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TECHNICAL JOB SPECIFICATION

499/22

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HIGH PRESSURE (HP) TRANSMISSION SYSTEMS

CONSTRUCTION SPECIFICATION FOR INSTALLATION OF PIPELINE BY HORIZONTAL DIRECTIONAL DRILLING

QUALITY ASSURANCE PAGE

CHANGES LOG

REVISIONS LOG

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ISO 21467
[Earth-moving machinery - Horizontal directional drills - Terminology and specifications]

"INSTALLATION OF PIPELINES BY HORIZONTAL DIRECTIONAL DRILLING" Project Number PR-227-9424: An Engineering Design Guide prepared by the American Gas Association.

Technical Standard **IGE/SR/26** – "Horizontal directional drilling and impact moling"

1.0 SCOPE

This specification specifies the minimum requirements for the installation of pipeline using the Horizontal Directional Drilling (HDD) method applied for pipeline project crossing rivers and other natural and artificial obstacles.

For the construction of HDD, the requirements of the following, listed in order of precedence shall be fulfilled:

- This Specification
- Relevant Drawings
- Relevant Requirements from Authorities and Utility Networks Owners

2.0 APPLICABLE CODES. STANDARDS. SPECIFICATIONS AND PRACTICES

Works described in this Specification shall comply with the requirements of the latest edition of the following Codes, Standards, Specifications and Practices as applicable, except if specifically modified hereafter:

- **ELOT EN 1594**
"Gas supply systems - Pipelines for maximum operating pressure over 16 bar - Functional requirements"

- **ELOT EN 12889**
"Trenchless construction and testing of drains and sewers"

- **ELOT EN 14457**
"General requirements for components specifically designed for use in trenchless construction of drains and sewers"

- **ISO 21467**
"Earth-moving machinery - Horizontal directional drills - Terminology and specifications"

- "INSTALLATION OF PIPELINES BY HORIZONTAL DIRECTIONAL DRILLING" Project Number PR-227-9424: An Engineering Design Guide prepared for the. Offshore and Onshore Design Applications Supervisory Committee of the Pipeline Research Committee at the American Gas Association.

- Technical Standard **IGE/SR/26**
"Horizontal directional drilling and impact moling".

- Requirements set out by Authorities.

3.0 RELATED PROJECT SPECIFICATIONS. STANDARDS. STUDIES, etc

The following Project Documentation shall be applicable:

- **Job Spec. No. 499/1** "Site Requirements".
- **Job Spec. No. 499/5** "Reinstatement"
- **Job Spec. No. 199/8** "Crossings "
- **Job Spec. No. 199/11** "River and Ravine Crossings"
- **Job Spec. No. 199/4** "Welding"
- **Job Spec. No. 199/2** " Transport and Stringing of Pipes"

- **Job Spec. No. 180/1** "Welding Inspection"
- **Job Spec. No. 199/7** "Tie-Ins"
- **Job Spec. No. 994/1** "Marker and Measuring Posts"
- **Job Spec. No. 199/5** "Corrosion Protection of Field Joints and Uncoated Pipeline Components"
- **Job Spec. No. 199/9** "Drying"
- **Job Spec. No. 181/2** "Pressure Testing"
- **Job Spec. No. 499/24** "HDPE Pipe"
- Crossings Relevant Studies, Construction Drawings

4.0 PRECEDENCE

Any case of conflict between the requirements of this specification and other relevant documents and specifications must be brought to the Owner's attention for clarifications, before Contractor proceed with relevant construction activities. Contractor shall inform promptly Owner's Representative. Unless otherwise specified, the following precedence order shall apply:

a. Crossing Studies / Construction Drawings

b. This Specification

c. Other Project Specifications

d. Codes and Standards listed in clause 2 herein above

e. Standard Drawings and Typical Details

5.0 CONTRACTOR'S QUALITY SYSTEM

The Contractor or subcontractor(s) responsible for the execution of crossing construction works of this project shall be featured by a quality control and assurance system.

It is Contractor's responsibility to complete properly the quality forms, which are applicable for the installation of pipeline by the HDD method in accordance with the specifications and codes.

After completion of each activity for crossing construction, all relevant quality forms shall be submitted to the Supervising Engineer for review / approval and final acceptance of the work.

Owner's Representative shall have the right to review all the relevant documentation and audit the relevant Quality procedures, as considered necessary, in order to ensure that the quality system is actually functioning satisfactorily.

The whole package of quality records for crossing construction by HDD method shall be part of the Final Documentation Package of this project and shall be checked by the Supervisor Engineer and/or Third Party Inspectors as applicable.

6.0 CONSTRUCTION

6.1 GENERAL

Two weeks prior to commencement of construction works the Contractor shall notify the relevant Authorities of his intention to start the works, provided that Contractor has got the relevant permit by the Authorities.

Prior to commencement of works, Contractor shall determine on the spot the actual location of any underground utility lines and other installations (if any) by any suitable method in order to avoid any damage to these substructures. The location of the underground utilities shall be shown on the drawings, but Contractor shall contact the Authorities in order to get the required information for the exact location of the substructures, or about the existence of other installations not shown on the drawings. Contractor shall restore any damage to existing installations in accordance with the instructions of utility's Owner.

Contractor shall carry out all required works for the construction of the crossings in accordance with the relevant applicable specifications, drawings, studies, etc. as mentioned in clauses 2 and 3 herein above, as well as the special requirements mentioned here below.

The HDD construction includes pits excavation, pipes transportation, welding, NDT, field joints coating, pipeline cleaning / gauging / pressure testing, installation of pipeline with HDPE ducts, backfilling, removal of excess material, reinstatement and marking of pipeline route.

All works shall be performed in accordance with safety regulations and rules as specified in the relevant safety codes and standards and as per requirements of the competent Authorities. Shoring up and retaining measures of excavated pits and trenches shall be performed wherever necessary. Proper warning signs, fencing and traffic arrangement shall be provided if necessary as required by Authorities.

Additional working area shall be provided to Contractor free of charge, as it is specified in relevant Construction specifications. In case that further additional space is required, to the above specified, Contractor shall proceed with all required actions and negotiations with the landowner and/or authorities at Owner's cost and after Owner's approval.

Contractor shall take all required actions in order to decrease the construction period of crossings from works commencement to completion of reinstatement.

6.2 HDD INSTALLATION PROCESS

Installation of a pipeline by HDD is generally accomplished in two stages. The first stage consists of directionally drilling a small diameter pilot hole along a designed and pre calculated directional path. The second stage involves enlarging this pilot hole to a diameter, which will accommodate the pipeline and pulling the pipeline back into the enlarged hole.

Drilling fluid is used throughout the operation to transport drilled spoil, reduce friction, stabilise the hole, etc.

6.2.1 BOREHOLE PROFILE DESIGN

Prior to any equipment being positioned on the bore a survey of the bore path will be performed. Once the crossing (ground) profile has been taken and the geotechnical investigation complete, a determination of the depth of cover under the crossing is made. Factors considered may include flow characteristics of the river, the depth of scour from periodic flooding, future channel widening / deepening and the existence of existing pipeline or cable crossings at the location.

In borehole profile must be included the followings:

-the optimum entry angle

-the optimum exit angle

During drilling the pilot hole a DCI locator with a deep transmitter for steering position will be used to overlay an "As Built" of the pilot, bore to electronically generate a final installed product line.

6.2.2 PILOT HOLE DIRECTIONAL DRILLING

A pilot hole is drilled beginning at a prescribed angle from horizontal and continues under and across the obstacle along a design profile made up of straight tangents and long radius arcs. The drilling rig with its inclined carriage is set up on one side of the obstacle (e.g. river) and adjusted to give the correct ground entry angle.

A schematic of the technique is shown in **FIGURE 1 in ATTACHMENT 1.**

Pilot hole directional control is achieved by using a non-rotating drill string with an asymmetrical leading edge. The asymmetry of the leading edge creates a steering bias while the non-rotating aspect of the drill string allows the steering bias to be held in a specific position while drilling. If a change in direction is required, the drill string is rolled so that the direction of bias is the same as the desired change in direction. The direction of bias is referred to as the tool face. Straight progress may be achieved by simply rotating or with a series of offsetting tool face positions.

Leasing edge asymmetry can be accomplished by several methods. Typically, the leading edge has an angular offset created by a bent sub. This is illustrated schematically in **FIGURE 2 in ATTACHMENT 1.**

It is common in soft soils to achieve drilling progress by hydraulic cutting with a jet nozzle. In this case, the direction of flow from the nozzle can be offset from the central axis of the drill string thereby creating a steering bias. This may be accomplished by blocking selected nozzles on a standard roller cone bit or by custom fabricating a jet deflection bit. If hard spots are encountered, the drill string may be rotated to drill without directional control until the hard spot has been penetrated.

6.2.3 DOWNHOLE MOTORS

Downhole mechanical cutting action required for harder soils is provided by downhole hydraulic motors.

Downhole hydraulic motors, commonly referred to as mud motors, convert hydraulic energy from drilling mud pumped from the surface to mechanical energy at the bit. This allows for bit rotation without drill string rotation. There are two basic types of mud motors; positive displacement and turbine. Positive displacement motors are typically used in HDD applications. Basically, a positive displacement mud motor consists of a spiral-shaped stator containing a sinusoidal shaped rotor. Mudflow through the stator imparts rotation to the rotor, which is in turn connected through a linkage to the bit. Steering is accomplished by offset housing (Bendsub).

6.2.4 STEERING - SURVEY SYSTEM

The survey information required for the steering of the drill tool is measured by a device (sonde) installed in or behind the drill head. The sonde sends magnetic signals to a surface locator placed at a distance from the sonde. The information from the surface locator is then transmitted through electromagnetic waves to a remote display unit in the control cabin placed at a maximum distance of 1000 m from the surface locator to enable steering to be accomplished.

As the measuring is executed continuously, the real position can be checked against the design position on the design profile drawing.

We need a directional bore steering system available to all utility and pipeline construction.

The above mentioned system enables the driller to guide the drill head with known positioning by providing immediate information on tool face, direction and inclination. This data is transmitted at the surface by computer to provide additional information on depth, course length and distance of a predetermined line.

The system consists of three main components:

- A downhole sonde
- A surface locator
- Driller's console remote display

The downhole probe is placed directly behind the bottom hole assembly, which may include a jetting head and oriented sub, or drill bit and mud motor. Information is gathered by the downhole probe and transmitted to the surface locator unit.

The surface locator unit consists of a standard portable computer and interface unit. The data is simultaneously processed and transmitted to the driller's console providing continuous information on drill head orientation.

6.2.4.1 TOLERANCES FOR DIRECTIONS

The pilot hole shall be drilled along the path shown on the plan and profile drawing the tolerances listed below. However in all cases Right of Way restrictions shall take precedence over the referred tolerances. In all cases, concern for adjacent utilities and / or structures shall take precedence over the listed tolerances.

Listing of tolerances does not relieve Contractor form responsibility for damages to the nearby engineering facilities and / or buildings.

The tolerance for direction is 5% on the depth.

Entry Point: Entry point will be specified in the drawings and the leading bore hole shall first go exactly through the soil surface at that point.

Exit Point: The distance between the initial (planned) and the actual exit point of the bore hole shall not exceed 5 meters to the left or the right of the pipeline axis.

6.2.5 REAMING AND PULLING BACK

Once the pilot hole is complete, the hole must be enlarged to a suitable diameter for the product pipeline. Enlarging the pilot hole is accomplished using either pre-reaming passes prior to pipe installation or simultaneously during pipe installation. Reaming tools typically consist of a circular array of cutters and drilling fluid jets and are often custom made for a particular hole size or type of soil.

6.2.5.1 PRE-REAMING

A pilot hole is pre-reamed before attempting to install pipe. For a pre-reaming pass, a reamer is attached to the drill string at the exit point, is rotated and is drawn to the drilling rig, thus enlarging the pilot hole. Drill pipe is added behind the reamers as they progress toward the drill rig. This insures that a string of pipe is always maintained in the drilled hole. Large quantities of slurry will be pumped into the hole to maintain the integrity of the hole and to flush out cuttings.

6.2.5.2 PULLING BACK

Once the drilled hole is enlarged, the product pipe can be pulled through it. The pipeline is prefabricated on the bank opposite the drilling rig. A reamer is attached to the drill string and then connected to the pipeline pull head via a swivel. The swivel prevents any translation of the reamer's rotation into the pipeline string allowing for a smooth pull into the drilled hole. The pull section is supported using some combination of roller stands and pipe handling equipment, to minimize tension and prevent damage to the pipe. The drilling rig then begins the pullback operation, rotating and pulling on the drill string and once again circulating high volumes of drilling slurry. The pullback continues until the reamer and pipeline break ground at the drilling rig.

6.2.6 <u>WORK SPACE</u>

6.2.6.1 RIG SITE

The rig spread requires typically a 30 m wide by 50 long area. This area should extend from the entry point away from the crossing, although the entry point should be at least 3 m inside the prescribed area. Since many components of the rig spread have no predetermined position, the rig site can be made up of smaller irregular areas. Operations are facilitated if the area is level, hard standing and clear of overhead obstructions. The drilling operation requires large volumes of water for the mixing of the drilling slurry. A nearby source of water is necessary.

6.2.6.2 PIPE SITE

Strong consideration should be given to provide a sufficient length of workspace to fabricate the product pipeline into one string. The width will be as necessary for normal pipeline construction although a typical workspace of 30 m wide by 50 m long should be provided at the exit point itself. The length will assure that during the pullback the pipe can be installed in one uninterrupted operation. Tie-ins of successive strings during the pullback operation increase the risk considerably because the pullback should be continuous. If local conditions (i.e. limited space) do not allow for fabricating one pipe string, one or more tie-ins may be required.

6.2.7 <u>MACHINERY AND EQUIPMENT</u>

Horizontal Directional Drilling equipment is made up of the following component parts:

- A Horizontal Directional Drilling Unit, which consists of a fixed ramp, a carrier structure, a swivel, an open vice system, a power supply system and an operation system. The pullback capacity of the Horizontal Directional Drilling Unit and supporting equipment (drilling pipes, bore hole devices etc.) should not be less than that calculated as necessary for pipe string pulling. The pullback capacity of the unit should always be verified that is capable to satisfy the required amount that is calculated for each crossing.

- A mud container with mixing and recycling capabilities for bentonite, polymer based mud.

- Drilling pipes.

- Bore hole survey system / Walkover type.

- Bore hole drilling device / Drill head or mud motor / reamers.

- Devices responsible for the exact location of the guide bore hole, measurements of mud consumption, mud pressure, as well as measurements of longitudinal load and rotation load on drilling pipes and tools set.

6.2.7.1 LOCATION OF SEPARATE COMPONENTS

At Rig Site the following components are located:

- Drill Rig with operations panel.

- Mud mixing / recycling unit / pit pump.

- 2 mud pumps (one on the drilling unit / one stand-alone).

- Electric Generator.

- Workshop.

- Water tank for water reserve.

-Personnel and foremen compartment.

-Storage for spare parts and bentonite.

-Mud storage.

-Pit.

-Excavator

At Pipe Site the following components are located:

-Exit point (outlet pit).

- Fleet for drill pipes. Storage for drill pipes.

- Compartment for personnel. Ready pipe string on roller supports.

- Holiday Detector. Side Booms

- Pit pump.

- Pit.

- Fluid Connection with the entry side

6.2.8 <u>DRILLING MUD</u>

6.2.8.1 TYPE

Technical data sheets to be provided by Contractor.

6.2.8.2 FUNCTIONS

The principal functions of the drilling fluid are listed below:

a. Transportation of Spoil. Drilled spoil, consisting of excavated soil or rock cuttings is suspended in the fluid and carried to the surface by the fluid stream flowing in the annulus between the hole and the pipe.

b. Bore Stabilization. The drilled or reamed hole is stabilized by the drilling fluid. This is critical in HDD pipeline installation as holes are typically in soft soil formations and are uncaused. Stabilization is accomplished by the drilling fluid building up a wall cake and exerting a positive pressure on the hole wall. Ideally, the wall cake will seal pores and produce a bridging mechanism to hold soil particles in place.

c. Cooling and cleaning of Cutters. Drilled spoil build-up on bit or reamer cutters is removed by high velocity fluid streams directed at the cutters. Cutters are also cooled by the fluid.

d. Transmission of Hydraulic Power. Power required turning a bit and mechanically drill a hole is transmitted to a down hole motor by the drilling fluid.

e. Hydraulic Excavation. Soil is excavated by erosion from high velocity fluid streams directed from jet nozzles on bits or reaming tools.

6.2.8.3 MUD MIXING UNIT

The drilling fluid is prepared in special mixing tank with a mud-hopper.

In the first step the tank is filled with water and then the bentonite is added in the concentration of approx. 4%. When the drilling mud is ready for use it is transferred to the suction tank and then to High Pressure Pumps.

The mud is pumped downhole and circulates back to the surface and collected in "return pits". Depending on the nature of the project, the mud is pumped from the return pits to a "settling and containment pit". These pits vary in size depending on pumping rates and contain the mud for recycling or disposal.

6.2.8.4 RECYCLING AND DISPOSAL

Mud that has been circulated downhole and collected in the containment pit is then passed through machinery that separate the cuttings from the mud. This process involves a series of shaking sieves and various size hydroclones.

Significant amounts of mud are normally disposed of at the end of a project. This mud can be disposed of by use at another drilling location spread onto raw land for water retention improvement or evacuate to a dump site.

Drilling technological process stipulates multiple use of the drilling mud by means of its regeneration/fitration. Upon the completion of a drilling the remaining drill mud can be used at another directional drilling location.

The Contractor is responsible for the disposal of surplus drilling mud upon the completion of the last pipeline pull-back to a place approved by competent authorities.

6.2.8.5 FACILITIES CONDITIONS AT THE DRILLING SITE

Drilling mud storage containers have to be properly faced and banked to prevent any leakage to the environment. All barrels, containers, connections, pipeline armature, pipelines, etc. have to be kept in good repair to avoid any leakage. In case of any leakage it is necessary to urgently remove the leaked liquid and repair the defect that caused the leakage.

6.2.8.6 UNFORESEEN APPEARANCE OF THE DRILLING MUD

In case of unforeseen appearance of the drilling mud on the surface the Contractor has immediately to remove this mud and to change its drilling program in such a way as to minimize any unforeseen losses of the drilling mud.

6.2.9 <u>RIG ANCHORING</u>

A reliable anchoring of the drilling rig is secured by fixing a carriage of the drilling rig to a rabbet anchor, which is installed at a specified place on Rig Site.

A metallic profile or concrete construction is used for the rabbet anchor.

6.2.10 MINIMUM RADIUS OF CURVATURE

The radius of the curves determined by the bending characteristics of the product pipeline, increasing with the diameter. The curve usually brings the profile to the elevation providing the design cover the pipeline under the obstacle (i.e. river bed). Long horizontal runs can be made at this elevation before curving up towards the exit point.

Drilling radius will be calculated based on the following formula set by RUHRGAS in 1996 for the installation of steel gas pipelines by means of HDD techniques:

$R_{min} = 1400 \times (OD^3)^{1/2}$

Where:

R_{min} = minimum bending radius

OD = Outside Diameter of product pipe (m)

6.2.11 INSTALLATION LOADS AND STRESSES

During the installation the pipeline is subjected to:

- tension required to pull the pipe into the pilot hole and around curved sections in the hole made up of.

- frictional drug due to wetted friction between pipe and wall of hole, fluidic drag of pipe pulled through the viscous drilling mud trapped in the hole annulus.

- unbalanced gravity (weight) effects of pulling the pipe into and out of a hole at different elevations.

- Bending as the pipe is forced to negotiate the curves in the hole,

- External hoop from the pressure exerted by the presence of the drilling mud in the annulus around the pipe (unless the pipe is flooded with a fluid at a similar pressure).

To minimize stress due to rotation of the pullback section of the pipeline, its connection with the drilling bet expander shall be done through a swivel.

The stresses and failure potential of the pipe are a result of the interaction of these loads. The maximum acceptable load applied on the pipeline during the pullback should not exceed the allowable limits for the grade of pipe material.

6.2.12 BUOYANCY CONTROL

Uplift forces resulting from the buoyancy of larger diameter lines can be very substantial. High pulling forces may be required to overcome drag resulting from buoyancy uplift. For this reason a buoyancy control system may be applied to compensate the uplift forces. The buoyancy control system is also a safety measure to avoid sticking the pipe in case the pull is delayed for any reason.

A constant buoyancy control system will be applied. This can be accomplished by inserting a smaller diameter line (i.e. HDPE pipe) into the pull section and filling the smaller line with water. The smaller line will be properly sized to hold the volume of water required per linear meter to offset the uplift forces. This system reduces in a controllable manner the upward buoyancy of the pipe string in the hole.

The reduction of buoyant weight affords minimum abrasion to the pipe's coating and avoids re-drilling of the top of the hole during the pull back. The buoyancy system will be installed immediately after the hydrostatic test of the pipe string. It is important that the complete system be set up and tested before the reaming operations start, since no delay should stop the drilling works.

6.2.13 SUPPORTS OF THE PULLBACK PIPELINE SECTION

The pullback pipeline section should be put into roller supports in the form of a continuous section (if possible).

The supports for the pullback pipeline section should provide free movement to it without causing any damage to the pipe and anti-corrosion coating.

Supports with polyurethane rollers, which can handle pipe from DN 100 to 900 will be provided for temporary installation and pulling of the coated pipe strings.

Rollers support consists of a steel frame. The frame is a welded construction, made of channels and it has the form of internal prism with supporting surface on the bottom. From one side, at the ends of frame's support the inclined metal sheets are welded to provide convenience during the pulling under the pipe string.

6.2.14 INSTALLATION OF HDPE PIPES FOR FIBRE OPTIC CABLE

The HDPE pipes shall be pulled together with the product steel pipe (with individual pull heads). In case the HDPE pipes are damaged (buckled) a separate bore parallel with the steel pipeline will be drilled and the HDPE pipes will be pulled back.

6.3 PIPE STRING FABRICATION

6.3.1 GENERAL

Simultaneously with drilling operations, the pipe string at the pipe site (opposite from the rig site) is welded up, coated, inspected and tested.

The fabrication, inspection and testing of pipe string is executed according to the applicable Construction Specifications mentioned in **clause 3.0** herein above.

6.3.2 PIPELINE COATING

Field joint welds will be coated with the heat-shrinkable sleeve, which is specific for horizontal directional drilling installations, after being checked and after receiving acceptance of their quality.

When the coating of all welds has been completed the relative quality forms will be issued and signed by Owner's Representative.

The coating shall be inspected with Holiday Detector immediately prior to entering the reamed hole. Additionally, field joints should be closely examined. Any defect found should be rectified according to the relevant specification. Damage to yard - applied pipe coating imposed by drilled installation in soft soils will be negligible if the hole has been properly drilled and reamed.

Following the completion of pulling back the pipeline a cathodic polarization shall be performed in order to check the integrity of pipeline's corrosion coating. In case of damaged coating the pipeline section crossing the obstacle by HDD shall be isolated from the rest pipeline at both ends through installing Insulating Joints at both ends. This section shall be catholically protected through a sacrificial anode, which shall be specified based on test measurements. In order to facilitate the bridging of pipeline sections before and after the isolated pipeline section (for cathodic protection current circulation) an additional HDPE duct with a cable shall be installed along the pipeline pulled back section in parallel with the ducts of fibre optic cable.

6.3.2.1 COATING FOR TRENCHLESS LAID PIPELINES

Trenchless laid pipelines (e.g. by horizontal drilling) require coating with specific characteristics such as:

- increased thickness,
- increased mechanical characteristics

A particular attention must be paid when a trenchless laid pipeline is installed.

Below acceptance criteria for the coating integrity in case of trenchless laid pipelines are given.

6.3.2.2 COATING INTEGRITY TESTING

METHOD "A": POST-INSTALLATION COATING INTEGRITY TEST

Immediately after installation of the directional drill, and before tying it in, the integrity of the coating shall be tested. The test procedure shall be finalised by the Contractor, and agreed by the Client's Representative. The final procedure shall be in accordance with the procedure below and shall determine the current density on the pipe in units of μA/m2/100mV polarisation change. The test data shall be recorded on the form provided below. If the current requirement is in excess of 0.1μA/m^2/100mV the DD pipe shall be removed from the drill, and the coating repaired or the coated pipe replaced. The replaced or repaired pipe shall be required to pass the same coating test.

1. Install a temporary groundbed to apply cathodic protection to the pipe in the HDD.

2. Measure the natural potential of the pipe at each end of the HDD.

3. Energise the temporary cathodic protection system, adjust its output, and allow it to polarise for at least 20 minutes so that an Off potential of between –900 and –1050 mV measured with respect to a standard copper/copper sulphate reference electrode is obtained at each end of the DD.

4. Activate a current interrupter in the circuit at a cycle of 25 seconds on, 5 seconds off.

5. Record the test current, and record the on and instant off potentials at the locations where the natural potentials were measured.

6. If the ratio of the on/off potential change at the groundbed end of the DD is more than 1.5 times that at the remote end, the test should be repeated using a more remote groundbed.

7. Calculate the surface area of pipe within the DD.

8. Calculate the polarisation change of the pipe at each end of the DD by subtracting the natural pipe potential from the instant off potential at each location. Calculate the average polarisation change by averaging the two results. Calculate the current density requirement in units of $\mu A/m^2/100mV$ of average polarisation change.

9. If the current requirement is in excess of 0.1 $\mu A/m^2/100mV$ the DD pipe shall be removed from the drill, and the coating repaired or the coated pipe replaced. The replaced or repaired pipe shall be required to pass the same coating test.

Table 1 – HDD Coating Test Report Form

Horizontal Directional Drill Coating Test Report	
Pipeline :	
KP:	**Location:**
Date:	**Tester:**
Result:	**Signature:**
OD(m)	**Length(m)**___________________(Length in contact with mud.)
Area :____________________to nearest 0.1 m2. [Area (m2) = 3.142 x OD (m) x Length (m).]	
A. Natural potential : ________ mV at CP site________remote site. Average =_____mV.	
B. On potential : ________ mV at CP site,________remote site. Average =_____mV.	
C. Off potential : ________ mV at CP site,________remote site. Average =_____mV.	
D. Current : ________ mV across shunt. ________CP current in uA =_____uA.	
E. Potential CP : ________ On potential CP site - Off potential CP site =_____mV.	
F. Potential remote :________ On potential remote site - Off potential remote site =_____mV.	
G. Potential ratio : (E) / (F) (Must be less than 1.5 for remote anode.) =_____	
H. Polarisation : (C) - (A) =_____mV.	
I. Current density : 100 x (D) / Area / (H) =________ uA/m2/100mV.	
Notes: Ensure there are no earthing, anodes or other connections to the HDD. Ensure no bare pipe is in contact with the soil, and that the bare end of the pipe is dry. Apply the CP current for at least 20 minutes.	

METHOD "B": CURRENT REQUIREMENT TESTS

For existing pipelines the design may be undertaken using the information from field tests.

In the case of some pipelines the only meaningful data that can be collected may be restricted to soil resistivities, soil analysis, stray current measurements, and the results obtained from a temporary impressed current cathodic protection system.

Due to different construction process during the laying of a pipeline, it may be necessary to undertake tests on specific sections to verify that the cathodic protection will be effective.

Typical sections that may require such tests include trenchless installations (e.g. horizontal directional drilling, cased pipelines) and sections isolated for hydrostatic testing.

These tests should be undertaken before the sections are tied in.

The cathodic protection effectiveness for those pipeline sections can be verified by measurement of the current demand I and the structure to soil resistance R based on the protection potentials E_P.

For this verification procedure of the respective pipeline section the future operating conditions as well as the worst case scenario are to be assumed:

- Value of the current density J_S, which is considered as a maximum for achieving the protection potential E_P,
- Maximum value of the soil resistivity ρ which is measured or determined in the relevant pipeline route.

With this assumptions, threshold values can be derived for the current demand I* and for the structure to soil resistance R*. This formula can be used:

$$I^* = \frac{16 * (E_{ON} - E_P)^2}{J_S * \pi * \rho^2}$$

$$Rco^* = \frac{\pi * J_S * \rho^2}{16 * (E_{ON} - E_P)}$$

SYMBOL	DEFINITION	UNIT
E_{on}	On Potential measured under CP operating conditions, at remote earth	V
E_p	Expected protection potential	V
J_S	Current density in A/m² on a bare steel surface	A
ρ	Soil resistivity	Ω.m
I*	Current demand for section	A
R_{co}* (R*)	Calculated coating resistance or structure to soil resistance for section	Ω
R_{co}	Measured coating resistance or structure to soil resistance for section	Ω

Note: These equations are based on the assumption of a single circular shaped coating defect and located close to the surface of the soil. This represents, compared to other theoretical coating defect combinations, the worst case conditions for the cathodic protection. The thickness of the coating is negligible related to the coating defect diameter.
For the verification of CP effectiveness the following conditions have to be fulfilled:

$$I < I^*$$

$$R_o > R_{co}^*$$

Note: These verifications can be applied for the assessment of the cathodic protection of trenchless laid pipeline sections or pipeline sections in casings (see **ELOT EN 13509**).

6.3.3 HYDROSTATIC TESTING

The prefabricated pipeline string will be cleaned / gauged / hydrostatically tested prior to pulling and after the pulling in accordance with the relevant Construction Specifications.

7.0 DOCUMENTATION REQUIREMENTS

All quality forms referred to other Construction Specifications, which are applicable for crossing works by HDD technique shall also be properly filled in by Contractor and reviewed/approved by the Supervising Engineer and/or Third Party Inspection as applicable.

The above is applicable for both mechanical (such as welding, NDE, coating, hydrostatic pressure test, etc.) and civil (such as reinstatement etc.) works.

No corrosion coating shall commence unless the relevant documentation of the preceding works has been checked and approved by Supervising Engineer and relevant permit has been granted.

Following the completion of the pulling back operation Contractor shall prepare the As Built drawing depicting the actually installed pipeline according to survey measurements taken during pilot hole drilling operation.

In addition to the above, the attached here to quality forms shall be prepared by Contractor.

8.0 ATTACHMENTS

ATTACHMENT 1: Schematic figure of HDD process

ATTACHMENT 2: Q.A. Form: Crossing by HDD Acceptance protocol

ATTACHMENT 1

SCHEMATIC FIGURE OF HDD PROCESS

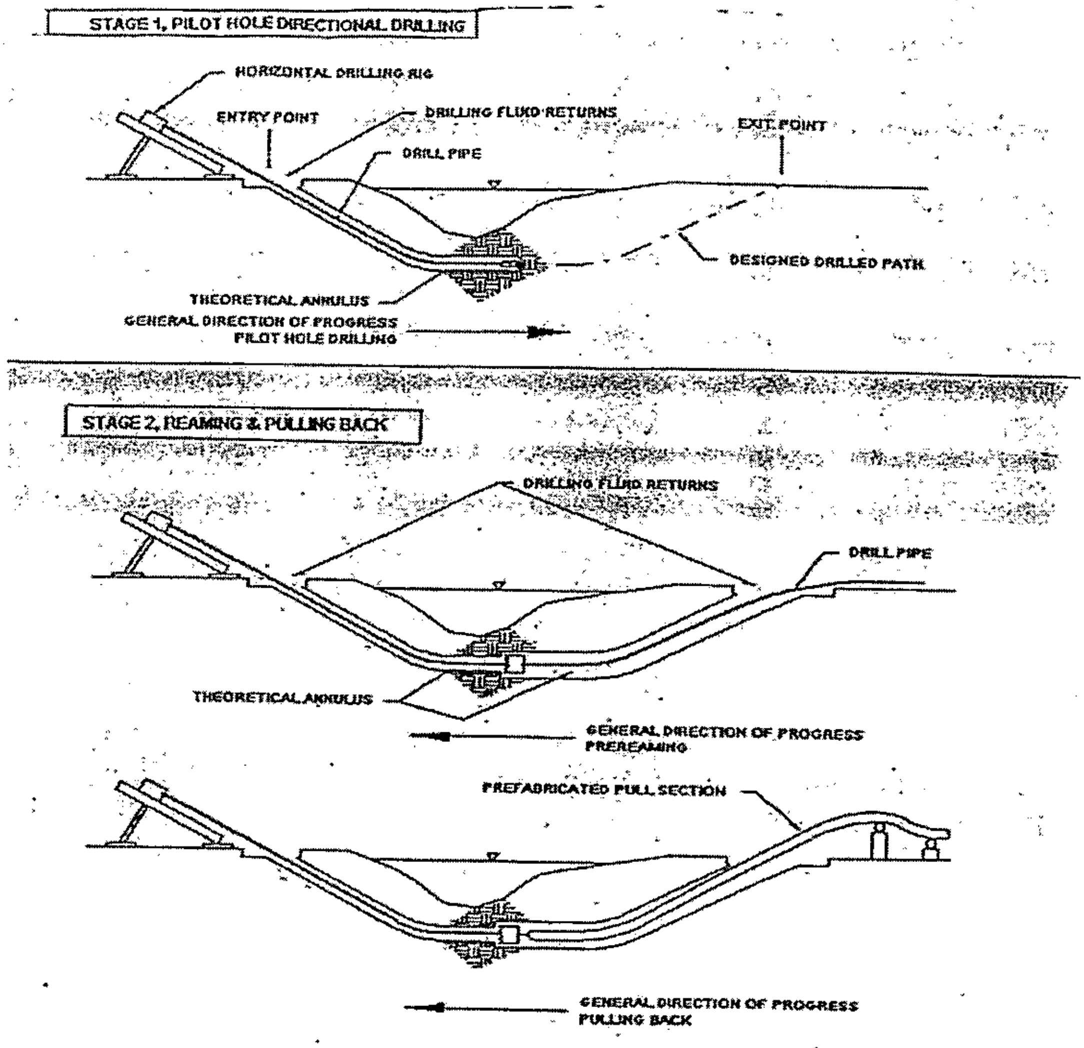
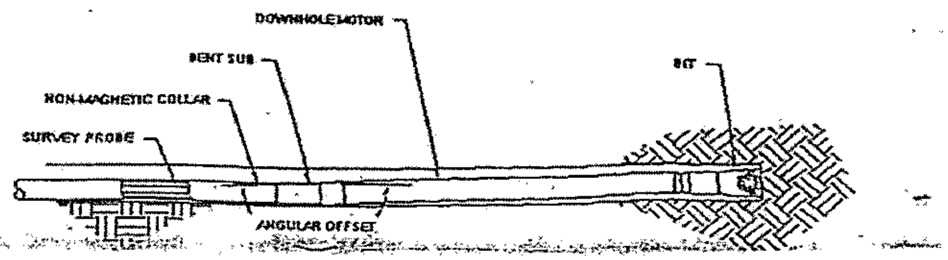


Figure 1
The HDD Process



ATTACHMENT 2

CROSSING BY HDD – ACCEPTANCE PROTOCOL CONFIRMATION OF CROSSING COMPLETION UPON PILLING BACK	
SUPERVISOR:	SECTION : .... REPORT No : ....
	REF. DRWGS : .... ISSUE DATE : ....
THIRD PARTY INSPECTION :	PREPARED BY : .... SHEET No. : ...... of ....
LOCATION (CHAINAGE Ki+) :	
CROSSING No :	CROSSING NAME :

ACTIVITY DESCRIPTION	YES	NO
1. CATHODIC POLARIZATION PERFORMED		
2. CATHODIC PROTECTION SYSTEM INSTALLED (If Required)		
3. PIPELINE PULLING BACK COMPLETED & ACCEPTED		
4. HDPE CONDUITS FOR FIBER OPTIC CABLE INSTALLED & TESTED		
5. FINAL (AS BUILT) SURVEY DATA AVAILABLE		
6. SITE CLEARANCE & REINSTATEMENT COMPLETED		

THE CROSSING HAS BEEN PERFORMED ACCORDING TO SPECIFICATIONS AND DRAWINGS		

NOTES:

CONTRACTOR **SUPERVISOR**