

ACS1120 Jacking, boring and microtunnelling

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ACS1120.1 Scope

This section provides for the installation of pipelines by means of jacking, boring, microtunnelling and similar techniques.

ACS1120.2 Definitions

Term	Definition
Annulus	The distance measured radially between the outside radius of the jacking pipe and the radius excavated by the outermost gauge cutter of a MTBM or the excavation profile.
Conditioners	Conditioners are materials that may be required to reduce the abrasive nature of the excavated materials or optimise consistency of materials for removal. They may include water, bentonite, foam, polymers, and other materials added to the excavated materials (cuttings).
Contact grouting	Grouting undertaken to the outside of the product pipe to fill voids and assure that intimate contact for load transfer between the pipe and the native host material has been achieved.
Cutting tools	Disc cutters, picks, drag tools, scrapers, and ripper tools mounted in the cutting wheel for loosening, cutting, dislodging, and fracturing of materials.
DTA	The Design Tunnel Axis (DTA) is the planned horizontal and vertical location of the pipe centreline, being the reduced level (RL) of the pipe invert, as shown on the drawings, plus one half of the internal diameter of the pipe.
Face	The location where excavation is taking place.
Guidance system	System that locates the actual position of the tunnel face relative to the design location.
Jacking pipe	A pipe that is engineered and manufactured with a smooth outer wall and watertight joints. The pipe is specifically designed to be jacked through the ground. As it relates to this Contract, jacking pipe is the product pipe for conveyance of stormwater
Jacking shaft	Excavated shaft at origin of pipe jacking length and where the jacking frame is positioned for pipe jacking
Lost ground or Over excavation	Loss or removal of material in excess of that replaced by the jacking pipe including ground that runs, flows, pipes with groundwater inflows, squeezes, and raveling creating voids or softened or loosened ground outside of the tunnel profile.
Lubricant	Material consisting of bentonite or artificial polymers that is injected into the annular space during pipejacking to reduce the friction on the pipe string and keep the annular space filled.

Term	Definition
MTBM	<p>Microtunnel Boring Machine. The plant used to excavate material generally for the purpose of installing pipes by jacking or other ground support systems.</p> <p>The machine may provide continuous ground support if required to control the ground likely to be encountered at the tunnel face.</p>
Overcut	The radial distance between the excavated perimeter of the outermost gauge cutter and the outside radius of the MTBM shield.
Reception shaft	Excavated shaft for the receiving of tunnelling plant (MTBM) at the end of a jacked length.
Slurry	Bentonite medium used with or without additives and maintained under pressure at the face to provide active face support, spoil removal and a cutting medium
Spoil	Excavated material consisting of a mixture of rock and soil cuttings and water removed from the tunnel. Spoil may include conditioners, bentonite, and polymers.
Vacuum excavation	Utilising vacuum to transport spoil from the cutting head to storage facility.

ACS1120.3 Materials

ACS1120.3.1 Pipe design and supply

Pipes shall comply with Auckland Council Stormwater Standard Specification ACS710: *Pipeline Construction*.

Pipe joints shall be either fixed or loose collar flexible joints with a jacking band and elastomeric seals. The jacking band shall be designed to withstand maximum installation forces.

Butt jointed pipes and in-wall jointed pipes may be used where there is a demonstrable track record of the particular pipe being proposed having been successfully used under similar conditions. The Contractor shall supply evidence of track record with their Tender.

ACS1120.4 Work method statement

Prior to commencing the Works, the Contractor shall prepare and submit a Work Method Statement including following items: Construction Plan, Tunnelling Method, Details of Equipment and Contingency Plans.

The Statement shall demonstrate that the proposed method complies with the Health and Safety at Work (Mining Operations and Quarrying Operations) Regulations 2016.

Any works that are notifiable works under the Health and Safety in Employment Regulations shall be lodged with WorkSafe New Zealand. Copies of notifications shall be supplied to the Engineer.

Where Principal Hazard Management Plans and Principal Control Plans are required to be submitted to the WorkSafe High Hazards Unit (HHU), the same document shall be submitted as part of the project Work Method Statement.

Notwithstanding any of the specific requirements detailed below, the Work Method Statement shall clearly and fully detail the methods and resources the Contractor proposes to construct the Works and shall cover all aspects of the Works including equipment and materials specifications, temporary works, equipment and pipe design and health, safety, and the environment.

ACS1120.4.1 Construction Plan

The following information shall be submitted:

- a) Names, qualifications, and experience of key crew members including the Tunnel Construction Manager, Temporary Works Designer, and Tunnelling Machine Operator/s
- b) Names, qualification, and experience of staff fulfilling statutory roles
- c) Proposed shift patterns
- d) Details of proposed specialist sub-contractors
- e) Drawing of work site indicating the location and footprints of all equipment, location of shafts, location of stockpiles, slurry containment pits and pipe storage
- f) Details of how equipment will be transported along the pipe and supported from the pipe so that damage to the pipe surface is avoided (the pipe shall not be damaged by the movement of equipment along the pipe internally)
- g) Arrangements for locating and working close to existing underground utilities
- h) Survey equipment and methods including alignment and grade control and a description of procedures to check the guidance system and reset or realign during construction
- i) Dewatering and by-passing arrangements

ACS1120.4.2 Tunnelling method

A Proposed Tunnelling Method, including supporting calculations and engineering drawings, shall be provided by the Contractor and shall include:

- a) Locations of jacking and reception shafts and intended pipejacking directions
- b) Provision for managing the expected hydrostatic loads due to groundwater
- c) Provision for managing the expected earth overburden loads
- d) Analysis and consideration of all geotechnical information
- e) Assessment of potential settlement effects and the measures to ensure that ground settlement induced by tunnelling work will not exceed threshold limits.
- f) Assessment of the boring risks associated with:
 - i. Nearby services
 - ii. Special or unique environmental constraints.
- g) Evidence that the selected construction method considers the selection of tunnelling equipment and related systems including but not limited to:
 - i. Shaft construction
 - ii. Thrust walls
 - iii. Jacking forces
 - iv. TBM face load applied to the ground and the cutter loads (rock installations only)
 - v. For rock installation; cutter wear assessment and number of planned face interventions
 - vi. Details and drawings of intermediate jacking stations, proposed spacing, number per drive, and criteria for installing.
- h) Evidence that the installation loads do not exceed allowable limits including:
 - i. Maximum installation force on the product pipe
 - ii. Stresses due to friction between the product pipe and the ground surface, the entry hole, the inside wall of the bore and bends
 - iii. Loads resulting from slurries and other lubricating methods and/or grouting.

ACS1120.4.3 Details of equipment

This shall include details of the equipment to be used and evidence that it is appropriate to the application, including reasonable factors of safety for geological conditions that could potentially be encountered.

ACS1120.4.3.1 General

The following information shall be submitted:

- a) Type and capacity of tunnelling equipment to be used on the project including general arrangement drawings
- b) Overcut dimensions
- c) Details on capacity, number, type, and arrangement of main jacks and any interjacks
- d) Description of lubrication mix equipment and procedure for lubricating the pipe during jacking operations, including estimated volumes for the anticipated soils
- e) Description of the guidance, alignment control, and steering systems with manufacturer's literature, drawings
- f) Grout type (if relevant), methodology and equipment for grout injection
- g) Details of power supply to be used
- h) Spare parts list and availability of spare parts for any MTBM and system. This shall include any provision for critical spare parts.

ACS1120.4.3.2 Open face MTBMs

In addition to the requirements of ACS1120.4.3, the following information shall be supplied for open-face MTBMs:

- a) Spoil Handling Plan including transport and disposal equipment and procedures
- b) Details of type and number of cutting tools
- c) Evidence that the cutter head and associated excavation tools are designed specifically to suit the expected ground conditions and shall include the following provisions as a minimum:
 - i. Cutter tool spacing shall be sufficient to permit efficient excavation of the material at the tunnel face
 - ii. Cutting heads are designed to permit the use and replacement of appropriate cutter tools for the expected ground conditions
 - iii. For pipe installations 1250 mm ID and larger, cutter tools shall be able to be replaced from behind the cutter face (back loading).

ACS1120.4.3.3 Slurry MTBMs

In addition to the requirements of ACS1120.4.3, the following information shall be supplied for slurry MTBMs:

- a) Spoil and Slurry Handling Plan including separation, transport, and disposal equipment and procedures
- b) Details of type and number of cutting tools

- c) Evidence that the cutter head and associated excavation tools are designed specifically to suit the expected ground conditions and shall include the following provisions as a minimum:
 - i. Cutter tool spacing shall be sufficient to permit efficient excavation of the material at the tunnel face
 - ii. Cutting heads are designed to permit the use and replacement of appropriate cutter tools for the expected ground conditions
 - iii. For pipe installations 1250 mm ID and larger, cutter tools shall be able to be replaced from behind the cutter face (back loading).
- d) Methodology for accessing the face of the machine where applicable
- e) Maximum allowable face pressure or slurry pressure that can be exerted at the tunnel face without fluid loss to surface, other structures or features or heave of ground
- f) Details of any required separation plant set-up including description of its operation and processing capacity.

ACS1120.4.3.4 Earth pressure balance (EPB) MTBMs

In addition to the requirements of ACS1120.4.3, the following information shall be supplied for EPB MTBMs:

- a) Spoil Handling Operations Plan including transport, and disposal equipment and procedures
- b) Details of type and number of cutting tools
- c) Evidence that the cutter head and associated excavation tools are designed specifically to suit the expected ground conditions and shall include the following provisions as a minimum:
 - i. Cutter tool spacing shall be sufficient to permit efficient excavation of the material at the tunnel face
 - ii. Cutting heads are designed to permit the use and replacement of appropriate cutter tools for the expected ground conditions
 - iii. For pipe installations 1250 mm ID and larger, cutter tools shall be able to be replaced from behind the cutter face (back loading).
- d) Methodology for accessing the face of the machine where applicable
- e) Maximum allowable face pressure that can be exerted at tunnel face without fluid loss to surface and without causing damage to underground structures or features or heave of ground.

ACS1120.4.3.5 Auger boring machines

In addition to the requirements of ACS1120.4.3, the following information shall be supplied for auger boring machines:

- a) Spoil Handling Plan including transport, and disposal equipment and procedures
- b) Evidence that the cutter head and associated excavation tools are designed specifically to suit the expected ground
- c) Where there is a possibility of variable ground, details of the cutter head's ability to deal with those conditions
- d) Details and sizing of steel sleeves / casings and method of insertion and removal.

ACS1120.4.3.6 Direct pipe thrusting

In addition to the requirements of ACS1120.4.3, the following information shall be supplied for direct pipes:

- a) Details of the pipe thruster including ability to meet maximum thrust requirements and controls to avoid damaging casing pipe or product pipe
- b) Spoil and Slurry Handling Plan including separation, transport, and disposal equipment and procedures
- c) Evidence that the cutter head and associated excavation tools are designed specifically to suit the expected ground conditions and shall include the following provisions as a minimum:
 - i. Cutter tool spacing shall be sufficient to permit efficient excavation of the material at the tunnel face
 - ii. Cutting heads are designed to permit the use and replacement of appropriate cutter tools for the expected ground conditions
 - iii. For pipe installations 1250 mm ID and larger, cutter tools shall be able to be replaced from behind the cutter face (back loading).
- d) Maximum allowable face pressure or slurry pressure that can be exerted at the tunnel face without fluid loss to surface, other structures or features or heave of ground.

ACS1120.4.3.7 Guided boring operations

In addition to the requirements of ACS1120.4.3, the following information shall be supplied for guided boring machines:

- a) Spoil Handling Plan including transport, and disposal equipment and procedures
- b) Evidence that the cutter head and associated excavation tools are designed specifically to suit the expected ground
- c) Where there is a possibility of variable ground, details of the cutter head's ability to deal with those conditions

- d) Details and sizing of steel sleeves and method of insertion and removal
- e) Grout type (if relevant), methodology and equipment for grout injection.

ACS1120.4.3.8 Pipe ramming operations

In addition to the requirements of ACS1120.4.3, the following information shall be supplied for pipe ramming operations:

- a) Spoil Handling Plan including transport, and disposal equipment and procedures
- b) Details of any steel sleeve including calculations to derive thickness required and consideration of buckling
- c) Method of excavation of spoil from the hammered pipe
- d) Method of insertion of product pipe where applicable
- e) Details of pipe leading-edge configuration.

ACS1120.4.4 Contingency plans

Contingency Plans shall be provided before the start of any works. Contingency Plans shall address the following:

- a) Excessive deflection or failure of temporary works
- b) Over excavation occurs
- c) Slurry loss to the environment
- d) Unable to advance due to obstruction in the ground or increased pipe friction
- e) Guidance system errors resulting in exceedance of DTA tolerances
- f) Jacking forces increasing dramatically or suddenly
- g) Jacking forces reach design capacity of pipe or jacking frame
- h) Jacking pipe failure or joint damage
- i) Groundwater inflows interrupt the continuance of efficient tunnel or shaft excavation
- j) The vacuum excavation unit fails
- k) Loose material is encountered when boring uncased tunnel sections.

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

ACS1120.5 Setting out and guidance systems

The Contractor shall provide a guidance system capable of displaying the precise position and orientation of the tunnelling machine on a continuous basis with numerical and graphical display of horizontal and vertical deviation from the Design Tunnel Axis (DTA) and direction with respect to the DTA. The system shall at least monitor, record, and display the following:

- a) Date, time, and tunnel chainage
- b) Line and level of cutting and TBM axis.

The guidance system is required to maintain line and level to the tolerances specified and shall have a reference device that indicates visually that the directional control has not been accidentally moved.

The Contractor shall select a guidance system that is adequate for the anticipated drive lengths and the atmospheric conditions expected in the tunnel.

In addition, the line and level of the installed pipe shall be confirmed once a day along the tunnel by independent means, (e.g. survey).

ACS1120.6 Laying tolerance

The Contractor shall take all measures necessary to correct the pipe alignment when the deviation from the required line and grade is within 75% of the maximum permitted deviation. Corrections to line and grade shall be no greater than 25 mm over a 6 m length or sufficient to prevent ponding, whichever is less.

The pipe manufacturer's permitted draw or angular deflection shall not be exceeded at any individual joint.

The Engineer shall be notified:

- Immediately, verbally and in writing, when the tunnel is off line or grade by 75% of the maximum allowed
- Immediately, verbally and in writing, when the tunnel is off line or grade by 90% of the maximum allowed. Include a written description of the operational changes being made to avoid attaining the maximum allowed
- Immediately stop works and notify the Engineer in writing when the tunnel is off line or grade by 100% of the maximum allowed unless it is unsafe to do so. Include a written description of the operational changes being made and provide to the Engineer before continuing tunnelling.

ACS1120.7 Ventilation and lighting

The Contractor shall provide sufficient ventilation and lighting in the tunnel, entry and exit points to ensure that a safe working environment is maintained at all times in accordance with current regulatory requirements.

Where any shaft or pipeline is a confined space, the Contractor shall comply with the corresponding regulatory requirements.

ACS1120.8 Settlement

Unless otherwise specified by the Consent, the Contractor shall ensure surface or ground monitoring points are recorded on the centreline ahead of, and behind, tunnelling operations at a minimum of 30 m intervals or at least three locations per tunnel drive. Additional reference monitoring points shall be installed perpendicular to the centre line monitoring points at a distance from the centre line to be agreed with the Engineer. The Contractor shall ensure surface monitoring readings are taken prior to active excavation reaching that point, when the tunnel face reaches the monitoring point, and when the zone of active excavation has passed, and no further movement is detected.

When monitoring points observe or indicate any surface disruption during the installation period, the Contractor shall notify the Engineer immediately. Any damage shall be repaired by the Contractor.

CCTV inspections of sewers and stormwater pipes crossed by, or within the settlement zone of the proposed pipe, shall be undertaken in accordance with Auckland Council Standard Specification *ACS1520 Internal Inspection of Pipelines* both before and after installation.

Gas, watermains and other pressurized pipelines crossed by, or within the settlement zone, of the proposed pipe shall be tested for leaks both before and after installation.

ACS1120.9 Installation

Before a particular section of pipe installation commences, evidence shall be provided that the pipes necessary for completion of the section are on site or in storage available for delivery to site during the operation. Where required, at least one intermediate jacking station assembly shall be available at the start of the pipejack, unless otherwise agreed.

The installation shall provide for the following performance requirements:

- a) Pipes are jacked into place in accordance with the manufacturer's specifications without damaging the pipe joints or the completed pipe section

- b) The tunnel shield is articulated and manoeuvred by steering jacks or other approved methods to enable accurate control of line and grade
- c) Equipment's capability to deal with obstructions (as identified in the geotechnical information)
- d) Being able to balance groundwater pressure encountered during the excavation
- e) Installation shall not affect any building foundations and shall provide for consistent support during and after installation.

In the event a section of pipe may be damaged during the jacking operation or joint failure occurs, as evidenced by visible groundwater inflow or other observations, the Contractor shall adopt at least one of the following procedures to correct the damage, as agreed upon by the Engineer:

- a) A damaged pipe that passes leakage test and maintains pipe barrel and joint structural integrity, may, if access is possible, be repaired in place by a method approved by the pipe supplier and accepted by the Engineer
- b) Damaged pipe, or pipe where joint failure is evident, shall be removed. Plans for removal shall be submitted to the Engineer.

Pipes, including lead pipes, which have been jacked through a pipe jack shall not be used elsewhere on the works. Cut pipes shall not be jacked.

On completion of the drive, intermediate jacking stations shall be left fully closed. All jacks, props, thrust rings and packing shall be removed, the ends of the pipes cleaned, a new packing ring glued to the receiving face and the joint jacked partly closed. An "O" ring seal shall then be inserted into the sliding joint and the joint jacked fully closed. The order of closing the stations shall be from the tunnelling shield working back.

The annular space between the sides of the excavated tunnel and the jacking pipes shall be constantly filled with an approved fluid at a pressure that will support the adjacent excavation. The fluid shall be thoroughly mixed prior to pumping or placing. On completion of the pipe jack, the annulus shall be filled by displacing the fluid with grout.

ACS1120.9.1 Spare parts

A list of the spare parts recommended by the manufacturer for the MTBM shall be supplied before pipeline installation commences, indicating critical items, item availability and delivery periods. Where critical spares are required, these will be kept on site unless otherwise agreed with the Principal.

ACS1120.10 Tunnelling fluids

Where fluids are used for lubrication or pressurizing the face, the system shall include pressure gauges, volumetric gauges, and shut-off valves on the pump or at the point of injection. The system shall measure the injection pressure and volume to sufficient accuracy so as to prevent an inadvertent return.

Fluids may consist of materials including API grade bentonite, polymers, additives, and water. The choice and quantity of materials is the sole responsibility of the Contractor. Sufficient spare materials shall be retained on or near the site to cater for unexpected events during tunnelling, such as fluid loss or machine jam. The Contractor shall use an appropriate fluid to suit the ground conditions as may be encountered on site during pipe installation operations.

Fluids to be used shall be environmentally sound and biodegradable.

The Contractor shall take extreme care in minimising the loss of fluids onto the ground or the environment. Returned fluids shall be properly contained, reclaimed, and recirculated.

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

ACS1120.10.1 Data monitoring system

The controls for the tunnelling system shall include a system that provides real-time data monitoring and acquisition, capable of storing and displaying the following information, as appropriate:

- a) Cutting wheel speed (in rpm), direction and torque
- b) Electric motor status and power consumption
- c) Data from the guidance system
- d) Thrust pressure of the main jacking station as well as intermediate jacking station(s)
- e) Required and actual face support pressure
- f) Roll and inclination
- g) Steering altitude
- h) Slurry/lubricant/spoil control system data
- i) Where applicable, ground conditioning system information including water and polymer flows and pressure, air flows and pressures
- j) Discharge system from excavation chamber including screw conveyor rotation speed (EPB machine) and gate position indication
- k) All gases included in the gas detection and monitoring system.

The data monitoring system shall store and record the required information via an automated data acquisition system in digital form for later use and retrieval. Access to real-time data for use by the Engineer shall be provided.

ACS1120.11 Jacking operations

Jacking operations shall comply with the following requirements:

- a) Jacking loads shall be such that they do not overstress the pipe being jacked and an intermediate jacking station shall be provided, where necessary, to achieve this
- b) Jacks shall be of the same size and load rating and shall be used with equipment such that the jacking forces are uniformly applied to the circumference of the pipe
- c) The jacking load shall be transferred to the pipes through a thrust ring, which shall be sufficiently rigid to ensure even distribution of the load
- d) Jacking frames and thrusting provisions shall be of suitable strength and design for the pipe size and jacking conditions that are likely to be encountered
- e) The pipe shall be jacked on guides that are properly braced to support the pipe section and direct it in the proper line and grade
- f) Up-to-date records shall be maintained of jacking loads and line and level measurements. A graphical relationship between the jacking force and the distance moved shall be produced to ensure that the necessary measures are taken to avoid exceeding the maximum permitted jacking forces
- g) All lifting holes and grouting holes shall be sealed
- h) Joint packing material designed to distribute the jacking load evenly shall be inserted at, and between, the pipe ends and at any intermediate jacking stations
- i) Before work may start on any thrust pit, it shall be demonstrated that the design will withstand the maximum jacking force of which the jacks are capable.

ACS1120.12 Jacking system

The jacking system, including intermediate jacking stations, shall be capable of continuously monitoring the jacking pressure, the rate of advancement, and the distance jacked. The hydraulic cylinder extension rates shall be synchronised with the excavation rate of the tunnel. There shall be a uniform distribution of jacking forces on the ends of pipes.

ACS1120.13 Daily jacking log

The Contractor shall submit a daily Jacking Log Report to the Engineer. This shall be a 24 hr/day time-based log. The log during tunnelling works shall be submitted to the Engineer by 10am on the following day. The log shall include as a minimum the following:

- a) Date
- b) Time of measurement
- c) Chainage of machine
- d) Position of the tunnelling machine in relation to design line and grade
- e) Number of each pipe installed and length of pipe
- f) Position of intermediate jacking station in the installed pipeline including exerted jacking force
- g) Maximum jacking forces exerted on the pipe at each section
- h) Description of materials being excavated by the machine
- i) Starting and finish times for each crew shift each day
- j) Record of static survey being undertaken
- k) Machine idle time and reasons
- l) Inclination and torque of cutting wheel
- m) Face pressure
- n) Hydraulic pressure(s)
- o) Description of maintenance activities, including time and date of replacement, component, and reason for change
- p) Observations of settlement or heaving
- q) Any unusual events
- r) Printed name of operator and signature.

ACS1120.14 Over excavation

Where over-excavation for the pipe occurs, any gaps between the outside of the pipe wall and the surrounding soil shall be pressure grouted with a material approved by the Engineer.

ACS1120.15 Reinstatement of jacking pits

Pits or trenches excavated to install pipe by jacking shall be reinstated as soon as practicable on completion of the pipe installation and any associated works, unless otherwise agreed by the Engineer.

ACS1120.16 Inspections and testing

At the end of each pipe installation, the pipeline shall be subjected to a hydrostatic or low-pressure air test in accordance with Auckland Council Standard Specification *ACS710 Pipeline Construction*. In the event of a failure, the Contractor shall seal and repair the defect in accordance with the specified methodology and the line shall be re-tested. Repairs and re-testing shall be at the Contractor's expense.

Where the pipe is of sufficiently large diameter to allow man access, during the course of the installation, the Engineer may organise periodical inspections during installation. Where pressure tests are considered by the Engineer to be impracticable or unsafe, a visual inspection may be permitted in lieu of a pressures test.

ACS1120.17 Post installation CCTV or visual inspections

All newly installed pipes shall be inspected with a CCTV camera or visually before full reinstatement of all service connections. The Contractor shall ensure that a clear view is obtained of the following:

- a) Full circumference of the pipeline along its full length
- b) All visual defects.

The Contractor shall comply with the Stormwater Standard Specification *ACS1510 Internal Inspection of Pipelines* for inspections and reporting.