ACS1130 Horizontal directional drilling (HDD)

Contents

ACS1130.1 Scope

This section covers the installation of pipelines by horizontal directional drilling. This specification should be read in conjunction with Auckland Council Standard Specification *ACS710 Pipeline Construction.*

ACS1130.2 Definitions

Term	Definition
Bending radius	Bend radius by definition is the forward distance required for a drill string to make a 90-degree turn. In practicality, bend radius is an indication of how much bending a drill rod or product pipe can take without doing significant damage.
Bottom hole assembly (BHA)	The lower portion of the drill string, typically consisting of the drill bit, bit sub, a mud motor (in certain cases), stabilizers, drill collar, heavy weight drill pipe and crossovers for various thread forms. The bottomhole assembly must provide force for the bit to break the formation (weight on bit), survive a hostile mechanical environment and provide the driller with directional control of the borehole. Oftentimes the assembly includes a mud motor, directional drilling and measuring equipment, measurements-while-drilling tools, logging-while-drilling tools and other specialized devices.
Cuttings	Spoils particles, also known as drilling spoils, created during the boring process.
Drill bit	The drilling bit is attached to the front of the boring head (Pilot Hole Assembly or Pilot Hole BHA). The bit mounts to the drilling assembly at an angle via a housing set to an offset angle. This angle is what provides the steering capability whilst pushing the drilling string.

Term	Definition
Drill fluid	A liquid medium, typically with good rheological properties, which is circulated through a drill borehole during the drilling operation which performs the following functions: • Controlling formation pressures • Removing cuttings from the borehole • Cooling and lubricating the drill bit or cutters • Transmission of hydraulic energy to the downhole tooling • Maintaining borehole stability.
The entry angle	The entry angle is the angle between the drill stem and the ground surface at the surface entry point (SPUD location).
The exit angle	The exit angle is the angle between the drill stem and the ground surface at the surface exit point.
Exit pit	The area where the drill pipe exits the ground and typically the service lines are conventionally pulled back.
Frac out	In certain conditions, the drilling fluid can build a large pressure in the borehole, if not managed correctly. If the pressure becomes great enough to overcome the overburden pressure provided by the strength of the formation, the ground will fracture allowing the drilling fluids to escape the borehole.
Polymer	Any natural or synthetic compound of high molecular weight comprising a large number of separated linked units, each a relatively light and simple molecule. Polymers are typically used to enhance the rheological properties of the drilling fluid.
Product	This is the pipe or conduit to be installed using the HDD process.
Roll (highside angle)	The rotational position of the drill head as it related to a clock face.
Sonde	An electronic device that fits inside the drill head and transmits a signal used for locating purposes. Also referred to as a transmitter or probe.
Step-off distance	The step-off distance is the horizontal distance between the entry hole and the beginning of the horizontal section of the borehole.
Strike alert	A warning system that is set off by contact with electrical power source.
Swivel	Attaches between the back reamer and the product being pulled back to keep the product from twisting.
Thrust	The rig capacity to push the drill stem into the ground without rotating.

Term	Definition
Torque	The rotational force applied to the drill stem joints.

ACS1130.3 Materials

ACS1130.3.1 Pipe design and supply

Only pressure pipes complying with *AS/NZS 4130 - PE Pipes for Pressure Application* shall be used for installation by horizontal directional drilling. PE100 polyethylene pipes shall be used, unless otherwise specified.

Unless specified otherwise, the Contractor shall be responsible for the supply of all pipes and fittings necessary to complete the installation and designed to withstand installation forces. The pipe size, type, wall thickness, and jointing system shall be suitable for the method of installation and for the service required.

Where the wall thickness of the product pipe is required to be greater than shown on the drawings due to installation loads, the internal diameter shall be maintained as indicated on the drawings unless otherwise accepted by the Engineer.

ACS1130.4 Work method statement

Prior to commencing works, the Contractor shall prepare and submit a Work Method Statement including following items: calculations, Construction Plan, tracking systems, Drilling Fluid Management Plan and Contingency Plans.

ACS1130.4.1 Proposed method

A proposed drilling method, including supporting calculations and engineering drawings, shall be provided by the Contractor and shall include evidence that:

a) The proposed borehole profile, has taken into consideration:
    1) Any and all available geotechnical information, particularly risks associated with the formation (such as highly variable formations, fractured formations, highly variable transitional formations etc.)
    2) The drilling risks associated with:
        I. The entry angle

II. Geometry of the ENTRY build section
III. Geometry of the EXIT build section
IV. The total vertical depth of the borehole (pipeline collapse implications during installation)
V. Nearby services
VI. Selection of the material for the product pipeline (particularly in relation to the design life criteria)
VII. Special or unique environmental constraints.

b) The subsequently selected construction methodologies have taken into consideration:
   1) The method of HDD (conventional reaming, forward reaming, forward motor reaming)
   2) The final borehole diameter
   3) A suitable pilot hole BHA (justifying jetting assembly or hard formation assemblies, the size of the pilot hole and the subsequent stabilisation, downhole motor specification (for the case of hard formation pilot hole drilling), desired mud flow and mud pressures, etc.)
   4) A suitable reaming BHA (justifying soft or hard formation tooling options, stabilisation, nozzle configuration / quantity, minimum mudflows and downhole pressures etc.)
   5) A suitable pipe installation methodology (pullback from EXIT to ENTRY, thrust from ENTRY to EXIT, etc.).

such that the following is ensured:

a) The bending radii do not exceed allowable limits; and
b) Pre-installation loads including self-weight spanning between any supporting structures do not exceed allowable limits; and
c) Installation loads do not exceed allowable limits including:
   1) Bending stresses due to radius of curvature and pipe over bend
   2) Maximum installation force on the product pipe
   3) Stresses due to frictional drag between the product pipe and the ground surface, the entry hole, the inside wall of the bore and bends
   4) Stresses due to frictional drag between the product pipe and drilling fluid
   5) Stresses due to torsional force
   6) Loads resulting from drilling fluid and/or grouting
   7) Construction installation loadings.

The Contractor must demonstrate that the above engineering works have been independently assessed and approved by a qualified engineer/engineering group.

ACS1130.4.2 Construction plan

The following information shall be submitted with the Construction Plan:

a) Type and capacity of drilling rig to be used on the project, including thrust and rotary torque. The drilling rigs pull/push capacity should be demonstrated to incorporate a safety factor of at least twice the anticipated drilling push/pull weights and/or the calculated push or pull installation loads, whichever is greater. It should be noted that the range of a particular rig for a particular product type can vary significantly depending on soil conditions, drill path profile (i.e. radius of curvature)

b) Names, qualifications and experience of key crew members

c) Project programme indicating the various tasks and their expected duration

d) Type and capacity of mud mixing system

e) Access requirements to site, including Traffic Management Plan

f) Drawing of work site indicating the location and footprints of all equipment, location of entry and exit pits, location of slurry containment pits and drill rod storage

g) A listing of any specialized support equipment (if applicable), including sucker trucks and/or pumps for mud recycling

h) Downhole tools and their suitability for the expected ground conditions

i) Construction method including:

    1) Diameter of pilot hole
    2) Number and size of reaming stages
    3) Demonstrated calculated reaming rate (penetration rate) including instantaneous penetration rate, production rate (including all assumptions for tripping into the hole, tripping out of the hole, tooling changes, cutter changes where applicable, maintenance downtime, etc)
    4) Use of rollers, baskets and side booms to suspend and direct the pipe during pull back
    5) Pull or thrust rate
    6) The number of sections in which the pipeline is to be installed (including tie-in weld times and field-joint coating times if applicable)
    7) The Drill Alignment Plan in the form of an electronically generated bore plan as detailed in the downhole survey construction method statement

8) Drilled bore logs and any computer output data from steering and tracking systems for each part of the works
9) Grouting type and procedure, if applicable
10) Method for achieving neutral buoyancy in the pipe sting during insertion
11) Details of any temporary or permanent casing to support the hole
12) Details of temporary works, retaining or supporting structures required for the installation of the pipework.

j) Contingency Plan if design tolerances are exceeded

k) The Contractor shall take all care to control, contain and manage the effects of the ingress of any groundwater into the boreholes during the drilling, reaming, product pipe installation and grouting processes. The Contractor shall provide details of these controls as part of the Work Method Statements prior to this work being undertaken.

ACS1130.4.3 Tracking systems

The following details of the tracking equipment shall be confirmed as being appropriate for the site-specific conditions:

a) Type

b) Operating range

c) Degree of accuracy.

The aspects noted below shall be included in confirming the appropriateness of the equipment:

a) Ground conditions, including the water table depth

b) Adjacent structures and utilities with the potential to cause interference

c) Accessibility

d) Design installation depths.

ACS1130.4.4 Drilling fluids management plan

The following information shall be provided as part of the Drilling Fluid Management Plan:

a) Proposed drilling fluid program and reasons for the selection given the expected formation conditions

b) Proposed source (quality and volume) of fresh water (or salt water for salt water-based mud programs) for preparing the drilling mud. Necessary approvals and permits are required for sources such as streams, rivers, ponds or fire hydrants

c) Method of slurry containment

d) Method of recycling drilling fluid and spoils (if applicable)

e) Method of transporting drilling fluids and spoils off site

f) Anticipated volumes and approved disposal site for drilling mud and spoils

g) Viscosity

h) Testing, key quality parameters and frequency

i) Contingency Plan for loss of drilling fluid while drilling, reaming or pipe installation is in progress

j) Contingency Plan for borehole failure

k) Material Safety Datasheets (MSD) for proposed drilling mud, encasing grout, drilling additives.

The Contractor shall use an appropriate drilling fluid to suit the ground conditions as may be encountered on site during the drilling, reaming and product pipe installation operations.

Details of any drilling fluids proposed for use and the estimated volumes to be used are to be submitted prior to the commencement of drilling. Drilling fluids to be used shall be environmentally sound and biodegradable.

Drilling fluid pressures shall be continually monitored by a downhole data logger to avoid or minimise hydraulic fracturing or over excavation. If hydraulic fracturing, loss of fluid or no returns are discovered, the Engineer shall be notified immediately, and the process shall be halted (if safe to do so) until actions are taken to control the losses or re-commence the returns.

Drilling fluids and cuttings shall be recovered and separated, and the drilling fluid re-used unless otherwise approved by the Engineer. The Contractor shall be responsible for the disposal of excavated material as well as excess fluid, water and waste. Containment barriers shall be used to prevent drilling fluid run-off from the construction site and frequent inspections along the bore path for upwelling drilling fluid shall be conducted. Clean-up of any inadvertent returns shall be performed in a timely manner.

The Contractor shall take extreme care in minimising the loss of drilling fluids onto the ground or the environment. Returned fluids shall be properly contained, reclaimed and recirculated. The Contractor shall detail the precautionary measures to be undertaken to minimise the impact of any inadvertent spillage of fluids on return or at the exit of the bore.

Cuttings and spent drilling fluids shall be disposed of properly and shall comply with all Auckland Council regulations.

ACS1130.4.5 Contingency plans

The following Contingency Plans will be submitted and approved before any works are undertaken:

a) A Contingency Plan in case of spill or surface seepage (e.g. drilling fluids, hydraulic fluids and spoils), including measures to contain and clean the affected area

b) A Contingency Plan in case of a stuck pipe, BHA twist-off or loss of cutter(s)

c) A Contingency Plan for the remedial treatment of joints, fractures and any other defects in the strata in the event of drilling fluid loss, cuttings loss or groundwater loss during the drilling, reaming and pipe installation processes

d) A Contingency Plan for ground heave or subsidence

e) Specific action(s) required to be taken in the event that the installed pipe fails the post installation leak test.

All Contingency Plans must be in accordance with all relevant legislation (National and district), consent conditions and Auckland Codes of Practices and Standards.

ACS1130.5 Setting out and verification of the pilot drill

The Contractor is to survey the entire pipe alignment and establish ground levels by installing wooden pegs and/or steel pins at following intervals unless otherwise specified in the particular requirements:

a) 6 m for non-grade or grade applications > 1.5% grade

b) 2 m for grade applications < 1.5% grade.

The Contractor shall confirm the horizontal and vertical alignment of the pilot drill head in accordance with the above intervals during the pilot drill operation. This information is to be supplied to the Engineer at the end of each day when pilot drilling is carried out. Should the Contractor not be able to achieve the pilot drill alignment to the required specifications, they shall inform the Engineer immediately.

Prior to any drilling operation, the Contractor is required to establish areas of interference along the drill alignment. The Contractor is to forward to the Engineer the findings in the form of a drawing or table referencing the location and the level of interference measured.

ACS1130.6 Tolerance

Boreholes out of line and level will not be accepted and, where these cannot be satisfactorily rectified by re-drilling, the Contractor shall use such other means of constructing the pipeline without disturbance to pavement structures or other property which the horizontal drilling was designed to preserve intact.

ACS1130.6.1 Installation tolerances – non-grade applications

Where the pipeline is for a non-grade application (e.g. pumped main, etc.), the maximum deviation of the longitudinal invert of the pipe from the design alignment shall be:

a) At fixed points such as chambers and MHs:

    1) 25 mm vertical, 100 mm horizontal

b) At any point in between the fixed points:

    1) Vertical tolerance shall be specified in the particular requirements

c) At any point in between the fixed points: Horizontal tolerance shall be specified in the particular requirements. Horizontal alignments are critical when pipes are installed close to property boundaries. Accepting pipelines deviating from the proposed alignment and crossing property boundaries will be at the Engineer's discretion.

ACS1130.6.2 Installation tolerances – on-grade applications

Where the pipeline is for an on-grade application (e.g. gravity pipe), the maximum deviation of the longitudinal invert of the pipe from the design alignment shall be:

a) At fixed points such as chambers and manholes: 25 mm vertical, 100 mm horizontal.

b) At any point inbetween the fixed points: Vertical tolerance shall be less than ±10% of the internal diameter from the design invert levels shown on the long section. The minimum pipe length for a transition from –5% to +5% of the internal diameter (or vice versa) shall be 20 m but such that no dips >10% of the internal diameter of the pipe occur or other critical levels are compromised.

c) At any point in between the fixed points: Horizontal tolerance shall be such that the installed pipe is fit for its purpose. Fitness for purpose will be determined by the Engineer. Horizontal alignments are critical when pipes are installed close to property boundaries. Accepting pipelines deviating from the proposed alignment and crossing property boundaries will be at the Engineer's discretion.

d) In addition, any pipeline specified to be straight, and on-grade will not be accepted unless a light can be sighted through the MH to MH length concerned.

ACS1130.6.3 Assessing vertical tolerance

On completion of the installation, allow water to flow through the line until the flow is observed for 10 minutes at the downstream end. Stop the flow and pull a CCTV camera through the line slowly minimising disturbance to puddles in dips, if any.

The CCTV record shall include an inclinometer on the camera and a suitable visual indicator scale that measures the depth of the ponding water.

ACS1130.7 Drilling operations

ACS1130.7.1 General

Only trained and appropriately experienced operators shall be permitted to operate the drilling equipment. They shall always follow the manufacturer's operating instructions and safety practices.

If a drill hole must be abandoned, the hole shall be filled with grout to prevent future subsidence.

ACS1130.7.2 Pilot bore – survey, guidance and location of drill head

The Contractor’s Drilling Method shall incorporate a survey system that will allow tracking of the drill head and drill path for the entire length of the bore. The survey system shall be capable of measuring the elevation and gradient of the bore path.

The Contractor’s Survey System shall incorporate the use of a wire line steering tool system to guide the direction of the drilling. The Contractor must also employ a surface tracking system as necessary and where the site conditions allow.

The Contractor may also utilise an alternate method(s) to achieve the designed vertical and horizontal alignment within the specified tolerances. Any proposed alternate method must be submitted for approval.

ACS1130.7.3 Equipment setup and site layout

Drill pits shall be excavated and reinstated in accordance with the requirements of Auckland Council Stormwater Standard Specification *ACS510: Earthworks* and the Particular Specifications. The Contractor shall advise and obtain approval from the Engineer for the position of the drill pits prior to starting physical works.

ACS1130.7.4 Drilling, reaming and product installation

Drilling fluid shall be used during drilling, reaming and product installation operations.

Reaming shall consist of one or more passes to enlarge the boreholes to accommodate the installation of the product pipes. In particular, the Contractor shall determine the bore diameter to allow for an annular void for the return of drilling fluids and spoils, and to allow for any bend radius of the product pipe. The Contractor shall demonstrate that the step size of each reaming pass does not generate excessive loading on the carrying capacity of the drilling fluid, the mud recycling system and the mud pumping capacity. Additional care shall be taken to ensure that the reaming step size does not risk borehole stability or introduce excessive downhole pressures.

A swivel and pull-head assembly, coupled with a suitably gauged downhole tool (for contingency measures) shall be designed and employed during the thrust or pull-back execution of the product pipe installation to prevent rotational torque being transferred to the pipe during pull-back.

A buoyancy system (ballast) shall be inserted into the product pipe progressively during the installation of the product pipeline in order that the product pipeline becomes neutrally buoyant when submerged in the drilling fluid/borehole.

The pipe must be sealed at either end with a cap or a plug to prevent water, drilling fluids and other foreign materials from entering the pipe as it is being pulled back or thrust forward.

Pipe rollers, skates or other protective devices shall be used to prevent damaging the pipe from the edges of the pit during pull-back, eliminate ground drag and reduce pulling force and subsequently the stress on the product. The Engineer may reject any section of pipe which has surface damage. Full details, calculations and drawings must be approved by the Engineer prior to any works being undertaken.

The product pipeline shall be welded into one string (if possible), and the pull-back to be conducted in a single continuous operation unless otherwise approved by the Engineer.

The pipe annulus is to be grouted.

ACS1130.7.5 Specification, jointing and testing of pipes and conduits

The pipe or conduit to be installed using HDD shall comply with the requirements of Auckland Council Stormwater Standard Specification *ACS710: Pipeline Construction*.

ACS1130.8 Grouting

ACS1130.8.1 General

The annulus between the borehole and the product pipe shall be grouted with a free-flowing filler for the full length of the borehole to provide structural support for the product pipe and to provide an effective seal against groundwater ingress/egress.

The method employed to achieve the grouting shall ensure the complete filling of the annulus and full encasement of the product pipe and shall be approved by the Engineer.

ACS1130.8.2 Grout mixtures

As a minimum, the grout mixture(s) shall comply with the requirements below:

The grout composition shall ensure that the following properties are attained:

a) The grout shall provide an effective stoppage of water ingress and create a permanent seal between:
    1) The borehole and the grout; and
    2) The product pipe and the grout
b) The grout shall be of a low-heat characteristic
c) The cured grout shall be impermeable and not develop micro-cracks or paths for water flow
d) The adhesive properties of the grout shall ensure no shear movement exists between:
    1) The borehole and the grout; and
    2) The product pipe and the grout
e) The grout shall have a minimum 50-year design life
f) The grout composition shall allow for ease and confidence of placement at the required location(s)
g) The grout composition shall have no adverse effect on the product pipe

h) The grout shall be compatible with the site conditions

i) The grout shall be environmentally sound.

In addition, the grouting around the annulus of the product pipe shall ensure a rigid encasement is constructed and so that full circle continuous support from the surrounding material is provided.

ACS1130.8.3 Grouting procedures

The grouting shall be carried out in stages to minimise the net pressure on the pipe created by the grouting process and the un-solidified grout column. The Contractor shall provide design calculations to show that the anticipated net pressure on the pipe does not exceed the critical buckling pressure of the product pipe divided by a safety factor of 2.5.

The Contractor shall ensure that the grouting process does not result in deformation of the product pipe or dislodging of supports and movement of the product pipe from its designed alignment.

Grouting shall start at the downstream end of the borehole and shall proceed in a continuous manner. Prior to, and during the entire grouting operation, the product pipe shall be filled full with water.

The Contractor shall ensure that the product pipe is not subjected to any hydrostatic pressure from the grout and/or groundwater during the grouting phase that cannot be withstood by the specified product pipe.

The Contractor shall maintain records of all grouting operations, which shall include (but not be limited to):

- The location of all grout lines
- Volume of grout pumped
- Grouting pressures
- Commencement and completion times
- Grout mixture details.

The Contractor shall submit one copy of this record at the completion of each day on which grouting is undertaken.

ACS1130.8.4 Drill logs

The Contractor shall at all times keep accurate and up-to-date records of all drilling operations, including all pilot hole, reaming and pullback stages on the project.

Pilot hole drill records shall include the following as a mandatory requirement:

- Project details including client, contractor, date(s)
- Drill pipe details
- Driller's name
- Steering engineer's name
- Mud motor details (if used)
- Drill bit size
- Time of each drill pipe entry
- Azimuth
- Mud pressure at the drill head
- Mud volumes
- Thrust and torque, and depth.

The Contractor will be free to add any other records as he sees beneficial for project quality records.

Reaming records shall include the following as a mandatory requirement:

- Project details including client, contractor, date(s)
- Reaming step sizes(s)
- Time of reaming
- Mud pressure, and mud volumes
- Thrust
- Torque
- The time of each drill pipe entry
- BHA details
- Driller comments for any and all drilling issues.

Pullback data logging records shall include the following as a mandatory requirement:

- Project details including client, contractor, date(s)
- Pullback pressure(s)
- Time of each drill rod removed while pullback operation is in progress.

ACS1130.8.5 Daily report

The following details must be recorded in the construction log:

a) Location
b) Date
c) Weather
d) Project
e) Safety instructions
f) Work executed
g) Sub-contractor work
h) Personnel engaged
i) Equipment used
j) Material consumption
k) Special events
l) Drilling records
m) Maintenance performed / breakdowns.

The following data must be evident from the drilling records:

a) Station
b) Time
c) Azimuth, inclination and tool face of the drilling head
d) Pull/thrust on drill pipe(kN)
e) Torque (kN)
f) Pump rate (l/min)
g) Pump pressure (bar)
h) Special events.

For all drilling operations, the following fluid data is to be recorded at a minimum of four times daily (or in the event that one or more of the critical control variables (shown below) tests out of specification):

a) Density
b) Viscosity

c) pH-Value

d) Circulating volume

e) Solid content.

ACS1130.9 Post installation pressure test

The installed pipeline shall be tested in accordance with Auckland Council Standard Specification *ACS710 Pipeline Construction*.