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 the most suitable Trenchless Technology methods available.

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, they are:

- Guideline for (Horizontal Directional Drilling, Pipe Bursting, Microtunnelling and Pipe Jacking).
- 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 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. (www.astt.com.au)

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 collection of hollow drill pipes, joined behind the drill head as it is inserted through the ground during drilling operation.

Drill Pipe - Hollows pipes that forms shaft on the drill rig.

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.

Entry Pit - Also called insertion or launching shaft.

Exit Pit - Also called reception shaft.

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 steerable trenchless method of installing underground pipes, along a prescribed path by using a surface launched drilling rig.

NUCA TAG - National Utility Contractors Association Trenchless Assessment Guide.

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

Pipe - New 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. Often establishes an engineering 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 Buyer.

3.0 SYSTEM DESIGN CONCEPT AND PARAMETERS

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

	PARAMETERS			
	BORE PLAN	**PIPE**	**GROUND CONDITIONS**	**DRILLING FLUID/SLURRY**
CONSIDERATIONS	Number of Bores	Type of pipe material	Rock Information	Characteristics
	Depth 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			Water Source
	Profile Survey			
	Site access			
	Work space layout			

TABLE 3.1 HDD PARAMETERS & CRITERIA FOR WORKS

Considerations and processes that should be undertake prior to commencing a HDD process are 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 specifications including (but not limited to) anchoring system and torques required;
- Description of drilling fluid used, recycling system employed, rates of operation, pumps, control system, and other equipment used;
- Proposal of a water supply for operation;
- Compile product pipe specifications (size, quantity etc);
- Proposal of a guidance and steering system, include limitations and access requirements;
- Proposal of pressure monitoring and electric recording systems, if required;
- Compile a Drilling Fluid mitigation plan including:
  - (a) Description of fluid along with manufactures specifications 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 and 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 telecommunication residential service cables. Larger rigs are capable of installing pipelines up to 1200mm in diameter. HDD rigs can be generally classified into three categories (Table 4.1). Each rig encompasses certain characteristics and features. Each Works installation range can be determined by parameters including rig size, soil conditions, and product diameters.

High Density Polyethylene (HDPE) pipe is the most commonly used for HDD projects around the world. HDPE pipes have good characteristics that include abrasion resistance, flexibility, toughness, and butt-fused joints. They are available in both high and medium density material, and in coil form (for smaller diameters), as compared to traditional pipes that are manufactured in 4m, 6m and 12m straight sections. HDPE piping maintain the same tensile strength at the joints even after being connected using the butt fuse process.

The designer or contractor may propose to use pipes other than HDPE if the 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

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 and is capable of providing an angled entry of up to 20 degrees. Drill rigs are classified into small, medium or large, as per Table 4.1.

	SMALL RIGS	MEDIUM RIGS	LARGE RIGS
Thrust/ Pullback	< 18000 kg	18000 – 45000 kg	> 45000
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 hp	150 – 250 hp	> 250 hp
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 x 6m - 2.5 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

Most HDD processes make use of a fluid assisted drill head at the end of a string. 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	Increase Width, length and/or angle for more aggressive steering
Modified Spade	Hard ground conditions	Modify by adding teeth, taper etc. to match conditions
Rock Bits	Rock Hard pan	Small surface steering area; abrasion and impact resistant cutters
Mud Motor Rock Bits		
Roller–cone (mill tooth, or PCD bits)	Soft rock (<35 Mpa)	
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 Reamer

After the pilot bore has been completed, the pilot drill bit is replaced with a reamer, which is then used to enlarge the borehole. The reamer is then pulled back and rotated to enlarge the borehole. The number of passes required in the reaming process depends on the ratio of the pipe diameter to the borehole which is typically a maximum of 1.5 to 1. The type of reamer used on the project also depends on the ground conditions identified in Table 4.3.

4.1.4 Pull Back

After the reamer has completed reaming the borehole, the pull back process begins. A swivel is attached to between the new pipe and the reamer. The swivel reacts to the rotational torques of the drill pipe and prevents the new pipe from any damage as it rotates. A safety break-away swivel shall also be installed between the pipe and the swivel. 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. The pull back shall continue and be completed without any interruption.

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 4.3: 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 any curvature along the drill path. Another function of the drill pipe is to transport drilling fluid to the drill head and reamer.

Drill string materials specifications shall be provided by the equipment manufacturer. These should indicate its bending radii, grade of steel and water tightness requirement for tubing sizes, associated tensional and torsional load capabilities, thickness, minimum and maximum tool joint torque capacity, ease of connection, and thread type.

4.1.6 Bore Tracking Equipment

The drill head is to be tracked during the drilling operation by using either a walkover or a wire system. The tracking system will transmit position, pitch, depth, direction, roll, and temperature and battery status, to the operator.

Walk over systems involve inserting a transmitter in the drill head. Walk over systems are 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 strengths. These systems generally function to depths of 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 interference. The contractor is 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 path is over 40m, then 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

Swivel connectors are types of tools that are used to attach the product pipe to the drill pipe during the pull back process. They are designed not only to prevent debris entry into the bearings, but also to prevent damage to the new pipe from the rotation force exerted from the drill pipe.

Other equipment may include new pipe support rollers on the surface during the installation process, cable pullers and breakaway connectors. They are commonly utilised on HDD sites and assist in the successful completion of many HDD works. 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 drilling fluid used for HDD is a Bentonite which can be modified with a Polymer and water mix. The fluid acts to stabilise & lubricate the borehole, cool down the transmitter, carry spoil and debris away from the borehole, and assist in the cutting process. The HDD process relies on the drilling fluid as the main means of ensuring the borehole does not collapse. Critical fluid characteristics needing consideration are viscosity, gel strength, fluid loss & fluid density, sand content, pH, and filtration control & 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 use as a water containment holding area and mixing drilling fluid and other requires washing during the project. The fluid is mixed to meet requirements dictated by the geological conditions of the Works. Mud recycling systems are used to clean out debris during the cutting so the fluid may be recycled (e.g. vacuum truck).

4.2 Pipe Materials

The HDD process requires the utilisation of pipe materials adept at withstanding tensile and bending loads. They will be light and durable, as well as abrasion resistant. HDPE are ideal materials for HDD pipes whereas concrete is not. The designer or contractor may propose the use pipes other than HDPE if the parameters of the alternative pipe materials can be clearly shown meets or exceed the properties of HDPE pipe.

4.3 Access and Exit Pit

HDD entry is mostly executed from the surface without the need for an entry pit. However, a relatively small containment of drill slurry is usually achieved in shallow entry and exit pits prior to removal or recycling. In addition, an exit pit shall be identified, or excavated, prior to any HDD implementation. HDD works commonly plan for the exit pit to be located and excavated at a tie in point to an existing system, or to utilise existing facilities such as an access chamber or connection valve. Any requirements to excavate small potholes (for accessing crossing utilities either for locating or load limiting reasons) should also be identified and considered.

5.0 INSPECTION AND TESTING

Pipe inspection and testing shall be performed to client's specification and the amount of testing required will be agreed to prior to commencing the Works.

The new pipe will be hydrostatically pre-tested prior to installation. Post installation pressure tests will also be performed on the pipeline.

CCTV inspection should be undertaken 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 using low-pressure air methods in accordance with ASTM C828.

6.0 CONSTRUCTION

6.1 Construction Sequencing and Programming

All the necessary studies and assessments 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 and identification of both entry and exit pits;
- Set up of controls and any auxiliary equipment;
- Set up of drilling rig;
- 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.
- When the bore is large enough, commence pipe pull back process;
- Pipe testing and inspection;
- Removal of the drill rig and other equipment;
- Disposal of any slurry or spoil;
- Grouting of the annular space between the exterior pipes surface with the internal surface of initial installed conduit;
- Lateral services connections (if applicable);
- Begin the restoration process;
- Project completion.

7.0 REFERENCES

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

Canadian Association of Petroleum Producers (CAPP) 2004, *Planning Horizontal Directional Drilling for Pipeline Construction*, Guideline, Alberta, Canada

Geotechnical Baseline Reports for Construction – suggested guidelines, *Randall J.Essex,P.E.* (ASCE) 2007

Griesbaum R. Kögler, R. 2009, *Horizontal Directional Drilling and Microtunneling – a comparison of two successful pipe-laying methods with regard on their strengths and weaknesses*, HERRENKNECHT AG,

International Society for Trenchless Technology (ISTT) 2005, *Horizontal Directional Drilling*, 2nd edition, Trenchless Technology Guidelines, Trenchless Technologies Information Centre

[1] Canadian Association of Petroleum Producers (CAPP) 2004, *Planning Horizontal Directional Drilling for Pipeline Construction*, Guideline, Alberta, Canada

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