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Kleiss Bag Stopping Evaluation Project

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Prepared For:
Operations Technology Development (OTD), NFP

GTI Project Manager:
Mike Adamo
R&D Manager
847-544-3428
Michael.adamo@gastechnology.org

GTI Technical Contact:
Dennis Jarnecke
Program Manager
847-768-0943
dennis.jarnecke@gastechnology.org

GTI Team Members:
Jeff Mainzer

Gas Technology Institute
1700 S. Mount Prospect Rd.
Des Plaines, Illinois 60018
www.gastechnology.org

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Signature Page

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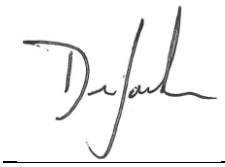
AUTHOR:		
Dennis Jarnecke		October 2015
	Title: R&D Manager	
REVIEWED BY:		
	Title:	
APPROVED BY:		
	Title:	

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Executive Summary

GTI has identified an innovative flow control system overseas that may provide effective flow control on various pipe material, sizes, and pressures while providing a more efficient means of operation. The Kleiss & Co inflatable stopping system appears to meet the needs of the North American LDC's by providing a flow control system that is easy to use and effective at stopping off flow in various pipe materials and a wide range of pipe diameters.

However, evaluation of the Kleiss flow stopping equipment needed to be performed prior to its use on gas systems in North America. The evaluation of this system included the Kleiss tapping equipment, bag system, bags, and other associated components. The objective of this project was to evaluate and test existing inflatable stopper technology capable of stopping off line pressures of 60 psig at pipe diameters up to 18-inches.

The Kleiss MDS System consists of four major components (similar to traditional steel tapping and stopping equipment): 1) Fittings to access the pipe, 2) Tapping machine with cutter, 3) Inflatable stopper, and 4) Stopping machine.

The Kleiss tapping and flow stopping system contains minimal components and has the ability to work on all pipe material – cast iron, polyethylene, PVC, and steel pipes. The same operation and procedures are used in all applications.

Kleiss Tapping and Inflatable Stopping Equipment

Kleiss System Name	MCS System Name	Max. System Pressure	Nominal Pipe Size	Pipe Material	Tap Size
P3	MCS3-216	3 psig	2" - 16"	CI, Steel, PVC, PE	1-1/8", 1-1/2", 2"
BZA-1-G1	MCS15-316	15 psig	3" - 16"	CI, Steel, PVC, PE	1-1/2", 2", 3"
	MCS15-1624	15 psig	16" - 24"	CI, Steel, PVC, PE	5-1/2"
	MCS15-24-30	15 psig	24" - 30"	CI, Steel, PVC, PE	8"
BZA-4-G1	MCS60-38	60 psig	3" - 8"	CI, Steel, PVC, PE	2-1/4"
	MCS60-1016	60 psig	10" - 16" (18" PE)	CI, Steel, PVC, PE	3-3/4"

GTI worked with Kleiss & Co. to identify, obtain, and receive training on the existing inflatable stopping systems applicable to the US natural gas industry. This included the tapping and stopping systems and accessories capable of stopping off line pressures of 60 psig at pipe diameters up to 18-inches.

GTI first developed a testing criteria based on input from the project sponsors. Based on this input the following evaluation needs of the system were identified:

- Review Kleiss systems procedure, safety, and its ability to work on U.S. sized pipes and fittings.
- Evaluate the inflatable stoppers for effectiveness in stopping the flow by simulating various field conditions (i.e., pipe material and size, temperatures, debris, pressures, etc.).
- Evaluate the system and stoppers for flow control by cycling pressure, temperature, and time.
- Evaluate the inflatable stoppers for durability – number of times the bags can be reused, and other bag durability testing.

Based on the information obtained from the field trials, the laboratory tests carried out, and an assessment of the results, the Kleiss tapping and stopping system has been found to be appropriate for natural gas applications for systems up to 60 psig for cast iron, steel, and PE pipes.

A summary of the laboratory test results can be found in the table below.

Kleiss Stopping Equipment Test Summary

KLEISS EQUIPMENT TEST SUMMARY (stopping system evaluations)	P3 (7.5 psig)	BZA-1-G1 (15 psig)	BZA-4-G1 (60 psig)
Flow Stopping Capability (measure flow with flow meter)			
Standard Pressure Test (measure flow past bag for 24 hours)			
6" PE pipe	0 leakage (5-7" bag)	0 leakage (5-7" bag)	0 leakage (5-7" bag)
6" PE pipe	0 leakage (6-8" bag)	0 leakage (6-8" bag)	15 SCFH Leak (6-8" bag)
6" Steel pipe	-	-	< 0.3 SCFH Leak (5-7" bag)
8" Steel pipe	1.2 SCFH Leak (6-8" bag)	0.3 SCFH Leak (6-8" bag)	0 leakage (6-8" bag)
12" Steel pipe	-	43 SCFH Leak (10-12" bag)	-
12" Steel pipe	-	13 SCFH (10-12" bag)**	-
16" Steel pipe	-	102 SCFH Leak (12-16" bag)	-
24 Hour Pressure Test (monitor bag inflation pressure over 24 hour period)			
8" steel pipe	(22 to 19 psig)	(36 to 33 psig)	(116 to 112 psig)
6" steel pipe			(116 to 112 psig)
6" PE pipe			(116 to 112 psig)
Temperature Cycling (32°F - 120°F)			
6" steel pipe			Pass (5" - 7" bag)
8" Steel pipe	Pass (6" - 8" bag)	Pass (15 psig - 6-8" bag)	
8" Steel pipe		Fail (25 psig - 6-8" bag)	
8" Steel pipe		Fail (25 psig - 6-8" bag)	
8" steel pipe		Pass (25 psig - 6-8" bag)	
Pipe Pressure Cycling (50% Sys Pressure to System Max + 10%)			
6" steel pipe (5-7" bag)		1.2 to 3.5 SCFH leakage	0 to 3.0 SCFH leakage
6" Steel pipe (6-8" bag)		0 leakage	0 leakage
8" Steel pipe (5-7" bag)		0.3 to 2.0 SCFH leakage	-
8" Steel pipe (6-8" bag)	0.3 to 1.3 SCFH leakage	0 to 1.0 SCFH leakage	0 leakage
Debris/Chip Evaluation (measure flow past bag over 24 hours)			
6" steel pipe (5-7" bag)			0.3 SCFH leakage
8" Steel pipe (6-8" bag)	0.4 SCFH leakage	0.4 SCFH leakage	0.3 SCFH leakage
Bag Durability Evaluation (open end pipes)			
Burst Test (increase bag pressure inside pipe until failure)			
8" steel pipe (6-8" bag)	77.7 psig	140.8 psig	384.2 psig
8" steel pipe (5-7" bag)			351.0 psig
System Over Pressure (pipe pressure greater than rated - 6 hour test)			
8" steel pipe at 12.5 psig	Pass		
8" steel pipe at 25 psig		Pass	
8" steel pipe at 100 psig			Pass
Stopper System Cycling (Insertion, pressurization, depressurization, and Removal)			
8" pipe at max pressure w/ outlet cracked and cycle 50 times	Pass	Pass	Pass
Debris/Chip Evaluation (same test as above)			
8" pipe at max pressure w/ outlet cracked cycle 10 times	Pass - No issues	Fail - Leaks due to shavings	Pass - No issues
Tapping/Bagging System			
Cutter/Tapping Machine Performance	CI, Steel, PE	CI, Steel, PE	Steel, and PE
Tap CI, Steel, and PE pipes 10 times each and evaluate	Pass - No issues	Pass - No issues	Pass - No issues
Tapping Machine Performance (Sealing, Safety)	CI, Steel, PE	CI, Steel, PE	Steel, PE
Overview of operation of tapping machine under pressure	Pass - No issues	Pass - No issues	Pass - No issues
Bag Stopping Machine and Components	Pass - No issues	Pass - No issues	Pass - No issues
Operational Procedures (evaluate direction of bags)	Pass - No issues	Pass - No issues	Pass - No issues

** Note: GTI conducted the test again using the newly designed 15 psig stopper with the black hydraulic hose and connector

Introduction

Effective natural gas flow control is critical to LDCs' operations ranging from routine construction and maintenance activities to responding to emergency situations resulting from third party damages on PE piping systems.

Today's line stopping equipment is the same equipment that the natural gas industry has been using for over 50 years. The equipment is heavy (takes multiple people or mechanical assists to maneuver), costly to maintain, and is very time consuming when installing necessary fittings (welding time and drilling).

One need is for use on larger diameter (8" – 24") cast iron and steel piping systems that operate at lower operating pressures (60 psig and less) and have limited options to control gas flow. Current bag stopping equipment can only be used up to 5 psig. Therefore, when cast iron and/or steel systems are operating at medium pressures (greater than 5 psig), the options for shutdown are either valves which may negatively impact customers or costly line stoppers.

Another need is related to the natural gas industry's move to the use of larger diameter polyethylene (PE) pipe. Manual and hydraulic squeeze tools are manufactured to squeeze the PE pipe to stop the flow of gas, however, squeezing vintage pipe may lead to premature failure due to the possible brittle nature of the aged PE material. In addition, squeeze tools for larger diameter PE pipes (8" and greater) are cumbersome and time consuming to use.

Some efforts have been made to address these needs such as TD Williamson's SHORTSTOPP® PE system and Goodman's One-Tap Launch Tube System™. However, both have their limitations and do not meet the existing needs of the industry. The SHORTSTOPP® equipment is designed to be used on 4 – 12-inch PE piping systems but the equipment is large and heavy. The Goodman system is also designed for 4 – 12-inch piping systems but can only be used at a maximum pipe pressure of 5 psig.

GTI has identified an innovative flow control system overseas that may provide effective flow control on various pipe material, sizes, and pressures while providing a more efficient means of operation. The Kleiss & Co inflatable stopping system appears to meet the needs of the North American LDC's by providing a flow control system that is easy to use and effective at stopping off flow in various pipe materials and a wide range of pipe diameters. However, evaluation of the Kleiss flow stopping equipment needs to be performed prior to its use on gas systems in North America. The evaluation needs to include the Kleiss fittings (or recommended fittings), tapping equipment, bag system, bags, and other associated components. Evaluations are necessary to validate the performance of the system to meet the various needs of the gas industry.

The objective of this project was to evaluate and test existing inflatable stopper technology capable of stopping off line pressures of 60 psig at pipe diameters up to 18-inches.

Kleiss & Co Flow Stopping Systems

The Kleiss MDS System consists of four major components (similar to traditional steel tapping and stopping equipment):

1. Fittings to access the pipe
2. Tapping machine with cutter
3. Inflatable stopper, and
4. Stopping machine

The Kleiss tapping and flow stopping system contains minimal components and has the ability to work on all pipe material – cast iron, polyethylene, PVC, and steel pipes. The same operation and procedures are used in all applications.

Fittings

Several Kleiss fittings exist to allow the different flow stopping systems to access the various sizes and types of gas pipe.

For the P3 low pressure system (up to 5 psig), the Kleiss fittings allow for a no-blow tapping and stopping operation without the need to use a valve and stuffing box. This unique fitting (see Figures 1 and 2) contains a rubber seal and flapper to eliminate gas release during both the tapping and stopping process. This fitting is currently manufactured from PVC and can be glued to PVC pipe or threaded into a stainless steel band clamp or PE fittings. GTI has recommended that this fitting be manufactured from polyethylene (PE) or polyamide (PA) materials for use in the North American natural gas industry.

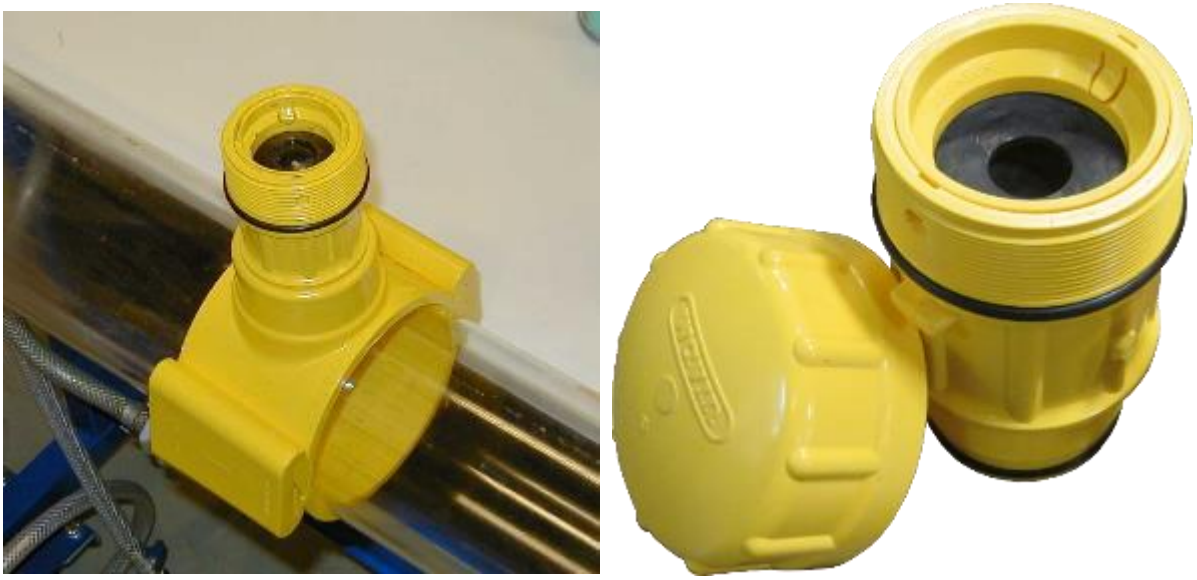

Figure 1. P3 low pressure system valveless – no-blow fittings

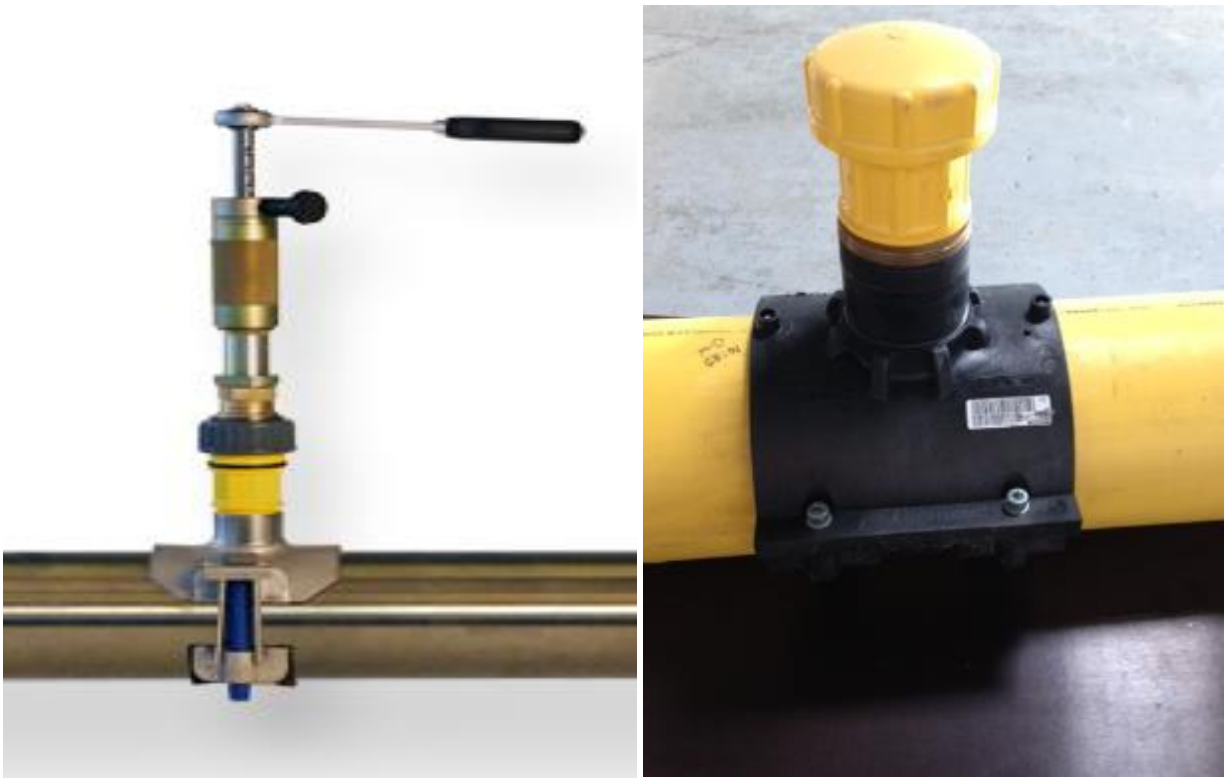

Figure 2. P3 Low Pressure System fittings threaded into stainless band clamps and PE fittings

The Kleiss medium (up to 15 psig) and high (up to 60 psig) pressure systems can be used on cast iron, steel, PVC, and PE piping systems using a variety of fittings. For cast iron, a full range of stainless steel strap style fittings exist to allow the pipe to be tapped and the flow of gas stopped (see Figures 2 and 3). For steel pipe, weld on fittings exist (see Figures 3 and 5). Finally for PE piping systems, Kleiss offers a series of electrofusion PE fittings (see Figures 2, 4, 6, 7, and 8).

The Kleiss PE fittings are electrofusion full encirclement type fittings (see Figure 4). However, the PE electrofusion fittings for use on 10" diameter PE pipe and larger incorporate nylon straps to secure the fitting to the PE pipe for joining (see Figure 8).

The PE fittings currently only maintain an ISO compliance rating. GTI has alerted Kleiss that the PE fitting must be in compliance with ASTM D2513 and associated standards. Once compliant, the fittings must also be marked accordingly.

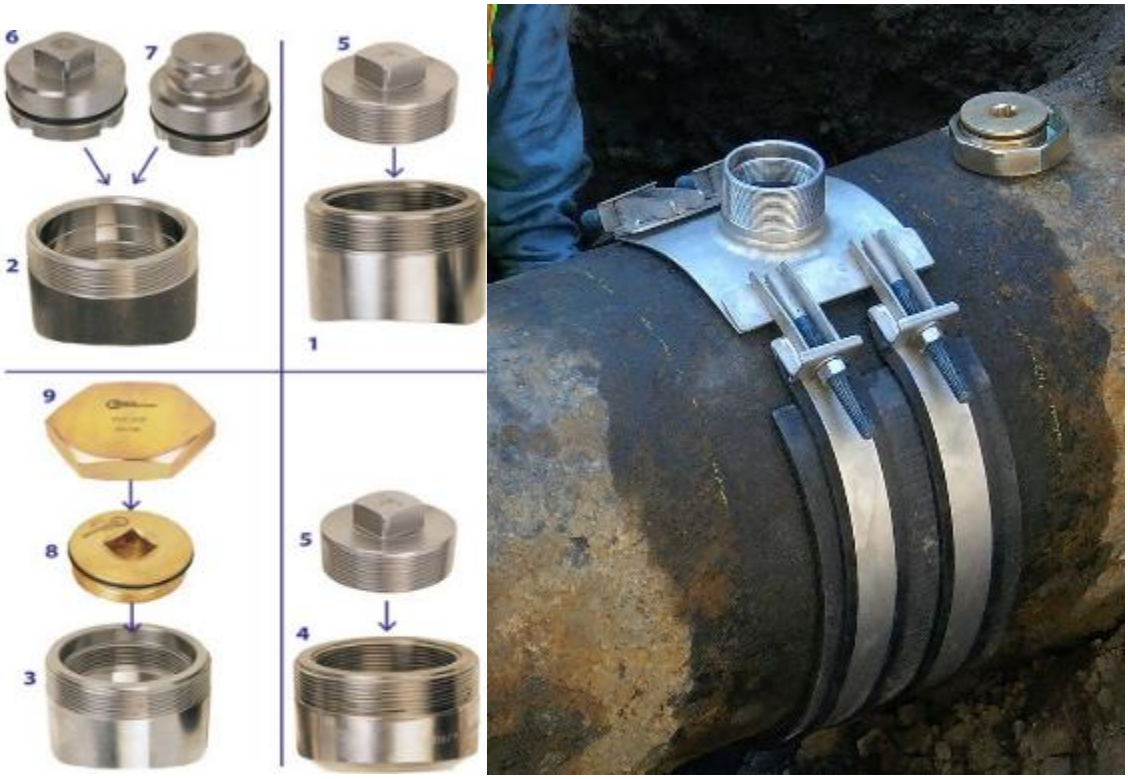

Figure 3. Kleiss steel weld on fittings and stainless steel strap style fitting for cast iron pipe

Figure 4. Kleiss electrofusion PE fittings

Figure 5. Kleiss BZA-4G1 stopping system attached to a weld-on fitting and steel pipe

Figure 6. Kleiss BZA-4G1 stopping system attached to an electrofusion PE fitting and PE pipe

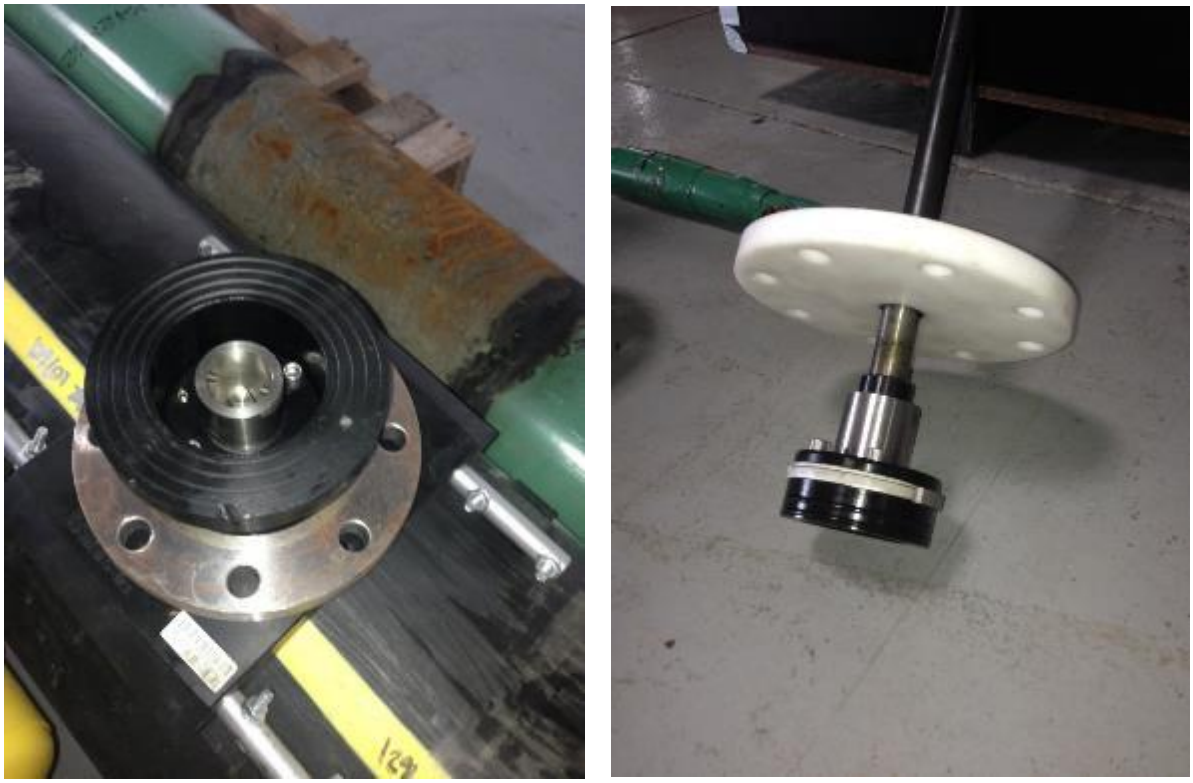

Figure 7. Kleiss electrofusion PE fitting and completion plug for 10" – 18" PE pipe

Figure 8. Kleiss BZA-4-G2 system attached to an electrofusion fitting on an 18" dia. PE pipe

Kleiss Tapping System

In order to install the inflatable stoppers into the gas pipes, Kleiss has a full line of tapping equipment and accessories. Table 1 lists the Kleiss and the US Distributors (MCS) model names.

Table 1. Kleiss Equipment information

Kleiss Tapping and Inflatable Stopping Equipment

Kleiss Tapping and Inflatable Stopping Equipment

Kleiss System Name	MCS System Name	Max. System Pressure	Nominal Pipe Size	Pipe Material	Tap Size
P3	MCS3-216	3 psig	2" - 16"	CI, Steel, PVC, PE	1-1/8", 1-1/2", 2"
BZA-1-G1	MCS15-316	15 psig	3" - 16"	CI, Steel, PVC, PE	1-1/2", 2", 3"
	MCS15-1624	15 psig	16" - 24"	CI, Steel, PVC, PE	5-1/2"
	MCS15-24-30	15 psig	24" - 30"	CI, Steel, PVC, PE	8"
BZA-4-G1	MCS60-38	60 psig	3" - 8"	CI, Steel, PVC, PE	2-1/4"
	MCS60-1016	60 psig	10" - 16" (18" PE)	CI, Steel, PVC, PE	3-3/4"

The low pressure system uses the LB493-C tapping tool. This system is for hot tapping steel, cast iron, and PE pipes and has a hole saw capacity of ¾" – 1-1/2". A hand ratchet is used to rotate the shaft, however, an optional air motor can be used.

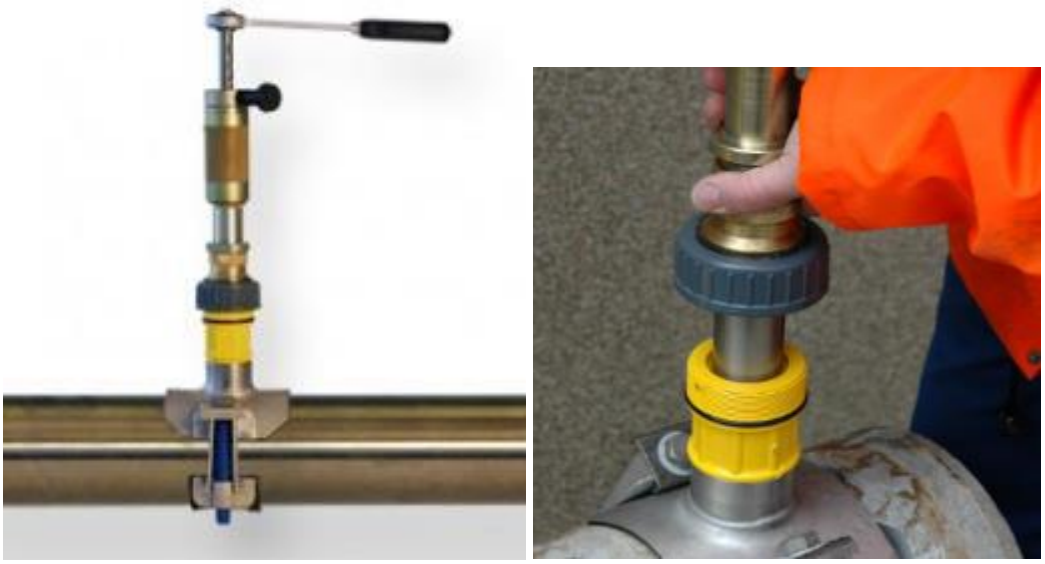

Figure 9. P3 (low pressure) hot tapping tool

Both the medium and high pressure systems (BZA-1-G1 and BZA-4-G1) use the MCS60-38 hot tapping tool. This system can be utilized with the hand ratchet for tapping PE pipes or the air motor (Figure 11) for tapping steel and cast iron pipes (see Figure 10). The MCS60-38 tapping tool kit (Figure 12) includes everything required to tap PE, steel, and cast iron pipes. Various drill bits and shell cutters are used based on the type of pipe being tapped (Figure 13).

Figure 10. Hot tapping tool for medium and high pressure systems.

Figure 11. Optional air motor to assist with the tapping operation

Figure 12. Hot tapping kit with all necessary accessories

Figure 13. Cutters used to tap PE, Steel, and Cast Iron pipe

Inflatable stopper

MDS (multi-dimensional) inflatable stoppers are used for pipeline isolation for natural gas applications up to 60 psig. The MDS stoppers consists of natural rubber with aramid fiber reinforcement. This reinforcement which has a cross-ply configuration is located between two layers of rubber. In order to increase adhesion to the pipe wall caused by friction, corundum crystals (aluminum oxide) are applied to the surface of the stopper for friction purposes (dark areas on the stopper in Figure 14). A telescopic rod is located inside the stopper. This rod is shortened as the stopper is inflated and extends as the stopper is deflated. This ensures that the inflatable stopper maintains a straight position at all times.

An additional hose is installed inside the telescopic rod. This allows the measurement of the upstream pressure (pressure in the isolated pipeline upstream or downstream from the inflatable stopper) via a small opening at the end of the stopper (Figure 15).

The stoppers may be reused many times. The stoppers must be visually inspected to identify any damage each time before it is reused.

Figure 14. Kleiss Inflatable Stoppers Deflated and Inflated

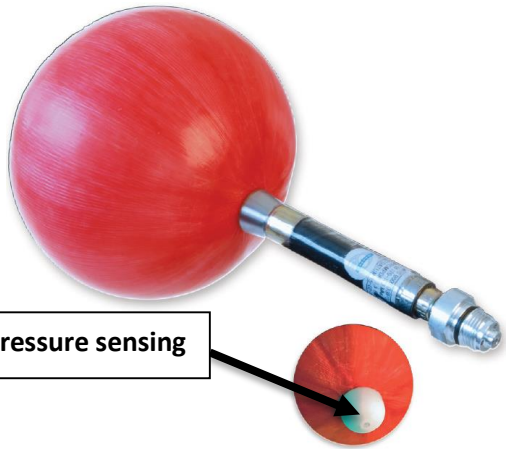

Figure 15. Pressure sensing

The MDS inflatable stoppers are able to be used on all pipe materials and each stopper is capable of being used on a range of pipe diameters – each one is good for two different diameter pipes (i.e., 6” and 8” diameter).

Kleiss Stopping System

Once the fitting is installed and tapped using the Kleiss tapping equipment, the appropriate stopper is installed to insert the inflatable stopper into the pipe and allow it to be inflated. As with the other Kleiss stopping system components, the Kleiss stopping tool is also used on various material types and sizes of pipe. The stopping system is divided up by maximum system operating pressures.

- Kleiss P3 System - 3 psig, 2" to 16" Pipe
- Kleiss BZA-1-G1 System – 15 psig, 3” to 16” Pipe
- Kleiss BZA-4-G1 System - 60 psig, 3" to 8" Pipe
- Kleiss MCS60-1016 System - 60 psig, 10" to 16" (18" PE) Pipe

Each stopping system uses a series of directional shoes which serve multiple purposes. The directional shoes first allow the stopper to be directed in the appropriate direction into the gas pipe. They also provide the correct height to allow the appropriate sized stoppers to be contained in the directional show and also allow the stopper machine to be lowered the appropriate distance into the pipe to allow the stopper to be inserted into the pipe.

Figure 16. Kleiss P3 stopping system and various size direction shoes for insertion of the stopper

Figure 17. Kleiss BZA-1-G1 stopping system for pressures and pipe diameters up to 15 psig and 16”

Figure 18. Kleiss BZA-4-G1 stopping system for pressures and pipe diameters up to 60 psig and 8”

Figure 19. Kleiss MCS60-1016 stopping system for pressures and pipe diameters up to 60 psig and 16" (up to 18" for PE pipe)

The Kleiss stopping system also allows for pressure sensing of both the upstream and downstream pressures in the gas pipe and also the inflatable stopper pressure (see Figure 22).

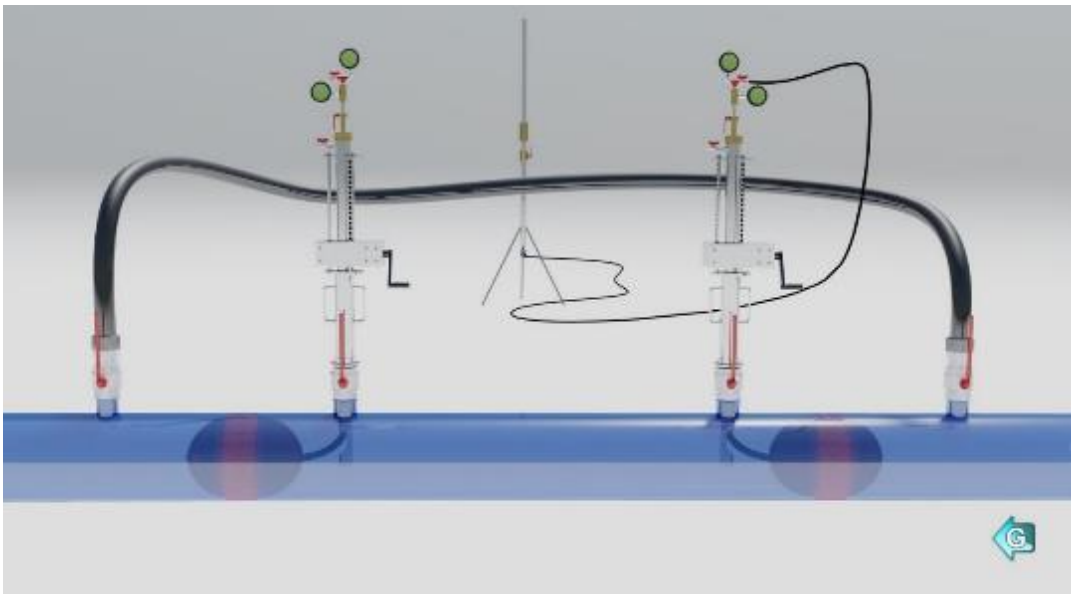

Figure 20. Depiction of the Kleiss system used to stop off the flow of gas with a by-pass and purge stack set up

Figure 21. Kleiss BZA-4-G1 stopping system with carrying case and inflation pump

Figure 22. Kleiss pressure gauges used to determine inflation pressure in stoppers and upstream/downstream pressure in the pipe.

Figure 23. Kleiss inflatable stopping system depicted deployed inside a pipe

Evaluation of the Kleiss Flow Stopping Systems

Line-stopping equipment used in the natural gas industry is usually heavy, takes multiple people or mechanical assists to maneuver, is costly to purchase and maintain, and is very time consuming when installing and tapping necessary fittings.

In response, GTI investigated new line-stopping equipment that has the potential to reduce these problematic issues.

This new line-stopping equipment may address several industry needs:

- One application is for use on larger-diameter (12- inch to 24-inch) cast-iron and steel piping systems that operate at pressures greater than five psig and have limited options to control gas flow. Currently, bag stopping equipment can only be used up to five psig. Therefore, when cast-iron and/or steel systems that are operating at medium pressures (greater than five psig) the options for shutdown are either valves – which may negatively impact customers – or costly line stoppers.
- Another application is related to the natural gas industry's increasing use of larger-diameter polyethylene (PE) pipe. Hydraulic squeeze tools are manufactured to squeeze the PE pipe to stop the flow of gas, but an alternative is needed.
- New inflatable stopping equipment may have the potential to be used in combination with traditional line-stopping equipment to provide additional safety. The inflatable stopper can act as a secondary stop with a vent (bleed) between the primary stop (traditional equipment) and the secondary stop. This application can potentially be used on higher-pressure systems (greater than 60 psig). The traditional stopping equipment can be used to stop-off the majority of the flow of gas; however, at times complete flow stoppage cannot be obtained. This inflatable stopping system could be used to completely stop off the gas flow while the "blow by" from the traditional stopper is vented to atmosphere. Therefore, the high pressures in the pipe will not be seen by the inflatable stopper.

In this project, GTI evaluated a system from a European manufacturer of equipment and materials, including several styles of flow-stopping products able to be used on gas pipes with diameters up to 18-inches and pressures up to 60 psig.

Kleiss & Co

Kleiss & Co started in 1967 as a trading company and evolved over time into a leading manufacturer of equipment, tools and materials for the construction of pipelines and pipeline related systems. Kleiss is headquarters and main production facility is in Zwijndrecht in the Netherland and they serve the oil, gas and water industry through an extensive network of overseas production facilities, branch offices, stockholding distributors and agents throughout the world.

Kleiss History:

1967: Kleiss & Co. founded

1998: Introduced MDS stoppers, as an enhanced and safer technology for the gas industry

2002: Pipesurvey International – pipeline cleaning, inspection, and smart pigging

2008: Manufacturer of VISCOTAQ pipeline coatings

Evaluation Efforts

The objective of this project was to evaluate the existing inflatable stopper systems and accessories manufactured by Kleiss. In addition, if the evaluation of the stopping system was promising, GTI would assist with the technology transfer for the U.S. natural gas industry.

GTI worked with Kleiss & Co. to identify, obtain, and receive training on the existing inflatable stopping systems applicable to the US natural gas industry. This included the tapping and stopping systems and accessories capable of stopping off line pressures of 60 psig at pipe diameters up to 18-inches.

GTI first developed a testing criteria based on input from the project sponsors. Based on this input the following evaluation needs of the system and test matrix (Figure 24) were developed:

- Overview of the Kleiss systems and review of its overall procedure, safety, and its ability to work on U.S. sized pipes and fittings.
- Evaluation of the inflatable stoppers for effectiveness in stopping the flow by simulating various field conditions (i.e., pipe material and size, temperatures, debris, pressures, etc.).
- Evaluate the system and stoppers for flow control by cycling pressure, temperature, and time.
- Evaluate the inflatable stoppers for durability – how many times can the bags be reused? What condition of the bag is detrimental to the performance of the bag?

KLEISS EQUIPMENT TEST MATRIX
Flow Stopping Capability (measure flow with flow meter)
Standard pressure test (min and max ID)
Temperature Cycling (32F - 120F)
Pipe Pressure Cycling (50% Sys Pressure to System Max + 10%)
Debris/Chip Evaluation
Bag Durability Evaluation (open end pipes)
Burst Test
System Over Pressure
Insertion, pressurization, depressurization, and Removal Cycling
Debris/Chip Evaluation (same test as above)
Tapping/Bagging System
Cutter/Tapping Machine Performance
Tapping Machine Performance (Sealing, Safety)
Bag Stopping Machine and Components (Valves, Adapters, Chip Removal)
Operational Procedures (evaluate direction of bags)

Figure 24. Kleiss Test Matrix

GTI received the various stopping and tapping equipment required to perform the evaluations from Kleiss. In addition, Kleiss representatives visited GTI to review the equipment and procedures in August 2012. Additional information on each system in Figure 25 can be found in the Appendix.

The systems received to date include:

- P3 System – 7.5 psig system (2” thru 16” pipe diameters)
- BZA-1-G1 System - 15 psig system (3” thru 16” pipe diameters)
- BZA-4-G1 System - 60 psig system (3” thru 8” pipe diameters)

Figure 25. P3 (low pressure 7.5 psig), BZA-1-G1 (medium pressure 15 psig), BZA-4-G1 (high pressure 60 psig) stopping systems

In order to evaluate the Kleiss systems, GTI obtained steel, cast iron, and PE pipe and installed the necessary Kleiss fittings to allow for the Kleiss tapping and stopping systems to be applied (see Figure 26). The test pipes included:

- 4”, 6”, 8”, and 16” steel pipe with various size weld on fittings
- 4”, 6”, 8”, and 18” PE pipe with various size electrofusion fittings

Figure 26. Cast iron, steel, and PE pipe to evaluate the Kleiss system

Based on the equipment received and the needs of the project sponsors, GTI received the training from the Kleiss representatives. One of the initial issues identified by GTI was the lack of equipment and procedural manuals in English for the various equipment and all of the dimensions and pressures were in metric.

After receiving the training, the GTI technical team proceeded with evaluation of the Kleiss tapping and stopping equipment.

Standard Pressure Test:

The standard pressure test is designed to evaluate the overall performance of the inflatable stoppers at various pressures over a 24 hour period. GTI evaluated the various Kleiss stopping systems (P3, BZA-1-G1, and BZA-4-G1) using 6" through 16" plastic and steel pipes. Fittings were installed on the pressurized pipes and the stopping systems deployed. GTI opened a downstream valve and monitored for any "blow by" past the inflated stoppers.

GTI followed operational procedures for installation and inflation of the stoppers provided by Kleiss. The inflatable stoppers were installed with the listed line pressure already present in the pipe. During stopper removal, GTI did not introduce downstream pressure across the stopper, but rather deflated the stopper allowing the downstream section of pipe to be re-pressurized.

Also, the Kleiss inflatable stoppers can each be used on two different pipe diameters. GTI evaluated the stoppers for the various range of pipes listed on each.

P3 (low pressure) – Standard Pressure Testing:

- 6” PE Pipe - room temperature measuring flow past the stopper for 24-hours

  Pipe pressure = 7.5 psig

  Results = 0 leakage downstream of the 120-160mm (5”-7”) stopper

- 6” PE pipe - room temperature measuring flow past the stopper for 24-hours

  Pipe pressure = 7.5 psig

  Results = 0 leakage downstream of the 140-215mm (6”-8”) stopper

- 8” steel pipe room temperature measuring flow past the stopper for 24-hours

  Pipe pressure = 7.5 psig

  Results = 1.2 SCFH leakage downstream of the 140-215mm (6”-8”) stopper

BZA-1-G1 (medium pressure) – Standard Pressure Testing:

- 6” PE pipe - room temperature measuring flow past the stopper for 24-hours

  Pipe pressure = 15 psig

  Results = 0 leakage downstream of the 120-170mm (5”-7”) stopper

- 6” PE pipe - room temperature measuring flow past the stopper for 24-hours

  Pipe pressure = 15 psig

  Results = 0 leakage downstream of the 140-215mm (6”-8”) stopper

- 8” steel pipe room temperature measuring flow past the stopper for 24-hours

  Pipe pressure = 15 psig

  Results = 0.3 SCFH leakage downstream of the 140-215mm (6”-8”)

- 12” steel pipe room temperature measuring flow past the stopper for 24-hours

  (Tested with Kleiss original bag - i.e. plastic tubing with compression fitting connector)

  Pipe pressure = 15 psig

  Results = 43.0 SCFH leakage downstream of the 240-300mm (10”-12”) stopper

- 12” steel pipe room temperature measuring flow past the stopper for 24-hours

(Tested with Kleiss *new designed bag* - i.e. black hydraulic hose and connector**)

Pipe pressure = 15 psig

Results = 13.0 SCFH leakage downstream of the 240-300mm (10”-12”) stopper

- 16” steel pipe room temperature measuring flow past the stopper for 24-hours

  (Tested with Kleiss original bag - i.e. plastic tubing with compression fitting connector)

  Pipe pressure = 15 psig

  Results = 102.0 SCFH leakage downstream of the 300-400mm (12”-16”) stopper

*GTI ran the same test again to reset the stopper in the pipe (to see if it decreased the leak rate) and this time the stopper failed. The stopper slid forward inside the pipe. After removing the stopper from the pipe it was found that the tube connecting the bag to the machine partially pulled out of the compression fitting exposing at least one fill hole. See Figure 27.

**GTI informed Kleiss of the issue with the fill tube pulling out of the compression fitting at the base of the bag. Kleiss indicated that the pressure should be equalized (upstream and downstream of the stopper) prior to deflating the stopper. GTI did not equalize pressure upstream and downstream of the stoppers and indicated to Kleiss that this same flow across the bag could occur during the installation of the stopper in the pipe under high flow conditions. To solve this issue, Kleiss decided to modify the 15 psig stoppers by designing and fabricating them in a similar fashion as the 60 psig stoppers – eliminate the poly fill tube and utility the black hydraulic hose and connectors.

GTI conducted the test again using the newly designed 15 psig stopper with the black hydraulic hose and connector.

- 16” steel pipe room temperature measuring flow past the stopper for 24-hours

  (Tested with Kleiss *new designed bag* - i.e. black hydraulic hose and connector**)

  Pipe pressure = 15 psig

  Results = Bag failed. Removed bag from pipe and found that threads cracked on the threads of the push rod on the stopping machine. This is where the stopping machine adapter is attached to bag. See Figure 28.

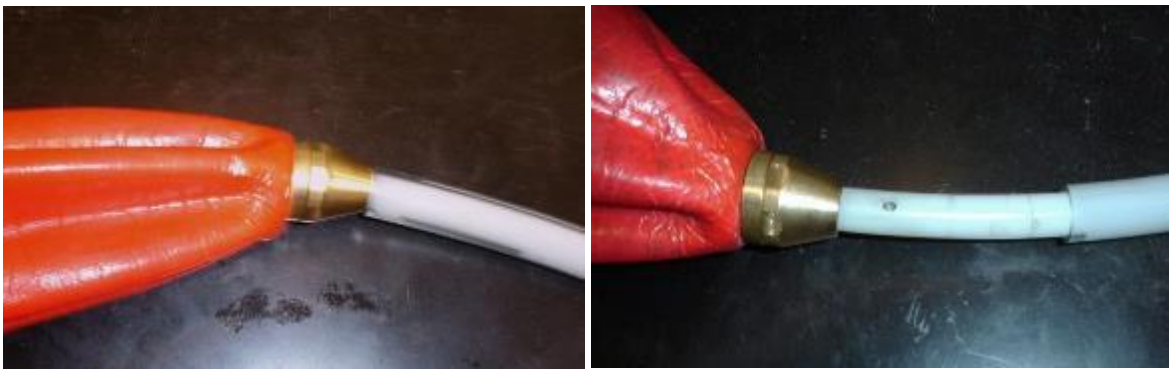

Figure 27. 15 psig stopper new (left) and 15 psig stopper after bag slid forward in pipe

Figure 28. Stem of stopping machine cracked with newly designed 16" stopper at 15 psig pipe pressure

Based on the results of the recent stopper failure (crack at the threads of the push rod), GTI suggested to Kleiss that they also include the grit material on the outside of the back which is found on the 60 psig stoppers and not the 15 psig stoppers (see Figure 28). This grit material will minimize the bag from slipping inside the pipe and therefore minimizing the stress on the stopper and the connectors. GTI received (4) 16" newly designed stoppers from Kleiss with grit surface applied to outer bag material similar to the 60 psig stoppers. Figure 29 shows the progression of the 15 psig stoppers; original design, modified with hydraulic hose and connector, and modified with hydraulic hose/connector and grit on bag surface.

Figure 29. Kleiss stoppers with and without the grit coating (dark strips on surface of bag)

Figure 30. Kleiss medium pressure (15 psig) progression of bag design – top bag is the original with poly tube and no grit – middle bag was modified to include hydraulic hose and connector – bottom bag was modified to include hydraulic hose/connector, and grit on bag surface.

BZA-4-G1 (high pressure) – Standard Pressure Testing:

- 6" PE pipe room temperature measuring flow past the stopper for 24-hours

  Pipe pressure = 60 psig

  Results = 0 leakage downstream of the 120-160mm (5"-7") stopper

- 6" PE pipe room temperature measuring flow past the stopper for 24-hours

  Pipe Pressure = 60 psig

  Results = 15.0 SCFH leakage downstream of the 160-215mm (6"-8") stopper

- 6" steel pipe room temperature measuring flow past the stopper for 24-hours

  Pipe pressure = 60 psig

  Results = less than 0.3 SCFH leakage downstream of the 120-170mm (5"-7") stopper

- 8" steel pipe room temperature measuring flow past the stopper for 24-hours

  Pipe pressure = 60 psig

  Results = 0 leakage downstream of the 140-215mm (6"-8") stopper

Based on the results of the standard pressure tests, both the P3 (low pressure) and BZA-4-G1 (60 psig) stoppers met expectations for stopping off the flow of gas inside of the various pipe sizes and materials. Issues were identified with the BZA-1-G1 (15 psig) stoppers during this test. Once the design of the

stoppers were changed (modified bags to include hydraulic hose/connectors and grit on bag surface), the 15 psig stoppers also met expectations for stopping off flow inside of the pipe.

24 Hour Pressure Test:

The 24 hour test is designed to determine the loss of inflation pressure in the bag over a 24 hour period. The test consisted of:

- Deploying the bag using the appropriate launch system
- Pressurizing the bag to the recommended bag inflation pressure
- Closing the inflation valve to bag
- Recording the bag inflation pressure after the 24 hour period

A 24-hour standard pressure test to monitor bag pressure was first conducted on **8" steel pipe**. The results are listed below:

P3 System (low pressure)

Pipe pressure = 7.5 psig

Initial bag inflation pressure = 1.5 bar (22 psig)

Bag pressure after 24 hours = 1.3 bar (19 psig)

BZA-1-G1 System (medium pressure)

Pipe pressure = 15 psig

Initial bag inflation pressure = 2.5 bar (36 psig)

Bag pressure after 24 hours = 2.3 bar (33 psig)

BZA-4-G1 System (high pressure)

Pipe pressure = 60 psig

Initial bag inflation pressure = 8 bar (116 psig)

Bag pressure after 24 hours = 7.8 bar (112 psig)

The 24-hour standard pressure test to monitor bag pressure was then conducted on **6" steel pipe**. The results are listed below:

BZA-4-G1 System (high pressure)

Pipe pressure = 60 psig

Initial bag inflation pressure = 8 bar (116 psig)

Bag pressure after 24 hours = 7.8 bar (112 psig)

The 24-hour standard pressure test to monitor bag pressure was finally conducted on **6" PE pipe**. The results are listed below:

BZA-4-G1 System (high pressure)

Pipe pressure = 60 psig

Initial bag inflation pressure = 8 bar (116 psig)

Bag pressure after 24 hours = 7.8 bar (112 psig)

Based on the results of the 24 hour bag inflation pressure test, all of the bags encountered minimal pressure loss during the test and maintained sufficient pressure to stop off the maximum intended flow in the pipe.

Temperature Cycling Test:

The temperature cycling test consists of placing an 8-inch steel pipe into the walk-in environmental chamber along with the Kleiss stopping system. The appropriate sized stopper is inserted into the pipe and inflated to the appropriate bag pressure. The pipe is pressurized to the maximum pressure of the stopper system and the temperature in the environmental chamber is cycled between 32°F and 120°F. The temperature cycles were held at each temperature for 2 hours with a 2 hour ramp time between temperatures. A total of four cycles were conducted for each test. The technical team monitored the bag inflation pressure and downstream flow for any blow by. Tests were performed with all three Kleiss systems with the following pressures in the steel pipe: 7.5, 15, and 60 psig.

Table 2. Temperature Cycling Test Results

TEST	PIPE SIZE	PIPE PRESSURE	BAG PRESSURE	BAG SIZE	PASS/FAIL *
Test 1	8" Steel	15 psig	37 psig	140-215 mm	Pass
Test 2	8" Steel	25 psig**	37 psig	140-215 mm	Fail

Test 3	8” Steel	25 psig**	37 psig	140-215 mm	Fail
Test 4	6” Steel	60 psig	120 psig	120-170 mm	Pass
Test 5	8” Steel	7.5 psig	22 psig	140-215 mm	Pass
Test 6	8” Steel	25 psig	60 psig	140-215 mm	Pass

** Pass: minimal leakage / Fail: bag seal failure*

*** Bag system used was only rated to 15 psig*

Tests number 2 and 3 resulted in failures. However, the Kleiss system used during these two tests is only rated to 15 psig and GTI increased the pipe pressure to 25 psig (10 psig beyond the rating of the system). Kleiss recommended increasing the bag pressures along with the pipe pressures. Test 6 duplicated tests 2 and 3 but with an increased bag pressure of 60 psig (versus 37 psig in tests 2 and 3). The test passed the temperature cycling evaluation even at a system pressure of 25 psig (equipment rated to 15 psig).

Pipe Pressure Cycling Test:

The Pipe Pressure Cycling test consisted of 6” and 8” steel pipe cycling from 50% system pressure to the maximum system pressure plus 10%. Each pressure was held for 10 minutes and cycled 25 times from 50% to max pressure + 10%. This test was conducted on all 3 Kleiss stopping systems.

P3 System (low pressure)

- **8” steel pipe** pressure cycling
  - 7.5 psig system with a 140-215mm (6”-8”) bag
  - Pressure cycling between 3.75 and 8.25 psig
    - Results at 3.75 psig = .3 SCFH leakage (avg.)
    - Results at 8.25 psig = 1.3 SCFH leakage (avg.)

BZA-1-G1 System (medium pressure)

- **6” steel pipe** pressure cycling
  - 15 psig system with a 120-170mm (5”-7”) bag
  - Pressure cycling between 7.5 and 16.5 psig
    - Results at 7.5 psig = 1.2 SCFH leakage (avg.)
    - Results at 16.5 psig = 3.5 SCFH leakage (avg.)
- **6” steel pipe** pressure cycling
  - 15 psig system with a 140-215mm (6”-8”) bag (Kleiss newly designed bag with hydraulic hose and connector)
  - Pressure cycling between 7.5 and 16.5 psig
    - Results at 7.5 psig = 0 leakage
    - Results at 16.5 psig = 0 leakage
- **8” steel pipe** pressure cycling
  - 15 psig system with a 120-170mm (5”-7”) bag

- Pressure cycling between 7.5 and 16.5 psig
    - Results at 7.5 psig = 0.3 SCFH leakage (avg.)
    - Results at 16.5 psig = 2.0 SCFH leakage (avg.)
- **8" steel pipe** pressure cycling
    - 15 psig system with a 140-215mm (6"-8") bag (newly designed Kleiss bag with hydraulic hose and connector)
    - Pressure cycling between 7.5 and 16.5 psig
        - Results at 7.5 psig = 0 leakage
        - Results at 16.5 psig = 1.0 SCFH leakage (avg.)

BZA-4-G1 System (high pressure)

- **6" steel pipe** pressure cycling
    - 60 psig system with a 120-170mm (5"-7") bag
    - Pressure cycling between 30 and 66 psig
        - Results at 30 psig = 0 leakage
        - Results at 66 psig = 3.0 SCFH leakage (avg.)
- **6" steel pipe** pressure cycling
    - 60 psig system with a 140-215mm (6"-8") bag
    - Pressure cycling between 30 and 66 psig
        - Results at 30 psig = 0 leakage
        - Results at 66 psig = 0 leakage
- **8" steel Pipe** pressure cycling
    - 60 psig system with a 140-215mm (6"-8") bag
    - Pressure cycling between 30 and 66.0 psig
        - Results at 30 psig = 0 leakage
        - Results at 66 psig = 0 leakage

Debris Testing:

In order to evaluate the durability and reliability of the Kleiss inflatable stopper, GTI conducted evaluations with debris (metal shavings from tapping operations) in the 8" steel pipe on all three Kleiss systems at the following pressures: 7.5, 15, and 60 psig. Each test lasted 24 hours and blow by/leakage across the bag was recorded with a flow meter.

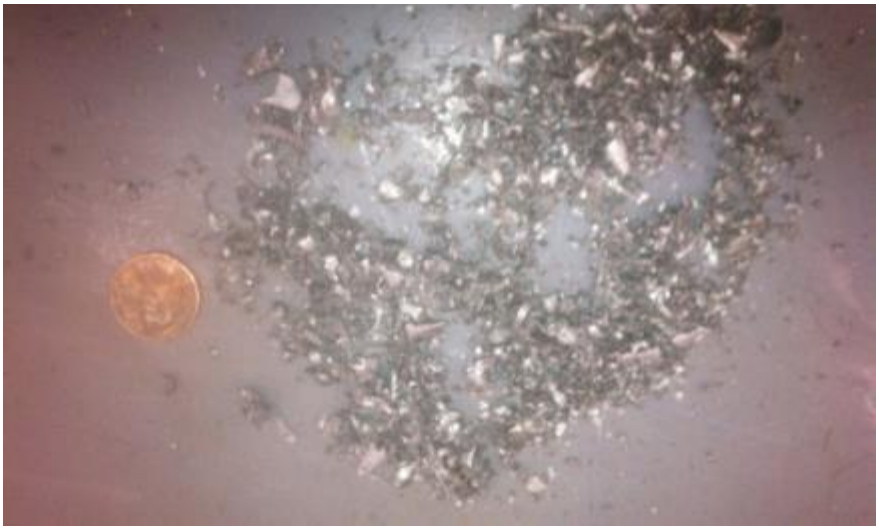

Figure 31. Steel shavings used for the debris test

Shavings from the tapping of the 8" steel pipe were used as debris during the test. The bag was purposely inflated in the area containing the debris.

The results are listed below:

Table 3. Results of the 24 hour Debris Test

KLEISS SYSTEM	PIPE SIZE	PIPE PRESSURE	BAG SIZE	LEAKAGE
P3	8" Steel	7.5 psig	140-215 mm	1.3 SCFH
BZA-1-G1	8" Steel	15 psig	140-215 mm	0.4 SCFH
BZA-4-G1	8" Steel	60 psig	140-215 mm	0.3 SCFH
BZA-4-G1	6" Steel	60 psig	120-160 mm	0.3 SCFH

After recording the blow-by on the initial evaluation with debris in the pipe, the bags were then cycled through this process 10 times each and checked for bag issues and/or failures. The bags were inserted, pressurized, depressurized, removed and evaluated. The results are listed below:

Table 4. Results of the 10 cycle Debris Test

KLEISS SYSTEM	PIPE SIZE	PIPE PRESSURE	BAG SIZE	Bag Issues?
P3	8" Steel	7.5 psig	140-215 mm	No bag issues or failures
BZA-1-G1	8" Steel	15 psig	140-215 mm	2 bag failures (leaks due to steel shavings)
BZA-4-G1	8" Steel	60 psig	160-215 mm	No bag issues or failures

Bag Burst Tests:

Burst testing was performed on the inflation bags to determine what pressures the bags could be inflated to before failure. The bags were inserted inside of the appropriate sized pipe (open ended pipe) and then slowly inflated until the bag failed. Below are the test results:

Table 5. Results of the Bag Burst Testing

KLEISS SYSTEM	PIPE SIZE	BAG SIZE	Standard Inflation Pressure	Bag Burst Pressure
P3	8" Steel	140-215 mm	22 psig	77.7 psig
BZA-1-G1	8" Steel	140-215 mm	37 psig	140.8 psig in 55 sec.
BZA-4-G1	8" Steel	140-215 mm	120 psig	384.2 psig in 175 sec.
BZA-4-G1	8" Steel	120-160 mm	120 psig	351.0 psig in 153 sec.

The bag burst test demonstrated that the Kleiss bags burst with a factor of safety between 3 and 4 times that of the normal recommended inflation pressure.

System Over-Pressurization Test:

All three Kleiss stoppers were evaluated by installing each into an 8" steel pipe with an internal pipe pressure greater than the maximum allowable pressure of the Kleiss system. One the Kleiss stoppers were deployed, the pressure in the pipe downstream of the bag was released and the stopper was deployed for 6 hours in the pipe. The test results were as follows:

- The Kleiss P3 (low pressure – up to 7.5 psig) system was deployed in an 8" steel low pressure system with a 140-215mm bag. The 8" pipe was pressurized to 12.5 psig. The P3 low pressure stopper **passed** the test.
- The Kleiss BZA-1-G1 (medium pressure – up to 15 psig) system was deployed in an 8" steel medium pressure system with a 140-215mm bag. The 8" pipe was pressurized to 25 psig. The

BZA-1-G1 medium pressure stopper **passed** the test. The new designed medium pressure bag was tested.

- The Kleiss BZA-4-G1 (high pressure – up to 60 psig) system was deployed in an 8" steel system with a 140-215mm bag. The 8" pipe was pressurized to 100 psig and held for 6 hours. The BZA-4-G1 high pressure stopper **passed** the test.

All three Kleiss systems passed the "system over pressurization" test.

Stopper System Cycling Test (Insertion, pressurization, depressurization, and removal cycling)

This test was also conducted to evaluate the durability and reliability of the Kleiss stopping system (stopping equipment, bag, and other components). Each Kleiss stopper system was tested for repeated use. The Kleiss stopper was installed on an 8" steel pipe and the bag was inserted, pressurized to the recommended pressure, depressurized and removed from the pressurized pipe. This process was repeated 50 times with the pipe at operating pressure and the outlet of the pipe cracked (to allow for flow and monitor blow by). The results of the 50 insertions and removals were as follows:

- The Kleiss P3 (low pressure – up to 7.5 psig) system was deployed in an 8" steel low pressure system with a 140-215mm bag. The P3 low pressure stopper **passed** the test of 50 insertion, inflation, deflation, and removal cycles.
- The Kleiss BZA-1-G1 (medium pressure – up to 15 psig) system was deployed in an 8" steel medium pressure system with a 140-215mm bag. The BZA-1-G1 medium pressure stopper **passed** the test of 50 insertion, inflation, deflation, and removal cycles.
- The Kleiss BZA-4-G1 (high pressure – up to 60 psig) system was deployed in an 8" steel system with a 140-215mm bag. The BZA-4-G1 high pressure stopper **passed** the test of 50 insertion, inflation, deflation, and removal cycles. However, the insertion of the 140-215mm bag into the 8" steel pipe and fitting was more difficult than the other systems. The tap hole and insertion tube is smaller on the 60 psig system than the low and medium pressure systems.

Cutter / Tapping Machine Performance Test:

BZA-1-G1 (medium pressure) and BZA-4-G1 (high pressure) drilling and tapping system

The GTI technical team conducted tests to evaluate the drilling machines for medium and high pressure systems. This operation was conducted on steel and PE piping systems using the Kleiss drilling equipment and supplied cutters.

Cutter (hole saw) performance: The supplied Kleiss cutters performed well on both plastic and steel pipe. The pipe coupon was retained in the cutter after each operation. In addition, the design of the PE cutter is such that all of the shavings/ribbons from the cutting operation are directed inside of the cutter

and retained by the pipe coupon. This greatly reduces any chance of pipe shavings interfering with the Kleiss stopping operation and any other pipeline operation downstream.

Tapping machine performance: GTI evaluated the tapping machine under normal operating conditions and no pressure leaks were encountered with the system during the installation, tapping, and removal of the tapping machine. The Kleiss system seals with the use of o-rings rather than sealing with NPT threads. This design proved to be successful in sealing and ease of installing and dismantling the equipment.

Overall, the Kleiss tapping system proved to be lightweight, robust and easy to use.

P3 (low pressure) drilling and tapping system

The operation of the Kleiss P3 System (low pressure 7.5 psig system) is slightly different than the medium and high pressure systems. The P3 system does not use a valve attached to the pipe fitting. Instead, its specialized no-blow fitting has an internal seal built in to enable a no-blow operation during both the tapping and stopping operations. A rubber seal and flapper, when under pressure, seals that gas from escaping without the use of a valve and stuffing box. This reduces the equipment, steps, and time required to complete the tapping and stopping operation. However, the no-blow fittings currently available from Kleiss are manufactured from PVC material.

During GTI's evaluation of the P3 tapping system, no issues were found with the equipment or the fittings. It is relatively easy to use. However, GTI discovered that the PVC fittings used will only shut off gas pressure up to 4.5 psig due to the flapper design. At pressures greater than 5 psig, the flapper may push out from the fitting allowing gas to escape.

Figure 32. P3 (low pressure) no-blow PVC fittings

Stopping Machine Performance Test:

P3 – Low pressure 7.5 psig system

Overall, the P3 system is ultra-lightweight, easy to use, and durable. The P3 system does not use a gear drive to insert and remove the bag and direction shoe from the pipe. The P3 system is small enough,

therefore, GTI agrees that it does not need one. The only recommendation on the P3 system is to add a bag direction arrow to the equipment.

BZA-1-G1 - Medium pressure 15 psig system

Overall, the BZA-1-G1 system is lightweight, easy to use, and durable. However, the GTI team did discover a few issues throughout the Kleiss evaluation program. The bag adapter fitting leaked in two separate areas. This is where the bag assembles to the stopping machine. GTI discovered these small leaks while monitoring for flow and leakage. It is recommended that machine pressure testing be conducted on a routine basis to verify the integrity of the system. Also, the gear box for lowering shoe is open (versus the high pressure system which is enclosed) which could cause dirt to build up over time. Finally, a permanent bag direction arrow on equipment would be helpful. GTI provided these recommendations to Kleiss for future considerations.

BZA-4-G1 - High pressure 60 psig system

Overall, the BZA-4-G1 system is lightweight, easy to use, and durable. However, the GTI team did discover a few issues throughout the Kleiss evaluation program. The bag adapter leaked at the gasket area where bag is tightened. Similar to the medium pressure system, a permanent marking/arrow for bag direction on the equipment would be very helpful for the operator.

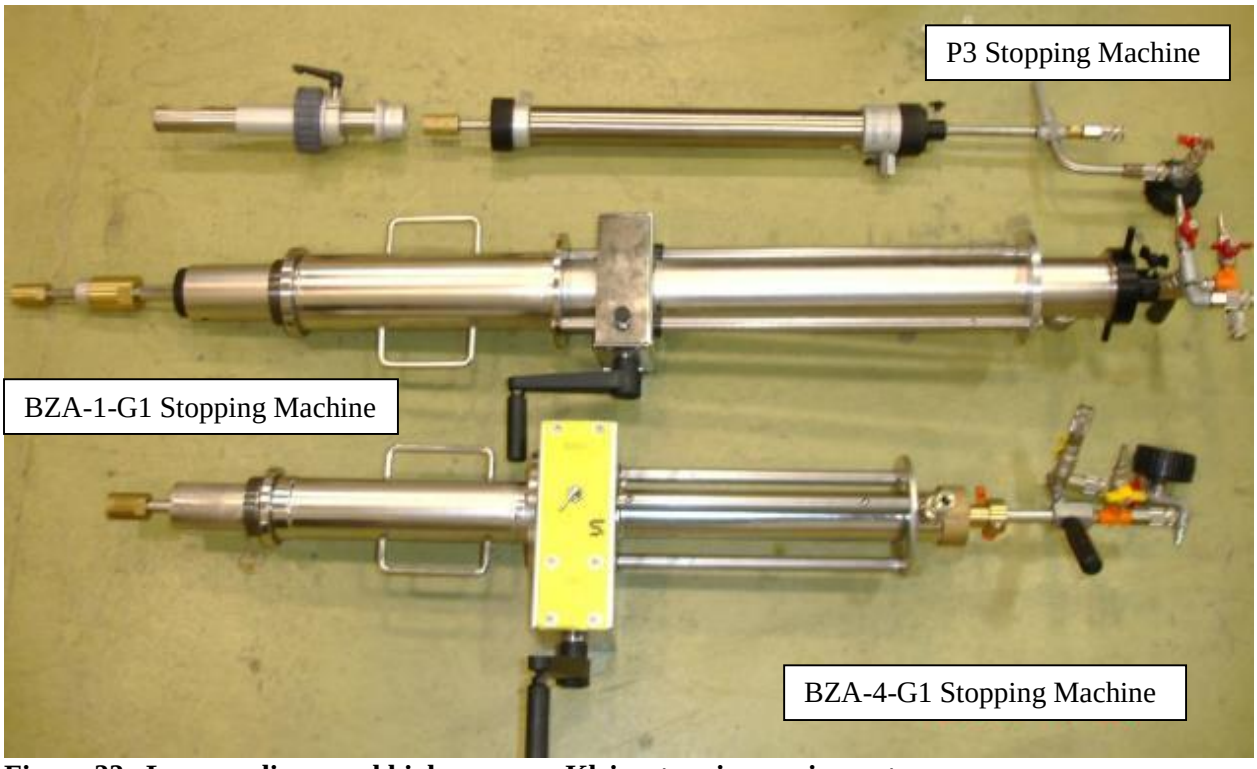

Figure 33. Low, medium, and high pressure Kleiss stopping equipment

Kleiss Stopping Equipment Test Summary

Table 6. Kleiss stopping equipment test summary

KLEISS EQUIPMENT TEST SUMMARY (stopping system evaluations)	P3 (7.5 psig)	BZA-1-G1 (15 psig)	BZA-4-G1 (60 psig)
Flow Stopping Capability (measure flow with flow meter)			
Standard Pressure Test (measure flow past bag for 24 hours)			
6" PE pipe	0 leakage (5-7" bag)	0 leakage (5-7" bag)	0 leakage (5-7" bag)
6" PE pipe	0 leakage (6-8" bag)	0 leakage (6-8" bag)	15 SCFH Leak (6-8" bag)
6" Steel pipe	-	-	< 0.3 SCFH Leak (5-7" bag)
8" Steel pipe	1.2 SCFH Leak (6-8" bag)	0.3 SCFH Leak (6-8" bag)	0 leakage (6-8" bag)
12" Steel pipe	-	43 SCFH Leak (10-12" bag)	-
12" Steel pipe	-	13 SCFH (10-12" bag)**	-
16" Steel pipe	-	102 SCFH Leak (12-16" bag)	-
24 Hour Pressure Test (monitor bag inflation pressure over 24 hour period)			
8" steel pipe	(22 to 19 psig)	(36 to 33 psig)	(116 to 112 psig)
6" steel pipe			(116 to 112 psig)
6" PE pipe			(116 to 112 psig)
Temperature Cycling (32°F - 120°F)			
6" steel pipe			Pass (5" - 7" bag)
8" Steel pipe	Pass (6" - 8" bag)	Pass (15 psig - 6-8" bag)	
8" Steel pipe		Fail (25 psig - 6-8" bag)	
8" Steel pipe		Fail (25 psig - 6-8" bag)	
8" steel pipe		Pass (25 psig - 6-8" bag)	
Pipe Pressure Cycling (50% Sys Pressure to System Max + 10%)			
6" steel pipe (5-7" bag)		1.2 to 3.5 SCFH leakage	0 to 3.0 SCFH leakage
6" Steel pipe (6-8" bag)		0 leakage	0 leakage
8" Steel pipe (5-7" bag)		0.3 to 2.0 SCFH leakage	-
8" Steel pipe (6-8" bag)	0.3 to 1.3 SCFH leakage	0 to 1.0 SCFH leakage	0 leakage
Debris/Chip Evaluation (measure flow past bag over 24 hours)			
6" steel pipe (5-7" bag)			0.3 SCFH leakage
8" Steel pipe (6-8" bag)	0.4 SCFH leakage	0.4 SCFH leakage	0.3 SCFH leakage
Bag Durability Evaluation (open end pipes)			
Burst Test (increase bag pressure inside pipe until failure)			
8" steel pipe (6-8" bag)	77.7 psig	140.8 psig	384.2 psig
8" steel pipe (5-7" bag)			351.0 psig
System Over Pressure (pipe pressure greater than rated - 6 hour test)			
8" steel pipe at 12.5 psig	Pass		
8" steel pipe at 25 psig		Pass	
8" steel pipe at 100 psig			Pass
Stopper System Cycling (Insertion, pressurization, depressurization, and Removal)			
8" pipe at max pressure w/ outlet cracked and cycle 50 times	Pass	Pass	Pass
Debris/Chip Evaluation (same test as above)			
8" pipe at max pressure w/ outlet cracked cycle 10 times	Pass - No issues	Fail - Leaks due to shavings	Pass - No issues
Tapping/Bagging System			
Cutter/Tapping Machine Performance	CI, Steel, PE	CI, Steel, PE	Steel, and PE
Tap CI, Steel, and PE pipes 10 times each and evaluate	Pass - No issues	Pass - No issues	Pass - No issues
Tapping Machine Performance (Sealing, Safety)	CI, Steel, PE	CI, Steel, PE	Steel, PE
Overview of operation of tapping machine under pressure	Pass - No issues	Pass - No issues	Pass - No issues
Bag Stopping Machine and Components	Pass - No issues	Pass - No issues	Pass - No issues
Operational Procedures (evaluate direction of bags)	Pass - No issues	Pass - No issues	Pass - No issues

** Note: GTI conducted the test again using the newly designed 15 psig stopper with the black hydraulic hose and connector

Evaluation of the Kleiss Stopping System by Others

GTI also held various communications with a large European gas utility throughout the project. This European utility was conducting a parallel evaluation of the Kleiss tapping and stopping system. Their testing concluded that based on the laboratory tests carried out and an assessment of the results, the technology of stop off bag insertion is found to be fit for the purpose (natural gas industry). The objective of this research project was to investigate whether it would also be feasible to use this method in the pressure range up to 5 bar. These investigations were carried out in cooperation with a GERG project.

A summary of the European gas utility testing includes the following:

Gas Bags:

The gas bags may be reused several times. The bag must be visually inspected to identify any damage each time before it is reused. Test results obtained by the bag manufacturer indicate that the burst pressure of the bag is higher than 24 bar, i.e. at least three times as high as the working pressure, depending on the bag diameter. The operating instructions clearly state that the gas bags must be cleaned using appropriate materials before and after use. The bags must also be stored in accordance with the manufacturer's instructions. Before the bag is inserted, it must be inspected for any leaks using a leak detection spray at a pressure of 300 mbar.

Gas Leakage:

The pipeline section between the two bags is depressurized. On the construction site, the gas leaking into this section as a result of leaks via the pressure-side bag is vented to atmosphere via a hose. This gas is referred to as "first-degree leakage gas". As this leakage gas is vented to atmosphere, there is no pressure build-up in the space between the two bags. The work area is located downstream from the vapour bag. After the work area has been depressurized using the positioning tool of the vapour bag the pipeline is normally cut. In this case the vapour bag provides protection in the event of a failure of the pressure-side bag and prevents the gas leaking via the pressure-side bag from reaching the work area. Gas escaping into the work area is referred to as "second-degree leakage gas". In normal operation there is no second-degree leakage gas. Downstream from the pressure-side bag the maximum leakage rate which is allowed is 30 dm^3/minute as against only 30 dm^3/hour in the work area (Figure 34).

In the laboratory tests, the gas leakage rate via a gas bag used as a pressure-side bag (first-degree leakage gas volume) was measured.

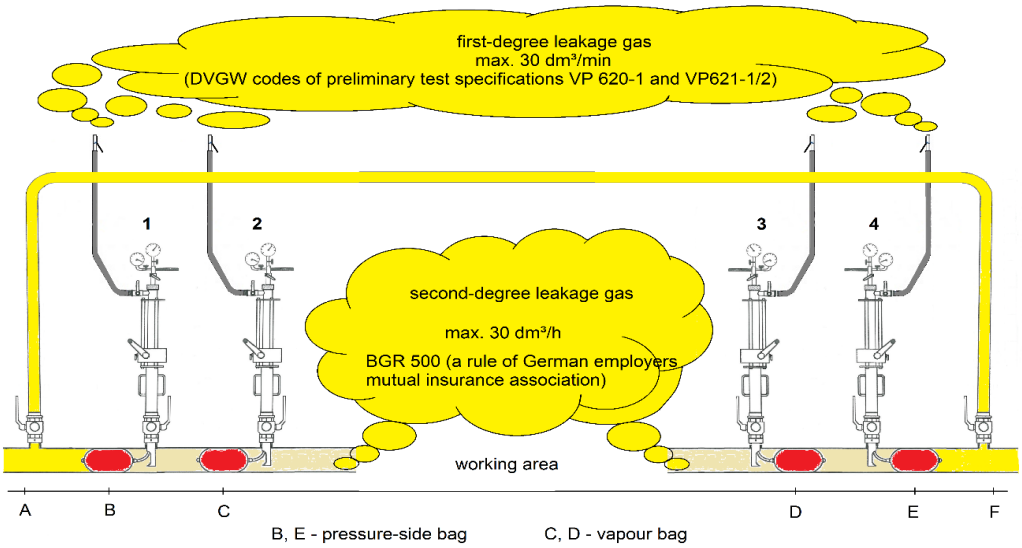

Figure 34. Leakage gas volumes allowed by standards at construction sites

Compressed air (available in the laboratory at a maximum pressure of 6.7 bar) was used as test gas. The gas bag was filled with nitrogen. The tests were carried out using a steel pipe and a PE100 pipe (DN 225). The test plan which was drawn up intended to cover possible conditions in the isolated pipeline section.

The stopper equipment was installed in accordance with the operating instructions of the manufacturer and the gas bag was inserted into the pipe. The gas bag was then inflated to a pressure of 8 bar using nitrogen. Following inflation, the pressure downstream from the gas bag was relieved and a gas flow meter (laboratory meter) was installed. This meter was used to measure any possible leakage between the pipe wall and the vapour bag at several defined time intervals. The results are given in Table 7.

Following the completion of the leakage-measurements, each test ended with the simulation of the failure of the pressure-side bag. These tests never failed.

Test conditions Isolating pressure 4 bar Working pressure 8 bar	Leakage gas volume	Pressure surge test
Steel (clean)	$\dot{v} = 0 \ldots 0.5\ dm^3/min$	passed
Steel (gas dust)	$\dot{v} = 19 \ldots \mathbf{36}\ dm^3/min$	passed
Steel (steel cuttings)	$\dot{v} = 2 \ldots 3\ dm^3/min$	passed
Steel (dust + cuttings)	$\dot{v} = 24 \ldots \mathbf{37}\ dm^3/min$	passed
Steel (dust + cuttings + moisture)	$\dot{v} = 10 \ldots 21\ dm^3/min$	passed
Polyethylene (clean)	$\dot{v} = 0.2\ dm^3/min$	passed
Polyethylene (one long PE cutting)	$\dot{v} = 0\ dm^3/min$	passed
Polyethylene (dust)	$\dot{v} = 6 \ldots 12\ dm^3/min$	passed
Polyethylene (cutting + dust + moisture)	$\dot{v} = 24 \ldots 27\ dm^3/min$	passed
Polyethylene (cutting + moisture)	$\dot{v} = 0\ dm^3/min$	passed

Table 7. Results of leakage gas volume and pressure surge tests

Summary of the Testing Performed by Others:

On the basis of the information obtained from the pilot construction sites, the laboratory tests carried out in Germany and France as well as an assessment of the results, the technology of gas bag insertion has been found to be appropriate for the purpose in systems up to 4 bar (respectively 5 bar) as used in this DVGW R&D project. The project team supports the approval of stop-off bags insertion technology by the DVGW Codes of Practice, initially up to a maximum isolation pressure of 4 bar, provided that the work is carried out by qualified, certified personnel.

Kleiss Stopper System Field Demonstrations

Based on the successful evaluation of the Kleiss system in a laboratory environment, the GTI technical team pursued field trials in order to evaluate the tapping and stopping equipment in actual field operations. These field trails would also allow feedback from the utility operators. GTI worked with interested utilities and identified sites to conduct actual flow stopping on natural gas pipes.

Michigan Gas Utility

The first field trial was conducted on a Michigan Gas Utility natural gas system in Detroit, MI on October 9, 2013. The Michigan Gas Utility identified a 16" cast iron main with a small leak on a drip on the pipe. This cast iron system has a MAOP of 15 psig and operates around 8 psig. Typically, the Michigan Gas Utility would use traditional bags to stop off the flow of natural gas. However, traditional bag systems are only good up to 5 psig, therefore, the Michigan Gas Utility would be required to lower the entire system pressure to 5 psig or below. The Kleiss stopping system (BZA-1-G1 – 15 psig system) can be used on the 16" cast iron pipe operating at 8 psig without lowering the system pressure.

Operation to be conducted: Stop off the flow of gas on the 2-way fed 16" cast iron pipe operating at 8 psig and remove the drip pipe from the bottom of the cast iron main.

Kleiss system used: BZA-1-G1 – medium pressure (15 psig) tapping and stopping system. Four stopping units were onsite, however, the Michigan Gas Utility determined that only one on each side of the leak would be needed. This was determined after observing a complete shut off of flow with only one stop on each side. It was also noted that the Michigan Gas Utility operators found about 2-inches of debris on the bottom of the 16" cast iron pipe with they removed the drip pipe.

Operators of the Kleiss system: A combination of two Kleiss employees and Michigan Gas Utility field operators.

Duration of the operation: The pipe was tapped and gas shut off in less than 2 hours.

Summary of operation: Overall the demonstration was a success. The Michigan Gas Utility employees were impressed with how quickly and easily the Kleiss stoppers could be deployed and removed. Below are various photos from the Michigan Gas Utility field trial.

Figure 35. Michigan Gas Utility 16” cast iron main

Figure 36. Conducting a pressure test on the fitting prior to tapping

Figure 37. Attach Kleiss saddle and ball valve attached

Figure 38. Michigan Gas Utility crews tapping the 16" cast iron main using the Kleiss equipment

Figure 39. Kleiss BZA-1-G1 medium pressure stopper units used to stop off the flow in the 16” cast iron pipe

Figure 40. Kleiss stopper installed on the 16” cast iron pipe

Figure 41. Michigan Gas Utility crews removing the drip pipe with the 2 Kleiss stoppers installed

Following the successful field demonstration at Michigan Gas Utility of the Kleiss system, GTI gathered various field comments from Michigan Gas Utility crew and other employees and shared them with Kleiss. The following are the comments provided by Michigan Gas Utility:

- Field personnel stated that this is a very good system. There were several suggestions that our field personnel feel will enhance the Kleiss product:
    1. Make all threads, bolts, fittings and connectors ANSI standard instead of metric.
    2. Lock the pilot drill to prevent rotation in the holder.
    3. Clear printed instructions that can be provided to our regulators and used for OQ.
    4. Develop a clean out tool to be used though the installed valve and fitting.
    5. Develop a coupon retriever in the event you have failure of the pilot bit.

Kleiss has either already addressed the enhancements recommended from Michigan Gas Utility and/or stated that they will do so very soon.

Gas Utility #2

As part of their infrastructure enhancement program, Gas Utility #2 is replacing their vintage cast iron piping system in a large urban city with PE pipe. This includes large diameter PE pipe – up to 18-inches in diameter. Hydraulic PE squeeze tools do exist for shutting off the flow of gas on these larger diameter pipes, however, they are large, heavy, difficult to install, and costly.

Gas Utility #2 is very interested in better understanding how the Kleiss system can be used to assist them in stopping the flow in their large diameter PE piping systems. A demonstration was coordinated

with Gas Utility #2 on May 12, 2014 to demonstrate how the Kleiss system can be used to stop off both a 6" steel and 18" PE pipe operating around 25 psig. For this demo, a 6" steel pipe and an 18" PE pipe were assembled and brought to their facilities along with the appropriate Kleiss equipment.

Operation to be conducted: Shop demonstration of the Kleiss system on both a 6" and 18" diameter PE pipe.

Kleiss system used:

- BZA-4-G1 – high pressure (60 psig) tapping and stopping system for the 6" steel pipe.
- BZA-4-G2 (MCS60-1016) – high pressure (60 psig) tapping and stopping system for the 18" PE pipe.

Operators of the Kleiss system: A combination of two Kleiss employees and Gas Utility #2 personnel operated the tapping and stopping equipment. The operation was conducted multiple times to allow several people to try the equipment.

Summary of operation: Overall the demonstration was a success. Gas Utility #2 employees were impressed with how quickly and easily the Kleiss stoppers could be deployed and removed. Below are various photos from the Gas Utility #2 shop trial.

Figure 42. Traditional squeeze tool for 16" PE pipe

Figure 43. Kleiss bag used to stop off the flow in the 18" PE pipe and EF fitting on the 18" pipe

Figure 44. Kleiss BZA-4-G2 tapping equipment – tapping the fitting on the 18" PE pipe

Figure 45. Kleiss stopping equipment on the 18" PE pipe – stopping off 25 psig line pressure

Figure 46. Gas Utility #2 personnel installing the Kleiss BZA-4-G1 stopping equipment on a 6-inch steel pipe

Gas Utility #3 Field Trial

Gas Utility #3 identified a field application for the Kleiss system as part of a project to replace existing 8" steel pipe with 8" PE pipe. The field operation took place on September 30, 2014.

Operation to be conducted: Stop off the flow of gas on a 3-way fed 8" steel pipe operating at 8 psig in order to replace the steel pipe with 8" PE. A valve was used to stop off the flow of gas from one direction and the Kleiss stoppers were used to stop off the flow from the other two feeds. Originally, two Kleiss stoppers were planned to be used on each feed, however, it was determined that one stopper was sufficient (100% stoppage of gas flow – no blow by).

Kleiss system used:

- BZA-4-G1 – high pressure (60 psig) tapping and stopping system for the 8" steel pipe.

Operators of the Kleiss system: A combination of two Kleiss employees and Gas Utility #3 personnel operated the tapping and stopping equipment.

Summary of operation: Overall the demonstration was a success. Gas Utility #3 employees were impressed with how quickly and easily the Kleiss stoppers could be deployed and removed. Personnel timed the 8" steel pipe tapping operation – it took 6 minutes. Below are various photos from the Gas Utility #3 field trial.

Figure 47. Kleiss weld on fitting and valve installed on the 8" steel pipe

Figure 48. Kleiss tapping equipment used to tap the 8" steel pipe

Figure 49. Gas Utility #3 crews using the Kleiss equipment to tap the 8" steel pipe

Figure 50. Kleiss BZA-4-G1 stopping equipment used to stop off the flow in the 8” steel pipe

Figure 51. Kleiss BZA-4-G1 stopping equipment installed on the 8” steel pipe

Additional Kleiss Trials

Gas Utility #4

- 6” steel gas pipe operating at 2 psig
- Kleiss stoppers used to stop off the flow of gas in order to repair a leak in the steel pipe (weld in a new section of 6” steel).

Figure 52. Kleiss field demo at Gas Utility #4

Illinois

- 6” PE pipe (Aldyl A) operating at 12 psig
- Kleiss stoppers used to stop off the flow of gas in order to cut and cap the existing pipe.




Minnesota

- 4” steel pipe operating at 25 psig
- Kleiss stoppers used to stop off the flow of gas in order to cut the steel pipe and weld in a valve.



Rhode Island

- 6” cast iron pipe operating at 10 psig
- Kleiss stoppers used to stop off the flow of gas.

Supporting Commercialization for North American Market

Based on the successful laboratory and field evaluations and interest from the project sponsors and other utilities, GTI worked with Kleiss to assist them in identifying a commercialization partner for the North America natural gas utility market. The current Kleiss system is manufactured and supported in Europe. While it may be possible to support the North American market from Europe it is not practical.

GTI identified and contacted several manufacturers and distributors that currently serve the North American natural gas utility market. Based on these initial discussions regarding the Kleiss system, GTI arranged for meetings between Kleiss and three interested commercializers. Face to face meetings were held at GTI and based on these meetings Kleiss continued discussions with all three potential commercializers of the Kleiss system. Kleiss selected one company to partner with and serve the North American natural gas utility market.

The commercializer for the Kleiss system in North America is Mainline Control Systems (MCS).

MCS is in partnership with Kleiss to stock, support, and distribute the Kleiss systems across North America. Their technical ability and existing knowledge of the natural gas utility industry allows them to educate and train the personnel operating the Kleiss tooling.

Additionally, MCS will work with local distributors who can provide the end users with local support teams. These distributors have strong industry and product knowledge and can quickly meet the needs of their customers.

MCS web page: http://www.mainlinecontrolsystems.com/home.html

MCS contact information: Mainline Control Systems
Phone: 844-FLO-STOP (844-356-7867)
info@mainlinecs.com

Appendix

Kleiss P3 Flow Stopping System (low pressure – 7.5 psig)

kleiss & co b.v.

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Flow stopping of gas pipelines 2"- 16" operating at pressure up to 0,5 bar (7.5 psi)

- **Ultra light-weight and easy to use**
- **Safe operating system and gas tight seal**
- **Using standard commercially available saddles and welding sockets**
- **For all pipes steel, cast iron, polyethylene up to 16"**
- **Patented system**
- **Using the MDS® inflatable stopper**
- **Maximum required drilling size 2" (49 mm)**

Key-element in the BZA P3 Flow stop system is the MDS inflatable stopper. This is a unique device which supersedes all flow stopping tools in terms of strength, flexibility and sealing against gas leakage. The MDS inflatable stopper is a super-fiber reinforced elastomer corpus with high flexibility.

Each MDS stopper is a multidimensional pneumatic device which easily adopts to a wide diameter range, offering a perfect seamless seal. The MDS stopper is designed with high safety factors and has been tested and approved worldwide by National Gas Authorities.

The BZA P3 system has been designed for temporary flow stopping of gas distribution pipelines which operate at pressure up to 500 mbar. The BZA P3 system has been designed and engineered especially to save on weight, volume, number of parts, portability and ease of use. The system is suitable for working on steel, cast iron, polyethylene and PVC, using standard saddles and sockets.

The BZA P3 bagging tool is a universal tool with 'shoes' at the lower end of the bagging tube which can be exchanged by means of a quick adapter. This way, one ultra light weight tool can be used for a wide diameter range. Two pressure gauges allow the operator to monitor both the pressure in the MDS stopper as well as the back pressure in the pipeline.

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Another unique development is the option to use the Polsafe® non-return valve . Instead of using a standard 2" valve it is also possible to mount this adapter in the saddle or socket, which will remain there after the operation. The Polsafe adapter allows for even faster operating time and reducing working time in the excavation area. The Polsafe adapter can be used in pipelines operating at max. 200 mbar (3 psi).

The BZA P3 system consists of a bagging tube and a number of bagging shoes which are mounted with a quick adapter to the tube. The shoes can be moved up and down in the short dome which allows the combined bagging tube and dome to be inserted into the gas main without gas leakage. The MDS stopper is connected to the bagging rod. The bagging rod is used to move the MDS stopper into the pipeline and inflate it up to its working pressure of 25 psi! Pressure gauges at the upper end of the bagging rod are used to monitor the pressure in the MDS stopper as well as the back pressure in the pipeline.

Flow Stopping device BZA-P3

Description	Product number
Flow stopping device BZA-P3 DN50 - DN400mm consisting of stainless steel RVS bagging tube, rod and gauge	12.000.500
Bagging Shoe Nr. 0 DN 50	12.000.505
Bagging Shoe Nr. 1 DN 63-DN 110	12.000.510
Bagging Shoe Nr. 2 DN 125-DN 200	12.000.520
Bagging Shoe Nr. 3 DN 250-DN 300	12.000.530
Bagging Shoe Nr. 4 DN 315-DN 400	12.000.531
Case	12.000.540
Pressure gauge unit, type MAN-3S, standard	12.000.560
Pressure gauge unit, type MAN-3D, pressure measurement	12.000.570

Description	Product number
BZA P3 bagging tube DN 50-DN 400	12.000.580
Gauge unit 1/4"	12.000.520
Valve and quick coupling	12.000.590
Inflation pump type 511	22.500.010
Wrench	11.000.210
Silicone spray	94.200.010
Silicone grease	94.200.020
Prepress gauge 0-160mBar	12.000.110
Bypass set 1.1/2"	12.000.120
Bypass set 2"	12.000.130
Bypass set 2.1/2"	12.000.135

Kleiss BZA-1-G1 Flow Stopping System (medium pressure – 15 psig)

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Flow stopping device BZA-1-G1

For pipes DN 80 - 400

The flow stopping device BZA-1-G1 is designed to shut off gas pipes from DN80-DN400. Also the use in waterpipes is possible.

Function:

On the pipe a saddle or welding socket is connected. The connection is 3" male and 2.1/2" female. A valve is connected on the saddle/socket. After drilling the flow stopping device is connected on the valve. The flow stopping device is able to insert the balloon in the required direction, after which it will be inflated. After the repair or replacement job is finished, the balloon can be pulled back and the saddle or socked be shut off using a plug.

This flow stopping device is able to shut off pipelines from DN80-DN400 with a maxumin backpressure of 1 bar at the complete range.

The flow stopping device is used with three different bagging shoes. Because of this design the balloon is always inserted in the centre of the pipe.

Bagging shoe 1: DN 80-DN100
Bagging shoe 2: DN125-DN200
Bagging shoe 3: DN250-DN400

Kleiss BZA-4-G1 Flow Stopping System (high pressure – 60 psig)

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FLOW STOPPING DEVICE BZA-1 4bar DN80-DN200

For the shutdown of the gas pipelines at 4 bar backpressure with the MDS inflatable stopper.

- **High level of safety while working.**
- **Easy-to-use.**
- **Using standard saddles and welding sockets.**
- **With pressure measurement and connection for by-pass.**
- **For all pipes to DN 200.**
- **Patented.**

The BZA-1 4bar system is designed for temporary shutdown of gas distribution pipelines at a pressure of 4 bar. The system is suitable for working on both steel and polyethylene. Uses standard saddles and welding sockets. There are therefore no special fittings required!
For the shutdown of the pipeline the MDS inflatable stopper is used. The MDS inflatable stopper is a patented multi-dimensional balloon. Through the seamless design the balloon has a leak proof sealing over the entire working range. Through the use of high-quality materials, implementation of strict production requirements and high design safety factors, the BZA-1 4 bar system offers the best security when working under-pressurized pipes.

Working on gas pipelines with BZA-1 4bar equipment offers enormous advantages:

- Are easy to handle and very easy-to-equipment.
- Range DN 80–DN 200 for all pipeline materials.
- Use of standard factory fittings
- Only one size drilling cutter of Ø56,5 mm is required for all line diameters (type 1004HM for steel and 1003 for PE).
- High safety factor.
- No interruption of gas flow because of bridging set (optional).

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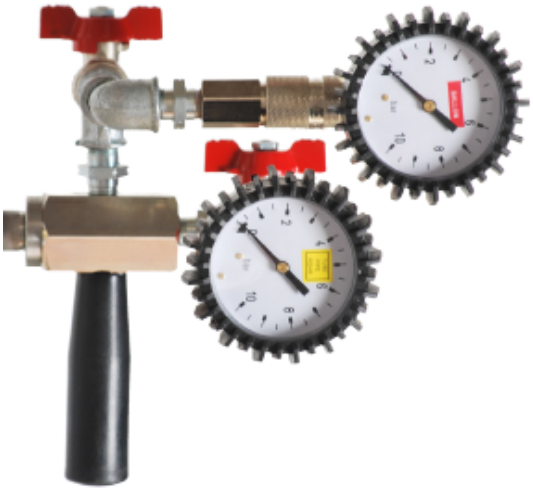

Works with saddle or welding socket with 2" female and 2.1/2" connection.

The BZA-1 4bar system consists of a movable bagging lance which is placed lead sealed in a dome. The Lance can move in the dome and the bagging shoe, which is at the end of the Lance, which van be positioned in the pipeline. Inside the bagging lance a bagging rod is located with the MDS inflatable stopper, which can be inserted into the pipeline and thereafter shall be inflated to shut-off the pipeline.

The MDS inflatable stopper is a seamless fiber reinforced rubber inflatable balloon which guarantees a perfect seal in the tube. The flexibility to fit the closing body shall comply with the form of the tube, and it results in the whole length a gas-tight sealing. Welds and other uneven patches therefore have no adversely affect the operation of the MDS inflatable stopper.

An additional advantage of the MDS stoppers is that they, because of their range are able to shut-off two consecutive nominal diameters. This is a very big logistical advantage. Each MDS inflatable stopper is individually tested after production. The MDS inflatable stopper is equipped with a bypass to measure the pipeline pressure continuously.

The BZA-1 4bar is also fitted with a connection for a bridging set (by-pass unit). Appliance BZA-1 4bar appliance including dome, Lance, pressure gauges, pressure gauge unit and two bagging shoes.

MDS Inflatable stoppers

MDS-B4-1D1b FE 70-90mm	Steel DN 80 mm
MDS-B4-2D1b FE 80-120mm	Steel DN 100 + 125 mm
MDS-B4-3D1b FE 120-160mm	Steel DN 150 mm
MDS-B4-4D1b FE 160-215mm	Steel DN 200 mm
MDS-B4-1D1b PE 70-90mm	DN 90, SDR 11 + 17 SDR
MDS-B4-2D1b PE 80-120mm	DN 110, 125, SDR 11 + 17 SDR
MDS-B4-3D1b PE 120-160mm	DN 160, DN 175 SDR 11 + 17 SDR
MDS-B4-4D1b PE 160-215mm	DN 200, DN-225, SDR 11 + SDR17

Pressure regulator pressure control unit for inflating MDS balloon with compressor pump. Pump for in- and deflating of the MDS balloon. Bus silicone spray for posting, and maintenance MDS end ball. All equipment is provided in lightweight ABS transport case.

END OF REPORT