpms detection capabilities that surpass those of a simple pressure-based system, such as the well-known Negative Pressure Wave based technologies.

The identical e-vpms hardware, with minor enhancements, serves dual purposes, covering both leak and TPI detection. However, there are distinctions in the deployment distance of the vibroacoustic sensors. Typically, shorter distances are employed to enable precise detection, localisation, and labelling of multiple TPI events, contrasting with the requirements for leakage detection.

### Detection principles of different technologies

As previously mentioned, e-vpms exploit distinct detection methods that can be deployed independently or combined on the same pipeline to enhance protection. Each method relies on a different physical principle, requires distinct input measurements, and provides varying output data.

#### Advanced negative pressure wave method

The e-vpms waveleak® employs an advanced negative pressure wave method, which distinguishes itself as a highly effective technique for real-time leak detection and localisation. It excels at promptly identifying the initiation, variation, or cessation of a leak. Strong deforming impacts and most precursor events of illegal tapping are also detectable with this method.

Elastic waves generated by sudden leak-related events are robust, abrupt, and propagate predictably in both directions. Consequently, once the negative pressure waves are detected and linked between sensors, the time difference of arrival (TDOA) method is used to locate the leakage.

This method exhibits exceptional sensitivity, capable of triggering alarms even in the absence of outflow. Notably, it remains independent of both the volume and duration of the leak. It boasts top-tier leak detection performance, effectively identifying leaks with hole diameters as small as 0.1 in. while

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**Figure 4. Weight drop equipment used to assess the energy transfer from the ground to the pipeline shell and fluid. It is used to calibrate the e-vpms TPI® detector.**



**Figure 5. Mechanical excavation performed to calibrate the e-vpms TPI detector.**

typically requiring the installation of one sensor every 30 km, with the potential to extend up to 50 km.

#### Compensated mass balance leak detection method

The e-vpms massleak® is an RTTM compensated mass balance leak detection method based on the principle of mass conservation. The pipeline is divided into mass balance sections defined by flowmeters or closed valves. The RTTM model provides density and area profiles. In a leak, mass unpacks, creating a negative rate, and the imbalance equals the leaked mass.

Clamp-on flowmeters measure mass flowrate, while RTTM processes pressure and temperature for real-time compensation and enhanced leak detection. Localisation is limited to the control volume, sensitivity depends on flowmeter accuracy, and detectability relies on leak volume and duration rather than its onset or end.

#### Acoustic noise leak detection method

The e-vpms noiseleak® is an acoustic noise leak detection method that utilises the continuous noise generated by the

fluid jet outflow for both leak detection and localisation purposes. The fluid jet consistently emits stationary noise, which propagates within the pipeline and reaches the vibroacoustic sensors. The data from adjacent vibroacoustic sensors is analysed, and if the correlation peak surpasses a predefined threshold, it signals the presence of a noise source associated with a leak. The TDOA is used to localise the noise source.

Detectability depends on the outflow rate and the duration of the leak, remaining independent of when the leak begins or ends.

#### TPI detection method

TPI detection includes the detection of excavation or works in the right-of-way, and illegal tapping precursor events. In scenarios involving excavation, this energy dissipates into the surrounding terrain, subsequently transferring to the pipeline shell and then to the fluid. In cases of impacts or welding, the energy affects the pipe shell and is also transferred to the fluid. These TPI events exhibit distinct yet discernible signatures, allowing the e-vpms TPI detector to label them effectively.

Even though the e-vpms TPI® is monitoring events with distinct signatures, the detection and localisation are like the e-vpms noiseleak detector. Further algorithms are used to determine the type of TPI activity that triggered the alarm. A TPI event is distinguishable from a leak and therefore cannot be mistaken as one.

The detectability of TPI events depends on factors such as the strength of the energy source, sensor spacing, and event duration. Notably, the performance of the e-vpms TPI is comparable with fibre optic systems, but it eliminates the need for fibre installation.

#### Deployment and requirements

The vibroacoustic sensors are installed on existing hydraulic branches, reducing the need for hot tapping, spaced tens of kilometers. There are two sensor block types (Figure 2): regular and shallow-water sensor block, which is submersible up to 10 m, making it ideal for swampy areas. Both sensor blocks are certified as ATEX (Ex i) compliant.

Onsite devices consume less than 20 W of power and can be powered by various means, including solar panels, fuel cells, or direct mains connection. The vibroacoustic sensors exhibit the ability to run for extended periods on battery, a valuable feature for a portable system.

Data collected by the field acquisition units are transmitted in real-time to the central processing server. For comprehensive coverage, the network data transfer employs available communication channels such as LAN, Wi-Fi, ADSL, UMTS, Satellite, with a minimal data usage of less than 20 kbit/sec.

#### Performance: integrity monitoring capabilities and KPIs

The e-vpms functions extend beyond leak and TPI detection. Whether in permanent or portable configurations, this versatile system can provide support to pipeline operators in various activities, including the successful cases described next.

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## Leak detection and localisation

### Illegal tapping

Enivibes has a long history battling illegal tapping in the Italian pipeline network, where almost 100% of all Eni refined product lines, along with other operators' pipelines, are monitored by e-vpms waveleak. An alarm is issued, on average, 5 – 10 minutes within the beginning of the leakage. In Figure 3, we show a hot tap detected by the system.

### Corrosion micro-vents in a pipeline before reactivation

During the COVID-19 pandemic, a period of decreased energy demand led to the temporary shutdown of some pipelines. A crude oil transportation pipeline had been inactive for several months and as the reactivation was planned, concerns arose regarding potential corrosion-induced damage during the shutdown that could lead to issues upon reactivation and was equipped with a permanent e-vpms system.

The permanent e-vpms system was used to monitor the pressure tests to assess the integrity of the asset, effectively segregating the 90 km long pipeline using shutdown valves and four vibroacoustic sensors in four consecutive pipe segments, each isolated by closed valves.

During the pressure tests, data processing of the pressure measurements by the e-vpms stations revealed a pipe segment with an abnormal pressure drop in comparison with the other segments. A more in-depth analysis, utilising e-vpms Computational Fluid Dynamics, provided evidence supporting the hypothesis of a minor leak within the suspected critical segment. During subsequent inspection of the identified segment, a minor vent on a pipe derivation was found on a hydraulic junction.

### Localisation of an existing leak during pressure test

A portable version of the e-vpms was installed in a water injection pipeline, where a leak was identified within a 3 km long buried segment of the line. Although pressure sensors alone could easily identify the presence of a leak due to the pressure variations in an isolated segment over time, a more sophisticated detector was needed for precise localisation.

Three hydraulic derivations along the pipeline were utilised to deploy three vibroacoustic sensor blocks. The leakage was accurately localised with e-vpms noiseleak. The area was excavated based on the predicted location, resulting in the discovery of a leak hole size of approximately 25 mm<sup>2</sup>, with an error margin of less than 25 m.

## TPI detection and localisation

The e-vpms TPI is a protection technology widely employed in pipelines worldwide. Within the recommended maximum sensor distance of approximately 5 km, it can detect and localise manual excavation activities. The response time is about 13 - 21 minutes, as it continuously monitors and identifies energy sources present within a specified spatial range. TPI events can be accurately localised with a precision of about 25 m.

The assessment of energy transfer from the soil to the vibroacoustic sensors involves a standardised impact test. This

test involves the drop of a weight onto the ground above the buried pipeline, ensuring consistent energy generation. Additionally, prior to deployment, the system undergoes calibration through excavation tests, encompassing both manual and mechanical procedures. The evaluation of energy transfer to the pipe shell itself is achieved through a series of non-deforming impacts directly applied to the pipe shell.

Figures 4 and 5 show the weight drop equipment and excavations performed in a pipeline transporting refined products.

## Pig tracking

Real-time pig tracking can be achieved using data from vibroacoustic sensors, whether from portable or permanent installations. This is possible by capturing the acoustic and elastic waves produced by the pig as it traverses the pipeline.

The system not only tracks the location and velocity in real-time but also identifies unexpected anomalies like impacts. Moreover, it can detect and pinpoint stuck pigs by locating reflections of the regular pipeline waves, ensuring efficient pipeline maintenance and operation.


## Valve-sealing quality assessment

Evaluating the integrity of shutdown valves holds paramount importance for safety, particularly in ageing pipelines where valve deterioration can go unnoticed. The e-vpms technology presents a comprehensive solution for assessing valve tightness through a combination of pressure analysis and acoustic reflectometry.

A case illustrating the efficacy of this method occurred in a crude oil pipeline, already monitored by the e-vpms, when concerns arose about valve tightness for multiple shutdown ball valves. The evaluation involved creating a pressure difference across valves and generating acoustic waves for integrity assessment that was analysed with the help of the e-vpms computational fluid dynamics to determine whether the efficiency of the valves.

## Conclusion

e-vpms stands as a valuable asset for pipeline operators due to its scalability and adaptability to any kind of operational conditions. Its versatility extends to pipelines of different diameters and fluid types, ensuring consistent performance both during pumping and sealed conditions without limitation on the minimum detectable leak quantity.

It is non-invasive, cost-effective, fully integrated with the existing equipment and therefore ideal for retrofitting existing pipelines, whether in onshore or offshore scenarios. Thousands of kilometers are already monitored worldwide, and thanks to a global alliance between Enivibes and SLB, the e-vpms technologies can be delivered in more than 100 countries. 

## Note

The e-vpms® is a mark of Eni. The e-vpms trademark is registered by Eni in the European Union, Canada, Russia, and the US. waveleak, TPI, massleak, noiseleak, and smartleak are software products; Enivibes is the copyright owner. The e-vpms® technology and patents are owned by Enivibes.



Figure 1. ETR with endlessly rotating welding head and rotating/tilting positioner.

# OVERLAY OVERVIEW OVERLAY OVERVIEW OVERLAY OVERVIEW

**Anton Leithenmair, Head of Automation, Fronius Welding Automation, Austria, discusses setting new standards in overlay welding systems.**

**F**rom planning, engineering, manufacturing and commissioning to the maintenance and servicing of overlay welding systems, customers can rely on Fronius Welding Automation to support them with its global service and partner network. The company is committed to delivering the perfect overlay welding result. All systems are manufactured in accordance with international compliance standards to ensure safety and reliability. Technical commissioning by Fronius experts and the preliminary acceptance by buyers from the oil and gas industry take place at the production site in Steinhaus, Austria. The systems are then delivered, installed on site – for example in Saudi Arabia, the UK, or the USA – and finally

accepted by international customers in the onshore and offshore sector. The comprehensive Fronius commissioning service includes expert training sessions and process optimisations at the start of production.

### **Realistic welding tests and feasibility studies**

Every new overlay welding project at Fronius Welding Automation begins with feasibility studies and welding tests. Overlay welding is a highly complex process. In addition to the base material of the components to be surfaced, parameters such as amperage, wire speed, welding speed, filler metal, shielding gas, ambient temperature, and humidity also play a decisive role. Even minor deviations can have unwanted

effects on the welding result. This is why welding tests should be as realistic as possible – with components, filler metals, and shielding gases that will also be used later on when the system goes into live operation. If possible, the tests should also be carried out under the same climatic conditions that prevail at the intended place of use. If these conditions cannot be achieved, the welding parameters must be adapted and optimised in line with the production environment during commissioning. Furthermore, these tests should ideally be done by Fronius experts to avoid any nasty surprises.

Anton Leithenmair, Head of Fronius Welding Automation: “We need an open, trusting exchange of information from the outset to ensure that overlay



Figure 2. Siegfried Wiesinger programmes the system using the HMI-T21 system controls.

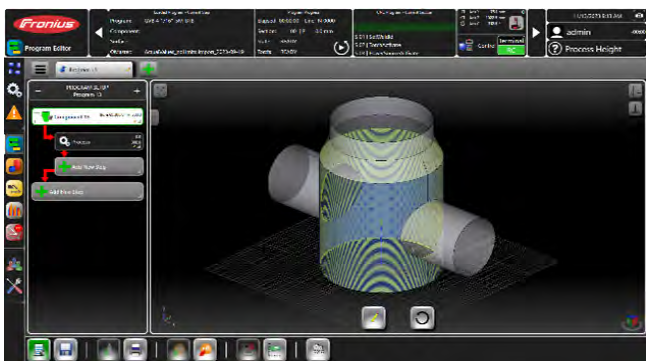


Figure 3. The HMI-T21 Program Editor.



Figure 4. Compact Cladding Cell with rotating positioner, HMI-T21 system controls, and remote control.

welding systems are customised to customer requirements. Are there any specifications regarding the filler metal and shielding gas? What about the local climatic conditions? One particularly important factor is being able to carry out our welding tests with original components rather than resorting to dummies. This is the only way our systems can deliver the desired welding results, even under the harsh conditions of continuous operation.”

### Complete solutions for the oil and gas industry

Fronius Welding Automation draws on a wealth of experience to devise innovative ideas for new system solutions. Over a period of more than 40 years, the company has developed application-based overlay welding systems that are either used as standard or modified to meet special customer requirements.

### Compact Cladding Cell (CCC) – smart and user-friendly

With a footprint of approximately 6 m<sup>2</sup> (64.5 ft<sup>2</sup>), the Compact Cladding Cell mounted on a transportable platform is a compact solution for overlay welding. It was developed as a cost-effective inner cladding solution for valve components. The maximum bore depth and largest possible component diameter are 1 m (39 in.), the highest component weight is 2500 kg (5511.56 lb). Despite its compactness, the system is an extremely powerful overlay welding system. It stands out for its ease of use, precise movement sequences, and comprehensive data recording options. The ergonomic design with a wirespool holder at a comfortable user height, welding torch quick-change system, and power sources on a rail extension speak for themselves. Plus, the CCC boasts innovative software functions, maximum process security, and ultimate reliability in continuous operation. The Automatic Multi-Sequence function allows the storage of multiple welding and movement parameters in the form of sequences. Starting from the home position, these are executed one after the other on a fully automated basis. The HMI system controls offer next-level ease of use with a 21 in. touch display, real-time process visualisation, multi-user management, and much more. For applications requiring the highest possible productivity, SpeedClad 2.0 is the process of choice.

### Endless Torch Rotation System (ETR) – almost unlimited possibilities

The ETR system was developed for larger, more complex components and has been an established solution for many years. Its key feature is an endlessly rotating welding head. This makes it possible to weld components with different bores and bore angles up to an internal diameter of 1 m (39 in.). The welding torch and the wirefeeder rotate together around the bore axis. Components are centred fully automatically, which shortens set-up times considerably and saves production costs. If there is a risk of the torch colliding with the component, the electropneumatic collision detection system stops all axes of movement and protects the welding torch against damage. Most recently, Fronius has enhanced its successful ETR system with the even more flexible ETR Ultimate system. In addition to overlay welding tasks, this versatile system also makes it possible to join larger components with challenging geometries and difficult seams. As with the Compact Cladding Cell, both the ETR and ETR Ultimate systems come with the convenient 21 in. system controls with touch display, real-time process visualisation, and multi-user management as standard. The same applies to the welding torch quick-change system, which is designed to save time. If necessary, the welding torch and positioner move in

sync in both the ETR and ETR Ultimate, while the SpeedClad 2.0 delivers maximum productivity for the overlay welding process here as well.

### All parameters live and at a glance

With a large, intuitive 21 in. touchscreen, multi-user accounts with individually assigned authorisations, process visualisation in real time, on-the-fly parameter adjustments, and innovative functions such as X-Ray View, Component Editor, Bore-to-Bore Advanced, actual value monitoring in real time, and STEP file import, the HMI-T21 system controls are ready for Industry 4.0. And, of course, the system offers remote maintenance capabilities. The X-Ray view provides a transparent outline of the component to give the operator an excellent overview. The Bore-to-Bore-Advanced function offers assistance when several offset transverse bores with non-90° angles or flanges with bores are to be surfaced. All relevant welding parameters are displayed live in the system-integrated actual value monitoring.

### A service that meets every need

The welding professional creates components step by step in the Component Editor via the HMI-T21 touchscreen. The height and diameter are defined by inputting the relevant dimensions, and the various components appear in real time as 3D graphics on the screen. In addition to cylindrical shapes, flat and conical shapes are also possible. There is also the option to model bores and extensions, such as flanges. The CNC technology now integrated at Fronius creates scope for even more component geometries than before, including intersection bores on conical components.

The welding processes are programmed in the Program Editor. Operators select the individual sections of the components and define the welding sequence. The welding direction is set from bottom to top by default but can be changed as required. One especially helpful aspect is that the welding torch can be shown at the starting point.

All welding parameters are defined in the Weld Editor. The system offers a selection of jobs with fixed parameters that can be adjusted at any time – even on-the-fly – in the Weld Adjust menu. Actual Value Recording (AVR) records the actual values of the welding current, voltage, wire speed, gas quantity, and welding position during the welding processes in table form. The PC software packages Data Logger HMI and Data Viewer HMI are optionally available for graphical evaluations and analyses.

Once the home position of the welding torch has been calibrated, it moves independently to the starting point for each overlay welding application. Siegfried Wiesinger, overlay welding expert at Fronius, explains: “The remote control can be used to fine-tune a range of parameters even just before igniting the arc — for example, the Arc Voltage Control (AVC) function adjusts the starting point and distance of the welding torch to the component.”

If welding work is interrupted, optimal seam overlaps can be created using the Path function. When restarting, the welding torch is moved to a short distance behind the end of the weld, and welding is then restarted from there.



Figure 5. High-performance Pipe Cladding System.

“In remote service mode, Fronius service technicians not only have access to the HMI-T21 but also the remote control. This allows welders to detect operator errors so they can work together to fix them. Plus, our systems are network-enabled,” adds Wiesinger. “This gives operations and workshop managers the opportunity to see how overlay welding work is progressing from their own office and intervene if necessary. The Offline Editor is particularly cost-effective as it allows welding work to be carried out while welding programmes are being created away from the system. This saves valuable production time.”

### High-performance pipe cladding system – because time is money

The Fronius Pipe Cladding System is a solution designed specifically for inner cladding of pipes with a length of up to 12.7 m (500 in.) — for example, risers in subsea pipelines. This system’s performance has now been significantly enhanced, with customers benefiting from higher deposition rates and welding speeds as well as shorter processing times. The modified overlay welding system now consumes less gas and fewer welding torch wear parts. The welding torch, wirefeeder, and high-resolution ArcView arc observation camera are cooled with incredible efficiency, ensuring reliable operation despite the high temperatures inside the pipes. Fronius customers not only benefit from a high-performance cladding system that meets every need at welding speeds of up to 1.7 m (67 in.)/min and deposition rates of up to 10 kg/h (22 lb/h), but also minimise their production costs at the same time. This enhances their profitability and gives them the competitive edge. The system variants are designed for pipe diameters of up to 914.4 mm (36 in.) and 1270 mm (50 in.).

### SpeedClad 2.0 – award-winning and blazing fast

Faster, resource efficient, more economical — with SpeedClad 2.0, Fronius is setting new standards in overlay welding of valve components. SpeedClad 2.0 is much more cost-effective than the pulsed TIG hot wire processes used across the sector. This innovation stands apart thanks to its high deposition rate, impressive speed, and low shielding gas consumption. In recognition of its exceptional results, the process was

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awarded the Excellence in Welding Award by the American Welding Society at FABTECH in Chicago on 13 September, 2023. The jury were impressed by the deposition rate of the nickel-based alloy used in overlay welding being increased from 1.63 kg (3.59 lb) to up to 6 kg (13.23 lb)/h, with Fronius now using a 1.6 mm wire (0.063 in.) in place of the 1.14 mm (0.045 in.) wire. The welding speed rose from 33 cm (13 in.)/min. to 135 cm (53 in.)/min., and the average pulsed current went from 240 amperes to 460 amperes. All Fronius customers are guaranteed the ideal heat input while simultaneously reducing argon gas consumption from 516 l/kg to as little as 140 l/kg. The fully re-developed welding torch system allows cladding of significantly narrower component diameters of 100 mm (3.94 in.) instead of 150 mm (5.91 in.). The heat input formula served as the starting point for the optimized cladding process: heat input = volts x amperes x 60/welding speed.


Sustainability is part of Fronius Welding Automation's genetic makeup, which is why many of its innovations not only deliver technical improvements but also reduce consumables – just as the SpeedClad 2.0 process does.

## Longitudinal and circumferential seam welding systems and robotic welding systems also in the range

As a solution provider, Fronius Welding Automation not only produces overlay welding systems but also mechanised welding systems and robotic welding systems for all industries.

These include longitudinal and circumferential seam welding systems, welding carriages, and handling-to-welding robotic welding systems. Collaborative systems, intelligent sensor technology, software solutions for data management, and offline programming including welding simulation open up profitable welding opportunities for metal processing companies starting with a single batch. The specific requirements for the welding technology are analysed together with the customer. This is followed by the creation of an individual solution.

To do this, Fronius has a construction kit of standardised components at its disposal. Starting with the feasibility study and continuing with planning, engineering, manufacturing, and start-up, the sale of welding systems is handled as a project. Since 1975, more than 3500 installed systems have been used across 45 different countries with over 2000 active customers. Covering an area of more than 11 000 m<sup>2</sup> (118 400 ft<sup>2</sup>), around 150 employees take on the welding technology challenges presented by their customers.

Fronius is one of the world's leading manufacturers of overlay welding systems and repeatedly brings new innovations to the market, such as the retrofittable SpeedClad 2.0 process that won the Excellence in Welding Award. As a general contractor, Fronius Welding Automation offers its buyers key advantages as a one-stop supplier for the entire system – including commissioning. Fronius Welding Automation strives to provide expert, customer-friendly service right from the start and throughout the entire service life of a welding system. Last but not least, every single user benefits from overlay welding systems that, thanks to update options and retrofitting, will remain state-of-the-art for years to come. 

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