VOL. VII, NO. 1 | 2015

# INNOVATIONS®

## $CO_2$ CAPTURED

...Now what?

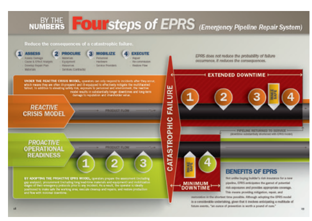
INNOVATIONS®
VOL. VII, NO. 1 | 2015






## DEPARTMENTS



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# Whither the Gold Watch?

**BY ERIC ROGERS**
VICE PRESIDENT, GLOBAL
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T.D. WILLIAMSON

It used to be that an employee stayed with a company 30 or 40 years, receiving a gold watch at the end of their decades-long career.

But now? Times, if you'll pardon the expression, have changed. Average job tenure is less than five years, government reports say. Where Baby Boomers valued longevity and stability, job-hopping is a way of life for younger workers. And with online resources like LinkedIn making it easier than ever for recruiters to mine companies for talent, holes can appear in your organization overnight.

Admittedly, this trend alone isn't enough to put gold watchmakers out of business. But couple it with what's being called the oil and gas industry's "Great Crew Change" – when an aging workforce retires without enough young replacements in the pipeline – and the threat of a significant talent gap is suddenly very real.

All is not lost, however. It is possible to prepare for and guard against a growing shortfall in human capital. I firmly believe that a robust, well-defined process of talent development is the answer.

At T.D. Williamson, we support talent development initiatives that engender employee loyalty, create growth opportunities, and identify and help prepare the next generation of leaders. This includes:

» Hiring not just for today's openings, but for future needs. Creating bench strength means there are multiple people who can move up to fill spots on the team.

» Onboarding that engages employees and affirms their decision to join your company. This effort involves all management and senior leadership.

» Development initiatives that show employees of all generations a clear path to future possibilities. Such training can provide new skills that improve job satisfaction.

» Teaming new employees with mentors and experienced subject matter experts, including people from different departments and functional areas. This approach enables the transfer of knowledge, can build personal relationships, and allow more senior staff to spot new leadership potential.

There's no denying that times have changed – and if we want to close the talent gap, we need to change, too. It's essential for us to listen to and understand our employees, then create the kinds of programs and workplaces that appeal to them.

Because in this new age, it's going to take more than the distant promise of a gold watch to attract – and retain – valuable talent.

“We support talent development initiatives that engender employee loyalty, create growth opportunities, and identify and help prepare the next generation of leaders.”

# GlobalPerspective

## RESEARCH IN PIPELINES

### Cliff Johnson

PRESIDENT, PIPELINE RESEARCH COUNCIL INTERNATIONAL

The oil & gas pipeline industry has become a larger part of the public dialogue than ever before. This increased awareness provides the industry with an opportunity to demonstrate our capabilities. There is a push from regulators and the public for a safer, more efficient and environmentally conscious pipeline system. In response, the industry has reaffirmed its commitment to operational excellence and has established a goal of zero failures. In order to reach this desired outcome, there is a necessity to develop the most effective tools and techniques. Pipeline Research Council International (PRCI) and its members – 40 of the world's leading pipeline operators and 39 solution providers (including T. D. Williamson) – have worked to develop this research agenda for the industry.

One of the key parts of the agenda includes enhancing and improving inline inspection (ILI) tools. ILI is one of the key techniques used to validate pipeline safety and integrity. PRCI is also working to reduce the impact of third-party damage to our pipeline systems. Third-party damage is the leading cause of pipeline failure and is an area that the industry needs to focus its attention. PRCI is looking at a number of options from underground-based (fiber optic solutions for new systems) and ground-based sensors (including car based), aerial (fixed wing, drone, or helicopter), and space (involving new satellite technology). Understanding who or what is on the right-of-way will allow us to make better decisions on how to respond to threats in a timely fashion. We are also working to enhance leak detection technology. If there is a release, the industry needs to be able to respond before the leak can become a critical issue.

To enable even greater step change technology development, PRCI is building a new facility in Houston, Texas, that will open in May 2015. The new Technology Development Center (TDC) will be located on an 8.5 acre site with a 30,000 sq. ft. workshop, office space, and meeting space, and it will include a state-of-the-art pull test facility. The pull test facility will be used to test and enhance the performance of ILI tools. The workshop will be able to host a variety of research activities with the initial focus being on nondestructive evaluation (NDE) tools. The TDC will also serve as a site for training on PRCI research results, and this will enable PRCI members to more rapidly adopt key findings.

For additional information on any of the above items please visit our website at **www.prci.org**.

Third-party damage to pipelines, caused by a variety of sources including utility excavation, continues to be a main threat in the oil & gas industry.

*Richard Thornton / Shutterstock.com*

## ADJUSTING TO THE NEW GAME

### Chad Fletcher

VP WESTERN HEMISPHERE OPERATIONS, T.D. WILLIAMSON

To claim that shale and unconventional developments in the United States have been anything less than game-changing on a global scale would be a gross understatement. As proven reserves, even with rapidly increasing production, have grown – nearly doubling for oil and up 40 percent for natural gas since 2008 – the new rules are here to stay.

However, by simply focusing on the new way to play, it can be easy to overlook the complexity of the infrastructure, regulation, and maintenance required to accommodate and sustain such a steep growth curve. A rising and formidable challenge – shared equally by upstream, gathering and transmission pipeline operators – is how to safely execute their largest capital expenditure growth programs, while simultaneously improving the performance and integrity of their existing pipeline systems; not to mention the mounting pressure to transport ever-increasing volumes without interruption to flow, and maintaining focus on financial performance and shareholder value.

Further upping the game's difficulty, U.S. operators must adjust to falling oil prices, with shifts in global supply and demand resulting in lows not seen since 2009. Many operators, however, have discovered the winning move: Drastically lower production and operating costs to remain competitive. Through strategic partnerships with specialized pipeline service providers and consultants, operators are becoming better prepared to meet the market's seemingly incompatible demands.

## NOCS: ROCK AND A HARD PLACE

### Roberto Mejia

DIRECTOR, LATIN AMERICA, T.D. WILLIAMSON

Synonymous with National Oil Companies (NOCs), the Latin American energy industry has historically underinvested in and overtaxed its infrastructure, resulting in aged and limited pipeline systems. To complicate matters, in the last decade, global energy prices have pressured NOCs to significantly increase their output, further stressing old infrastructure.

Somewhat between a rock and a hard place, the NOCs are also facing increasing safety and environmental regulation. Although often performing the dual role of regulator and producer, the NOCs have developed a strong partner network to navigate this challenge. It's common for them to collaborate on and adopt one another's best practices, and to lobby for similar legislation. They also depend on specialized partners for guidance on new technology and operational innovation.

This reliance on their peers and industry partners has helped NOCs accomplish their sometimes conflicting goals of increased uptime and production on aging infrastructure, and compliance to tightening regulation, allowing them to safely grow their pipeline networks from south of the Rio Grande to Tierra del Fuego.

# Avoid Surprises

## and Premature Grey Hair

Using inline inspection to comply with pending PHMSA rules

New regulations from the Pipeline Hazardous Materials Safety Administration (PHMSA) are a lot like those first grey hairs that inevitably come with age: Even though you expect them, they can still sneak up on you.

Take, for example, PHMSA's Advisory Bulletin 2012-06.

It was PHMSA's notice to U.S. natural gas transmission operators about the changes they'll be required to make when verifying and reporting operating specifications for maximum allowable operating pressure (MAOP) and maximum operating pressure (MOP). Part of the agency's proposed Integrity Verification Process (IVP), the pending regulation means that all gas transmission operators will eventually have to integrate new methodologies into their integrity management programs and be ready for agency audits.

Although the bulletin was issued more than two years ago, the timetable for compliance remains unknown. No one can say with certainty when IVP will go into effect. Even the comment period, originally expected for early 2015, has turned into a moving target.

None of this, however, absolves operators from their future responsibility. IVP is on its way. So while the expectation is clear, the possibility still exists that the proposed rule could catch operators off guard.

The best bet to avoid a sneak attack is through advanced planning and preparation. That's why even though the regulation isn't a reality yet, many operators are looking to get a head start.

### All Pipe Joints Are Not Created Equal.

Among the requirements of PHMSA's ADB–2012–06 is the validation of material records. In many cases, though, those records are insufficient, were lost over time, or were never kept in the first place.

So this leaves operators asking two questions: Is it possible for me to satisfy the IVP requirements without incurring all of the associated costs of extensive excavations and laboratory testing? And, if so, can I accomplish the same results through non-destructive methods alone?

The answer to both questions is yes.

"The solution is twofold," says Chuck Harris, Commercialization Manager for Pipeline Integrity Technology at T.D. Williamson (TDW). "First, inline inspection (ILI) with a comprehensive technology like the Multiple Dataset Platform, or MDS, to classify pipe joints by their characteristics. Second, following the integrity report, verification of materials through the Positive Materials Identification (PMI) process."

As the market's most comprehensive inspection platform, MDS is comprised of a robust combination of complementary technologies. When specifically applied to IVP requirements, MDS provides the following:

- **Low Field Magnetic Flux Leakage (LFM)**, the foundational dataset for grouping pipe joints. LFM reveals mechanical characteristics related to manufacturing and milling through background gauss levels and microstructure changes.
- **Deformation or Geometry inspection (DEF)**, which identifies bore and long seam trim characteristics.
- **High Field Axial Magnetic Flux Leakage (MFL)**, used to confirm magnetic properties.
- **SpirALL® MFL**, which distinguishes differences in long seam characteristics.
- **Radial/IDOD (internal/external discrimination)** used to identify additional characteristics related to the internal pipe wall.

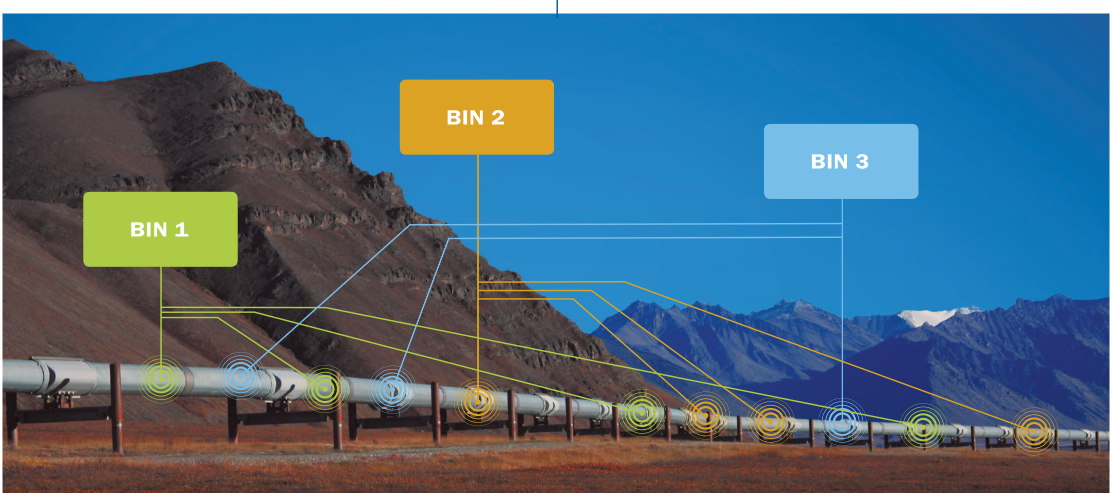
In a certain sense, MDS allows operators to go back in time: The platform can identify carbon steel pipe joint characteristics based on the manufacturing or milling process, information that can unlock the mystery of what a large section or even an entire pipeline is made of.

As Harris explains, pipe joints with similar manufacturing or milling should share certain similar material properties. MDS can be used to identify common characteristics of a representative sample of pipe joints, producing information that can be validated by the PMI process and then applied more broadly.

"Let's say MDS has allowed you to identify 1,000 similar joints that are grouped together in what we'll call a bin," Harris says. "It would be possible, and it's our objective, to allow a subset of those 1,000 joints to be validated by PMI and apply the findings to all 1,000.

"This could then be used as the basis for identifying material characteristics for all of the joints in an entire bin. In other words, by validating a subset of joints, we could determine the characteristics of all of them," Harris adds.

The result is the foundation for establishing complete material records where none exist. And not only will that fulfill future PHMSA rules, it can keep operators from looking over their shoulders for surprises – and maybe stave off a few grey hairs in the process.




MDS can be used to identify common characteristics of a representative sample of pipe joints, producing information that can be validated by the PMI process and then applied more broadly – saving thousands of miles of joint testing.

# HSE and the THREE BEARS

Whether due to human error, unforeseen circumstance, or aging equipment, the best deterrent to potential disaster is a proactive defense

The animal kingdom has long served as a rich well that's routinely tapped to depict the dangers – overt and covert – for issues of pipeline safety. Let's take bears, for example. We'll let "hibernating bears" symbolize incidents that arise after years of corrosion, harsh conditions, and other natural or man-made forces take their toll on legacy pipeline and equipment. "Circus bears" can be an analogy for occupational safety, and "backyard bears" will be our metaphorical stand-ins for process safety.

## Keeping the "Three Bears" at Bay: Prevention and Solutions

Each "bear scenario" presents its own unique set of challenges, but while they may differ in frequency and severity, they have one thing in common: No matter how tame you think a bear may be, it's still a wild animal, and wild animals must always be considered potentially dangerous.

Identifying the "three bears" of pipeline safety is only the beginning. According to Barry Hollis – T.D. Williamson's Global HSE Manager – HSE isn't about dealing with the bears after they've shown up. It's about being prepared to take them on if and when they do. "Safety is not the absence of incidents," he says, "but rather the strength of your defenses."

So let's take a closer look at three scenarios for potential calamity, and some possible solutions to keep the bears at bay.

SCENARIO 1

## DON'T LET SLEEPING BEARS LIE: INVESTING IN LEGACY EQUIPMENT SAFETY

Legacy pipeline and equipment – hibernating bears – lead to danger when out of sight becomes out of mind. And yet, these "bears" may be the trickiest to contend with because it's sometimes hard to convince companies to invest time and capital in safety upgrades if there haven't been any incidents.

Say you have a section of pipe that's been in operation since the 1970s. Back when it was laid, the technology was state-of-the-art. But over the years, perhaps priorities shifted and new projects took precedence: Companies merge and expand. Records aren't always updated. Perhaps, when production increased, some scheduled maintenance was overlooked, or postponed – and there's never been a problem ... so far.

But then one day, while one of your crew is performing some routine troubleshooting, that 1970s-era pipeline suddenly suffers a failure. He winds up in the hospital with life-threatening injuries, and the impact to the local environment is substantial.

### So, What Should You Have Done? Kept Up With The Times.

Hollis says there is a lot of advanced safety technology being deployed within the industry. For example, T.D. Williamson introduced its patented double block and bleed STOPPLE® Train isolation system. This technology effectively puts additional layers of protection between the pressurized contents of the line and the personnel performing repairs or maintenance.

"We're trying to shift the industry [toward these kinds of upgrades]," Hollis says. "But while some companies have adopted this new standard, others say, 'Well, we've been successful with what we have. The risk is minimal, so why spend the money?'"

People operate under the assumption that if there hasn't been an accident, their equipment is safe. Hollis says this is simply not the case: No matter how vigilant inspection and maintenance may be, you can't count on old equipment to behave the way it did when it was new. While there's no way to prevent 100 percent of incidents involving older pipelines, taking a proactive approach to maintenance and upgrading equipment to comply with evolving industry standards will cut down the number of incidents dramatically.

"Safety is not the absence of incidents," says Barry Hollis, "but rather the strength of your defenses."

SCENARIO 2

## A TRIP TO THE CIRCUS: PAYING ATTENTION TO PEOPLE AND PROTOCOLS

Most occupational injuries are usually triggered by an individual worker's unsafe work practices and they are the one to suffer the consequence: lacerations, slip, trips, and falls, repetitive motion, etc. In theory, it should be easy to avoid most occupational safety hazards: You establish rules and protocols, and your people follow them – but things aren't always that simple.

Think about the circus: Sometimes, despite the posted warnings, people still test the patience of the performing bears. This is also true for employees following protocols. Say you have a particular safety protocol in place: All personnel must wear a protective facemask to perform "Task A." So far, so good.

But it turns out that the masks provided, although up to code, don't offer the visibility required to complete the assigned task. Workers repeatedly bring the problem to the attention of a supervisor, but it's considered "low-priority," so nothing gets done. Eventually, fed up with getting nowhere and still needing to meet quotas, workers just stop wearing the masks – and then a chemical spill sends a dozen maskless workers to the hospital.

### So, What Can You Do? Bring It Down To The Human Level.

At the end of the day, what's really important is how efficiently you get feedback from the personnel in the field, and how effectively you act to solve their problems via proper supervision. Hollis says that while cutting-edge computer programs are well and good, the best solutions don't have to be complicated or high-tech. Sometimes, less really is more.

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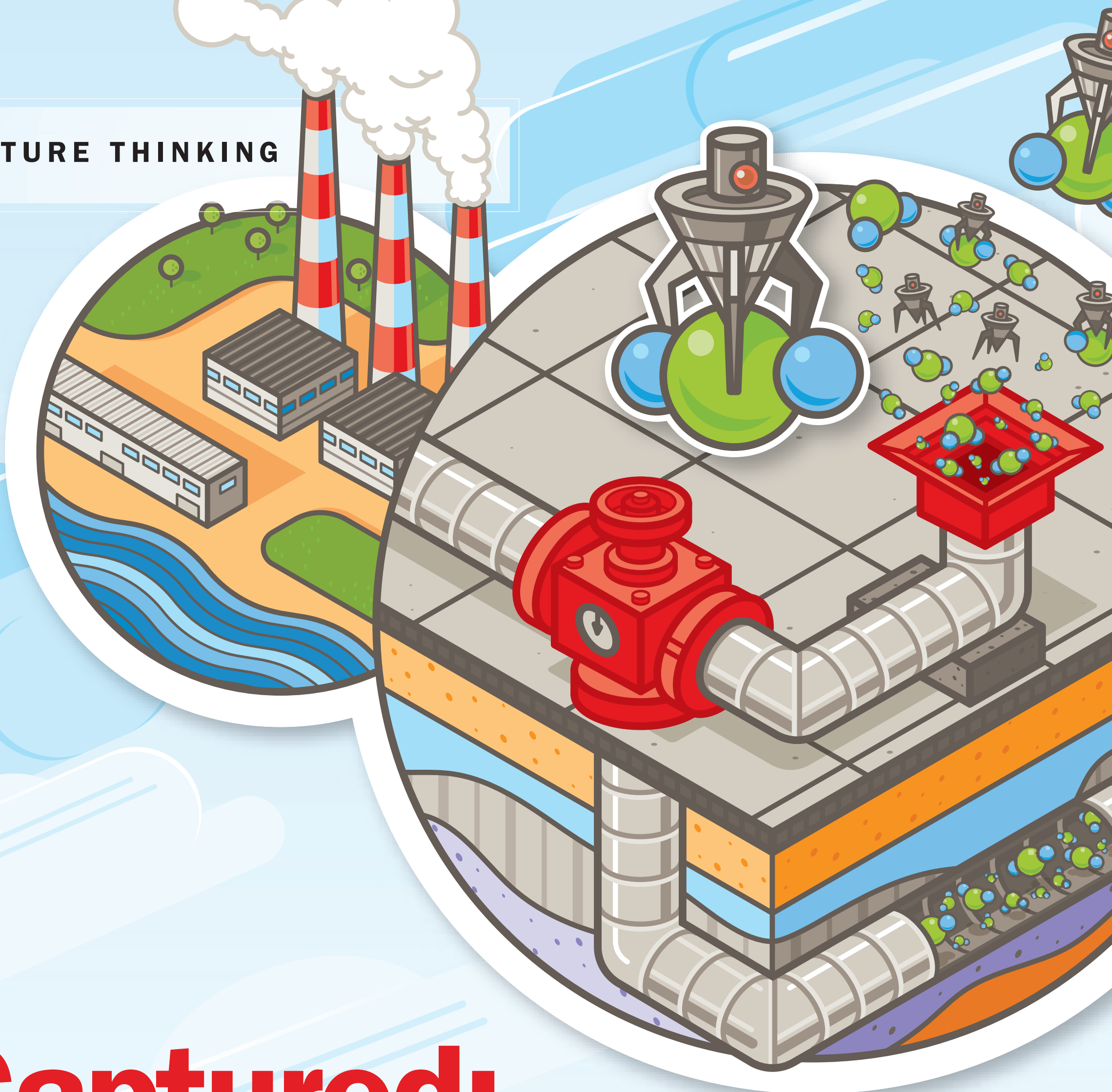
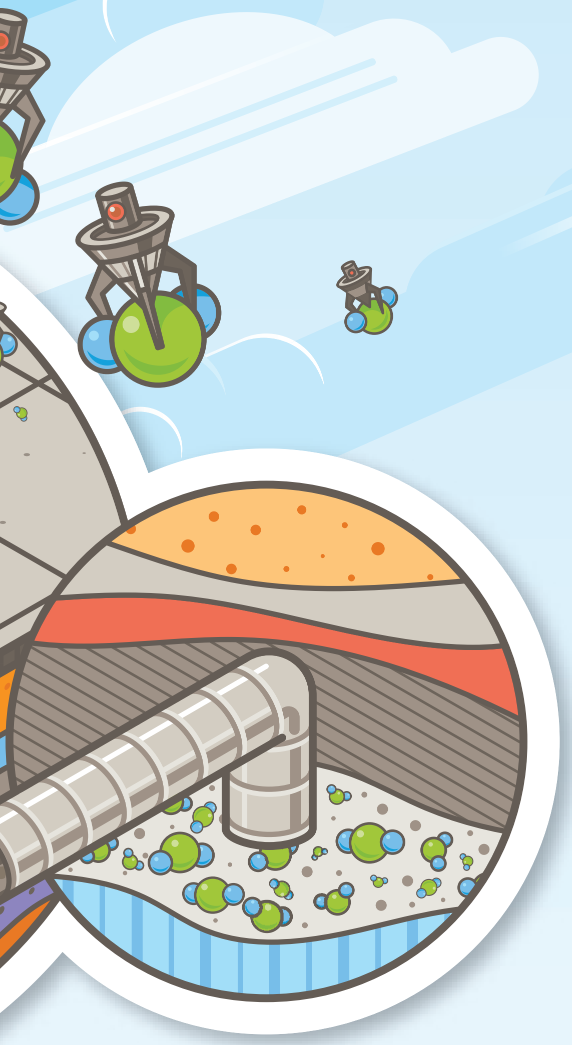


# Captured: Now What?

Industry and governments turn to carbon-capture technology to control emissions

In April 2008, British consumers got word of an exciting new beverage called EV-EON: sparkling water that got its fizz from carbon dioxide ($CO_2$) captured from coal-fueled power stations.

An animated video promoting the bottled water showed flying saucer-like devices sucking emissions from smiling power plant smokestacks. It would have been a great idea, had it been real. The water promotion was an April Fool's prank designed to raise awareness of carbon capture and storage (CCS) – a set of technologies to capture $CO_2$ from industrial and energy-related sources before it pollutes the atmosphere. Fast forward to today: With global concerns mounting about climate change and air quality, there's little need to raise



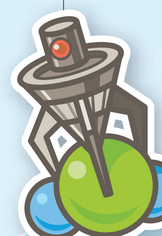
awareness about the importance of CCS. Businesses and government leaders around the world are looking to this process as a way to prevent large amounts of harmful $CO_2$ from escaping into the atmosphere.

The good news is that the technology behind CCS is nowhere near as far-fetched as the $CO_2$ charged sparkling water in the EV-EON prank. In fact, thanks to decades of research and development, CCS technology is a viable option for companies in the power, oil and gas, chemical, and refining sectors to offset their $CO_2$ production.

"CCS has made significant progress over the years," says Luke Warren, Chief Executive of the London-based Carbon Capture and Storage Association (CCSA). "The processes involved are considered safe, with limited scientific and engineering challenges."

And it's a solution that couldn't have come at a better time. In April 2014, the Intergovernmental Panel on Climate Change (IPCC) says global $CO_2$ emissions must be cut 50 to 80 percent to avoid the most damaging effects of climate change. It's a lofty goal – but it's one that Warren and other CCS experts think is attainable.

"CCS can achieve large emission reductions and is considered a key option within the portfolio of technologies needed to tackle climate change," Warren says. "According to the International Energy Agency, to achieve a 50 percent cut in global emissions by 2050, CCS will need to contribute nearly 20 percent of $CO_2$ reductions. Indeed, the IPCC concluded that the cost of tackling climate change could more than double if CCS isn't deployed."



## Proven Three-Step Technology

After CCS captures $CO_2$ emissions during industry operations, the $CO_2$ must then be compressed, transported, and injected into an underground geological formation.

> The processes involved are considered safe, with limited scientific and engineering challenges.

One of several effective technologies for capturing the $CO_2$ is amine scrubbing. The process utilizes a water solution containing organic compounds that bind with $CO_2$ and separate it from other emitted gasses. The pure $CO_2$ is then compressed into a supercritical fluid for pipeline transfer.

Of course, once the $CO_2$ is captured and compressed, it has to be stored somewhere. This step calls for injecting the $CO_2$ "through a well into sedimentary rocks a mile or more below the surface," says Susan Hovorka, Senior Research Scientist with the Bureau of Economic Geology at the University of Texas at Austin, which recently hosted an

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# Market Trend:
## Spending Money Up Front for a Stable Investment

Asset owners become increasingly proactive to ensure long-term return on investments.

As far as long-term, stable financial investments go, it's hard to beat a pipeline. While the value of product flowing through it will fluctuate from month to month, the pipeline itself will endure as a high-earning investment for as long as it continues to operate. Considering that the average pipeline operates for 50-plus years, it's no wonder that investors – often infrastructure investment companies – are jumping at the opportunity for a stable return. In the United States, these infrastructure investment companies are known as master limited partnerships (MLPs). Some MLPs, like Enterprise Products, specialize in pipeline investments, while others, like BlackRock, purchase pipelines as one investment of many in their portfolio.

No matter how they fit into a company's portfolio, pipelines are always purchased with the same intent: Generating income for as long as possible. But since many infrastructure investment companies don't typically have engineers on the payroll, they purchase pipelines as intact operations – relying on the expertise of existing employees, contractors, and service companies.

Although the pipeline's engineers and other operators usually remain the same when an infrastructure investment company purchases a pipeline, key management decisions tend to focus on protecting the asset – an opportunity for experts to aid in pipeline integrity.

### Fee-based Decisions

To understand some of the operational decisions behind infrastructure investment company owned pipelines, it's important to understand the revenue stream of their assets.

By definition, infrastructure investment is in the asset itself – the pipeline – rather than the product flowing through it. As the most efficient form of product transport, a pipeline is an attractive proposition to companies who wish to get their product to market – these product owners therefore pay fees to the pipeline operators (shippers) for the provision of safe, efficient transport of their resources. Beyond the asset value itself, fees are the revenue stream for infrastructure investment company owned pipelines.

In many areas, market liberalisation is managed by ensuring that access to these fee-based pipelines is provided for multiple product owners, often encouraged by financial regulation. However, due to the scale of investment required to build the pipelines themselves, it is more difficult to provide a choice of pipeline providers to product owners. As some consider this scenario to be monopolistic, there is a desire to ensure that the operators of fee-based pipelines feel the need to continuously improve the effectiveness and efficiency of their organisation and provide best-value to their customers. To encourage this, fees are often regulated.

In assessing fees, regulators will seek to ensure a fair price is paid by both shippers and by final consumers, while providing opportunity for the most progressive pipeline owners. Pipeline performance can impact fee-based decisions, including the manner in which operating expenditures (OPEX) are reduced, even if that necessitates additional upfront capital investment (CAPEX). At the other end of the scale, fees may be set at a level that forces a less efficient operator to drive cost out of its business, if it is to remain viable.

## Long-term Investment Means Above-and-Beyond Maintenance

Service companies, in particular, help infrastructure investment companies qualify and quantify risk to their pipeline assets through inline inspections and non-destructive evaluation. In fact, they often establish partnerships to complement an infrastructure investment company's long-term investment strategy.

One example of this risk-based approach is Nord Stream AG, a consortium of five shareholders that owns two offshore gas pipelines that operate through the Baltic Sea from Russia to Germany. "Nord Stream's operating life is 50 years," says Jean-François Plaziat, the company's Deputy Technical Director of Operational Maintenance and Engineering. "To achieve that amount of time, our company has developed a long-term pipeline integrity management strategy. Regular pipeline inspections and maintenance works are essential parts of the plan, including annual maintenance of mechanical components and testing of the automation system."

Inspections and testing allow the company to quantify the risk – and consequences – of potential damage and accidents. And if the potential consequences are too high, then they will spend the requisite funds to prevent them. For example, at Nord Stream, "the main risk of damage is related to third-party impact such as sinking ships," says Plaziat. Therefore, "the pipeline is continuously monitored by a leak detection system," ensuring quick emergency response if needed.

## An Investment in Improvement

Perhaps the most important difference of operating a pipeline as a long-term investment is that the managing company is likely to pursue integrity assessments and make improvements beyond those required by safety inspectors. Infrastructure investment companies need to completely understand the condition of their pipeline through testing and inspections – and they need trusted partners to help them identify improvements that can enhance the versatility, safety, and efficiency of their investment for years to come.

## OPEX vs. CAPEX

[operating expenditures] [capital expenditures]

### What Does It Mean For Operators?

When it comes to finding ways to decrease OPEX, most infrastructure investment companies look to engineers, service companies, and other operators for guidance. For example, one way to decrease OPEX is to make the pipeline more efficient. An efficient pipeline system requires less time and money to operate. This means that infrastructure investment companies are especially open-minded if suggested improvements – like tie-ins or refurbishments – increase the efficiency and versatility of the pipeline and allow them to reduce OPEX. "More than ever before, if a pipeline engineer has a sound rationale to justify an approach, this rationale is given proper consideration," explains Bill Rees, General Manager for T.D. Williamson, Central Europe. "These companies are looking out for their shareholders, so if they can spend money now to ensure long-term stable returns, they will."

### CAPEX

- Right of Way
- Construction
- Linepipe
- Cleaning/Scraping facilities
- SCADA

### OPEX

- Equipment and pipeline inspection, maintenance and repairs
- Insurance
- Labour
- Consumables
- EPRS and emergency contingency
- Legal
- Local taxes
- Flaring and gas shrinkage (lost gas)
- Buildings and utilities
- Depreciation

# PHMSA:
# COMPLIANCE AT A CELLULAR LEVEL

**Regulation Will Test Operator Knowledge of Material Properties**

- A Call For 'Traceable, Verifiable, and Complete' Records
- Early Adopters Prepare Ahead of the Proposal Becoming A Mandate
- NDE Techniques Can Save Time and Money
- Preliminary Results Are Nearly Instant
- PMI: Determining The DNA Of Pipelines

Do you have your grandfather's stubborn streak, or your great-aunt Irena's love of music?

Perhaps your cousin twice removed was a math whiz in New Delhi, who passed his dark eyes and numbers sense onto you.

Most people are eager to trace the origins of their traits and find out where their personality, preferences or appearance came from.

And some individuals are lucky: They have access to genealogies handed down through the ages that help them understand the family influences that have shaped who they are today.

For others, it takes a little more digging to uncover their personal history, perhaps a few dozen hours on an historical records website or a cheek swab sent off to a DNA testing service.

But understanding what you're made of and where you come from isn't just for people. Pipelines have provenance, too. And just like an unknown ancestor, the complete back story of a pipeline section – information about material grade and chemical composition, for example – isn't always available, either.

Maybe the records were never kept in the first place. Or they were lost through time, or when assets were transferred or sold. Or the

records exist, but the information is incorrect.

Soon, however, the days of missing and incomplete materials records for gas transmission pipeline operators in the United States will be over, with hazardous liquids operators following shortly.

That's because the Pipeline Hazardous Materials Safety Administration (PHMSA) has regulation pending that will require operators to verify the records they use to establish and support the maximum allowable operating pressure (MAOP) of pipelines in high and moderate consequence areas[1]. In addition, PHMSA has announced its intention to eliminate a grandfather clause that has allowed gas transmission operators to rely on historical data for establishing the MAOP of pipe installed before 1970.

As a result, operators will have to perform what is essentially a comprehensive pipeline genealogy project in order to meet the upcoming regulations. Included will be validating and documenting the mechanical properties – such as construction materials by grade and specification, yield strength, and tensile strength – of all pipelines located in high and moderate consequence areas, regardless of when they were built.

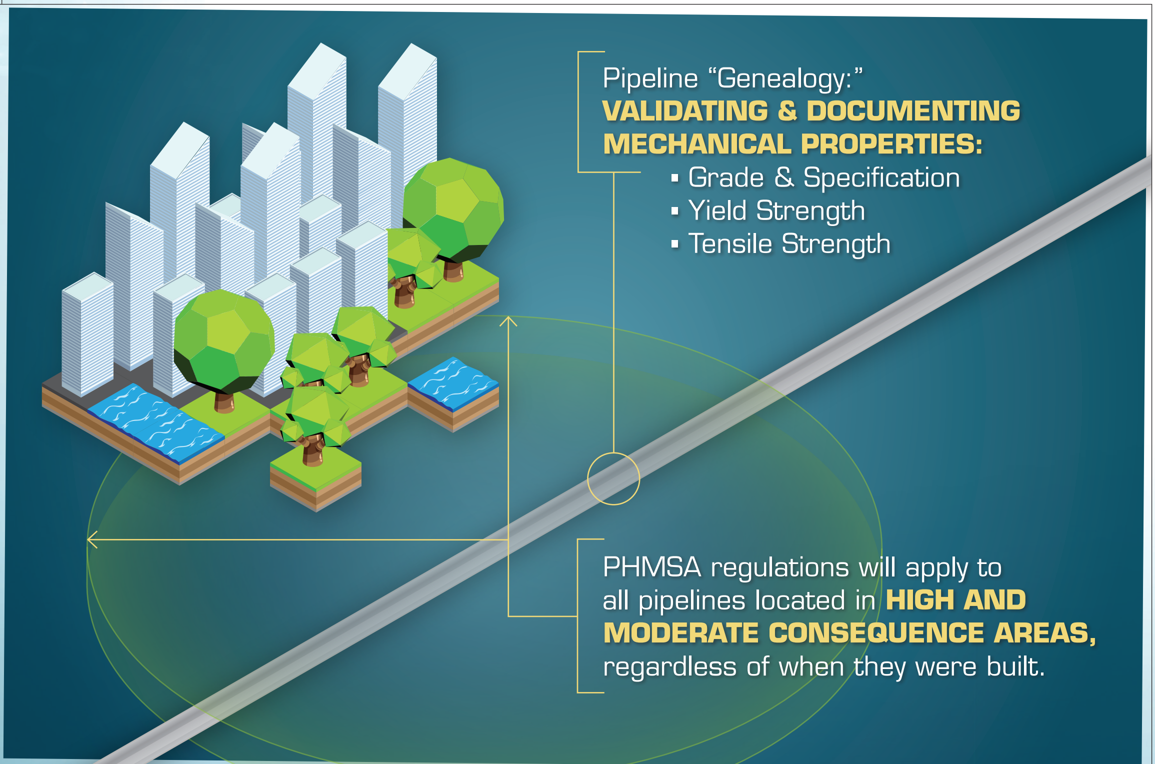
But how will they find out what they don't already know?

Unlike curious family members, pipeline operators can't just search the industrial equivalent of a genealogical database. But to get to the information they need, there is an alternative as unobtrusive as a DNA cheek swab: Non-destructive positive materials identification (PMI) technology used as part of a complete integrity verification process (IVP).

## A Call For 'Traceable, Verifiable, and Complete' Records

Like any number of governmental regulations that arose from a public safety concern, PHMSA's pending rules were motivated by an accident, and a catastrophic one at that: A deadly explosion and fire caused by the rupture of a gas pipeline in the state of California.

In the United States, the National Transportation Safety Board (NTSB) is among the first on the scene to investigate the cause of significant pipeline incidents as well as aviation, railroad, highway, and marine disasters. During




[1] Visit **phmsa.dot.gov** for a criteria-based definition of high and moderate consequence areas

the course of their inquiry into the California pipeline failure, the NTSB found that a ruptured section of pipe had been identified on the as-built drawings as seamless when it was actually longitudinally seam-welded, which meant the pipeline was being operated outside of its original design criteria. The NTSB subsequently recommended that operators establish pipeline records if none existed in order to verify that operating conditions are within the specifications of the line configuration – a recommendation that PHMSA is upgrading to a regulation.

In its advisory bulletin (ADB-2012-06) regarding the pending regulation, PHMSA states that operators "must assure that the records are reliable" when calculating MAOP and that "these records shall be traceable, verifiable, and complete." PHMSA defines verifiable records as those "in which information is confirmed by complementary, but separate, documentation." The agency also said that operators may need to conduct other activities such as in situ examination, measuring yield strength, and non-destructive evaluation (NDE) or otherwise verify the characteristics of the pipeline to support a MAOP or Maximum Operating Pressure (MOP) determination.

"Traceable, verifiable and accurate recordkeeping in the pipeline world is crucial," PHMSA Administrator Cynthia Quarterman said when she announced the pipeline verification advisory in 2012. "It enables us to respond more quickly in the event of an emergency, as well as gives us a more accurate snapshot of the overall infrastructure."

## Early Adopters Prepare Ahead of the Proposal Becoming a Mandate

Response to the advisory has, naturally, been mixed. Some operators and organizations have jumped immediately onto the bandwagon, determined to have their records in place before the proposed regulation becomes a mandate in 2015. Others remain in wait-and-see mode.

The Interstate Natural Gas Association of America (INGAA), a nonprofit trade association whose members represent about two-thirds of the natural gas transmission pipelines in the United States, is encouraging early adoption.

In a statement, INGAA said that its members have "committed to a systematic validation of records and maximum allowable operating pressure for their pipelines in highly populated areas that predate federal regulations. INGAA members are developing a process to demonstrate traceable, verifiable and complete records with examples of the types of records."

But beyond the essential importance of complying with regulations, there's additional value to understanding pipeline properties.

For example, in a response to PHMSA's 2011 Pipeline Safety Report to America, metallurgist Kenneth Kraska says that developing necessary pipeline documentation keeps operators in compliance with American National Standard Institute (ANSI) codes. Documentation is necessary not only for records review, but whenever welding is performed, replacement pipe materials are obtained, or a pipeline is being reviewed for re-rating, Kraska explains. Welding on a pipeline without thorough knowledge of the materials involved, the correct welding procedure, or the composition of welding filler metal is also an ANSI violation, he adds.

But there's also a positive financial case to be made in support of the regulation, and it goes like this: Operators who've had to downgrade pipeline pressure for lack of the records that would justify higher pressure are losing money. By performing PMI, they may find out that their pipelines can actually accommodate higher pressure and, therefore, increased capacity.

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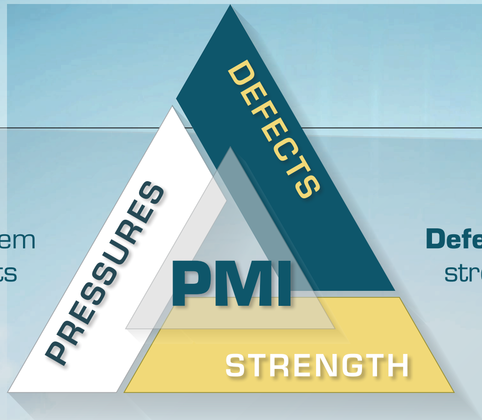



**Pressures** above system limits can cause defects to grow

**Defects** can alter both strength and load

**Strength** is determined by the ability to withstand pressure

There are three interdependent attributes of **positive materials identification** (PMI) technology. A lack of knowledge about any attribute can upset the overall equilibrium.

And while the PHMSA ruling only applies in the United States, similar benefits could accrue for Middle Eastern and Russian natural gas transmission and the Canadian oil sands. In addition, verifying higher operating pressures is considered essential for the safe operation of pipeline reversals and conversions, two activities that are now occurring worldwide.

## NDE Techniques Can Save Time and Money

In engineering, project management, and other disciplines, the triangle is used to represent the interdependent nature of certain attributes, like time, cost, and scope. The triangle is also useful when it comes to considering positive material identification.

In PMI, one side of the triangle represents material strength, another is the load or pressure, and the last side symbolizes defects. In order to keep the triangle from collapsing, all three have to relate to one another appropriately.

For example, strength is determined by the ability to withstand pressure. Defects can alter both strength and load. And pressures above system limits can cause defects to grow.

However, a lack of knowledge about any side can upset the overall equilibrium. With appropriate information, operators can keep their triangle in balance.

For generations operators have had to rely on destructive techniques to identify pipeline materials and MAOP, utilizing a time-consuming, costly procedure that involved cutting out a coupon and sending the piece away to be lab-tested.

But not any longer.

That's because the positive material identification process offered by global pipeline integrity services provider T.D. Williamson (TDW) utilizes multiple non-destructive technologies that eliminate the need for cutting into the pipeline and can be completed while product continues to flow. TDW's patent-pending PMI can provide a high level of accuracy with less effort, lower total cost, and shorter turnaround.

And beyond that, says Chuck Harris, Commercialization Manager for Pipeline Integrity Technology at TDW, the predictive nature of TDW's PMI techniques mean they can reduce the potential for costly field failures when part of a comprehensive integrity verification program.

## Preliminary Results Are Nearly Instant

TDW's PMI solution includes multiple NDE methods (see The A-B-Cs of PMI table on the opposite page).

The process begins by establishing an area to inspect, followed by determination of yield and tensile values, plus chemical composition and carbon equivalence. The results are then compared to American Petroleum Institute specification API 5L, tables 4 and 6, to ascertain the pipe material grade.

According to Chris Caraway, NDE Operations Manager, TDW's process, performed completely in the ditch in about four hours, means there's "zero destruction to the pipe and product in the line is never affected. The NDE PMI process leaves no potential leak path."

Reporting time is also much shorter than other PMI methods. Initial findings are almost instantaneous. The operator often has a draft in-hand before the technicians leave the field. Normal turnaround for the complete report is five days.

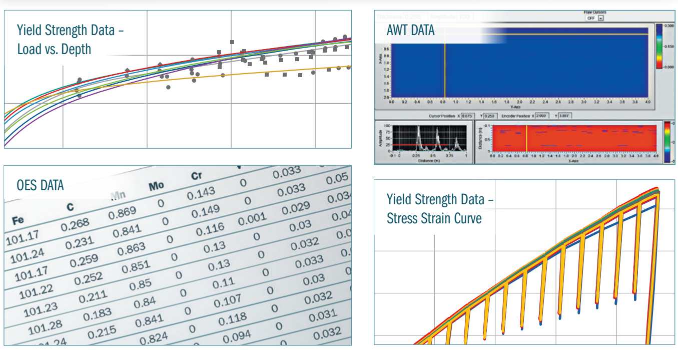
Which is less time than it takes to get a cheek swab result back from the DNA lab.

## PMI: Determining the DNA of Pipelines

While tracking down relatives and adding leaves to the family tree can be fun, there's a serious side to it, too. Like when that cheek swab identifies potentially lifesaving information about the genes you share with your ancestors.

And in that way, PMI is very much like DNA testing for pipelines: It's a way to dig deeper than old records and photographs allow, providing information at the cellular level, mitigating risk today and in the future, while maintaining compliance with industry regulations.

Data samples identified by PMI techniques:





# THE A-B-Cs OF PMI

TDW'S PMI SOLUTION IS A STEP-WISE PROCESS THAT INCLUDES THESE NON-DESTRUCTIVE TECHNIQUES

**ULTRASONIC THICKNESS TESTING (UTT)**
uses high frequency sound energy to verify Actual Wall Thickness (ATW).

**AUT B-SCANNER**
scans pipes circumferentially to detect corrosion and other anomalies.

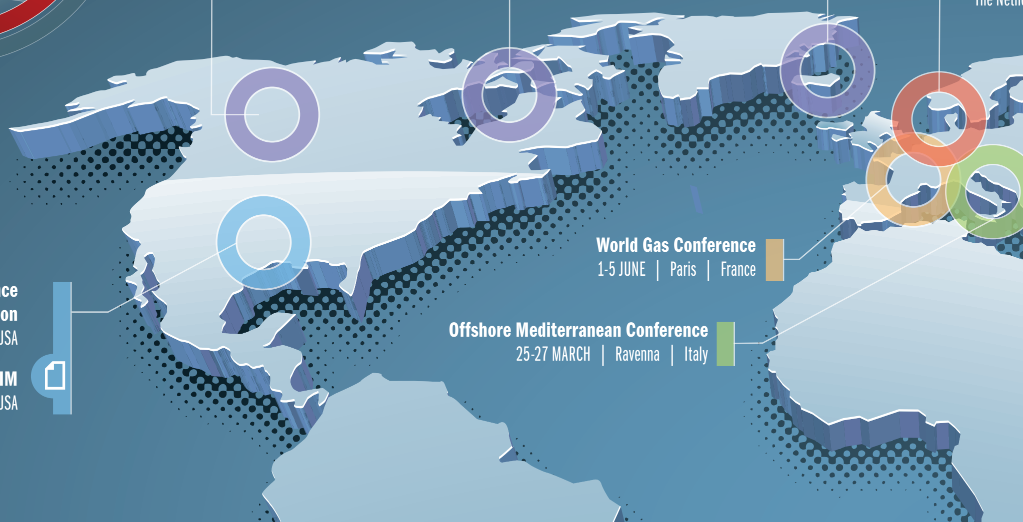
**AUTOMATED BALL INDENTION (ABI)**
uses a sophisticated algorithm to determine material yield strength based on a stress strain curve generated by equipment software.

**OPTICAL EMISSIONS SPECTROMETRY (OES)**
identifies and determines the concentration of elements as well as the carbon equivalency value for welding purposes.

**MAGNETIC PARTICLE TESTING (MT)**
uses the application of a magnetic field to detect the presence of surface or near-surface discontinuities.

# TouchPoints

TDW Events, Papers & Conferences




## Pipeline Pigging & Integrity Management Conference

February 9-12, 2015 | **Houston, TX USA** | Booths 120 / 122 / 124

**SILVER SPONSOR: T.D. Williamson**

In 2015, many pipeline owners and operators remain focused on two primary aspects of their business: flow assurance and asset integrity. Now, combine volatile geopolitical events with fluctuating oil prices and the stakeholder demand to increase product throughput, ensure operational safety, and maximize efficiency becomes stronger than ever.

To help PPIM attendees rise to these unique market challenges and achieve their goals, TDW will be offering expert consultation on topics such as: NGL recovery in wet gas systems; Advanced interactive threat detection; Pipe materials verification; Paraffin removal; and System expansion and maintenance.

Schedule time with a Subject Matter Expert now: **tdwontour@tdwilliamson.com**

## FEBRUARY 2015

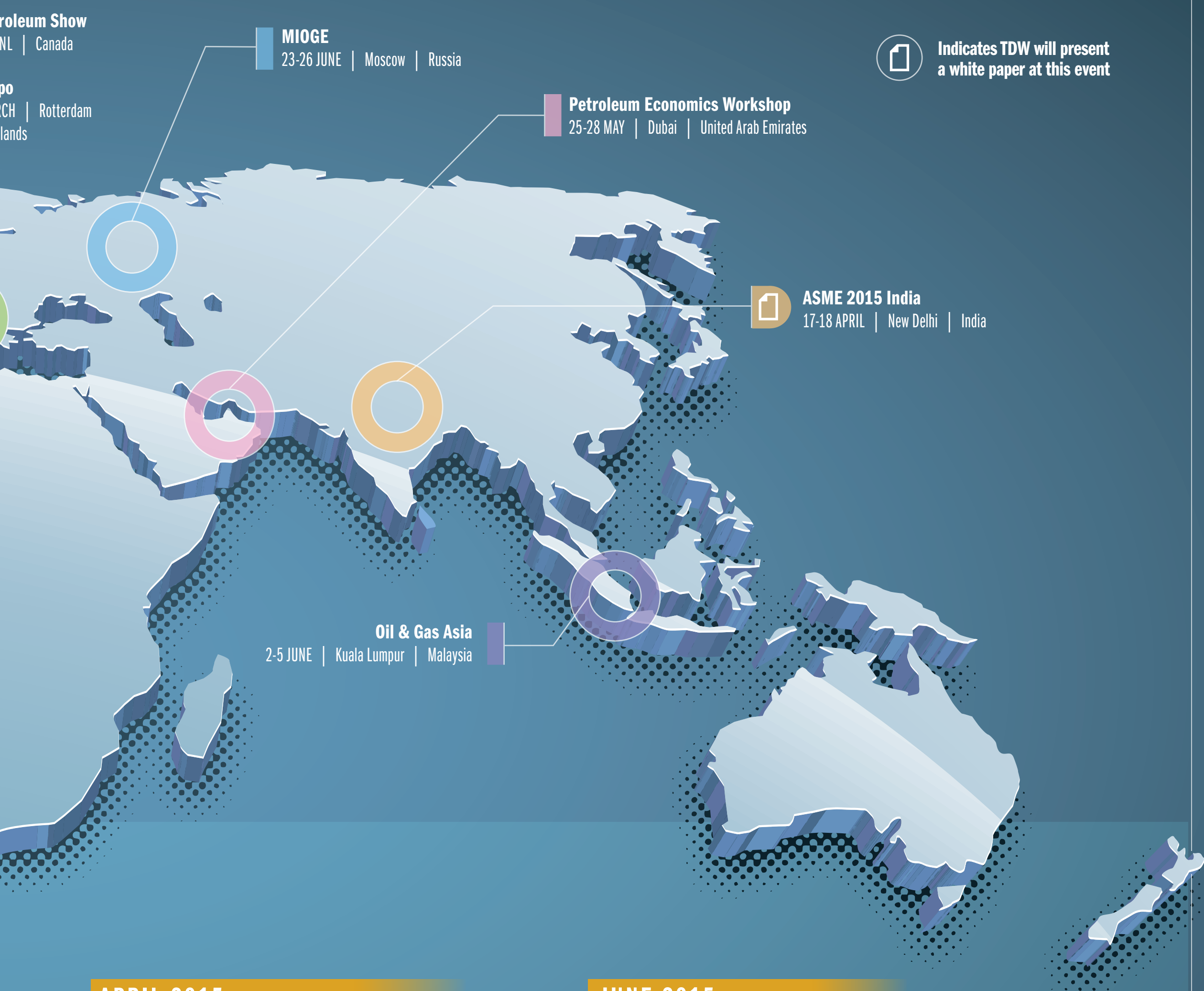
9-12 **PPIM**
Houston, TX USA

## MARCH 2015

17-19 **Stoc Expo**
Rotterdam, The Netherlands

25-27 **Offshore Mediterranean Conference**
Ravenna, Italy

**TDW experts deliver —** providing technical presentations and hands-on demonstrations throughout the world. To learn more: **tdwontour@tdwilliamson.com**.




## APRIL 2015

17-18 **ASME 2015 India**
New Delhi, India

19-21 **CGA Engineering Conference**
Toronto, ON, Canada

## MAY 2015

19-22 **AGA Operations Conference & Biennial Exhibition**
Grapevine, TX USA

25-28 **Petroleum Economics Workshop**
Dubai, U.A.E.

## JUNE 2015

1-5 **World Gas Conference**
Paris, France

2-5 **Oil & Gas Asia**
Kuala Lumpur, Malaysia

15-17 **NDT in Canada**
Edmonton, AB, Canada

17-18 **Atlantic Canada Petroleum Show**
St. John's, NL, Canada

23-26 **MIOGE**
Moscow, Russia

# FROM DOGS & DRONES TO INSPECTION OF ALL KINDS

## Diverse Expertise Helps Detect Third-Party Damage

Max hated water, and Ron knew it. Max never liked to swim. He didn't even want to bathe regularly, truth be told.

But this day was different. There was Max, bounding over the reeds in a Canadian swamp as fast as his legs could carry him, oblivious to the fact that he was dashing through water up over his chest.

Max and Ron had been trying to locate a low pressure gas leak in a damaged circa-1950s concrete pipeline for three days when, as Ron remembers it, Max "just started going nuts." Within seconds, Max had splashed into the aqueous muck, a signal to Ron that he'd found his mercaptan-scented target.

Max's reward? A hearty scratch behind the ears and a dog biscuit.

You probably already guessed that Max was a dog. A German Shepherd, to be exact – and one which had been specially trained to use his sense of smell to track drugs. And Ron Mistafa is the owner of Calgary, AB-based Detector Dog Services International Ltd, a company that uses trained "detector dogs" to sniff out dangerous pipeline leaks. Ron brought Max out of retirement in the hopes that the former police dog could use his skills and training to identify and mitigate third-party damage, long considered the leading threat to pipeline integrity and safety throughout the world.

## Third-Party Damage: A Problem That Knows No Boundaries

Jeff Foote, Director, Pipeline Integrity Technology, at global pipeline services company T.D. Williamson, has been analyzing third-party damage for a decade. His interest in the topic was piqued when he became involved with the Association of Oil Pipelines, an organization of pipeline operators in the United States that has studied the causes of pipeline incidents.

Although the group identified other issues that contributed to pipeline failure – among them, structural flaws, fatigue, age, and even operator error – third-party damage clearly topped their list. Utility excavation in shared rights of way is a major source of damage, often occurring when giant mechanical shovel teeth graze a pipeline's exterior. But mechanical shovels aren't the only potential source of damage: Even something as seemingly innocuous as a farmer tilling his field has caused everything from pipeline dents to explosions.

These are situations that know no national boundaries.

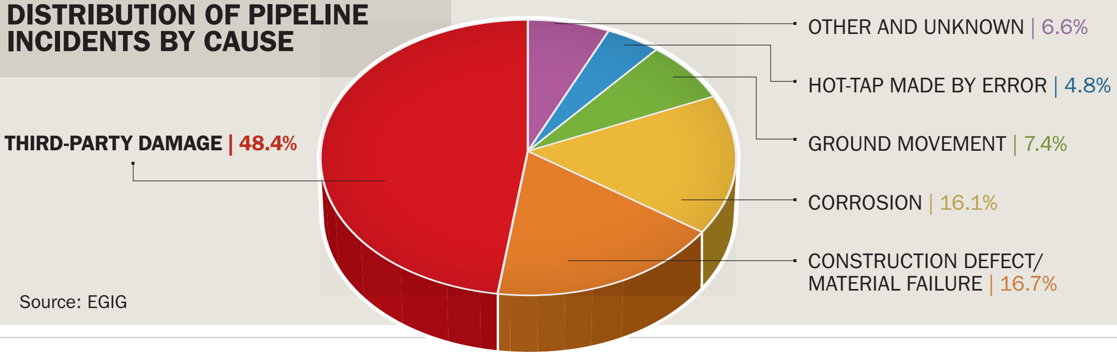
CEPA, the Canadian Energy Pipeline Association, points to "accidental damage caused by excavation and construction around pipelines" as "one of the greatest single causes of damage to pipelines."

Similarly, the 17 major gas transmission system operators who comprise the European Gas Pipeline Incident Data Group (EGIG) report that by far the greatest cause of loss-of-gas incidents is external sources.

And in the United States, the Pipeline Hazardous Materials Safety Administration (PHMSA) calls "third-parties digging in the vicinity of buried pipelines the greatest threat to pipeline safety."

For all of this common concern, there are, fortunately, widely available damage detection and repair solutions, including new and innovative technologies, from detector dogs like Max to virtual microphones and inline inspection tools. And each solution has a place in a comprehensive pipeline integrity program.

### DISTRIBUTION OF PIPELINE INCIDENTS BY CAUSE




Source: EGIG

## On The Scent: Detector Dogs Go Straight To The Source

The reason a dog can locate gas pipeline leaks is as plain as the nose on its face: The canine sense of smell is anywhere from 10,000 to 100,000 times more acute than ours. For perspective, if we were talking about sight instead of smell, an object that a person could see from a half of a kilometer (third of a mile) away could be seen by a dog 4,800 km (3,000 miles) away, just as clearly.

But that's just one of the innate abilities that gives dogs a leak-locating advantage, says Ron Mistafa.

Not only can dogs be trained to detect thousands of substances, they can find quantities of lost product as small as 0.07 ml. Dogs are also portable and have built-in locomotion, which makes them capable of inspecting long lengths of pipe each day. And they're generally quite quick at their craft: Mistafa says that one of his dogs found a leak in a record five minutes.

Dogs also offer spot-on precision. "Where the dog starts to dig, that's where the leak is," Mistafa explains. "As a result, the operator only has to dig once to do the repair."

## Solutions From Above: Drones Provide Detailed Detection

While dogs excel at keeping a nose to the ground, operators are increasingly looking to drones – or "unmanned aerial vehicles" (UAV), if you will – to provide a bird's eye view of leak detection.

While Europe is still fine-tuning its UAV regulations, the United States just recently granted the nation's first approval to fly unmanned aerial surveys for oil company BP. Drones have been approved for commercial use in Canada since 2008. The country's leader for "airborne sensing" solutions is Ottawa, Ontario-based ING Robotic Aviation, founded and run by Ian Glenn.

Glenn flew UAV missions for the Royal Canadian Navy in Afghanistan, turning his attention to the civilian sector when Canada's combat role in the Afghan war wound down. ING Robotic Aviation now flies across Canada and the Arctic, providing mapping, inspection, and monitoring services for clients in forestry, mining, and utilities, as well as oil and gas.

"There are over 430,000 km (approximately 267,000 miles) of pipeline in Alberta alone," Glenn says. "Monitoring these pipelines is a monumental task. Compared to traditional methods, no other technology besides aviation robotics can gather as much detailed information nearly as quickly, cost effectively, or safely."

As an example, Glenn says that a UAV equipped with a high resolution, multispectral sensor could observe changes in vegetation – like grass and plants dying – that can signal a pipeline leak. What's more, airborne capabilities allow operators to find pipeline damage with less risk and a smaller environmental footprint, Glenn adds.

"A good pipeline integrity management will combine cleaning, pressure information, and external surveillance," Glenn says. "We're an important part of the puzzle."

But whatever combination operators use to solve the leak detection puzzle, Glenn has one piece of advice: Don't call his UAVs "drones."

"We avoid using the 'D word,'" he says with a laugh. "Think about it: there are spy drones and killer

**"A good pipeline integrity management will combine cleaning, pressure information, and external surveillance. We're an important part of the puzzle."**

*— Ian Glenn, CEO, ING Robotic Aviation Inc.*

drones. And those aren't always positive, are they? We're actually about aviation that flies robots."

## Ears Underground: Intelligent Listening

If dogs depend on smell and UAVs on sight, it only stands to reason that another innovation in pipeline damage detection would rely on sound.

Through its Distributed Acoustic Sensing (DAS) technology (i.e., fiber optics), UK-headquartered OptaSense puts what it calls "a pair of ears" every 10m (about 32 feet) along the pipeline to monitor third-party activity that has the potential to cause damage, including people, rock fall, or moving vehicles. According to Dr. Chris Minto, OptaSense Operations Director, DAS can provide instant detection of an event, its location, and its classification.

As an example of the technology's capabilities, Minto says, "We can detect a pilferage party trying to dig down to a pipe and allow enough warning to enable a responder to get there before the pipe is breached."

The company recently extended what it calls the power of sensing to the Internet, introducing mobile device applications that use the DAS sensor to place the owner "right in the action."

"Imagine the guiding hand on the right of way telling you which way to go to get to the event you are interested in," Minto explains. "Cell phone and tablet applications have their place, but communications reach-back is essential, together with a controlled method of confirming location. This helps in many places where directions and mile markers may be vague."

## The Inside Track: Inline Inspection Can Prevent Catastrophes

TDW's Jeff Foote agrees that "unique and creative" ways to identify pipeline damage are part of a holistic approach to integrity assessment and management. But he cautions that sniffing dogs, overhead surveillance, and fiber optics aren't a replacement for having a good inline inspection (ILI) program to detect cracks, deformations, and other defects – problems that could turn into catastrophes with just some pressure cycling.

"Inline inspection is a critical part of the set of things operators have to do to maintain integrity," he says. "It's also a first line of defense, in that ILI can uncover dents, gouges and other damage before they have a chance to worsen into leaks or ruptures."

"The dent that no one knows about might not seem like an immediate threat," says Foote. "But it also may not take much for it to become a leak that's environmentally severe or pipe break that results in explosion and major public safety consequence."

Among the tools available to TDW clients are Deformation (DEF) and Geometry (LGT) measurement inspection tools to identify dents, and magnetic flux leakage (MFL) inspection to identify gouges with metal loss typical of inadvertent backhoe contact.

"We also offer a low field magnetic (LFM) inspection technology that will find local changes in metal property around the perimeter of a pipe dent," says Foote. "This is critically important to preventing the possible crack formation and fatigue failure at the location of a pipe dent that re-rounds when operating pressure is applied."

With a combination of these inspection methods and comprehensive analysis, TDW can provide dent prioritization reports that are highly useful to an operator's overall risk assessment program.

In a perfect world, Foote suggests, third-party damage would be eliminated through prevention. And operators are making efforts toward that ideal: think warning signs, line markers, perimeter security, blast and wheel load calculations, and, in the United States, the federally mandated '8-1-1 Call Before You Dig' awareness campaign.

Yet damage to pipelines from third-parties continues to happen in the real world.

So until Foote's ambition is achieved, the industry will continue to leverage all of the pieces of the integrity puzzle. Dogs will keep sniffing, drones will keep watching, microphones will listen, and intelligent inline inspection will remain a smart way to uncover anomalies before they become consequential.

# Safety Matters

CONTINUED FROM PAGE 9

"Whether it's your service shop, or manufacturing facility, it's amazing what you can get done with just a piece of butcher block paper and a marker. Start by writing the word 'Safety' on top. Under that, have people list everything they have concerns about," he explains. "Next, you have a column for who is going to own it, one for the anticipated completion date, and you leave a blank for when it really gets done."

The next step is to talk things over and prioritize. And while the list may be big to begin with, as a line gets drawn through each problem solved, "people will begin to feel empowered again – like they're part of a community, part of a team – versus just being a number," says Hollis.

And when people feel empowered and listened to, they're less likely to bend the rules. It's a win-win for safety.

SCENARIO 3

## A BEAR IN YOUR BACKYARD: PROCESS SAFETY AND PREVENTION

"Backyard bears" – process safety incidents – are usually characterized as "low frequency and high severity." These are the incidents that result in multiple injuries and major damage to the facility and/or the environment, such as several pipeline incidents and spills recently in the news.

There are many factors that can negatively impact process safety, but perhaps the most egregious is the failure to acknowledge and accept reality. Denying that bears exist – or pretending they can't really hurt you – can result in fatal errors.

As a manager sitting in an office upstream, you know your company has invested the money for proper tooling. You strive for the best procedures and the best policies. Thing is, though, as people get higher and higher up in a corporation, they can forget what it's like to be on the front lines, and the disconnect between perception and on-site reality can result in increased risk.

Sure, on paper, your people have the perfect conditions: level ground, the right equipment, and favorable weather, but in the real world, things might be different. "Say instead of ideal circumstances, you find yourself in a little fenced-off area in the middle of a farm," Hollis says. "The pipe is different from your original specs, the excavation is all wrong, your crew doesn't have scaffolding, and [rather than what you'd planned on], they're using a backhoe and some slings to get the job done."

When accidents happen, it's easy to blame workers for not following protocol, but Hollis notes that it can be difficult to "write a perfect safety procedure for an imperfect situation."

### So, How Do You Address This "Disconnect"? Step Out From Behind Your Desk.

Planning for the concept rather than the reality puts projects, personnel, and the environment at risk. When workers are forced to improvise with equipment and implementation to complete tasks under unexpected conditions, safety procedures must adapt to meet changing circumstances. To avoid risky disconnects, Hollis says it's critical to leave the office and take a look at what's going on in the field. "You have to get up, go out on the floor, go out to the site, and see what's really going on, then act accordingly," he says.

## The Final Analysis

The fact is, people are going to make mistakes, so plan and provide tools for workers to be error-free when performing critical steps of a task. Set your workers up for success and build systems and process that can quickly recover when the "bears" show up. Pretending they don't exist, or simply maintaining the status quo, isn't enough to keep your personnel and assets safe.

Hollis believes a culture of outmoded corporate safety may be the most dangerous bear of all, noting that the oil and gas industry continues to judge total recordable incidence rate in terms of personal safety. "But zero incidents does not necessarily equate to safety," he explains. That's because zero isn't always zero in an atmosphere where accidents aren't routinely reported, or when data on near misses (which occur a lot more frequently than actual incidents) isn't properly taken into account.

"You have to get upstream to find the real indicators that tell you about the culture," he says. "Does your company have the integrity? Do you have the courage to say no to an immediate opportunity or pressing 'need' when you know your equipment hasn't been properly serviced? This industry has got to have a learning culture. It's irrelevant whether it's safety, quality, production, or finance ... It's how quickly can you learn from other peoples' incidents and your own, and how quickly can you adapt or change the direction you're going. You have to be accountable. So, ultimately, what all of us have to be asking is: 'How do we know bears are present, and what are we doing to keep them away?' "

CONTINUED FROM PAGE 11

international conference on carbon capture. "This type of injection of water, brine, and gases has been done for many decades."

And although there are several possible methods out there for capturing $CO_2$, most in the industry agree that there's really only one transportation method that makes sense: pipeline.

## Opportunities on the Horizon

Mike Kirkwood, Ph.D., is Director of Transmission Market Development for T.D. Williamson (TDW), which has experience cleaning and inspecting pipelines carrying naturally occurring $CO_2$ to production wells for enhanced oil recovery. Kirkwood says pipeline is an optimal choice for moving compressed $CO_2$ to storage sites because pipelines have a strong safety record, and existing pipeline technology – such as specialized welding and valve installation techniques – can be leveraged with new and repurposed CCS pipelines.

But Kirkwood is quick to point out that pipeline transportation isn't without challenges. Hot tapping a $CO_2$ line, for instance, will require special care. $CO_2$ is sensitive to temperature and pressure changes, and slight fluctuations – common during a hot tap or cleaning operation – could trigger a phase change from gas to liquid or solid, essentially creating dry ice that could damage or block the pipeline. Another challenge is that many pipeline inspection tools contain urethane components. Urethane is a popular choice because it offers elasticity and is abrasion-resistant. But urethane naturally absorbs $CO_2$, a problem that under certain circumstances, such as a change in pressure, could cause the urethane to burst. Because of this, Kirkwood says, a number of inline inspection tools will need to be re-designed or special procedures developed.

And finally, there's the issue of corrosion. Although carbon steel pipelines are considered the most durable and affordable option for CCS transportation, they are also highly susceptible to corrosion – and carbon-captured $CO_2$ is corrosive by nature and, combined with the other impurities, can make for a heady corrosive mix.

The result? "You're probably going to have to inspect more," Kirkwood says. "It comes back to what the service companies are going to do to help the operators manage and operate these pipeline systems."

## Building Momentum

As of February 2014, there were 21 large-scale CCS projects in operation or construction globally, the CCSA reports. In Norway, the long-running Sleipner project – widely credited with being one of the first CCS projects of its kind – is still underway. Since it started operating in 1996, the Sleipner project "has captured nearly 1 million tons of $CO_2$ every year from gas production and injected it into a deep saline formation under the North Sea," says Warren.

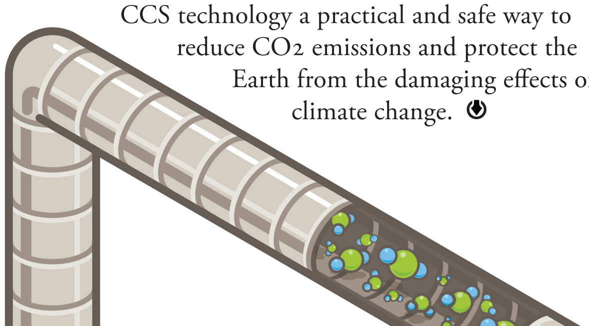
In the United Kingdom, the upcoming White Rose project will capture $CO_2$ from a coal/biomass facility, while a similar project called Peterhead will capture $CO_2$ from a fossil gas power plant.

And in October 2014, Canada's SaskPower added a CCS facility to its Boundary Dam power plant in Saskatchewan. The project is projected to reduce carbon emissions from the coal-fired plant by 90 percent.

"SaskPower has made significant progress in making a valuable contribution to demonstrating a viable technical, environmental and economic case for the application of CCS to power plants," Warren says, adding that he hopes projects like Boundary Dam will provide momentum for similar projects around the world.

Further, the CCSA has reported, a number of regions are looking to develop pipeline networks that will enable cost effective harvesting of $CO_2$ emissions from multiple sources. The White Rose project in the UK, for example, will include the "Yorkshire Humber CCS Trunkline," a pipeline able to carry a large amount of $CO_2$ from power and industrial emitters. Similar pipeline projects are being developed in Alberta and Australia.

Someday, you may be able to walk into a convenience store to buy a bottle of something that resembles the fictional EV-EON. But until then, innovators around the world, representing a wide range of industries, are working to make CCS technology a practical and safe way to reduce $CO_2$ emissions and protect the Earth from the damaging effects of climate change.



BY THE NUMBERS

# Four steps of

## Reduce the consequences of a catastrophic failure.

### 1 ASSESS
- Assess Damage
- Cause & Effect Analysis
- Develop Repair Plan
- Materials

### 2 PROCURE
- Materials
- Equipment
- Resources
- Services (Contracts)

### 3 MOBILIZE
- Personnel
- Hardware
- Service Providers

### 4 EXECUTE
- Repair
- Re-commission
- Restore Flow

**UNDER THE *REACTIVE* CRISIS MODEL,** operators can only respond to incidents after they occur, which means they are often ill-prepared and ill-equipped to effectively mitigate the multifaceted fallout. In addition to elevating safety risk and environmental impact, the reactive model results in substantially longer downtimes and long-term damage to reputation and shareholder value.

***REACTIVE* CRISIS MODEL**

PRODUCT FLOW

***PROACTIVE* OPERATIONAL READINESS**

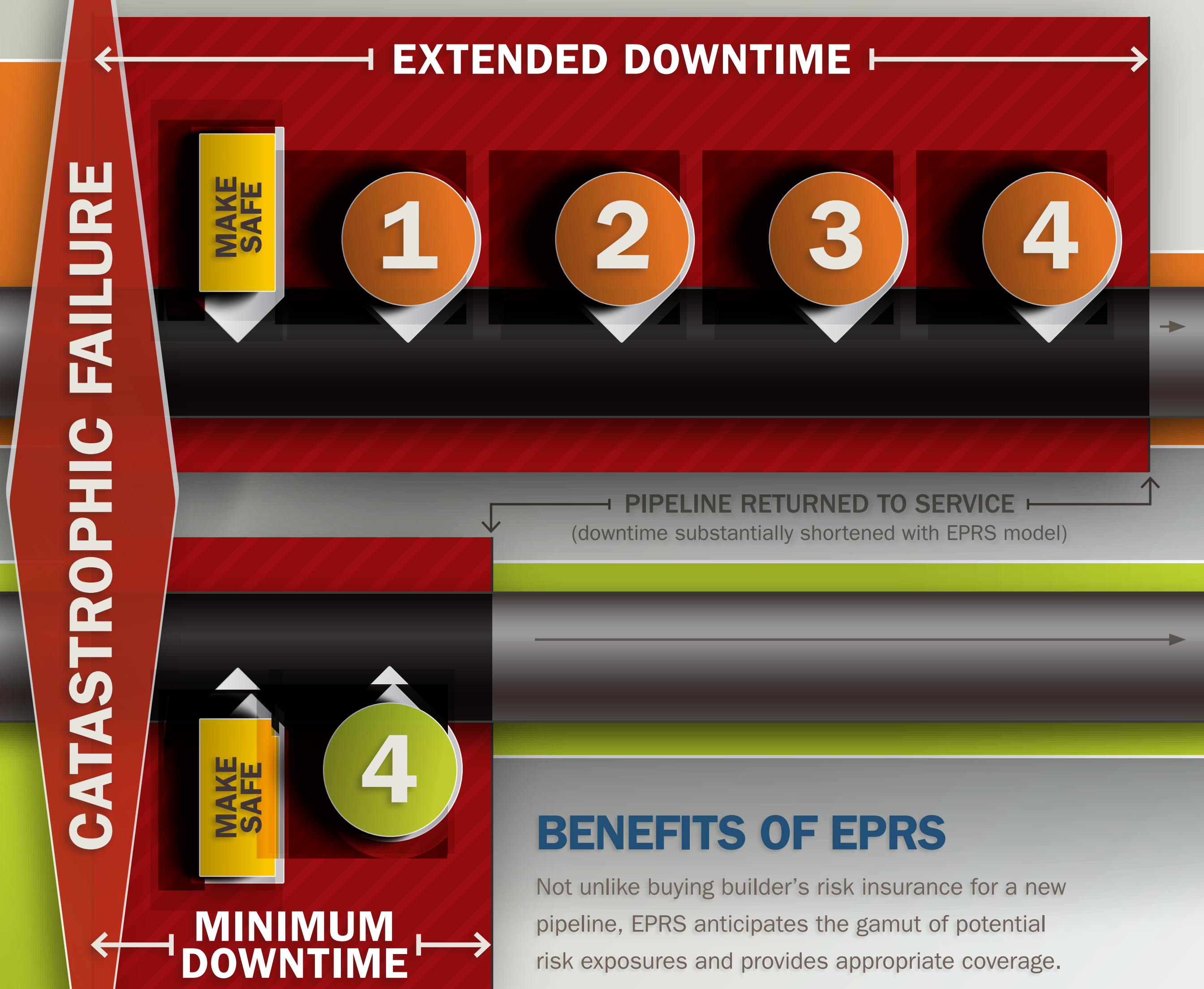
PRODUCT FLOW

1 2 3

**BY ADOPTING THE *PROACTIVE* EPRS MODEL,** operators prepare the assessment (including gap analysis), procurement (including long lead-time materials and equipment) and mobilization stages of their emergency protocols prior to any incident. As a result, the operator is ideally positioned to make safe the working area, execute cleanup and repairs, and restore production and flow with minimal downtime.

# EPRS (Emergency Pipeline Repair System)

*EPRS does not reduce the probability of failure, it reduces the consequence of failure.*




## BENEFITS OF EPRS

Not unlike buying builder's risk insurance for a new pipeline, EPRS anticipates the gamut of potential risk exposures and provides appropriate coverage. This means providing mitigation, repair, and restoration in the shortest time possible. Although adopting the EPRS model is a considerable undertaking, given that it involves anticipating a multitude of future events, "an ounce of prevention is worth a pound of cure."