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Specification for

Trenchless Installation of Electrical Conduits by a BC Hydro Customer

DESIGNED/RECOMMENDED	REVIEWED	APPROVED
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1.0 Scope

This specification applies to the requirements for installation of electrical conduits by a specified trenchless method by a customer, in accordance with the design completed by the customer and accepted by BC Hydro. The customer shall furnish all labour, equipment, material and supplies, and shall perform all works necessary to provide BC Hydro with a completed duct/casing and installed cable as required under these Specifications. The dimensions of the casing shall be agreed to with BC Hydro. This Specification includes sections specific to installation by Horizontal Directional Drilling (HDD), and the Jack and Bore (JABU) method.

1.1 Related Sections

The following BC Hydro requirements are covered by this specification:

1) Horizontal Directional Drilling (Section 3)
2) Jack and Bore (Section 4)

2.0 General Requirements

2.1 Customer Submittals

A. The customer shall submit to BC Hydro a minimum of three (3) weeks prior to commencement of the work:
   1) The signed and sealed design and Issue-for-Construction Drawings for review and acceptance;
   2) A Geotechnical Factual Report;
   3) An Environmental Management Plan, and
   4) A Quality Control Plan.

B. The design and Issue-for-Construction Drawings shall incorporate the BC Hydro review comments. BC Hydro's review of the submittal and acceptance of the Customer's proposed material, design and construction methodology shall not relieve the Customer of his duties and responsibilities as specified under these specifications.

2.2 Meetings

1) BC Hydro's Representative will arrange and conduct a project kick-off meeting with the customer, their representative and any subcontractors, prior to initiation of the project.
2) During the construction, the customer shall attend weekly progress meetings with BC Hydro's Representative and the relevant key personnel

on safety, construction progress issues and public impact remediation requirements.

2.3 Construction

2.3.1 General

1) The work described in the Contract Documents shall be carried out by a specialist contractor (including subcontractors) of recognized ability, who has experience in the supervision and execution of the work. All work shall be performed only by operators experienced in the use of the equipment chosen and under the direct control of knowledgeable, trained and skilled personnel experienced in conditions similar to those expected to be encountered during the course of execution of the specified work(s).
2) The customer's activities shall be confined to the works area and access accepted by BC Hydro.
3) During the process of the work(s), the customer shall assist BC Hydro's representative by providing suitable and safe access to effectively monitor site operations, equipment and processes.
4) The customer shall follow Best Management Practice throughout the execution of the work(s) until its completion, and complete all work(s) as shown in the accepted design.
5) Where the quality of material or the product is not specified on the drawing or in the specifications, BC Hydro's on-site instructions shall apply.
6) The customer shall, at all times, provide and maintain competent supervisory personnel and labour, and material, tools and equipment as necessary to complete the work, in accordance with the accepted design.
7) The customer shall promptly comply with any written request by BC Hydro for full disclosure of the relevant knowledge, skill, prior experience and professional standing, or technical or trade certification, of any person appointed, employed or used by the customer in carrying out any part of the work.
8) The customer shall employ a BC Hydro approved safety watcher for any work on BC Hydro energized facilities.

2.3.2 Supply of Electricity and Water

The customer is responsible for the cost of supplying electricity and water for the performance of all work(s) necessary for, or incidental to, carrying out the work in accordance with these specifications and drawings.

2.4 Codes and Standards

In addition to all codes and standards referenced elsewhere in the Contract Documents, all materials and equipment supplied and work performed herein shall conform to the latest edition of the applicable industry codes, standards, references and recommended practices listed below. In case of conflict, the requirements of this specification shall prevail.

1) API RP 5C1 Recommended Practice for Care and Use of Casing and Tubing.
2) API RP 52 Land Drilling Practice for Protection of the Environment.
3) API BULL 5C2 Bulletin on Performance Properties of Casing, Tubing and Drill Pipe.
4) BC Hydro Class of Work Specification (COWS) 1323 R8.

3.0 Horizontal Directional Drilling

3.1 Scope

1) The work specified in this section includes installation of a duct or duct bundle by Horizontal Directional Drilling (HDD). It also includes all associated works as shown on the Contract Drawings and as required under these specifications including, but not limited to, grouting, shaft backfilling and site restoration for projects with a bore diameter of up to 1,000 mm and drive length of 1,000 m.
2) The customer shall furnish all labour, equipment, material and supplies and shall perform all works necessary to provide BC Hydro with completed installation of the duct/duct bundle. The completed works shall conform to the profile and grade shown on the Contract Drawings.
3) This section shall be read in conjunction with Section 2, General Requirements.

3.2 Definition of Terms

The following definitions of terms shall have the meaning assigned to them except when the context otherwise requires:

Annulus: The space between the conductor casing and the outside diameter of the duct/duct bundle, or between the finished reamed hole and the duct/duct bundle.

Borehole: A hole created by mechanical excavation of soil/rock along the bore path.

Best Management Practice: Effective, practical, structural or non-structural methods that prevent or reduce the movement of sediment,

nutrients, and pollutants from the land to surface or groundwater, or that otherwise protect water quality from potential adverse effects of construction and/or operational activities.

Conductor Casing: A hollow steel casing installed at the entry and/or exit end(s) of the bore path, to facilitate directional drilling and installation of the duct/duct bundle, without being hindered by obstructions or unstable ground.

Design: Drawings, plans, calculations and specifications, and revisions to them that define the work to be constructed, produced by the customer and accepted by BC Hydro.

Duct: A hollow cylinder of polymer used to house electrical cables; also called pipe.

Duct Bundle: A bundle of ducts configured and formed to the satisfaction of BC Hydro and installed inside the borehole.

Drill String: A continuous length of pipe made by fusing different pipe sections.

Entry: The area where the drill rig is located and the drill string enters the ground.

Entry Angle: The angle between the drill stem and the ground surface at the surface entry or exit point.

Exit: The area where the drill string exits the ground.

Frac-out: An inadvertent release of drilling slurry outside the circumference of the bore path.

Horizontal Directional Drilling (HDD): a trenchless surface-launched method of installing pipes below ground, using a surface-mounted drill rig that launches and installs a drill string at a shallow angle to the surface and has tracking and steering capabilities.

Obstructions: Boulders larger than 600 mm in maximum dimension encountered along the design bore path.

Slurry: A fluid, or mud, comprised of water and additives (bentonite and/or polymers) used in transporting the drill cuttings to the surface and stabilizing the borehole.

Thrust: The capacity of the drilling rig to push the drill string into the ground without rotating.

Torque: The capacity of the drilling rig to apply rotational force to the drill string.

Tracking System: Surveying tools used for tracking the position and orientation of the downhole cutting tool in the X, Y and Z components.

Wet Installation: A method of installation which requires weighting the duct/duct bundle prior to pulling it into the completed borehole to prevent

dragging the duct/duct bundle along the circumference of the borehole, reduce pull back force, reduce risk of pipe damage and increase the factor of safety against pipe buckling.

3.3 Design Standard – Duct and Duct Bundle Installation Requirements

1) The Engineer of Record's (EOR) design shall comply with BC Hydro's requirements as specified in these specifications and the requirements of all the stakeholders impacted, or likely to be impacted, by the work(s).
2) The design life of the completed work(s) shall be 75 years.
3) The completed works(s) shall be serviceable following a 1 in 475 years seismic design event, or as otherwise proposed by the EOR and accepted by BC Hydro.
4) The duct(s) shall be made of HDPE or other materials acceptable to BC Hydro and be of an inside diameter acceptable to BC Hydro. The dimension ratio (DR) of the duct shall be determined by the EOR.
5) The welding of the HDPE ducts shall be in accordance with ASTM F2620: Standard Practice for Heat Fusion Jointing of Polyethylene Pipe and Fittings.
6) All as-contracted ducts shall have a smooth inside wall including, but not limited to, all joints and connections.
7) When a duct bundle which carries electrical cables is installed, the minimum clear spacing between the ducts in the bundle shall be 58 mm.
8) The design configuration of the duct bundle shall be maintained during installation of the ducts inside the borehole.
9) Any grout surrounding the duct/duct bundle shall have thermal resistivity not greater than 90 $^{\circ}$C-cm/W. The grout shall have a minimum 28 day compressive strength of not less than 1 MPa, and be of low heat of hydration. It shall be non-toxic and meet the requirements of the B.C. Waste Management Act. The individual ducts in the duct bundle shall not displace from their designed position, deform or be damaged due to the heat of hydration generated by the grout.

3.4 Submittals

3.4.1 Submittal Requirements

The submittal shall comprise completed drawings and written descriptions identifying details of the proposed methods of construction and the sequence of operations to be performed during construction. The drawings and descriptions shall be sufficiently detailed to demonstrate that the proposed material and procedures meet the requirements of this section. All drawings shall be legible, in English, with dimensions in metric

units. The customer shall provide the following for BC Hydro's review, a minimum of three (3) weeks before the commencement of work(s) on-site:

1) Complete methodology of the drilling and duct/duct bundle installation, including:
   a) equipment specifications and capabilities, including the thrust and torque capacity of the drill rig certified by the manufacturer;
   b) the size of the pilot hole;
   c) the number and size of the pre-reams;
   d) the estimated pipe pull-back force with calculations;
   e) the type, accuracy and limitations of the downhole and surface surveying equipment, real time data recorders and their valid calibration certificate;
   f) the number of sections in which the duct/duct bundle is to be installed;
   g) sample daily data recorder forms showing drill pressure, torque and rates in terms of revolutions per minute, and drilling speed in inches/centimetres per minute;
   h) sample duct fusion forms;
   i) methods of minimizing and/or preventing gouging of the duct during handling and pull back;
   j) a Quality Control Plan including methods of testing the quality of fusion of weld pipe joints and methods of verifying the capacities of the installed duct/duct bundle;
   k) a method of dealing with potential obstructions that may be encountered along the bore path, and
   l) wall thickness, diameter and length of the conductor casings, should they be used.
2) A detailed schedule of Work(s).
3) A drawing showing the location and footprints of drill rigs, the service trailer, site lab, mud handling equipment and drilling slurry containment areas in the works area.
4) Details of noise mitigation measures.
5) A statement of whether any partial or full closure of roadways is required during duct fusion and pull back. If necessary, a traffic diversion plan must be provided, stating its duration.
6) A slurry pumping, management and containment plan, including management of slurry spillage from frac-out, recycling/transport and an approved disposal site.

7) Emergency procedures for inadvertently boring into a live power line, natural gas line, water line, sewer line or fiber-optic cables. Procedures must comply with B.C. Regulations.
8) A method of disposal of excess water.
9) The duct bundle configuration, if relevant.
10) Duct manufacturer's data regarding tensile strength and recommended minimum bending radius.
11) The type and thermal resistivity of the grout.
12) A method of grouting the annulus.
13) A detailed settlement monitoring plan.

3.4.2 Submittal Review

BC Hydro shall comment on the customer's submittals within fifteen (15) working days after the date of receipt of the submittals. BC Hydro's review of the customer's proposed materials, design and construction methodology shall not relieve the customer of his duties and responsibilities as specified under the Contract.

3.5 Construction

3.5.1 Equipment

1) The drilling rig and mud mixing system shall have the capacity required to successfully complete the installation.
2) The drilling rig shall be equipped with an electrical strike safety package. The package shall include a warning sound alarm, grounding mats and protective gear.
3) The tracking system must be able to provide, on a continuous basis, data on the X, Y, Z axis on the pilot hole drilling as the drilling progresses. The operating range and degree of accuracy of the tracking records shall be adequate to meet project conditions. All measuring equipment shall have valid calibration documentation.

3.5.2 Installation

1) The customer is fully responsible for the preparation of the site to construct the works and for construction of the works, including installation of the duct/duct bundle and the use and disposal of drilling slurry, in compliance with the requirements of the Ministry of Environment and Department of Fisheries and Oceans, other regulatory agencies, and to BC Hydro requirements.
2) All utilities along and on either side of the proposed drill path shall be identified, and utility owners shall be notified of the impending work.

3) If instructed by BC Hydro, a noise control system shall be installed on both entry and exit sides.

4) If instructed by BC Hydro, the customer shall verify the accuracy of the Measurement While Drilling (MWD) Tracking System by using a ground survey grid system, such as that by Tru-Tracker, or an equivalent.

5) If a borehole must be abandoned, the hole shall be grouted at the customer's expense.

6) Suitable non-toxic slurry shall be used to support the drilled/reamed borehole and for transportation of the drill cuttings.

7) The customer is responsible for dealing with any environmental and other consequences arising from frac-out.

8) Ground heaving shall not be caused by reaming or duct/duct bundle installation.

9) Duct/duct bundle installation shall be performed in a manner that minimizes the over-stressing and straining of the pipe. At no time shall duct be stressed above the allowable tensile and limiting unconstrained collapse stress specified in the design.

10) Following successful installation of the duct/duct bundle, the slurry in the annulus shall be completely replaced with low thermal resistivity and low heat of hydration cementitious grout, unless otherwise accepted by BC Hydro. The duct/duct bundle must not be disturbed or damaged during grouting or execution of any works associated with grouting.

11) The installed duct/duct bundle shall be mandrel-tested to BC Hydro standards. Appropriate remedial works shall be completed should the test fail, and the test repeated until the test passes the full length of the duct(s).

3.5.3 Drilling Profile Tolerances

1) The centre of the completed reamed borehole shall be no more than +/-1.0m of the centreline of the design alignment and profile.

2) The off-set of the completed borepath shall nowhere be more than 1.0 m from the design vertical and horizontal alignment. The radius of any unintended curvature along the bore path shall not be less than 1200 times the outside diameter of the drill rod.

3.5.4 Pipe/Duct Joining and Bundle Fabrication

1) Duct fusion shall be accomplished using the butt-fusion method by qualified fusion technicians in strict conformance with the pipe manufacturer's specifications.

2) The duct joints shall have a smooth, uniform, double rolled-back bead made while supplying the proper melt, pressure and alignment. If directed by BC Hydro, the internal beads shall be removed so that the inside surface of the joints is clear and smooth. All joints shall be made available for inspection by BC Hydro before pipe pull back.

3) All duct fusion welded joints shall be X-rayed. Any defective joints will be rejected. The customer shall redo any rejected joints at their own expense.

3.6 Acceptance

Any borehole and installed duct/duct bundles which do not comply with the following requirements will be rejected:

1) The borepath and reamed borehole must meet the alignment and grade tolerances specified in 3.5.3.

2) The mandrel test must be successfully completed.

3) BC Hydro must be provided with a set of As-Built Drawings showing the duct/duct bundle alignment, profile and inverts. The Drawings shall be constructed from actual field records. All As-Built Drawings should be signed and sealed by a Professional Engineer.

4.0 Jack and Bore

4.1 Scope

1) The work specified in this section includes:

   a) Installation of a steel casing for projects with a bore diameter of up to 1000 mm and drive length of less than 100 m by tunnelling, with the Jack and Bore Method.

   b) Installation of a duct/duct bundle and grouting of the annulus between the casing and the duct/duct bundle.

   c) All associated works, including backfilling the shafts and site restoration, as required under the Specifications.

2) This Specification shall be read in conjunction with Section 2, General Requirements.

4.2 Definition of Terms

The following words and expressions shall have the meaning hereby assigned to them, except when the context otherwise requires:

Advance Length: The length of tunnel in each excavation and support cycle.

Casing: A pipe installed as an internal protection to the product pipe(s)/duct(s)/ duct bundle, and/or as a protection to a tunnel.

Duct Bundle: A bundle of ducts configured and formed to the satisfaction of BC Hydro and installed inside the primary support of the tunnel.

Drive Length: The continuous length of a tunnel between two consecutive shafts.

Entrance Ring: A ring constructed opposite a thrust wall to guide and align trenchless tunnelling equipment into the ground to be tunnelled.

Entry Shaft: A vertical or sloped excavation constructed to launch the tunneling equipment.

Exit Shaft: A vertical or sloped excavation constructed to receive the tunneling equipment.

Face: The undisturbed soil immediately in front of the cutting head of the tunnel excavating equipment.

Full Face Control: Complete support of the excavated face at all times.

Inner Annulus: The void between the inside walls of the casing and the duct bundle.

Jack and Bore: A technique of tunnel excavation by horizontal auger boring and installing primary support to the tunnel by jacking a casing from the entry shaft. Alternative methods of tunnel excavation may be used.

Jacking Shaft(s): Vertical or sloped excavation(s) constructed to set up equipment at the beginning of a tunnel drive. This includes hydraulic jacks, thrust wall(s) and entrance ring(s).

Outer Annulus: The over-cut.

Over-cut: The difference between the diameter of the cutting head of the tunnelling equipment and the casing.

Primary Support: A support system selected by the customer to support the tunnel excavation. This can be steel casing(s), or segmental concrete pipes, or steel liner plates, or cylindrical pipes of any other material.

Reception Shaft(s): A vertical or sloped excavation constructed to receive the tunnelling equipment.

Rescue Shaft(s): A vertical or sloped walled shaft constructed to rescue a stalled cutting head.

Shaft(s): A generic word to describe all shafts: jacking shaft, reception shaft and rescue shaft.

Thrust Wall: A structure designed to distribute the loads from jacking into the adjacent soil.

Tunneller: Tunnel excavating equipment.

4.3 Design Standard – Casing and Duct Installation Requirements

1) The EOR's design shall comply with BC Hydro's requirements, as specified in these specifications, and the requirements of all the stakeholders impacted, or likely to be impacted, by the work(s).
2) The design life of the completed work(s) shall be 75 years.
3) The completed works(s) shall be serviceable following a 1 in 475 years seismic design event or as otherwise proposed by the EOR and accepted by BC Hydro.
4) The casing shall be made of mild steel and shall be capable of withstanding the jacking forces and the live and dead loads it will be subjected to during its service life.
5) The casing shall be designed and constructed such that the cables inside the ducts housed in the casing can be replaced at a future date.
6) The casing shall be protected from long term corrosion by cathodic protection. Alternatively it should be designed with sacrificial thickness sufficient to maintain its minimum structural capacity through the design life
7) The duct(s) shall be made of HDPE, or other materials acceptable to BC Hydro, and be of an inside diameter acceptable to BC Hydro. The dimension ratio (DR) of the duct shall be determined by the EOR.
8) The annulus between the casing and the duct/duct bundle shall be grouted by low heat of hydration cementitious grout which, when tested in accordance with IEEE 442-1981, shall have a maximum thermal resistance of 90 ^{0}C-cm/W in dry conditions.
9) Long-term settlement of the casing shall not damage the constructed works. Special attention to differential settlements is required, particularly at the connections to the connecting duct banks.
10) The maximum uniformly-distributed differential settlement or heave of the connecting unreinforced duct bank and the casing is 25 mm over 6 metres. (Abrupt localized settlement of heave will not be tolerated).
11) When a bundle of ducts is installed inside a casing, a minimum of 95 percent of the annulus between the duct bundle and the casing shall be filled with grout which complies with BC Hydro specified thermal resistivity requirements.
12) All as-constructed ducts shall have a smooth inside wall including, but not limited to, all joints and connections.
13) The design configuration of the duct bundle shall be maintained during installation of the ducts inside the casing.

4.4 Submittals

1) The submittals shall be completed drawings and written descriptions identifying details of the proposed method of construction and the sequence of operations to be performed during construction.
2) The drawings and descriptions shall be sufficiently detailed to demonstrate to BC Hydro that the proposed materials and procedures will meet the requirements of this section.
3) A detailed settlement monitoring plan shall be submitted.
4) All drawings shall be legible, in English, with dimensions in metric units.

4.4.1 Tunnelling

The submittals shall include:

1) A dewatering plan, including the location of the drawdown monitoring wells (piezometers).
2) The arrangement drawings and technical specifications of the tunneller and trailing equipment.
3) The magnitude of over-cut proposed.
4) The method of controlling the line and grade of the tunnelling operation.
5) The number of personnel permitted in the tunnel at one time.
6) The tunnel ventilation plan.
7) The tunnel rescue plan.
8) The schedule of tunnelling work, including shaft excavation and casing guide rail or jacking frame setup. The tunneller setup, launch, exit and removal for each drive length.
9) The method and details of spoil removal. This includes: equipment type, surface storage, processing and disposal; calculations for volume of soil removed per metre of installed casing, and the spoil disposal location.
10) The proposed contingency plans for critical phases of the tunnelling including:
    a) Dealing with a strong hydrocarbon-like smell detected in the spoils from excavation;
    b) Dealing with buried debris or a boulder of such size or type that the cutting head cannot break or bore through;
    c) Maintaining the target laser if it is distorted by heat and/or humidity, or has been knocked out of alignment;

d) The contingency plan if the casing is damaged, and

e) A tunnel rescue and ventilation plan.

11) The grouting techniques to be used for over-cut, if any, including the grouting equipment, pumping and injection procedures, pressure grout types and mixtures.

12) The details of the jacking method, including jack setup, and jack thrust reaction bearing installation.

13) The details of the method proposed to cushion and distribute jacking forces at casing joints to prevent damage.

14) The estimated jacking loads and relevant calculations.

15) The type of pressure/load measuring devices to be used for jacking, and their calibration certificate valid to the date of proposed completion of the jacking works.

16) Any geotechnical investigations performed by the customer as relevant to tunnelling.

17) The quality control methods proposed for the tunnelling operation. The submittal shall include supervisory control to ensure that the work is performed in accordance with the design.

18) The method of fabrication of the duct/duct bundle and its installation inside the casing.

19) The method of grouting the annulus.

20) A cross section showing the duct/duct bundle and the grout inside the casing.

4.5 Construction

4.5.1 General

1) The customer is responsible for complying with environmental regulations. Should a storm water drainage system be used to discharge excess water from the site, the quality of the water so discharged shall meet the requirements of the relevant regulating authorities. Special precautions must be undertaken to ensure that the customer's work(s) does not result in the discharge of sediment or other deleterious material to any watercourse.

2) The settlement of all utilities and adjacent buildings which may heave or settle due to the customer's performance of the work shall be monitored to an accuracy of +/- 1 mm.

3) The backfill shall be placed as per COWS 1323 R8.

4.5.2 Pipe Jacking Records

The customer shall maintain the following records during jacking of the casing:

1) A record of construction events and observations.
2) Completed field forms for checking line and grade, with achieved tolerance relative to design alignment.
3) Jacking load records.
4) Indications of damaged casing joints and proposed corrective action.

4.5.3 Grouting

1) The customer shall fill voids in the outer annulus should the over-cut be greater than 19 mm, and any other void created by caving or collapse of earth over the exaction, to the satisfaction of BC Hydro.
2) The customer shall fill the voids in the inner annulus by a grout which meets specified thermal resistivity characteristics.
3) The customer shall be responsible for placing the grout such that: no voids are left in the outer or inner annulus; the duct bundle does not float during grouting, and the integrity and design configuration of the duct bundle is maintained at all times throughout this operation. The individual ducts in the duct bundle shall not displace from their designed position, deform or be damaged due to the heat of hydration generated by the grout.
4) The thermal resistivity of the grout to be used for filling the inner annulus shall be proven by testing grout mix samples. The test results shall be provided to BC Hydro.

4.5.4 Casing Alignment and Profile Tolerances

1) The deviation of the centreline of the completed casing shall be no more than +/- 200 mm from the design centreline of the BC Hydro accepted design.
2) The actual volume of the grout placed in the inner annulus shall be less than 5% of the theoretical volume of the voids in the inner annulus.

4.6 Duct Testing

1) The customer shall proof the duct(s) and the casing, in the presence of a BC Hydro Representative, by pulling a standard polyethylene mandrel, sized for the casing and the duct(s) to be tested.
2) In the event that the test mandrel does not pass easily through a duct, or foreign material is found, or the test mandrel is scored or damaged,

then the ducts(s) shall be cleaned and the test repeated until BC Hydro is satisfied as to the condition of the casing/duct(s).

4.7 Acceptance

Acceptance is based on successfully completing the entire defined work. Successful completion includes: the casing; duct/duct bundle; successfully completing the mandrel testing and pressure testing of the pipe; installing all connector couplings on the end of the casing pipe; backfilling, and acceptable site restoration. Installations which do not comply with the following requirements will be rejected:

1) The borepath and reamed borehole must meet the alignment and grade tolerances specified in 4.5.4.
2) The mandrel test must be successfully completed.
3) BC Hydro must be provided with a set of As-Built Drawings showing the duct/duct bundle alignment, profile and inverts. The Drawings shall be constructed from actual field records. All As-Built Drawings should be signed and sealed by a Professional Engineer.