



Code of Practice
Upstream Polyethylene Gathering
Networks – CSG Industry
Version 4

Companion Paper CP-11-002
Guidelines for Flowstopping
Rev 0

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Important note on use of the *APGA Code of Practice for Upstream Polyethylene Gathering Networks in the Coal Seam Gas Industry*.

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Preface

Companion Papers have been developed by the Working Group responsible for the *APGA Code of Practice for Upstream PE Gathering Networks – CSG Industry* (the Code) as a means to document technical information, procedures and guidelines for good industry practice in the coal seam gas (CSG) industry.

Since 2008, the development of the LNG export industry based in Gladstone, Queensland, with its related requirement for a large upstream CSG supply network of pipelines and related facilities presented the impetus for significant improvements in design and best practice approach.

The principal motivation for the initial development of the APGA Code of Practice was safety and standardisation in design and procedures and to provide guidance to ensure that as low as reasonably practicable (ALARP) risk-based requirements were available to the whole CSG industry. Accordingly, the Code is focused solely on this industry and the gathering networks using locally-manufactured PE100 pipeline. The Code is a statutory document within Queensland.

The incorporation of Companion Papers in Version 4 of the Code is intended to provide information and best practice guidelines to the Industry, allowing the Code to be limited to mandating essential safety, design, construction and operation philosophies and practices.

These documents form part of the suite of documents together with the Code and are intended to:

- a) be used in the design, construction and operation of upstream PE gathering networks
- b) provide an authoritative source of important principles and practical guidelines for use by responsible and competent persons or organisations.

These documents should be read in conjunction with the requirements of the Code to ensure sound principles and practices are followed. These documents do not supersede or take precedence over any of the requirements of the Code.

A key role of the Companion Papers is to provide the flexibility to incorporate endorsed industry practices and emerging technologies expeditiously, as/when necessary.

A related benefit is that the Companion Papers can be referenced by the wider resources industry which uses similar PE gathering networks for gas or water handling, including coal bed methane (CBM) in underground coal mines; mine de-watering; or the emerging biogas industries (agricultural, landfill, etc.).

1 Scope

The scope of this Companion Paper is the definition of recommended competencies and practices for undertaking flow stopping.

Appendix E of the Code version 3.0 was developed primarily to address concerns of industry and the statutory authorities to achieve conformance with water and gas industry distribution systems practice for PE pipes related to the use of squeeze-off units (SOU) up to DN 315. Additionally, as the CSG industry matured to larger sizes, SOUs have increasingly become more in conformance with ASTM Standards, and US practice. Latest advice obtained from PIPA/PPI is that alternatives to SOUs techniques are being developed, including clamps, plugs and flow stop bags.

It has been recognised that there are challenges associated with PE gathering system depressurisation in emergency response situations, even though the majority of PE gathering systems operate at relatively low pressures (less than 2 bar for gas, less than 4 bar for water).

In parallel, there is an objective to streamline the Code. The transfer of some Appendices, especially those with evolving technologies, to Companion Papers shall meet both of the above objectives.

The Flow-stopping methods in the Rev 4.0 of the Code are referenced in Sec 11.5.2.2.

2 Introduction

This Companion Paper describes methods used to temporarily control or stop flow in polyethylene piping systems in the event of routine maintenance or emergency response operations. Flow stopping systems must not be used as a permanent shut-off device. These flow stopping or flow control techniques are generally used for isolation of tie-ins or in emergency repairs. The limitations of each process will be detailed in each applicable section.

2.1 Methods of flow stopping

The main methods of flow stopping are:

- squeeze-offs
- plugging
- semi supported flow stop bags.

3 Plastic pipe competency standards

3.1 Introduction

Squeeze-off is a technique used to temporarily control or stop the flow of gas or liquid in a polyethylene pipe by compressing the pipe between parallel bars with a mechanical or hydraulic squeeze-off device until the inside surfaces make contact.

ASTM standards listed below provide guidance on the qualification of tools and equipment along with operator and procedure qualification:

- ASTM F1041, Standard guide for squeeze-off of Polyolefin Gas Pressure Pipe and Tubing
- ASTM F1563, Standard Specification for Tools to Squeeze-Off Polyethylene (PE) Gas Pipe or Tubing
- ASTM F1734-03, 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

3.2 General

When conducting a flow stopping technique such as a squeeze-off, consideration must be given to the distance between existing welds, repair welds, branch saddles and the placement of squeeze-off tools. When applying a squeeze-off to a section of pipe, the pipe comes under considerable stress as the pipe becomes compressed. This can affect welded joints, couplings and fittings. Special consideration should be given to aged pipe, pipe that has been subjected to UV exposure and pipe that has integrity issues (such as wall thickness thinning).

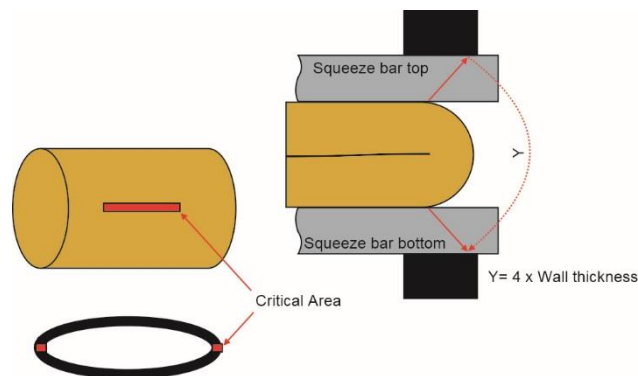


Figure 1: Critical squeeze area

3.3 Qualification

As per the Code, qualifications of squeeze-off for pipelines less and equal than DN315 is not required. However, consideration should be given to the approval of the squeeze-off procedures and tools. There are various proprietary devices for squeezing off pipe. Manufacturer's guidelines/instructions should be followed when using specific machines. Basic rules apply to the squeeze-off of both small and large bore pipe work. This includes but is not limited to the following:

- 1) Competent person (see CP-02-001) to write a squeeze-off procedure and to conduct the squeeze-off operation.
- 2) A suitable squeeze-off tool suited to the application.
- 3) Squeeze and release times.
- 4) Qualification procedures should be completed at MAOP where applicable.
- 5) Safety measures to reduce the risk of static electrical charge on PE pipes.

- 6) Requirement to not squeeze-off within 5D of a previous or known future squeeze-off OR within the distance of existing EF/butt weld and fitting as shown on Figure 2.
- 7) Do not squeeze-off damaged pipe.
- 8) Do not over squeeze the pipe by reducing or removing the calculated shims/ squeeze stops.

Failure to comply with the above could lead to integrity issues within the pipe which could lead to catastrophic failure.

Qualification for pipe sizes greater than DN315 shall be mandatory. Squeeze-off tools larger than those used for DN315 pipe require a qualification process approved by the operator. This qualification process shall take into account the following:

- 1) Squeeze-off tool
 - a. internal pressure of the pipe;
 - b. controlled squeeze time;
 - c. controlled release time;
 - d. identification and use of a suitably sized machine with adequate compression strength to squeeze the pipe taking into account the internal pressure of the system;
 - e. maximum squeeze-off duration (normally 24 hours); and
 - f. damage caused to the pipe during squeeze by the squeeze bars.

- 2) Qualification Procedure:
 - g. The process to qualify the tool;
 - i. maximum compression squeeze rate (usually 50 mm/min);
 - ii. maximum release rate (usually 12 mm/min);
 - iii. maximum and minimum differential pressure of pipeline; and
 - iv. effect of the squeeze has on defect pipe.
 - h. Detailed analysis and report;
 - i. Testing in accordance with ASTM F1563-01.

- 3) Training:
 - a. Competent operators to conduct squeeze-off.
 - b. Familiarisation with operation the tool.
 - c. Tool limitations.

As per F1563-01, an evaluation of the squeeze-off tool should be conducted for flow control performance. This is normally conducted with air to simulate gas. However, to mitigate risk associated with pneumatically pressurised pipe, a simulation should be conducted with water. The objective of the test is to demonstrate the flow stop ability under pressure, and the amount of bypass once the pipe has been squeezed shut.

3.4 Tools and equipment

Prior to conducting a squeeze-off, operators should ensure they have the right tools to complete the squeeze-off.

Tools and equipment are to include:

- 1) personal protective equipment (PPE) which is to include gas and oxygen monitoring devices and breathing apparatus for use where work is to be carried out below ground level and/or pipe is to be cut or opened;
- 2) approved squeeze-off tool fitted with limiting stops;
- 3) paper towels and water for cleaning pipe;
- 4) identification labels (i.e. tape with 'Squeeze-off Applied' markings);
- 5) clean damp non-synthetic cloth/earth strap (where applicable); and
- 6) alignment and re-rounding clamps post squeeze-off.

Prior to conducting any squeeze-off, the pipe shall be cleaned and free from dirt and debris around its entire circumference. The pipe must be cleaned over a length of a minimum of $0.5D$ either side of the squeeze tool. This will stop any dirt being pressed into the pipe during the squeeze-off.

3.5 Multiple squeeze-off

When conducting an isolation, multiple squeeze-offs may be required to ensure 100 per cent isolation. This will be in accordance with the operator's requirement/ isolation procedure. For example, on a gas system a double block and bleed (DB&B) is typically required. This is normally conducted with two squeeze-off units and a vent in between.

Consideration must be given to the distances between squeeze-off tools and fittings. Figure 2 below dictates the minimum distance requirements. However, on older/ legacy gathering systems further consideration should be given to distances from squeeze-off to fittings and welds. Consideration to distances from squeeze-off to fittings such as $5D$.

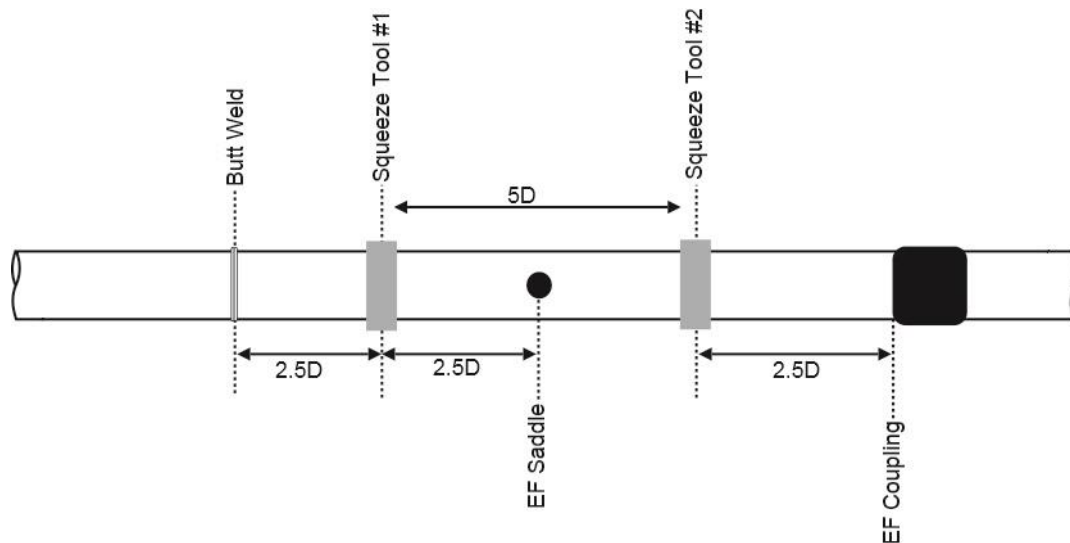


Figure 2: Squeeze-off distances

When using multiple squeeze-offs, the order in which to activate the isolation requires careful planning. As an example to undertake a repair on a gathering line, with reference to Figure 3 it is recommended to isolate and bleed in the following order:

- 1) Operate Squeeze #1;
- 2) Operate Squeeze #2;
- 3) Repair is isolated;
- 4) Operate Squeeze #3;
- 5) Open bleed #1;
- 6) Operate Squeeze #4; and
- 7) Open bleed #2.

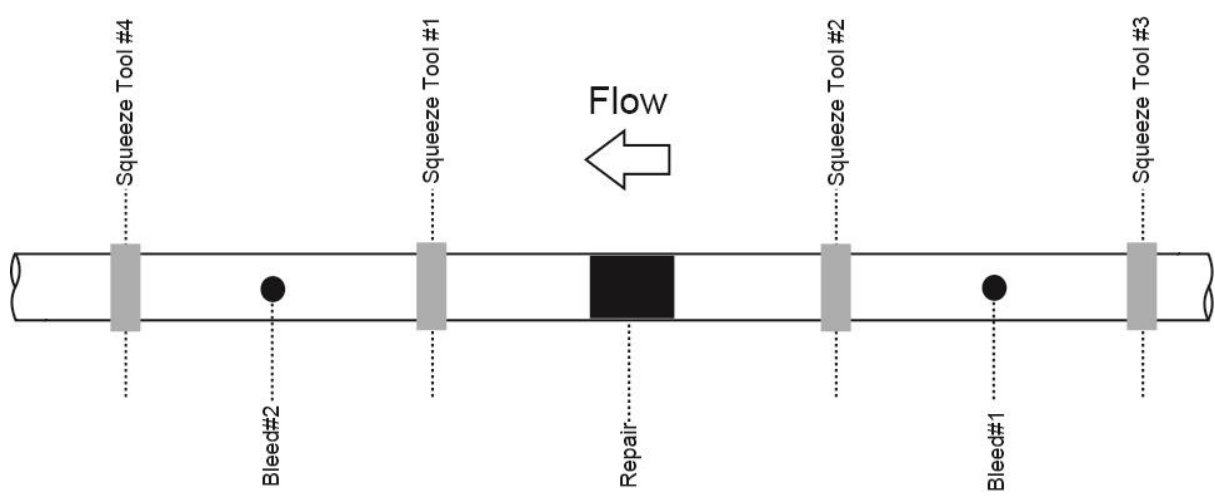


Figure 3: Squeeze-off configuration

3.6 Squeeze-off procedure

Before conducting a squeeze-off, investigations and tests should be made to determine the type, grade, size, and wall thickness of the pipe to be isolated.

For legacy pipework with missing MDRs, tests may be undertaken at any time before the squeeze-off is needed and records of these tests must be established and then retained. See ASTM F1734-03, *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* for details.

The following detail outlines the principles to preparing a squeeze-off procedure:

- 1) The pipeline material and dimensions.
- 2) The operating pressure within the pipeline.
- 3) The requirements for a temporary bypass.
- 4) The temperature of the main or service material.
- 5) Pipe area to be squeezed must be substantially free from marks or scratches especially longitudinally along the pipe and in the squeezed ears region.

- 6) The suitability of various diameters of squeezing bars or rollers for various pipeline diameters and wall thicknesses, refer to ASTM F1563-01.
- 7) The maximum compression squeeze rate of 50mm/min is recommended in ASTM 1041. This rate is considered slow enough to allow stress relaxation in the pipe.
- 8) Prior to squeeze-off, provision should be made to prevent static electricity (i.e. damp non synthetic cloth or earth rods).
- 9) A slow release rate is critical to avoid damage to the pipe and should be a maximum of 12mm/min as recommended in ASTM F1041-02.
- 10) The provision of stops, integral to the device's operation, which limit the gap between the roller bars in accordance with qualified procedure (frequently at the value of 10 per cent compression of pipe wall thickness at the point of squeeze).
- 11) The device should be placed at 90° to the pipeline centreline and at the recommended minimum distance for the material and associated diameter.
- 12) The provision of mechanical safety devices on hydraulic squeeze-offs to prevent hydraulic 'leak back'.
- 13) Post squeeze-off, the squeeze-off device, hot air, hot water, or any other means, should not be used to accelerate the re-rounding of the pipeline.
- 14) Before the pipeline is returned to operation, the squeeze-off should be clearly identified (e.g. with permanent ink or paint around the full circumference of the pipe and at least 5 x diameters longitudinally or other means such as inscribed tape) to ensure the area at minimum distance of pipeline diameters from the squeeze-off is not squeezed off again, thus minimising the future risk of wall cracking.
- 15) Following squeeze-off of PE, inspections for damage must be made. Provided there is enough time, pipe can be allowed to regain some of its original shape. Specially made re-rounding tool is then implemented if required.
- 16) After re-rounding, reinforcement clamps or fittings at the squeeze-off point shall be installed as per manufactures guidelines; unless an engineering review shows that stress relief is not necessary.
- 17) Finally, the location of the squeeze-off and its repair clamp should be loaded on the GIS system for record keeping.

3.7 Re-rounding tools

On completion of a squeeze-off, as the tool is released the pipe shall start to resume its original state. However, there may be a requirement to re-round the pipe at the squeeze-off to enable the installation of a reinforcement clamp. Re-rounding tools are normally a two-part clam shell which overlays the pipe.

When re-rounding a pipe with a re-round tool (see Figure 4), consideration should be given to the following:

- 1) type of re-rounding tool (mechanical or hydraulic);
- 2) no sharp edges on the circumference of the tool; and
- 3) tool opens wide enough to accommodate pipe ovality.

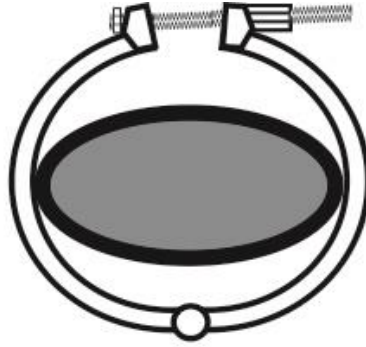


Figure 4: Rounding tool

4 Bagging-off

4.1 Introduction

Other mechanisms of flow stopping techniques such as 'bagging off' or 'plugging' require a branch connection to be made (such as by installing a saddle). With a branch connection, consideration should be given to the internal ID of the saddle. For example, most saddle sizes are SDR 11 and therefore the wall thickness reduces the ID.

Using a saddle connection to insert a bag or a plug requires an isolation valve. This valve can be either permanent or temporary.

There are some technologies which allow bags and plugs to be inserted into a live system without the use of a permanent valve. However, these technologies currently only suit small bore, low pressure systems.

4.2 General

Bagging-off uses an existing or a welded branch saddle to the pipeline fitting with an isolation valve. An inflatable bag is then inserted into the pipeline. When the bag is in the required position it is inflated to stop flow (refer to the manufacturer's recommendations). Bags are deflated and withdrawn once flow is to be reinstated.

Installing and using vents between bags is recommended to prevent a build-up of pressure and to act as a DB&B.

When conducting a flow stopping technique such as bagging-off, consideration should be given to the operating pressure of the pipeline, and to confirm the selected bag stop is suitable for a flow stop application.

Bagging-off can be used in conjunction with squeeze-off to perform a DB&B. However, it is recommended not to use a bag-off as a primary isolation.

Semi-supported bags are normally devices that are supported within the pipe with an anchor system whereas non-supported bags are only supported by the bladder and inflation hose.

Bags are readily available in different materials which normally dictate the inflation and flow stop pressure.

Bagging-off configurations are available in different forms. For example, single entry bags and single entry double bag systems as shown in Figure 5.

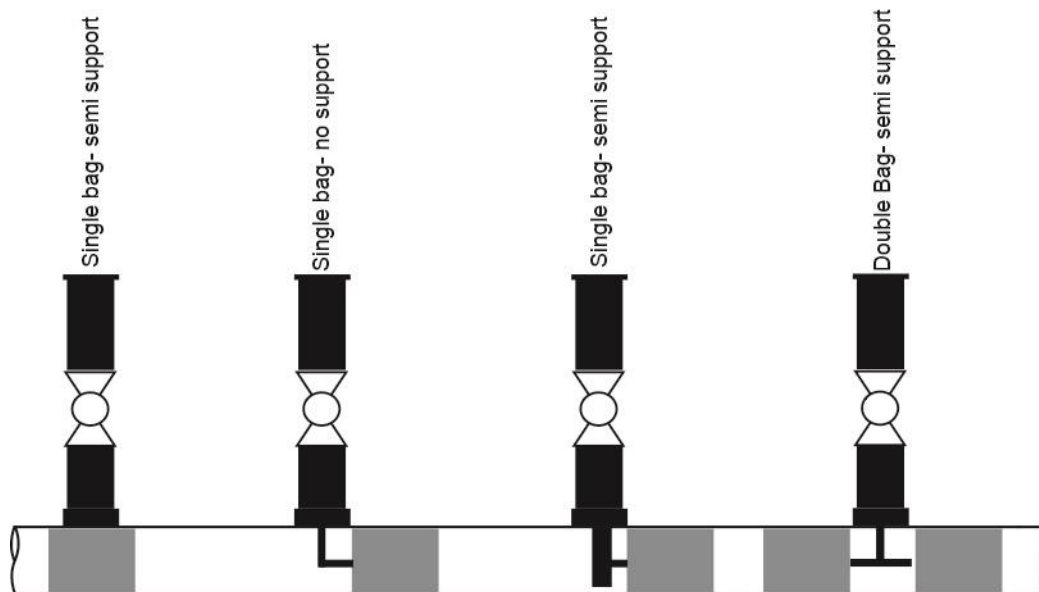


Figure 5 Bagging-off types

4.3 Qualification

The qualification of bagging-off is not mandatory. However, consideration should be given to the bag, insertion device and the application it is used for.

When planning to use bagging-off as a flow stop technique, consideration should be given to the following to ensure the tool is suitable to execute the operation safely. See *GIS/E19:2006 Primary Iris Stop Bags* for referenced bag testing and qualification.

Qualification should include but not limited to the following:

- 1) Qualification of the bagging off procedure including qualification for the insertion and flow stop method.
- 2) Qualification of the flow stop method should be completed to demonstrate the flow stop capabilities. The parameters for the qualification (e.g. flow, pressure, fluid type, pipe size) need to be defined.
- 3) Qualification of competent person (as per CP-02-001) to conduct the bagging off operation.
- 4) Pipeline size, operating pressure and gas velocity.
- 5) Suitable bag designed to withstand the required differential pressure (DP) and flow velocity.
- 6) Size of bag required and size on entry into pipe through saddle.
- 7) Storage of inflatable bags.
- 8) Leak tests to measure bypass around the bag.

- 9) Pull tests for neck assembly on unsupported and semi-supported bags.
- 10) Bag insertion device:
 - a. Gland sealing system to withstand MOP of pipeline.
 - b. Purging of the insertion mechanism.
 - c. Mechanism for ensuring bag remains in place.
- 11) Bag inflation mechanism, bag MOP pressure and system to maintain bag pressure.
- 12) Differential pressure (DP) across bag.
- 13) Pressure/ flow stop capability.
- 14) Free-standing test, rupture tests including test reports.

4.4 Tools and equipment

Before conducting a bagging-off, operators should ensure they have the right tools to complete the flow stop:

Tools and equipment are to include:

- 1) personal protective equipment (PPE) which is to include gas and oxygen monitoring devices and breathing apparatus where work is to be carried out below ground level and/or pipe is to be cut or opened;
- 2) approved bags and bagging insertion/ extraction tool fitted with a pressure relief protection system;
- 3) medium to fill bag (e.g. nitrogen or liquid - refer to manufacturers guidelines); and
- 4) vent pipes with flame traps and earth strap (where applicable).

4.5 Bagging-off procedure

Prior to conducting a bagging-off flow stop, investigations and tests are required to determine that the particular type, grade, size, and wall thickness of the pipe to be isolated.

The following outlines the principles to conducting a bagging-off procedure:

- 1) as applicable, the flow stop method must be rated to the pressure of the pipeline being flow stopped, or greater;
- 2) the pipeline material and dimensions;
- 3) the operating pressure within the pipeline;
- 4) the requirements for a temporary bypass;
- 5) the temperature of the main or service material;
- 6) branch saddle connection with an isolation device to insert bag through;
- 7) methodology of inserting the bag;
- 8) methodology of pressurization and maintain bag pressure;
- 9) contingency plan should the bag rupture; and
- 10) post bagging-off, a suitable method of extracting the bag

4.6 Bleeds and drains

When conducting DB&B, consideration should be given to location of the vent (e.g. it may not necessarily be installed on the top of pipe). Conducting isolations on water gathering networks can

be problematic. There are circumstances where slurry, coal fines or other debris has restricted the sealing of the squeeze-off / bagging tool leading to small quantities of bypass. When conducting repairs or modifications on gathering networks issues with contamination of the welds can also occur. In these circumstances, a drain can be welded to the bottom of the pipe and used as a bleed to establish a DB&B isolation. However, noting that hydrocarbon is present in water networks, and water present in gas networks, there may also requirement for a vent on top of the pipe to expel any hydrocarbon bypass to atmosphere. Vents should be piped away from the excavation and erected at least 2.5meters above ground level to promote a safe working environment.

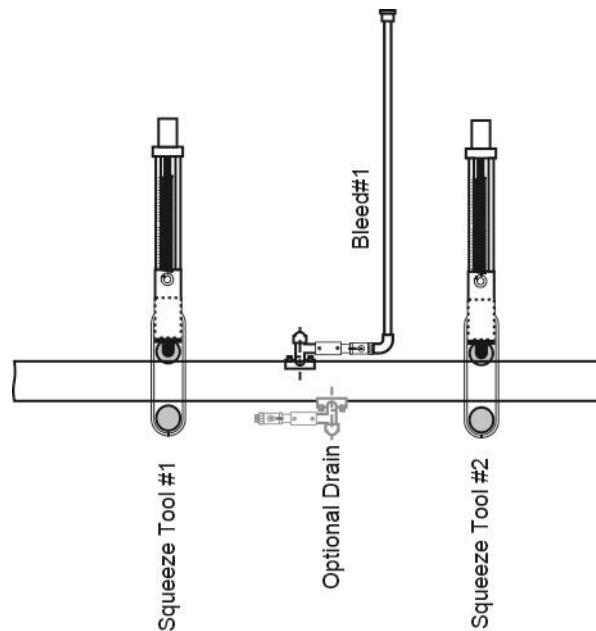


Figure 6: Bleed and drain configuration

4.7 Bypass

During the operations and maintenance of a gathering asset, a shutdown may be required to conduct a repair or modification. In this circumstance, a bypass may be required to keep the asset operational. Planning and executing a bypass should only be conducted by competent personnel. Consideration must be given to the following:

- 1) MAOP/operating pressure of the flow line in relation to the parent main;
- 2) size and flow rate of the bypass to compensate the isolation and maintain flow;
- 3) testing and pre-commissioning of the bypass;
- 4) location and connection to existing asset;
- 5) third party damage;
- 6) mechanical damage;
- 7) fire protection;
- 8) length of the bypass; and
- 9) slugging (dual phase flow).
- 10) Bypass temporary or permanent (if permanent, must be rated to the MAOP of the existing system).

The installation of a correctly sized bypass may also be used on systems to minimise pressure on the flow stop. An example of this is where a squeeze-off tool has been qualified for 500kPag and the

system is operating at 600kPag. A suitably sized bypass would alleviate pressure from the flow stop. Bypasses can be achieved by either temporary measures such as rated hoses, steel piping or welded PE piping. In all cases, the bypass must meet the minimum system pressure requirements and undergo a strength and leak test prior to commissioning.

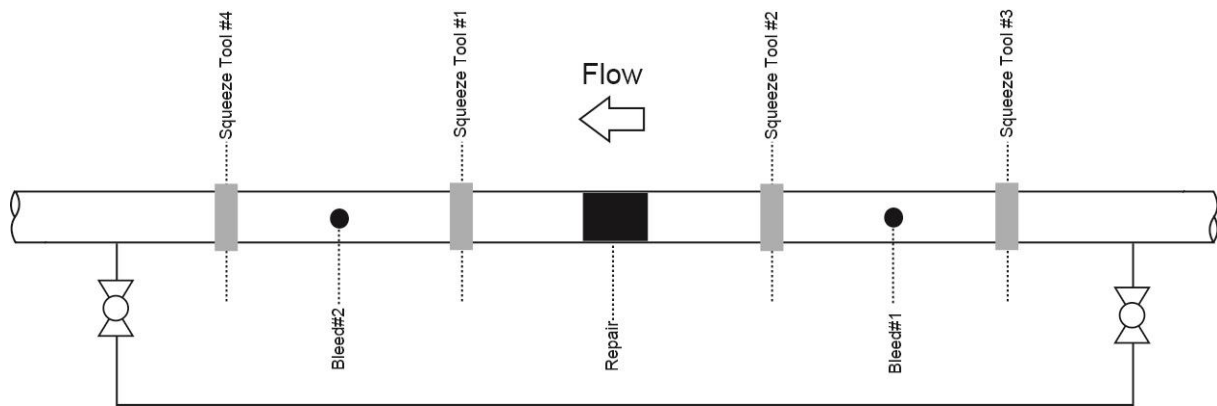


Figure 7: Bypass configuration

5 Hot tapping

5.1 Introduction

Hot tapping (or in-service tapping), also known as branch drilling, is a method that can be used for providing a branch connection to a live or non-operational pipeline. It is a method that is also used in conjunction with flow stopping techniques such as bagging-off and plugging.

Hot tapping can be a high-risk operation that should only be conducted by qualified competently trained personnel. When conducting a hot tap, precautions must be given to the following:

- 1) Pipe and fittings preparation;
- 2) Continuous checking of gas concentration;
- 3) Assembly of the pressure drill and correct drill heads (including coupon catcher);
- 4) Correct measurements;
- 5) Drilling operation;
- 6) Removal of drilling machine; and
- 7) Successful removal of the coupon.

5.2 Qualification

The qualification of branch drilling on live services is not mandatory. However, when planning to conduct a live branch connection or hot tap consideration should be given to the following:

Qualification should include, but not limited to the following:

- 1) qualification of a hot tap procedure;
- 2) qualification of competent person to conduct the hot tap operation;
- 3) pipeline size, SDR and operating pressure.
- 4) internal ID and pipe cutter size;

- 5) pipe drill calculations;
- 6) pilot drill and coupon catcher; and
- 7) pressure rating off the drill.

5.3 Procedure

Branch drilling equipment and procedures should be approved.

When selecting equipment and determining the operating procedure, the following should be considered:

- 1) The pipeline material and dimensions;
- 2) Ensuring the saddle and associated fittings such as permanent valves has undergone strength and leak test;
- 3) Use of earth rods or use of damp non-synthetic cloths to counter static electricity;
- 4) With reference to Figure 8 the length of the drill and travel calculations;
- 5) Number of turns to fully open and close the main branch isolation valve;
- 6) Drill alignment;
- 7) Without operation, check drill passes through valve and touches pipe;
- 8) Leak test on assembled drill prior to pipe penetration;
- 9) Purging of drilling machine once pilot drill has penetrated pipe;
- 10) Ensuring the pipeline is fully cut and the coupon retained in the drill head;
- 11) The retraction of the drilling machine past the isolation valve; and
- 12) Ensuring the isolation valve is fully closed, the drilling machine is de-pressurised and removed from the branch saddle.

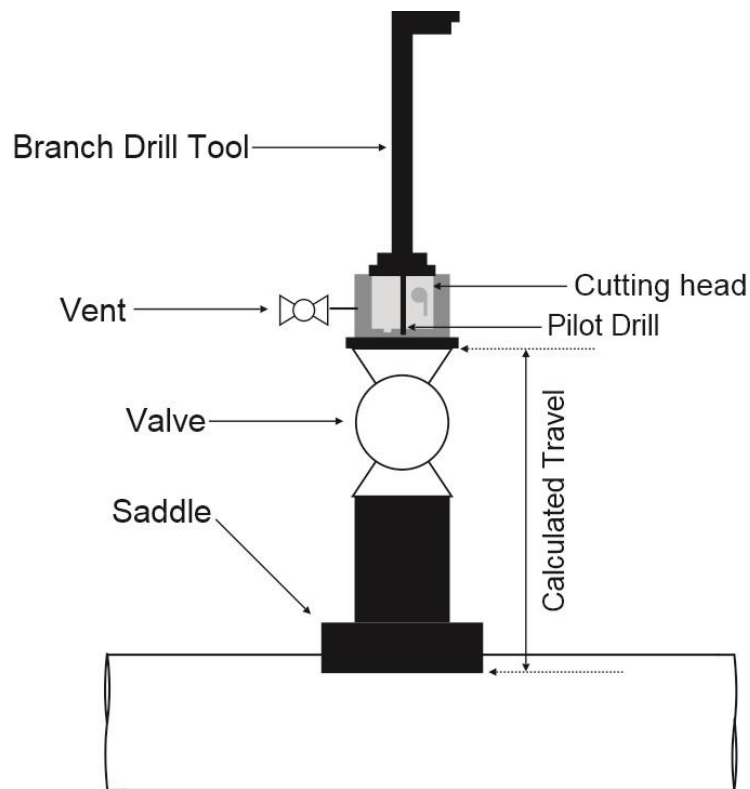


Figure 8: Branch drill set up

Drilling calculation travel distance considerations:

Distance of Travel 1 = Pilot drill on pipe.

Distance of Travel 2 = Cutting head on pipe.

Distance of Travel 3 = Cutting head through pipe.

5.4 Tools and equipment

Tools and equipment are to include:

- 1) personal protective equipment (PPE) which is to include gas and oxygen monitoring devices and breathing apparatus where work is to be carried out below ground level and/or pipe is to be cut or opened;
- 2) pressure leak test equipment;
- 3) approved branch drilling machine;
- 4) nitrogen to purge drill;
- 5) alignment and re-rounding clamps;
- 6) clean damp non-synthetic cloth; and
- 7) earth strap (where applicable).

6 Plugging

Plugging is a specialist technique used to stop or control flow by mechanically installing plugs in the pipeline. Using a hot-tapping machine, a hole is cut in the pipeline through the tapping fitting and a valve. A plugging machine is then bolted on to install the plug assembly. Using vents between plugs is recommended to prevent build-up of pressure and to act as a double block and bleed.

At the time of writing this companion paper, plugging systems are generally used on PE pipelines up to 315mm diameter utilising specialist PE saddles.

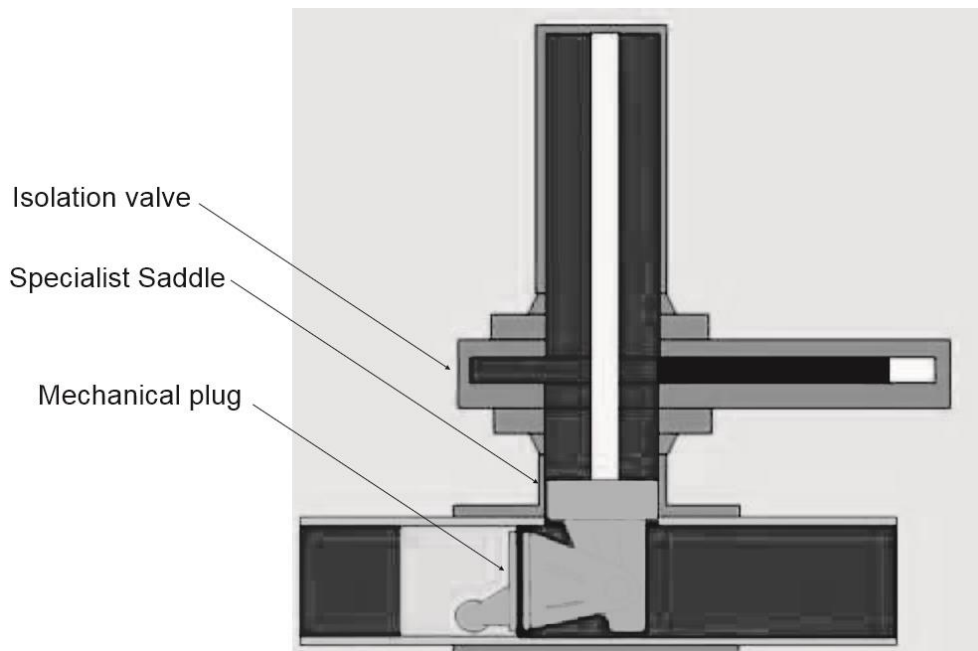


Figure 9: Mechanical plug insert

7 Training and competency

The use of flow stopping and hot tapping equipment is a specialised activity requiring specific competencies and is regarded as high risk activities.

All staff involved should be required to demonstrate competencies relevant to the specific equipment used as per companion paper CP-02-001 Competency.

8 References

APGA Companion Paper CP-02-001 - Competency

ASTM F1041, Standard guide for squeeze-off of Polyolefin Gas Pressure Pipe and Tubing

ASTM F1563, Standard Specification for Tools to Squeeze-Off Polyethylene (PE) Gas Pipe or Tubing

ASTM F1734-03, 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

GIS/E19:2006 Primary Iris Stop Bags