COMPLEX LINING PROJECT UNDER BROOKLYN'S GOWANUS CANAL IS A WINDOW TO HISTORY

By: Mario Carbone, Progressive Pipeline Management

Gas main infrastructure is extremely expensive to replace and in some cases near impossible. Since 2002, Progressive Pipeline Management has been installing the Starline® Cured In Place Lining trenchless technology for natural gas main renewal. The nature of lining and pipeline rehabilitation is that most of the time the pipeline is buried in the ground. After the job is done, we drive the roads over the lined pipes. Rarely would we stop to appreciate the painstaking complexity of the job. Gowanus was different in every way.

The rehabilitation project for National Grid was to line two 30-inch cast iron natural gas mains installed in the 1890s underneath Brooklyn's Gowanus canal. It was complex, nerve-wracking, fulfilling, historical, and in the end, fun. With a series of complex engineering challenges at every step, the entire project has taken more than three years.

We were dealing with a pipeline that starts 20 feet above ground, makes a sharp turn down into a shaft with a 30 foot vertical drop. The pipe has multiple bends and a bastard fitting inside a tunnel underneath the Gowanus canal. It travels back up the shaft on the other side. One challenge led to another. Lots of trial and error. A big headache was figuring out how to deal with a bastard fitting that was larger than the liner with an abrupt 90-degree angle. We had to reconfigure our equipment to line "upwards" instead of using conventional pits to line underground. Every little nerve-wracking step had to fall into place before we could move forward. Each challenge was faced and overcome one plan, one step, one segment at a time.

Tunnel underneath Gowanus is over 130 years old. Note the detailed brickwork on the walls

AT EVERY MEETING WITH NATIONAL GRID, I WOULD SAY, "I'M WILLING TO TRY IF YOU'RE WILLING TO TRY." AND THEY ALWAYS WERE.

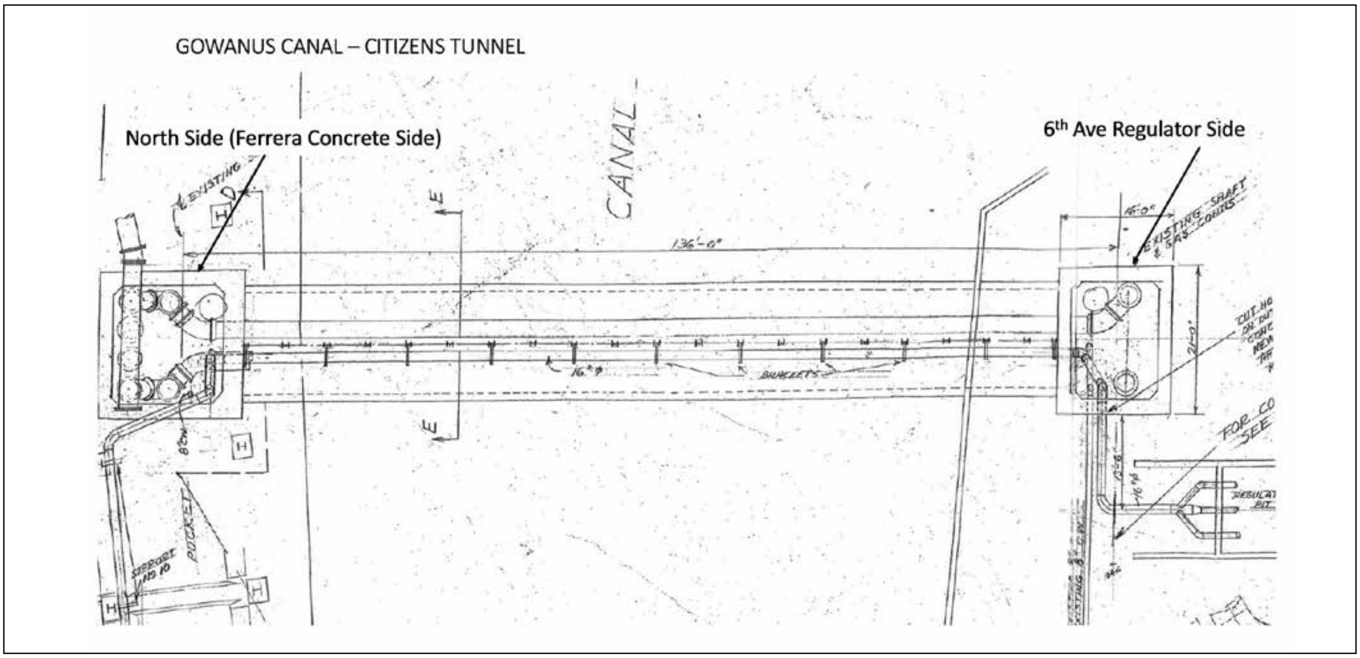
You know what kept me going? The history. Going into the tunnel is like stepping back 130 years. The brickwork in the tunnel is perfect, like a work of art. It's hard to grasp that just after the Civil War a group of men built the canal and then dug a tunnel underneath it. That's before power tools, cherry pickers or jack hammers. Then, in the early 1900s, three cast-iron pipelines were installed in the shafts and tunnel. All done with ropes, horses, wagons and muscle. If we had to build this today, the undertaking would be monumental.

Gowanus Canal is a 1.8-mile-long canal in the New York City borough of Brooklyn. The canal was completed in the late 1860s and became a hub of Brooklyn's maritime and commercial activity. By the 1880s it was a key location for concentrating heavy industry, coal gas, manufacturing plants, oil refineries, machine shops, chemical plants and more. There were also residential communities where workers lived.

More than once I thought, "If our ancestors could build this tunnel and install the pipes, then we should be able to figure out how to line it so they'll last another hundred years."

ENGINEERING & DESIGN

The sketches National Grid handed us were around 100 years old. The detail was perfect, showing the overhead view and tunnel. The



Sketch from National Grid showing both shafts and pipelines are over 100 years old

pipes enter the shaft, make their way down the shaft until we get to the bottom of the tunnel. The two 30-inch pipes and a smaller one are detailed in the sketch. In the tunnel, you can walk from shaft to shaft alongside the two pipes. The north side of the canal has the Ferrara Concrete company and the south side has a regulator station.

A major headache and source for numerous engineering discussions surrounded the bastard fitting with a 36-inch drip on the North side. The bastard fitting was an odd shaped unconventional fitting with two big problems for us. One, the drip is larger in size than the 30-inch liner going in. Drips were designed to catch liquids that are in the gas stream. Today these drips are obsolete because the natural gas process is much dryer.

Back to our history lesson. When this pipeline was built 100 years ago, natural gas was made from coal and refined to extract the gas. That extraction process was wet. Over time, the liquid in the gas would drop out into the pipeline and gather at the bottom. The drip would catch all the liquid and the fitting would connect to a pump and would extract the liquid that was collected in the drip.

As a turnkey project, PPM ran the job from soup to nuts with close observation from National Grid. It began with engineering. National Grid tasked PPM to run the entire project due to the highly complex nature of the project. Our construction and engineering partner was Bancker Construction. They did the digging, acquired the material, equipment and manpower.

The second problem on the bastard fitting was that the 90-degree angle was too abrupt for the lining to adhere and cure. It took a great deal of time to come up with the best scenario to approach it. Upon investigation, we realized that removing the fitting wasn’t an option. At the right end of the fitting are two flanges bent in towards each other at 22 ½ degrees. They depend on each other for thrust blocking. The pressure in the pipe is pushing on the other flange in the other direction. If we had removed a flange, it would hinder the other’s ability to support itself.

The solution was to remove the two 15-foot vertical segments of pipe to give us access to the bastard fitting. They were then lined separately above ground. The segments were to be reinstalled at the end, after lining the pipe. We needed to get our equipment in to start working on the solution for lining the horizontal drip.

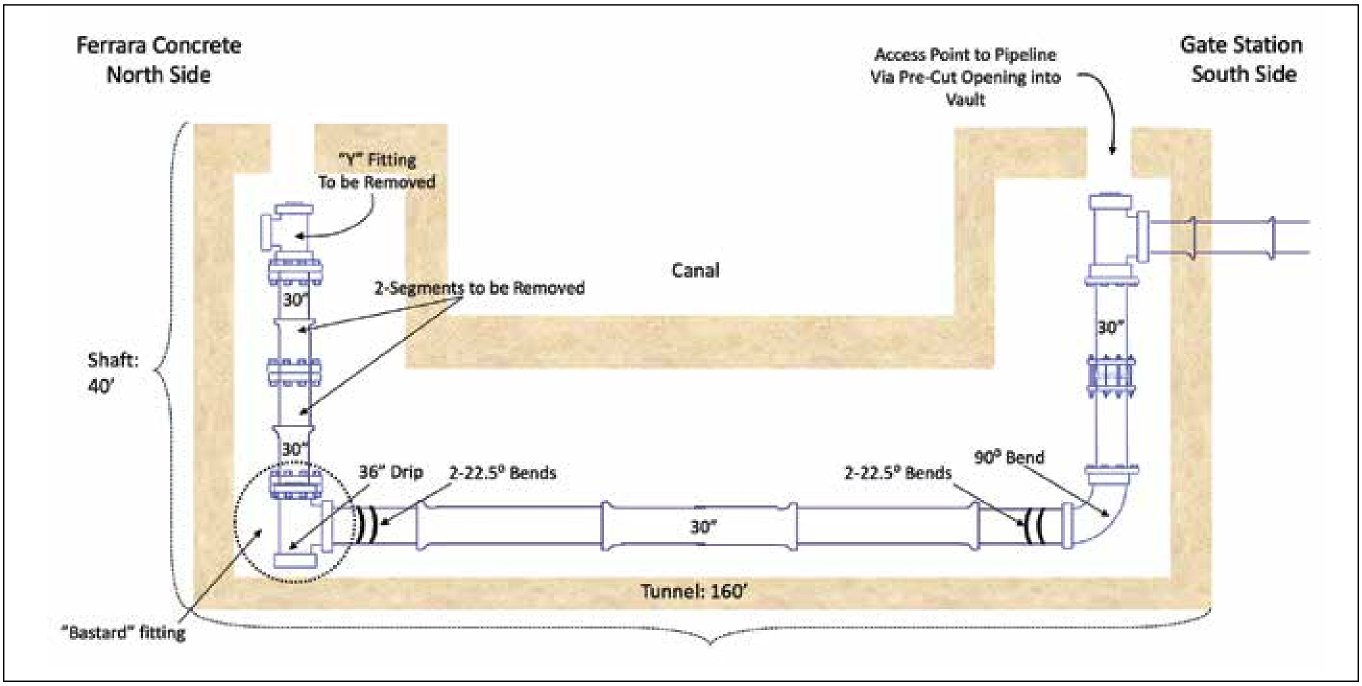
AGGRAVATION OVER CONDENSATION

The pre-cleaning CCTV inspection revealed that the pipeline was oily. EPA rules and regulations dictate how we dealt with it. We used an environmental company to wash and decontaminate the pipes. All liquids and the oils had to be disposed of in an environmentally safe way.

The next problem was drying the pipeline. Usually, drying was no big deal. We dry the pipe by pulling in fresh air from one side to the other with a giant vacuum truck. After a day or so, it would dry.

It was summer of 2017 with the outside temperature in the 80s. Inside the tunnel was in the low 40s. As we brought warm air into the tunnel, it started to rain inside the pipe. We were bringing warm outside air into a cold environment. The amount of condensation that we were creating was counterproductive. The issues of temperature change from outside to inside the tunnel caused a nightmare.

After a day or so of pulling the hair out of my head, I decided to turn it around and pull the cold air from the tunnel into the pipe and out into the atmosphere. We hired Montauk Services who introduced a system using a compressor to draw the moisture out of the pipe. It helped, but so much time had lapsed that we decided to come back in the winter when the temperature outside and inside would be closer. There was so much condensation, we had to repump, dispose of the liquids and dry all over.



CARBON FIBER REINFORCEMENT

One further large problem had to be addressed. On the south side of the canal, at the access point, the opening on the horizontal and vertical portion, was a 30-inch "T." There was a gap in the pipe inside the 30-inch pipe. When lining, without reinforcement, part of the liner would be exposed. To solve that problem we installed a carbon fiber reinforcement, one of the strongest products that PPM has developed. It's stronger than steel and very durable. We made the sleeve, then we installed a bladder, that acts like a balloon inside it. The balloon squeezes the carbon fiber tightly to the pipe and is inflated so the carbon is tightly fit. After it dries, it is deflated and removed. This "bridge" was installed so that the liner would not burst during installation.

BUILDING A 90-DEGREE FITTING

The final step in preparation for lining was to build a 30-inch, 90-degree bend fitting. We had to build it with "feet" so the 90 could rest on the top flange without damaging it. The liner would protrude out from and across that gap. When it was lined, we needed to cut the liner physically and remove the 90. Without "feet" there would have not been a way to separate the 90 and the top T section. We lined through the 90, across this gap and into the section that had the carbon fiber. The feet rested on a wooden gasket made out of plywood. It was a cheap solution that gave a buffer for the feet to rest on so they would not damage the cast-iron gasket beneath.

LINING UPWARDS TOWARDS THE PIPELINE

The 90-degree bend had to be anchored to two traffic plates. As the liner goes into the 90 degree bend fitting, it would push forward. The liner could not turn easily or make the bend. The thrust would have broken the feet and possibly broken the flange, which would have done a world of damage. We needed to support and overtake the thrust power of the inversion, which led to another innovation. Traffic plates and straps were mounted and calculated to be greater than the thrust power.

Final preparations were in place to line upwards to the 90 degree

Liner is being inverted as transfer hose is held up by a cherry picker towards the pipeline bend, instead of the conventional down, towards the pipe. The drum is 12 feet tall. The liner with adhesive inside is connected to the drum. There are stainless steel rollers in the drum. We had to hold the transfer hose up at the same time with the backhoe just to get it in position.

To hold the hose with the liner, a cherry picker had to be rigged to hold the inversion head onto the 90 while the liner was inverting. Bancker provided the cherry picker to lower and lift the equipment in and out of the tunnel. The moment we pressurized the hose, it wanted to go forward. We had to go back and forth with minor adjustments to the pressure and change the speed of the inversion process. After all the prep, it only took a day to line about 200 feet, down the shaft, across the tunnel and back up the vertical on the other side of the canal.

Vertical segment with carbon fiber sleeve that inflates, pushing the liner against the wall of the flange liner to cure and adhere to the pipe wall

INNOVATING TO DEAL WITH FLANGES

One of the final steps was to install the two vertical segments in front of the bastard fitting that had been lined separately. Once again, there was a problem that needed custom design and engineering. The vertical segments had flanges on each end. When the sections were installed, the flanges would touch and the liner couldn't adhere properly to the wall of the pipe. The solution was to add extra inches of liner protruding to cover up the other flange. When we brought the pipe down to meet the other pipe, the extra liner would encompass it and seal. The inflatable bladder was used again to push against the wall of the flange.

Nothing about this job was typical. Almost daily, we were designing and creating solutions and retrofits. It was nerve-

AFTER ALL THE PREP, IT ONLY TOOK A DAY TO LINE ABOUT 200 FEET

wracking, as we were never completely certain our solution would work. We would decide on a particular approach and explain to them 'this is what we think will solve the problem.' At every meeting with National Grid, we made sure they understood that we were trying things for the very first time. I would say, "I'm willing to try if you're willing to try." And they always were.

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

What made it fulfilling was overcoming the challenges. Perhaps that's the way our forefathers built the tunnel and laid the cast iron pipe 130 years ago. They faced each challenge, designed a solution and forged ahead one brick at a time.

ABOUT THE AUTHOR:

Mario Carbone's *ingenuity and perseverance define his leadership. His decades of experience enable PPM to design, develop and test new technologies and robotics while complying with required industry standards. He spent thirty two years in design, maintenance and construction with Brooklyn Union Gas/KeySpan Energy and ten years as the senior manager for gas research and development with KeySpan Energy. Mario is versed in current regulations for corrosion and pipeline environmental procedures. His inventiveness to overcome challenges led PPM to win the Trenchless Technology Project of the Year.*