Code of Practice

Upstream Polyethylene Gathering Networks – CSG Industry

Companion Paper CP-05-003

Trenchless Construction

Rev 1

April 2025

Contents

Acknowledgements

This Companion Paper has been prepared by the Australian Pipelines and Gas Association (APGA) CSG Committee working group. The working group members contributed significant time and resources at the working group level in developing and reviewing this companion paper and their support is acknowledged. The support of the APGA Board and the APGA Secretariat is also acknowledged.

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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 related to the safe and efficient installation of trenchless construction (horizontal directional drilling, micro tunnelling and auger or thrust boring) and should be considered as supplementary to the Code.

Trenchless construction has become more common and accepted in industry as both environmental conditions related to disturbance necessitate minimised disturbance and increased number of contractors being available to undertake trenchless work, has brought down unit costs.

There is minimal printed information available related specifically to trenchless construction for large diameter PE pipelines (over 630mm), and it is expected this companion paper will assist in large diameter installation and greater acceptance.

2 Introduction

Trenchless construction comprises various types of subsurface construction techniques that employ materials, methods and equipment to install a pipe or casing between two defined points where it has been determined that the usual open trenching or plough in methods will impact on a project, from community or environmental aspects. Examples include railways, roads, rivers/major creeks and environmentally sensitive areas. The range of trenchless techniques can be categorised into the following subsets:

- horizontal directional drilling (HDD).
- micro tunnelling (closed face).
- auger or thrust boring (open faced).

In all cases, the profile and layout design shall be performed by qualified engineers with relevant design experience.

The choice of method requires consideration of the crossing configurations, soil characteristics and any possible loads that may be applied to the pipe network infrastructure as a result of sub-terrain conditions or surface activities. Utility authorities, councils or government departments (e.g. Main Roads) may dictate which methods are permitted for the crossing. All trenchless construction methods ultimately excavate a horizontal hole (or holes) between the two defined points into which an infrastructure pipe or similar is inserted. A casing pipe may be initially inserted where necessary. The pipe(s) are pushed or pulled into position depending on the trenchless method being adopted.

Each trenchless construction technique has its own suite of considerations. These are summarised in detail in this Companion Paper and various publications referenced.

Each technique has to ensure that third-party awareness is adequate for the nominated life of the infrastructure; this is achieved in several ways, as detailed elsewhere in the Code. These include:

- marker signs.
- marker tape or equivalent (where practical).
- delineated easement (e.g. by clearance).
- tracing and locating materials.

3 Technical review

3.1 Trenchless construction general

Each trenchless construction technique has its own suite of considerations; however the following are applicable to all techniques:

- Operational considerations. Trenchless construction is a minimal surface impact technique.
- Consider access if the pipeline or service needs to be removed or inspected.
- Environmental considerations, such as; sensitive areas, soil types, water course etc.
- Competency of personnel designing and constructing the chosen method.
- Signage and third party awareness.
- Pipeline pressure ratings or de-ratings according to the construction method used.
- Solids build up in low points.
- Pressure testing, (to be in accordance with the Code of Practice).
- Casing pipe requirements. Jacking loads during installation can mean that PE pipes are unable to be used as single pass systems.
- Site investigations (topographical surveys, hydrographic surveys, etc.).
- Service and utility locations (Before You Dig Australia / pot-holing etc.).
- Sub-surface investigations (test holes/bores, soils analysis, etc.).
- Tensile loads on carrier pipes during pull through of bored holes.
- Pipe fabrication / stringing considerations (i.e. bundling of multiple strings, rollers/ equipment for support during insertion etc.)
- When annulus grouting should be considered (again third parties may stipulate this) or if shallow and risk of settlement.
- Safety (machine safety practices, entry into excavations, exposure to chemicals used in drilling, high pressure fluids, etc.)
- The COP advises that an installation factor of 1.2 applies for directional drilled crossings, but this factor may well apply to any bore, as “the appropriate value to be determined by assessing the magnitude of surface damage and longitudinal strain caused by propriety methods”. Note: The impact of a non 1.0 installation factor may be a different SDR pipe at the crossing with ‘challenging’ conditions.

Construction drawings should be made of all trenchless requirements. This will minimise construction risks, facilitate approvals and enable accurate “as built” drawings to be made.

Further advice and discussion on the different techniques is available from the Australasian Society for Trenchless Technology at www.astt.com.au.

3.2 Case vs uncased

Consideration should be given to determine whether trenchless crossings should be fitted with casings. Considerations include:

Using a casing

While a casing can be used for curve trenchless application, it would compound installation difficulties. In addition, curved casings typically increase installation radius of curvatures – expanding the scope of the installation.

Straight casing (i.e. for thrust bores), are a common requirement under rail lines, and under roads.

In general, defined benefits of using casings with PE carrier pipes are:

- Higher integrity of pipe installation if using casings, (minimises risk of pipe surface damage).
- Potential for relaxation of pre-testing requirement.

The above factors enable the argument that a higher design factor is not required; therefore no change in SDR rating is required - removing the need for transition pieces.

Not using a casing

In general, defined benefits of not using a casing with PE carrier pipes, is reduced crossing scope and hence reduced installation cost. However, risk to mechanical damage is higher.

3.3 Rail crossing requirements

There is an Australian Standard (AS 4799 Installation of underground utility services and pipelines within railway boundaries) covering technical requirement of work in rail land; Some rail authorities impose additional special measures. Prior to any proposed crossing of rail infrastructure the proponent must contact the relevant authority to gain approval and determine if they have any specific requirements over and above AS 4799 (and AS 2885 for Gas and Liquid Petroleum Pipelines).

These special conditions typically address the following concerns:

- Avoidance of working in rail land boundaries.
- Requirement for a casing to ensure any possible leak in carrier pipe does not affect rail activities (due to potential for a fire and explosion) and in the case of liquids being transported – erosion.
- Settlement and subsidence of the rail line.
- Avoidance of the possibility of track lift due to boring / drilling.

Therefore, there may be specific requirements on the use of casing pipes, grouting between pipe and bore and limitation of fluid pressures / avoidance of large diameter HDDs under rail lines.

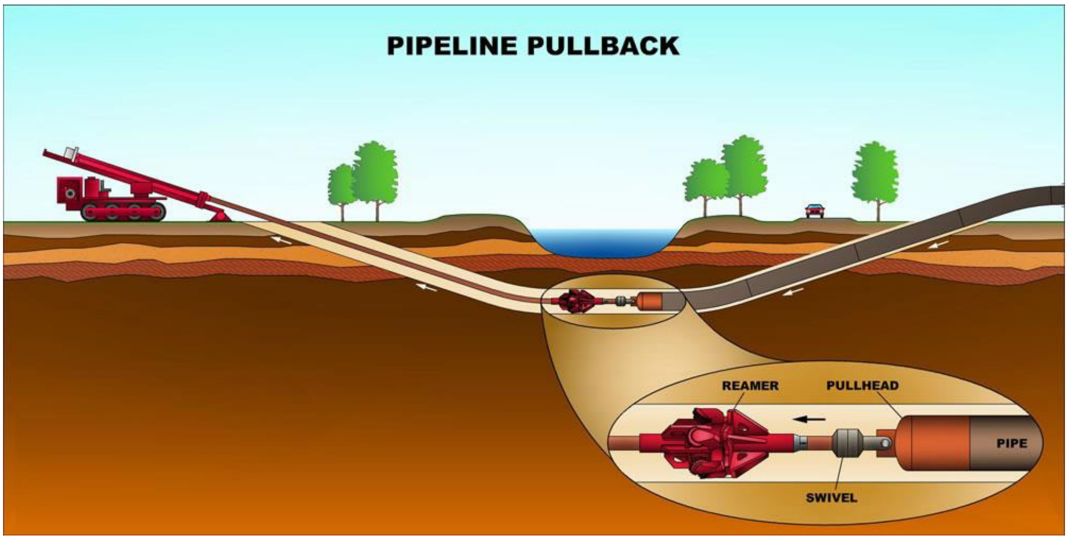
3.4 Major sealed road requirements

Sealed roads are typically crossed by boring as the authorities do not want to have their sealed surfaces disturbed or disrupt traffic flow. There is an Australian Standard (AS 2566.1 Buried Flexible Pipelines, Part 1 Structural Design), covering the methodology for calculating loads on proposed bored crossings, which will enable designers to undertake the necessary calculations, to ensure the a flexible pipe without casing is suitable. Some road authorities however impose additional special measures requesting implementation of casings. This is typically requested to: *ensure all equipment will be able to cross the pipeline without notification and to ensure minimal hindrance on their ability to undertake emergency works of roads at often reduced covers*.

Prior to any proposed crossing of road infrastructure the proponent must contact the relevant authority to gain approval and determine if they have any specific requirements.

3.5 Horizontal directional drilling

Diagram of typical HDD operation



HDD is used for the installation of pipes and utility lines and is characterised by its use of a surface-mounted drill rig that launches and places a drill string at a shallow angle to the surface and has tracking and steering capabilities.

The use of HDD is intended to minimise surface damage, restoration requirements, and disruption of vehicular or maritime traffic with little or no interruption of other existing lines or services.

When proposing to use HDD the following should be considered:

- Subsurface conditions. (Considerations should be adequately determined and the drill path should be aligned horizontally through a geological stratum that is stable, homogeneous, and devoid of gravelly soils, loose deposits and discontinuities.) Geotechnical investigations typically comprise of a series of sub-surface investigative bore holes being drilled adjacent the HDD alignment, where cores are recovered for physical and geotechnical laboratory analysis to assess and obtain soil properties necessary for HDD design process. The following soil properties are required for HDD design purposes; particle size distribution, angle of internal friction (Ø), soil unit weight (Ɣ), soil cohesion(C), undrained strength (C_u), Young's modulus (E) and Poisson ration (η). The sub-surface geotechnical investigative drilling is also used to identify layers of sand, gravel or cobbles and the like that may have an effect on the HDD hole stability and directionality. These tests will enable designers to confirm if crossings are suitable for HDD or alternative techniques as listed below should be employed.
- Drilling fluid management (including water extraction, approvals, collection and transfer of fluids, hydro-fracture and waste disposal).
- Steering and drill rod constraints (both the minimum radius of the product pipe and drill rod should be considered, typically for small diameter PE pipes the drill rod will be the limiting factor and the radius of curvature should not be less than 1200 times the drill rod diameter).

- Drill path profile and trajectory including specification of drill entry point, drill exit point and the product pipe radius of curvature.
- Entry and exit tangent section lengths (including entry tangent casing to prevent inadvertent near surface returns).
- Analysis of stresses for selected drill path.

PE pipe shall be selected and installed as follows:

- Operational and installation loads including internal (operational) pressure loads, external (operational) hydraulic and earth loads, and net external pressure.
- Pipe resistance to earth loads including pipe deflection (ovality) and unconstrained collapse.
- Axial bending stress, axial tensile stress and torsional stress.
- Pulling force including pipe stiffness, coefficient of friction, effective weight and buoyancy forces, hydrokinetic pressure, and special considerations for bundled pipes (where applicable).
- For the insertion of large diameter PE pipes or pipe bundles addition of ballast water should be considered to counteract buoyancy forces.
- Combined loads during installation including reduced PE collapse strength and thermal effects.
- Combined loads during operation including thermal stresses.
- Removal of the external butt weld bead should be considered where the carrier pipe is to be installed in a casing.
- A visual inspection of the first two (2) metres of carrier pipe pulled through the exit point (drill entry point) should not show signs of yielding or other damage. Gouges or scratches shall not exceed 10% of the minimum wall thickness.
- Grouting may be specified to fill the annulus between the drill hole and the carrier pipe (or between the casing pipe and the carrier pipe).
- Gauging to demonstrate that the ovality limits as per the design criteria are met may be specified.

<u>NOTE</u>: Grouting pressures need to be carefully monitored to ensure that pipe buckling is avoided. Consideration should be given to filling the pipe with water during the grouting process.

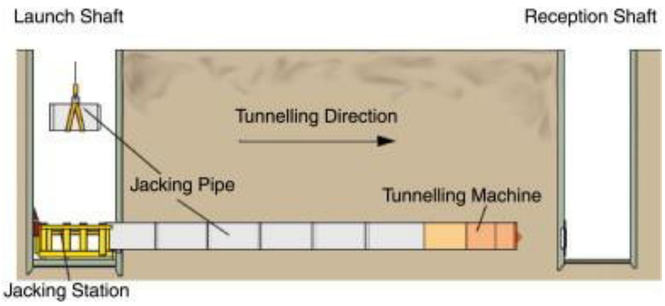
NOTE:

A) ASTT *Guidelines for Horizontal Directional Drilling, Pipe Bursting, Microtunnelling and Pipe Jacking,* ASTM F1962 and Chapter 12 of the PPI PE Guidelines Handbook provide guidance on methods used in the design and selection considerations of PE pipe for HDD. It is recognised that there are circumstances where a suitable PE pipe is not available (due to limits in SDR) to satisfy stress criteria for the installation. In this case, it is recommended that the full crossing be cased using a casing of suitable material.

B) The Code advises that an installation factor of 1.2 applies, however for pipes designed and installed in accordance with *Polyethylene Pipe for Horizontal Directional Drilling – PPI* a design guide of 1.0 may be used.

3.6 Microtunnelling (closed face)

Diagram of typical microtunnelling operation



Microtunnelling, sometimes called closed face boring, is a form of trenchless construction that employs a remotely operated microtunnelling boring machine.

Microtunnelling is typically used in situations where a pipeline needs to traverse under rail, road or other sensitive features and the geology is uncohesive, granular and water charged.

The limitations and disadvantages of microtunnelling are:

- Microtunnelling must be installed on a relatively flat and constant grade. This results in the process requiring pits or shafts at either end.
- Microtunnelling is unable to negotiate tight vertical or horizontal curves.
- Microtunnelling requires elaborate machinery to conduct and support the process which has an impact on time and cost.

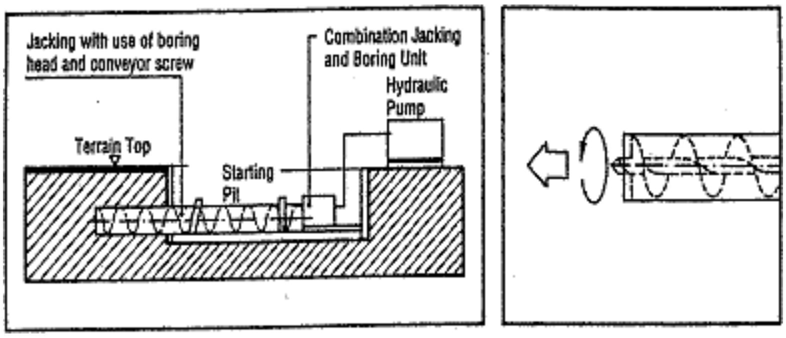
When proposing to use microtunnelling the following should be considered:

- Geology and hydrogeology.
- Pipeline / tunnelling alignment.
- Design and construction method of pit / shaft and thrust wall construction.
- Design and construction method of launch and reception seals.
- Design and construction method of carrier pipe spacers and annulus grouting.
- Approvals from the client and all relevant third parties (e.g. road, rail and environmental authorities) for the use of this method.
- Settlement monitoring of sensitive structures and a comprehensive contingency plan for settlement problems.

It is noted that to date in the Queensland CSG projects to date, there has been minimal use of this technology.

3.7 Auger boring or thrust boring (open face)

Diagram of typical auger boring operation



Auger Boring is one of the oldest trenchless methods for installation of pipe sections under obstacles. The bore is formed from a launch pit by means of an open faced rotating cutting head that is pushed through to a receiving pit. Typically the rotating head is hydraulically pushed through and the soil removed back to the launch pit by helical auger sections as the casing is jacked into place. This method only offers limited steering capabilities and limited length and is normally used when precise accuracy or length is not crucial.

When proposing to use auger boring the following should be considered:

- Auger boring tends to be suitable for straight, uncontrolled drives in softer ground, although some systems offer limited steering capability and rock conditions can be possible with specialised equipment.
- Ground conditions may mean limitations in terms of depth and capability particularly in high water table areas.
- Auger boring does not normally install carrier pipes directly but installs casing pipes.
- Launch pit dimensions for auger boring machines may mean access requirement limitations and the use of large bell holes and shoring equipment.
- Disadvantages include limited bore lengths and an inability to avoid obstacles in the bore path.

3.8 Excavator mounted augers

Excavator mounted augers are in effect a sub set of auger borers. However, they are worthy of special discussion.

Diagram of excavator mounted augers

With the advancement of technical equipment, there is increasing use of excavator mounted augers. These can be used application where it is required to bore under shorter crossings such as under other utilities. This would involve open cut trenching up to the required bore on each side and then lowering in the auger into the open trench to undertake the bore.

4 Risk management

Each trenchless crossing should have a risk assessment undertaken at project definition stage, to examine risks. This should be done in accordance with a structured risk assessment process, as per the Code. This will give guidance in selection of optimum crossing methodology.

At design stage and prior to commencement of construction, this should be repeated.

Hazards should be identified, control methods investigated as required, and risks reduced to ALARP.

4.1 Blockage management

It should be noted that by undertaking trenchless construction, there is typically the introduction of new low points. These low points produce risks to network performance. For gas pipelines, this will be in the form of potential liquid low points, which may require the introduction of low point drains to manage. For water line, this will be in the form of potential areas of solids drop out points, which may need to be managed.

5 Skills requirements

When performing the design of major trenchless crossings, consideration shall be given to requirements of having the relevant design documentation signed by RPEQ signatories. This is often an 'other authorities' requirement, when the crossing is under a major road or railway.

In addition, construction staff should be assessed to ensure they are competent, to confirm existing skills and pinpoint if further training may be required.

Competence may be demonstrated against the Australian Qualification Framework (AQF). The AQF is the national policy for regulated qualifications in Australian education and training. It incorporates the qualifications from each education and training sector into a single comprehensive national qualifications framework.

The Australian Drilling Industry Training Committee (ADITC) recognises five levels of AQF qualification for the drilling industry: Certificate II (offsiders); Certificate III (driller) which is the trade level qualification; Certificate IV (senior trade or supervisory personnel); Diploma (drill supervisors) and Advanced Diploma (drilling business managers). The appropriate level of trained staff should be engaged for the specific task at hand, or training is undertaken under supervision to assist personnel to reach the appropriate level.

Personnel may also hold current competency in machine use by verification of competency (VOC).

It should be noted that APGA pipeline engineering competency standard PP010 deals with Trenchless Construction. The competency enables a pipeline engineer to understand the main issues associated with the range of trenchless technologies, specify the key parameters for each one, communicate effectively with personnel performing trenchless installation, and operate as part of a construction team for a pipeline/network for which trenchless technology is being applied, ensuring that it meets all of the requirements of the asset owner.

This competency will not enable the engineer to act as an expert in any particular trenchless technology or oversee installation using a trenchless technology. However, Pipeline engineers with this competency will be able to contribute to specifying requirements for trenchless pipe installation and communicate with construction contractors responsible for trenchless pipe installation. PP010 specifies the knowledge and experience required for competence in this area and can be used to assess whether a pipeline engineer has the required competency to undertake the functions specified.

6 References

APGA Code of Practice for Upstream PE Gathering Networks – CSG Industry

APGA Training Package PP010 - Trenchless Construction

AS2566.1 Buried Flexible Pipelines, Part 1 Structural Design

AS2885 Pipelines – Gas and liquid petroleum

AS4799 Installation of underground utility services and pipelines within railway boundaries

ASTM F1962 Standard Guide for Use of Maxi-Horizontal Directional Drilling for Placement of Polyethylene Pipe or Conduit Under Obstacles, Including River Crossings

ASTT (Australian Society for Trenchless Technology), Guidelines for Horizontal Directional Drilling, Pipe Bursting, Microtunnelling and Pipe Jacking

PPI (Plastic Pipe Institute) Handbook of PE Pipe

The Australian Drilling Industry Training Committee (ADITC)