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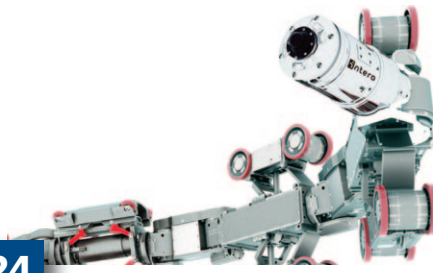

Assessment of Long Seam Weld in ERW and Flash-Welded Pipes
Integrity issues related to long seam welds and flash-welded pipes are well documented. A failure in the seam weld of such pipes has the potential to propagate over a significant distance along the pipe. The emergence of robotic inspection now offers a viable alternative for inspecting these pipelines, enabling a deeper understanding of their integrity conditions.

Engineering Innovations Emerge from Lining Challenges
The trenchless pipeline renewal technology of Cured-in-Place-Lining (CIPL) has proven to be an effective alternative to conventional replacement methods for cast iron and steel pipelines. This technology requires a collaborative team approach and up front engineering. Details on a complex lining project in Brooklyn's Gowanus Canal that led to creative solutions.

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TRENCHLESS TECHNOLOGY PERSPECTIVE

Thinking Outside the Box is the Path to Innovation

George Ragula, RagulaTech Inc.

Welcome to the seventh edition of Trenchless for Gas Infrastructure, now published twice annually in response to increased demand and interest in information on the cost savings, environmental advantages and social benefits derived from the use of various trenchless technology methods. These technologies offer the best and most comprehensive toolbox of new installation, renewal and rehabilitation techniques for gas distribution infrastructure, yet many of these tested, proven applications still remain underutilized, despite numerous benefits.

For example, use of CIPL for pipeline rehabilitation is demonstrably the best approach in many situations, having been used on pipeline repair projects for more than 30 years, yet ironically CIPL lining techniques for cast iron and steel pipe remain poorly understood, and the vast potential CIPL and other trenchless methods harbor for helping to usher in the dawning hydrogen economy often are downplayed.

Although HDD has long been a mainstay of new pipeline construction, trenchless renewal and repair techniques such as Cured-In-Place-Lining (CIPL), Pipe Bursting, Pipe Slitting, and Pipe Ramming can significantly extend the life cycle of existing gas distribution pipelines. Today's increased inspection, repair, and replacement standards, and the pressing need to further reduce GHG emissions, increase the importance and urgency of giving these lesser-known trenchless methods careful evaluation.

As always, utilizing trenchless methods requires thinking outside of the box in solving both onsite construction issues and alleviating the pressing social and environmental challenges we face today. Key to this process is the ability to translate abstract concepts into proven, ultimately successful, field-tested solutions. Effective implementation and evaluation of construction methods can only be accomplished by actual real-life application.

Moving abstract concepts and efforts into proven workable technologies in the ground requires a willingness to push boundaries and explore new concepts in actual field conditions. Various trenchless methods can be effectively pilot tested on smaller jobs as viable alternative solutions applied to specific environmental situations and terrain. A greater understanding of the efficacy and practical value of these methods is best obtained by subjecting them to rigorous evaluation outdoors in the field, in the natural environment, far away from corporate offices.

"What you don't know, you just don't ever know."

Field personnel have intimate working knowledge that can't be acquired behind a desk, and practical learning can only be realized from actual constructability, whether pilot or full-scale. The people with boots on the ground are best equipped with the practical skills and expertise to properly evaluate the benefits and pitfalls of new construction methods. Feedback garnered from these individuals is invaluable in evolving real-life workable solutions. Until you try something, you'll never really know for sure what works – these techniques have to be lived, breathed, and touched in real time. What you don't know, you just don't ever know.

The best way for these trenchless construction methods to gain traction and improve understanding of the profound advantages they can yield is by pilot testing on small jobs in the field. This dynamic process is ongoing, never-ending, always advancing, just like science continues to evolve. Thinking outside the box is the true path to innovation in solving today's construction issues and pressing social and environmental challenges.

Organizations like NASTT, in conjunction with AGA and GTI Energy, serve as catalysts for this process, because education and training are the foundation of successful implementation of new techniques. It is exciting to see the benefits and advantages the gas industry can potentially achieve through the use of these construction methods at the right time and on the right job, but one needs to be more knowledgeable in this area and that is simply done through education and training – exactly what these organizations do for their membership.

Well-deserved recognition and appreciation is extended to the dedicated membership and hard working staff of NASTT for their continued support of outreach efforts to the natural gas industry. In the vanguard of this collective effort are the forward-thinking members and leaders of the NASTT-NE Chapter, who continue to sponsor and promote this magazine to benefit the natural gas industry with practical knowledge, thereby benefitting society as a whole.

George Ragula

RagulaTech Inc.,
NASTT Hall of Fame Member

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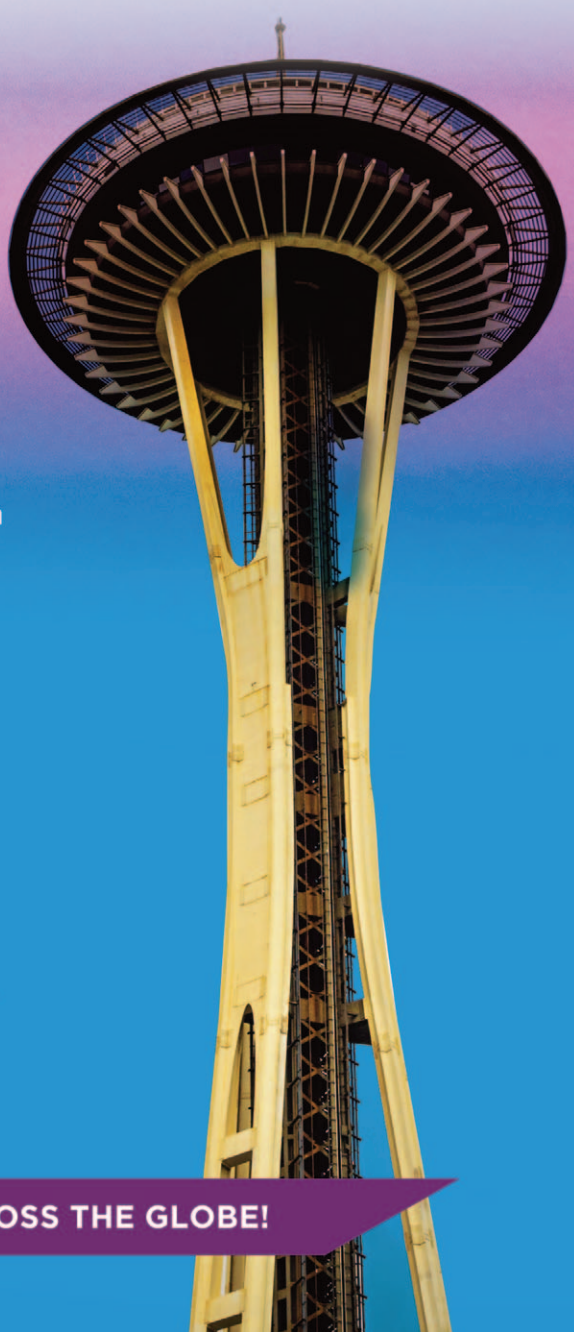

SAFETY & OPERATIONAL EXCELLENCE – ACROSS THE GLOBE!

WE ARE STEWARDS OF OUR ENVIRONMENT

Matthew Wallin, PE., Chair, NASTT

North America relies heavily on dependable sources of energy, yet the infrastructure supporting these utilities is aging. While natural gas and electrical utilities continue to provide safe and reliable solutions, they must continually work to maintain energy flow, even in the midst of rehabilitation, replacement, or new installations. The overarching goal is to reduce backlog of leaks, lower CO_2 emissions, and minimize equipment footprint.

The adoption of trenchless technology has become increasingly prevalent as utilities and resources are moved underground. In scenarios where there are limited easements, congested utility corridors, or areas that are difficult to access, trenchless technologies present an attractive solution due to their ability to minimize or entirely eliminate excavation and surface disruption. The North American Society for Trenchless Technology (NASTT) is dedicated to facilitating the exchange of technological advancements in this field. These innovations are influencing the way both utility owners and contractors approach underground infrastructure management.

Employing trenchless methods necessitates creative problem-solving to address today's construction challenges. Given that a substantial portion of a utility's budget, often more than 50 percent, is allocated to construction, trenchless technology can potentially offer improved reliability at reduced costs. The key to successful implementation lies in understanding when and how to apply these methods, which can be achieved through comprehensive education and training.

NASTT stands out as a strong and growing society in North America, consisting of engineers, contractors, municipalities, utilities, manufacturers, academics, and other stakeholders who share a strong commitment to the practical, social, and environmental benefits of trenchless technology. The organization's mission to advance trenchless technology is achieved through the dissemination of technical information, support of research and development, education, and training. NASTT serves as a collective voice for all sectors of the trenchless technology industry, and for over three decades, its dedicated staff and volunteer members have been providing seminars and training on these environmentally friendly construction methods to communities across North America.

Climate change is an urgent concern for North America, with utilities focusing on clean, renewable energy and reducing greenhouse gas emissions. As NASTT continues to promote new technologies, the gas industry stands to benefit from improved safety, reduced excavation and emissions, lower rates of third-party damages, and a decrease in the risks associated with excavation activities. The organization consistently reviews and updates its training materials and offers both virtual and in-person courses. Exciting developments in educational resources that are particularly valuable to the gas industry are set to be rolled out in the coming months regarding horizontal direction drilling (HDD) and cured in place pipe (CIPP) technologies. For the most current information on upcoming events, please visit our website at www.nastt.org/training/events.

To learn much more about the range of trenchless technologies directly from many of the industry's leading professionals, be sure to mark your calendars and save the date for next year's NASTT 2025 No-Dig Show being held in Denver CO, March 30 – April 3. The city of Denver is a perfect location for our industry to come together in the American west to celebrate and educate with the theme, Green Above, Green Below. Our Rocky Mountain/Great Plains Chapter is one of our most active and rapidly growing, reflecting the increase of trenchless activity in the region, including the gas industry.

It is important that our industry is a steward of our natural resources, and we welcome the opportunity to provide events where the industry can learn about the latest in innovative trenchless products and services. We would like to reach out to the gas industry specifically and invite you to attend the No-Dig Show next year or any of our other training event opportunities. Learn more about the options available at www.nastt.org/no-dig-show and www.nastt.org/training/events

We welcome your feedback and questions! Please reach out to us at any time at info@nastt.org.

Matthew Wallin, PE

Chair, NASTT Board of Directors

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NO-DIG SHOW 2025

Call for Abstracts

SUBMISSION DEADLINE: JUNE 30, 2024

The North American Society for Trenchless Technology (NASTT) is now accepting abstracts for its 2025 No-Dig Show in Denver, CO at the Colorado Convention Center March 30-April 3, 2025. Prospective authors are invited to submit a 250-word abstract outlining the scope of their paper and the principal points of benefit to the trenchless industry.

The abstracts must be submitted electronically by June 30, 2024 on the NASTT website:

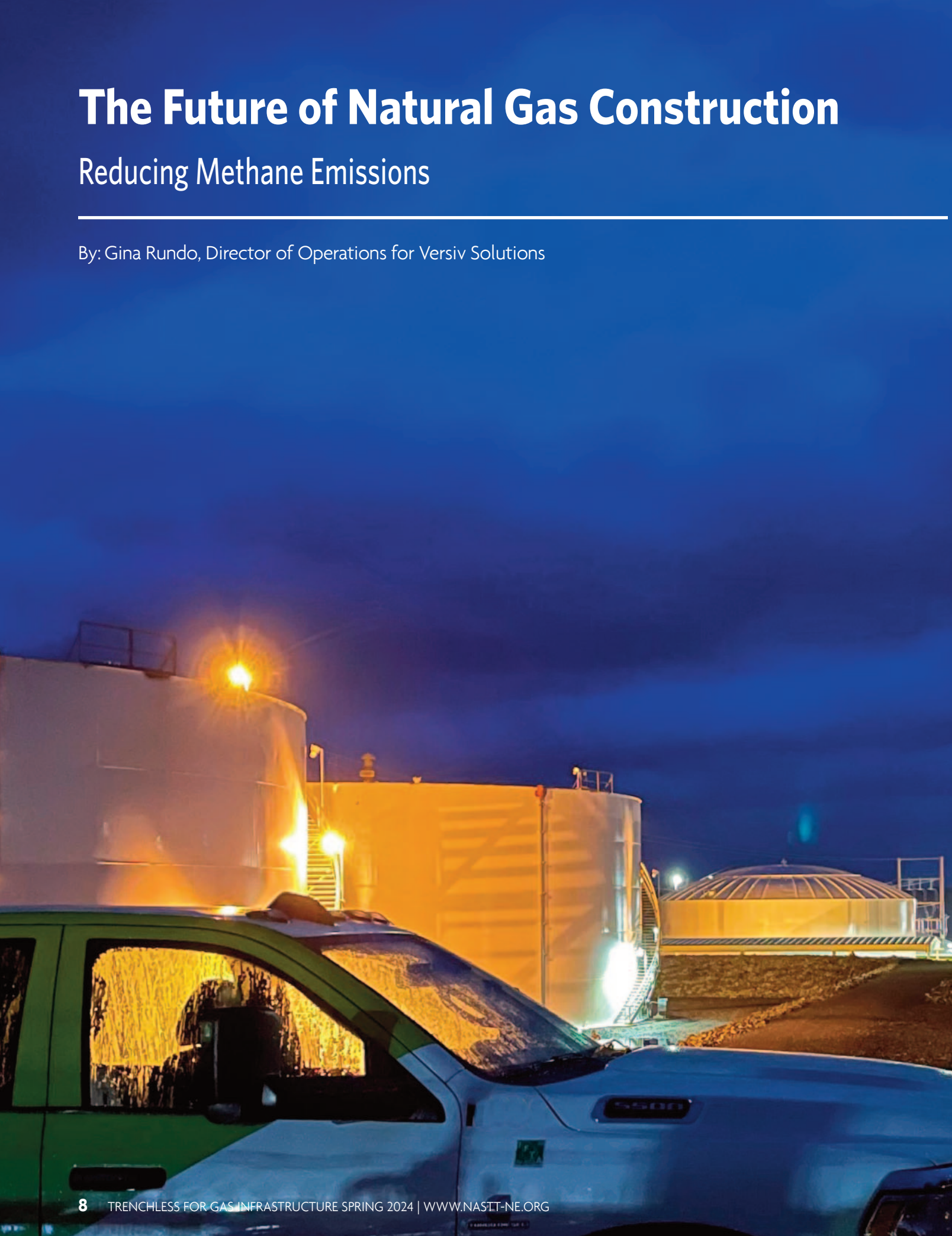
nastt.org/no-dig-show

The No-Dig Show is owned by the North American Society for Trenchless Technology (NASTT), a not-for-profit educational and technical society established in 1990 to promote trenchless technology for the public benefit. For more information about NASTT, visit our website at nastt.org.

The Future of Natural Gas Construction

Reducing Methane Emissions

By: Gina Rundo, Director of Operations for Versiv Solutions



Sustainability has emerged as a leading concern in the ever-evolving landscape of the energy sector. As regulatory pressures mount and environmental consciousness rises, the reduction of methane emissions has taken center stage.

Natural gas utility construction has a long history of evolving to meet new standards, while continuing to deliver safe, reliable energy where communities need it most. Today, environmental stewardship requires innovative solutions.

One groundbreaking technology, Cross Compression, is reshaping the industry's approach to pipeline construction and maintenance, particularly in mitigating methane emissions. This article delves into the transformative potential of Cross Compression, examining its implementation, strategic significance, and the advantages it offers over conventional methods.

Understanding Cross Compression: A Paradigm Shift in Pipeline Maintenance

At the heart of Versiv's innovative approach lies Cross Compression technology—a methodology designed to mitigate methane emissions in gas pipeline operations. Many industry experts may be familiar with alternatives names like: Venting Recovery, Recompression, Temporary Compression, Mobile Compression, Pipeline Evacuation, etc. Whatever you prefer to call it, unlike conventional methods, which often fall short in effectively addressing emissions, Cross Compression offers a solution that combines efficiency, reliability, and environmental stewardship.

By harnessing the power of specialized equipment and advanced techniques, operators are empowered to achieve substantial reductions in methane emissions while optimizing operational efficiency.

The evolution of pipeline evacuation technology from its inception in 1967 to the present day underscores a remarkable journey of innovation and research and development (R&D). Initially conceived as a solution for transmission projects with high flow and volume, the field witnessed a transformative moment in 2017 with the introduction of the first commercially available mobile compression unit to the distribution system. This pivotal development not only marked a significant milestone but also ushered in a new era, as operators adopted comprehensive Environmental, Social, and Governance (ESG) plans.

The Cross Compression Process, Simplified:

1. Connect to system in need of evacuation

2. Connect to receiving system

3. Cross compress volume into receiving system

Disconnect from each system.

This graphic shows that there is a wide range of magnitude or release and frequency of methane release within the industry.

Since then, continuous advancements in technology have propelled these mobile compressors to handle a wide range of projects ranging from high flow and large volume to smaller projects with significant societal impact – just think of all the 911 calls if someone smells natural gas near a school or neighborhood during pipeline construction. This progression not only reflects the industry's commitment to pushing the boundaries of innovation but also underscores its responsiveness to the evolving needs of the sector. Our customers expect us to deliver energy sustainably and natural gas operators are increasingly rising to the challenge.

Moreover, the journey of innovation and R&D within the pipeline evacuation sector highlights a paradigm shift in approach and capability. What began as a rudimentary solution has evolved into a sophisticated and versatile technological ecosystem capable of addressing complex challenges in the energy infrastructure landscape. The integration of cutting-edge advancements has not only enhanced the efficiency and effectiveness of pipeline evacuation processes but has also expanded the realm of possibilities for operators and stakeholders.

By leveraging emerging technological innovations, such as enhanced mobile compressors, the industry has not only overcome previous limitations but has also

unlocked new opportunities for mitigating methane emissions with unprecedented scale and scope. This relentless pursuit of innovation underscores the industry's commitment to driving sustainable progress and ensuring the seamless functioning of critical infrastructure systems.

Mitigating Blowdown Events: Beyond Environmental Impact

The repercussions of blowdown events are multifaceted, extending beyond environmental concerns to encompass broader societal and operational implications. Blowdowns were traditionally needed in order to safely perform necessary work. While releasing methane was a necessity in the past, it can have environmental consequences. Additionally, the distinct odor and audible disturbances associated with blowdown events can disrupt the tranquility of residential areas, businesses, and educational institutions, exacerbating concerns among residents and necessitating swift and effective mitigation measures.

In response to the pressing need for proactive solutions, various voluntary release mitigation options have been explored, each with its own set of advantages and considerations. Flaring stands out as a commonly employed technique, whereby gas is burned off to mitigate atmospheric release. While effective in reducing methane emissions, flaring poses challenges related to safety, visual impact, proper measurement validation, and permitting constraints, which underscores the need for alternative approaches.

Cross Compression represents another innovative approach to blowdown event mitigation. Also known as Drawdown Compression or Mobile Compression, Cross Compression involves the installation of connection fittings on isolated pipeline sections to facilitate gas recycling through mobile technology. Cross Compression offers numerous advantages, including minimal visual and sound disturbances, modular mobility, and proven success in reducing blowdown events. Despite its effectiveness, Cross Compression requires planning and may necessitate additional time for project execution, as well as aligning with other forms of intentional release mitigation activities.

System Pressure Lowering presents a different approach, where the gas is di-

verted to a lower pressure system. While effective in preventing atmospheric release, this method may be limited by the system allowance. Stopple or Stopper Installation offers a targeted solution to minimize blowdown length by installing fittings to further isolate the pipeline. While effective, this method may incur additional costs and introduce complexity to the pipeline system. All of these methods can be paired to reach maximum emissions reductions and should be evaluated.

Incorporating Cross Compression: Execution Options

Now that you know the history and the options, one question remains... How do I execute Cross Compression on my projects? Incorporating Cross Compression into purging procedures requires a thorough assessment of various factors to determine the best execution approach. Regardless of the method you choose, it is necessary to take steps to change your internal culture to understand and adopt Cross Compression. With any change to operations, behavior change is key to sustainability of the endeavor.

Firstly, it's essential to evaluate the specific requirements of the project, considering factors such as the volume of gas, worksite footprint limitations, drawdown time allowance, complexity, and community implications. Cross Compression, with its specialized equipment and expertise, may be ideal for projects demanding high precision and efficiency, whether those are projects have significant flow and volume requirements, or take place in urban environments with high population density.

The decision to use a contractor, or more importantly a specialty services contractor, also hinges on resource availability and capability. Assessing whether the internal team possesses the requisite skills and experience to execute the task efficiently while maintaining project timelines is crucial. Additionally, evaluating the potential benefits of outsourcing to a trusted supplier, such as access to the latest advanced technology, specialized equipment that fits the scope of work, and a dedicated workforce, can inform the decision-making process. It's important to work with a specialty contractor who is very experienced in live gas service, versus someone who doesn't typically work on live pressurized systems. Ultimately, weighing the pros and cons of a specialty service provider versus self-performing ensures the most effective and efficient approach tailored to the unique requirements of each project.

In many ways, choosing to work with an experienced specialty contractor is like hitting the "easy" button to implement Cross Compression on your projects. By using an outside contractor, operators can more seamlessly navigate the challenges of finding specialized talent and retaining them in an aging workforce, maintaining ongoing training, proper maintenance programs, resource allocation, ongoing rapid innovation and R&D making investments become quickly obsolete, and the fluid and complex schedule of pipeline construction projects.

Making any significant business or operational decision requires a systematic approach. One method of evaluating the right choice for your operations is a three-stage Implementation Phase evaluation consisting of: Phase 1, the Innovation Incubator phase; Phase 2, the Innovative Candidate phase; and Phase 3, the Initiative Candidate Phase.

Implementation Phases:

1. Innovation Incubator

2. Initiative Candidate Stage

3. Strategic Program

Now, let's delve into how to evaluate incorporating Cross Compression using the Implementation phases approach, starting with Phase 1, the Innovation Incubator phase. This phase serves as the foundation, where the problem statement and potential opportunities are identified. Key considerations include program sustainability, time, and resources. For instance, understanding how the proposed plan aligns with current and future strategies, estimating the additional time required for project completion, and assessing available technology and internal expertise are critical steps. Moreover, exploring outsourcing options to trusted suppliers can supplement internal capabilities and streamline project execution.

Moving on to Phase 2, the Initiative Candidate phase, defining key outcome measures for success is critical. Analyzing expectations and potential impacts across environmental, operational, and social aspects provides a comprehensive framework for evaluating the feasibility and effectiveness of initiatives such as Cross Compression. Quantifying benefits such as reduced emissions, operational cost savings, and enhanced social value underscores the significance of implementing innovative solutions.

Finally, Phase 3, the Strategic Program phase, aligning the chosen solution with business, human, and technical objectives ensure strategic alignment and facilitates successful implementation. Developing robust plans and tools to support change management, testing the solution in live environments, and facilitating adaptation among stakeholders are essential steps towards realizing the desired outcomes. Partnering with specialty services contractors offers distinct advantages such as access to best-suited equipment, streamlined execution, minimized risk, and enhanced scheduling capabilities, ultimately maximizing the success of the implementation phase. For example, Versiv's expertise in utilization, training, maintenance, and innovation ensures optimal performance and risk mitigation. By leveraging Versiv's extensive experience and industry-leading capabilities, operators can achieve greater efficiency, reliability, and environmental stewardship in their operations.

Case Study Spotlight: City of Clarksville and Bear Garden Projects

Operators are finding that partnering with a specialty contractor like Versiv to implement Cross Compression is the right choice for a wide range of projects. One of those compelling case studies, showcasing the efficacy of Cross Compression technology can be found in the City of Clarksville, Tennessee's pipeline improvement project. Through Versiv's innovative

PHOTO CREDIT: CLARKSVILLE NEWS

"I am very pleased to partner with the Versiv team on this natural gas project to lower our environmental impact while achieving our compliance goals," said Mark Riggins, Gas & Water General Manager. "I'm also proud to be on the forefront of this innovative technology for the benefit of our natural gas system."

approach and strategic implementation, the City of Clarksville was able to successfully reduce methane emissions while maintaining operational efficiency.

Clarksville Gas & Water provides water and wastewater services to citizens in the City of Clarksville, Tennessee and Montgomery County and natural gas service to five surrounding counties in Tennessee and Kentucky, including the Fort Campbell, Kentucky military installation. The Clarksville Gas Department began a 12-inch-high pressure natural gas pipeline improvement project in early May 2023 on Highway 41-A South. The project scope included gas main spot replacement and pipeline infrastructure maintenance. The conventional spot replacement process evacuates and releases natural gas including methane gas from a high-pressure gas main line into the atmosphere in order to replace segments of the line. With the use of Cross Compression, natural gas from the main line was saved and methane gas emissions were significantly lowered by using specialized equipment to recycle it from one section of the main line into another section instead of venting it into the atmosphere.

With approval for similar initiatives in other regions, Versiv continues to demonstrate its leadership in sustainability and innovation within the industry.

Another project in a different environment, was incorporating Cross Compression into scheduled power plant maintenance. Maintenance plays a crucial role in ensuring the uninterrupted and

safe delivery of electricity from power plants. Versiv collaborated with industry leaders Dominion Energy and Columbia Gas of Virginia during their scheduled outage for routine maintenance at the Bear Garden Power Plant. The strategic partnership leveraged Versiv's innovative cross-compression solution to mitigate environmental impacts while enhancing safety for on-site workers.

Through the implementation of Versiv's cross-compression technology, these companies achieved remarkable results in methane capture and recycling, significantly reducing emissions during the maintenance operation. Those methane savings translate into tangible environmental benefits, and also ensured uninterrupted energy delivered from the plant.

This collaborative endeavor underscored the effectiveness of innovative solutions in addressing industry challenges while prioritizing sustainability and safety. By seamlessly integrating Versiv's cross-compression technology into the maintenance process at Bear Garden Power Plant, the partners demonstrated their collective commitment to operational efficiency and community well-being. This successful partnership not only exemplified the power of collaboration, but also served as a testament to the impact of innovation in driving positive change within the energy sector.

Versiv projects range in scope and size, and notably location. Whether conducting Cross Compression in a bustling downtown environment or keeping a major airport fully operating, Cross Compression allows vital utility construction to take place safely, efficiently, and without community disruption.

"As communities continue to prioritize environmental responsibility and sustainable practices, these projects serve as shining examples of proactive and impactful solutions..."

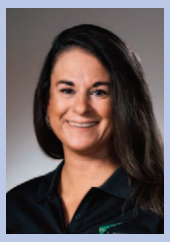
As communities continue to prioritize environmental responsibility and sustainable practices, these projects serve as shining examples of proactive and impactful solutions that benefit both industry stakeholders and the broader community.

Future Outlook and Innovation in Cross Compression Technology.

As we look to the future, the journey of Cross Compression technology is unfolding with unprecedented momentum and new possibilities. With each passing milestone in research and development, the landscape of blowdown event mitigation undergoes transformational shifts, propelled by a collective commitment to innovation and sustainability. As the

intricate interplay between equipment design, service delivery, monitoring systems, and government regulations continues to evolve, Cross Compression represents the future of our industry, bringing in a new era of efficiency and effectiveness in addressing environmental challenges. Under the Artera umbrella there are several contractors offering turnkey services in Cross Compression.

Seemingly strong organizations have suffered because they have not been fast or nimble enough to change in response to technological change, changes in the market, or the changing requirements of their customers. As stakeholders across sectors embrace the need for sustainability in the natural gas industry, we have an opportunity to enhance our operations, change the culture of our organizations, and future-proof the delivery of safe, reliable natural gas.



ABOUT THE AUTHOR:

Gina Rundo is an esteemed figure within the energy sector, serving as the Director of Pipeline Operations at Versiv Solutions. With over fifteen years of experience in the industry, Gina brings a wealth of knowledge and expertise to her role. Her extensive background encompasses leadership positions in corrosion management, integrity management, GIS services, compliance, and asset management. Prior to her tenure at Versiv, Gina played a pivotal role in leading internal live gas operations for a Fortune 200 utility, with a specific focus on hot tapping & plugging, pipeline pigging, and cross-compression services across multiple states.

ABOUT VERSIV:

Versiv, an Artera company, is the trusted leader in safety and environmental solutions for the energy and natural gas industries to help our partners meet their ESG commitments. Today, Versiv's primary focus is on providing Cross Compression services as an alternative to venting, flaring, or blowdown during pipeline repairs and installation. Versiv's contributions to the industry are significant and far-reaching. With 34+ operating companies currently benefiting from its services and operations spanning 21 states, Versiv has emerged as a valued partner in blowdown event mitigation. Leveraging its extensive footprint across 41 states and over 130 locations, Versiv has successfully mitigated over 1,104 blowdown events, demonstrating its commitment to operational excellence and environmental stewardship on a national scale. Our scale differentiates us from the competition, allowing Versiv to be responsive and cost effective. Learn more about Versiv and its solutions at www.versivsolutions.com.

Innovations and Advancements in Liners for Positive Pressure Applications

Various Project Challenges Required Appropriate Engineered Solutions

By: George Ragula, RagulaTech Inc.

INTRODUCTION

Semi structural liners have been successfully used by the gas industry as a renewal technique since they were first introduced in the early 90s. The process has undergone extensive and comprehensive 3rd party testing by several independent laboratories/ agencies including Gas Research Institute (GRI), Institute of Gas Technology, Batelle Laboratories, University of PA, Cornell University, NYSEARCH Northeast Gas Association, Gas Technology Institute (GTI, formerly GRI), and US DOT PHMSA.

During this period, lining has proved to be a viable renewal technique that adds significant life to an existing pipeline. Like any new process, advancements and innovations have been in the forefront and an integral part of the process improvement strategy. Necessity is the mother of invention, and various project challenges required appropriate engineered solutions for them to be cost effectively completed while minimizing disruption and labor needs.

INNOVATIONS/ ADVANCEMENTS DEVELOPED AND IMPLEMENTED

1. Structural Reinforcement Sleeves (SRS)

One of the first major hurdles that needed to be overcome involved avoiding the costs associated with the need for additional preparatory work in removing fittings with piping gaps larger than what a semi-structural liner could safely bridge and replacing these with short sections of steel prior to lining. Such fittings typically consisted of abandoned large-diameter tees or crosses, or drip pots (Figure 1) that were used in the old manufacturing gas days for collecting natural distillate fluids and condensates that were removed periodically from the pipeline through a standpipe accessed at grade. Cutting out and replacing such fittings prior to lining was a major obstacle to a lining project because it added substantial additional costs to the project. Frequently it was impossible to access these fittings because of their location.

The author was fortunate enough to be attending a NASTT regional event discussing the use of high strength/low weight fiber reinforced polymers (FRP) to reinforce weak areas in pipelines and related structural applications at the same time a project was unfolding at PSE&G which involved a leaking 16-inch diameter cast iron (CI) gas main operating at 15 psig crossing a RR that could not be accessed to remove and replace a pot drip located directly under the tracks. The pot drip was 24 inches in diameter, which meant it contained a 24-inch gap in piping (Figure 1) that a liner could not adequately support with internal pressure on the pipeline. With the knowledge gained about FRPs from this event, the solution conceptualized involved:

1. Cutting the standpipe off remotely using robotics using two cuts – one below the invert of the pipe and the second above the crown of the pipe with both cut sections dropping into the bottom of the pot.

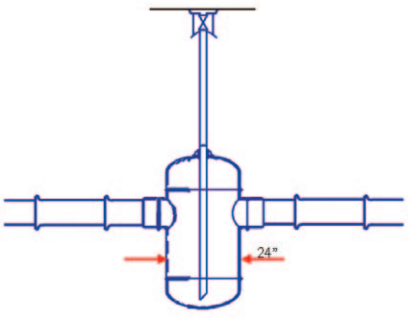


Figure 1. 24-inch drip pot schematic

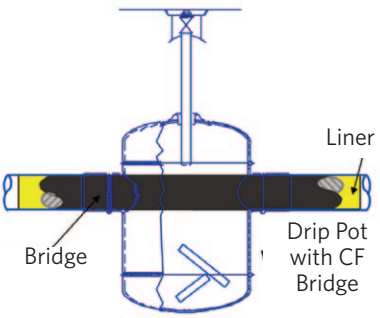


Figure 2. Drip pot with SRS and liner installed

2. Bridging the 24-inch-long gap in piping (located approximately 90 feet in from one cut section of the pipeline) with a 48-inch long section of FRP using an expandable pig.
3. Lining the existing segment of piping taken out of service, including the short segment containing the FRP bridge made of carbon fiber (CF) as shown in Figure 2.

Aboveground installation tests were completed that were supplemented by 3rd party independent testing to 250 psig to solidify the concept. Testing confirmed a conservative safety factor of 4 at the in-service pipeline operating pressures. This testing confirmed the FRP bridge performs as a standalone pressure-carrier section and interacts with the liner similar to the original carrier pipe. The project was eventually successfully completed using this novel concept and represented an industry first.

Like any new ideas, other applications and sleeve configuration variations were only limited by one's imagination, so it was only matter of time before the use of such sleeves was expanded to bridging large corrosion holes (Figures 3 and 4). The SRS acts as a secondary internal wall sleeve at bridge abutment walls where corrosion is usually accelerated due to the presence of standing water, salt from snow operations, etc. (Figure 5). It can also perform as an internal repair sleeve for repairing CI pipeline breaks prior to lining, and other casing/carrier pipe transition zone areas.

2. Tether Belt for Traversing Multiple Bends

In general, the larger diameter of the host pipe, the more bends a liner can successfully navigate through it due to the corresponding increase in force on the liner distributed over a larger area with the same given inversion pressure. This is an inherent advantage when lining larger mains with multiple bends but is a distinct disadvantage in 6-inch and smaller diameter pipelines.

A leaking critical exposed 6-inch diameter main bridge crossing over the PATH RR tracks going into NYC (only one of two PATH crossings to NYC from NJ) contained multiple bends (two 45 degree and two 90 degree) that were outside the normal installation envelope. The PATH system at that point fed a major hub in NYC, and as such, transported vast numbers of commuters requiring numerous trains running on very short intervals. A conventional liner inversion installation using only compressed air could not navigate that number of bends, even within a 100-foot pipeline length. An aboveground piping test section was constructed of PVC pipe replicating the piping configuration of the exposed bridge crossing for shop testing as shown in Figure 6.

Figure 3. Corrosion hole

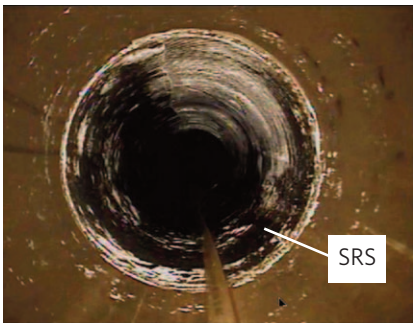


Figure 4. SRS awaiting liner installation

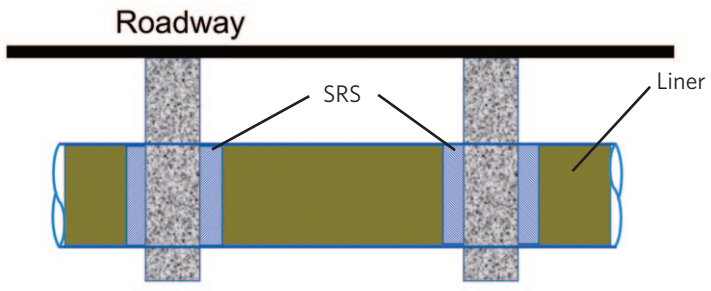


Figure 5. SRS installation in bridge abutment walls

Figure 6. Shop test pipe

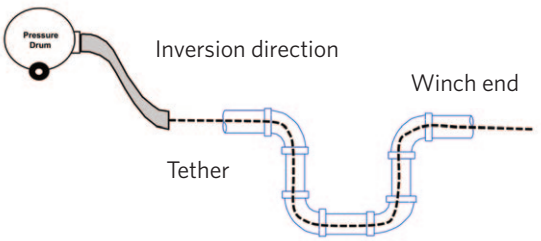


Figure 7. Multi-bend conceptual schematic

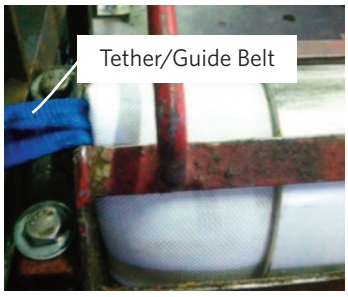


Figure 8. Tether

The solution involved the installation of a tether in the liner that would be pulled with a winch simultaneously as it was being pushed by the compressed air to help guide the liner thru the bends (Figure 7). This provided additional overall force to install the liner that was critical in navigating the difficult bends. With the help of this tether or guide belt (Figure 8),

the liner was able to successfully navigate the bends and make a timely repair before the potential of shutting down the PATH system became a grim reality impacting hundreds of thousands of daily commuters.

3. CI Main Break Using SRS in RR ROW

Working within a RR ROW always creates issues and delays when trying to obtain RR authority necessary approvals – a lengthy process to say the least. The fix is generally to try and avoid working within RR ROWs as much as possible. An 8-inch diameter CI main break within a RR ROW required an immediate solution. Normally, the break would have been excavated and an external repair sleeve installed, but since this break was within the RR ROW this was impossible to do in a timely manner.

Previous use of the SRS was limited to bridging gaps in piping (either due to fittings, or corrosion holes), so the concept that evolved was the internal installation of an SRS over the circumferential break and then lining thru that segment of piping taken out of service outside the ROW, including through the SRS in the ROW as shown in Figures 9-12. This approach also sealed any potential joint leaks on the pipeline, while providing leak-free long-term continued operation of the facility.

4. Stranded Grit from Cleaning Operations

Internal sand blasting equipment working in tandem with vacuum equipment is used to internally clean and remove debris, oxides, etc. from the host pipe in preparation for lining. Occasionally, in larger diameter pipelines typically 30-inch and up, stranded grit (Figure 13) is discovered after the cleaning operation. All this material needs to be removed prior to the actual lining of the pipe. In the past, this has entailed man-entry, and the safety protocols associated with it, to remove the grit/debris using vacuum hoses piped to an outside vacuum source. This is a tedious process which is very time consuming with major worker safety implications. The time required to remove the grit manually is a direct function of stranded grit area within the pipe, which can be considerable dependent on the grade changes of the pipe.

This problem occurred on the last leg of a 36-inch diameter pipeline that involved multiple inversions. The critical feed had to be gassed-in prior to cold weather approaching and NJ was already experiencing nighttime temperatures in the mid-30s, so time was of the essence. A new concept was originated for fabricating a roller pig that would reduce the annular area of the pipeline, thereby increasing the velocity of vacuum flow between the OD of the roller pig and the ID of the host pipe without the need for man-entry (Figure 14). The roller pig would be pulled towards the open cut end of the pipe with a winch, while on the opposite end a vacuum source attached to an end cap would pull the stranded material out due to the increased velocity generated by the pig.

The development of this technique reduced the grit removal time by 75 percent, while improving safety by eliminating man-entry. As with most new ideas being adapted for further purposes, it was only a matter of time before the roller pig system was used for removing standing water from abandoned pipelines being prepared for lining, where water infiltration and intrusion was a problem.

Figure 9. CI Circumferential crack

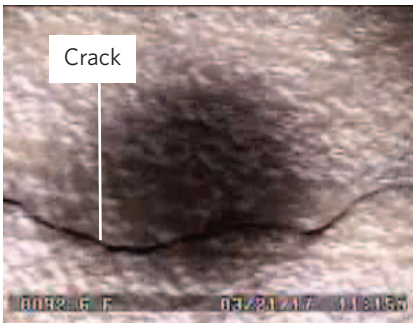


Figure 10. Crack after sandblast cleaning

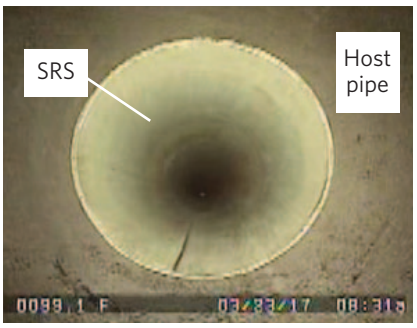


Figure 11. SRS installed

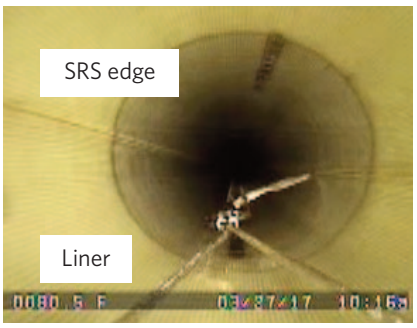


Figure 12. Final liner installation

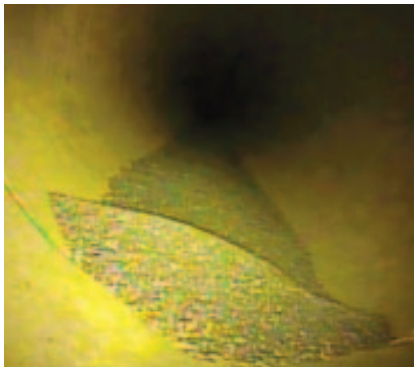


Figure 13. Stranded grit/sandblast debris

Figure 14. Roller pig

Figure 15. U-tube pipeline geometry

Figure 16. Full-scale testing

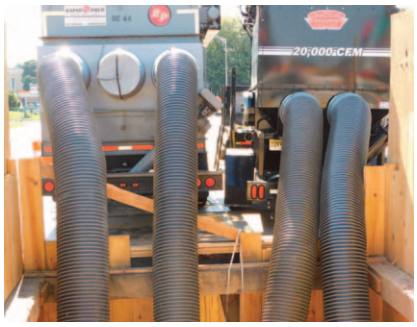


Figure 17. Dust collectors

5. Redesign/Reconfigure Vacuum Equipment Used in Cleaning Operations

The sporadic problem of stranded grit became a particular concern involving a leaking 42-inch diameter renewal project with a u-tube geometry configuration crossing an 8-lane major highway. The surrounding streets were approximately 30 feet higher than the major thoroughfare and the added effect of gravity aggravating the stranded grit phenomena combined with pipeline geometry became a major concern as shown in Figure 15. The tight outage window demanded a more comprehensive understanding of factors causing this issue to occur and its mitigation.

Full-scale testing to evaluate the overall vacuum process used for grit/debris removal was conducted several months before the start of the project (Figure 16). The objective was to thoroughly evaluate, measure, and improve overall vacuum efficiency/effectiveness to completely eliminate the potential of stranded grit. Various process parameters were measured, adjusted, and modified to provide assurance that all the grit/debris could be effectively and reliably removed for this project. The modifications and improvements identified after the testing included:

1. Upsizing vacuum inlet hoses from 8-inch diameter to 16-inch diameter,
2. Replacing 6 individual vacuum trucks anticipated for the 42-inch with two dust collectors capable of generating 60,000 cfm of vacuum. Refer to Figures 16 and 17
3. Utilizing measurement equipment for periodic real-time measurement of velocity and vacuum to confirm optimum operation.

These modifications ensured complete removal of the grit/debris while also providing the added benefit of an overall smaller jobsite equipment footprint and corresponding reduced manpower requirements. The implementation of these improvements ultimately were proven out on the jobsite and led to a successful project that was completed one month before the scheduled outage window.

6. Curtain Grouting to Eliminate Water Infiltration and Intrusion (I&I)

Because of the high-water table expected, combined with depth and pipeline geometry on a leaking 42-inch diameter main, it was certain that water I&I would occur once the high pressure main was abandoned in preparation for lining as shown in Figure 18. This would wreak havoc on the internal cleaning phase of the project by creating a grit/debris mud mess and could potentially add significant delays, while also compromising bonding strength between the liner and host pipe.

Curtain grouting was explored as a possible solution during the planning phase of the project because of its routine use in sewer and water applications to successfully eliminate I&I. This process had never been incorporated into a natural gas pipeline project, so further detailed review and analysis was necessary. The curtain grouting process involved man entry, drilling 3/8-inch diameter holes thru the pipe wall, installing nipples with check valves, and then injecting a special grout thru the nipples that reacted with the surrounding water/soil to prevent water from entering the pipe, as shown in Figure 19. Once cured, the nipples were cut-off, ground smooth, and a layer of epoxy installed, which was followed by the normal internal sandblast cleaning process.

After further reviewing the details of the process, procedures and subcontractor qualifications, this innovative method for stopping I&I was incorporated into the job. Once the leaking main was abandoned and camera inspected to confirm geometry, presence of any anomalies, and I&I locations, curtain grouting was immediately employed to limit the volume of water accumulation in the pipeline that would have required removal prior to starting the sandblasting phase of the pre-lining process. A section of pipeline approximately 40 feet long was success-

Figure 18. I&I after pipeline abandonment

Figure 19. Curtain grouting injection ports

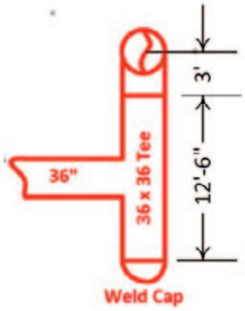


Figure 20. Stack drip fitting

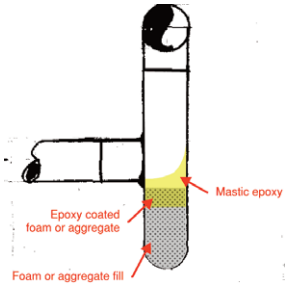


Figure 21. Proposed design

fully grouted to stop the inflow of water and once the accumulated water was pumped out the successful completion of the project became a routine matter.

7. Use of High Strength Epoxies

Even with the development of the SRS and its successful incorporation into lining projects to avoid the removal of fittings with wide gaps in piping, some fittings, by virtue of their geometry, still needed to be cut-out and replaced with steel pipe. An example of this kind of fitting was a stack drip shown in Figure 20. Its function was to collect pipeline fluids like a pot drip fitting but was used predominately at very deep pipeline locations and stream crossings.

One lining project involving a 36-inch diameter pipeline crossing a stream contained a fitting of this type that was at a depth of over 20 feet and located in an abandoned gas station property containing environmental monitoring wells for monitoring the soil contaminated from leaking underground gasoline tanks (Figure 20). Replacement of this fitting with a straight piece of pipe and two 90s was prohibitive because of the extreme depth and costs associated with environmentally approved contaminated soil removal requirements.

Having worked with epoxies for many years in a variety of applications, I undertook a study to determine if we could modify the geometry of the stack drip,- essentially a 36x36-inch tee with a leg running down that was capped, and a vertical leg running up to a 90 degree bend, by making the tee into a 90 degree bend using layers of epoxy installed over pea gravel aggregate in the vertical capped-off leg as shown in Figure 21. The two-part heated epoxy was a high strength epoxy that cured to a compressive strength of 15,000 psi. Worker entry into the pipeline was required for the installation. Figures 22, 23 and 24 illustrate the transformation of the stack drip fitting from a tee to a 90 degree bend that has been successfully lined.

During the planning and scheduling effort, an inoperable 30-inch diameter gate valve that could not be removed because of heavy subsurface utilities surrounding the gas main also was targeted to have the 6-inch-long valve gate well gap (Figure 25) filled with this epoxy as well (Figure 26). In addition, the source of the leak was narrowed down to a 30x36-inch steel corroded reducer, so prior to lining the plan was to install several layers of epoxy on the ID of that fitting to give it more strength, rigidity and wall thickness prior to lining the entire piping run (Figure 27).

Figure 22. Aggregate layer

Figure 23. Epoxy layer

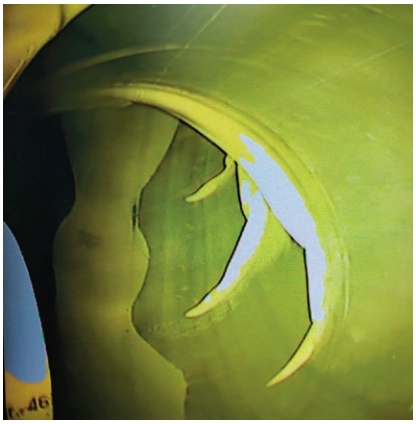


Figure 24. Lined fitting

Figure 25. Valve gate well 6-inch gap

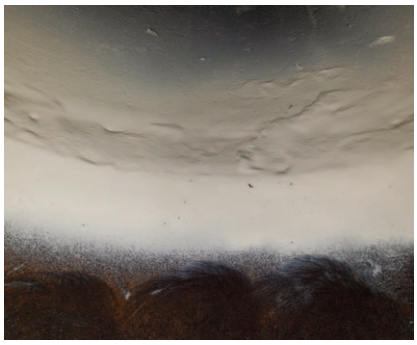


Figure 26. Epoxy-filled well gap

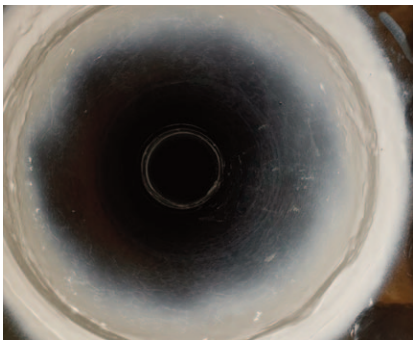


Figure 27. 30x36 inch reducer

Figure 28. Full-scale shop testing

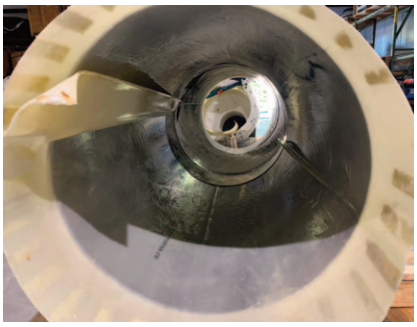


Figure 29. 36-inch liner in 30-inch pipe wrinkle

Figure 30. Actual guide pipe field installation with reducer at 30-inch inlet

8. Installing a 36-inch Diameter Liner Thru a Pipeline Containing a Short Section of 30-inch Diameter Pipe/Fittings

Because of the location of the majority of bends, a leaking 36-inch diameter pipeline that contained a short section of 30-inch diameter piping had to be lined starting from the 30-inch side. This had never been done before, but there were no other options. The concern with starting a 36-inch liner into 30-inch pipe was proper liner alignment, excessive wrinkling and other transient effects that might cause other issues with an inherently unstable liner "bubble" as it enters the pipe.

Since this was never attempted before, it was critical that full-scale shop testing be performed

The concept developed involved installing a short 36-inch diameter guide pipe with a 36x30-inch reducer welded onto it. In that way, the 36-inch liner bubble became stable in that wider section of piping before it traversed thru the guide pipe reducer connected to the 30-inch pipe. After traversing thru approximately 10 feet of 30-inch pipe it would travel through a second reducer opening it back up to 36-inch pipe for the remainder of the 165-foot piping run.

Since this was never attempted before, it was critical that full-scale shop testing be performed using full diameter pipe, fittings, and liner to prove the concept (Figure 28). Such aboveground testing was successfully performed, and wrinkling was minimal. The single wrinkle just under 6 inches in width was filled with resin so a tight bond was assured with minimal impact to flow (Figure 29).

9. Cast Iron (CI) Non-destructive Testing (NDT)

As the gas industry application of liners expanded to larger diameter CI mains for predominantly pipeline capacity reasons, the ability to identify and measure the integrity of CI pipe became more critical in determining the strength and expected life of an underground facility. This gave utitilities the unique capability to devise appropriate replacement strategies and priorities. The conventional line of thought governing the replacement or renewal of a CI facility is based upon uninformed decision making as a result of the lack of integrity-related data. Consequently, most retirement of CI facilities are based on breakage history combined with operating pressure level, with consideration given to active leaks. Available technology needs to be utilized to help determine appropriate replacement options and replacement rankings based on existing pipe integrity of the pipe. This encompasses taking measurements capable of determining wall thinning, graphitization and cracking – all critical parameters when considering lining as a viable renewal technique.

Fortunately, the author was in a position to determine the integrity of two critical 30-inch CI crossings installed in 1914 under the Passaic River in Newark, NJ. The river waterfront was undergoing major redevelopment and a decision needed to be reached regarding the condition of these mains. After researching technologies capable of CI NDT worldwide, broadband electromagnetic (BEM) technology was selected and successfully utilized because of its proven 20-year global record in determining CI wall thinning, graphitization and locating cracks.

Fast forwarding to the present, while it was clear this technology had a distinct use for CI pipeline condition assessment to provide valuable data for repair or replace decisions and establishing priorities, it also quickly became evident this technology could be used effectively to determine host pipe condition/integrity in lining applications, most particularly for large diameter gas mains 16 inches and larger in diameter. BEM technology was implemented for determining pipeline integrity for CI mains identified for lining and could also be used for periodic monitoring of the host pipe integrity over time to satisfy any questions by the regulators, or other authorities having jurisdiction. A distinct advantage of BEM technology is that minimal cleaning of the pipe wall is required, and in the case of steel pipe applications, the protective coating does not need to be removed. BEM can be deployed on the ID or OD of the pipe.

While I was at Public Service Electric & Gas the technology was used for RR crossings to satisfy the RR authorities the CI main had sufficient integrity to be lined. However the greater application of BEM came from its use on the large diameter pipelines targeted for lining due to their extremely high replacement costs, congested subsurface where finding a clear lane was virtually impossible, and

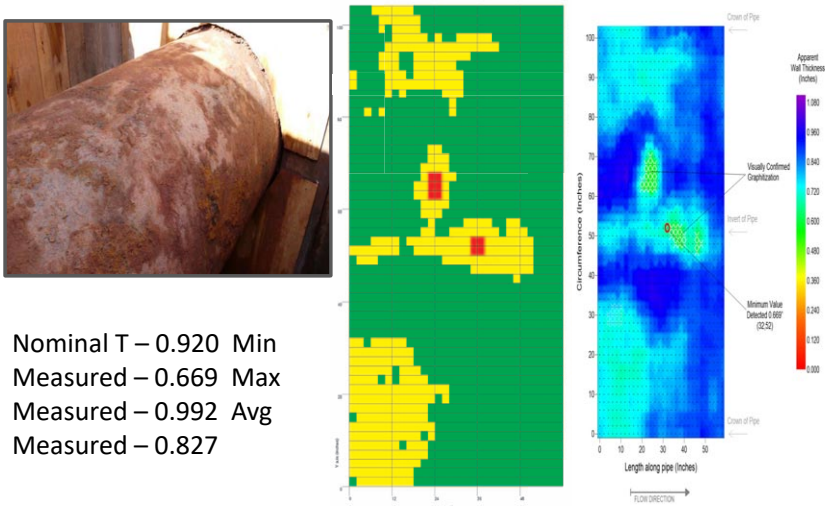


Figure 31. CI main with field-generated data and post-processing output

desperate need to maintain or even increase pipeline capacity. Lining as a renewal technique always increases natural gas pipeline capacity since it significantly reduces the laminar friction factor which reduces the pressure drop across piping segments.

Figure 31 provides additional detail from a leaking 30-inch CI pipeline that was eventually lined and depicts the entire process. Real-time lap top displays are shown in a color-coded format with:

- Green indicating a greater than 90 percent wall thickness
- Yellow indicating a 70-90 percent wall thickness
- Red indicating a wall thickness less than 70 percent

A post-processing option can be used to provide further details and clarification regarding the exact magnitude of the wall thickness with a multi color coded output and key shown on the far right.

The use of this technology has added another tool in the proverbial toolbox of lining and has helped expand its use as a viable renewal technique.

10. Restraint Plug

Sometimes in-line large diameter tees that are deep and/or inaccessible due to heavy subsurface cannot be cut off as is routinely done and abandoned prior to lining a pipeline. Such was the case on a project containing a 36x20-inch tee. A large diameter take-off of this type has to be temporarily bridged to provide adequate bearing surface for the liner inversion and for the subsequent pressure test in order to prevent a blow-out of the liner before the pipe is reinstated into service.

The immediate solution might have been to utilize an SRS that would eventually need to be cut-out after the pressure test to reinstate gas flow into the bull of the tee. This could potentially create a future leak path under the SRS because of the different bonding, combined with the material characteristics between the liner and SRS.

The solution for this challenge was to develop and fabricate a specially designed restraint plug, shown in Figure 32, that was fabricated into three individual components for ease of assembly into the 36-inch pipe under the confined space entry protocols. The cover plate of the plug assembly was machined to a 36-inch radius to match the internal diameter of the 36-inch steel pipe. This plug was designed to function as a bearing surface for the liner inversion and subsequent 25 psig pressure test.

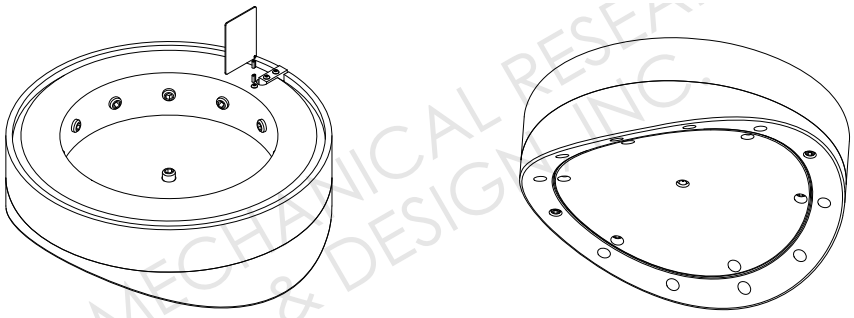


Figure 32. Restraint plug design

The sequence of installation steps at the 20-inch tee was as follows and shown in Figure 33:

1. Install three individual restraint plug components at 20-inch tee outlet and torque bolts to specifications.
2. Install telltale yellow tape to visually locate restraint plug after lining.
3. After lining and pressure test carefully cut and remove liner over plug and disassemble restraint plug.

CONCLUSIONS

The gas industry has consistently led the evolution of liners as a trenchless renewal technique since first generation technology was adopted by the industry in the early 90s. While second generation technology improvements have helped support this evolutionary process, advancements and innovations conceived and specifically developed to provide custom engineered solutions for projects have pushed the envelope. Many of these advancements have been built, improved, and expanded based on previous successes to the point where it is not uncommon to have major challenging projects solved using a multitude of successful innovative approaches involving combinations of innovative concepts previously conceived, tested and successfully implemented.

As a recognized expert in this area having been involved at the ground floor level, it has been exhilarating to have been a part in playing a leading role in all the advancements and innovations that have been incorporated into the process. In the 90s, potential lining projects fell to the wayside because they could simply not be done due to external environmental factors, types of fittings utilized, pipeline geometry, local terrain/geography, and high-water tables to name a few. In today's world, this is, with very few exceptions, no longer the case. Suffice to say, there will still be challenges that need to be met with innovative solutions

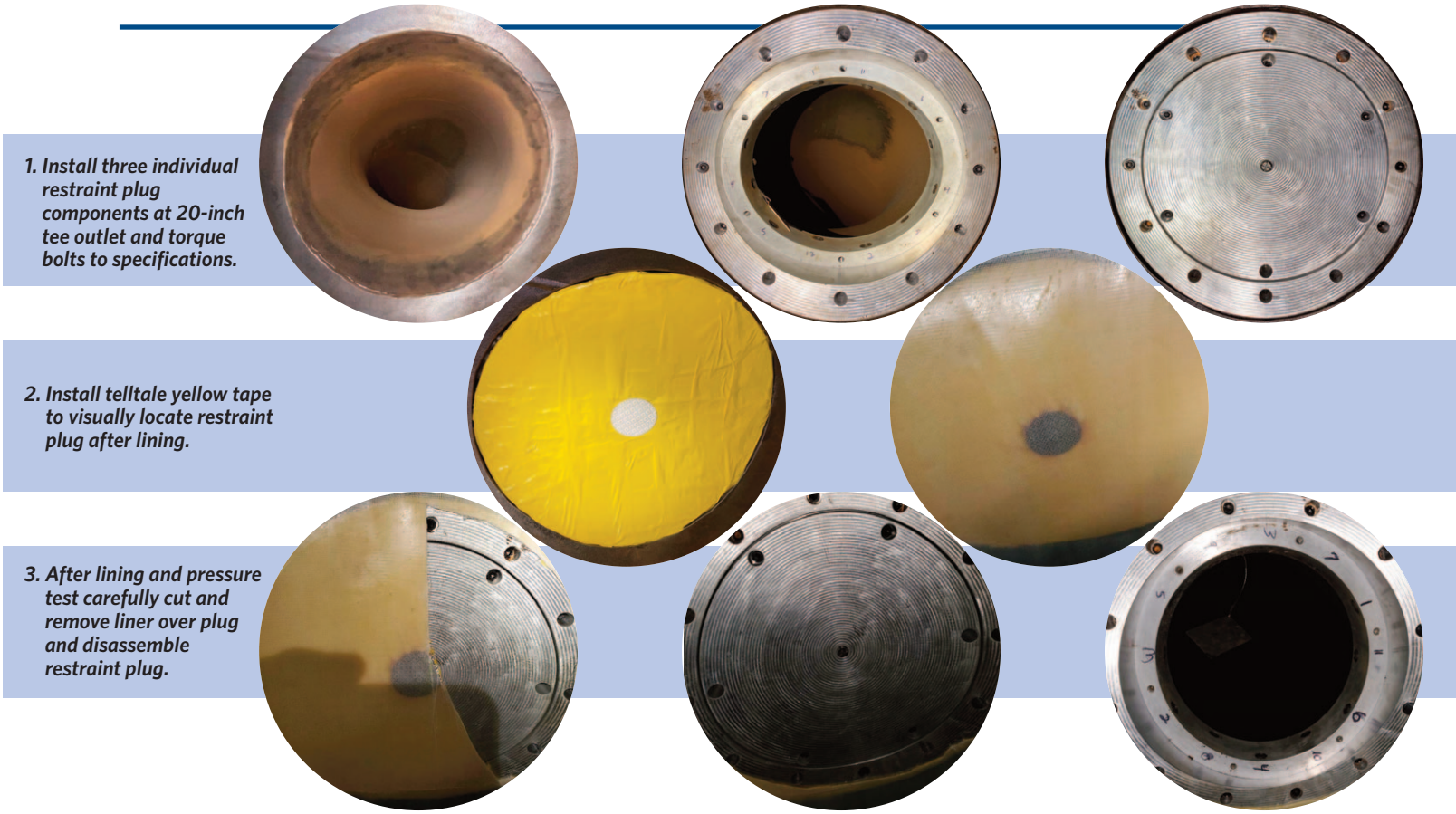


Figure 33. Sequence of installation/removal of restraint plug at 20-inch tee before/after pressure test

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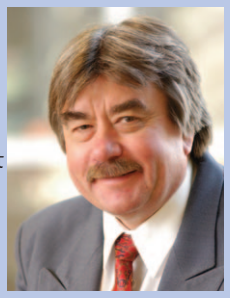
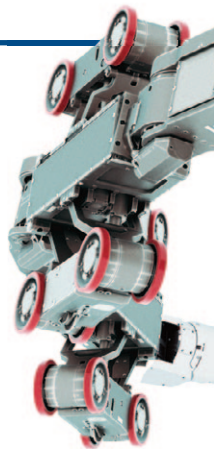
ABOUT THE AUTHOR:



George Ragula is President of the consulting firm of RagulaTech Inc. He previously served as the Distribution Technology Manager at Public Service Electric & Gas (PSE&G) with over 46 years of experience in gas industry engineering, operations, construction, research/development/deployment and management. George is a noted authority on trenchless applications for the gas industry having spent 36 years specifically focused on trenchless. He received his B.S. in Mechanical Engineering from Polytechnic Institute of Brooklyn in New York. George is a past Chair of NASTT and serves on the NASTT No-Dig Show Program Committee. He also teaches several NASTT courses on various trenchless technology topics, including CIPL for the Gas Industry. Prior to retiring from PSE&G, George conceived, developed, engineered and implemented several innovative solutions outlined in this article to solve unique project challenges that resulted in PSE&G receiving three Trenchless Technology Project of the Year - Rehabilitation Awards.

Assessment of Long Seam Weld in ERW and Flash-Welded Pipes Using Circumferential Magnetic Flux Leakage Technology on Robotic Pipeline Inspection Platform



By: Rod Lee, Intero Integrity Services

In the beginning of 2022, Intero introduced a sensor technology aimed at mitigating integrity concerns associated with long seam welds in challenging-to-inspect pipelines. After extensive research, development, and testing spanning several years, a circumferential magnetic flux leakage (CMFL) sensor was successfully created and integrated into the Pipe Explorer robotic pipeline inspection platform (Figure 1). The development of this technology was made possible through NYSEARCH, and the Northeast Gas Association [1].

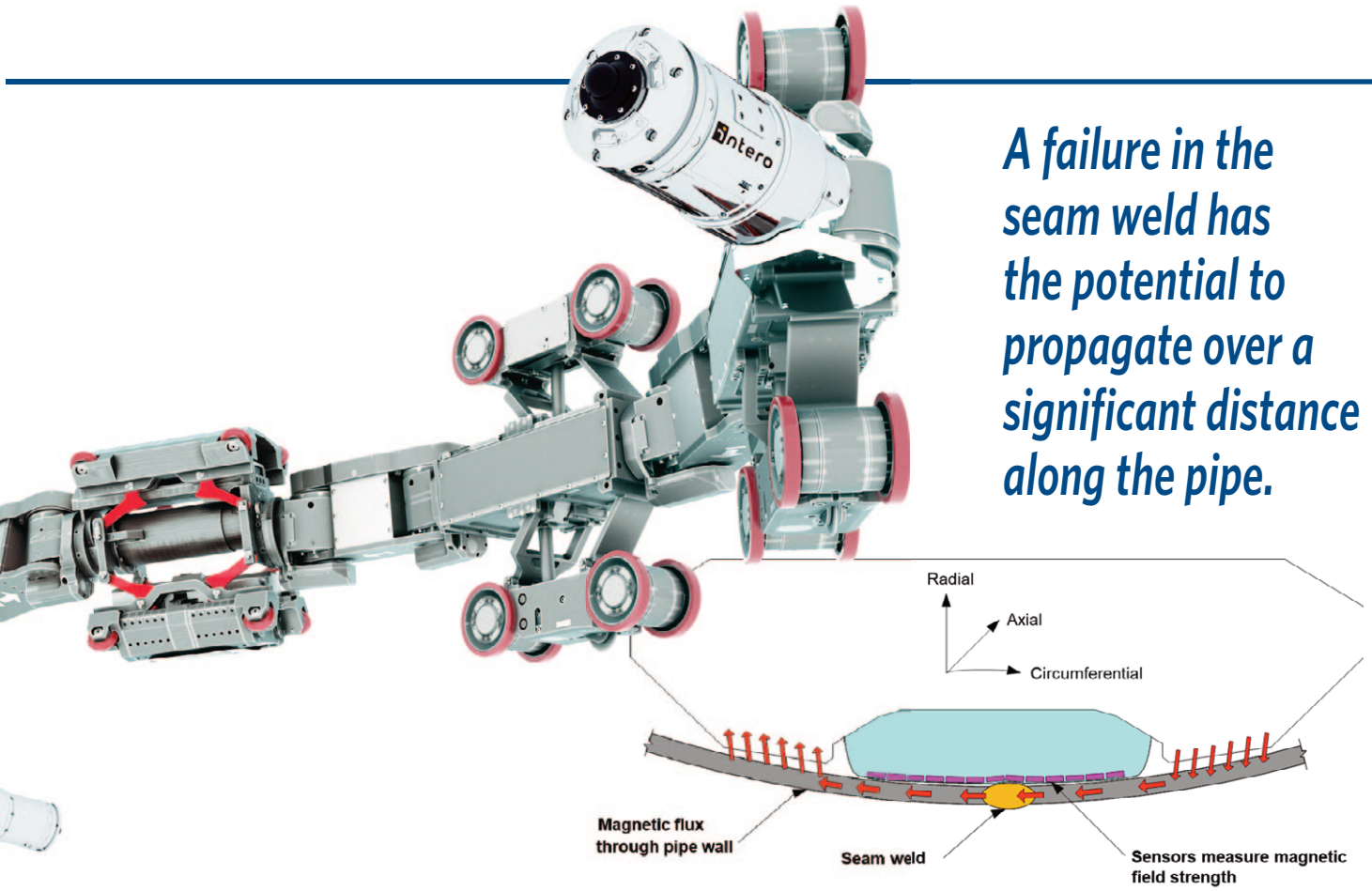
Numerous pieces of literature and research have documented integrity issues related to long seam welds [2] Specifically, low-frequency-welded ERW pipes and flash-welded pipes are particularly vulnerable to selective seam weld corrosion, cracks, and crack-like anomalies that tend to develop in the vicinity of the long seam weld [3]. A failure in the seam weld of such pipes has the potential to propagate over a significant distance along the pipe, leading to the rapid release of substantial quantities of product into the environment. Although free-swimming inline inspection is a highly valuable approach for evaluating these pipe types, not all pipes are readily compatible with free-swimming inline inspection tools for many combinations of reasons. These pipes are commonly referred to in our industry as unpiggable, difficult-to-inspect, or challenging-to-inspect due to several categories of reasons [4]:

- Certain features in these pipelines act as barriers that prevent the passage and navigation of free-swimming inspection tools. Examples of such features include mitered bends or elbows, short-radius bends or elbows, and unbarred tees.
- These pipelines lack the necessary infrastructure for launching and receiving free-swimming inline inspection tools, such as launchers and receivers.
- These pipelines have limited flow characteristics, as they operate at pressure and flow levels that are insufficient to propel traditional free-swimming inspection tools.
- The configuration and features of these pipes are unknown, which significantly elevates the risk of traditional inspection tools encountering navigational barriers.
- These pipelines cannot accept a liquid medium as a coupling agent for ultrasonic sensing technology, and natural gas services cannot be interrupted.

Before the introduction of inspection tools designed for challenging-to-inspect pipes, pipeline operators had been relying on other assessment methods for their difficult-to-inspect pipes, such as hydro or pressure tests, direct assessment, or sometimes opting not to perform any assessment at all. The emergence of robotic inspection now offers an alternative for inspecting these pipelines, enabling a deeper understanding of their integrity conditions. Ultimately, this technology equips pipeline operators with valuable data that can be used to make proactive decisions regarding the operations and maintenance of these pipelines.

One of the most notable distinctions between robotic pipeline inspection and free-swimming inspection tools is the method of propulsion. Robotic tools use internal motors for propulsion, rather than relying on the pressure differential of the pipeline product for movement. Another significant difference is the degree of control. While free-swimming tools lack control and are influenced by the flow of the product in the pipeline, robotic tools can be controlled in real-time, either through a cable or tether connection or by means of a wireless signal. Depending on the sensor systems employed, the data acquired by robotic tools can be either identical or similar to that obtained by traditional tools.

Robotic pipeline inspection systems, like Intero's Pipe Explorer, provide the means for inline inspection of pipes that are not suitable for conventional free-swimming inline inspection methods. For natural gas pipelines, the Pipe Explorer can be deployed and retrieved through an industry-standard hot tap fitting, all while ensuring the normal operating condition of the natural gas pipeline is main-



A failure in the seam weld has the potential to propagate over a significant distance along the pipe.

Figure 2: A cross-sectional schematic of the CMFL sensor integrated into the Pipe Explorer

tained, thereby ensuring that gas services remain unaffected.

Once it's deployed inside the pipeline, the Pipe Explorer is equipped to locate and measure metal loss such as corrosion, using an axially oriented MFL sensor, as well as identify dents and mechanical damages through a laser sensor. With the recent inclusion of a CMFL sensor, the Pipe Explorer is now equipped to not only find and measure axially-oriented features such as selective seam weld corrosion but also to detect crack-like anomalies on or near the long seam weld (Figure 2). The addition of a CMFL sensor addresses anomalies with dimensions that are considered axial-slotting in the Pipeline Operator Forum (POF) Anomaly Classification System.

In summary, the integration of a CMFL sensor into the Pipe Explorer robotic pipeline inspection platform has allowed operators the evaluation of anomalies near long seam welds in pipelines ranging from 16 inches to 26 inches in diameter. As of 2023, Intero has assessed over 30 kilometers of 16-inch and 20-inch pipelines using the robotic inspection method, thereby improving the safety of these pipelines through a deeper understanding of their integrity conditions, surpassing the capabilities of conventional inspection methods. The data obtained has facilitated proactive maintenance efforts, addressing various issues like selective seam weld corrosion and other crack-like features. Continuous improvements in algorithms, technology, and operations will further enhance the capabilities of this service offering. Furthermore, there are ongoing efforts to extend this service offering to cover pipelines with 10 and 12-inch diameters.

ABOUT THE AUTHOR:

Rod Lee is the Global Business Development Manager for MFL robotics at Intero Integrity Services. He is a licensed professional engineer of Ontario. He lives in Toronto, Canada.

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Engineering Innovations Emerge from Lining Challenges

A Complex Lining Project in Brooklyn's Gowanus Canal Led to Creative Solutions

By: Mario Carbone, Progressive Pipeline Management

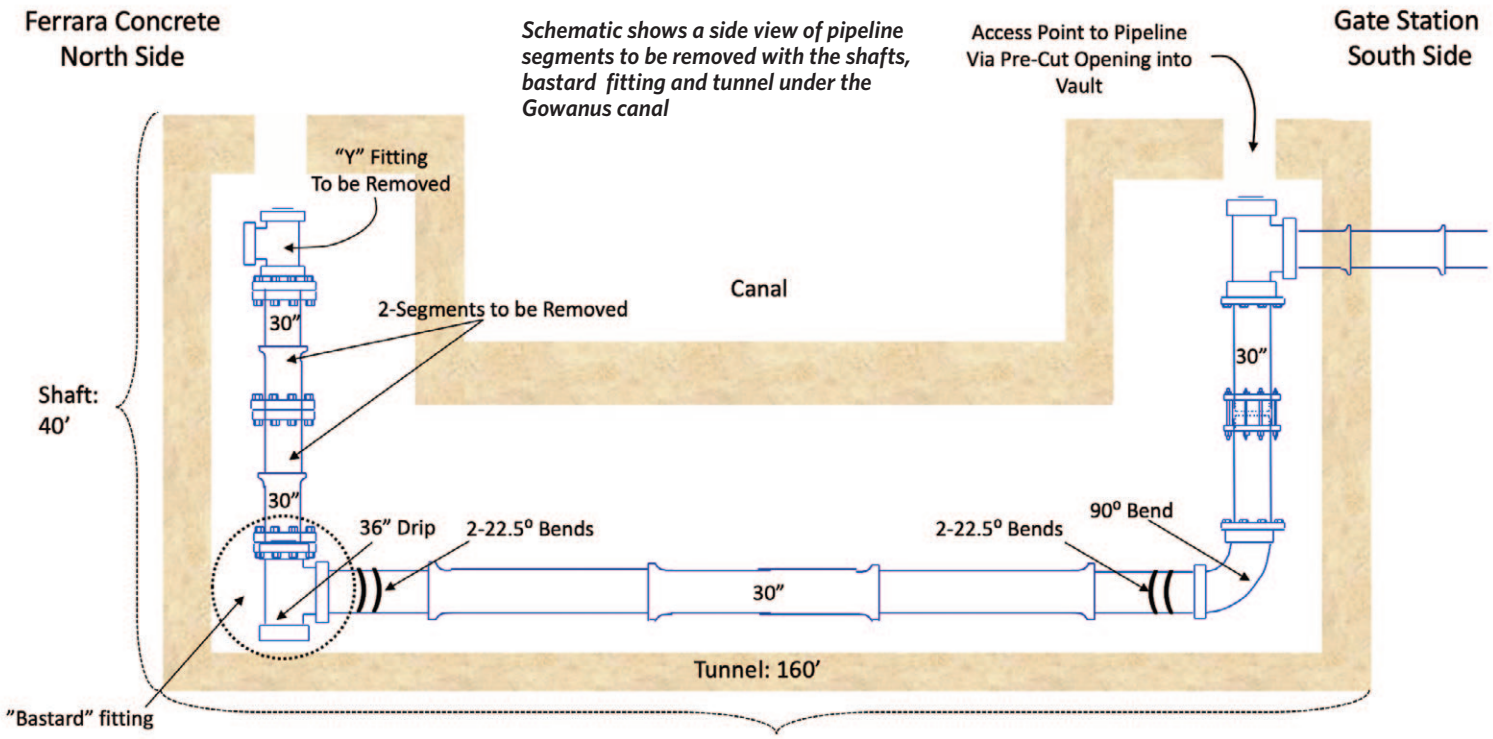
Since 2002, Progressive Pipeline Management has been installing the Starline® Cured-In-Place-Lining trenchless technology for natural gas main renewal. The trenchless pipeline renewal technology is proven to be an effective alternative to conventional replacement methods for cast iron and steel pipelines.

Cured-in-Place-Lining relies on engineering, whether it is a conventional lining application, or there are multiple complications. Rehabilitating natural gas pipelines requires a collaborative team with hands-on expertise of both natural gas and lining. Engineering innovation emerges from a need to solve a problem.

Every lining project, no matter how small or how complicated, requires up front engineering. Preparing the projects involves a knowledge of both gas procedures as well as lining applications. The two disciplines merge into a subject matter expertise and the ability to create new engineering processes. The 30-inch turnkey project in Brooklyn's Gowanus Canal challenged what we thought was possible. There were several times we wondered, can it be done? With the creative engineering and ingenuity of National Grid and Progressive Progressive Management, the challenges became a catalyst for multiple innovations.

CAN IT BE DONE?

There was nothing conventional about this project. The drawings showed a pipe configuration I had never seen. The 30-inch cast iron pipeline started above the ground and turned straight down 40 feet. It bended again, entered a tunnel for 200 feet, turned sharply with a 36-inch drip and up the other side of the canal. Access points to the pipe were extremely limited. The process of cleaning the pipe-



line's interior before lining had to be redesigned. The challenge of lifting the debris 40 feet to a vacuum truck, had to be overcome. A completely new approach to connecting the lining fitting to the pipe needed to be invented and engineered. Almost every lining standard and procedure would have to be redesigned, tested, and implemented.

After weeks of internal discussion within PPM's engineering group, we worked through options and recommendations with National Grid's engineers, pipeline and construction experts. Our collective expertise encompasses the best of rehabilitation technology, pipeline construction, gas engineering and distribution. Each scenario was considered and debated.

Even as we discussed possible solutions, I knew from experience to expect the unexpected. In lining, like chess, you can't see the challenges all at once. At best you see the next one or two moves. As each new challenge appeared, we would have to face it head on and then be ready for the next one.

THE BEST-LAID PLANS

After many weeks, we had a project design for the Gowanus Canal, on paper. When we got on site and entered the tunnel where the pipe travels under the Gowanus waterway, it was obvious that everything on paper needed to change. Although National Grid's drawings were accurate, what we found was much more complicated.

Separating or cutting the pipe segment to gain access to the pipe interior was our first challenge. The two 30-inch pipes were tightly packed within the old, brick walls. Conventional tooling wouldn't work to cut the pipe because of the limited surrounding spacing. No one wanted to disturb the bricks that were set in the 1890s.

The only way to preserve the brick tunnel was to disassemble the old cast iron vertical flanges and bring them out of the tunnel. We lifted the pipe segments out onto the ground intending to line them. Once the vertical cast iron flanges were removed, we realized it would not work to reassemble these flanges and put them back in place for lining. Under the weight of the 40 feet of 30-inch cast iron pipe, the gasket material that sealed the flanges had a strong possibility of leaking gas over time. I had seen it before. These flanges could not be lined. A different approach needed to be engineered to guarantee a leak free connection of the flanges.

THE ELEVATOR CONCEPT

We invented a solution to the potential leaking flanges with the innovation that is born from necessity. The new design consisted of an inflatable bladder or cylindrical balloon and a short segment of liner with impregnated adhesive that surrounded the bladder. The bladder with the liner was lowered into the pipe, until the bladder and liner made its way to the location of the flange. We observed the process on CCTV. The bladder was inflated and the wet adhesive liner pressed against the interior of the flange. This sealed liner would be secure for the next 100 years. The new approach, named the Elevator Concept, has become a useful tool for pipe access.

CONNECTING TO A VERTICAL PIPE

The pipe in this project was vertical; it started above ground and then sharply bent down 90 degrees. PPM had never lined a segment of pipe in a vertical downward application. How do we get a liner up into a piece of large diameter cast iron pipe when the lining process was designed to work on a piece of pipe that is horizontal in the ground? Lining equipment, pressure drums, pipe cleaning and CCTV equipment are all designed to recondition pipelines horizontally, the conventional direction of pipelines.

The cutting-edge build we designed had a bend on top of the vertical pipeline, eliminating the need to cut the pipe for access. This new "change in direction" fitting required more than just simple mounting. It had to be temporarily welded and anchored to a road steel plate. The road plate acted as thrust blocking, which stabilized the new fitting while it was bolted in place. The new fitting changed the profile from a vertical downward connection to a horizontal connection. We also had to design a way

The inflatable "bladder" designed to inflate inside the pipe segment, ensuring that the adhesive liner was flush with the pipe

The "change in direction" fitting redesigned the profile from a vertical downward connection to a horizontal connection

for it to be disconnected with ease after lining. The new fitting remained connected until the liner was cured and ready for pressure testing.

CHANGE IN DIAMETER

There was an old 36-inch drip within the 30-inch pipeline that became our next engineering challenge. When a "bastard" fitting is found, it is usually removed before the lining process can proceed. This bastard fitting could not be removed. Lining a 30-inch pipe that had a 36-inch fitting somewhere within the pipe segment was a big issue. Before the project could move forward, a solution to line the 36-inch bastard fitting needed to be engineered and tested.

Time for another innovation. Maybe the Elevator Concept that solved the problems on the vertical flanges could work. Rather than simply lowering the inflatable bladder and impregnated liner, we needed to traverse the horizontal piping. The bladder was too large for the 30-inch pipe because the bastard fitting was 36-inch in diameter. We used a new bladder that was collapsible. It traversed through the smaller diameter pipe with the liner to the position of the 36-inch fitting. The bladder was inflated and the liner cured, leaving behind the bonded liner.

The bladder engineering innovation solved the problem and made its way into our toolbox. Today, the bladder is used to reinforce bridge abutments. We pull the bladder into the corroded segment of the pipeline through the abutment wall. It had a carbon fiber sleeve wrapped around it. With the bladder inflated and the sleeve bonded inside the pipe, the segment was stronger than it ever was. The extension enabled access.

AN UNEXPECTED ENEMY — CONDENSATION

Just when we thought the pipe related issues were solved, another unanticipated challenge showed up. It was summer of 2020. In Brooklyn NY it was hot, with ambient temperatures in the 80°F range. Within the tunnel, under the Gowanus waterway, the temperature was a cool 40°F. While a relief from the summer heat, the tunnel temperature created a big problem for cleaning the interior of the pipe. The temperature change from a warm, damp 80°F degree to the cool, dry 40°F within the pipeline created a significant amount of condensation.

Tunnel underneath Gowanus dates back to the 1880s. Note the detailed brickwork on the walls.

To line properly, a pipeline needs to be dry, clean, smooth, and free of debris. When cleaning to prepare for lining, a sandblaster travels inside the pipe while the guzzler truck pulls the sand and the debris out. Fresh, warm, damp air goes into the cool dry pipe using a guzzler truck. Normally this is never an issue, because both ends of the pipe are in the same temperature environment. Here, pulling warm damp outside air into the cool dry pipe underground created a significant amount of condensation to the point where it was "raining" inside the pipe. The sand turned into mud.

After a day of racking our brains, we had an idea. What if we pull the cold air from the tunnel into the pipe and then out into the atmosphere. We introduced a system using a compressor to draw the moisture out of the pipe. Before pulling the warm, damp air into the guzzler, it was sent into a large air dryer. This avoided additional moisture causing a condensation headache. The next time outside and inside temperatures are different, we have another tool in our toolbox to combat unwanted condensation.

"Lining the Gowanus Tunnel pipeline was one of the most complex projects our department faced. ... Teamwork, PPM's engineering and expertise were invaluable to the success of this job."

Up to the final lining preparations, we had to innovate by rigging a cherry picker to hold and lift equipment in and out of the tunnel.

It only took a day to line 200 feet of the pipeline. The liner was installed down the shaft, across the tunnel and back up the vertical on the other side of the canal.

This project was unusual, and nerve-wracking. We faced each new challenge with our collective experience engineering gas infrastructure and lining applications. At every meeting with National Grid, we

made sure they understood that we were trying things for the very first time. I said, 'I'm willing to try if you're willing to try.' And they always were.

With the skills, time in the field and the willingness to try new solutions, we can overcome any lining challenge. Afterwards, we look back and say it was fun.

Bill Howe, the National Grid Project Manager said it the best.

"Lining the Gowanus Tunnel pipeline was one of the most complex projects our department faced. It started with identifying the existing conditions of the cast iron pipe, installed back in the 1920's. The lining process involved a challenging inversion through the vertical section in the access shaft, and complex custom fittings to align to the existing pipe. Teamwork, PPM's engineering and expertise were invaluable to the success of this job."

PPM PROGRESSIVE PIPELINE MANAGEMENT
THE INFRASTRUCTURE RENEWAL SPECIALISTS

Progressive Pipeline Management (PPM) is a NJ-based, full-service contractor that has been committed to improving the safety and longevity of pipeline infrastructure for more than 22 years. PPM offers the latest trenchless robotics and technologies to perform condition assessments and renew aging, damaged or leaking underground infrastructure, including pipelines of all types and sizes. The Starline® Cured-In-Place-Lining (CIPL) technology is the only approved liner for natural gas pipelines and adds 100 years of new service life to the existing pipe while eliminating methane leaks and emissions. This innovative and green solution has been installed in over 1 million feet of gas mains in 20 states.

ABOUT THE AUTHOR:

Mario Carbone, Chief Operating Officer leads PPM's key projects and spearheads the testing of new technologies and robotics. He spent thirty-two years in design, maintenance and construction with Brooklyn Union Gas/KeySpan Energy and ten years as the senior manager for gas research and development with KeySpan Energy. Mario holds three gas pipeline industry patents for new technologies in gas pipeline purging, live gas polychlorinated biphenyls (PCBs) pipeline sampling, and live service pipeline transfer without interruption. In addition to his expertise in Starline® CIPL, engineering and managing field operations, Mario is versed in current regulations for corrosion and pipeline environmental procedures. His inventiveness to overcome challenges led PPM to win the Trenchless Technology Project of the Year multiple times.

Two of PPM's six Starline® cured-in-place-lining inversion drums for lining mains from 12 – 48 inches. "Kong" is on the left and "King Ghidorah" on the right.

EQUIPMENT ENGINEERED FOR CURED-IN-PLACE-LINING

PPM has invested heavily in developing a fleet of equipment that enables it to maximize productivity and sustainability. Starline Cured-in-Place Lining (CIPL) uses a process that inserts a liner that cures ambiently and adheres to the host pipe, adding 100 years to the life of the pipe.

40,000 cf dust collectors from Rapid Prep are ideal for cleaning large diameter pipelines. They save time and are highly efficient.

The 30-inch spin blaster is used for sandblasting. It can clean mains from 16 – 48 inches.

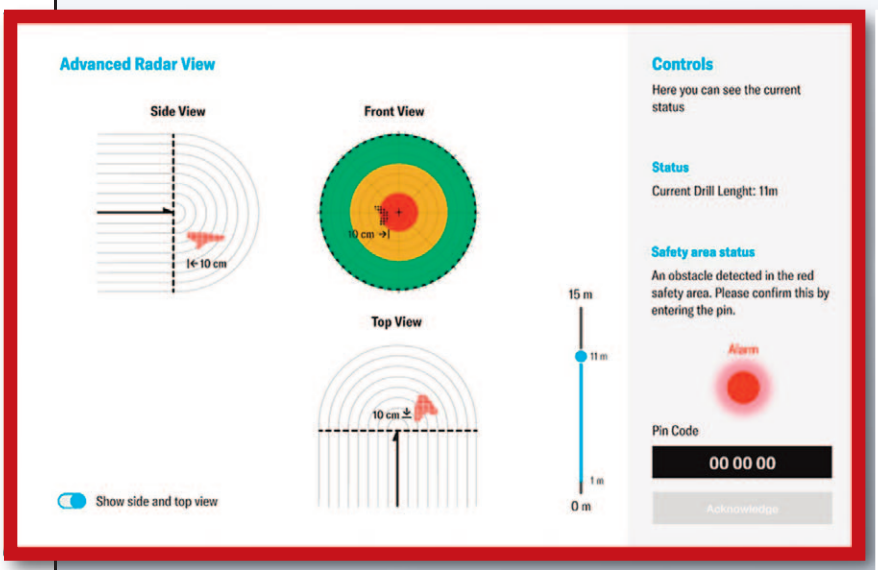
ARIES LETS CCTV robotic camera inspects mainlines and laterals prior to and after lining.

Preventing Damage from Horizontal Directional Drilling

Giving Sight to a Blind Technique

GTI ENERGY
solutions that transform

OTD
Operations Technology Development



The equipment incorporates "look ahead" technology based on radar incorporated into the drill head

With sponsorship from Operations Technology Development, NFP (OTD), GTI Energy is closely engaged with utilities and leading manufacturers to develop and commercialize minimally invasive technology to reduce third-party damage to underground utilities. The aim is to produce safe, cost-effective equipment that leads to faster installation and repairs, less traffic delays, significant time and cost savings, and fewer impacts on the environment.

One effort, a real-time ground-penetrating radar obstacle detection system called ORFEUS (Optimized Radar to Find Every Utility in the Street), is focused on preventing damage during horizontal directional drilling (HDD) to install underground pipes and cables. The equipment incorporates "look ahead" technology based on radar incorporated into the drill head to detect and warn the operator of any obstacles in the pathway, offering substantial benefits.

The system was developed in Europe and brought to the U.S. by OTD and GTI Energy for on-site testing to evaluate it for North American markets. Following successful outcomes, an agreement with European partners was signed. Pipeline and Hazardous Materials Safety Administration (PHMSA) is providing funding to enhance system functionality and move the technology toward commercialization. TRACTO, an HDD equipment manufacturer and parent company of TT-Technologies, will bring the technology to market in the U.S.

For more information contact:
Dennis Jarnecke, Senior R&D Director, Energy Delivery, GTI Energy
847-768-0943 | djarnecke@gti.energy

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THE 7 HABITS OF HIGHLY EFFECTIVE INSPECTORS & FIELD LEADERS

Powerful Lessons in Third Party Inspections

By: Dan Lorenz, P.E.,
Joe Knows Energy

10 years ago, my client told me "I don't trust any Third-Party inspector or Inspection Company, I simply don't trust that someone who I hardly know and hardly knows our culture will be High Performing and aligned with our needs."

This has led us at Joe Knows Energy on a journey to determine how we can predict High Performance, when selecting a candidate who fits a specific client's need. We have tested and evaluated over 40,000 candidates for front line leadership positions. This article is a summary of what we have figured out so far.

7 Habits of Highly Effective People, since it was first written in 1989 by Stephen R. Covey, has sold over 20 million copies worldwide. We taught this book back in the 90's to all levels of our excavating business, from laborers and operators to administration and executives. It was very impactful, and I am still getting calls from people who tell me how much a difference it has made in their lives. There is a whole new generation who has not had the benefit of these principled center leadership teachings.

In this article, we will provide the basics of these habits, modified for our world today and with a core focus on front line leaders. We will discuss this with a focus on your role as a "Front-Line Leader", however these habits are intended to be applied to all the roles in your life. When applied broadly across all your roles, it will allow you to achieve High Performance in your role as a front-line leader.

To read the *7 Habits of Highly Effective People* yourself, here's a link to order the book: The 7 Habits Of Highly Effective People (https://en.wikipedia.org/wiki/The_7_Habits_of_Highly_Effective_People) I am confident you will find the contents invaluable to yourself and your business.

Habit 1: Be Proactive

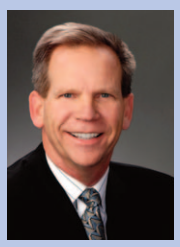
1 Recently, a friend and former employee called and said "You know Dan, I am dying. And I remembered the principle you taught me over 30 years ago. I need to be Proactive. The drug the doctors had me on was causing me to not eat. I fired the doctors and am now taking a more proactive approach to my treatment!".

This habit starts with how you see yourself, your personal vision. What is your identity? Many inspectors see themselves as cops, simply holding the contractor accountable to following the specifications. Are you simply a "project witness"?

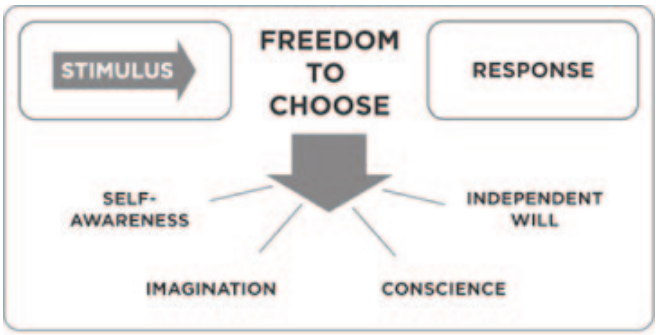
Our research suggests that those people who see themselves as a "Front-line Leader", capable, empowered and committed to helping the team executing the project at a high level is the first building block of success.

This takes a deep understanding of yourself and your fit for the front-line leadership role. **The #1 value that we see them have is a willingness to hold themselves and others accountable.** In this role, you are on an island, on a project, removed from the support of the rest of the company. Faced with changing conditions, weather, traffic, existing utilities, and all of the human factors.

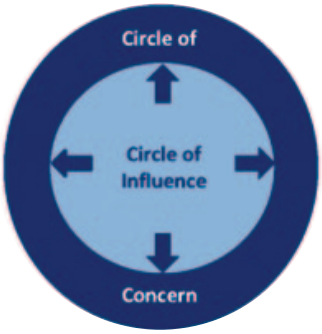
ABOUT THE AUTHOR



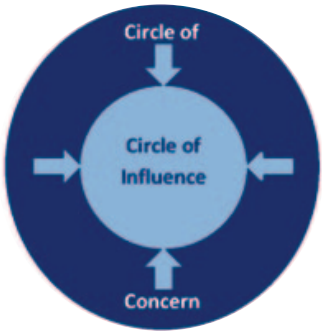
Dan Lorenz P.E., Founder and President of **Joe Knows** , has over 40 years leading construction, training, and inspection services companies. He is passionate about elevating safety and quality cultures with frontline professionals. Joe Knows Energy provides staffing, recruiting, and consulting services to the utility and energy industries. To find out more, visit their website: www.joeknowsenergy.com or contact Dan at 614-989-2228 or dan@joeknowsenergy.com.



PROACTIVE MODEL



Proactive Focus
Positive energy enlarges Circle of Influence



Reactive Focus
Negative energy reduces Circle of Influence

When holding yourself and others accountable, there are several principles to consider which we will briefly explore.

STIMULUS AND RESPONSE

Responsibility = response-ability, you are free to choose your response. Being self-aware of your strengths and blind spots makes you more capable of responding appropriately under pressure. Using your imagination to find a better way to respond based on the unique circumstance that you are faced with. For example, I know that I have a tendency to make too quick of decisions, and I know that I have very little time to make a decision, I empower the right person with the right information to make me aware of critical factors frequently .

PROACTIVE VS. REACTIVE MINDSET AND LANGUAGE

Believing that, in the split second before I respond, that I can coach myself to respond in a way that will be effective, versus the way I might instinctively respond. I can look for a 3rd alternative solution, I can control how I express my feelings, I can consider the other person's perspective, and I can choose to prioritize empathy and understanding, fostering a more constructive and harmonious interaction.

CIRCLE OF CONCERN AND INFLUENCE

The circle of concern helps me better understand what I should spend my time focusing on. Considering that I should limit what I am concerned about, what I spend my time trying to fix or influence, to those items that can influence. I shouldn't try to change a specification; I should try to influence the foreman to plan ahead.

REACTIVE LANGUAGE	PROACTIVE LANGUAGE
There's nothing I can do. That's just the way I am. He makes me so sad. They won't allow that. I have to do that. I can't I must, If only.	Let's look at our alternatives. I can choose a different approach. I control my own feelings. I can create an effective presentation. I will choose an appropriate response. I choose. I prefer. I will.

Habit 2: Begin with the end in mind

2

This habit is based on the principle of:
All things are created twice, mentally, and physically. Leadership is needed for the first creation and management for the second creation.

When leading and managing, it is important to do so with a Principle Centered approach. By centering our lives on correct principles, we create a solid foundation and effective habits.

Some of the principles include:

- We are loyal to the **truth**, and we are responsible to help record and be a source of the truth.
- The Platinum rule "**do onto others as they would want to be done to them.**" This goes beyond the Golden Rule of treating people as you want to be treated, challenging ourselves to customize the approach to dealing with people. An example of this is when we take the time to understand what the specific needs of this specific client, on this specific project, on this specific day with this specific set of people.
- When we all follow these **7 habits**, we all can achieve a level of **interdependence** that is extraordinary.

THE 7 HABITS OF HIGHLY EFFECTIVE INSPECTORS & FIELD LEADERS

	Urgent	Not urgent
Important	**Quadrant I** • Crisis • Pressing problems • Deadline driven projects	**Quadrant II** • Relationship building • Finding new opportunities • Long-term planning • Preventiative activities • Personal growth • Recreation
Not Important	**Quadrant III** • Interruptions • Emails, calls, meetings • Popular activities • Proximate, pressing matters	**Quadrant IV** • Trivia, busy work • Time wasters • Some calls and emails • Pleasant activities

Habit 3: Put first things first

Over the last 20 years, the Utility Industry has done a great job improving its safety culture. This is an example of the benefits of putting first things first. No longer is it acceptable to put production ahead of safety.

One visual tool that is helpful in remembering this habit is the **time management matrix**.

Quadrant II thinking, **taking the time to schedule the important but not urgent is critical**. In deciding what is important it is important **to remember the concept of balancing the Production P and the Production Capacity PC**.

An example of this taking the time to train effectively and define expectations is a PC activity that fuels production.

The other important lesson we have learned is that when seeking high performance, the priority of what we focus on is critical. It is **People, then Process and then Tools**.

Remember to strive to be **Effective with People and Efficient with things**. Too often we forget that **Gas is Easy and People are Hard**. We need to schedule time to invest in applying the Platinum rule with people. **With this, we build trust, which is the highest form of human motivation! We engage not only people's hands but their minds and their hearts!**

There are **6 ways to build trust**, through filling an **emotional Bank Account**:

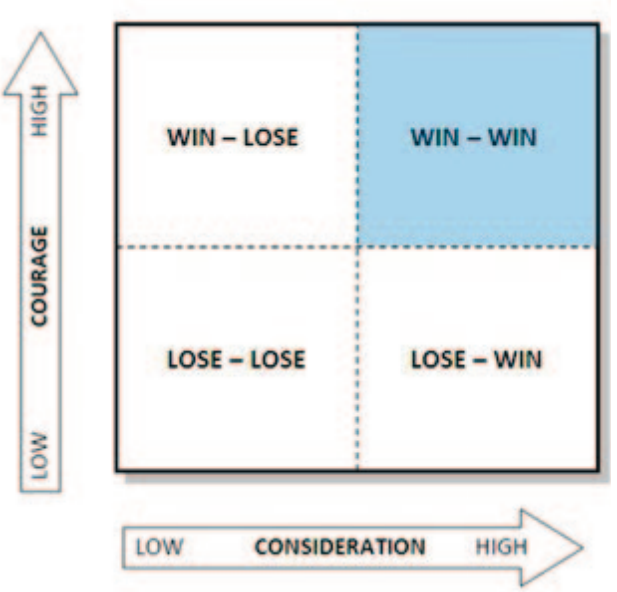
- Understand the individual deeply, as we discussed with the Platinum Rule.
- Attending to the little things that are important to them.
- Keeping commitments
- Clarifying expectations
- Not speaking poorly of those not present
- Apologize sincerely when you make a withdrawal.

Habit 4: Think win-win

To understand Win-Win we can look at the Courage and Consideration diagram.

This visual shows that it requires a high level of Courage and Consideration. We have found that it is critical to have an Abundance Mentality to have a Win-Win mindset. **An abundance mindset requires that we are interacting with people who believe that there is the possibility, that when we all work together, the pie we are seeking a part of will expand.**

A practical example of this is an inspector understanding the foreman's perspective. Likely the foreman not only is required to meet the safety, quality, and schedule for the project, but they must also meet and exceed the production and client satisfaction performance metrics. These pressures are real and often caused by conflicting priorities. Those front-line leaders who know how to assist each other with these challenges are likely to be Highly Effective.



Habit 5: Seek first to understand then be understood

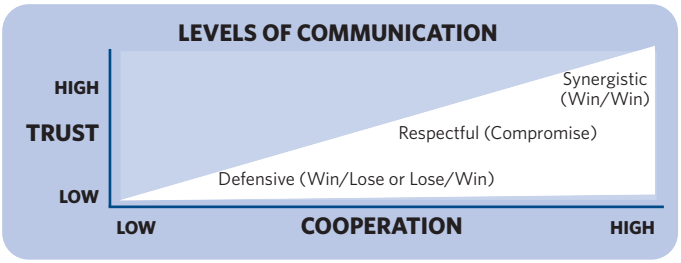
5

One of the indicators that you are a professional is your ability to Diagnose before you prescribe. This is often the result of the front-line leader's ability to master the 5th level of listening, empathetic, listening with the intent to understand. This involves getting inside their frame of reference that was outlined in Habit 2. Once we understand their frame of reference and their issues, we seek to be understood,

We have come to understand that highly effective field leaders are really "change agents" The equation reflecting our understanding taping into their motivations concerns to lead them through change. The equation that we believe leads to effective change is the following:

(A + A) x A = Change

- **Acknowledgement** - reflects their concerns and challenges.
- **Ambition** - helps them see the benefits for them when they act.
- **Affect** - encourages them to act by getting them excited about the results they could produce.



Habit 6: Synergize

6

The essence of synergy is to value differences, to respect them, to build on strengths, and to compensate for blind spots.

Key is to have authentic understanding of others on the team and to have alignment of purpose and responsibilities.

We utilize two tools to help us build synergy.

- 3-part assessment, understanding **how we work**, **what we value** and **how we are gifted**. We share this info with teammates gaining not only an understanding of each other but also how members compliment each other creating a complimentary team.
- **Mission, Vision, Core Values** – building these together allows us to be aligned in what is important to each other.

In the above levels of communication chart, note that the key factors are cooperation and trust.

One example of synergy is when the two front-line field leaders, the inspector and the foreman, work together to fuel safety, quality and efficiencies. Maybe the inspector uses his many years of experience to anticipate and avoid costly issues and delays.

Habit 7: Sharpen the saw — continuous renewal mindset

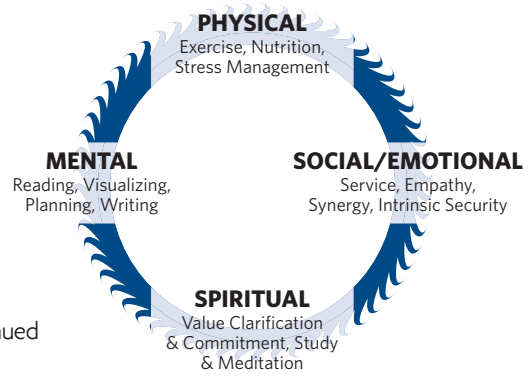
7

Habit 7 is all about the process of renewal and continuing to sharpen our practices of the 7 Habits... There are four dimensions that support the idea of a continuous renewal mindset.

- **Physical Dimension** – exercise, nutrition, stress management
- **Spiritual Dimension** – value clarification and commitment, study, self-awareness
- **Mental Dimension** – reading, planning, writing.
- **Social/Emotional Dimension** – service, empathy, team building

Personal daily habits and private victories spent in renewal of the four dimensions is key to fueling this habit. Consistent renewal sets us on an upward spiral for continued growth and change.

An Example of creative training is a program we developed to teach these habits. We decided to produce videos discussing all the key elements of this book. We have all our front-line leaders listen to it and then a week later, as a team, discuss how we all applied these lessons and what we learned.



Note: All Habits and Diagrams discussed in this article have been referenced from the 30th Edition version of the **7 Habits of Highly Effective People**, which is linked above in the opening paragraph.

Enhanced Locating Technologies for Underground Pipelines with Better Accuracy

By: Kaushik Biswas PhD, GTI Energy

One leading cause of damage to underground pipelines is directly related to locating issues. Due to depth of cover, type of ground cover, pipe material, pipe size, soil moisture, and proper equipment operations, it is difficult to accurately locate underground gas infrastructure. A California Energy Commission (CEC) and Operations Technology Development (OTD)-funded project developed and demonstrated an enhanced pipeline locating technology with improved locating accuracy compared to current practices and technologies. The project team primarily consisted of GTI Energy (GTI), White River Technologies (WRT), and Trident Engineering.

The technology of interest is WRT's APEX technology, which is shown in Figure 1. The APEX is an advanced electromagnetic induction (EMI) system, originally designed for identification and characterization of buried unexploded ordnance (UXO) and other munitions and explosives of concern. The APEX contains a sensor head comprising of an array of induction coil transmitters that generate multi-directional, low-frequency magnetic fields below the ground surface. When the transmitter field impinges upon a metal object, such as a UXO or a metallic pipeline, it induces eddy currents on the surface of the object. These eddy currents rapidly decay and generate a time-varying secondary magnetic field that is sensed by the APEX receivers that measure the vector components of this decaying field. As the transmitter fields impinge on the pipe in different directions, these responses can be deconstructed to represent the polarizations of the pipe principal axes (i.e., one large longitudinal and two smaller lateral), as shown in Figure 2. A key benefit of this 3D EMI approach is that the deconstruction of the pipe's response through geophysical inversion of the data produces accurate information about the pipe's 3D location and its diameter.

Figure 1. Operation of WRT APEX for detecting an underground transmission pipeline survey during a pilot demonstration in Wheeler Ridge, CA

Locating issues are a leading cause of damage to underground pipelines.

This article is a follow-up to an article in *Trenchless for Gas Infrastructure* 2022 (pp 49–50) that briefly described the baseline evaluation of the APEX in a controlled test bed, called the "pipe farm" at GTI's facilities in Des Plaines, IL. The pipe farm was designed to contain a brand-new underground pipe system with known 3D spatial coordinates. GTI and Trident Engineering performed a baseline evaluation of three existing, non-intrusive commercial off-the-shelf electromagnetic sensors to map the buried pipelines. Next, the APEX technology was also used to map the buried pipelines at the pipe farm.

Simultaneously, WRT implemented hardware and software improvements to optimize the performance of the APEX technology. The hardware improvements included increasing sensitivity of the receivers to increase the signal to noise ratio and increasing the transmitter field strength to induce a stronger response at greater depths. The software improvements focused on overcoming the challenges associated with mapping locations that contain large amounts of underground metal debris. When processing the data to extract pipe location parameters, these clutter items can produce enough signal to skew the results of the pipe estimates and reduce location accuracy. The first software modification was data aggregation to increase the number of measurements from a single survey transect included in the data inversion to better constrain inversion of pipe parameters in cluttered environments, versus a single sample of APEX data acquired over the pipe at different locations along the pipeline. The aggregate approach combines several measurements acquired during transit across the pipe to provide a

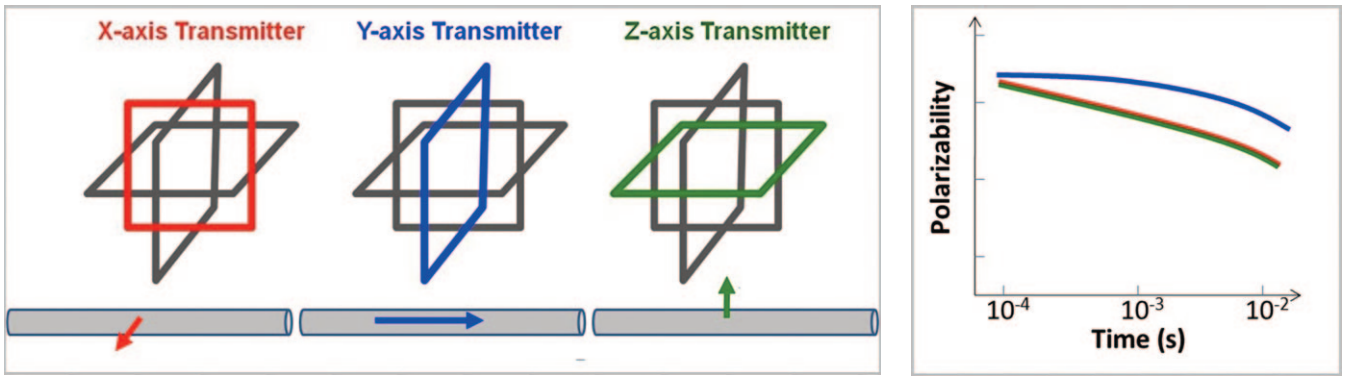


Figure 2. LEFT: Each Transmitter Creates a Unique Polarization of the Pipe that is Determined by the Direction of the Magnetic Field Impinging on the Pipe. RIGHT: Overall Response of the Pipe to the Transmitters can be Deconstructed into Principal Components Described by a Set of Three Time-Dependent Principal Electromagnetic Polarizabilities

broader sampling of the pipe response at each location along the pipeline. Another software modification was to use a multi-target inversion by implementing a multi-source model that can account for several objects, including clutter and pipes, in the inversion of the aggregated data. The multi-target, aggregate method was expected to resolve all objects clearly to provide accurate estimates of their depth and polarizability signatures.

Figure 3 shows the depth estimates of an 8 inch buried pipeline at the pipe farm from three commercially available electromagnetic (EM) tools and the WRT APEX. The APEX depth estimates are based on the results using the original software (WRT APEX) and using the improved algorithms following software optimization (WRT APEX Opt.). For comparison, the actual depth of the center of the pipeline are also shown. It is observed that, with the software optimization, the APEX depth estimates are the most accurate. Table 1 shows the average depth errors of the three commercial EM tools and the APEX from three different pipelines at the pipe farm. The depth errors of the optimized APEX were much lower than the original APEX estimates and the three commercial EM tools.

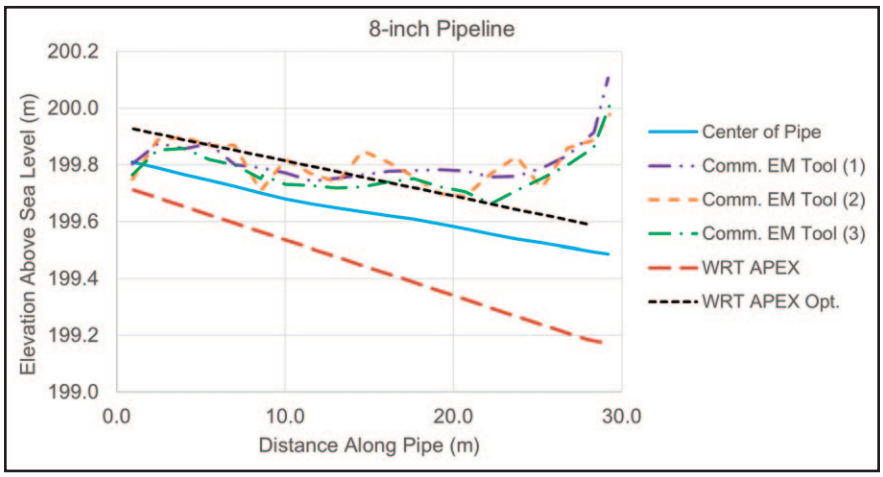


Figure 3. Comparison of depth estimates from different locator tools with the actual pipe depth

Table 1. Average pipe location error for the commercial locator technologies (average of three commercial technologies tested) and the APEX.

Pipe Run	Commercial Locator Avg. Offset (m)	Original APEX Avg. Offset (m)	Optimized APEX Avg. Offset (m)
2″	0.137	0.246	0.135
4″	0.186	0.143	0.110
8″	0.169	0.198	0.112

Following the test of the APEX at GTI's pipe farm, pilot field demonstrations of the APEX were performed at multiple sites within Southern California Gas Company (SoCalGas) service territories. Locations with underground transmission lines were considered to obtain a diverse mix of ground covering materials while maintaining an appropriate depth range suitable for the APEX solution. The following four sites were selected for the pilot demonstrations:

1. **Pico Rivera, CA** – This site contained a variety of pipeline segments at known underground locations that were installed for training purposes. Two locations were selected that included buried 2-inch and 12-inch diameter lines.
2. **Wheeler Ridge, CA** – This site contained several transmission lines passing through an agricultural zone, with pipe diameters exceeding 30 inches in diameter.
3. **Camarillo, CA** – This site contained a transmission line buried along a roadway passing through a mix of suburban and agricultural zones.
4. **Somis, CA** – This site contained a transmission line buried along a roadway passing through an agricultural zone.

These sites were also surveyed using one commercial EM tool. Furthermore, a

Figure 4. APEX surveys near a drainage ditch and along a roadway

subset of these locations was selected for ground truth activities that included pothole exposure of the pipelines. Two transmission lines at Wheeler Ridge and the 12-inch pipe at Pico Rivera were selected as locations for potholing, due to ease of access. Due to the accessibility issues with the two roadside surveys, the Camarillo and Somis locations were not selected for ground truthing.

Based on the limited survey results from the two sites where potholing was performed, the APEX system showed 30-73 percent reduction in horizontal errors and 80–97 percent reduction in vertical errors compared to the commercial EM tool.

One challenge encountered during the APEX demonstration was access restrictions to the pipeline areas to be surveyed. The Camarillo and Somis pipelines were located along roadsides and access to the presumed pipeline area was somewhat restricted by potential traffic interference. The restricted access issue was further compounded by the presence of drainage ditches and vegetation and the APEX survey lines were acquired in directions compatible with the available survey area (Figure 4). Comparison with the commercial EM locator indicated that the APEX survey was not conducted over the pipeline.

To enable APEX surveys over challenging terrains such as ditches, trenches, swales, and steep or rocky terrain, a hand-carry attachment to the cart can be utilized. This attachment enables two operators to carry and maneuver the sensor in difficult ground conditions by offering a two-wheeled (chariot) mode as well as a hand-carry mode (no wheels), as shown in Figure 5.

Figure 5. APEX operation in the chariot mode (left) and hand-carry mode (right) using the hand-carry attachment

ABOUT THE AUTHOR:

Kaushik Biswas, PhD has 15+ years of experience managing multi-partner projects funded by DOE, DOD ESTCP, California Energy Commission and the industry, with responsibilities including technical leadership, interactions with sponsors, and financial and technical progress reporting. His communication and outreach skills are demonstrated via numerous journal publications (650+ citations and h-index of 14 per Google Scholar), conference presentations and presentations to sponsors and in stakeholder meetings.

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Advancing Safety in Natural Gas Operations

The Crucial Role of Innovative Purging Devices

By: Joshua Ott, SafePurge

Safety stands as the cornerstone of success in the realm of natural gas operations. As professionals entrusted with the responsibility of safeguarding both personnel and assets, we continually seek ways to enhance safety measures and mitigate risks. Among the multitude of procedures critical to safe gas operations, purging stands out as a pivotal yet often misunderstood process. In this comprehensive exploration, we delve into the multifaceted nature of purging operations, underscore the necessity for innovative purging devices, and advocate for a cultural shift towards enhanced safety protocols, equipment, and worker qualifications.

Understanding the Complexity of Purging Operations

Purging, in the context of the natural gas industry, encompasses the removal of unwanted gasses from pipelines, equipment, and/or confined spaces. The objectives of purging can vary significantly depending on the operation. In some scenarios, the goal is to achieve 0 percent gas concentration, effectively eliminating all traces of hazardous substances. Conversely, in other instances, purging aims to achieve 100 percent gas concentration, ensuring the integrity and effectiveness of gas systems. Another form of purging in the natural gas world is the process of introducing nitrogen, or another inert gas, to deplete oxygen levels inside a system. The goal here is to alleviate the combustible gas/oxygen mixture. The distinction between these objectives highlights the need for precise execution and adherence to company-specific standard operating procedures (SOPs). An additive solution to that could be a National standard for purging.

Navigating Unique Challenges

Executing purging operations presents distinct challenges, particularly in adhering to SOPs. Each company establishes its own set of protocols governing purging procedures, outlining steps to be followed, safety precautions to be taken, and equipment to be used. However, ensuring strict compliance with these procedures in the field can be challenging. Non-standardized equipment causes workers to improvise with what is available at hand and factors such as time constraints, operational pressures, and human error can all contribute to deviations from established protocols, heightening the risk of accidents and incidents. For example, a crew that normally just uses a pipe to purge from a meter set is tasked to purge a new house line and can't seem to find their "pipe", are generally going to shortcut and just purge right from the meter to get the job done for the day.

Addressing Root Causes of Incidents

Costly incidents, including explosions, fires, leaks, and environmental damage, occur annually due to improper purging practices. These incidents are often attributable to three major risk factors: human error, inexperience, and complacency. Human error, stemming from the lack of training and non-standardized equipment across different facilities and locations, can lead to critical mistakes during purging operations. Inexperience, particularly among newly trained personnel, may result in inadequate understanding of procedures or equipment operation. Complacency, perhaps the most insidious of the three, occurs when individuals become accustomed to routine tasks and overlook potential hazards. Performing a task the "old way", although it may feel comfortable, can easily cause compliance issues with new equipment and standard operating procedures that are currently in place. Addressing these risk factors is paramount to preventing incidents and ensuring the safety of personnel and assets. In addition, Learning from industry associations and peer companies can help identify root causes of purging incidents even if you have not encountered them within your own organization.

The Key Factors of Innovative Purging Devices

Innovative purging devices offer a solution to the challenges inherent in purging operations. Each operating gas company has it's own unique standard operating procedures, but industry wide, there are a few common factors shared among them all. "Above ground purge height is one of those common factors, and is the one most often ignored, especially when working in a ditch or excavation. The Purge distance from buildings is another important consideration to protect from gas accumulation under overhangs and into soffits. The addition of testing ports to reach 100 percent gas, grounding rods, standardized sizing to fit your system and

Executing purging operations presents distinct challenges

the inclusion of pressure gauges have become common practice. Even special case scenarios should be considered, like older buildings with meters inside the building.

By providing a reliable means to work within the standard operating procedures, while minimizing risks, innovative purging devices play a crucial role in safeguarding personnel and assets. A lack of standardized purging devices available for purchase, causes many companies to use what equipment they have available to purge their systems to company standards. Additionally, without manufactured and insured products, many companies can open themselves up to litigation if an incident occurs. These are just some examples of key factors that we have seen in common across different gas companies that have designed purging equipment themselves.

The Necessity of Standardized Tooling

In addition to innovative purging devices, standardized tooling is essential for ensuring consistency and safety in purging operations. Standardizing purging equipment will help bridge the gap between the company procedures/standards and real world field application. Standardized tooling encompasses equipment, procedures, and training protocols that adhere to industry best practices, such as maintaining a safe distance from an overhang or soffit, and regulatory requirements. By standardizing tooling across operations, companies can mitigate the risk of human error, inexperience, and complacency while facilitating compliance with company-specific Standard Operating Procedures.

Advocating for Cultural Change

To truly advance safety in natural gas purging operations, we must advocate for a cultural shift towards enhanced safety protocols, equipment, and worker qualifications. This entails fostering a culture of accountability, where safety is prioritized at every level of the organization. It involves investing in ongoing training and development programs to ensure that personnel are equipped with the knowledge and skills necessary to perform purging operations safely and effectively. Purging operations require continuous evaluation and improvement of SOPs and equipment to reflect the latest advancements in technology and industry best practices. Additionally, purging is usually thought of as the "start" or the "end" of the job, and all of the dangerous work happens in between. Various industry purging incidents have shown that safety entails the entire job, not just the parts of the job that we think of as dangerous.

Above: Air mover in use with gate valve

Right: Purge stand in use

Promoting Transparency and Accountability

As professionals in the natural gas industry, it is incumbent upon us to promote transparency and accountability in our operations. This includes regularly reviewing company-specific SOPs for purging operations and comparing them to actual practices in the field. By identifying discrepancies and addressing areas for improvement, we can enhance safety standards and prevent costly incidents. Organizations are being proactive, working with gas companies to address the discrepancies in purging standards and procedures. With collaboration and more standardized tooling, we can help to mitigate purging risks. Let us commit ourselves to fostering a culture of safety that prioritizes the well-being of our personnel and the integrity of our operations.

The need for innovative purging devices, standardized procedures, and a cultural shift towards enhanced safety protocols in the natural gas industry is undeniable. By recognizing the complexities of purging operations, addressing root causes of incidents, and advocating for continuous improvement, we can mitigate risks, prevent accidents, and ultimately, save lives. Let us remain vigilant in our commitment to safety, ensuring the continued success and sustainability of our industry.

Still ensuring that workers return home safely – this time in the context of gas operations

From Route Clearance in Iraq to Gas Safety:

The Inspiring Journey of Joshua Ott and SafePurge

In the busy city streets of Baghdad, amidst the chaos of conflict, Joshua Ott embarked on a mission of paramount importance: route clearance. Deployed in 2004, Ott's duty was clear - prevent people from blowing up. Using specialized vehicles known as the "Buffalo" and "Husky," he and his team traversed trash strewn streets, detecting and neutralizing roadside bombs. Today, Ott continues his mission to safeguard lives, albeit in a different arena. As the founder of a company developing patented purging devices for the natural gas industry, he's revolutionizing safety measures and ensuring that workers return home safely – this time in the context of gas operations.

A Soldier's Tale

Deployed to Iraq with C Company 612th Engineer Battalion during a tumultuous period, Ott's role was anything but ordinary. Operating from the confines of heavily armored mine clearance vehicles called the Buffalo and the Husky, he and his team meticulously scanned roadsides for improvised explosive devices (IEDs) – the silent killers of war zones. Their mission was not just about clearing routes; it was about protecting lives and preventing tragedy. Ott received ribbons to include Global War on Terrorism, Iraq Campaign, National Defense Service, and Army Commendation Medals, as well as a Combat Action Badge and a Purple Heart.

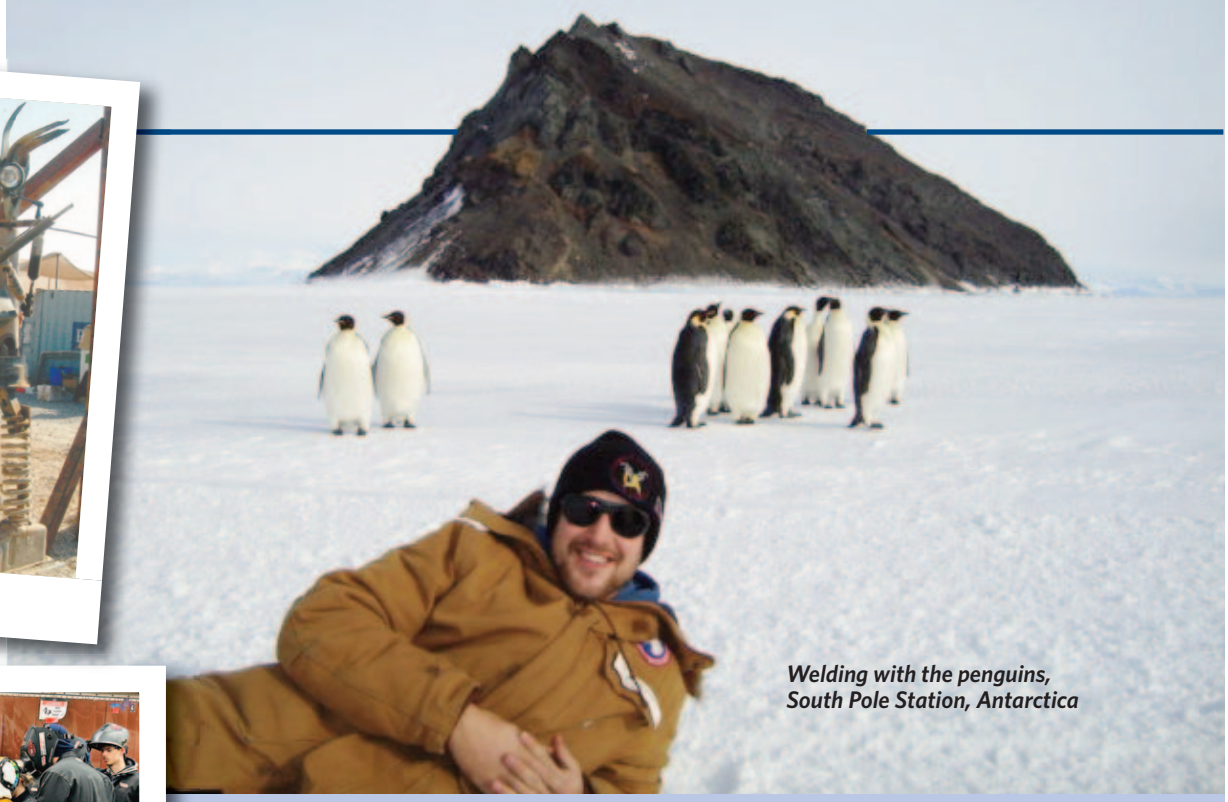
During his deployment, Ott kept his welding skills sharp by helping to custom up-armor a humvee for a bomb-sniffing K9 team. He also built a custom statue out of blown up vehicle parts. This "statue soldier", later dubbed Sgt. Junk by in-theater soldiers, stood guard over C Company's motor pool. Years later, Ott was informed that the statue was brought to the States and now resides in a private war museum in Portsmouth Ohio.

Civilian Career

After some training at various trade schools and community colleges out of high school, Ott became a welder, pipefitter, and pipeliner. He began his welding as a freight car repairman for a major Railroad, then welded in chemical factories, power generation plants, and various manufacturing facilities. He later began welding on pipelines, mainly in the natural gas industry. Ott has also participated in some unique opportunities in his career, like welding on the Alaskan pipeline and welding at the South Pole Station, Antarctica.

High School Initiative

In the past three years, Ott has focused his efforts to bring back trades to our schools. He started a program going into local classrooms to show students an introduction to welding. The intent is to "spark" interest into alternative career opportunities where college is not a necessity. He is not completely partial to just welding, either. He encourages students to look into other trades, such as electricians, plumbers, and operators. Ott says, "There are a lot of



Welding with the penguins, South Pole Station, Antarctica

Joshua has focused his efforts to bring back trades to our schools

students out there who don't belong in the college route. I feel that I have a responsibility to let them know what options are out there for them".

Innovation in Gas Safety

After being involved in multiple incidents in his natural gas pipeline career, and knowing of multiple other related incidents industry wide, he recognized the need for enhanced safety measures in purging, and Ott founded his own company. Originally called CrazeWeld, Ott later rebranded to SafePurge to better describe the nature of his tooling. Driven by a mission to prevent accidents and save lives, he applied his knowledge of detecting threats in the battlefield to the realm of gas operations. The result? Patented purging devices that are revolutionizing safety standards in the industry.

Pioneering Purging Devices

Ott's patented devices are a testament to innovation and ingenuity. Designed to either rid pipelines of gas or to achieve 100% gas in a pipeline system, while covering and abiding by company specific standards and procedures. Ott's continued drive for safety and innovation has led him to develop new specialized SafePurge designs to meet company specific standards and industry best practices. Some of those SOPs consist of "above ground purge height", "purge stand size requirements", and "testing port accessibility". Ott's purging devices minimize the risk of explosions or gas leaks, safeguarding both personnel and assets.

Impact and Recognition

Ott's contributions to safety in the natural gas industry have not gone unnoticed. His innovative devices have garnered acclaim for their effectiveness and reliability, earning the trust of industry professionals worldwide. SafePurge now has tooling "coast to coast", into Canada, and this year will be pushing into Europe, Australia, and New Zealand. With each installation, Ott's company reinforces its commitment to protecting lives and assets, leaving a lasting impact on the industry.

A Legacy of Safety

In a world where safety is paramount, Joshua Ott stands as a beacon of hope, reminding us that with the right tools and determination, we can prevent people from blowing up – whether it's on the battlefield or in the gas fields.

ABOUT THE AUTHOR:

Joshua Ott's journey from the battlefield to the gas fields exemplifies the transformative power of dedication, innovation, and a steadfast commitment to safety. Through his ingenuity and determination, Ott continues to make strides in safeguarding lives and preventing accidents, leaving a legacy that resonates far beyond the confines of the natural gas industry.

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