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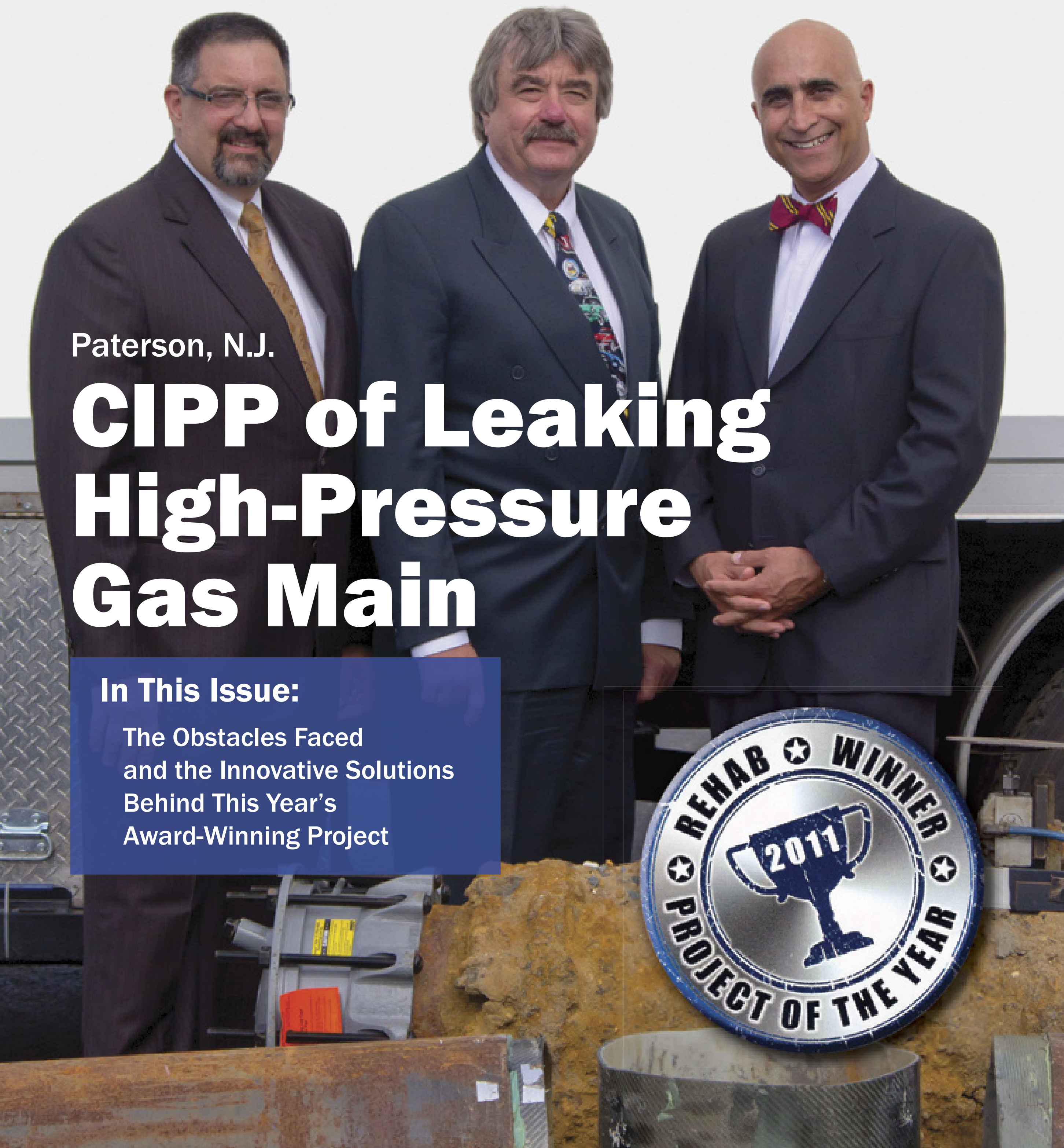
Paterson, N.J.

# CIPP of Leaking High-Pressure Gas Main

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The Obstacles Faced and the Innovative Solutions Behind This Year's Award-Winning Project


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# CIPP of Leaking High-Pressure Gas Main

Sharon M. Bueno — Oct 27, 2011

A leaking gas pipe doesn't, on the surface, scream Project of the Year winner, but when you listen to how this project unfolded and how the problem was solved, there's no question that it is a truly innovative and challenging project, deserving of such a distinction.

The project in Paterson, N.J., brings a lot to the table—inventiveness, ingenuity and patience. Who would have thought that a 700-ft gas main would be the center of so much fuss? Freezing temps, an innovative robotics device and a recently invented carbon fiber laminate were key elements in this project.

The challenges Progressive Pipeline Management (PPM) and Public Service Electric & Gas Co. (PSE&G) overcame, as well as those they prepared for, make the rehabilitation of this 16-inch, high-pressure gas main the 2011 *Trenchless Technology* Project of the Year.

"With this project, I know it's something that's never been done in the gas industry," says PSE&G distribution technology manager George Ragula.

"This project was unique and outstanding because of all the on-the-spot design and the creation of robotic equipment we needed to make this happen," says PPM executive vice president Mario Carbone.

"The newly developed PipeMedic™ carbon laminate was literally the missing link in this project that allowed bridging across the two-foot gap in the pipe," says Professor Mo Ehsani, the inventor of PipeMedic™ laminates.

## The Situation

This rehab project was slated to be done in late fall 2010 but due to delays, did not get under way until January 2011—in the middle of winter in New Jersey. Each day brought bitterly cold temperatures and snow. PPM and PSE&G thought the line would be out of service for seven days; due to unforeseen obstacles, it was 22 days.

The utility had been dealing with its leaking 100-plus-year-old, high-pressure cast iron pipe for some time. But by 2010, the situation needed to be remedied as it was causing safety and environmental issues to the surrounding area, exasperated by the frost in the ground. However, the pipe's location made a quick fix and line replacement unlikely. Enter trenchless technology.

The 16-inch line was originally installed in the early 1900s, serving as a major gas outlet to a gas manufacturing plant located about a mile away. The line served as that major feed for the distribution of the plant through the 1950s—until replaced by natural gas. The line was converted into a natural gas line and a metering and regulating station was built at the old gas complex.

Today, the main serves as a major outlet for a metering and regulation station, feeding PSE&G's gas distribution system. One of the line's largest customers is St. Joseph's Hospital, which had been experiencing poor pressure problems with its gas heating equipment.

The 700-ft section of pipe traveled down a private driveway and then underneath a set of active railroad tracks, traversing through an active truck dock loading/unloading area where it had excessive depth (24 ft) due to grade changes that occurred over time, and back onto private property. "To replace this pipeline because of where it is and how it traveled would be an astronomical cost. Rehabilitation was the only course of action," says Carbone, whose company is the exclusive North American licensee of the Karl Weiss Technologies GmbH's Starline cured-in-place lining (CIPL) technology for the rehab of metallic pressure pipes, including natural gas mains.

The project would be complicated but with the proper planning and design, Carbone had no doubt it could be done. Planning was critical to the project's success—particularly figuring out how to reline a critical section of the pipe under two sets of railroad tracks that was divided by a drip pot (a collection device that holds excess liquids from the old gas manufacturing days created

*PPM overcame several obstacles before the most routine part of the project could happen: the CIPL work.*


*The simulated test of what the **PipeMedic™** carbon laminate sleeve would look like once installed.*

through the gas traveling through the pipe) and a vertical standpipe (a pipe that goes from inside of the drip pot starting at the very bottom of the pot, out of the gas main and to the road surface where the liquids are siphoned out).

"We knew we couldn't remove [the drip pot] and that we were going to have to cut off the siphon pipe internally and install a bridge of some sort afterward to connect the two sections [in order to line the entire pipe]," says Ragula.

Since the drip pot couldn't be removed and replaced with a section of straight pipe that could then be relined, a trenchless method for the removal of the standpipe had to be designed, developed and tested. Additionally, the 24-inch gap across the drip pot could not be lined because it was too long of an unsupported length of liner, so a means of installing the bridge across the gap that could be later lined along with the segment of cast iron pipe was needed.

## The Solution

Carbone and Ragula reviewed and tested several products for the drip pot bridge before finding their answer. Ragula had participated in a Trenchless Technology Road Show in Newark, N.J., and while there came across QuakeWrap, a leading designer, supplier and installer of innovative fiber reinforced polymer (FRP) products for repair and strengthening of structures. Company founder Dr. Mo Ehsani had developed a product—PipeMedic™—using carbon and glass fiber reinforced polymer laminates to repair and strengthen steel, cast iron, corrugated metal, clay, brick, concrete, PCCP, wooden pipes and culverts.

"Seeing that product, I realized that it was perfect for our application due to its strength and minimal thickness [0.026 in.]," says Ragula, a 20-year veteran of gas main relining. In addition, the material has a natural curvature, making it relatively easy to configure it into an internal sleeve.

"George approached me and said he had this challenging problem that he runs into a lot and he has no solution for," Ehsani says. "He thought my invention could solve that problem. We started a testing program and the Gas Technology Institute (GTI) tested our laminates for this unique application. As far as the repair of pipes by bridging a two-foot gap in an existing pipe, this was the first application for our PipeMedic™."

With that part of the problem solved, Carbone and Ragula turned to designing a robotic device to cut away the standpipe and install the PipeMedic™ laminate. A new robotics device was designed, developed and successfully tested for cutting out the standpipe. The delivery system for the PipeMedic™ laminate had to be modified by adding a sled to the front of the robotic device so the packer pig could successfully be centered in the drip pot, which meant the front of the pig had to be pulled to the opposite edge of the drip pot preventing the pig from falling into the pot.

The process of cutting the standpipe and installation of the PipeMedic™ laminate was simulated and tested at PPM under the watchful eye of GTI. The GTI test results indicated that the simulated drip pot pipe section met the pressure requirements of industry standards for cured-in-place liners. During the actual project, it took just a few minutes for the robotics system, which had an Aries camera attached, to travel down the main and an hour to cut away the standpipe in several cuts with the cut pipe sections dropping into the bottom of the pot. Using the robotic device, the PipeMedic™ laminate coated with epoxy resins was inserted into the pipe. After the resin cured, the CIPP process for the entire 700-foot pipe was pretty straightforward.

## Obstacles

Having the solution to rehabbing the line in hand, PPM and PSE&G experienced "onsite audibles, as Ragula referred to them.

First up was the condition of the pipe, which was completely filled with debris including sand, rocks and caked-on residue

### PIPEMEDIC™ LAMINATES

*The development of PipeMedic™ laminates began in 2008 by Dr. Mo Ehsani, Professor Emeritus of Civil Engineering at the University of Arizona. Using a special manufacturing process, these laminates are constructed with one or more layers of carbon or glass fabric saturated with resin and pressed together to form a very thin solid sheet. The laminates are manufactured in rolls 4-ft wide x 150-ft long that can be easily cut to any size in the field. With a thickness ranging between 0.01 and 0.025 inches, the laminates are flexible enough to be coiled for insertion into pipes as small as four inches in diameter. The tensile strength of the laminates ranges between 60,000 – 155,000 psi.*

*The high strength of the laminates in two orthogonal directions allows them to resist both hoop and longitudinal stresses that could be present in certain applications. Furthermore, these laminates incorporate a thin glass veil on both surfaces; this allows the PipeMedic™ laminate to be in direct contact with steel pipe surfaces without any concern about galvanic corrosion that could result by allowing carbon fabric and steel to come in contact with each other.*

of oxides and tar from years of manufactured gas passing through it. "The pipe was 16 inches in diameter and we couldn't pull an eight-inch pig through the line," Carbone says. "The residue had built and built and built until the line was almost completely filled. It sticks to the pipe and you can't get it off."

The heavy debris was removed by using a NLB high-pressure water-jet blasting system. A sandblasting tool head was modified to deflect the majority of the grit toward the bottom of the main in an effort to remove the excessive debris. All of this was made more difficult by the below freezing temperatures and daily snow accumulations.

With the main out of service, groundwater started entering the pipe and the source of the leakage had to be eliminated prior to lining. After the debris was cleaned-out, a closer camera inspection revealed a crack in the pipe allowing water to seep in. This required modifying a robotic tool-head to lay-down and trowel cement over the cracked pipe to eliminate the water entry.

The cold temps also impacted the curing time of both the carbon laminate bridge and CIPP liner. It took three days to cure the resin for the carbon laminate and five days for the adhesives to cure to the old pipe. ■

Sharon M. Bueno is managing editor for *Trenchless Technology*.

**Owner:** Public Service Electric & Gas Co.

**Contractor:** Progressive Pipeline Management

**Engineer:** Public Service Electric & Gas Co., Progressive Pipeline Management, QuakeWrap, Inc.

**Manufacturer:** PipeMedic™ by QuakeWrap, Inc., Karl Weiss Technologies GmbH, Aries

*The **PipeMedic™** laminates and method of repair of pipes described in this paper are subject to pending U.S. and international patents by Professor Mo Ehsani*

## TESTING OF PIPEMEDIC™ AT GAS TECHNOLOGY INSTITUTE

*Before the laminates could be used on the pipeline renewal job, the material's strength and stiffness and its suitability for such an application had to be tested and confirmed. Gas Technology Institute (GTI) was selected by PSE&G to develop a test protocol that would satisfy the requirements of ASTM F-2207 and manage the overall testing program of using the laminates for rehabilitation of gas pipelines. GTI's work included providing and installing the necessary instrumentation, overseeing and conducting the testing, analyzing the test data and presenting the results of this work in the form of a final report with appropriate recommendations.*

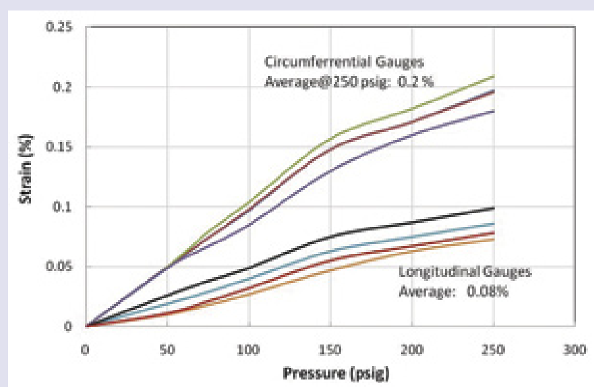
*The testing program included testing three pipe diameters. The first sample was the 16-inch diameter pipe that was constructed during the demonstration phase; that repair included 3 plies of PipeMedic™ biaxial carbon laminate. In addition, two smaller samples with diameters of 6 and 12 inches, respectively, were constructed and tested. These two specimens were retrofitted with a biaxial glass laminate applied in two plies. All three specimens included a 24-inch free-standing laminate section, which extended an additional 12 inches into each side of the pipe.*

*The PipeMedic™-steel pipe system was lined with CIP, capped at both ends, thrust-restrained and connected to a hydraulic pressure system to apply controlled test pressures. Strain gages and displacement sensors were installed to monitor circumferential and longitudinal strains in PipeMedic™ during the loading.*

*The requirements for the CIP system as specified in ASTM F-2207 include performing test at a pressure not less than twice the certified maximum allowable operating pressure (MAOP) of the pipeline for a minimum of one hour without leakage. For these gas mains, MAOP is 60 psig. All pipe sections were tested under hydrostatic pressure that was increased every two hours by 50 psi up to the maximum pressure of 250 psi, more than four times the MAOP.*

*The measured strains in the laminate were about ¼ the ultimate values, indicating that the PipeMedic™ system could have resisted pressures as much as 900 psi. The loading imposed on the laminate causes a combination of hoop and longitudinal stress. This can be seen from the measured strains. The longitudinal gages that were positioned at four inches from the end of the laminate, recorded an average strain of 0.085% that is 43% of the average strain measured in the hoop direction. This clearly demonstrated the importance of PipeMedic™ laminates constructed with sufficient strength in longitudinal and transverse directions to resist the imposed loads.*

*The test results further demonstrated that the liner–composite sections could stand the applied pressure without leakage.*




*Circumferentail and Longitudinal strain in PipeMedic™ laminate for the 16-inch pipe*

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