

Advances in Line Stopping of Polyethylene (PE) Natural Gas Pipelines

White Paper

Overview

When polyethylene (PE) pipes were first introduced to gas distribution in the late 1960s, they offered a significant upgrade in terms of cost efficiency, durability and ease of installation. Since then, PE pipes have come to dominate the landscape of gas distribution systems. In the United States and Canada, more than 90% of natural gas distribution systems use PE pipes in their installations. PE pipes are also used in a majority of installations in Australia and are increasing their market share throughout the world.

The advantages of PE pipes in gas distribution are clear when compared with traditional metal piping systems. Unlike metal pipes, PE pipes are not susceptible to corrosion or rust, and they are extremely resistant to cracks caused by environmental stresses. As PE pipes are lightweight, flexible and easy to store, installation and maintenance of distribution systems is simplified dramatically compared to metal piping. PE pipes also provide substantial energy savings: less energy is needed to manufacture PE pipes than metal pipe products, and the superior longevity of PE pipes ensures that energy savings are delivered over a longer lifespan.

While PE pipes offer improved longevity and durability when compared with metal systems, it is occasionally necessary to perform maintenance or make emergency repairs on PE gas distribution systems. From replacements of older fittings and joints to line relocation projects or installations of isolation valves, it is essential for utilities to be able to isolate flow in PE distribution lines. In the more than five decades since PE pipes became commonly used in gas distribution systems, a number of methods have been used for these flow isolation projects. Vastly different in execution, these flow isolation methods each present a different set of strengths and weaknesses in terms of efficiency, reliability, and long-term impact on a PE piping system.

The most common polyethylene pipes used in gas distribution systems are MDPE (medium density PE)-PE2708 (PE2406 and HDPE (high density PE)- PE4710/PE100 (PE3408), In the United States, the use of polyethylene pipe for gas distribution is governed by the Code of Federal Regulations, 49 CFR Part 192 - Transportation of Natural and Other Gas By Pipeline: Minimum Federal Safety Standards. Pipe is manufactured and tested according to ASTM D 2513. In Canada, similar regulations are prescribed by the CSA Group in CSA Z662 which regulates the design, operation and maintenance of oil and gas pipeline systems.



Fig. 1. Line Stopping Performed On a 4" PE Gas Main to Remove an Outdated Pipe Fitting

Methods of Controlling and Stopping Flow in Polyethylene Natural Gas Pipelines

Several competing methods exist to control and stop the flow of natural gas in PE pipelines. While some methods are nearly as old as PE pipelines themselves, other techniques have emerged recently and present a viable alternative to established practices. The following evaluation of PE flow control techniques provides information and context on each method, while also assessing the strengths and weaknesses of each practice.

Squeezing

Because of the flexible and rugged qualities of PE pipes, squeezing or squeeze-off was established several decades ago as an effective means of flow control in PE distribution systems. Squeezing is performed by compressing PE pipe between parallel bars; complete shut-off is achieved when the inside surfaces make contact. While the technique is simple, it requires specially-designed squeeze-off tools that must be calibrated to the specific diameter and standard dimension ratio of the pipe. Proper equipment and performance allows the procedure to be performed effectively without inflicting long-term damage to the pipe.

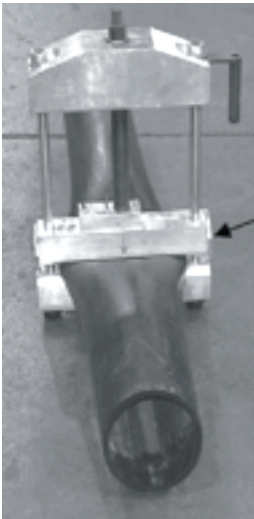


Fig. 2 Squeeze-Off Tool
(Photo: Plastics Pipe Institute)

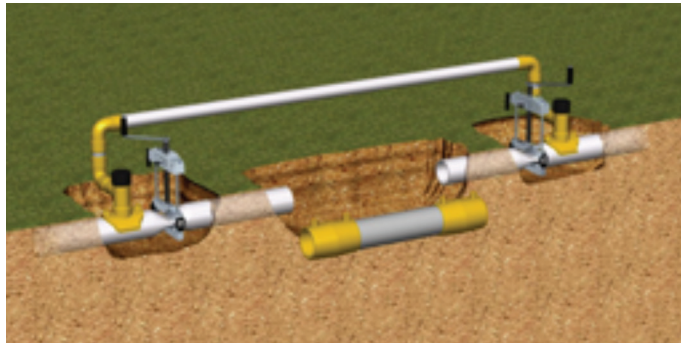


Fig. 3 Animated Rendering of Squeezing in a PE Pipeline

Advantages

The design of PE gas distribution networks includes the deployment of isolation valves at critical locations, allowing sections of the system to be isolated for maintenance. Squeezing allows for localized isolation when existing isolation valves are insufficient to handle maintenance or emergency repairs. In addition to maintenance applications, squeezing is also a useful flow control technique for making installation tie-ins.

When properly executed, squeezing does not cause any long-term structural damage to a PE pipeline. The ruggedness and flexibility of polyethylene enables the pipe to regain its original diameter when the squeeze-off tools are released. No consequential loss in service life is to be expected.

Particularly when compared with flow control in metal distribution systems, squeezing offers considerable advantages in terms of speed and cost. With the proper equipment, squeeze-off can be performed very quickly, leading to reduced maintenance costs and minimal service interruptions. The length of time required for squeezing compression and release depends on the interior diameter of the pipe.

Limitations

While squeezing allows for PE flow control without causing long-term structural damage, it can lead to leakage or pipe failure when improperly performed. If incorrect equipment is used, or if the correct equipment is used inappropriately, it can cause unacceptable strain on the pipe. Additionally, squeezing can only be safely performed once in a single area; repeated flow control requires a different isolation technique or the installation of a valve. All other methods of controlling and stopping flow can be conducted repeatedly, as the entry point that has been tapped into the pipeline can be easily reused as necessary.

Because of the inherent simplicity of the method, squeezing is not suitable for anything except complete flow shut-off. Throttling or partial flow control is not possible through squeezing, and some seepage can also occur in larger pipes or in some high-pressure situations. In these cases two squeeze-offs may be performed, with all maintenance being performed only downstream of the second squeeze-off. If downstream pipeline flow is required, additional bypass fittings must be installed as squeezing has no integral bypass capability as in line stopping or other methods. See Fig 3.

Relevant Standards *Squeezing of PE pipes is governed by standards issued by the American Society for Testing and Materials (ASTM). Relevant standards for squeezing equipment and techniques are ASTM F1734 - Standard Practice for Qualification of a Combination of Squeeze Tool, Pipe, and Squeeze-Off Procedures to Avoid Long-Term Damage in Polyethylene (PE) Gas Pipe; and ASTM F1563 - Standard Specification for Tools to Squeeze-off Polyethylene (PE) Gas Pipe or Tubing.*

Bagging Isolation

The insertion and inflation of bags to isolate sections of pipeline has been a standard practice in metal gas pipelines for more than five decades. The practice was introduced to PE pipelines over a decade ago and represents an alternative to the more common squeeze-off technique. The bagging isolation technique is performed by deploying a mechanical saddle fitted with an integral valve. An entry point is established through hot tap drilling, and the bag is inserted using a bag tube that is connected to the saddle. In many cases, two bags are installed in a series to create a double block and bleed isolation.

Advantages

In comparison to squeezing, bagging does not involve any deformation of the PE pipe. Additionally, bagging does not pose the risks for damage or pipe failure associated with improper performance of squeezing for flow isolation. Bagging also reduces the area required for excavation when conducting a flow control procedure.

Limitations

Bagging isolation can result in failure should the bag burst during the flow control procedure. The risk factor for bag failure is associated with the diameter and operating pressure of the pipe, with larger and higher-pressure pipelines carrying an increased risk of bursting. Bag failure can also be caused by operator error or in the use of materials in poor condition.

Due to the risk of bag failure, flow control through bagging isolation is suitable only in low-pressure applications. Double block and bleed procedures are recommended to mitigate the risk of bag failure, but a failure of both bags could result in a substantial amount of gas being released downstream. PE pipes pose an additional risk when compared with metal systems: the smooth inner walls of PE pipelines provide less grip for the bag material, introducing the possibility of one or more bags slipping due to differences in pressure.

Hybrid Bagging Isolation - Iris

The hybrid bagging isolation/iris flow-stopping technique is similar to bagging in both method of isolation and delivery system. Hybrid isolation involves the introduction of a metal support known as an iris to support the inflated bags in applications with larger diameters or increased operating pressures.

Advantages

While maintaining the same advantages as bagging isolation, hybrid isolation supports increased operating pressures and diameters that would carry a risk of bag failure without the introduction of the metal iris. Inserted into the pipe in a closed position, the iris is a metal fan that can be opened to fully support the inflated bag.

Limitations

The inclusion of a metal iris with an inflated bag increases the acceptable pipe diameter and operating pressure for safe performance. However, hybrid isolation is still only safe for use in low- and medium-pressure situations. Hybrid isolation in high-pressure operations could result in failure.

Repair Clamps

In some instances, full-encirclement-type band clamps are used to reinforce wall thickness after squeezing has been performed on a PE pipe. Repair clamps may also be used to cover holes caused by accidental punctures or abandoned service line connections. The appropriate use of repair clamps on PE pipes has been debated by manufacturers; many manufacturers do not support the practice, while others allow it for repairs where the pipe is capable of maintaining its structural integrity.

Advantages

According to ASTM Standard F1025, repair clamps can offer “a convenient, effective, and safe means of restoring the integrity of an in-service pipeline, without cutting out a section of pipe.” These clamps can offer reinforced wall thickness after a squeeze-off procedure is performed.

Limitations

Even when approved by a manufacturer, the circumstances in which repair clamps can be safely and effectively used are extremely limited. Repair clamps must be used only in temporary circumstances, and they can only be deployed in areas where the pipe can maintain its structural integrity.

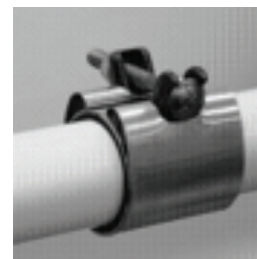


Fig. 4 Repair Clamp

Relevant Standards *The use of repair clamps in PE pipe installations is governed by ASTM Standard F1025 - Standard Guide for Selection and Use of Full-Encirclement-Type Band Clamps for Reinforcement or Repair of Punctures or Holes in Polyethylene Gas Pressure Pipe.*

Line Stopping

The newest technique for flow control in PE gas distribution systems is line stopping. Serving as a control or temporary valve, a line stopping system is inserted into the pipe using a hot tap connection. To stop the flow of gas in the pipe, the line stopper and its housing is attached to an entry valve and mechanically lowered into the pipe. After the procedure is completed, the line stopper is removed and an integral plug is used to seal the hot tap connection.

Current examples of line stopping products include the Shortstopp PE Plugging System from TD Williamson, the Shur Stop PE Line Stopping System from Mueller Co., and the MTD POLYSTOP Line Stopping System from MT Deason. Each system offers varying capabilities with regard to operating pressures and fittings; each product should be researched individually to determine its appropriateness for a specific installation.



Fig. 5 Still Image of PE Line Stopping System

Advantages

Line stopping allows for flow control procedures to be performed in large diameter and high pressure situations, providing increased possibilities for operations when compared with bagging or hybrid isolation systems. Modern line stopping systems allow for machine-to-machine bypassing, eliminating the need for external bypass fittings in many situations. This technological advancement also reduces the excavation footprint compared with other methods of controlling and stopping flow, a critical benefit when excavation size must be kept small due to urban surroundings or existing infrastructure.

In addition to the broad range of applications for line stopping equipment, the plugging technique eliminates the potential for structural damage associated with improper squeezing procedures. Line stopping preserves the integrity of the PE pipe at all times, allowing for enhanced longevity of distribution systems.

Limitations

First generation line stopping systems were limited in application due to their heavy weight and were not designed specifically for use on PE pipes. PE electrofusion fittings had to be developed with pressure ratings compatible with vintage and current PE gas systems. Modern, advanced PE line stopping systems are lighter in weight and are dedicated specifically for PE pipes. Line stopping systems are similar in weight to large squeezing tools and other systems.

Conclusion

As PE pipes continue to comprise the majority of gas distribution installations in North America and around the world, it is important to identify the best method for flow control and isolation. Each technique for flow control - squeezing, bagging, hybrid isolation, repair clamps and line stopping - offers different strengths and weaknesses. The context for a PE flow control procedure must be carefully considered when determining the best method, particularly with regard to pipe diameter and operating pressure.

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