Section of 36-inch abandoned cast iron pipe

OVERCOMING CHALLENGES KEY TO WORLD RECORD 36-INCH CIPL GAS MAIN RENEWAL

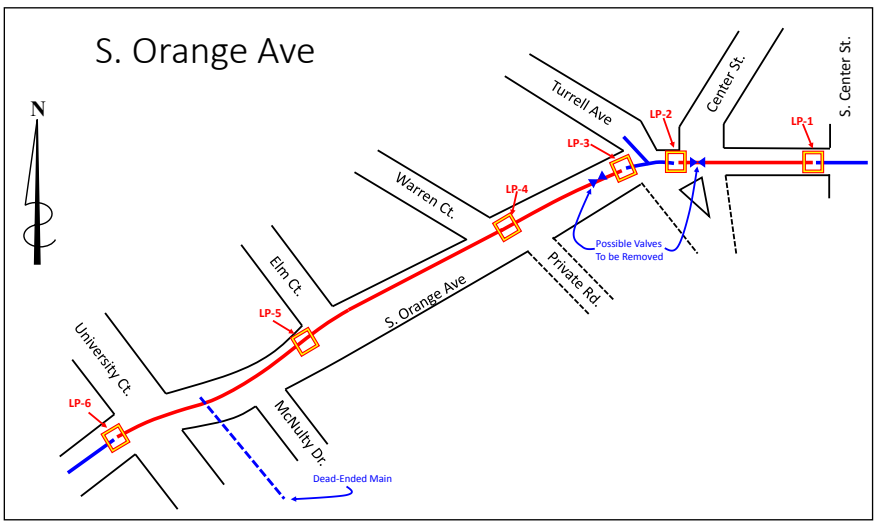
World Record Diameter Gas Main Relined in South Orange, NJ

By: George Ragula, Public Service Electric & Gas

South Orange Avenue is a major urban thoroughfare running through the Seton Hall University campus and into a nearby popular park. I was there on a late November day last year. The sun glistened on orange and yellow leaves and there was a chill in the air. I watched as pedestrians descended again on the crosswalks hustling to class and meetings. Traffic was again back to normal. It was an unlikely setting for the World Record 36-inch Gas Main Reline we had achieved only a week before. I breathed a sigh of relief and thought back on the design process and the challenges we faced during construction which led ultimately to our World Record achievement.

This large diameter feeder main reline was one of the most demanding projects of my 40-year career. Running under this section of South Orange Ave. was a 2,000 LF stretch of 36-inch cast iron gas main pipe originally installed in the fifties. With increasing deterioration over the years a lot of short term sporadic emergency work had been done on this section of cast iron pipe, however a long term permanent solution for this critical feeder main had not yet been formulated. There were now a total of 15 known joint leaks pinpointed along this section so it was critical immediate action be taken to implement a comprehensive long term solution.

Ultimately, the best and most effective long term solution we found required a Cured-In-Place-Liner (CIPL) renewal of this 2,000 LF section of 36-inch cast iron gas main – a new world record as the largest diameter CIPL project ever done on a gas main! This challenging undertaking required innovation, calculated risks and occasional round the clock shifts to complete. It was made possible by the exceptional work and expertise provided by the dedicated teams at Public Service Electric & Gas (PSE&G), Progressive Pipeline Management (PPM) and Karl Weiss Technologies GmbH. The outcome of our teamwork was a successful permanent renewal of the feeder main using trenchless technology and a new world record set for the largest diameter gas main renewed with CIPL!



South Orange Avenue 36-inch feeder main alignment

WITH SUCH AN UNPRECEDENTED SIZE DIAMETER OF PIPE TO BE LINED, A DETAILED GAME PLAN WAS CRITICAL, AND CONSIDERABLE TIME WAS INVESTED INTO PLANNING AND COORDINATING OUR APPROACH.

DECISION TO LINE: JUNE/2017 – SEPTEMBER/2017

Buried at an average depth of 4 feet under the fresh pavement surface of South Orange Ave., the 36-inch high pressure main was embedded amongst a congestion of subsurface utilities including telephone, water, multiple sewer lines, storm drains, cable, and electric. There was also a 12-inch low pressure gas main running parallel under the same street. Finding a clear alignment to relocate the main through this complex subsurface environment was therefore impossible, so replacement of the cast iron pipe was out of the question.

We considered our options. Often the easiest and most cost effective solution is to insert a much smaller diameter higher pressure plastic pipe within the host pipe. However, this was not a viable option as the 36-inch cast iron pipe was already running at 15 psig and we didn't have any 60 psig systems nearby to use as a source to maintain current volume through the smaller diameter plastic.

Another option was to excavate and encapsulate all the leaking joints over a period of time. There were already 15 known joints that leaked and it was only a matter of time before all of the cast iron pipe joints would need to be repaired. Spaced at eighteen foot intervals encapsulating all the joints along the busy South Orange Ave. corridor, was deemed impractical, cost prohibitive, with the likelihood of major negative impacts on traffic flow and the surrounding community. We concluded that the only viable and cost effective approach which guaranteed minimal disruption was trenchless renewal of the pipe using CIPL. Because it was the summertime, it was feasible to use the adjacent low pressure main as a relay to maintain service to customers as construction proceeded.

In June 2017 the decision was finalized to renew the 2000 LF section of the 36-inch cast iron main with Starline® Cured in Place Lining. For expertise in lining gas mains, all roads lead to the team of highly skilled infrastructure specialists at Progressive Pipeline Management (PPM). Since 2002, PPM have been the sole contractors in North America, exclusively licensed to install Starline® CIPL for natural gas main renewal applications. The Starline® product was originally developed by Karl Weiss Technologies GmbH, a German company with extensive experience in natural gas liner applications. The Starline® liner has undergone ten years and $14M worth of testing with PHMSA, Cornell University, and NYSEARCH. This independent testing of the liner in live pressurized pipe has determined a 100+ year's lifespan for the product. There are no other liners available for use in the gas industry that are backed with the same pedigree and extensive testing protocol.

With such an unprecedented size diameter of pipe to be lined, a detailed game plan was critical, and considerable time was invested into planning and coordinating our approach. There was significant lead time needed for the liner, materials, pipe, valves and related equipment to be manufactured and shipped. We calculated the length of liner required and determined there would be six access pits requiring excavation to install four separate liner segments varying in length from 260LF to 650LF. A specially designed custom inversion drum also needed to be manufactured and shipped from Germany.

Since this was the first installation of CIPL for such a large diameter of gas main, we felt it was important to have onsite technical support from the liner manufacturer in Germany. Karl Weiss Technologies GmbH sent Holger Turloff, a technician deeply experienced

Custom pig fabricated to remove stranded grit

Project Team: Public Service Electric & Gas, Progressive Pipeline Management and Karl Weiss Technologies GmbH

in lining large diameter gas mains. His help was invaluable in directing and training the crews through their first time working with the equipment necessary for installing this record-setting large diameter liner.

Based upon approximately a week for installation of each of the four liner segments, it was going to be a major challenge to meet a gas-in date of November 1/2017 so that this critical 36-inch feed main was back online before the cold weather hit. There were additional complications, delays and challenges which arose during the pre-construction and construction phases.

PRE-INSTALLATION: SEPTEMBER/2017 – OCTOBER/2017

From prior experience renewing cast iron gas mains, we knew there would be challenges, some known, and many unknown. We solved one of them in the planning phase, averting a potential failure of the liner material, by designing a reinforced four-ply polymer carbon fiber patch to bridge a four inch tap hole in the pipe. This patch concept was adapted from the circumferential structural reinforcement sleeve made of carbon fiber or steel that we occasionally use to bridge gaps in pressure pipe before lining (see NASTT-NE Journal Fall/2017 pp38-40).

The onsite preparations began with abandoning the 2000 LF section of main to be lined. There were two dead ended lateral mains that needed to have back feed relays installed first, before we could take the 36-inch cast iron pipe out of service. Excavations were done in locations on the 36-inch main where lateral feeds were disconnected, services were transferred and valves were replaced. These became our lining excavations. On the whole project overall, 4 old deteriorated valves were replaced with four new ones. Provisions for temporary relay feeds were put into place in the locations where the valves were being replaced.

Once excavation of the pits was underway, we knew there would be required adjustments and unforeseen circumstances related to equipment or the site. Lining four segments demanded we juggle multiple priorities with sites and equipment at the same time. Before cleaning of the pipe section commenced, a pre-clean CCTV inspection was run on each of the four segments to confirm the pipeline geometries, check for anomalies and protrusions, and assess overall internal conditions of the host pipe.

CHALLENGE: STRANDED GRIT IN SEGMENT TWO

To prepare the pipe for lining, sandblasted grit was used to clean the interior pipe wall down to white metal to ensure a tight bond between liner and host pipe. Based upon our previous experience doing sandblast cleaning and vacuum removal in large diameter mains, we thought the suction generated by an equivalent of five vacuum units would be more than sufficient to remove the debris and residual grit material from each of the four segments post-cleaning.

Due to the sequencing of access pit excavations, Segment Two was cleaned

Liner wet out involves mixing two-part chemicals

Starline® Cured in Place Liner coming off the drum guided as it enters the host pipe

first. However post-cleaning inspection revealed there was still roughly a 150 foot length of stranded grit material remaining in the pipe after the vacuum removal process was complete. Two more vacuum sources were added the next day to bring the total to seven vacuum units, along with a special fitting to increase suction. Even after an entire extra day was spent using seven vac sources, there were still piles of grit left behind in the pipe. A conventional pig didn't work to push the grit out either.

Time to innovate. We fabricated a custom pig with rollers and a tethered hold back. The rollers centered the pig into the pipe reducing the area into a small annular space. This drastically increased the suction velocity in the areas between the pipe's interior surface and pig. With vacuum source at one end we would slowly pull the pig back towards the other end against the airflow, moving it over the areas where grit had accumulated. We used CCTV to monitor the pig's position and confirm grit removal. It took us another day using this innovative process to successfully remove all the stranded grit.

The seven vac sources were effective by themselves at removing the residual grit from pipe Segments One, Three and Four. Finally, post cleaning CCTV confirmed each segment was clean and ready for the liner installation phase. We retired the custom pig.

LINER INSTALLATION: OCTOBER/2017 – NOVEMBER/2017

Segments of CIPL 36" Cast Iron Pipe	Feet	Days to Complete
One	650	7 days
Two	565	26 days
Three	450	6 days
Four	260	3 days

Lining began October 9th and was completed November 19th. Note the length of time required to complete Segment Two.

For each of the four segments, the host pipe ends were prepared at the entry and exit pits. This involved placing a crib

Liner entering host pipe after going through inversion cone

under the host pipe entry point with a T bar to help center the liner into the pipe. On the receiving end an end catch fitting was used to stop the liner. After we prepared the host pipe ends for each segment, the pipe was ready for liner installation.

The liner wet-out was done by mixing two-part epoxy resin in predetermined quantities based on diameter and length of each segment to be lined. The mixed resin was poured into the open end of the liner. Securing the liner tail properly was a critical step that prevented resin from leaking out once the liner was loaded up with epoxy. For this large diameter we prepared the tail for each segment with special adhesive tape before attaching the liner with 4 bolts to the retention belt that pulls the liner into the pressure drum. While being loaded into the pressure drum the liner was pulled through pre-set rollers gapped to wet-out or spread the epoxy inside the entire length needed for the planned inversion.

Connection of the tail to the retention belt was critical for control of the liner once it was pressurized and while inverting under air pressure. A twenty to thirty foot section of tail remained un-inverted inside of the liner while it cured with positive pressure maintained for two to three days. Once cured and deflated, the catch on the receiving end was removed and the tail pulled out. On the inversion end the cured liner was cut and separated from the pressure drum and on both ends the liner was cut flush to the end of the host pipe. Each segment was then ready for the post-lining CCTV inspection.

CHALLENGE: DELAMINATION AT ENTRY

On smaller diameter lining projects, the inversion cone is placed in the entry pit, next to the host pipe. With a large diameter liner like this, the inversion cone is placed on the pressure drum above ground, about 20 to 30 feet away from the host pipe. Doing this keeps the entry pits to a reasonably sized excavation, saving money and reducing the carbon footprint.

However, when the inversion cone is above ground, it is difficult to optimize the liner entry angle into the host pipe, the pit entry angle, and the position of the liner at the inversion cone and still have the liner be perfectly centered into the host pipe. For each segment, the T-bar and cribbing helped guide the liner into the host pipe, but the liner entry angles caused a minimal liner liftoff or local delamination at the immediate entry point.

After the liner was cured and the ends cut flush, we found that there was a very slight crescent-shaped piece at the entry end that was dis-bonded for a couple of inches at the end point where the liner entered the host pipe. We successfully repaired this minor issue on each of the four segments using epoxy and a mechanical retention band. The band held the liner in place while the local epoxy repair cured.

CHALLENGE: LINER CHAFE

These same liner entry angles also increased chafing from the retention belt which caused minor leaks on the exposed portion of the liner outside of the host pipe. The retention belt secures the tail thereby controlling installation speed and providing the capability to retract the liner. When we completed the inversion on Segment One, we used an eight-inch wide retention belt. At a few points along the liner there was too much friction between the belt and liner causing chafing and minor leaks. To prevent this liner chafe issue for Segments Two, Three and Four, we switched to a four-inch belt and doubled the lubrication.

THE BIG CHALLENGE: SEGMENT TWO

As the chart above shows, Segment Two took much more time than the other three segments taking a total of 26 days to complete. First, as noted above, delays were caused as we grappled with removing the piles of stranded grit in this segment that were left behind after cleaning. While the grit issue was being resolved, we were able to maintain schedule by moving ahead with lining Segments Three and Four. By then, we had already learned how to effectively handle the minor delamination and retention belt chafing issues notes above.

On Wednesday October 25 we were still on schedule to meet the November 1st gas-in date. That day, during the final liner installation on Segment Two, we were only 15 feet away from the catch end when one of the tail bolts failed and tore a hole in the liner due to the considerable forces at this large diameter. This meant we could no longer maintain positive pressure and complete the liner installation on Segment Two. Fortunately the retention belt was still attached to the tail with the 3 remaining bolts. We worked around the

clock to retract the liner and remove it from the pipe.

It being late October, with outdoor temperatures rapidly dropping, there was substantial pressure on us to get the 36-inch feeder main back into service as soon as possible. Now, with the liner failure in Segment Two, meeting the scheduled November 1 gas-in date was impossible.

We had to make a quick decision, and ensure it was the correct one. Would it be better to simply gas-in the entire 2000LF section and allow the leaks to continue in Segment Two? Or would it be more optimal to relay Segment Two, and look at attempting to line the segment again in Spring/2018? Neither of these options were desirable or cost effective.

Instead, we were elated when Karl Weiss Technologies GmbH agreed to manufacture an emergency replacement liner. They had it delivered to us and through Customs in record time. The new liner order was placed on Friday, October 27 and was received by us on Monday, November 13 – an incredible turnaround time of two-and-a-half weeks!

Working round the clock, the replacement liner was successfully installed into Segment Two on Tuesday, November 14 – a mere 24 hours after it had been delivered! This time round, we modified the tail bolt design to six bolts to be extra cautious, and there were no further problems. After four days of ambient curing, the final CCTV inspection was on Sunday, November 19. The results were excellent. A 25 psig pressure test confirmed the integrity of the line. We gassed-in on Monday, November 20, in time for the cold Northeastern winter fast approaching. Thirty-six inch diameter – a new World Record for the largest gas main ever relined.

With a permanent solution in place, and a new World Record under our belts, we won't have issues out there with the feeder main under South Orange Avenue for years to come. Most importantly, we gassed-in in time for the winter months, so our valued customers were not adversely affected. Successfully, achieving our world record for the largest diameter CIPL ever completed on a gas main required teamwork, true grit and a lot of preparation to persevere through the inevitable challenges.

ABOUT THE AUTHOR:

George Ragula *is the Distribution Technology Manager at Public Service Electric & Gas (PSE&G) with over 40 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 30 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.