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NASTT NORTHEAST REGIONAL CHAPTER

2020
SPRING/SUMMER

World Record 42-Inch Gas Main CIPL

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NORTHEAST REGIONAL CHAPTER

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Printed 06/20 in Canada.

New World Record CIPL Achieved with Planning, Experience and Networking

Challenging Renewal of 42-Inch Trunk Gas Main under the Garden State Parkway in East Orange, NJ Sets New World Record

By: George Ragula, Public Service Electric & Gas

INTRODUCTION

Technical innovations gained from previous experience, detailed planning, field innovations, and the knowledge base provided by industry research and development were key elements in helping us achieve a new world record last summer lining the largest diameter gas pipeline ever renewed using CIPL.

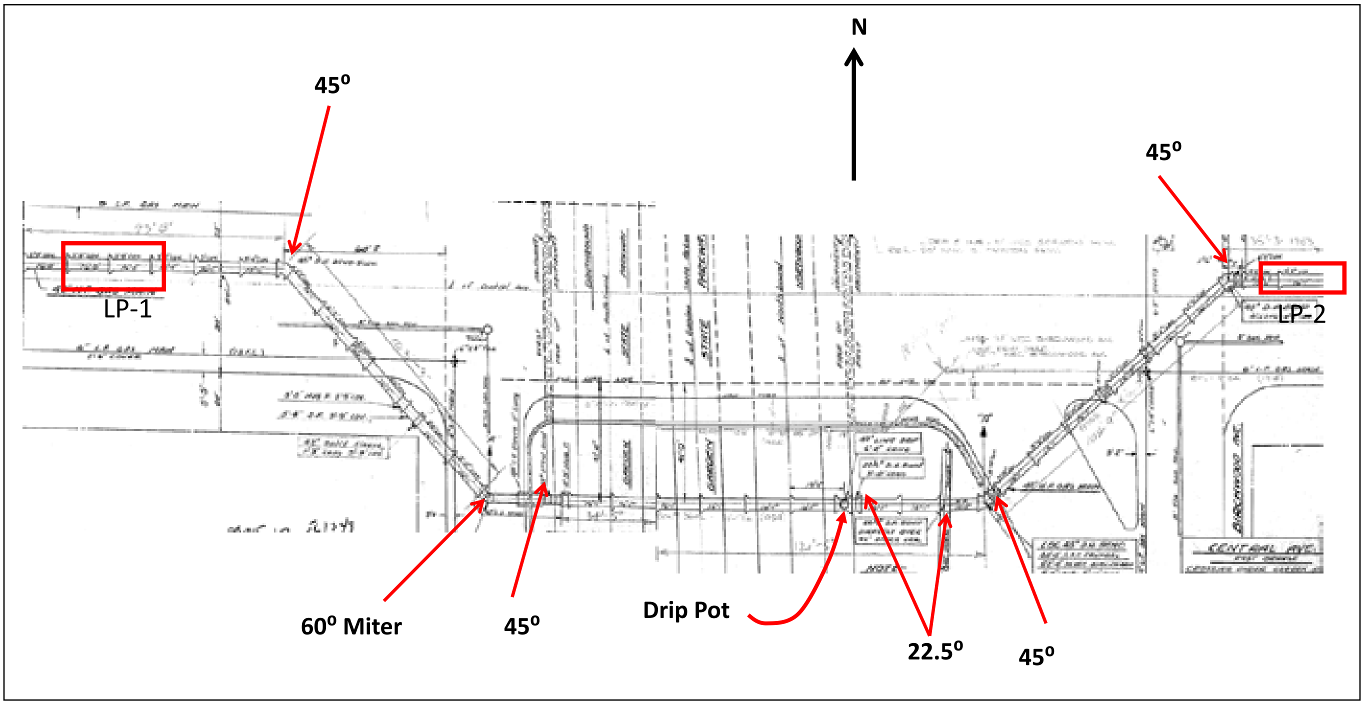
The new world record diameter milestone set on July 19, 2019 lining 573 feet of 42-inch high pressure cast iron (CI) gas main crossing under the Garden State Parkway at the Central Avenue Bridge in East Orange, New Jersey was accomplished because of the lessons learned by ourselves and lining contractor Progressive Pipe Management (PPM) of Wenonah NJ, in overcoming challenges on previous CIPL projects renewing progressively larger diameter CI gas mains. This breakthrough milestone was achieved with help and expert advice from NASTT industry colleagues.

Records are made to be broken, and surpassed with even greater achievements.

> *"A tremendous win from a well-engineered plan!"*
>
> -David Wickersham, President/CEO, Progressive Pipeline Management

Research and development, based on acquired experience, provides the foundation for this effort. Two years ago in September 2017 we set a new world record, and a major breakthrough for CIPL at the time, when we lined 2,000 LF of 36-inch CI feeder main in nearby South Orange. Largest diameter ever back then, it was one of the most challenging projects I'd ever faced. The lessons we learned lining the 36-inch pipe became invaluable in planning future projects with larger diameters and longer inversions. The obstacles we overcame on this landmark 36-inch project in 2017 were instrumental in driving the new technical innovations that were crucial in setting the new milestone World Record 42-inch CIPL in summer 2019.

World record 42-inch CIPL was accomplished because of lessons learned on previous projects



Pipe segment was inaccessible and difficult to repair with seven bends in total

LAYOUT

The Garden State Parkway (GSP) is the longest highway in New Jersey, a key toll road stretching from south to north across the state. East Orange, known as "The Crossroads of New Jersey," is centrally located only a few miles from the Newark Airport and less than half an hour away from New York City. The 42-inch main runs directly under Central Avenue, the main artery through East Orange, which crosses over the GSP at the Central Avenue Bridge.

Installed underneath Central Avenue in 1954 using inner-tite mechanical joints, the 42-inch main descends down a steep embankment right before the bridge to cross the Garden State Parkway at roughly 7 feet below the freeway lanes. The Parkway itself is situated 25 feet below grade level from the surrounding streets. After crossing underneath the GSP, the pipe climbs back up under the opposite highway retaining wall, snaking westward after a series of bends directly below Central Avenue.

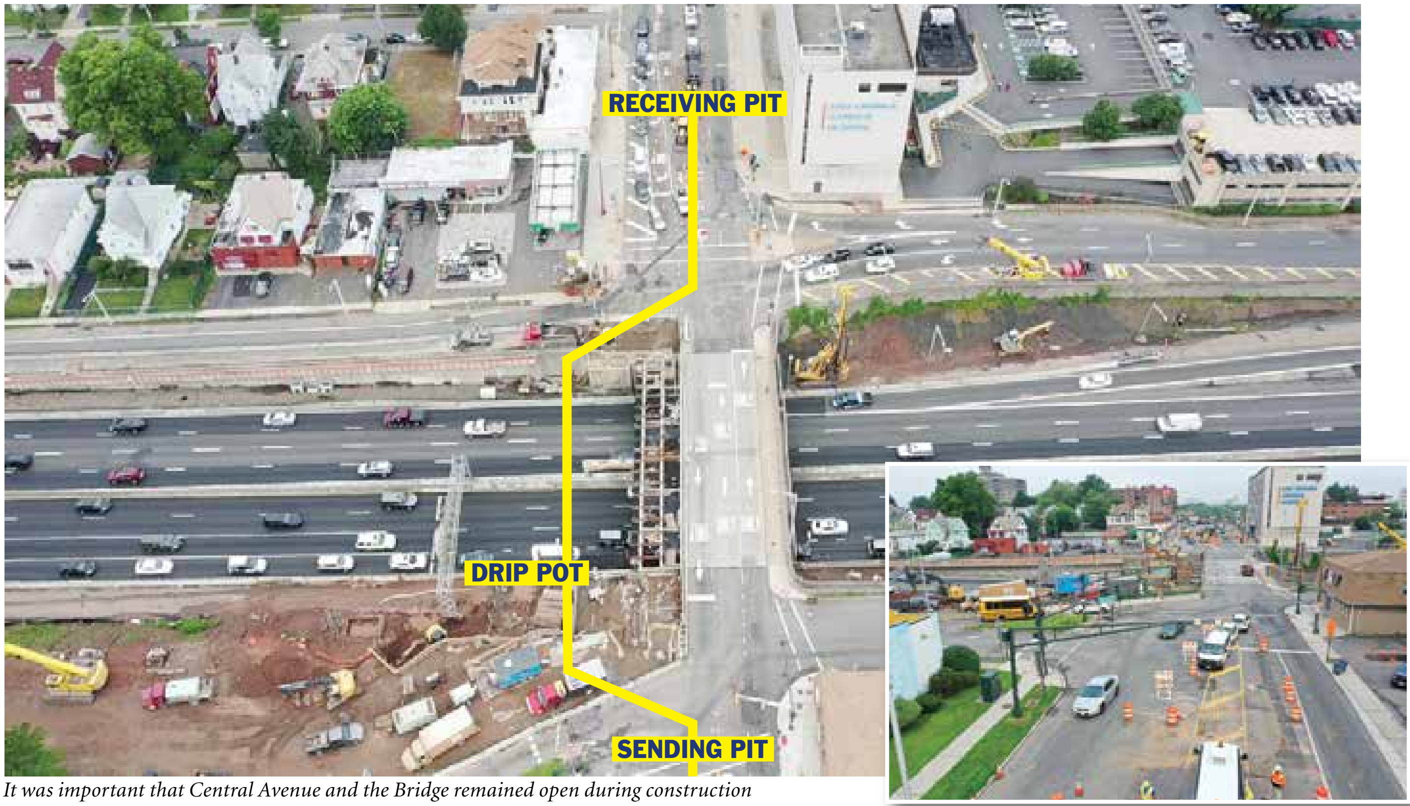
In order to negotiate the steep grade change and cross under the below grade eight-lane GSP, the 42-inch pipe was originally built in a shallow basin shape, essentially a flattened "u-tube" configuration. This segment of pipe was a very complicated layout to repair with seven bends in total: three 45-degree bends, one 45-degree steel miter bend included in a short section of steel pipe, which also contained a 60-degree miter bend, and two 22-1/2-degree bends. Because of the below grade construction of the GSP, the section of pipe crossing under the freeway lanes was a low point in this area for the gas distribution system, which meant there was also a drip pot fitting for liquid collection and removal, a holdover from the early days of wet manufactured gas. The drip pot created a 48-inch gap in the pipe, which had to be bridged with a custom fabricated steel structural reinforcement sleeve (SRS).

Careful planning of the Central Avenue project was necessary to overcome this extremely challenging pipe layout and geometry, and we knew the solutions had to be very well thought out. Based on the knowledge acquired from our experiences in previous lining projects, we were able to anticipate many of the challenges encountered with the large 42-inch diameter, which resulted from the inaccessibility and unusual pipe layout on this project. Carefully designed and serendipitous technical innovations were implemented which resulted ultimately in a well-coordinated smooth liner installation, with no issues, and a very successful outcome with ample time left before the September 1 gas-in date.

CIPL

When the New Jersey DOT announced in late 2014 it was planning the reconstruction of the Central Avenue Bridge, along with improvements to the adjacent highway shoulder areas where our main was located, a preliminary survey of this segment of pipe done by PSEG revealed significant leakage at the inner-tite mechanical joints. This was no surprise with inaccessible pipe of this type and age.

Most of the aging inventory of large diameter cast iron pipe used in gas mains is still in remarkably good condition. The pipe walls are very thick and graphitization is uncommon and generally inconsequential, however leaking joints are the weak link regularly encountered in large diameter CI pipelines. Generally, leaks at these joints are costly to point repair due to their size and depth. Because the joints in large diameter gas mains are usually spaced at 12- or 18-foot intervals, excavations or potholing these joints



It was important that Central Avenue and the Bridge remained open during construction

to repair them by encapsulation is both time consuming and difficult. CIPL offers a practical and cost effective trenchless repair and renewal alternative due to these time and cost challenges, therefore its use continues to expand in the gas industry.

At the outset of planning back in 2014, we determined that because of the challenging layout of the 42-inch pipe and deep, inaccessible location under the GSP, CIPL renewal was the best, in fact only, viable option to repair and renew this section of main. Excavations or potholing across the GSP traffic lanes were out of the question, and with the East Orange Hospital nearby, it was imperative that Central Avenue and the Central Avenue Bridge remained open during construction. Additionally, CIPL provided the advantage of being able to locate the sending and receiving pits on each side of the GSP far enough away to minimize any interference with the simultaneous Central Avenue Bridge reconstruction work, which already was creating traffic gridlock.

INNOVATIONS

The close proximity to the bridge reconstruction, and requirement for traffic flow to stay open along Central Avenue for the duration of the project, were key considerations in planning. Careful planning and a detailed game plan was critical, and considerable time was invested in a comprehensive design effort to prepare for the lining work. Our ingenuity and resourcefulness were stretched to meet the challenges posed by the diameter, geometry and inaccessibility of the main. Helped along with some advice from industry experts, innovative solutions were found during the design phase that arose from the lessons learned on previous lining projects.

These first-ever technical innovations for lining CI gas pipe included:

- New inversion drum & transport hose to handle large diameter liner
- Injected curtain grouting preventing water penetration into depressurized pipe
- Robotic self-propelled sandblasting unit for cleaning pipe
- Dust collectors (64,000cfm) used for high velocity post-clean grit removal to prevent stranded grit issues.
- Largest fabricated steel SRS ever built to bridge 48-inch long drip pot gap
- Inverting a large diameter liner through seven bends & multiple grade changes
- Additional reinforcement to liner tail and catch end

BRIDGE RECONSTRUCTION

With the formal announcement in early January 2019 of the start of the Central Avenue bridge reconstruction in the summer, intensive, detailed final planning for the gas main renewal project immediately ramped up. Because this was a critical major gas main feed for the overall gas network, there was an extremely limited window for service outage with gas-in and completion mandated by September 1. We had to work fast and get materials into place quickly. Lining this pipe size and configuration had never been attempted before, so it was important that every detail was meticulously reviewed and mapped out before construction began.

Preliminary live CCTV inspection was done in late January using a variable geometry crawler installed through a 4-inch tap hole. The inspection showed the interior of the pipe was relatively clean and confirmed there were no anomalies or fittings that could interfere with the lining, aside from the 48-inch gap created by the drip pot fitting.

After the locations of the sending and receiving pits along Central Avenue were established on either side of the bridge, a total of 700 feet of the Starline® liner product was ordered from the German manufacturer, Karl Weiss Technologies GmbH. This gave us enough left over for wastage and the expected 12-week delivery turnaround would ensure the liner was in place by end of May, well before the excavating contractor move-in date.

Project contractors PPM specialize in gas infrastructure construction and, since 2002, are exclusive North American installers of the Starline® liner product. Developed specifically for renewing high pressure large diameter natural gas mains, the patented Starline® liner system has undergone ten years of rigorous testing with PHMSA, Cornell University, and NYSEARCH, demonstrating the potential for a 100+ year service lifespan. According to David Wickersham, PPM President and CEO, "There are simply no other liners available for use today in the gas industry that have a similar testing pedigree." All PPM crews are thoroughly trained and familiar with installing the liner, which uses a specially formulated two-part epoxy to bond the liner to the host pipe. The epoxy is mixed onsite and applied to the liner just before inversion.

INVERSION DRUM

The 700 feet of liner ordered was well inside the load capacity of the new liner inversion drum, purpose built for installations on large diameter gas mains. Developed and custom fabricated by the German lining manufacturer, the new inversion drum incorporated lessons learned from previous large diameter lining projects including the world-record setting 36-inch gas main CIPL renewal project two years ago in South Orange.

The new inversion drum featured a transport hose for the liner that significantly decreased aboveground equipment footprint, reduced the size of the sending pit, and also protected the liner from inadvertent chafing due to angle of entry during inversion. Increased liner capacity, and a redesign of the drum outlet mechanism were additional new improvements which dramatically reduce set-up time and greatly increase crew efficiency during liner installation. The improvements to the liner installation equipment, in conjunction with excellent surface preparation and cleaning beforehand, led to a problem-free liner installation.

GROUTING FIRST

Before cleaning the pipe interior, it was important to first ensure the inner pipe wall was dry, and eliminate any water inflow once the pipe was taken out of service. Experience hard won on prior jobs had shown how water infiltration can derail even the most carefully designed cleaning and liner installation process. Due to the high water table, and pipe depth over 30 feet below grade where the main crossed under the GSP, we expected substantial water intrusion once pressure was off the line.

The main was abandoned June 26, and when the pipe was CCTV inspected a week later during the contractor move-in on July 3, we found the drip pot at the low point had already collected over 70 gallons of water inflow. Close inspection located the source of inflow at the 45-degree mitered steel bend on the short section of steel pipe.

Several potential solutions to stop water inflow had been closely examined during the planning phase and the preferred method selected was curtain grouting, which injects an expanding hydrophilic grout into the surrounding soil. The grout forms a dense semi-rigid foam barrier around the pipe exterior preventing water intrusion from the outside. Avanti AV-275 Soilgrout was recommended for this application since it is designed to bind together and waterproof loose granular soils, and withstands repeated wet/dry cycles.

This was the first time the curtain grouting method had ever been used on a gas main to prevent water entry. Subcontractor Camden Group from Butler New Jersey was brought in for this challenging first-time application of grout from inside a gas main. Man entry was required for the grouting operation, so extensive safety precautions were taken, with rescue harnesses, fresh air circulation, gas monitoring equipment and a confined space rescue team onsite. A body board and pulley system was employed to get workers down to the infiltration site, at the mitered steel elbow. Crews then injected the grout into the soil surrounding the area of inflow by pumping it through check

More than 70 gallons of water collected in the drip pot a week after main abandoned

First-ever application of curtain grouting from inside a gas main required man-entry

Grout pumped into soil through check valves stopped inflow from heavy rainfall

valves in multiple 3/8-inch holes drilled into the pipe.

Surprisingly, after pumping only five gallons of grout into the soil surrounding the pipe, the water inflow stopped. As Scott Laubshire of Camden Group noted, "Based on the project specifics we planned to pump at least 60 gallons into the soil. You can imagine the look on my face when we pumped five gallons of AV-275 grout, and the infiltration stopped!" This was confirmed the next day when, following a significant overnight rainfall of more than 2 inches, the pipe interior was still completely dry at the infiltration site. The grout then cured over the weekend, and on Monday July 15 the operation was completed when excess grout was removed, and the check valves ground flush with the inner pipe wall.

With the first-time use ever of injected curtain grouting to prevent inflow and infiltration prior to cleaning we created a dry interior for sandblast cleaning the pipe, and overcame a major potential cause of liner disbondment. This innovation is an important milestone certain to be used in future projects as a crucial step before cleaning, where water intrusion is encountered in depressurized pipe.

GRIT CLEANING

Thorough cleaning of the pipe interior to remove debris and built up residue is necessary to ensure proper bonding of the installed liner to the host pipe. Ensuring sufficient air velocity to first sandblast clean the inside of the pipe, and then recover the leftover grit, was expected to be a significant hurdle, considering the diameter and geometry of the pipe, combined with the effects of gravity.

Maintaining a minimum 45mph velocity was an achievement, considering pipe diameter and geometry

Self-propelled robotic sand blast unit, "The Beast" efficiently cleaned the metal to a NACE-2 finish

There had been challenges on several previous jobs, especially the record-setting 36-inch CIPL in South Orange, where it had taken a lot of time and effort to remove all the residual grit after sandblast cleaning, almost critically delaying the entire project. Because of this previous experience, we did extensive testing and assessment of different configurations of vacuum equipment ahead of time in the planning phase, in an attempt to find the optimal equipment configuration for maintaining adequate airflow velocity.

In consultation with well-known vacuum excavation expert, John Walko of Excavac, we finally opted to use two dust collectors, with an equivalent 64,000 cfm vacuum capacity, in lieu of eight vacuum trucks. This decision significantly reduced our onsite equipment footprint and potential impact to traffic. Additionally, we determined that upsizing the inlet hoses from 8-inch to 16-inch created better airflow. Considering the large pipe diameter and difficult geometry descending down then back up under the steep embankments on either side of the GSP, maintaining a minimum 45mph velocity was a considerable achievement. For the first time ever on a CIPL project, we had air velocity and vacuum measuring gauges available for real time monitoring during sandblast cleaning and grit recovery operations.

Initial attempts to winch a sandblast head through the pipe didn't work effectively, so we deployed a self-propelled robotic sand blast unit, with an electric motor, designed in California, which was recently purchased by PPM. The unit was very effective in cleaning the pipe even though man-entry was necessary to guide the unit through each of seven bends, as it would frequently topple over due to its high center of gravity. Nevertheless, the sandblast unit, nicknamed "The Beast" by the PPM crew, efficiently cleaned the metal down to a bright-white NACE 2 finish.

According to Wickersham, "It worked brilliantly. The video camera on the unit allowed real-time views of results during cleaning. Very quick set-up, the crew was cleaning within 10 minutes. We'll be using it again on large diameters. Another progressive step up for gas CIPL."

LARGEST SRS

After post cleaning CCTV inspection confirmed the inner pipe surface was ready for lining, one final critical step was necessary before installation could begin. The drip pot had been kept active throughout the cleaning in order to collect the expected water inflows following abandonment of the main prior

Resourceful Miller Pipeline crew successfully installed largest SRS bridge ever fabricated to grouting. Since this fitting was at the low point under the GSP it helped reduce excess accumulations of water in the pipe before the curtain grouting stopped inflow. When the main was abandoned, we had replaced the existing steel standpipe with a temporary plastic standpipe, which was removed once the water intrusion was stopped.

Using man-entry, with all the necessary safety protocols, a 6-foot prefabricated SRS made from ¼-inch thick carbon steel, was installed by Miller Pipeline crews to bridge the 48-inch drip pot gap, with a 12-inch overlap extending onto the existing pipe on both sides. The SRS was designed to eliminate any sharp edges which could potentially tear the liner. It was rated to a maximum allowable operating pressure (MAOP) of 66 psig – well above the usual 15 psig MAOP of the 42-inch main, and the 22.5 psig intended for the pressure test at the end of construction.

It took time and effort to position the bridge within the pipe. After several unsuccessful attempts to pull the SRS in two halves through the several bends to the drip pot, it was disassembled into four quarters in order to have adequate clearance moving it 140 feet through the pipe and 45-degree bends Reassembling the SRS at the drip pot was challenging since there was a 22 ½-degree bend connected to one end of the pot. A lot of cutting and fitting work was necessary to finally get it to lay flat on the limited straight section of pipe before the start of the bend radius. The experience and resourcefulness of the Miller Pipeline crew were instrumental in the successful installation of the largest SRS bridge ever fabricated to date. Just before lining commenced, the Miller Pipeline crew also installed Weko Seals in two segments of pipe that were also abandoned as part of the shutdown outside of the immediate CIPL work area.

Because of summer heat-wave, work began at 4am installation day

Inversion pressures required six tail bolts

SUMMER HEAT

Because of the heat wave in the northeast, there was concern the resin could cure prematurely, so a 4am job start was planned on the day of the liner installation, Friday, July 19. We hoped to get the liner wet-out and inversion completely done well before onset of the mid-afternoon heat. The wet-out process involved mixing 40 cans of two-part epoxy, which is then poured into the liner, saturating it. The resin soaked liner is then squeezed through pinch rollers so that the

Careful planning ahead of time helped the liner installation run perfectly

Sending pit, Central Avenue East

Receiving pit, Central Avenue West

epoxy is spread out evenly, impregnating the full length of the liner.

This intricate and tightly choreographed assembly line process involved many people spreading the 2,000 pounds of resin, folding the liner and helping to load it into the inversion drum. Large amounts of lubricant were also applied to the outside of the liner to minimize the friction from the seven bends and two vertical inclines that needed to be traversed during the inversion process.

Based on our previous experience on the 36-inch job using the pressures required to successfully invert the liner through large diameter pipe, six tail bolts were installed in the liner tail to prevent a blow-out at the catch end.

Fittings were then installed onto the abandoned pipe in the sending and receiving pits at either end, and the inversion drum transport hose containing the resin soaked liner was connected to the open pipe end in the sending pit on the east side of the GSP.

SEVEN BENDS

Inversion began at approximately 1 pm, taking just over an hour, with air pressure ranging from 5-7 psig, for the liner to hit the catch end at the receiving pit on the west side of the GSP. In total, the 570-foot 42-inch liner was inverted through 7 bends and two steep slopes on either side of the GSP.

New custom built inversion drum has transport hose for liner

The transport hose was then removed and nitrogen was hooked up to supply make up air to maintain 8-10 psig inside the pipe while the liner ambient cured. Ambient curing took only two days because of the heat wave, so the following Monday, July 22, both ends of the liner were cut and trimmed flush to the pipe.

Final post-lining CCTV inspection confirmed the liner was very tightly bonded with the host pipe, smooth, and entirely free of anomalies. The final pressure test was done immediately afterwards in order to prevent any potential water infiltration from causing liner disbondment.

The test of 22.5 psig held steady overnight. It dropped slightly to 22.44 psig, because hot compressed air in the pipe had cooled overnight.

Following the successful pressure test, pressure was reduced to 10 psig to maintain positive pressure within the pipe until

Final post-lining CCTV

tie-in scheduled for 3 weeks later. Finally, the renewed 42-inch main was successfully gassed-in on Thursday, August 22nd, and everyone involved with the project breathed a sigh of relief for meeting the tight outage window deadline.

Lining this complex challenging segment of pipe was done in record time, and the overall construction process completed two-and-a-half weeks ahead of schedule. The precision coordination during construction, and seamless execution of a complex design plan were possible because of the upfront amount of time and effort we invested in the detailed planning and design of this CIPL project, and the incredible teamwork among ourselves, PSE&G crews, PPM, bridge contractors, and the subcontractors.

Detailed planning and incredible teamwork were keys to success. From left to right: Holger Turloff, Karl Weiss Gmbh, Shane LoPresti, PPM, George Ragula, PSEG, Tom Nestoras, PPM

"Tremendous coordination and careful planning were employed among ourselves, the subcontractors and also the state bridge contractor to ensure the safe and productive work environment we needed to tackle this challenging job", Wickersham summarized, "The successful permanent renewal of this difficult and inaccessible stretch of 42-inch main set a new world record for the largest diameter gas main ever renewed using CIPL technology! A tremendous win from a well-engineered plan!"

LOOK AHEAD

Our achievement in setting a world record for the largest diameter gas pipeline ever to be renewed using CIPL was spurred along by several necessary first-ever technical advancements and improvements to equipment and procedures. These innovations will help improve and speed up work on all future projects lining gas pipe. The technical advances we made establish CIPL as a viable renewal technique on any large diameter gas pipe moving forwards. Because of the upfront planning, expert advice and sheer hard work invested to set this new world record milestone in the gas industry, there are no longer any upper limits to pipe size that can be renewed using CIPL methods. Inventive and curious, humanity's leaders will continue to build a better future using trenchless technology. World records are made to be broken. Research and development, the process of continuous innovation, lights the path.

"If we knew what it was we were doing, it would not be called research, would it?"

(Albert Einstein)

ABOUT THE AUTHOR:

George Ragula *is the Distribution Technology Manager at Public Service Electric & Gas (PSE&G) with over 42 years of experience in gas industry engineering, operations, construction, research/development/deployment and management. George is a noted authority on trenchless applications for the gas industry having spent 32 years specifically focused on trenchless. He received his B.S. in Mechanical Engineering from Polytechnic Institute of Brooklyn in New York. George is a past Chair of NASTT and serves on the NASTT No-Dig Show Program Committee. He also teaches several NASTT courses on various trenchless technology topics, including CIPL for the Gas Industry.*