Coiled Polyamide-11 High Pressure Gas Pipe Costs Less to Install and Operate Than Steel Stick Pipe

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For rapid and economical installation it is difficult to beat coiled plastic pipe. For higher pressures in the range of up to 250 psig it is now possible to install coiled polyamide-11 (PA-11) gas pipe instead of steel in diameters up to two inches. In a study[1] done by Arkema Inc. and Gas Technology Institute (GTI) it was concluded that polyamide-11 pipe could be installed by all of the conventional methods including plowing and directional boring in addition to the more common open-cut trench methods. Coiled pipe can be used in all of these methods and offers cost advantages over long lengths of plastic pipe fabricated from butt-fused sticks.

Although detailed and robust fusion procedures are available for the various plastics used as gas pipe, including PA-11, it is a reality that each fusion represents an opportunity for a problem to develop despite the best efforts of well-qualified technicians and inspectors. Although fusion problems are rare in plastic pipelines assembled by qualified personnel, it makes good sense to avoid constructing pipelines from stick pipe joined by fusion methods when coiled pipe is available.

The cost savings, in the form of reduced installation costs as well as the elimination of a cathodic protection system, have been realized by natural gas distribution companies while installing high-pressure systems. These installations have occurred over the past two years as part of a development program designed to test the suitability of PA-11 gas pipe in a variety of pressures, climates, and soil types.

Nashville Gas, Questar Gas, and Public Service Company of New Mexico (PNM) each installed coiled PA-11 pipe in pressures from 175-200 psig to test the assumption that it would be more economical than a conventional steel pipeline constructed of 40-foot sticks.

Demonstration Projects

Working closely with GTI, the utilities obtained state and federal waivers for the PA-11 installations because the operating pressures would be higher than the 125 psig allowed for plastic pipe in Title 49 Code of Federal Regulations Part 192.123. Additionally, a design factor of 0.4 would be used for designing the pipe instead of the 0.32 design factor required in Part 192.121.

Since these installations, Arkema Inc. has petitioned the U.S. Department of Transportation (USDOT) to amend the pipeline safety regulations to permit PA-11 pipe to be used at pressures up to 200 psig, limited by its hydrostatic design basis rating, and with a design factor of 0.4 without the need for waivers. Federal action is pending.

Coiled PA-11 pipe requires a straightener/re-rounder for installation because the pipe takes a set on the coil after extrusion. Although the force required to uncoil the pipe is small, if a straightener is not used, the uncoiled pipe will tend to elastically re-coil, like a spring, which is both inconvenient and a safety hazard.

The April 2003 Nashville Gas installation was the first use of coiled PA-11 pipe. It was part of a much larger project that also used about 5,000 feet of PA-11 pipe in 40-foot sticks. A PLCS-coiled pipe trailer and 2-inch pipe straightener were used

Figure 1: PA-11 pipe uses conventional straightening and re-rounding tools. One end of the pipe was directed through the straightener and secured to a cable.

to uncoil the coiled PA-11 pipe at Nashville Gas. One 500-foot coil of 2-inch PA-11 was secured on the unwind stand of the trailer.

One end of the pipe was directed through the straightener and secured to a cable. (Figure 1) A backhoe was used to pull the pipe from the unwind stand, through the straightener, and off the trailer. (Figure 2) The straightened pipe was then laid in the trench. The use of the coiled pipe greatly increased the speed at which the pipe was installed. Butt-fusion joints are only required every 500 feet instead of every 40 feet as with the stick pipe.

Figure 2: A backhoe was used to pull the pipe from the unwind stand, through the straightener, and off the trailer.

All the pipe in this project was installed by open-trench technique and all the joints were made by butt fusion. Nashville Gas personnel made fusion joints after certification training given by the GTI. The PA-11 pipeline operates at 175 psig in a Class 3 location. There are now eight residential services connected.

In June 2003 Questar Gas installed about 4,200 feet of PA-11 pipe as two parallel 2-inch SDR11 pipelines serving a single industrial customer and operating at 200 psig. (Figure 3) Questar Gas obtained waivers from the State of Utah and the USDOT for the same reasons as Nashville Gas. Two 2-inch pipelines were specified because the desired single 4-inch PA-11 pipe was not yet available.

Figure 3: Questar Gas installed about 4,200 feet of PA-11 pipe as two parallel 2-inch SDR11 pipelines serving a single industrial customer and operating at 200 psig.

One of the pipelines consisted of 2,000 feet of coiled PA-11 pipe using four 500-foot coils. Another 2,200 feet was installed using 40-foot sticks. As with the Nashville Gas installation, the joints were made by butt fusion by the utility's own construction crews. Again, a PLCS-coiled pipe trailer and straightener were used for the coiled-pipe installation.

The PNM installation was accomplished in November 2004. It consists of 2.5 miles of 2-inch SDR11 pipe operating at 175 psig. This was the first installation to use coiled PA-11 pipe exclusively for the distribution pipeline. There were seven coils of nominally 1,000-feet (Figure 4), and 12 coils of nominally 500 feet laid into open-cut trench dug with a tracked trenching machine.

Figure 4: Loading a 1,000-ft coil onto the PLCS deployment trailer for the PNM installation.

All the joints were made by butt fusion by PNM technicians. The trenching rate limited the pipe installation rate despite the relatively rock-free soil. Even considering that there were delays while waiting for trench, the entire 2.5-mile pipeline was installed and connected in about four working days by a five-man crew, including the trench machine operator.

Cost Comparisons

In a 2002 survey of 35 gas utilities located around the United States, we received total installed cost (TIC) information about both steel and plastic pipe installations of various lengths and diameters. The data revealed a range of TIC for pipe, excavation, burial, inspection and other typical line-item components of a gas pipe construction job.

The data revealed that in 2002 the typical TIC for 2-inch steel gas pipe ranged from $14-41 per foot based on 2001-2002 steel pricing. The range was representative of various soil types, climates and job mileage. At the same time we learned that 2-inch plastic pipe generally costs about $5-7 per foot to install after it is delivered to the job site if it is installed using sticks.

At PNM it was concluded that the cost of installation of pipe from long coils is about $3 per foot. The 2-inch SDR-11 (Standard Dimension Ratio used to describe pipe wall thickness) PA-11 pipe used for the projects at Nashville Gas and Questar Gas cost about $10 per foot. Two-inch SDR11 PA-11 pipe used for the PNM installation was supplied for about $8 per foot. This puts the TIC range of a PA-11 pipe project at $11-17 per foot which is very competitive with steel costs.

The economics of coiled PA-11 pipe can be illustrated using the examples of the three utilities that have installations. Nashville Gas and Questar performed stick and coil installations at the same time using their own personnel and conventional equipment. The most obvious advantage of coiled pipe is that there are far fewer fusions in a coiled installation. In the same 500-foot installation made with 40-foot sticks there would be about 12 fusions.

Each butt fusion takes about 15 minutes including cooling before handling and inspection, resulting in approximately three hours of technician labor devoted entirely to fusing pipe. Nashville Gas installed a 500-foot coil of 2-inch SDR11 PA-11 pipe in about an hour.

The experience at Questar was similar and benefited from technique developed during the coiled PA-11 pipe installation at Nashville Gas. Each 500-foot coil was deployed and fused onto the adjoining segment in about 40 minutes, taking less than three hours to install the 2,000 feet of coiled pipe. In contrast, construction of the same length of pipeline from 40-foot sticks took about 10 hours. Because of the experience gained at the Questar and Nashville coiled-pipe installations, PNM could deploy and fuse a 1,000-foot coil in about 45 minutes.

Plastic pipe is manufactured in a continuous process that lends itself well to making a coiled product. Finished coil diameter is the principal factor that limits the pipe diameter for coiling to product availability. Larger diameter pipes must be coiled around larger diameter hubs than smaller diameter pipes to avoid excessive ovality in the product. As the pipe and hub diameter increase, the coil diameter approaches the maximum dimensions for shipping to the job site without special permits and routing; at some point so little pipe can be put on the coil that it loses any installation cost advantage.

At this time, for PA-11, 2-inch SDR-11 is the maximum size available in coils. We anticipate the availability of coiled 4-inch SDR-11 pipe as more process experience accumulates at the pipe manufacturer.

Conclusion

Coiled 2-inch SDR-11 PA-11 pipe offers substantial cost advantages over stick pipe in any size because fewer time-consuming fusions are necessary. The reduced number of fusions also results in increased reliability for the coiled pipeline component compared to a similar length constructed of butt-fused sticks. The 2002 survey of 35 gas utilities shows that total installed cost of 2-inch steel is frequently higher than the total installed cost of PA-11 coiled pipe.

The total installed cost gap increases after factoring in today's increased steel pricing and reduced PA-11 pricing compared to the prices in 2002. Since PA-11 is a thermoplastic material not requiring cathodic protection there are additional continuing cost savings over the life of the system.

[1] Patadia, H., Pitzi, T.J., Kanninen, M.F., and Mamoun, M.M., "An Evaluation of Polyamide 11 for Use in High Pressure/High Temperature Gas Piping Systems," Proceedings 1997 International Symposium — Plastic Piping Systems for Gas Distribution, Lake Buena Vista, FL, pp. 107-122. ***P&GJ***

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