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Polyamide (PA11 and PA12) Use in High Pressure Natural Gas Distribution Systems – Installations and Performance Review

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Abstract

The natural gas industry has long understood the advantages associated with plastic piping materials. In addition to being easier to handle and join, plastic piping materials eliminate the need for long-term corrosion control and the associated costs. Since the mid-1990's, there has been an on-going effort to utilize the plastic piping system at higher operating pressures. The Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA) has amended the Federal Code to allow the use of the PE materials at increased pressures up to 125 psig. Concurrently, the industry has also sponsored research into new materials that can operate at pressures up to 250 psig while maintaining the overall benefits of plastic piping materials – Polyamide 11 and 12 (PA11 and PA12).

In order to be proactive, GTI initiated various comprehensive research programs to validate the feasibility for the use of Polyamide materials in high pressure gas distribution applications through comprehensive laboratory testing and field experiments. The results of these research programs demonstrated that these materials are very promising candidate materials for high pressure gas distribution applications.

Based on the success of the laboratory testing and "off system" field experiments, several PA11 and PA12 installations were installed in the public right of way on a natural gas system.

This paper presents an overview of the numerous polyamide natural gas plastic pipe field installations with operating pressures up to 250 psig. The overview includes the Special Permit requirements, layout, materials, and operating pressures, as well as the installation methods employed to complete the installations.

Introduction

The natural gas industry and the associated regulatory bodies within the US clearly recognize the benefits of thermoplastic natural gas transportation systems through their experience with polyethylene. The existing natural gas transportation infrastructure in the US is incapable of meeting the projected future demand for natural gas consumption. A number of initiatives exist to increase the efficiency and capacity of the existing infrastructure without compromising the public safety. One of these initiatives is to identify materials capable of operating safely and cost effectively at higher pressures without compromising throughput. Polyamide 11 and 12 (PA11 and PA12) have been identified as two of several materials capable of achieving this objective.

PA11 & PA12 thermoplastic pipe materials are an excellent alternative to steel pipe in high pressure applications up to 250 psig (17 Bar). PA11 & PA12 is easier to install than steel and eliminates the need for costly long-term corrosion control measures.

Several new pipeline installations of PA11 and PA12 performed under special permits have helped to and/or are instituting changes to the federal code governing the safe use of plastic piping systems.

Working with various PA11 and PA12 resin suppliers, GTI coordinated PA11 & PA12 installations at several U.S. natural gas utilities looking to use this new material to meet the challenges of high-pressure gas lines. These installations assisted to validate the use of PA11

& PA12 at higher operating pressures and help change federal code to allow the permanent use of these piping systems.

A New Option

Light in weight, PA11 & PA12 pipe is not only corrosion-resistant and easier to handle and install than steel, it offers all the benefits of plastic polyethylene (PE) pipe while extending the range of operating pressures and temperatures. By employing PA11 & PA12 systems as lower-cost substitutes for steel piping systems, gas distribution operators can now realize significant installation and labor savings, while eliminating long-term corrosion control headaches and the need to reduce the rate of flow.

In recent years, GTI has conducted feasibility studies, sponsored by PA11 & PA12 resin suppliers and Operations Technology Development (OTD) at several U.S. utilities, designed to evaluate the performance of PA11 & PA12 in various environments across a wide range of utility practices and procedures. In this way, GTI provided a basis for revising 49CFR Part 192.123 to permit the use of PA11 & PA12 at higher operating pressures.

Recent field installations—at Energy West in Montana, Atmos Energy in Mississippi, and several at Atmos Energy in Texas—demonstrated the benefits of PA11 & PA12 piping for various applications. At Energy West, PA12 piping was installed to run new high-pressure gas lines in order to provide gas service to a new area. The Atmos Energy installation in Mississippi was designed to demonstrate the benefits of using PA12 piping for the rehabilitation of older high-pressure steel lines. The Atmos Energy installations in Texas demonstrated the ability of PA11 to be used to replace existing steel pipe connecting city gate stations – providing gas supply from one town to the next.

Special Permit Process

The safe use of plastic piping systems are governed by 49CFR Part 192 of the Code of Federal Regulations which set forth the minimum standards that must be adhered to by all LDCs. In particular, plastic piping cannot operate at pressures greater than 125 psig and subjected to the use of a 0.32 design factor in the Barlow formula contained within Section 192.121.

In order for U.S. utilities to install PA11 and PA12 piping the Federal Code must first be amended to allow for its approved use at higher operating pressures. Based on positive experiences at various utility “off system” installations including Nicor Gas, National Fuel, City of Mesa Utilities, WE Energies, and MichCon Gas, and others, Special Permits were drafted to eliminate certain restrictions in order to further test and evaluate the PA piping systems in future commercial applications. Specifically these Special Permits requested the following:

- Allow operation of PA piping systems at pressures greater than 100 psig
- The use of PA11 & PA12 at operating pressures as limited by its hydrostatic design basis
- The use of a 0.40 design factor instead of the 0.32 design factor within the Barlow formula used to calculate operating pressure
- Maximum design pressure of 250 psig

Utility PA11 Special Permits and Federal Code Approval

In an effort to build regulatory support for the use of PA11 piping systems at higher operating pressures, GTI, with the support of several gas distribution companies, planned public right of way installations throughout the United States. Two main objectives of these installations are to characterize the effects of various geographic and climatic environments; and to incrementally increase the range of operating pressures, as limited by PA11's long term hydrostatic strength (as represented by its HDB rating), in order to precipitate a change in the Code of Federal Regulations.

Based on years of laboratory testing and development of standards for PA11 along with successful installation experiences at Illinois (Nicor Gas), Louisiana (Atmos Energy), Tennessee (Nashville Gas), Utah (Questar Gas), and New Mexico (New Mexico Gas), the Pipeline and Hazardous Materials Safety Administration (PHMSA) granted the use of PA11 thermoplastic piping systems at higher operating pressures than currently allowed starting on Jan.25, 2009. The PHMSA final rule issued in late December 2008 allows distribution and transmission pipeline operators to start using PA11 of a .40 allowable design factor at operating pressure up to 200 psig

PA12 Special Permits

Energy West PA12 Special Permit

In order to gain Federal Code approval for PA12 (similar to PA11) utility installations under Special Permits must be undertaken. A Special Permit was submitted to the Montana Public Service Commission in September 2008 to request the use of PA12 at higher operating pressures. The Montana Public Service Commission (Montana Commission) reviewed the Special Permit request along with a collection of reports from the previously performed evaluation efforts of the PA12 piping system. After review, the Montana Commission granted approval for the Special Permit request on February 4, 2009 to deviate from 49 C.F.R. §§ 192.59, 192.121 and192.123, and allowing Energy West to operate up to five miles of PA12 natural gas distribution pipe designed utilizing a design factor of 0.4 and a maximum design pressure of 250 psig.

The Department of Transportation, PHMSA, also approved the Special Permit request without restrictions.

Atmos Energy Special Permit

Another Special Permit was submitted to the Mississippi Public Service Commission on March 11, 2009. The Mississippi Public Service Commission (Commission) reviewed the Special Permit request along with a collection of reports from the previously performed evaluation efforts of the PA12 piping system. After review, the Commission approved the request on June 2, 2009 (DOCKET NO. 09-UA-115) and submitted it to the Department of Transportation (Pipeline Hazardous Material Safety Administration (PHMSA) to request to deviate from 49 C.F.R. §§ 192.59, 192.121 and192.123, by allowing Atmos Energy to operate up to ten miles of PA12 natural gas distribution pipe designed utilizing a design factor of 0.4 and a maximum design pressure of 250 psig.

The Department of Transportation PHMSA approved the Special Permit request in August,

2009 without restrictions.

The Special Permit received by Atmos Energy was the second to allow the use of PA12 piping system. This will allow for additional evaluations of the PA12 piping system to its maximum pressure rating (250 psig) based on its current hydrostatic design basis and the use of a 0.40 design factor.

Utility Installations

Atmos Energy – Texas – PA11 Installations

After PHMSA amended the Federal Code allowing for the use of PA11 piping systems to be installed and operated at pressures up to 200 psig, Atmos Energy in Texas worked with Georg Fischer Central Plastics – manufacturer of Hyperplast pipe, which is based on Arkema's Rilsan PA-11 resin to supply the materials to replace aging steel piping systems operating at pressures greater than 125 psig. Since these existing piping systems which provide natural gas from one city to another operate at pressures greater than 125 psig, polyethylene (PE) pipe was not an option. Therefore, they chose PA11 to not only save on the total installed cost of the replacement PA11 pipe compared with steel pipe, but to also eliminate the need for corrosion protection now and in the future.

Over a period of three years, Atmos Energy planned, designed, and installed about 10 different steel replacement projects using the Hyperplast PA11 piping systems.

	Location	Length (Feet of Pipe)	Size	Installation Year
Project 1	Frost, TX	6,000	4"	2010
Project 2	Coolidge, TX	55,440	4"	2010
Project 3	Grossbeck, TX	7280	4"	2010
Project 4	Hubbard, TX	16040	4"	2011
Project 5	Frost, TX addition	7600	4"	2011
Project 6	Waco, TX I-35 Bore	600	4"	2011
Project 7	Grossbeck, TX add-on	14,000	4"	2011
Project 8	Priscilla TX and Hubbard	24,000	4"	2012
Project 9	Ferris TX	23,360	4"	2012
Project 10	Various (service tubing, risers, transitions)	2,000	1"	various
Total Footage to Date		**156,320**		
Miles of Pipe		**29.61**		
Meters		**47,652**		

Table 1 – Atmos Energy Installation History of PA11 Pipe

Figure 1 – 4" PA11 Hyperplast pipe to replace existing steel piping system

Figure 2 – Standard butt fusion equipment used to connect PA11 pipes together

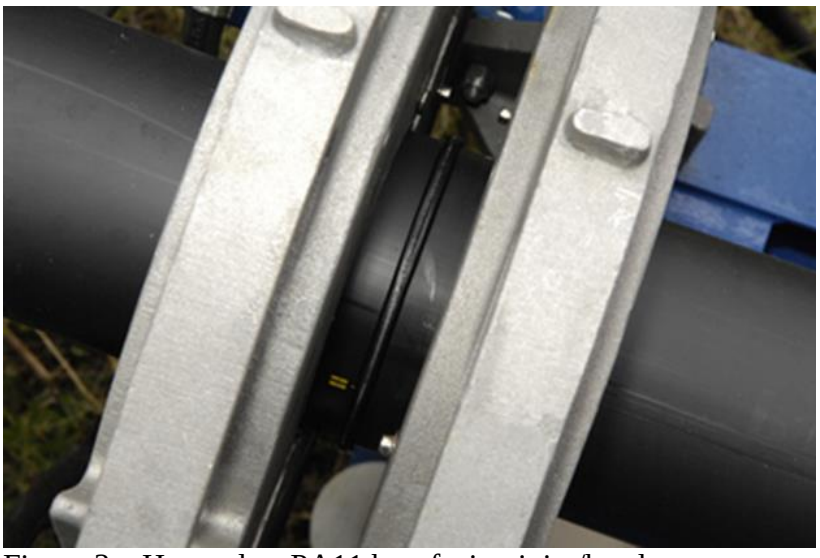

Figure 3 – Hyperplast PA11 butt fusion joint/bead

Energy West – Montana – PA12

In order to further test and support a change in the Federal Code for future installations of PA12 piping systems, an installation was planned at Energy West (distributor of natural gas service in Montana). This was the first PA12 installation installed on a natural gas system under a Special Permit. The installation was initiated and completed during July/August 2009 with the test leg being completed in October 2009 just outside of Great Falls, MT (between Ulm and Cascade).

Just prior to the Special Permit submittal, Energy West selected a suitable site for installation of the Evonik PA12 piping system. The site selected also required concurrence by the Montana Commission. For the selected site Energy West planned to install approximately 15,000 feet of pipe made from Evonik Vestamid® resin as part of a project to convert a vaporized propane distribution system to natural gas in the town of Cascade, Montana. The installation took place in class 2 and 3 locations allowing natural gas to be extended from Ulm to Cascade (just outside of Great Falls, MT). 4-inch SDR13.5 PA12 pipe was installed using both open cut and horizontal directional drilling techniques. Approximately 1280' of pipe was installed using the directional drilling technique (under roadways). The 4" PA12 resin was extruded into 50' sticks of pipe by AD Technologies (Duraline). In addition, a 300' coil of 4" SDR 13.5 pipe was also supplied for installation.

The entire system was installed and then leak/pressure tested with air/nitrogen at 342 psig. After a successful pressure test, the pressure was reduced and secured at an operating pressure of 150 psig in October 2009.

Figure 4 – 4" PA12 pipe supplied in both coiled and 50' long sticks

Figure 5 – PA12 was butt fused using traditional equipment and methods

Figure 6 – Installing the 4" – PA12 Piping system in Montana (Energy West)

In addition to the 4" PA12 main pipe installed to extend natural gas service to Cascade, MT, Energy West installed approximately 15 PA12 services. This allowed the few homes along the pipeline route to also be served by natural gas.

Evonik PA12 resin was used by pipe and fitting manufacturers (Duraline, RW Lyall, and Nupi) to make 1" service tubing, anodeless risers, excess flow valves, and electrofusion service tees and couplings.

Figure 7 – Installation of PA12 electrofusion service tees and other service components

Figure 8 – Installing the PA12 services

Atmos Energy – Mississippi – PA12

To further test and support a change to the Federal Code allowing for the use of PA12 piping systems at higher operating pressures, another public right of way installation was planned at Atmos Energy (distributor of natural gas service in Mississippi). The first ever 6-inch diameter PA12 installation under a special permit took place on Atmos Energy's system in Greenville, Mississippi. The installation was initiated and completed during August/September 2009.

Both Evonik and UBE PA12 resin was used to produce the pipe and fittings. The site selected is in a class 3 location paralleling an existing 6" steel pipeline located in an Atmos Energy easement. The 6" SDR13.5 PA12 pipe was installed using both open cut technique and horizontal directional drilling. A total of 1,491 feet of PA12 pipe was installed.

After the 6-inch PA12 pipe was installed, the entire system was leak/pressure tested with air/nitrogen at 300 psig – giving it a maximum operating pressure of 175 psig. After a successful pressure test, the pressure was reduced and secured at the current operating pressure of 165 psig on September 4, 2009.

Figure 9 – Installation of the 6-inch PA12 pipe in Greenville, MS

Figure 10 – Using directional drilling to install the PA12 under a roadway

Conclusions

As LDC's continue to seek out new materials and push towards changing the code of federal regulations in order to maximize their assets, comprehensive testing and evaluation is necessary to ensure continued safety and reliability of the overall gas distribution network. To that end, GTI with support of several utilities, the PA11 and PA12 resin suppliers, and various pipe and fitting manufacturers planned and executed various testing and pipe installation projects to validate the use of PA11 and PA12 at higher operating pressures throughout the United States.

Based on the testing and installation, GTI feels that PA11 and PA12 piping systems will have a major impact on the natural gas industry. PA11 and PA12 will provide an attractive alternative for gas companies in terms of installation. It also does not have the disadvantages of steel piping systems, such as long-term corrosion issues and the need to pass separate corrosion and coating inspections. Finally, PA11 and PA12 piping systems can be installed using familiar fabrication and construction techniques already used for low-pressure PE gas pipe.