Australasian Society for Trenchless Technology

Standard for Horizontal Directional Drilling

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1.0 BACKGROUND

This Standard has been developed by the Australasian Society for Trenchless Technology (ASTT) to assist users of Trenchless Technology in Australia and New Zealand in selecting and utilising HDD method.

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 Horizontal Directional Drilling information can be obtained from the ASTT website (www.astt.com.au), they are:

- Guideline for (Horizontal Directional Drilling, Pipe Bursting, Microtunnelling and Pipe Jacking).document number?
- Specification for Horizontal Directional Drilling.
- 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 parameters (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.

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

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

Contingency Plan - A plan for backup procedures, emergency response, and post-disaster recovery.

Contractor - Person or company undertaking the Works required.

Designer - the person(s) or company responsible for the design of the Works.

Drill String - A assembly of drill pipes, used to thrust and rotate the drill head.

Drill Pipe - Hollow thread pipes connected to form a drill string.

Environmental Impact Assessment - assessment of the possible impact—positive or negative-that a proposed project may have on the environment.

Entry Pit – A point where the drill rig starts its drilling process penetrating into the ground.

Exit Pit – An area where the drill rig exit the ground when completed drilling its pilot bore.

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 underground pipes, along a prescribed path by using a surface launched steerable drilling head.

HDPE - High Density Polyethylene.

NUCA TAG - National Utility Contractors Association Trenchless Assessment Guide.

Operator - Suitably trained or qualified person who operates machinery, an instrument, or other equipment.

Pipe - Product installed inside the ground after the drilling is completed.

Relevant Authorities - Local council, government bodies and/or landowners who are responsible for land being drilled through.

Risk Management Assessment - The overall process of identifying all the risks to and from an activity and assessing the potential impact of each risk.

Specifications - Specific set of requirements for an item, process, method, material, system or service.

Stake Holders - Asset Owner, Contractors, Engineer and Designer.

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

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

Works - The project or task to be completed by the Contractor on behalf of the Buyer.

3.0 SYSTEM DESIGN CONCEPT AND PARAMETERS CONSIDERATION

Work designed to be undertaken using HDD methods entails many considerations and parameters that are unique to each project. A table of key parameters and appropriate considerations for HDD work is depicted in Table 3.1. This table serves as a reference tool to assist TT Users in understanding the key issues when undertaking HDD work.

PARAMETERS				
	BORE PLAN	**PIPE**	**GROUND CONDITIONS**	**DRILLING FLUID/SLURRY**
CONSIDERATIONS	Number & diameter of Bores	Type of pipe material	Rock formation	Characteristics
	Depth & length of Bore	Wall thickness	Geotechnical sampling	Mixture calculation
	Depth of Cover	Allowable Stress	Std Penetration Test	Containment size
	Penetration Angles	Pipe & Joints coating	Std Classification of Soil	Recycle methods
	Radius of curvature	Pipe Diameter		Water Source
	Profile Survey	Joint type		
	Site access			
	Work space layout			

TABLE 3.1 HDD PARAMETERS & CONSIDERATIONS FOR WORKS

The Client and Contractor should consider processes that should be undertaken prior to commencing HDD outlined as follows;[1]

- 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 mobilisation, rig installation, pilot hole drilling, hole reaming operations, pull back operation, depth of cover, entry angle, and any other pertinent data;
- Confirm drill rig required specifications including anchoring system, forces, torques required;
- Description of drilling fluid used, recycling system employed, rates of operation, pumps, control system, and other equipment used;
- Proposal for a water supply for operation;
- Compile product pipe specifications (size, quantity etc);
- Proposal for a guidance and steering system, include limitations and access requirements;
- Proposal for pressure monitoring and electric recording systems, if required;
- Compile a Drilling Fluid mitigation plan including:
  (a) Description of fluid along with manufactures specifications material data sheet(MDS) and authorisation from appropriate agencies for use of fluid,

(b) Emergency response plan with notification procedures, emergency equipment onsite, emergency containment plans and descriptions of cleaning and recycling systems,

(c) Disposal plan complete with estimate of volume and composition of waste, method of containment, onsite disposal, and offsite disposal with written authorisation from appropriate agencies (e.g. Land fill owners).

4.0 MATERIALS AND EQUIPMENT

A wide range of HDD units exist in the market place today. The smallest drilling rigs are typically used for installing residential telecommunication service cables. Larger rigs are capable of installing pipelines up to 1200mm in diameter and over 1000m in length. HDD rigs can be generally classified into three categories (Table 4.1). Each category can perform different tasks. The choice of drill rig can be determined by parameters including soil conditions and pipe diameters.

HDPE pipe is the most commonly used for HDD projects around the world. HDPE pipes have characteristics that include abrasion resistance, flexibility, toughness, and low profile butt-fused joints. They are available in both high and medium density material, and in coil form (for smaller diameters). Traditional pipes (e.g. Concrete, clay, and ductile iron) and sectional pipes that are manufactured in 4m, 6m and 12m straight sections. HDPE piping also maintains full tensile strength at the joints as a result of butt fusion welding.

The designer or contractor should only propose to use pipes other than HDPE if the installation parameters of the alternative pipe materials can be shown to meet or exceed the properties of HDPE pipe.

4.1 Equipment Requirements

4.1.1 Drill Rig

Drill rigs are classified into small, medium or large, as per Table 4.1. The rig is typically anchored onto the surface on the centreline of the bore path at a distance ranging from 1m to 6m away from the entry point. The angle of initial ground penetration cvan be as high as 20 degree to the horizontal, depending on the diameter of the drilling dead.

	SMALL RIGS	MEDIUM RIGS	LARGE RIGS
Thrust/ Pullback	< 18000 N	18000 – 45000 N	> 45000 N
Maximum Torque	< 5500 N.m	5500 – 27000 N.m	> 27000 N.m
Rotational Speed	> 130 rpm	90 – 210 rpm	> 210 rpm
Carriage Speed	> 0.5 m/s	0.46 – 0.5 m/s	0.46 m/s
Carriage Drive	Chain, Cylinder or Rack & Pinion	Chain or Rack & Pinion	Rack & Pinion with or without Cable Assist
Drill Pipe Length	1.5 – 3 m	3 – 9 m	9 – 12 m
Drilling Distance	< 215 m	< 610 m	< 1230 m
Installed Pipe Diameter	Up to 250mm	Up to 400mm	400 to 1200 mm
Power Source	< 150 KW	150 – 250 KW	> 250 KW
Mud Pump	< 285 L/min	190 – 760 L/min	> 760 L/min
Weight of Drill Rig	< 6800 kg	< 27200 kg	> 27200 kg
Rig Footprint Area (width x length)	1m x 3m - 2m x 6m	2 mx 6m - 2.5m x 13.5m	> 2.5m *13.5 m
Recommended Work Area Requirements	6m x 18m	30m x 45m	45m x 75m

TABLE 4.1: RIG TYPE CLASSIFICATIONS[2]

4.1.2 Drill Head

HDD processes make use of a fluid assisted drill head. There are a wide variety of drill bits available in today's TT industry, and they suit many different ground conditions. Some of the most commonly used drill bits and their applications are shown in Table 4.2:

DRILL BIT TYPE	APPLICATIONS	COMMENTS
Slant Face Bits		
Flat Spade Bent Spade	Clay Sand Organic Soils	Increased Width, length and/or angle for more aggressive steering
Modified Spade	Hard ground conditions	Modified by adding teeth, taper etc. to match conditions
Rock Bits	Rock Hard pan	Small surface steering area; abrasion and impact resistant cutters
Rock drilling Bits		
Roller–cone, mill tooth	Soft rock (<35 Mpa)	Are these used in HDD?
Sealed Bearing Roller-cone, Tungsten-Carbide Inserts	Medium rock (35 – 70 Mpa)	
Sealed Bearing Roller-cone, Drag bit	Hard rock (>70 Mpa)	No moving parts
Polycrystal Diamond Compact(PDC) Drag bit	Hard rock formations	Generally too expensive and fragile for HDD applications

TABLE 4.2: DRILL BIT TYPES AND APPLICATIONS[2]

4.1.3 Reaming Head

After the pilot bore has been completed all the way to the exist chamber, the pilot drill bit is replaced with a reamer, which is then used to enlarge the borehole. The reaming head is pulled back whilst rotating to enlarge the borehole. The number of passes required in the reaming process depends on the fluid diameter of the borehole. For a ratio of borehole to pipe diameter typically in the range of 1 to 1.5. This can be achieved in between 3 to 5 passes.

*Do you mean ratio of "pilot borehole" or "final borehole"?

CATEGORY	TYPE	APPLICATION	COMMENTS
Compaction	Barrel, Spiral	Mixed Soils Clays Silts Sands Cobbles	- Minimal flow characteristics - some cutting capability - minimal mixing - must have overcuts to maximise circulation - caution due to more potential for ground heaving - best application after pre-ream is completed
Mixing	Wheel,	Soft soils,	- Excellent flow characteristics

	Blade, Combination, (wheel/blade) Off-set bar, Wing	Clays, Sands,	- good cutting capability - facilitates suspension of cuttings in drilling fluids - minimal compaction - best used only on pre-ream because may tend to cut bottom of hole on subsequent reams
All-Purpose	Fluted, Modified compaction	Varied soil conditions	- Moderate flow characteristics - moderate cutting capability - substantial compaction
Hole - Opener		For hard soil and rock formations.	- Excellent flow characteristics - excellent cutting capability - low torque due to rolling cutters - used for reaming and pre-reaming hole

TABLE 4.3: TYPES OF REAMER

4.1.4 Pull Back

Pull back is the process of drawing the new pipe backwards trough the borehole. The swivel connecting the new pipe to the reeming head ensures that the pipe is not twisted by the rotation of the drill string and reamer. This allows the new pipe to be pull through safety. After the reamer has completed reaming the borehole, the pull back process begins. A swivel is attached between the new pipe and the reaming head. The safety break-away swivel reacts only to axial tension force. A safety break-away swivel is also installed between the pipe and the reamer head. The safety break-away swivel acts as a tension fuse. The break-away force is set at such a level that no tension damage will be done to the pipe. This ensures that if the pulling force of the drill pipe is greater than the maximum allowed for the new pipe, the break-away swivel will disconnect first before damaging the pipe.

CATEGORY OF REAMER	TYPE OF REAMER	APPLICATION	COMMENTS
Compaction	Barrel Spiral	Mixed Soils Clays Silts Sands Cobbles	- Minimal flow characteristics - some cutting capability - minimal mixing - must have overcuts to maximise circulation - caution due to more potential for ground heaving - best application after pre-ream is completed
Mixing	Wheel Blade Combination (wheel/blade) Off-set bar Wing	Soft soils Clays Sands	- Excellent flow characteristics - good cutting capability - facilitates suspension of cuttings in drilling fluids - minimal compaction - best used on pre-ream because can cut bottom of hole on subsequent reams
All-Purpose	Fluted Modified compaction	Varied soil conditions	- Moderate flow characteristics - moderate cutting capability - substantial compaction
Hole - Opener		For hard soil and rock formations.	- Excellent flow characteristics - excellent cutting capability - low torque due to rolling cutters - used for reaming and pre-reaming hole

TABLE 4.4: TYPES OF REAMER[2]

4.1.5 Drill pipes

The drill string must have sufficient strength to withstand the rotational torques and longitudinal forces that are encountered during HDD process. The drill pipes must also be flexible and smooth enough to accommodate the required curvature along the drill path. The drill pipe also transports drilling fluid to the drill and reaming head.

Drill string material specifications are provided by the equipment manufacturer. These should indicate its bending radii, grade of steel and water tightness requirement for tubing sizes when transporting the drilling fluid, associated tensional and torsional load capabilities, thickness, minimum and maximum tool joint torque capacity, type of each tube connection, and connection thread type.

4.1.6 Bore Tracking Equipment

The drill head is to be tracked during the drilling operation by using either a walk-over or a hand-wired system. The tracking system will transmit the following data to the operator; position, pitch, depth, direction, roll, temperature and battery status.

Walk-over systems involve inserting a transmitter in the drill head. Walk over systems should only to be used where an operator has full access to all the surface area directly above the bore path. Varieties of transmitters are available for different penetration depth. These systems generally function at depths of up to 40 m. The receiver is often a small, hand held portable device. The Operator must be qualified and skilled, as sufficient care must be taken when interpreting data, due to possible electronic or electrical interferences. The contractor is normally required to keep a logbook containing drill pipe number, pitch, depth, steering commands, apparent underground obstructions and ground conditions.[2]

In situations where access above the bore path is not feasible (e.g. drilling under a body of water) or where the bore depth is over 40m, then hard-wire systems shall be used.

Bore tracking accuracy can be significantly improved using supplemental surface monitoring systems. One such system involves setting up a grid with known corner point locations to track the bore. This system can track bore depth 3 times the width of the grid, and can track under bodies of water by setting up the corner points on the shores. The grid may have up to 32 corners.

4.1.7 Ancillary Equipment

The tools that are used to attach the product pipe to the drill pipe during the pull back process are called as Swivel connectors. The main function of the swivel is to connect the new pipe and other tools to the pulling tools. They are also designed to prevent damage to the new pipe from the rotation force exerted from the drill pipe.

Other equipment may include pipe support rollers for the new pipe on the surface during the installation process, cable pullers and breakaway swivel connectors. The contractor should be fully aware of industry available HDD accessories, as well as their functions and capabilities, and utilise these accessories whenever required for any HDD works.

4.1.8 Drilling Fluid or Slurry

The ?most commonly use? drilling fluid used for HDD is a Bentonite mixture which is modified with a Polymer and water mix. The drilling fluid performs the following functions:

- Spoil and debris removal,
- Drill head lubrication,
- Reaming head lubrication,
- Transmitter coolant,

- Drill string lubrication,
- Borehole stabilizing.

The HDD process relies on the drilling fluid as the main means of ensuring the borehole does not collapse. Critical fluid characteristics that need to be considered are viscosity, gel strength, fluid loss & fluid density, sand content, pH, filtration control and filter cake.

HDD projects require separate mixing systems, holding tanks, and mud recycling systems. The mixing system provides proper mixture containment for the drilling fluid, additives and the water. The holding tank is not only use as a water containment area, but also provides drilling fluid mixing and a washing point during the project. The drilling fluid is mixed to meet requirements dictated by the geological conditions of the Works. Recycling systems are used to clean out debris during the cutting so the fluid may be recycled. (These are often referred to as mud recycling systems)

4.2 Pipe Materials

The HDD process requires the utilisation of pipe materials that can withand the expected axial tension and bending loads. They should also be abrasion resistant .HDPE pipe is normally sufficient in all these areas.The designer or contractor may propose the use pipes other than HDPE if the proposed pipe properties can be clearly shown meets or exceed the properties of HDPE pipe for the HDD project.

4.3 Entry and Exit Pit

HDD entry is mostly executed from the surface without the need for a large entry pit. A small containment of drilling fluid is created at the entry end for removal or recycling of the slurry. In addition, an exit pit shall be identified, or excavated, prior to any HDD implementation. Any requirements to excavate small access potholes (for accessing crossing utilities either for location or load limitation reasons) should also be identified and considered.

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 hydrostatic testing will also be performed on the pipeline.
CCTV inspection should be undertaken post installation to ensure the internal pipe is structurally 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. Is there an Australian Standard?

6.0 CONSTRUCTION

6.1 Construction Sequencing and Programming

The construction sequence shall be completed prior to commencing any HDD construction works.

The construction sequence shall involve:

- Pre-construction planning, environmental assessments, and public relation initiatives and consultations;
- Project sign off by all clients;
- Excavation of both exit pits and entry side fluid containment;
- Set up of drilling rig;
- Set up of controls and any auxiliary equipment;
- Set up of guidance system;
- Set up of the slurry lines and hydraulic hoses;
- Drill pilot hole through to the exit pit;
- Attach reamer, and commence the reaming process. Increase reaming headdiam and repeat as required
- When the bore has reached the required diameter , commence pipe pull back process;
- Pipe testing and inspection for pre and post installation;
- Removal of the drill rig and other equipment;
- Disposal of any slurry or spoil;
- Grouting of the annular space between the exterior pipes internal surface with the installed conduit inside;
- Lateral services connections (if applicable);
- Begin the restoration process to pre project condition;
- Project completion.

7.0 REFERENCES

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[2] Bennett, D. Ariaratnam, S.T. Como, C.E. 2004, *Horizontal Directional Drilling Good Practices Guidelines*, HDD Consortium, Virginia, USA