Australasian Society for Trenchless Technology

Standard for Pipe Bursting

Rev	Description	Author	Checked	Approved	Authorised	Date
2	Minor changes	JP	JP	JP	JP	1 June 2015
1	General Revisions	JC	MI	NH	JP	03 Feb 2010
0	Issued for Use – Client Comments Incorporated	JC	MB	NH	JP	08 Sep 2009

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1.0 BACKGROUND

The Australasian Society Trenchless Technology has developed this Standards to assist industry users in Australia and New Zealand in utilising Pipe Bursting.

This document does not replace any existing relevant manuals or standards. It remains the users responsibility to ensure that all relevant laws, standards and specifications are adhered to during the course of a Works.

Additional Pipe Bursting information can be obtained from the Australasian Society Trenchless Technology website (www.astt.com.au), they are:

- Guideline for (Horizontal Directional Drilling, Pipe Bursting, Microtunnelling and Pipe Jacking).
- Specification for Pipe Bursting.
- National Utility Contractors Association Trenchless Assessment Guide, a web-based tool that can be used for identifying trenchless construction methods suitable for a particular set of project attributes (i.e. diameter, length, depth, geological conditions, and so on).

2.0 DEFINITIONS

A number of abbreviations and technical terms have been used in this standard:

ASTT - Australasian Society for Trenchless Technology

CCTV - Closed Circuit Television. The use of video cameras to visually inspect the works. Often used where man entry not feasible/ possible.

Client - Person or company requiring the Works to be undertaken.

Environmental Impact Assessment - assessment of the possible impact-positive or negative-that a proposed project may have on the environment; considering natural, social and economic aspects.

Contractor - Person or company undertaking the Works required.

Entry Chamber - Also called insertion, thrust, drive or launching pit. A point in the ground where the pipe bursting machine is setup to start the bursting process.

Exit Chamber - Also called reception pit. An area where the pipe bursting machine complete it bursting process.

Feasibility Study - Preliminary design and study to ascertain whether commencing the works would prove viable or feasible.

GBR - Geotechnical Baseline Report for all anticipated conditions.

Guideline - General information about an item, process, method, material, system or service.

HDD - Horizontal Directional Drilling. A trenchless method of installing new underground pipes, along a prescribed path by using a surface launched drilling rig equipped with a steerable drilling head.

HDPE - High Density Polyethylene Pipe.

MTBM - Microtunnelling Boring Machine. Mechanized excavating equipment that is remotely operated, steerable, connected to and forward by the jacking system thrust.

NUCA TAG - National Utility Contractors Association Trenchless Assessment Guide.

PB - Pipe Bursting. A trenchless method of replacing existing pipes. Involves destruction of existing pipe while simultaneously installing the new pipe.

Specification - A document that specifies, in a complete, verifiable manner, the requirements, design, behaviour, or other characteristics of a system, component, product, result, or service and, often, the procedures for determining whether these provisions have been satisfied.

Standard - A document that provides uniform technical criteria, methods and processes to established a norm.

TT - Trenchless Technology. Technology for installing pipelines or creating bores without the need of full surface excavation.

Work - The project or task to be completed by the Contractor on behalf of the Clients.

3.0 SYSTEM DESIGN CONCEPT AND PARAMETERS CONSIDERATIONS

There are many factors that have to be considered before specifying the Pipe Bursting (PB) process for any Works. The actors include:[1]

- Pipelines Design operating flows, pressures and temperatures;
- Pipelines Flow variations (peak, start-up, minimum flows);
- Construction materials requirements (Corrosion protection [internal and external], wear considerations, load parameters, design and maximum thrust allowable);
- Equipment requirements (operating requirements, capabilities, suppliers and manufacturers equipment constraints);
- Site layout (access to site, entry and exit chamber excavation, locations of equipment and pipe material storage);
- Area of operation (existing utilities, nearby dwellings, heritage sites, wildlife habitats and fauna & flora).

The contractor shall take the following steps in planning a PB process:

- Perform all required feasibility studies, Environmental Impact Assessment and surveys, site protection plans, geotechnical report (or GBR), risk assessments and contingency planning;
- Detail each step of the process including but shall not limited to mobilisation, winch installation, pipe bursting operations, including old (existing) pipe specifications;
- Confirm bursting winch specifications including but not limited to an adequate anchoring system, pull forces and torques required;
- Propose water supply for operation;
- Compile replacement pipe specification (size, grade, quantity, joint types);
- Compile Contingency Plans in regards to failure to complete the Works, surface heave, striking of other utilities, loss of the bursting head, and other possibilities identified in the associated Risk Assessment.

4.0 MATERIALS AND EQUIPMENT

4.1 Equipment Requirements

The pipe bursting method of pipeline replacement uses of a bursting head pulled though the existing pipe connected to the rods of the bursting head, the new pipe is pulled into the borehole, whilst the existing pipe is being destroyed. The head is pulled with sufficient force to rupture the existing pipe. The fragment of the "burst pipe" are displaced into the ground immediately surrounding the pipe. Equipment commonly required for PB includes an anchoring system to secure the winch, a bursting head to destroy the old pipe. A cutting tool is sometime attached to the bursting head. In the case of ductile materials such as PVC, Ductile Iron, Galvanised steel a cutting tool is attached to the bursting head. The cutting tool enhances the bursting process by cutting through the existing pipe material. At the end if the bursting head is a swivel coupling. This coupling is used to attach the new pipe, allowing the pipe to be pulled into the borehole whilst the existing pipe is being destroyed.

4.1.1 Pulling Device

The pulling device shall be a continuous tension winch installed at the exit chamber. The pulling device shall be capable of generating sufficient force to be able to pull the bursting head and new pipe string through the existing pipe and to cause the existing pipe to be burst outwards into the surrounding soil.

The pulling device shall develop sufficient tension force to:

i. Pull the bursting head through the existing pipe, destroying it and displacing the fragment.
ii. Pull the new pipe into the borehole, created by the bursting head.

The pulling device is commonly a continuous tension winch, installed at the exit chamber end of the job.

A continuous tension winch system is a winch unit situated at the exit chamber, located on the surface, which is attached to the bursting head in the entry chamber via a cable or chain. When utilising a continuous tension winch system, the cable or chain and winch shall be situated in an enclosed environment ensuring safe operation in order to minimise risk of injury to the working crews and public, and to minimise risk of damage to crossing utilities or property.

A system of guide pulleys and bracing at the exit chamber shall be provided to minimise the potential risk of the winch cable sustaining damage by coming into contact with the existing pipe or fragment. The trench shoring supports that are used in the entry chamber shall be installed such that they cannot make contact with the cable, burst head or replacement pipe[2] during the process.

Where the new pipe diameter is greater than 1.8 times the existing pipe, the tension required to pull the bursting head rises significantly. It is common practise, in such cases to use an HDD rig and drill string to provide the tension force.

The winch supporting frame shall be setup at the exit chamber. This is to act as a buffer and provide a working spacing to ensure the bursting head has sufficient space to exit the exit chamber. This also allows some extra new pipe to be pulled through into the exit chamber for reconnecting to the old pipe.

4.1.2 Pushing force for hydraulic Bursting

It is important to observe the pushing force within a hydraulic bursting process. A common challenge for applying hydraulic bursting process is the obstructions within the host pipe. Many times these obstructions were not fully taken into consideration or remove while planning the bursting work. This creates additional pushing force on the bursting head that is trying to break the obstructions. If these obstructions were not broken during the process, the tension cable that is guiding the bursting unit will continue to pull the bursting head into the soil formation cavity that is not created. This will generate more tension and force on both bursting head and the tension cable.

Many common accessorises tools can be used within the bursting process to reduce such obstructions such as new pipe connector, rear expander, front connector and expander, and roller blade that become entangled with existing obstructions within the pipe alignment during the bursting process and can act against the bursting process to reduce the force require by the bursting head.

4.1.3 Bursting Head

The bursting head is the most important component of any PB Works. The bursting head destroys fragments the pipe and displaces the fragments into the surrounding soil. It also enlarges the bore, and pulls through the replacement pipe with the help of a pulling device. There is a range of different PB head available at present. These are described below:

4.1.3.1 Pneumatic Bursting

The most common type of PB head uses in impact/percussive mechanism powered by compressed air. It is know in the industry as Pneumatic bursting. The bursting head is able to develop a percussion frequency of 180 to 580 blows per minute. Each blow drives by the bursting head into the pipe. The tapered profile of the bursting head causes the axial impact force into radial force causing the pipe to burst and the fragments to be displaced. Pneumatic bursting is used to install pipes under 600mm in diameter.
In order to provide good guidance for the pulling chain or cable, a pulley system is mounted at the exit chamber. This will reduce the possibility of damage to the chain/cable from contact with the existing pipe or fragments of the pipe once burst. It will also reduce the risk of the chain/cable becoming entangled with any fragment, which would cause a considerable increase in tension forces.

If the percussion created during pneumatic pipe bursting are likely to have negative effects on adjacent pipes, then hydraulic bursting is often considered as an alternative.

4.1.3.2 Hydraulic Bursting

Hydraulic bursting uses a different bursting mechanism from Pneumatic bursting. The bursting head is pulled into the existing pipe then is expanded radically using a hydraulic cylinder mounted internally to burst the pipe. Hydraulic bursting is used primarily for on-line replacement of deep sewers and gravity pipelines.[3]

4.1.3.3 Static Bursting

Static bursting utilises a taper profile bursting head to develop radial bursting forces when the head is pulled through the existing pipe. The head also forces the fragmented pipe into the surrounding soil. The static bursting method uses either a cable or rod and a winch system to provide the required force to burst the pipe and pill in the new pipe. Static Bursting is capable of bursting metallic pipes.

In installations where the new pipe is sectional in design, it is common not to use a cable or chain as the pulling mechanism.

In such instances a rod based system is used. This types of system us capable of developing higher forces than the winch system. The rod system is also capable of acting in pull and push mode. The rods are first pushed into the existing pipe from the exit chamber towards the entry chamber. Once this is complete, the bursting head is attached and pull back through the existing pipe. The rods are connected by means of couples that allow the transmission of axial tension and compression. The rods are normally short and light in weight to allow for use in small size exit chambers. Due to the need to add in or remove rods, the rods based system is not continuous, making it slower than the cable/chain system.

4.1.4 Other PB Methods

Five other pipe bursting methods are listed this section. They are namely pipe splitting, pipe implosion, pipe eating, pipe ejection & extraction, and pipe reaming.

4.1.4.1 Pipe Splitting

Pipe Splitting is variant of the static pipe bursting method. In this case the bursting head has specially designed bladed rollers. As the bladed rollers are pulled through, they split the host pipe as opposed to fragmenting. This process reduces potential damage to the replacement pipe. Pipe Splitting is normally utilised for the replacement of pipes made of ductile material such as steel, galvanised steel, ductile cast iron, plastic. It is also used for the installation of pre-chlorinated replacement pipe.

4.1.4.2 Pipe Implosion (Crushing)

This method implodes the existing pipe by crushing it radically inwards and then displacing the fragments radically outwards into the surrounding soil. The crushing is achieved using a cylinder shaped, steel bladed head. Behind this head a taper profiled head displaces the broken fragments and created a borehole for the new pipe. The crushing head is slightly larger than the existing pipe. This method is particularly suitable for replacing pipes which have collapse or ruptured.

4.1.4.3 Pipe Eating

Pipe eating is a technique based on Microtunnelling, where the defective pipe is excavated together with the surrounding ground. The pipe-eating MTBM shield is thrust forward along the route of the existing pipeline using hydraulic jacks. Cutting teeth and rollers in the cutting head cut the pipe. Additional cutting devices close to the edge of the cutting head cut the surrounding ground to the required diameter for the new pipe.

The new pipe is connected to the back of the tunnelling shield and transmits the thrust. The pipe-eating shield entered at the entry shaft and recovered at the exit shaft. The new pipe replaces the defective pipe when the process is completed.

The advantages of this system are that all of the old pipe material is excavated, new pipe alignment is possible and totally independent of the old pipe and the line and level of the new pipe can be accurately controlled. This method is mostly commonly used for the replacement of old existing concrete sewer pipes.

4.1.4.4 Pipe Ejection and Extraction

Both of these methods are only used where the existing pipe is still competent. Both require that the forces used to remove the pipe can be transmitted along the length of the pipe. Due to the high frictional forces needed to drive the existing pipe through the ground, it is normally only achievable on short drive lengths.

Pipe ejection is a variant of pipe jacking utilizing a jacking frame in the entry pit. Pipe extraction is a variant of static bursting utilizing a pulling frame in the exit chamber.

4.1.4.5 Pipe Reaming

Pipe reaming is an variant of the HDD technique, specially adapted for pipe replacement.

A drill string is inserted through the existing pipe to an exit point further along the pipeline. A specially designed reaming tool is attached to the drill string and pulled back through the pipe by the drill rig whilst being rotated. During this reaming process, the existing pipe is fragmented by the cutting teeth of the reamer tool. Simultaneously a new pipe is pulled in behind the reaming head. Drilling fluid is used to lubricate the process and remove the old pipe material as spoil.

The advantage here is that one piece of equipment with relatively minor modifications can be used for two very different trenchless techniques. There is also no need for major entry chamber excavations at the drill rig end.

This technique is limited to non-metallic pipeline replacement and is capable of handling ground conditions such as rock, concrete encasements, service taps, and collapsed or misaligned pipes as it can used HDD drilling head to cut through some of these non metallic pipe materials and difficult ground conditions.

4.2 Standard Guide for Method Selection

Pipe bursting is suitable for replacing ductile pipes. Table 4.1 is a general standard to selecting the correct pipe bursting method when considering pneumatic, hydraulic or static methods. Other less common PB methods shall be consider based on a case-by-case basis as each project is unique and those less common methods have limited capabilities.

EXISTING PIPE MATERIALS	PNEUMATIC / HYDRAULIC	STATIC
Metallic pipes including aluminium, copper, ductile iron, wrought iron, steel, or stainless steel	No	Yes
Plastic pipe, including HDPE or MDPE,PVC,CIPP, or fibreglass	Yes	Yes
Prestressed or bar-wrapped concrete cylinder pipe (PCCP or BSCCP), corrugated metal pipe (CMP), or corrugated plastic pipe	No	No
Fracturable pipes, including asbestos cement (AC), reinforced concrete pipe (RCP), CI, VCP	Yes	Yes
Valves, stainless steel clamps or repair bands, point repairs	No	No
Pulling in pre-chlorinated replacement pipe	No	No

TABLE 4.1 – GENERAL STANDARD FOR SELECTION OF PNEUMATIC/ HYDRAULIC OR STATIC PIPE BURSTING METHODS[4]

The Contractor shall identify the locations of all existing point repairs made to the pipeline prior to commencing any work from "As-Builts" drawings, records or information provided by the client. Table 4.2 indicates the types of information required for documentation prior to PB when identifying the point repair along the old pipe. The contractor shall also take extra precautions when PB a reinforced concrete pipe. It may be necessary from time to time to excavate to clear reinforcement which accumulating around the bursting bead.

TYPE	INFORMATION REQUIRED
Type and size of affected pipe	Type, Diameter
Adjacent pipe condition	Describe
Cause of leak or damage	Describe
Length of repair or replacement	Length
Clamp required, type and size	Type, Diameter, Length
Pipe required, type and size	Type, Diameter, Length
Solid sleeve required for pipe, type (CI or DI), and size	Type, Diameter, Length
Backfill material	Concrete, Stone, Flowable Fill, Other

TABLE 4.2 – REQUIRED INFORMATION FOR PREVIOUS POINT REPAIR LOCATIONS[4]

It must be noted that those selected pipe bursting equipment may not be suitable to break through or out any previous point repairs, in which case other cutting heads, equipment or processes may be required.

4.3 Replacement Pipes

Replacement pipes shall have a nominally flush exterior and be suitable for trenchless installation as per the manufacturer's recommendation. New PVC pipes shall be joined by hot fusing prior to installation. If there is insufficient space for this operation when using PVC replacement pipe, then pipes are to be connected with spline locking joints. If the preferred replacement pipes are ductile iron pipes then special flush joints are to be used[4]. Joints shall be water tight as per the manufacture specification.

4.4 Entry Chamber, Exit Chamber, Access Chamber

PB Works require excavation chambers at the head (entry) and tail (exit) end of the pipe and must be of sufficient size to accommodate the bursting rig. Additional access chambers maybe required at bends in the pipe alignment, as well as lateral connections.

Smaller potholes for accessing crossing utilities shall be considered for locating and prevention of damage to other existing utilities.

5.0 INSPECTION AND TESTING

Pipe inspection and testing shall be performed to client's specification.
The new pipe will be hydrostatically tested prior to installation. Post installation testing will also be performed on the pipeline.
CCTV inspection should be undertaken post installation to ensure the internal pipe is integrally sound. Any defects that may be structurally detrimental to the completed installation shall be repaired or replaced.
Individual pipe joints shall be tested post installation using low-pressure air methods in accordance with ASTM C828.

6.0 CONSTRUCTION

6.1 Construction Sequencing and Programming

The construction sequence shall be completed prior to commencing any PB construction Works.

The construction sequence shall involve:

1) Pre-construction planning, environmental assessments, and public relation initiatives/consultations;
2) Project sign off by all stakeholders;
3) Excavation/identification of the entry and exit chambers, as well as any access chambers required for service disconnection or utilities crossing;
4) Disconnection, and if necessary by-pass flow pumping, of all laterals from the pipe to be replaced;
5) Setting up controls and any auxiliary equipment;
6) Lowering PB equipment (winch and cables, hydraulic pulling unit and cable, or rigid pulling rods) into the exit chamber;
7) Setting up any electronic recording equipment required;
8) Setting up pulling mechanism and attaching bursting head at entry chamber;
9) Pulling bursting head and replacement pipe through from the entry to exit chamber;
10) Pipe Testing & Inspection;
11) Reconnecting of all laterals;
12) Removing Bursting equipment from exit chamber;
13) Restoring site to pre-construction condition;
14) Project completion.

7.0 REFERENCES

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