TRENCHLESS

FOR GAS INFRASTRUCTURE

FALL 2023

APRIL 14-18 | PROVIDENCE, RI

NASTT NO-DIG SHOW 2024

Industry Collaboration & Partnerships:

NASTT 2024 NO-DIG SHOW PREVIEW

April 14-18, 2024 Providence RI

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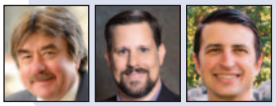

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TRENCHLESS TECHNOLOGY PERSPECTIVE

Industry Partnerships are the Path towards a Brighter Greener Future

George Ragula, RagulaTech Inc.

Welcome to the sixth edition of *Trenchless for Gas Infrastructure* and the inaugural second magazine published this year. The twice yearly format, with Spring and Fall editions is being launched by NASTT-NE in response to increased demand and interest for information on the operating envelope, cost savings, environmental and social benefits available through the use of various trenchless technology applications. Many times, challenging projects can only be performed cost effectively using state-of-the-art trenchless processes.

Trenchless technology offers the best and most comprehensive toolbox of new installation, renewal and rehabilitation techniques for gas distribution infrastructure. Together the various applications of trenchless technology comprise the fastest growing sector of the construction industry worldwide. With good reasons.

Gas leaks contribute considerably to greenhouse gas emissions so pipeline repair, replacement, renewal and rehabilitation techniques play a crucial role in reducing these emissions. Trenchless applications should be at the forefront when it comes to discussions on leak-proofing gas pipelines, while reducing GHG emissions. Trenchless provides innovative and cutting-edge approaches to repair leaks in the gas distribution system while preparing for the dawning hydrogen economy. In fact, intensive testing on pipe lining products for compatibility with hydrogen intermixed into the gas stream is already underway.

Notably, the NE region is well known for severe pavement moratoriums and costly surface restoration requirements/specifications within various jurisdictions. With projects utilizing trenchless applications completed in less time with less equipment, site restoration costs are dramatically reduced, thereby allowing a greater proportion of the project budget to be spent on actual pipe replacement/repair. More bang for the buck! Additionally, with the social and environmental costs associated with open cut excavation being eliminated, the impact of necessary gas system repairs and infrastructure upgrades on nearby residents, businesses and communities are significantly alleviated using trenchless methods.

The time has come for trenchless technology to be at the forefront when considering gas construction projects. Trenchless applications will be highlighted next April 14 – 18 at the NASTT No-Dig Show in Providence RI. With a preponderance of legacy cast iron and steel pipe infrastructure situated across the northeast– the densest concentration of gas infrastructure in North America – it is more than "fitting" that the premier Trenchless Technology educational and networking event in North America will be hosted in the northeast region for the first time.

It is well-known that the Northeast has the most congested subsurface infrastructure of any region in North America, so it is a "can't miss" opportunity for gas industry construction and operations decision-makers to consider taking full advantage of the beneficial convergence of interest offered by the 2024 NASTT No-Dig Show in Providence.

You get out of it, what you put into it!

Both the Northeast Gas Distribution Council (NEGDC) and Northeast Gas Association (NGA) have taken an active role in promoting and supporting this unique event because these organizations know it will equip the gas industry with information necessary to achieve aggressive GHG reduction targets, and meet every regulatory and legislative challenge head on. Recently, the NEGDC worked closely with NASTT in redeveloping the new and improved HDD Good Practices Course, which will be introduced as a centerpiece of this event (see pg 9). Earlier this year, the American Gas Association (AGA) and NASTT jointly hosted a two and half day workshop in Atlanta which showed the importance of delivering high level practical information to the gas industry on the numerous benefits of utilizing trenchless construction methods.

Industry collaboration and partnerships like these are paving the way for a brighter greener future for North America through the use of trenchless technology. These organizations share a common goal of achieving ever greater quality and efficiency in construction techniques. All the stars are aligning for this great event, a one of a kind networking opportunity which promises to be a unique gathering of the Northeast infrastructure community remembered for many years to come! Be sure to spend the day prior to the HDD course exploring the vast tradeshow exhibition, largest in the world and the most awesome display of underground infrastructure technology found anywhere. Immerse yourself in the wealth of information, networking and sheer fun at the 2024 NASTT No-Dig Show in Providence! As always true, you get out of it, what you put into it!

George Ragula

RagulaTech Inc.,
NASTT Hall of Fame Member

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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, 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 are set to be rolled out in the coming months regarding horizontal direction drilling (HDD) and cured in place pipe (CIPP) methods. 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 the NASTT 2024 No-Dig Show being held in Providence, RI, April 14-18. The city of Providence is a perfect location for our industry to come together in the northeast region to celebrate and educate with the theme, Green Above, Green Below. It is important that our industry is a steward of our natural resources, and we welcome the opportunity to provide a forum to 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 and consider attending one of our two updated Good Practices Courses on HDD or CIPP. Registration options are available for full conference attendance, one-day attendance, exhibit hall passes, and/or training courses at the end of the show. Feel free to create an attendance package that best meets your goals and preferences. Learn more about the options at www.nastt.org/no-dig-show.

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

Industry Exhibits

Networking Events

Educational Sessions

3 Reasons the Gas Industry Should Attend the NASTT 2024 No-Dig Show

APRIL 14-18 | PROVIDENCE, RI

NO-DIG SHOW 2024

Join Us in Providence!

The NASTT No-Dig Show is the largest trenchless technology conference in the world, where professionals attend to learn new techniques that will save money and improve infrastructure. This show offers topic tracks over the course of three days with peer-reviewed, non-commercial presentations, including case studies detailing environmentally friendly trenchless solutions and cost-saving opportunities for utilities and municipalities.

NASTT's GOOD PRACTICES HDD EST. 2003

NASTT's HDD Good Practices Course

NEW! This course has been updated and revised to include the latest research and industry developments.

Course Dates: April 17-18
Regular Course Rate: $450
Public Utility & Municipal Rate: $300
CEUs are provided for course attendance

Gas Industry Technical Track Sessions

Register as a Full-Conference Attendee and gain access to over 130 Technical Sessions including an all Gas Industry-related track.

No-Dig Show Exhibit Hall Pass

Visit the Exhibit Hall and network with over 200 organizations ready to help solve your infrastructure challenges. Exhibit Hall is open Mon-Wed with access all three days.

Exhibits Only Rate: $125

GREEN ABOVE.
GREEN BELOW.

Registration opens in December!
Visit nodigshow.com for more details.

WELCOME MESSAGE FROM NASTT-NE CHAIR

Eric G. Schuler, P.E. NASTT-NE Chair

Welcome to the 6th edition of the NASTT Northeast Regional Chapter's Trenchless for Gas Infrastructure Journal! I hope that you find the content in this publication to be forward-thinking and practical. The NASTT-NE Chapter thanks the continued support of sponsor's for this crucial publication highlighting the gas industry.

2024 will bring in leadership changes to the Chapter, as we stay committed to changing Executive Committee and Board Roles/Responsibilities on a two-year cycle. I will be phasing out into a "Past Chair" role, with the current Vice Chair, Treasurer, and Secretary being elevated. We will be welcoming Tom Loyer into the Executive Committee as the Secretary starting in 2024.

We have a need for volunteers, especially from the gas industry as we look to expand educational offerings for that sector of the market going forward. This Regional Chapter is always evolving, growing, and learning from our past experiences relating to both Journal content and annual conference results.

We are a volunteer-run organization and it takes a strong commitment from a select group within this industry to keep things moving forward as we strive to provide sound educational and networking experiences for our 7-state region.

We have a need for volunteers, especially from the gas industry

NASTT is hosting the annual No-Dig Conference in Providence, RI for 2024. This is shaping up to be a great event and early numbers for vendor/sponsor participation are remarkable. In July I was fortunate to be able to get a sneak peak of the event venue through my participation on the No-Dig 2024 Planning Committee.

Downtown Providence is truly a beautiful area and the venue is top-notch for this event. This is the first No-Dig Conference in the Northeast Region, so we are hoping to draw new attendees from the large municipal centers that are just a short drive from Providence (NYC, Boston, etc).

If you have never attended one of these National events, I highly recommend you attend this one. You will not be disappointed with the networking and educational opportunities that are offered.

Thank you for the opportunity to write another Welcome Message for you. This will be my last one as I will be completing my term as Chair at the conclusion of 2023. I look forward to the continued Northeast Chapter support of this publication and for the continued evolution of this publication. I hope to see some of you at No-Dig 2024! Enjoy the day!

Eric G. Schuler, P.E.

Chair, NASTT-NE

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NORTH AMERICAN SOCIETY FOR TRENCHLESS TECHNOLOGY

educate • train • research • publish

Northeast Gas Distribution Council

Sponsored By NASTT & Northeast Gas Distribution Council (NEGDC)

New HDD Good Practices Course

Wednesday April 17 – Thursday April 18, 2024

Updated and revised to include the latest research and technical developments, the new NASTT Horizontal Directional Drilling (HDD) Good Practices Guidelines Course presents a unique opportunity to learn the key elements of a successful HDD project from planning to job completion. Our instructors are HDD specialists in the field who can help answer your questions and concerns even if they are not outlined in the course agenda.

This course builds upon the successful 2 ½ day joint AGA/NASTT Trenchless Technology Workshop in Atlanta which focused on case studies demonstrating cutting edge HDD technologies for the gas industry. The new course to be introduced at the NASTT 2024 No-Dig Show in Providence RI was developed in conjunction with the Northeast Gas Distribution Council (NEGDC), and is ideally suited for gas operations and construction executives, contractors and engineers.

COURSE AGENDA OVERVIEW

- HDD Applications & Processes
- HDD Equipment & Materials
- Steering, Locating & Monitoring
- HDD Design
- Hydrofracture Calculations
- Settlement Calculations
- Borepath Planning
- HDD Tooling
- Drilling Fluids Overview
- HDD Construction Considerations

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NO-DIG SHOW 2024

COURSE CREDITS

NASTT offers Continuing Education Unit (CEU) certificates for educational sessions at the NASTT 2024 No-Dig Show. 8 PDHs/.8 CEUs are available for the new HDD Good Practices Course.

ACCOMMODATIONS

There are a variety of hotels in Providence if you need overnight accommodations. Here are the official conference hotels located nearby the Rhode Island Convention Center. Discounted rates are available for the NASTT 2024 No-Dig Show:

Omni Providence Hotel	**Graduate Providence**	**Hilton Providence**	**Courtyard by Marriot**
1 West Exchange Street	11 Dorrance Street	21 Atwells Avenue	32 Exchange Terrace
401-598-8000	401-421-0700	401-831-3900	401-272-1191

REGISTRATION

Cost is $450, with $300 reduced rate for Public Utility and Municipal registrants. For further details and registration visit:

www.nodigshow.com

NASTT 2024 No Dig Show Preview

Welcoming North America's Underground Infrastructure Community to the Populous Northeast!

The NASTT-NE Chapter looks forward to hosting the 2024 No-Dig Show in Providence, Rhode Island April 15-17. Hosting North America's premier trenchless educational and networking event in the Northeast for the first time, presents a golden opportunity for the Northeast Trenchless community to showcase the progress it has made in utilizing trenchless applications as the preferred method for underground infrastructure construction in the Northeast.

Within an easy day's drive from most cities in the populous northeast – Providence is just a few hours' drive from Portland ME, Philadelphia, PA, NY, NJ, VT and CT – the 2024 NASTT No-Dig Show promises to draw significant attention from top infrastructure decision-makers across the Northeast including municipal authorities, utilities, engineers, contractors, suppliers and policy-makers.

The 2024 NASTT No Dig Show motto "Green Above, Green Below" exemplifies the trenchless industry's position as an important steward of our environment and natural resources, utilizing approaches that have significant environmental and social benefits. Trenchless Technology is at the forefront of ongoing efforts to reduce GHG emissions.

As our planning kicks into high gear, check the website www.nodigshow.com for updates and further information. This is a one of a kind networking opportunity, and promises to be a unique gathering of the Northeast infrastructure community remembered for many years to come!

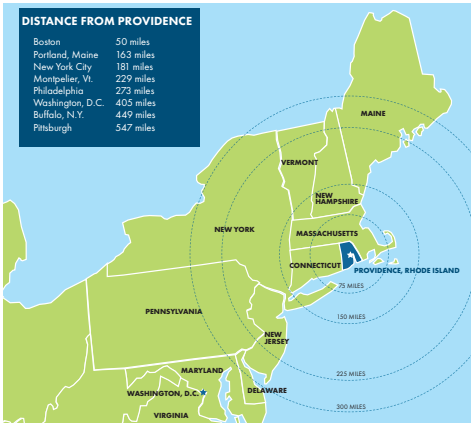
The excitement and anticipation for the event is building – be a part of the excitement as a presenter, sponsor and exhibitor!

Babs Marquis CCM

Delve Underground
2024 No-Dig Show Planning Committee Chair
Secretary, NASTT Board of Directors
Past Chair, NASTT-NE Chapter

The NASTT No-Dig Show is being hosted in the Northeast for the first time

Rhode Island Convention Center



Providence is an easy day's drive from most cities in the Northeast

APRIL 14-18 | PROVIDENCE, RI

NO-DIG SHOW 2024

See You Next Year in PROVIDENCE

2024

SCAN THE QR CODE TO VIEW A VIDEO AND LEARN MORE ABOUT PROVIDENCE!

High Production Piercing Tools in SoCal

Trenchless Gas Service Line Installation with Henkels & McCoy

By: TT Technologies

ABOVE: Henkels & McCoy recently completed 100 gas service line installations in San Diego, CA using Grundomat piercing tools from TT Technologies. BELOW: Piercing tools are a staple in the gas industry for service line installations because they are trenchless and accurate. A Henkels & McCoy crewmember lines up the shot with a Grundoscope Aiming Frame.

Trenchless technology has been closely linked to the gas industry for decades. And one of the tools that has had a significant impact on that industry is the pneumatic piercing tool. From the old-world streets of Europe to the residential neighborhoods of North America, piercing tools have allowed gas utility contractors to install countless miles of gas service lines without major disruptions and costly restorations. While the social benefits of trenchless piercing tools are undeniable, the bottom line is the tools are effective.

On a project recently completed in San Diego, CA, one of the country's most storied contractors, Henkels & McCoy (H&M), Blue Bell, PA, demonstrated the hard-working effectiveness of the tool in a very basic, straightforward way. The project consisted of 11,000 feet of gas mainline installed through directional drilling, often the piercing tool's partner in crime, and over 100 services for a residential neighborhood. The existing steel gas line in the area was aging and was ready for replacement.

According to Henkels & McCoy General Foreman, Nick Vargas, the piecing tool is an attractive service installation method for a variety of reasons. He said, "The piercing tool allows us to have a competitive edge in bidding. And also keeps the impact to homeowner's property minimal. It provides a 95 percent time savings on restoration and replacement, as well as significantly reducing homeowner complaints. Plus, it reduces the risk of worksite trench hazards."

For the project, H&M utilized several Grundomat pneumatic piercing tools from trenchless equipment manufacturer TT Technologies, Aurora, Ill. According to Ty Green, Piercing Tool Specialist, TT Technologies, two sizes of Grundomat piercing tools were used. He said, "For this project Nick's crews used 2-inch and 3-inch tools for the service lines. These are your bread and butter tools. Great for services. Versatile, highly reliable and high production."

HENKELS & MCCOY, TOP QUALITY COMPANY

Henkels & McCoy (H&M) is a respected, multi-faceted design, engineer and utility

"The social benefits of trenchless piercing tools are undeniable"

contractor. In addition to other types of utility operations, H&M offers comprehensive natural gas distribution construction services, utilizing the most modern and advanced methods of installation for residential, commercial, and industrial applications.

According to Vargas, safety is a core value at H&M. He said, "We follow a daily safety management system of items that help us track and improve safety all the time. The company looks at trends and causes and continually improves the safety programs we use in the field. We're always trying to operate at the highest safety standards for everyone in the company, as well as clients and the community at large. We work to be the safest contractor out there."

Henkels & McCoy is also well versed in all forms of trenchless technology, including horizontal boring with piercing tools for residential gas service line installations.

ON THE JOB

H&M crews were installing one-inch diameter gas service lines from the main line to the house. The launch and receiving pits were excavated by hand. The launch pits for the project varied from location to location, but on average measured 5 feet long, approximately 34 to 36 inches deep and about 18 inches wide. Those pits were located at the gas main.

The exit pits varied in size depending on the layout for the bore. Vargas said, "Yeah, the exit pits were located by the meter. Depending on how much room we have, sometimes they'll make the pit about the same length as the launch pit. That way they can pull the mole out. Other cases, there'll be just a small hole. They'll have to reverse the piercing tool back out. We bored under driveways, walkways, everything. Sidewalks, for sure. And across the streets, too. With installations ranging from 35 to 40 feet and up over 100 feet, we got some pretty significant shots with that tool."

H&M crews approached each service on the project in San Diego individually in terms of how the service line was finally installed. According to Vargas, crews installed services in any number of ways. Vargas said, "In some situations we're attaching the new service to the air hose of the Grundomat pulling the new service in with it. It all depended on what the soil conditions were like and the layout of the job. Sometimes they would connect it onto the end of the hose and pull it back. Sometimes crews would pull in a piece of rope and then pull the service in after the bore."

According to Vargas, some homes receive temporary service. He said, "After we energize that service, they [gas utility] will come in and if they have an acces-

The trenchless Grundomat piercing tool was the ideal choice for the project in San Diego. The residential location of the project featured a significant amount hardscape with bores traveling under sidewalks, driveways and walkways.

Minimal excavation was required for the launch and exit pits. Bores lengths averaged 35 to 40 feet, with some as long as 100 feet.

Henkels and McCoy crews achieved high production levels with the piercing tools, completing up to four installations per day.

sible tee to feed the house, they will. If not, they shut them off. Most of the time they try 'bagging' it or putting it on the 'bottle.' It just depends. But the residence is only out for a short amount of time either way. They're very proficient at it."

RESULTS

Production is the name of the game and Vargas has multiple crews and tools running in the field. He said, "We have several crews on the job. So, there will be anywhere from two to three, maybe four piercing tools running at the same time. Each crew has a designated area, and each crew has fusers and then those that are shooting the moles. After the service is in, the fuser comes out and ties the service into the main and into the residence. So, they're not different crews, just different crew members."

Green said, "They got very good production in the field, between two and four installs completed per day. It all depends on the length of the boring and the soil conditions, but those are solid numbers."

In all the Henkels & McCoy crew completed around 100 gas service line installations, ranging in length from 35 to 100 feet, with the piercing tools. Bores took a half-hour to 45 minutes to complete. Proper grade was maintained by using a Grundoscope aiming frame, surveyor stake and a smart level. But even with these tools, the piercing tool itself needed to maintain its path in varying soil conditions.

> *"The piercing tool keeps the impact to homeowner's property minimal."*
>
> - Nick Vargas, General Foreman, Henkels & McCoy

Vargas said, "You hammer it in a little bit, check the line with the scope and then continue or make an adjustment. They were able to make adjustments just shooting the tool off the ground. We had a couple of shots where the ground was too soft, and the tool will actually just sit there and bounce. I call it swimming. But most of the time, instead of running it wide open, you can throttle down about half to two thirds, and that helps overcome that 'swimming' situation. That's the hardest thing we had on this job. This one was pretty decent."

Green said, "The accuracy of the Grundomat is significant. And the tool is ideal for economical service line installations. The tool has a reciprocating head. The chisel head assembly moves independently of the main casing, creating a pilot bore for the rest of the tool body to follow. This ultimately leads to greater bore accuracy because it hammers away at solid obstacles. But as Nick said you have to change the approach a little in softer soils. And obviously they have that tool dialed in! Nice project."

Eversource Evaluates Trenchless Technology

Route 140 Bridge Crossing Showcases Benefits of CIPL

By: Sean Wang & Dan Schadt, Eversource

RESEARCHING THE TECHNOLOGY

As a part of Eversource's Gas Engineer Cohort program we were paired up with a fellow cohort and presented a list of potential topics for a capstone project. We had no idea the long, arduous yet rewarding journey ours would take us on, culminating in a pilot project and now a full-fledged program being utilized by Eversource.

We were assigned the topic of rehabilitation of large diameter (16-inch+) cast iron pipe, with a focus on Progressive Pipeline Management's (PPM) Cured-in-Place-Lining (CIPL). From the viewpoints of people who had been in the gas utility business for less than 3 weeks at that point, we didn't understand why we were rehabilitating large diameter cast iron when we could 'simply' replace them with new coated steel or plastic mains. However, once we began researching trenchless technologies and their applications, we quickly realized how invaluable trenchless technologies were for a utility looking to ensure safe operations, repair leaks and reduce emissions.

We were fortunate to be supported by John Leskow, an Eversource Principal Engineer and our project mentor, for the entirety of the project. Although we had never seen the process in action, John had been able to observe it on a project in Rhode Island and emphasized the importance of the technology and its potential for use in Eversource's future.

In December of 2022, we took a trip to New Jersey to observe PPM install CIPL into approximately 950 feet of a 20-inch cast iron pipeline for PSE&G. Braving the cold weather, we were able to learn a considerable amount about the process and take a lot of pictures which would end up becoming extremely useful for our final capstone presentation.

For our capstone presentation, we took the stance that trenchless technologies should become a part of Eversource's portfolio of solutions in improving safety, reliability, repairing leaks and reducing fugitive emissions. We compared CIPL against traditional open cut replacement and external joint sealing in 4 different categories: Safety, Customer Satisfaction, Environmental Impact and Cost. In our comparisons, we found that in specific situations and locations, these trenchless technologies are the most favorable option meaning that while there is no one size fits all solution, they can certainly be an extremely useful tool when options are limited.

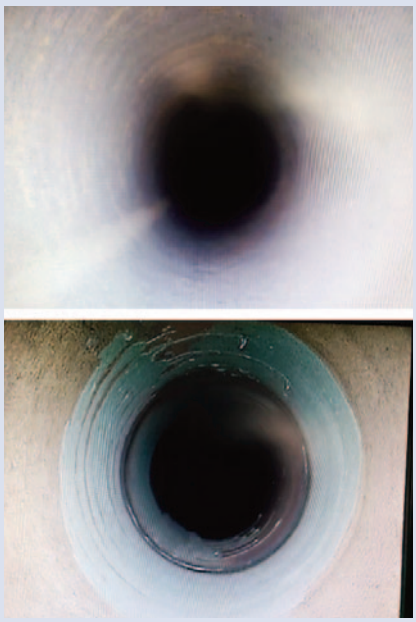
The shoring box used during the project. The shoring boxes are inconvenient as they split the pit into 2 which make it difficult to maneuver personnel and the inversion tube.

When we began our project, we were focusing on the rehabilitation of large diameter cast iron because that has traditionally been one of the costliest to repair of our leak-prone assets in our portfolio. We quickly found that New England, having such an old infrastructure system, still contains many miles of cast iron to rehabilitate or replace. However, these large diameter cast-iron mains maintained by Eversource are mostly located in densely populated territories such as Cambridge, Somerville, Worcester, and Springfield, which makes lining projects difficult due to the number and density of services. When looking for possible projects to propose for the presentation, we were introduced to a leaky segment of 8-inch Steel HP pipe going across a bridge in Duxbury by Eversource Lead Engineer, Richard Salvarezza. The pipe on the bridge is crossing a heavily traveled Route 3, and had extensive corrosion due to pouring water from a road drain above the main, and during the winter months, road salt, directly onto the pipe.

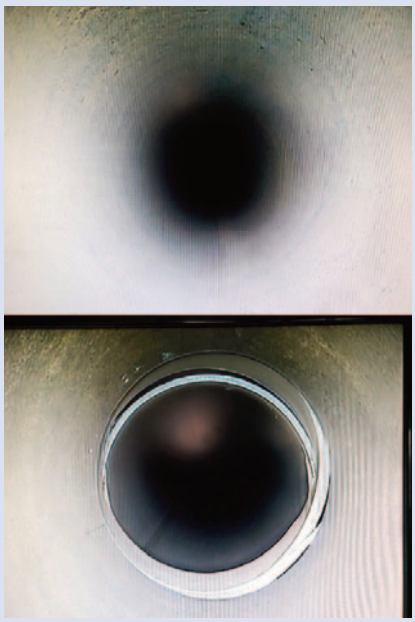
PUTTING THE PROJECT INTO MOTION

As we began discussions on the Duxbury bridge crossing and the major stakeholders became informed about the project, we were informed about a 6-inch Coated Steel HP bridge crossing on Route 140 that ran over Interstate 495 in Mansfield. This bridge crossing was classified as a class 2 leak and required urgent repair as gas odor was smelled from over 100 feet away. It is a particularly difficult location to perform the required repairs or replace the pipe due to its proximity to freeway ramps and being within a mile of the Xfinity Center Concert Venue. Additionally, with Route 140 being a state road, state permitting would be a requirement. These constraints, along with the difficulty of replacing or remediating pipe on bridges through the abutment wall, made this bridge a great opportunity to showcase the benefits of CIPL.

Internally, we discussed the possibility of using CIPL to repair the current leak and rehabilitate the pipe to prevent any future leaks and we followed that up with a site walk with PPM to discuss the viability of the project. After these preparatory discussions, we moved forward with the decision to design and schedule the project. Our biggest concern was with the schedule, as with any work performed in this area, we would need to avoid conflicts with any events being held at the Xfinity Center. As luck would have it, we found a 2-week gap between concerts where we hoped to be able to prep, line, pressure test and tie-in the pipe. After overcoming some minor hurdles, all that was left to do was order the materials and complete the project.



Pre-clean inspection of the pipe at the bridge abutment.



Camera inspection after cleaning was done of the pipe at the bridge abutment.

"We quickly realized how invaluable trenchless technologies were!"

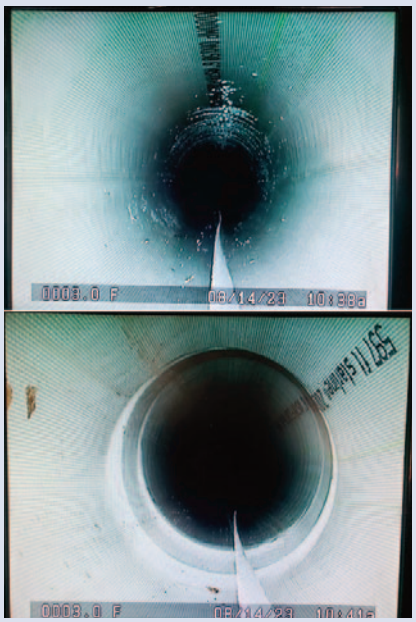
As our scheduled dates drew closer, the weather report grew more ominous with heavy rain threatening to derail the timeframe. We determined that with our limited options for alternative schedules and with the quick time frame that PPM proposed completing the lining process, it was worth it to push forward.

Before PPM could begin the lining process, Eversource crews worked for 2 days to excavate the proposed pits and prep the pipe in the bridge to begin purging. Mueller linestops were used on both sides of the bridge and the pits were dug to PPM's specified dimensions to allow for the inversion of the liner. The morning of August 10, 2023, we were finally ready for PPM to begin running their procedure. Eversource crews reopened the excavations, removed the end caps on the project pipe and installed end caps on the live ends of the pipe before turning the pipe over to PPM to begin their cleaning process.

Once Eversource crews turned over the pits, PPM technicians quickly got to work prepping to inspect and clean the pipe. The first entry into the pipe was made by a camera rover to perform a pre-cleaning inspection of the pipe. The pre-cleaning inspection is to determine problem spots in either the pipe geometry or characteristics of the pipe that will prevent the lining project from going smoothly. As seen in Figures 1 and 2, the interior of this pipe was relatively clean due to it being part of a high-pressure system.

After inspection, the sand blaster was deployed to clean the pipe walls, so that the liner could adhere properly to the pipe wall. Due to the segment of pipe being just under 500 feet, all entries into the pipe were able to be performed through a singular pit. There was potentially an opportunity to perform cleaning and lining on the same day but with heavy rain looming on the radar, the decision was made to postpone the lining until the following day to ensure that the project was completed in a safe and proper manner.

The next morning, the PPM technicians began preparing the adhesive and liner for the job. The wet-out prep process was completed in roughly 2 hours, and the inversion cone was secured to the fitting that had been installed on the host



Photos taken from the inspection after the liner had cured in the pipe over the weekend. (Photos courtesy of PPM)

pipe the day prior. PPM then proceeded to pressurize the annular space causing the liner to begin inverting and adhering to the inside of the 6-inch pipe. The entire lining process was completed in 2 days, which helped us prove why lining was the correct choice for this project.

After the segment of pipe was lined, the liner was left in place under pressure to allow the adhesive to properly cure before the final pressure test is conducted. Following the successful completion of the pressure test, the lined pipe was ready to be gassed in. Eversource crews completed the tie-ins/activations on Monday night. The pipe was back online less than a week from when the excavations on Route 140 began.

The project was a success in the eyes of Eversource. Even with the challenges of scheduling and the occurrence of inclement weather, thanks to the coordination and communication between Eversource and PPM and the hard work of all the technicians involved, the project was still able to be completed within a week.

ADJUSTMENTS AND POTENTIAL FOR FUTURE PROJECTS

From an operational point of view, the Route 140 Bridge lining in Mansfield was a success. Director of Maintenance at Eversource, Dan Henry, had some ideas for future lining projects such as planning to use engineered timber shoring as opposed to the shoring boxes seen in the pictures above. The benefits of using the timber shoring over shoring boxes is to keep the center of the trench open. If shoring boxes are used, the entry and exit pits will be split in two, hindering the movement of the technicians and the alignment of the inversion tube. Timber shoring can also be adapted based on depth of main and location to be made flush with the road. This will allow crews to lay plates over the pits overnight making the project easier operationally and saving time otherwise required for backfill and paving.

Although Dan Henry does not see CIPL taking the place of pipeline replacement,

he does see it continuing to fill a niche in future work. It will be a useful tool for remediating pipe that would require significant work and expenses otherwise, such as rail and bridge crossings. CIPL saves the utility company in permitting expenses, as most permit costs are directly related to the paving area for the restoration of the road or sidewalk. The excavated pits required for lining are significantly smaller than the excavated area for direct replacement, therefore the permitting costs are significantly smaller.

CONCLUSIONS

Since the completion of the project in Mansfield, Eversource has held discussions with PPM to discuss future projects. Eversource has found potential projects ranging from 4 to 18 inch diameters of various metallic pipes for lining. We have determined that pipe lining is a great solution for projects like bridge and railroad crossings as it reduces the work in railroad Right of Ways, lowers the amount of work and time required to complete the project in comparison to direct replacement and is more cost effective in some cases. Utilizing CIPL technology, Eversource will have the ability to rehabilitate more pipelines that may have been postponed if thought to be more difficult and expensive to remediate.

Innovative Technology Benefits

By: Progressive Pipeline Management

The PPM Starline 2000 system can line pipelines from 4 to 42 inches with a MOAP to 180 PSI. Our technology has also been independently tested by NYSEARCH/PHMSA and Cornell University. The case study determined a 100+ year viability of field-aged Cured-in-Place pipe as alternative to full pipeline replacement. The tests also determined that CIPL provides substantial pipeline renewal and is a viable option to conventional replacement methods for cast-iron and steel distribution pipelines. Our product meets ASTM 2207-02 and 2207-06. Due to further advancements in our operating procedures and equipment, PPM now has the capability to line segments up to 1,300 feet with only two excavations.

One of PPM's most innovative trenchless techniques is the use of using Carbon Fiber Structural Reinforcement Sleeves (SRS) to secure the integrity of damaged pipelines. High strength carbon fiber material in the form of a "sleeve" is inserted robotically into the pipeline. Carbon fiber is light, with high-tensile strength, high temperature tolerance, and low thermal expansion, properties which make carbon fiber ideal in diverse applications, from aerospace and engineering, to motorsports and sailing.

PPM's robotic devices and method of installing carbon fiber sleeves, have been part of our ongoing effort to improve the efficiency of CIPL. The proprietary process was developed in 2011 and is used effectively to reinforce bridge abutments, reinforce corroded high-pressure gas mains, and to span gaps in pipelines (for example, where drip pot standpipes must be removed). PPM can design, develop and test custom robotics to install carbon fiber sleeves in pipelines safely and effectively. Robotics with extendable reach features can cut away the existing drip standpipes, allowing the carbon fiber sleeve to create a "bridge" across the drip cavity. The carbon fiber bridge allows for seamless lining without incurring costs for unnecessary and costly excavations.

ABOUT THE AUTHORS

***Minqui Wang** is an associate engineer with Eversource Gas's Complex Project Management team. He earned a Bachelor of Science in Chemical Engineering from the University of California, Berkeley.*

***Dan Schadt** is an associate engineer with Eversource Gas's Complex Project Management team. He has a Bachelor of Science in Petroleum Engineering from the University of Alaska, Fairbanks.*

Mingqi and Dan joined Eversource as part of the Gas Engineering Cohort Program where they completed a capstone project on the rehabilitation of large diameter cast iron pipe.

Novato Landslide Emergency HDD Response

Fast-Paced Design-Build Collaboration Ensures Uninterrupted Gas Supply

By: Phill Perron, MSc, PMP, rmc, HDD Company

A waterlogged hill in Novato, California gave way and triggered a landslide in April of 2023. There were two natural gas transmission lines buried under this hill, and although they remained intact after the initial slide, the risk to their integrity was too great. These lines served a population of more than 250,000 people in Marin County, north of San Francisco, and immediate action was required. The solution: two horizontal directional drills (HDDs) carried out by HDD Company, subcontracted by ARB, in response to this active landslide. These two HDDs, executed with precision and expertise, played a vital role in ensuring the uninterrupted flow of gas to the residents of Novato.

The American Augers Maxi Rig, with its incredible push/pull force of 900,000 lbs and rotary torque of 47,775 ft-lbs, became the cornerstone of this ambitious undertaking. It was supported by two Vermeer SA400 High-Pressure Mud Pumps with a max flow of 550gpm and a Kemtron Tango 1000T Cleaning System to manage the spoils.

Time was of the essence in this emergency project, and HDD Company did not disappoint. They successfully mobilized to the site within an astonishing 48-hour window. This rapid response demonstrated the company's commitment to meeting PG&E's urgent needs while maintaining the highest safety and quality standards.

The project's design was handled by Campos EPC, a company known for its expertise in engineering, procurement, and construction. In a fast-paced design-

Landslides had occurred in this region over the years

build collaboration, HDD Company actively participated in refining the project design to ensure it met the specific requirements of the job. The project's schedule was particularly demanding, given that the gas line had to be temporarily installed under the K-Rail of an active highway. To meet these stringent timelines, HDD Company conducted round-the-clock operations, rapidly mobilizing a second shift so there would be no break in operations.

The first HDD was no small feat, spanning approximately 1,700 feet. This bore presented a unique set of challenges, from changing geotechnical conditions to the need for continuous 24-hour operations to meet the tight schedule. Furthermore, the rigorous planning regime that HDD typically subjects their projects to before construction was not possible in this case. Historical geotechnical data available publicly was used to establish the ground conditions, with all project stakeholders aware that the 'Franciscan mélange' that is common in this area would be even more varied than usual. The geotechnical conditions at the project site were highly varied and constantly changing due to the drilling taking place under an active landslide area. Landslides had occurred in this region over the years, further complicating the geotechnical aspects of the project. HDD Company had to proceed with limited information and rely on best practices to reduce the risk.

Geotechnical conditions at the project site were highly varied and constantly changing

Geotechnical borings were conducted while HDD 1 was in progress, and the project's design was amended based on these findings during the drilling of HDD 2. Given the elevation and condition of the hills, the concern was that an inadvertent return could be nearly impossible to remediate if it occurred. Depending on the severity of the inadvertent return, the release of fluid could also further impact the highway and render the crossing location unusable. A high degree of finesse and precision was required to monitor and manage the annular pressure of the bore.

To make matters even more challenging, the landslide denied access to the exit side of the HDD, making it impossible to run the tailstring as originally planned. In response, HDD Company implemented an ingenious solution. They safely conducted the process of forward reaming the bore to a larger 24-inch diameter, allowing for the installation of the gas pipeline without the need for the conventional tailstring. This lack of access also prevented HDD from deploying a coil wire to allow for a wireline steering program to be deployed. Instead, HDD deployed a Vector Magnetics ParaTrack Steering Tool with a Gyro Module to allow the operators to safely steer the bore with a high degree of precision in the varied ground conditions.

HDD 2 was even more substantial, covering a distance of approximately 2,000 feet. Armed with the as-drilled experience from HDD 1 and the newly acquired geotechnical profile from the borings, HDD was able to adjust the drilling mud recipe to mitigate the issues with the drilling fluid that were causing the annular pressure to rise to the limits of the pressure envelope. HDD Company consulted with internal mud engineering resources, leveraging its parent company, The Crossing Group's extensive experience, to amend the mud plan to mitigate some of the pressure issues. In close collaboration with the project team, HDD Company decided to amend their tripping and for-

Rapid response was essential – crew mobilized to the site within an astonishing 48-hour window

Round the clock operations were conducted to meet stringent timelines.

Pipeline was installed without the need for a conventional tailstring.

ward reaming strategy to reduce this sharp risk of an inadvertent return to levels that could be mitigated by best practices.

The entire project, involving both HDDs, was completed in under 50 days. This remarkable achievement was the result of meticulous planning, efficient execution, and the exceptional teamwork displayed by all the parties involved.

The success of this project can be attributed not only to the expertise and capabilities of the teams involved but also to their seamless collaboration and real-time cooperation. The partnership between PG&E, ARB, Campos EPC, and HDD Company was truly exceptional. This included the collaborative commercial project delivery model that was employed for the execution and the 'solutions-focused' thinking which was key to project success.

The involvement of Campos EPC, with their expertise in design and construction, was pivotal in creating a project plan that could adapt to changing conditions while maintaining the highest safety standards. Their ability to amend the design based on real-time geotechnical data during the drilling of HDD 2 highlights their adaptability and commitment to delivering a successful project.

HDD Company played a central role in the project's planning and execution. Their rapid mobilization, utilization of the American Augers Maxi Rig, and ability to conduct operations around the clock were instrumental in meeting the demanding schedule. Their innovation in overcoming the challenges posed by the landslide, such as forward reaming the bore, showcases their problem-solving abilities and commitment to project success.

The Novato HDD project stands as a testament to the power of collaboration and real-time cooperation in the field of gas infrastructure. By working together and combining their respective strengths, PG&E, ARB, Campos EPC, and HDD Company were able to overcome significant challenges and ensure the successful completion of the project.

The successful collaboration between PG&E, ARB, Campos EPC, and HDD Company ensured that the community's gas supply remained uninterrupted. This project not only highlights the importance of rapid response in emergency situations but also the power of teamwork and adaptability in overcoming complex challenges.

ABOUT THE AUTHOR:

Phill Perron MSc, PMP, RMC, is Vice President of Projects at HDD Company, a division of the Crossing Group. His career is marked by a diverse and distinguished background. Phill served in the Royal Canadian Air Force for ten years, where he contributed his expertise as a Supply Chain Operations Officer. In 2019, he embarked on a new chapter in his career by joining the Crossing Group. Phill has earned a Master's degree in Supply Chain and Logistics, focused on the supply chain challenges experienced in the deployment and sustainment of HDD rigs in the US.

Kemtron Tango 1000T Cleaning System managed the spoils.

Entire project, with two HDD bores, was completed in under 50 days

High degree of finesse and precision was required to monitor and manage the annular pressure.

Bridges to No Repair – CIPL the Right Choice

By: Mario Carbone, Progressive Pipeline Management

Since 2002, Progressive Pipeline Management (PPM) has been renewing natural gas pipelines in challenging situations including highways, bridges, railroad lines and environmentally sensitive areas. We use the Starline® Cured-inplace-lining, which is a proven, cost effective trenchless technology that extends the life of a pipeline by 100 years.

In 30 years, I haven't met a utility that didn't have pipelines along bridges in their inventory. As bridges age, so do the pipelines. Like us, they are getting older. Over forty percent of the bridges in the US are over fifty years old. In the Northeast, gas pipelines and bridges are typically 75 – 100 years old.

As they age, pipelines are vulnerable to corrosion. Leaks come from corrosion, which is accelerated in pipelines along bridges. Repair of a gas pipeline alongside a bridge or overpass is nothing like a repair in a typical roadway where a pipeline is buried. Let's say a leak is identified in the abutment wall. Go-to methods are to put a sleeve on or to remove the pipe from the abutment wall and replace the piece of pipe. Here's the dilemma. The owner of the bridge will never allow that. If you can't disturb the pipe on the bridge, or cut and cap the main, there are no viable alternatives. Leaking pipelines on bridges cannot be repaired using conventional methods of replacing the pipe. There is another way that has been around for 30 years. Cured-in-place-lining is a proven and cost effective way to repair pipelines without disturbing the bridge.

WHY ARE PIPELINES ON BRIDGE CROSSINGS SO DIFFICULT TO REPAIR?

Pipelines run under or alongside and traverse the bridge's abutment walls. The position of some of these gas pipelines places them in a problematic location as they are mostly hung under or alongside the bridge structure, limiting access to the pipeline. In some cases, and the most convenient, the pipeline is resting on top of the structure completely exposed except for where it reenters the road or offsets into the abutment walls. Most of these bridge or overpass crossings place the pipeline through the concrete abutment wall of the structure, either with a protective sleeve, or in some cases without a sleeve.

Bridges are highly susceptible to the elements. Wind, salt and extreme temperatures accelerate corrosion, which is the reoccurring issue, especially where the hangers supporting the pipeline make contact with the gas-carrying pipe. The greatest corrosion concerns are within the abutment wall itself, where the concrete accelerates the localized corrosion. The pipeline is weakened at that juncture and in most cases a gas leak is present. Excessive corrosion of the pipeline where the pipe enters the abutment wall of the bridge cannot be repaired without removing the pipe.

Figure A. Bridge with pipleline hanging under bridge

Figure B. Brige with pipeline alongside

Figure C. Pipeline under bridge going towards abutment

"CIPL IS THE RIGHT CHOICE AS AN ALTERNATIVE TO CONVENTIONAL MAIN REPLACEMENT GIVEN THE LOWER COSTS AND 100-YEAR SERVICE LIFE. BRIDGES, ROADWAYS WITH HIGH RESTORATION COSTS, HISTORICAL AREAS, AND RAILROAD CROSSINGS ALL MAKE CIPL THE LOGICAL CHOICE."

- CASEY GIAMBRONE, VICE PRESIDENT, PROGRESSIVE PIPELINE MANAGEMENT

BRIDGES TO NO REPAIR

Let's say a manager in charge of a bridge sends the leak truck out to investigate, and decides that a section needs to be replaced. Here's where the nightmare begins. Pipelines at bridge crossings require multiple levels of approvals, and layers of restrictions, from the owner and regulators. Bridges are owned by municipalities or railroads, so the utility is limited to what is permitted by these owners. Traditional replacement presents utilities with multiple engineering hurdles to overcome.

When a bridge or crossing is functioning, the owners are not open to a utility coming in and messing with the pipeline. When a bridge is in need of repairs, there is no way the owner will let anyone near it. Existing pipelines are grandfathered into the bridge, but any replacement pipe or hanger is not. The structure of the bridge may or may not support a new pipe and the owner won't take a chance with it.

In addition to owner permissions, there are regulator and Department of Transportation (DOT) approvals and inspections. Engineering designs have to be submitted and approved to the bridge owner, DOT and city/county regulators before any traditional replacement can be completed. Hangers that support the pipeline need to be replaced with new hangers of approved designs, per owner's SOP. Re-engineering pipe supports and hangers, or attempting to remove the old corroded pipe from the abutment wall, are cost prohibitive methods, and in most cases simply not allowed. Even a simple change in hangers can sometimes make the project a no-go.

Removing the pipe that is nestled in an abutment wall is an extremely costly and difficult process that affects the structure of the bridge. The local municipalities or owners of the bridge will not allow the replacement of the pipeline, especially where it enters and exits the abutment wall of the bridge structure. A bridge owner will never permit a utility or contractor to drill through the foundation of the abutment wall to put a pipe in. If they were to gain permission, the equipment, insurance and safety protocols required would be cost prohibitive.

The red tape and headaches that come with trying to use conventional replacement lead to months and months of dead ends. All the while the leak is still there and getting worse. This is what is meant by "Bridges to No Repair."

HOW BIG IS THE BRIDGE PROBLEM?

There are more than 614,387 suspension bridges in the U.S. Forty percent are 50 years or older. Pennsylvania has the thirdlargest number of bridges in the nation with 25,000 state-owned bridges, some dating back to 1929. On top of that are the millions of overpasses that cross creeks, highways or railroad tracks. These are still bridges although not as iconic as the Brooklyn Bridge. The majority have utilities, since pipelines have to go under or over the pass.

CURED IN PLACE LINING A SOLUTION FOR BRIDGE CROSSINGS

There is a simple solution to the headaches that come with "Bridges to no Repair". Reconditioning the pipeline using Curedin-Place Lining (CIPL) reinforces the pipeline within the abutment wall without disturbing the pipeline or the structure of the bridge. The first step is to review the drawings of where the pipe connects to the road. The process is done using two excavation points at the beginning and ending points where the liner is inserted. These excavation pits are done outside or beyond the limits of the bridge. We cut and cap the main and line it from

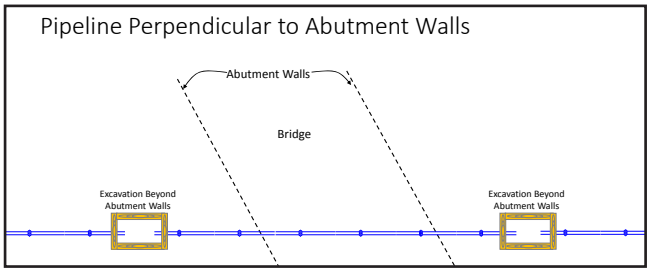


Figure D. CIPL process takes place outside the limits of the bridge

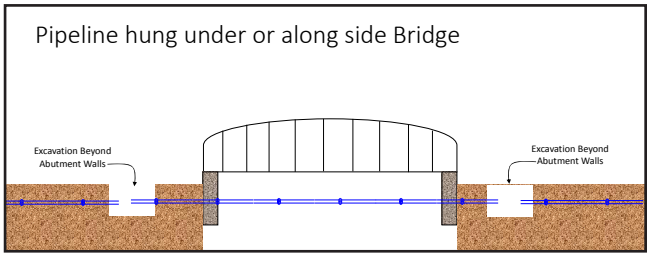


Figure E. Same process if pipeline hangs under or alongside bridge

Figure F. SRS liner prep

Figure G. Interior of pipeline with SRS installed at the bridge abutment

these two points. Leaving the pipeline in place and repairing it using CIPL falls within "grandfathering" guidelines, thus avoiding the need for total replacement. CIPL is far less expensive than replacement, and in most cases is the only viable option.

CARBON FIBER STRUCTURAL REINFORCEMENT SLEEVES (SRS) IDEAL FOR ABUTMENTS

PPM developed an innovative solution that prevents the need for the removal or excavation of a pipeline. Installing a structural reinforcement sleeve (SRS) has been a choice of gas utilities throughout the industry for this purpose. The carbon fiber SRS reinforces the corroded pipe with a carbon fiber sleeve without the need to remove the pipe. The SRS has been tested at pressures to 250 PSI and approved by the Gas Technology Institute for its strength, durability and compatibility with PPM's Starline CIPL product. This innovative approach is accomplished by installing a Carbon Fiber sleeve into the gas carrying pipeline directly at the bridge abutment wall. PPM's SRS sleeves are made of a high strength carbon fiber laminate with a glass outer skin, and are installed robotically into the pipeline. The laminate composite material and glass outer coating prevent corrosion.

The carbon fiber material bonds to the interior of the pipeline, and improves the pipe's integrity at the position of the installation. While each project is unique, carbon fiber SRS can save utilities as much as $500,000 per project by preventing future corrosion and eliminating the need for costly additional excavations and pipe work.

During a 12-inch rehabilitation project in East Orange NJ, the pipeline went directly through the bridge's concrete abutment wall. Figure G shows the SRS sleeve and PVC pipe successfully installed between the abutment wall and wrought iron main. The liner has already been installed in main. As noted, this section was cut out and the utility re-installed an expansion joint at that point.

CURED-IN-PLACE-LINING PROCESS

Whether on a bridge or under a highway, the CIPL lining process follows the same steps, with the entire process taking just a couple of days. After the sending and receiving pits are excavated, the first step requires a pre-clean CCTV inspection. Robotic cameras confirm the pipeline geometries, check for anomalies and protrusions, and assess the overall internal condition of the host pipe. The next step involves a thorough internal surface preparation using robotic sandblasting and subsequent recovery of the leftover sand and debris.

Adhesive is mixed and prepared and added to the liner. The liner is loaded into the Starline drum, and then inverted and inserted into the pipe. The Starline® liners are a seamless / jointless circular woven fabric-hose made of polyester yarns and a plastic coating (PU/PE) which is bonded as inner liner into the host pipe using a solvent-free two-component adhesive custom fit to each project. After the liner cures, it is cut out on both ends flush with the end of the pipe.

The CCTV camera is inserted again to ensure it looks good. The final step is a pressure test and the gas is turned back on. During the entire process, the host pipe remains in the bridge, with no interference at all with the bridge structure. All the action happens at the excavation points. The owner will not have issues with a process that happens outside his domain. The complete reconditioning of the entire segment, plus the SRS reinforcement of the pipeline at the abutment wall, is typically within a few days. Curing times vary depending on the ambient temperatures. Reconditioning a pipeline will add an additional 100 years of reliable life to the old existing pipeline including the reinforcement of the pipeline at the abutment walls.

The entire lining process does not disturb the pipeline, will not affect the supporting hangers, or disturb the pipeline within the abutment wall. Cured-in-place-lining plus the Carbon Fiber SRS is

Figure H. PPM team members load the liner into the Starline pressure drum prior ao inversion in the excavation pit

Figure I. PPM Cured-in-place-liner inversion in process

a perfect marriage and ideal solution to expensive, and often impossible, repairs within bridge pipelines.

"CIPL is the right choice as an alternative to conventional main replacement given the lower costs and 100-year service life. Bridges, roadways with high restoration costs, historical areas, and railroad crossings all make CIPL the logical choice."

— Casey Giambrone, Vice President, Progressive Pipeline Management.

BACKED BY INDEPENDENT RESEARCH & TESTING

Extensive R & D and independent testing on rehabilitated pipe with the Starline technology has confirmed a service life of 100-plus years. The natural gas industry has invested over $15 million in testing of the liner and its capabilities at such esteemed institutions as Cornell University, Battelle Labs, ASTM, NYSEARCH and PHMSA. PPM now has liners capable of installation at a maximum allowable operating pressure of 99 PSI, 180 PSI, 250 PSI and soon, 450 PSI.

PPM holds the exclusive license for North America for the Starline® liner. PPM has decades of specialized expertise associated with gas pipeline related issues, including lining and trenchless technology. This depth of understanding and engineering of the entire project is applied from inception to completion. The PPM team and crews have collaborated with industry experts at leading utilities and institutions. Together, they have developed and tested innovative technology that will extend the life of gas infrastructure for generations to come. Through advanced robotics and offering Broadband Electromagnetic Inspection technology, PPM is taking pipeline integrity management into the 21st century.

"The beauty of CIPL is that it not only not only addresses the leaks that our customers have identified, but eliminates the ones that have not been identified. The most dangerous leaks in the industry are the ones you don't know about."

— Casey Giambrone, Vice President, Progressive Pipeline Management.

ABOUT THE AUTHOR

Mario Carbone's ingenuity and perseverance define his leadership. His 46 years in the gas pipeline industry include 32 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's decades of experience enable PPM to design, develop and test new technologies and robotics on demand while complying with required industry standards. As a respected authority on innovative trenchless techniques, he has frequently been a speaker at industry events.

What to Do When your As-Builts are Not As-Found!

New Trenchless Method Overcomes Project Hurdles in Record Time

By: Mary Neher, Bennett Trenchless Engineers
Joshua Hampton, Pacific Gas and Electric
Sean Dearborn, Pacific Gas and Electric
Brian Avon, Carollo Engineers

INTRODUCTION

In 2011 Pacific Gas and Electric (PG&E) began a massive hydrostatic testing program to assess the condition of a portion of their high pressure natural gas distribution pipelines. As part of this program it was determined that Line 153, a 30-inch diameter pipeline which runs through the cities of Newark and Fremont in California's San Francisco Bay Area, needed to be evaluated. Even without testing, however, one section of Line 153 was identified for replacement in order to minimize safety risks and operations and maintenance issues: the above ground crossing of Interstate Highway 880 (I-880) on the border between the two cities.

Line 153 was constructed in 1949, prior to the construction of I-880, close to a set of Union Pacific Railroad (UPRR) tracks. When Caltrans constructed I-880 in the 1960s they chose to route the freeway under the existing railroad tracks and high pressure gas line. This resulted in the surface of the freeway being located approximately 20 feet below the surrounding ground and an approximately 220-foot aerial span of 30-inch diameter steel gas line with a single support in the center of the freeway with two supports on the engineered slope of 880 (as shown in Figure 1). Thus, to eliminate the exposed gas pipe and the risk of pipeline exposure from potential traffic accidents, PG&E began the process of designing a new, below-grade crossing of the freeway.

In 2014, Gas Transmission Services (GTS) completed a routing study and alternatives analysis that identified six potential options that would meet the goal of eliminating the risk of traffic accidents impacting the pipeline. These alternatives included hanging a new pipe on the UPRR bridge, constructing a pedestrian bridge and hanging the pipe from that, as well as four trenchless options which included both microtunneling and HDD alignments for crossing I-880. In order to meet the desired construction schedule, HDD was recommended as the preferred alternative.

Figure 1. Photo of the 30-inch diameter high pressure natural gas line aerial crossing of I-880

PG&E requested that Bennett Trenchless Engineers (BTE) evaluate the feasibility of the HDD crossing recommended in the GTS Alternatives Analysis report. After analyzing a variety of factors including the anticipated geotechnical conditions, settlement and hydrofracture risks, pullback load and pipe stress analyses, available work areas and pipe laydown areas, existing utilities, and other improvements and structures; BTE concluded that the proposed HDD crossing of I-880 was not feasible. Upon reaching this conclusion, BTE devised and evaluated several microtunneled alternatives to overcome the deficiencies identified with the HDD crossing. After discussions with PG&E, the contractor, and Golder Associates, a preferred microtunneled alternative was selected. There were numerous project constraints that affected the trenchless design including congested work areas, a railroad crossing, a flood canal crossing (at grade and in a siphon beneath the freeway), a below grade eight lane highway, two

aquifers (one of them artesian), and a hard construction tie-in deadline.

Due to the risk and complexity of the project the design was heavily scrutinized and every known obstacle was thoroughly vetted. Unfortunately, designers can only account for what they know, and after six days of smooth construction the crew hit an unknown obstruction. This paper discusses the routing analysis, design, and construction phases of this project. Included is a thorough discussion of how the project team and the contractor coordinated the dig-up to find and remove the obstruction. The paper will also discuss some additional construction impacts that were caused by the dig-up itself.

SITE AND GEOTECHNICAL CONDITIONS

The trenchless crossing of I-880 was located in a densely developed area, shown in Figure 2. In this area, I-880 ran roughly northwest-southeast. A set of two UPRR tracks crossed above the freeway approximately 125 feet north of the existing Line 153 at a slightly skew angle running northeast-southwest. The area north of the UPRR tracks and west of the freeway (lower left corner of Figure 2) was primarily residential and contained a mixture of single family homes and apartment buildings.

South of the UPRR tracks and west of the freeway (lower right corner of Figure 2) was a business park containing a variety of commercial ventures including a cross fit gym, sign shop, archery supply store, and others. In addition, the Alameda County Flood Control Channel runs parallel to I-880 along the northern edge of the business park. The area east of the freeway and south of the UPRR tracks was commercial (upper right side of Figure 2). Businesses in the area included a manufacturing facility, utility contractor, and rental car lot.

In addition to the surface features and typical existing utilities in the residential area including water, sewer, and the 30-inch PG&E gas line and valves, there were several significant existing underground features. These underground features,

"Engineers, contractors, and owners need to be able to trust in as-builts."

Figure 2. Aerial view of the project location

which were primarily associated with the Caltrans operations, include the Alameda Flood Control Channel siphon crossing of I-880, which is located just south of the UPRR crossing; a dewatering system associated with the below grade portion of I-880; a retaining wall with foundation elements on the west side of I-880 that was built in association with the dewatering system pump station; and a system of storm drains in the center and on the shoulders of I-880. Figure 3 shows the locations of the critical underground and surface features. As-builts of the facilities were provided by Caltrans. The dewatering assets were all located north of the proposed of the alignment and were isolated to the area just around the pumping station. The microtunnel would cross under the edge of the retaining structure, however, Caltrans had this portion of the retaining structure foundation identified as a shallow spread footing. The retaining wall directly in front of the pumping station was constructed using drilled piles reinforced with I-beams.

The geotechnical investigation for the trenchless crossing of I-880 was performed in two stages. An initial investigation, consisting of two borings, was performed by Kleinfelder in 2013. These two borings were located near the ends of the proposed HDD crossing and are shown on Figure 5. As the feasibility evaluation progressed, supplemental borings were recommended to provide information relevant to evaluating the microtunneling alternatives. Specifically, a boring was recommended at or near each proposed shaft location with two monitoring wells recommended to evaluate groundwater elevations and fluctuations. The supplemental investigation, which included three new borings, was completed by Golder in 2015. The locations of the Golder borings are shown on Figure 5. Figure 4 shows the geotechnical conditions interpreted from the Golder borings. The geotechnical conditions encountered by the Golder borings were consistent with the conditions encountered by the earlier Kleinfelder borings. Generally, the anticipated geotechnical conditions consisted of an upper clay layer, extending 18 to 23 feet below the ground surface underlain by a 5 to 8-foot thick upper aquifer consisting of loose to medium dense poorly grade sand to silty sand. Below the upper aquifer was a 17 to 19-foot thick layer of firm to stiff lean clay and below that was the lower aquifer which consisted of medium dense to dense well-graded sand with varying amounts of gravel and poorly graded sand to silty sand to the maximum depths of the borings.

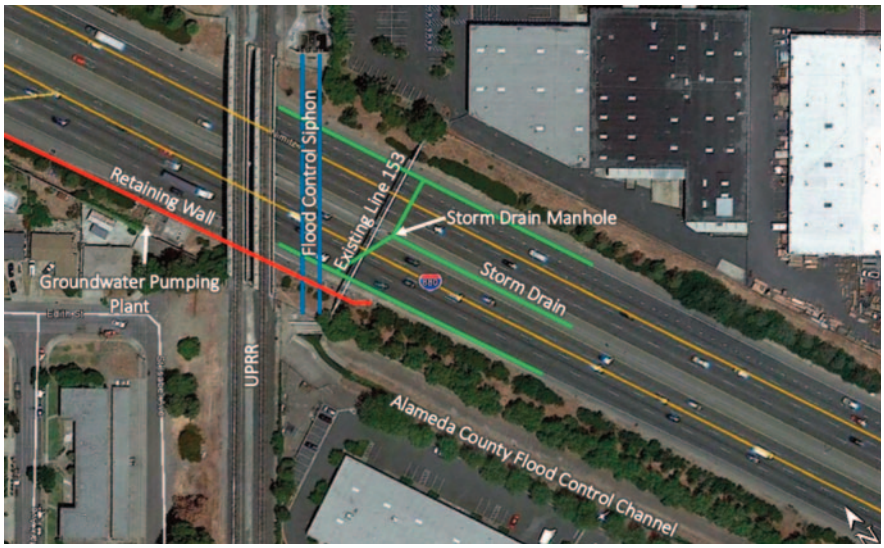


Figure 3. Existing underground features in the vicinity of the trenchless crossing

ALIGNMENT ALTERNATIVES AND SELECTED DESIGN

Two primary HDD alignment alternatives were analyzed as part of the feasibility analysis, both of which are shown by Figure 5. The first, proposed by GTS, was approximately 1,100 feet long and had a minimum clearance of approximately 12 feet from the centerline of the bore to the surface of I-880. Settlement and hydrofracture calculations performed during the feasibility analysis showed that this was not sufficient clearance to adequately protect the Caltrans facilities and other critical surface features. The second alternative was an approximately 1,370-foot crossing that was lengthened and deepened to provide adequate clearance from I-880, the UPRR tracks, and the Alameda County Flood Control Channel while still maintaining installation pipe stresses at acceptable limits.

Unfortunately, the technical drilling challenges and settlement and hydrofracture risks, which were mitigated or resolved by the second alignment alternative, were not the only challenges that needed to be overcome. The logistical issues related to available work areas and the impacts on businesses and residents were far more challenging. On the west side of the freeway, there was marginally adequate work area to set up the HDD rig and support operations. Overhead electric lines, businesses and closely spaced residences, and a lack of sufficient straight work area, however, would have prevented this side of the crossing from being used as pipe fabrication and lay down. On the east side of the freeway, there was approximately 400 feet of pipe fabrication and laydown area identified for the original, 1,100-foot crossing. To extend the laydown area any further would have required closing Central Avenue, a busy thoroughfare that crossed I-880; blocking numerous residential driveways; and use of multiple pipe segments that would result in several intermediate welds during pullback. The 1,370-foot long alternative identified as necessary to reduce settlement and hydrofracture risks further exacerbated the problems with the inadequate layout area by requiring more pipe to complete the crossing while simultaneously reducing the layout length that would not require street closures or driveways being blocked from approximately 400 feet to approximately 265 feet.

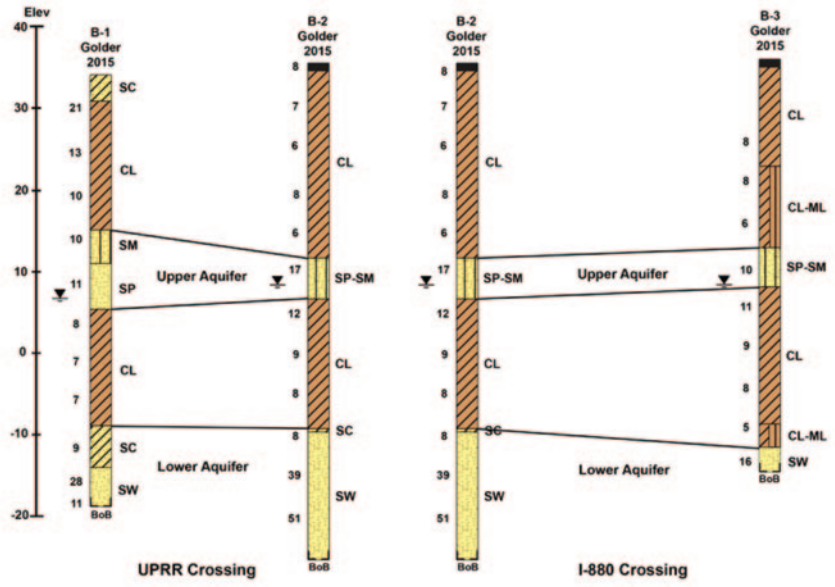


Figure 4. Geotechnical profile interpreted from Golder borings

It was concluded that the amount of time required to fabricate the complete pipe string or make the intermediate welds would be unacceptably long and could not be appreciably reduced. To accomplish the installation a major street and many driveways would have to be blocked for a long period of time, numerous intermediate welds would have to be made which would result in unacceptably high risk of the pipe becoming stuck or the bore collapsing and causing settlement damage to the freeway, or some combination of the two. In addition, there were no alternative pipe layout areas on either side of the freeway which could resolve the disruption time and severity, even if the bore alignment was changed. Another concern was that the preferred HDD alignment was at a significant skew angle to I-880 (Caltrans prefers crossings which are perpendicular or near-perpendicular to its facilities). There was concern that, even if the other logistical issues were resolved, Caltrans would not grant a waiver of its permit con-

ditions if an alternative which complied with existing permitting requirements could not be devised. Due to this potential impact on the project schedule and the inadequate pipe layout area, the HDD crossing was deemed fatally flawed and not feasible.

Once HDD was eliminated as a feasible trenchless installation method for the I-880 crossing, attention turned to devising a pipe jacking solution. Due to the depth of the freeway below grade and the presence of two aquifers, one under artesian pressure, microtunneling was selected as the clear choice for the crossing of I-880. During the feasibility analysis, four microtunnel crossings of I-880 were considered. The first two alignment alternatives, shown in Figure 5, each consisted of two microtunneled drives: one parallel to I-880 and the other crossing at a skew angle to reach the approximate exit point of the original HDD alignment.

After discussions with PG&E and the Contractor, two additional pipe jacking alternatives were developed. The third was a single microtunneled drive that crossed both the UPRR tracks and I-880. The fourth alternative consisted of two drives, a short drive to cross the UPRR tracks and a longer drive to cross I-880. After analyzing the settlement risks, relative costs, and site constraints, alternatives 1 and 2 were eliminated. Alternative 3 initially looked promising, but after some research and investigation it was determined that the siphon under I-880 containing flows from the Alameda County Flood Control Channel was deeper than anticipated. To cross the siphon with sufficient clearance to avoid the risk of settlement damage would have required the trenchless crossing penetrate the lower aquifer, which would have dramatically increased the risks associated with the crossing and the cost of building the jacking and reception shafts. Alternative 3 was therefore eliminated from consideration and pipe jacking alternative 4 was selected as the preferred option.

"Final success of this project truly comes down to the entire project team!"

Pipe jacking alterative 4 consisted of two drives: an approximately 130-foot shallow drive perpendicular to the UPRR tracks and a deeper, approximately 350-foot drive below I-880. The two drives required a total of three shafts: a shallow jacking shaft on the north side of the railroad tracks for the short crossing, a joint reception/ jacking shaft south of the railroad tracks and west of I-880, and a deep reception shaft on the east side of I-880. An invert elevation of 22.5 feet was selected for the UPRR track crossing, which resulted in approximately 11 feet of cover

between the crown of the new pipeline and the ground surface. The short drive was located above the groundwater elevation and both aquifers so the allowable construction methods were auger boring, guided boring, and microtunneling. The specifications also allowed the jacking shaft for the short drive to be constructed using nonwatertight methods.

As mentioned previously, due to the depth of the freeway, groundwater elevation, and two aquifers, microtunneling was determined to be the only feasible trenchless method for the longer drive. Selection of the microtunnel driveinvert elevation was challenging as there were several factors that had to be balanced: the pipeline had to have sufficient clearance to mitigate the risk of settlement damage to I-880 and existing storm drains while avoiding the risk of encountering the lower aquifer which could have resulted in problems for the trenchless construction and permitting issues. An invert elevation of 0.5 feet was selected for the pipeline which resulted in approximately 15 feet of clearance between the crown of the 30-inch diameter pipe and the road, approximately 8 feet of clearance between the crown of the gas line and the invert of the existing storm drains, and approximately 10 feet of clearance between the pipe invert and the anticipated location of the top of the artesian lower aquifer.

There were several additional design considerations that had to be addressed with the selected trenchless alternative. One set of issues that the design team looked at had to do with the installation of the gas product pipe. For corrosion management reasons, PG&E does not typically install their transmission pipelines in casings. However, on a previous PG&E project there was an issue with the microtunneling machine veering significantly off of line and grade while attempting to direct jack the gas product pipe. Direct jacking the gas product pipe also has the downside of being a time-consuming process as each product pipe joint has to be welded, x-rayed, and coated. For a 30-inch pipe, this process could take as much as an 8-hour shift per

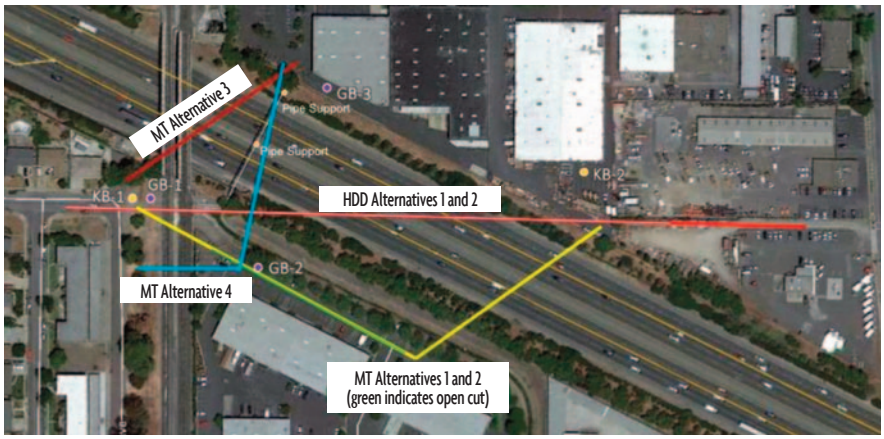


Figure 5. HDD and microtunnel alignment alternatives identified during the feasibility analyses

weld. To address all of these issues, the design team specified the Contractor use a sacrificial casing while tunneling and then displace the sacrificial casing with the product pipe. Each product pipe weld would still take many hours, but the Contractor could demobilize the microtunneling machine and most of the support equipment, leaving just what was necessary to run the jacking frame to push the product pipe.

Several design issues were tied to the shaft sizing and shaft construction method. Alameda County Water District (ACWD) has strict permitting conditions in this area in order to avoid cross-contamination between the two aquifers. As a result, the allowable shaft construction methods for the two deep shafts were restricted to cutter soil mixing (CSM) and secant piles. Sizing and positioning of the shafts was also a challenge because the shafts needed to be sized to accommodate the trenchless construction activities as well as construction of the gas pipe risers at angles that would allow a smart pig to be run through them while maintaining adequate clearance from the excavations to nearby buildings and other site features such as the existing 30-inch diameter Line 153 pipeline. There were also restrictions on where the microtunnel drive could be located to avoid the existing gas pipeline support in the center of the freeway, the existing gas pipeline on the east side of I-880, the flood canal, and the storm drains and storm drain manhole in the center of I-880. The design team allowed a maximum jacking shaft excavation size of 40 feet by 40 feet

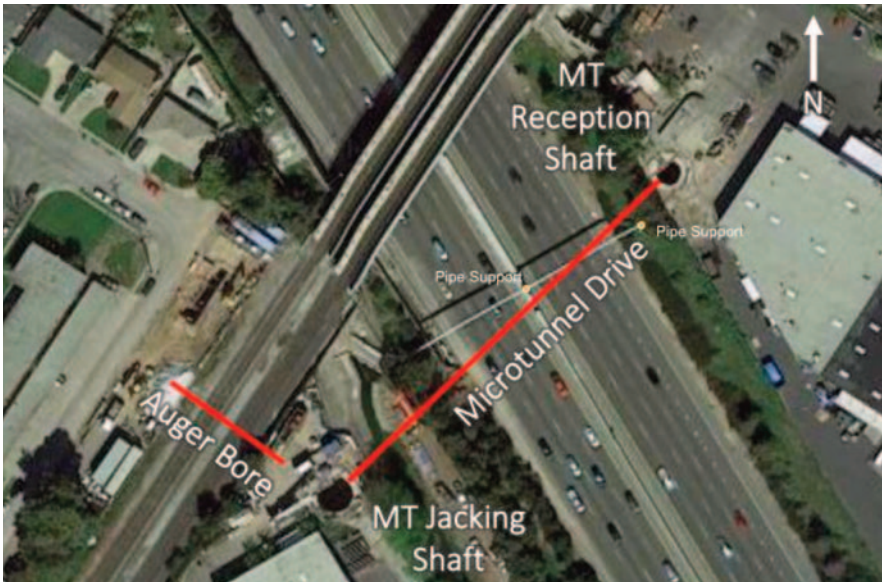


Figure 6. Aerial photograph showing the location of the shafts, microtunnel drive, and auger bore drive

and maximum reception shaft excavation size of 40 feet by 30 feet, and left the selection of the final shaft size to the Contractor.

The final alignment and shaft locations are shown in Figure 6. The alignment threaded the needle between the supports for the existing pipe while maintaining adequate clearance between the shaft excavations and buildings/site features. As a result, the microtunnel drive passed beneath the edge of the Caltrans retaining wall and a storm drain manhole. These existing features were of significant concern as they could result in an unsuccessful microtunneling drive. The design team therefore obtained as-built documents from Caltrans and dedicated a significant amount of time to determining the as-built location and foundation type of the retaining wall as well as the invert elevation of the storm drain manhole. There was not much information available about the construction of the storm drain manhole, but the storm drains were dipped and it was determined that the foundation of the manhole construction would have to be at least 7 feet thick for the microtunneling machine to strike it. As this was highly unlikely (it would be highly unusual for this type of construction in this area), the risk of striking or damaging this feature was deemed low. Based on the as-built drawings that were obtained, it was determined that the retaining wall foundation was a spread footing and that there would be sufficient clearance between it and the microtunnel that the risk of striking or damaging it would be very low.

Unfortunately, as we will discuss in more depth, the retaining wall as-builts did not actually reflect what was constructed which led to a significant problem during the trenchless construction.

START OF CONSTRUCTION

Shaft construction began in early December 2016 when Malcom Drilling started installing the two CSM wall shafts. The launch shaft was to be 30 feet in inside diameter with the reception shaft being 20 feet. Both shafts would have floors constructed out of eight-foot diameter jet grout columns. It was necessary to jet grout the shaft floor prior to excavation in order to keep water from the lower aquifer from flooding the shaft. The jet grout plugs for the launch and reception shafts were approximately 18 and 13 feet thick respectively. While the launch shaft was installed without issue, an abandoned utility was struck during the installation of the reception shaft. The abandoned line was removed, capped and then construction continued after an observed holiday.

Figure 7. Photos of the pieces of metal found in the spoils coming off of the separation plant

After the jet grouting and CSM walls were completed the shafts were excavated. By jet grouting the slab, the only water that needed to be disposed of was from the saturated soil inside the shaft. The bottom of the shaft was cleaned and a smooth working slab was poured. Vadnais Trenchless (a subsidiary of Primoris Services Corporation, PSC) mobilized to the site in late January of 2017. After troubleshooting to resolve an issue with a booster pump and a new light source in the head that was creating glare on some of the gauges, Vadnais launched the 30-inch microtunneling machine (MTBM) on February 1, 2017.

On the first day of tunneling, they successfully buried the machine and set the first section of sacrificial Permalok casing. They had some difficulty fully engaging the gasketed joint between the MTBM and the casing because there was not much frictional resistance along the bore and they did not want to push the face of the MTBM into the clay, as this could result in challenges when they resumed tunneling. They therefore spent a portion of the day welding temporary connections between the machine and the jacking frame. This enabled them to close the gap in the joint by the end of the day. Tunneling resumed the following day and Vadnais successfully installed the first 20-foot section of casing at an advance rate of approximately 0.75 inches per minute. On the third day of tunneling Vadnais spent some additional time dealing with the lighting inside the machine. At this point in the tunnel their solution to the glare problem they encountered at the start, diffusing some of the light with a welding shield, resulted in not enough light to see the gauges. A crew member went into the tunnel and was able to make some small holes in the welding shield and remedy the problem.

After this was resolved, tunneling of casing joint two proceeded smoothly at an advance rate of approximately 1.5 inches per minute. In the afternoon a small leak occurred in one of the slurry lines running along the northern fence of the site. Some slurry flowed under the fence and a small amount entered the Alameda County Flood Control Channel. The Contractor documented the spill, notified the appropriate people, and cleaned up the slurry before leaving the site. The following two days of tunneling proceeded smoothly. Each day Vadnais

installed a joint and a half of Permalok (30 feet of total production per day) at an advance rate of approximately 1.5 inches per minute.

After six overall smooth days of tunneling, a significant problem occurred on February 7, the sixth day of tunneling. Setup of the sixth section of Permalok casing was completed and tunneling resumed around 8:50. At 11:10, with the MTBM head located approximately 126 feet from the face of the jacking pit, torque abruptly spiked to over 100 percent of capacity (the machine had been running consistently at 60 percent torque) and the machine rolled 13 degrees. Shortly thereafter, angular gravel and coarse sand started coming off of the separation plant, which was a departure from the consistent clay soils that had been encountered up to this point. Vadnais continued attempting to advance, alternating the rotation direction of the head between clockwise and counterclockwise to keep the machine roll between 10 degrees in either direction. After 10 minutes, earth pressure on the face dropped to practically nothing until, once every approximately 10 seconds, it would spike to over 10 tons per square meter.

Vadnais stopped tunneling and notified the construction team and PG&E of the sudden change in tunneling conditions. It was determined that the MTBM was approximately 9 feet short of the freeway and 11 feet short of the first storm drain that crossed the alignment. The surface features that were present near the location of the tunnel face were the toe of the embankment and the retaining wall on the southwest side of the freeway. With this in mind, after a discussionwith the construction team, Vadnais was directed to continue tunneling but to proceed with caution. Tunneling resumed for just over ten minutes. At this time, several small pieces of metal an inch or less long (shown in Figure 7) were found in the spoils coming off of the separation plant. Vadnais shut down and notified PG&E of the situation.

DIG UP AND REMOVAL OF OBSTRUCTION

After measurements were taken, it was clear that the mictrotunneling head was located directly behind the retaining wall. Either the retaining wall was deeper than the as-builts had indicated or something was buried under the wall. Discussions quickly developed into how to get down to the head to find out what was in front of the machine. Teams worked in parallel to get access to perform night work on the shoulder of Highway 880, design an excavation plan, and initiate discussions with Caltrans Engineering.

As the microtunnel alignment was designed between two aquifers, groundwater management was going to be a challenge during the dig up operations. ACWD was closely consulted throughout this project and recognized that the project was in an emergency situation. Therefore, ACWD allowed the team to proceed with the excavation under the existing permits. Due to ongoing construction activities on Highway 880 near the project site and Caltrans policies regarding multiple active projects within a certain distance of each other on the same highway, access to the location above the MTBM was limited. However, in mid-February a crew was able to go out with a vacuum excavator at night to begin an exploratory excavation on the back side of the retaining wall. The plan was to follow the back side of the wall and find the depth of the shallow footing to confirm the as-builts and locate what was struck. From this investigation it was determined that the MTBM had encountered an I-beam poured into theretaining structure. After confirming that the as-builts showed a shallow spread footing, an engineer at Caltrans, not originally part of the Caltrans permit review team, recalled that indeed piles were driven for the full length of the retaining structure and that the as-builts were incorrect.

Caltrans agreed to allow PG&E to remove the section of I-beam impeding the installation of the new gas pipeline and a larger excavation plan was designed. Caltrans also agreed to allow PG&E and ARB to perform their night work until the obstruction could be removed.

On Febuary 25, 2017 the contractor began excavating and lowering a large reinforced vault. Additional sheet-piles were eventually driven around the I-beam to increase the size of excavation. Due to the amount of groundwater encountered, the lowering of the box and the overall excavation process was slow. However, on Saturday March 11 the Contractor exposed the front half of the machine. That next week the obstruction was cut out of the way and the shaft was backfilled with slurry.

COMPLETION OF TRENCHLESS CONSTRUCTION

Microtunneling operations resumed on March 16. On that day, Vadnais installed approximately 30 feet of casing (the remainder of casing six, all of casing seven, and a portion of casing eight). At the end of the day, they had a slurry valve malfunction at the face which they addressed by refilling the hydraulic oil reservoir for the valves the following day. Unfortunately, after installing the remainder of casing eight and a portion of casing nine, they continued having problems with the valve and so only achieved a total of 14 feet of production on March 17. So, on the following day they created a slurry bypass circuit in the jacking shaft to work around the problems with the valve and continued tunneling. (The problematic valve could not be accessed or repaired while the MTBM was underground.) When they resumed tunneling casing nine, slurry traveled back through the annular space and was able to reach the surface through the backfilled emergency excavation at the toe of the embankment. Slurry entered the storm drain on the shoulder of I-880 and got into the canal siphon. The construction team cleaned up the spill and Vadnais was able to finish installation of casing nine with no further slurry releases.

At this time, PG&E was becoming increasingly concerned about meeting the hard schedule deadline for tie-in of was due to an allowed clearance on the line that all parties involved were trying to

coordinate. After discussions with the design and construction teams and PG&E, the decision was made to begin installation of the product pipe behind sacrificial Permalok casing nine. With nine sacrificial casings installed, it was felt that the steering issues encountered on the previous PG&E microtunneling project had been adequately mitigated. Even if the product pipe were to be significantly less than straight, there would still be enough flexibility in the sacrificial casings to allow for steering response. PSC and Vadnais therefore welded a short transition section to the front of the first section of gas product pipe and, on March 18th installed it in the pipe jacking string.

Vadnais began installing the first section of gas product pipe at 12:50 on March 18 and immediately saw slurry returns at the ground surface on the shoulder of I-880. The slurry returns occurred at the same location as the morning when they occurred during installation of casing nine. After cleaning the spill and a discussion with the construction team, Vadnais reattempted to advance the first section of gas product pipe. This time they made several changes to their tunneling start-up sequence which resulted in no additional slurry loss to the surface. At the end of the day, a total of 208 feet of pipe was installed. When they attempted to resume tunneling the following day, however, they once again had a problem with losing slurry. There was no spill at the ground surface this time, but the separation plant operator reported that they lost slurry from the separation plant tank and workers monitoring the rescue operation reported water making its way into the excavation. There was no vac truck on site at the time to clean up or assist with containing a spill that could impact the freeway, so Vadnais shut down for the day without advancing the tunnel.

The following morning, with a vac truck staged and ready to clean up any inadvertent returns, Vadnais once again attempted to resume tunneling. Initially they struggled to maintain circulation, but after some additional adjustments they were able to successfully install the second section of gas product pipe with no problems. Over the next five days, Vadnais installed six additional sections of gas product pipe. Tunneling operations proceeded smoothly and the only reason that production rates were not higher was that it took approximately eight hours to weld, inspect, and coat each gas product pipe. Vadnais and ARB coordinated closely to enable the welding and tunneling crews to switch at appropriate times so that installation would proceed as quickly as possible. On March 29, the MTBM reached the soilcrete wall of the reception shaft at the end of gas product pipe nine, 346 feet from the face of the jacking shaft. The MTBM was pushed out of the exit seal and successfully retrieved on March 30.

Vadnais resumed installing the remaining product pipe and the projectwas completed in time for the original tie-in.

CONCLUSIONS

This project proves that even with a complete geotechnical report, a thorough routing analysis, and using the correct trenchless installation method for the anticipated conditions, you cannot design for the unknown. We were ultimately able to find the obstruction and, as it turns out, the I-beam was visible just below the ground surface but engineers, contractors, and owners need to be able to trust in as-builts. Correcting these drawings could have saved money, time, and a great deal of effort by all parties involved.

With all that said, the final success of this project truly comes down to the entire project team. Owner, contractor, and engineers all working together to find the problem, put together a plan, and then put that plan into action. Without everyone working together as a team this problem would not have been solved in the time that it was and, with trenchless projects, time can be your worst enemy.

ACKNOWLEDGEMENTS

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Pacific Gas and Electric Company, incorporated in California in 1905, is one of the largest combined natural gas and electric energy companies in the United States. Based in Oakland, the company is a subsidiary of PG&E Corporation. The company provides natural gas and electric service to approximately 16 million people throughout northern and central California.

How Augmented Reality Can Transform Natural Gas Operations Training

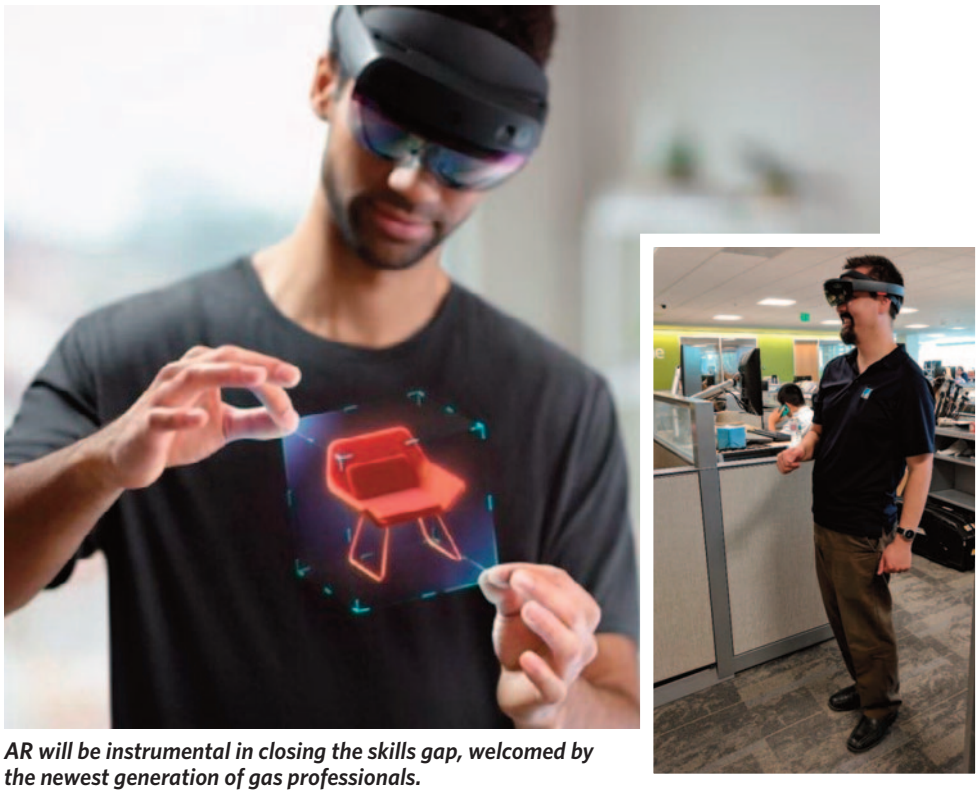
By: Ahra Kwon, Senior Project Manager, NYSEARCH

The natural gas industry is experiencing a tremendous amount of change. With that change, comes the need for more resources meaning more highly trained gas operators need to be trained and qualified faster to prepare the network to accept new and emerging fuels, and to replace aging infrastructure. Simultaneously, retirements of personnel have expanded the need to bring in a new, younger workforce that needs a fast-paced and high degree of training and certification by various entities. This results in a need for expanding gas operator training programs and a need to innovate on methods for training.

Today, to rise to a fully rated, high level gas operator, training must be gained in the classroom and in the field. Rarely are gas industry field conditions able to be simulated without actual participation in field activities. Augmented Reality (AR) provides a means to bring 3D imagery and animation that depicts various tasks or scenarios to gas company training programs. This accelerates the ability for the trainee to experience the conditions that are required for that task and to make the process for gaining knowledge more accurate and efficient.

The belief is that Augmented Reality technologies will be instrumental in closing the skill gap that is responsible for the shortage of skilled workers. Because AR will allow more workers to do high-skill jobs, and improve their performance in this work, industrial productivity will grow. Further, due to the young age and interest with 'gamification', the newest generation of gas professionals would likely welcome with little inhibition the latest generation of technology for their training and take more interest in a job and a training program that is embracing digital state-of-the-art technology.

NYSEARCH, an RD&D consortium with members from natural gas Local Distribution Companies (LDC) across North America, completed a research project evaluating the benefits and challenges of adopting the use of AR with Microsoft HoloLens. The program began in 2017 with a pilot program to test and learn about the full capabilities of AR, specifically with the first-generation Microsoft HoloLens. NYSEARCH funders then collaborated in 2019 through 2020 with CraneMorley, Inc., a training and skills education-based content developer, to create a gas leak investigation application on the second-generation Microsoft HoloLens, which was released during the app development period. In 2020 through 2023, CraneMorley delivered unique gas operations training applications for NYSEARCH funding utilities based on each utility need on where they felt AR could have the highest impact in gas operations training.



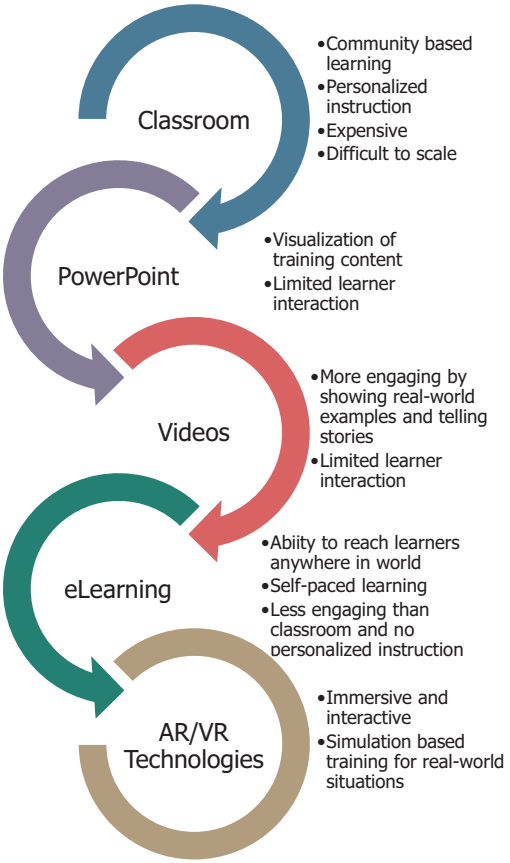
AR will be instrumental in closing the skills gap, welcomed by the newest generation of gas professionals.

A Microsoft 365 Dynamics Guide developed for residential meter set assembly created a more immersive, skills-focused environment

AR/VR technologies have the potential to revolutionize the way training is delivered.

THE EVOLUTION OF TRAINING DELIVERY

The evolution of technical training has been a dynamic process, driven by the rise of new technologies, the need for more flexible and cost-effective training, and the desire to provide learners with a more engaging and immersive learning experience. The natural gas industry has generally followed the changing methods of training delivery and always remains focused with on-the-job training and hands-on experiences for developing a fully trained gas operator.



Classroom training has been the most dominant method of training for centuries. It offers several benefits, such as personalized instruction, relationship building, and a sense of community. However, it can also be expensive, time-consuming, and difficult to scale to large groups of learners. PowerPoints and Videos enhanced the classroom experience, but those methods alone do not offer a high impact learning experience for trainees.

eLearning is a more recent method of training that uses electronic media to deliver instruction. eLearning offers several benefits, such as the ability to reach learners anywhere in the world, to provide self-paced learning, and to save time and money. However, it can also be less engaging than classroom training, and it can be difficult to provide personalized instruction.

AR/VR technologies offer the latest advancement and opportunity in training and learning. These technologies allow learners to interact with virtual environments and objects, which can make training more immersive and engaging. This can be a very effective way to train learners on complex tasks or to provide them with a realistic experience of a real-world environment. However, AR and VR technologies are quickly advancing and thus changing, and they can be expensive and difficult to implement. AR/VR technologies have the potential to revolutionize the way training is delivered.

AUGMENTED REALITY VALUE REALIZED WITH NYSEARCH R&D PROJECT

For the natural gas operations industry, the biggest value provided is the use of Augmented Reality for skills-based training of complex tasks that accelerates and enhances effective classroom training and supports on-the-job training activities. Augmented reality (AR) is a technology that superimposes a computer-generated image on a user's view of the real world, thus providing a composite view. Augmented reality (AR) is a rapidly developing technology with the potential to transform natural gas operations training. AR can be used to create realistic simulations of dangerous or hazardous situations, provide real-time instructions and guidance to trainees, and make training more engaging and immersive.

One of the most significant benefits of AR for natural gas operations training is the potential to improve safety. AR can be used to create realistic simulations of dangerous or hazardous situations, allowing trainees to learn how to respond without actually putting themselves at risk. For example, NYSEARCH built an AR training application that simulated a residential gas leak, allowing trainees to practice how to address the customer who called about the leak, identify, and contain the leak without being in the presence of a live gas leak.

AR can also be used to increase the efficiency of natural gas operations training. It can be used to provide real-time instructions and guidance to trainees, help-

ing them to complete tasks more quickly and efficiently. For example, an AR training application could overlay instructions on a physical object, such as a piece of machinery, helping a technician to troubleshoot a problem more quickly.

In addition to improving safety and efficiency, AR can also enhance the learning experience for natural gas operations trainees. AR can make training more engaging and immersive, helping trainees to retain information more effectively. For example, an AR training application could overlay 3D models of equipment on a physical environment, allowing trainees to see how the equipment works in a realistic setting. This can help trainees to understand complex concepts more easily and to remember what they have learned for longer.

Finally, AR can also reduce the costs of natural gas operations training. AR can eliminate the need for travel and physical equipment, which can save companies significant amounts of money. For example, an AR training application could be used to train workers on a new piece of equipment without the need to bring the equipment to the training location or have students travel to a training location. Microsoft HoloLens offers a Remote Assist capability that could offer these cost-savings for gas utilities.

NYSEARCH funders spent significant time with CraneMorley to identify the best use case for the Microsoft HoloLens where AR would have the highest impact on trainees. One utility funder identified a valve changer tool, and a Microsoft 365 Guides application was built to enhance and increase engagement and interaction with their valve changing procedure. At another utility, a new bolt-tee removal tool was rolled out and the training supervisors noted how difficult training and retention of learned material was for this new tool. Thus, an AR application was built to help students understand the tool intricacies and its inner workings as the tool entered the pipe using 3D holograms to superimpose images on reality. Another utility funder focused their AR training application on the building of a residential meter set specific to their procedures especially in cold winter conditions. Another utility funder built a plastic pipe fusion Guides with McElroy fusion equipment. A further utility funder identified Line Locate as their most failed training topic and an AR Microsoft Guides was developed to enhance and immerse the student with different line locating scenarios built for a training simulation site based at the utility training headquarters.

AR has the potential to transform natural gas operations training by making it more safe, efficient, effective, and affordable. NYSEARCH members explored a handful of opportunities where AR could have the most impact. As AR technology continues to develop, we can expect to see even more innovative and effective ways to use AR to train workers in the gas industry.

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AR technology offers Remote Assist capabilities, reducing the need for travel

Augmented reality provides an immersive 'heads-up' and 'hands-free' training experience

A Microsoft 365 Dynamics Guide being developed for Line Locating at Southwest Gas in Tempe, AZ

ABOUT THE AUTHOR

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