ISSN 2229-5518

Construction of Cross Country Ethane Pipeline

DAHEJ NAGOTHANE ETHANE PIPELINE PROJECT

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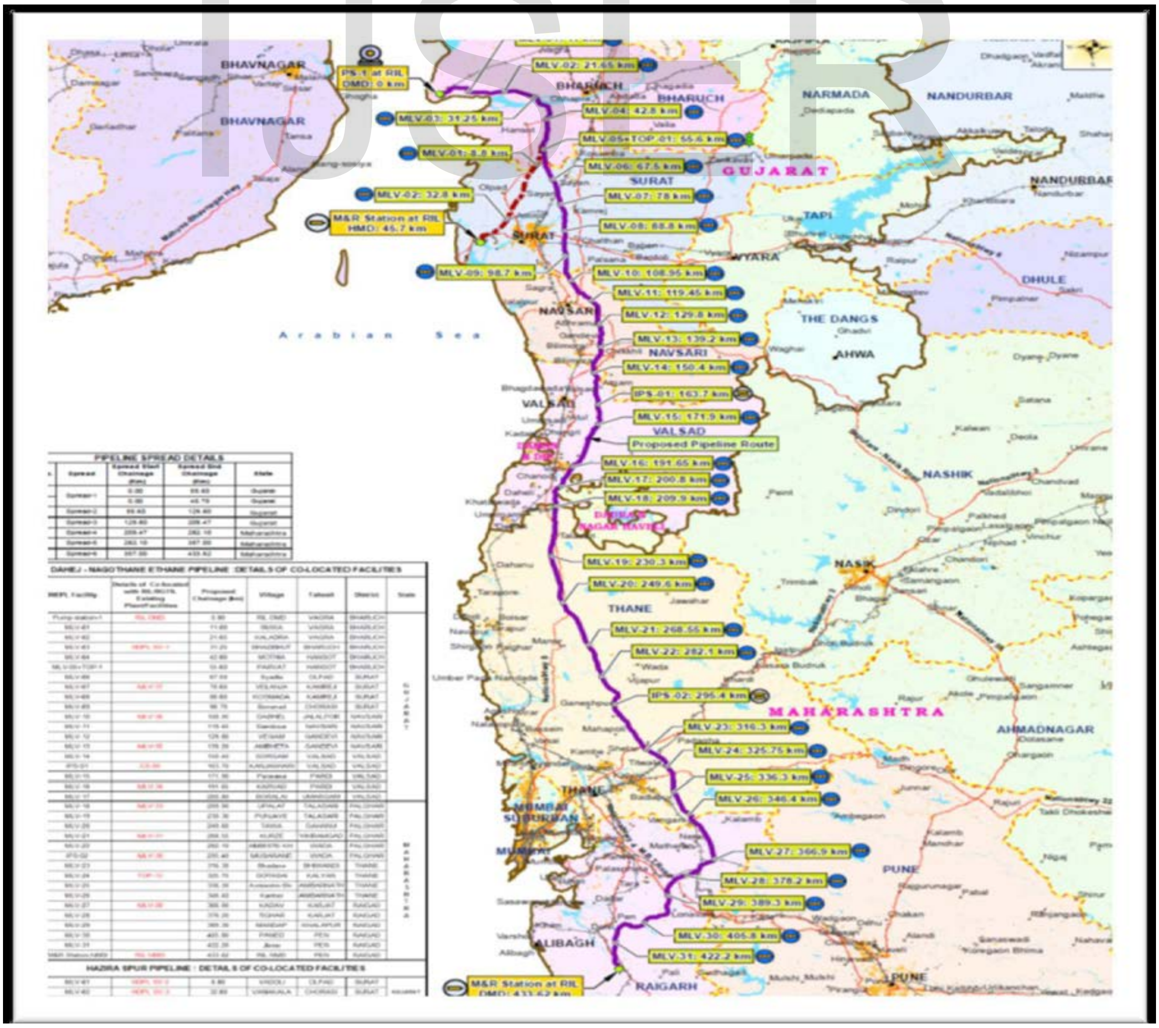

ISSN 2229-5518

ABSTRACT

We got an opportunity to work at Dahej Nagothane Ethane Pipeline project (Reliance Gas Pipeline Limited) and participated in construction activities of pipeline like ROU opening, clearing & grading, Stringing, Welding, NDT, HDD, Hydro testing & tie-in.

We have been given a chance to Work at site along with the Site Engineers and we have gained an overview of the approved industrial procedures and ITP stringently being followed for laying Product Pipeline and ensure Quality and safety as per the specified standard codes.

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DAHEJ NAGOTHANE ETHANE PIPELINE PROJECT

Project Brief

RGPL proposes to build ,operate & maintain pipeline for delivering liquid Ethane from DMD (Dahej Manufacturing Division) to HMD (Hazira Manufacturing Division) & NMD of RIL. The Pipeline will travel through the states of Gujarat & Maharashtra. System capability of Pipeline shall be 1.4 MMTPA (175 TPH) ; 0.62 MMTPA(77 TPH) to HMD & .78 MMTPA (98 TPH) to NMD.

Project Facilities

- Total Pipe length : 480 km
    - Trunk Pipe Line : 12 " Uniform Dia x 433.567 km
    - Spur Pipe Line : 8" Uniform Dia x 45.952 km
- Mainline Pump Station : at DMD
- Main Line Valves : 34
- IPS : 2
- M & R Station : 2 at HMD & NMD

CODES AND STANDARDS

The latest edition of following Codes and Standards are referenced in this Specification and all provisions of these reference codes and standards shall be applicable. -

AMERICAN SOCIETY OF MECHANICAL ENGINEERS (ASME)

B 31.4 - Pipeline Transportation System for Liquid Hydrocarbons

ASME B16.47- Large diameter steel flanges (NPS 26 through NPS 60

ASME B16.48- Steel line blanks

ASME B16.3 - Valves- flanged, threaded and butt welding end ASME B16.25-Butt welding ends

ASME B16.5 - Pipe flanges and flanged fittings ASME SEC VIII, DIV-1 Boiler and Pressure Vessel code

ASME SEC IX - Qualification slandered for welding and brazing

ASME B16.9 - Factory-made wrought steel butt welding fittings

ASME B16.10 - Face to face and end to end dimension of valves

ASME B16.20 - Metallic Gaskets for pipe Flanges-Ring-Joint

ASME B31.3 - Process Pipeline

ASME B36.10 - Welded and seamless wrought steel pipe.

AMERICAN PETROLEUM INSTITUTE (API)

API 1110 - Recommended Practice for the Pressure Testing of Steel Pipelines for the Transportation of Gas, Petroleum Gas, Hazardous Liquids, Highly Volatile Liquids, or Carbon Dioxide.

API 5L - Specification for line pipe

API 520 - Sizing selection and installation of pressure Relieving in refinery.

API 540 - Electrical installation of petroleum processing units API 6D -Pipeline valves

API RP 1102 - Steel pipeline crossing Railroad & highways API 6 FA Specification for fire test for valves

API 607 - Fire test for soft-seated quarter turn valve

API 610 - Centrifugal Pump for general refinery service

API 1104 - Welding of pipeline and relative facilities

OIL INDUSTRY SAFETY DIRECTORATE (OISD)

OISD Sty 214 - Cross Country LPG Pipelines OISD–Standard-114-Hazardous chemical and their handling

OISD-Standard-113 - Classification of areas for electrical installation

OISD-Standard-118 - Layout for Oil and Gas Installation

OISD-Standard-119 - Inspection of Pumps

OISD-Standard-141 - Design and Construction requirement for Cross Country Hydrocarbon Pipelines

OISD-Standard-138 - Inspection of Cross Country Pipeline Onshore

OISD-Standard-150 - Design and safety requirement for LPG mounted Storage facility

OISD-Standard-163 - Process Control Room Safety

ISO STANDARDS/CSO

ISO 148 - Determine the impact strength of steel and energy absorbed by charpy V-notch.

ISO 15590- 1 - Induction bends, fittings and flanges for pipeline Transportation.

8502-3 - Preparation of Steel Substrates before Application of Paints and Related Products – Part 3: Assessment of Dust on Steel Surfaces Prepared for Painting (Pressure Sensitive Tape Method)

11124 - Preparation of Steel Substrates before Application of Paints and Related Products – Specifications for Metallic Blast Cleaning Abrasives

Z245.20-10 - External Fusion Bond Epoxy Coating for Steel Pipe

SWEDISH STANDARD (SIS)

0055900 - Preparation of Steel Substrates before Application of Paints and Related Products – Visual Assessment of

DIN/EN STANDARDS

EN 10204 - Metallic products: types of inspection documents EN 10045/1 Metallic products: Charpoy impact test-test Methods (V &U notches).

DIN 30670 - Polyethylene coatings for steel pipe and fittings

KEY PARAMETERS IN PIPELINE

- Pipeline Operating Life : 35 years
- Operating hours : 16 hours per day (365 days/year
- Pigging Facilities : Permanent pigging facilities suitable for IP
- Subsoil Temperature : 20 through the entire length of the Pipeline (1.2 m below ground)
- Pipeline Laying : Buried
- Sectionalizing Valve : Sectionalizing valves have been proposed at Maximum distance of 12km as per ASME B31.4 &OISD-214 and as per evaluation Profile requirement
- Pressure Control Valves : 1 PCV at each pump and receiving station.
- Remote Operated Valves : 1 ROV at each receiving station.
- Pipeline Corrosion Protection : External coating and impressed current CP

CHAPTER-1

MAINLINE CONSTRUCTION

1. Main line Construction Activities

1.1 Route Survey

- Equipment

✓ Theodolite.

✓ Dumpy level.

✓ 30 meters measuring tape.

✓ Ranging rod.

- Alignment and Location survey

The Surveyor are aware of the general conditions of the terrain before starting survey. A preliminary survey for locating the center line of pipeline alignment on the ground is carried out as follows:

✓ Preliminary survey is carried out along the route of the proposed pipeline to establish and flag control points.

✓ The existing features and obstructions along the route that are not shown in available maps or drawings are located and identified. Mining and built up areas are avoided.

✓ Turning points (TPs) are located considering the following:

✓ Avoid objectives during construction variability like power, telephone & telegraph poles, walls, tube wells or such other structures falling on the trench alignment, also structures like boundary walls, houses, etc. should be at a sufficient distance.

✓ Ensuring proper angle of crossing by keeping as nearly right angle to road/rail/streams, etc. as possible.

✓ Theodolite and ranging rods are used to carry out Pipeline survey. Bench marks, intersection points and other survey monuments are installed /identified

- Bench marks

✓ On regular interval installed of two hundred meters minimum duly marked for easy identification with name of pipeline, progressive pipeline Chainage with yellow paint on base color of red. The staking shall be on the edge of ROW.

✓ Every turning point shall be install stake and on both sides of all road, river, rail and canal crossing etc.

✓ A temporary bench mark shall be established at every Turning point preferably on some permanent structure. For easily identification, bench marker should be paint.

1.2 Clearing and Grading

- The ROW boundary lines shall be staked so as to prepare the strip for laying the pipeline. All construction activities are performed within the prescribed width (limits) of the ROW. The variation in this width caused by local conditions or installation of associated pipeline facilities or any existing facilities of Owner will be informed. The following will be taken care of prior to the start of the operation

1.3 Stacking

- Install benchmarks, Intersection points and other required survey monuments.
- Stake two ROW markers every 100 meters.
- Set out a reference line with respect to pipeline centerline at a convenient location. Marker on reference line shall be at a distance of maximum 100 meters for straight-line sections and maximum 10 meters for horizontal bends.

- Install distinct marks on the ref line locating and indicating special points, such as contract limits obstacle, crossings, change of wall thickness, including corresponding Chainage etc
- All markers shall be of suitable materiel and shall be colored red with numbers printed in white. Number shall be identical to centerline marker number with letter A (left site) B (right site) added, looking to flow direction for easy identification and shall be maintained till permanent markers are installed and as built drawings are submitted approved.

1.4 Pipe Stringing

- Individual joints of pipe are strung along the right of way adjacent to the excavated ditch and arranged so they are accessible to construction personnel. A mechanical pipe- bending machine bends individual joints of pipe to the desired angle at locations where there are significant changes in the natural ground contours or where the pipeline route changes direction.

1.5 Trenching

- Pipeline trench is dug using an excavator on cleared and graded ROW/ROU in most of the cases.
- In cultivable land and other areas specifically designated by the COMPANY, top 30 cm of the arable soil on the pipeline trench top and stored separately to be replaced in original position after backfilling and compacting rest of the trench.
- It is required that fresh soil recovered from trenching operation, intended to use for backfilling over the laid pipe in the trench is not mixed with loose debris or foreign material.
- The excavated material shall never be deposited over against the strung pipe. Suitable crossing should be provided and maintained over the open ROU wherever

necessary to permit general public, property owners or his tenants to cross or move stock or equipment from side of the trench to the main path.

- On slopes wherever there is danger of landslides, the pipeline trench shall be maintained open only for the time strictly necessary.
- In certain sloppy section before trench cuts through water table, proper drainage shall be ensured, both near the ditch and ROU in order to guarantee the soil stability.

	Location	**Minimum Cover in meters**
a)	Industrial, Commercial & Residential Area	- 1.00 meter
b)	Rocky Terrain	- 1.00 meter
c)	Minor Water Crossings/Canals/drain/nala/stream	- 1.50 meter
d)	River crossing for which Scour depth is defined (below Scour)	- 1.50 meter
e)	River crossing (Bank width < 50 below lowest bed level)	- 1.50 meter
f)	River crossing (Bank width > 50 below lowest bed level)	- 2.50m -1.5 for rock
g)	Water crossing by HDD (Below least bed level)	- 2.50 m
h)	Uncased / Cased road crossing/ Station approach	- 1.20 m
i)	Railroads crossing	- 1.70 m
j)	Drainage ditches at road & railway Crossing	- 1.00 m
k)	Marshy land and creek area	- 1.50 m

1.6 Welding

Welding shall be carried out by manual Shielded Metal Arch Welding Process (SMAW). Once welded specimens are visually cleared, it shall be subjected to Radiographic testing and subsequently to destructive testing. Destructive testing shall be done as per API 1104 standard.

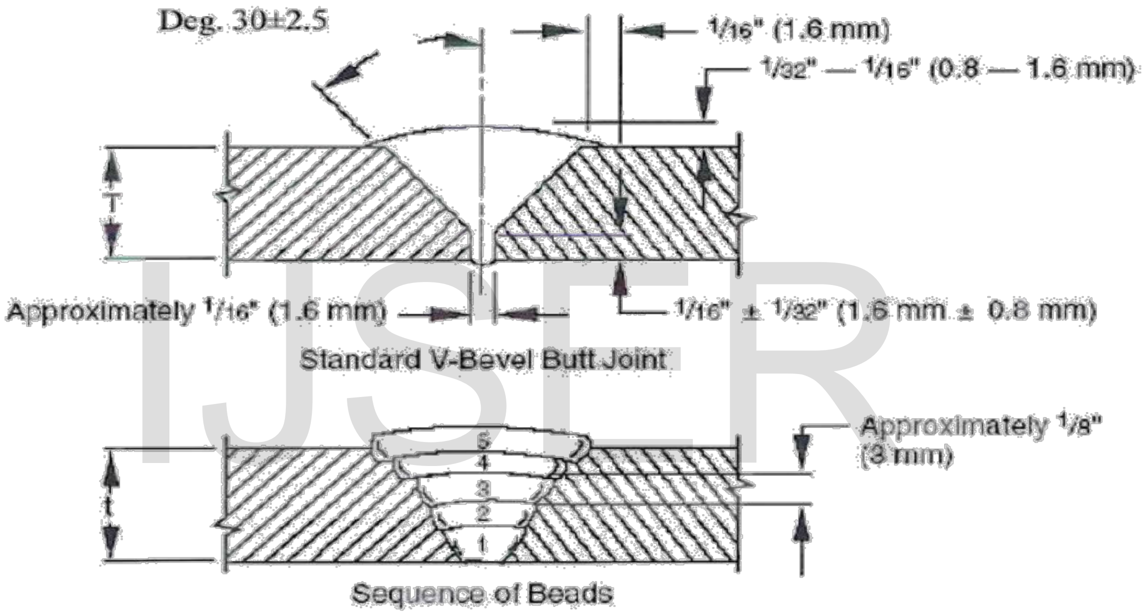

Figure 2 Welding Process

- Preparation for Welding

Weld is made by the manual shield metal arc method. Before the welding procedure is begun all the foreign materials should be removed from the beveled ends. If any

of the beveled edges of the pipe is damaged to the extent that satisfactory welding contact cannot be obtained, the damaged pipe ends shall be cut and field beveled with beveling machine. Should laminations, split ends or other defects in the pipe be discovered, the length of the pipe containing such defect shall be segregated, repaired or removed from the line.

- **Welding Procedure**

Prior to start of production welding, a pipe welding procedure should be established, qualified and recorded for submission. All positions welds shall be made with the pipe resting on suitable and sufficient number of skids with the work clearance as specified. The number of beads required shall be governed by the wall thickness of the pipe, provided that the completed shall have a substantially uniform cross section around the circumference of the pipe. The root bead shall be applied completely around the pipe and immediately run by a grinder and the grove shall be thoroughly cleaned for visual inspection of all free scale, slag or flux and other foreign material prior to the application of successive beads. The stringer bead must approach full and complete penetration throughout the periphery of the weld and built up with reinforcement at the root.

The hot pass should fully penetrate the pipe level at each side of the stringer making a deposit heavy enough to avoid pin holing. The completed weld is to be cleaned from all scale. The minimum and maximum limits of reinforcement and the width of completed welds should be in accordance with relevant standards. After completing every pass, the same shall be cleaned and flattened by grinding and power brushing.

Interruption between first pass and second pass and to third pass should be as approved Welding procedure. After completion of the third pass the wielding can be suspended, so as to allow the weld joint to cool down provided the thickness of the weld metal deposited shall be 50% of the pipe thickness or minimum of 03 passes whichever is more. Upon restarting the welding pre- heating shall be carried out.

After completion of welding, visual inspection is done and all the surface defects are removed as per the specification. NDT shall be carried out as per the approved NDT procedures. Repairs shall be done as per approved WPS and if required it shall be tested for NDT.

1.6.1 NON-DESTRUCTIVE TESTING

✓ Radiography Testing (RT)

Radiographic examination is done by using x-rays and Gamma rays. The acceptable limits of defects and removal of defects shall be as per the relevant codes of fabrication.

The following techniques are carried out for radiographic works

- For mainline joints, the radiography shall be taken using internal crawlers by single wall single image technique.
- For Tie-in joints and joints with fittings where internal crawlers cannot be used, the radiography shall be taken using external x-ray machine by double wall single image technique.

Case 1 – By using Internal X-Ray Crawler (Single wall – Single Image technique)

This procedure is adopted to radiograph all the production welds other than tie-ins. In this technique the number of exposure shall be one only. The minimum length of the film shall not be less than complete circum. length and to have sufficient overlap at the ends.

The position markers shall be at 05 cm intervals from datum point (zero point shall be on top of pipe) and the division shall run clockwise in ascending order, viewed in the direction of pipeline laying progress around complete circumference.

The unexposed film packed in the cassette ready with the joint identification number and I.Q.Is shall be wrapped around the circumferential weld at equal distances.

The X-ray crawler shall be inserted from the open end of the pipe and shall be propelled by battery power to the place of interest by use of a remote control. Radiation safety regulations must be taken into account. Radiation source shall be positioned within 5 mm of center of weld circle. Radiation angle with respect to weld and film is 900. The machine emits radiation as per pre-set exposure time.

Case 2 - By Using External X-ray Equipment (Double wall, single image technique)

This procedure is adopted to radiograph tie-in / repair joints or joints which are inaccessible to internal x-ray crawler. In this technique the number of exposures shall be four per weld minimum subject to demonstration of sensitivity and

required density. The minimum length of each film shall not be less than 300 mm and should maintain a minimum film overlap of 40 mm. Maximum film length (diagnostic film length) per exposure shall not be more than that qualified in the procedure.

The equipment shall be positioned so that the radiation beam passes through the center of the section under examination and will be offset from the plane through the

weld by the minimum distance required to prevent the image of one side of the weld falling the image on the other side. The film will be placed diametrically opposite the focal point with a minimum of 4 number exposures at 900 displacements.

The position markers shall be at 05 cm. intervals from datum point (zero point shall be on top of pipe) and the division shall run clock-wise in ascending order, viewed in the direction of the pipeline laying progress around complete circumference.

Equipment

- X ray Crawlers with Module/ Battery packs & Drive Assembly.
- X-ray Machine with Control panel & cables. Iridium — 192 Gamma ray camera.
- Pilot Command

- Survey Meter & Dosimeter
- Densitometer.
- Film reviewing facility, Dark Room Accessories & Consumables

Films, chemicals and water.

✓ **ULTRASONIC TESTING**

This procedure intends to describe the ultrasonic test for detecting discontinuities in weldment and HAZ. All ultrasonic tests are performed manually by A scan pulse echo method employing contact through Couplant film.

Personal Qualification

Personal performing ultrasonic testing according to procedure shall be qualified and certified of U.T. U.T. level — II as per ASNT SNT -TC-IA. All qualification certificates must be current.

Surface Preparation

The finished contact surface is to be in the uncoated condition and free of weld spatter and any roughness that would interfere with free movement of the search unit I probe or impair the transmission of ultrasound.

The weld surface must be finished so that they cannot mask or be confused with reflection from defects and must merge smoothly into the adjacent base material.

The adjoining base material through which the ultrasound will travel while doing ultrasonic testing must be completely scanned with a normal beam / straight beam probe to detect discontinuities, at least 1.25 x longest skip distance to be used which might affect the angle beam result. This does not form the base for acceptance /

rejection criteria for the weld but the presence within the beam path shall be recorded in the report.

Distance Amplitude Curve

The DAC curve are drawn for each variation in combination of nominal angle of reflection (probe angle) and frequency or when changing the probe or U.T. equipment or both.

Couplant

Couplant used will be of IOC or BP 2T oil mixed with white grease, and shall not be detrimental to material being inspected.

Methodology

- Place the probe on reference block to obtain a reflection from the required notch.
- Maximize the indication and adjust to approximately 80% of the full screen height using the gain control. Make a mark on the CRT at the peak of this indication using cursor setting. Note the gain in dB.
- Repeat the step 2, without disturbing the gain (dB) using reflection from the required reflector at different beam path length.
- In such a manner take at least three reflectors at three different path lengths and mark each. The gain (dB) noted in step 2 is DAC gain.
- Connect all points marked with a smooth curving line. This line is referred as DAC curve for that particular test system.
- Similarly plot 50% and 20% DAC by built in mechanism.
- Similarly, repeat steps 1 to 6 above for construction of DAC
- Curve from the Side Drill Hole (SDH).

CHAPTER-2

2 FIELD JOINT COATING

After welding the pipe joints, the pipe ends have to be coated with a suitable coating in the field. This type of coating is referred as Field joint coating. The heat shrink wraparound sleeve which is used as the field joint coating system shall consist of a solvent free epoxy primer applied to the pipe surface and over which a radiation cross-linked high density Polyolefin backing coated with high shear strength copolymer/hot melt adhesive is wrapped. Wrapped polyethylene backing is shrunk to form a tight fit around the joint by application of heat. Heat shrink wraparound sleeve field joint coating system shall be suitable for a maximum continuous operating temperature of 600C (Tmax) and the ambient soil temperature for the expected design life. Heat shrink wraparound sleeves shall comply with DIN EN 12068, Mechanical Resistance Class C, Temperature Class HT, Special Application Class UV and designation DIN EN 12068 – C HT 60 UV. The backing material will be provided with either dimple or other means to indicate that the desired heat during shrinking in the field is attained. The heat shrink wraparound sleeve will be of a size such that a minimum overlap of 50 mm is ensured (after shrinking) on both sides of the yard applied corrosion coating of pipes. The sleeve will be supplied in pre-cut sizes to suit the pipe diameter and the specified overlap requirement. The pre-heat and application temperatures required for the application of the shrink sleeves should not result in any damage to the applied mainline coating.

The total thickness of the heat shrink wraparound sleeve on as-applied condition shall be as follows:

On Pipe Body - Min. 1.8 mm; Average - 2.0 mm

On Weld Bead - Min 1.6 mm

Codes and Standards for Field Joint coating:

DIN EN 12068 Cathodic protection - External organic coatings for the corrosion protection of buried or immersed steel pipelines used in conjunction with cathodic protection - Tapes and shrinkable materials.

ISO 8503-1 Part 1: Specification and definitions for ISO surface profile comparator for the assessment of abrasive blast cleaned surfaces.

ISO 8503-3 Preparation of Steel Substrates before Application of Paints and Related Products; Surface Roughness Characteristics of Blast-Cleaned Steel Substrates; Part 3:

2.2 MATERIAL/ APLICATION TOOLS/ TESTING EQUIPMENT

2.2.1 Field Joint Coating Material:

- HTLP 80 HP Heat Shrinkable Sleeve with closure patch
- S1301M Epoxy Part A & Part B (100% solid epoxy) Ratio 3:1

2.2.2 Application Tools for Heat Shrink Sleeves:

- S1301M Epoxy pump set - Part A & B
- Measuring cups 50ml, 200 ml
- Applicator pads kits
- BN-80 Gas torches with hose and regulator
- LPG Gas Cylinders
- Silicon rollers
- Digital thermometer with flat probe

- Wet film thickness gauge
- SA 2½ Surface Comparator Plate

2.2.3 Application Tools / Material for Surface Preparation:

- Abrasive blasting unit
- Air compressor
- Abrasive media (copper slag / garnet / grit) of suitable mesh size to ensure surface

roughness of 50-70 microns.

2.2.4 Testing Equipment:

- Press -O_ film with micro meter
- Peel test & coating thickness gauge
- Holiday detector with Zeep meter
- Digital thermometer with flat probe
- Hygrometer (To measure humidity and dew point)
- Stanley & peel cutter knife

2.3 SURFACE PREPARATION

Oil, grease, salt and other contaminants shall be removed from steel surface by wiping with rags soaked with suitable solvents. Solvent cleaning shall be done in accordance with SSPC-SP1.

2.3.1 Blast Cleaning

Each field joint shall be blast cleaned using a closed cycle blasting unit or an open expendable blasting equipment. With the closed cycle blasting unit, steel or chilled shots and copper slag can be used and with the expendable type blasting equipment Garnet material can be used. During blast cleaning the pipe surface temperature should be more than 3°C above Dew Point, while the Relative Humidity should not be greater than 85%.

Prior to surface cleaning the surfaces should be completely dry. The surface shall be cleaned to a grade Sa 2½ in accordance with Swedish Standard SIS-055900 with a roughness profile of 50 – 70 microns. The dust contamination on the blasted surface permissible shall be of a rating max 2 as per ISO 8502 –3. Surface roughness profile can be measured using an approved profile comparator or using Press-O-Film in accordance with ISO 8503-1. The surface cleanliness grade, roughness profile and dust contamination shall be checked on every joint.

Figure Surface Profile gauge

Figure Press-o- film

Blast cleaned surface shall be coated within 2 to 4 hours depending upon the conditions stated below:

Relative Humidity (RH) > 80 % 2 hours

Relative Humidity (RH) 70 - 80 % 3 hours

Relative Humidity (RH) < 70 % 4 hours

Surface delayed beyond this point or surface showing any visible rust stain, should be blast cleaned again.

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Figure Joint before blast

Figure Sand blasting

2.3.2 Surface Inspection

The field joint surface shall be inspected immediately after blast cleaning and any feature of the steel surface such as weld spatter, laminations or other imperfections considered injurious to the coating integrity made visible during blast cleaning shall be removed by filing or grinding. Pipes affected in this manner shall be then re-blasted if the defective area is larger than 50 mm in diameter.

➢ **Beveling of Polyethylene Coating Edges**

If not factory beveled, bevel the line coating edges on both sides of the weld bead to approximately 15°. The ends of existing mill coating shall be inspected. Unbounded portions of the coating shall be removed and then suitably trimmed. Portions where parent coating is removed shall be thoroughly beveled, and cleaned.

➢ **Epoxy primer mixing**

S1301M epoxy has to apply only on the steel surface. (not on the PE surface) .The epoxy has to dispensed in the ratio of 3:1 (Part A : Part B)(60 and 20 ml) using calibrated strokes of Part A & Part B pumps. This epoxy should be sufficient for 1 joint to achieve 200 microns wet film thickness (WFT).

Figure Primer

- **Pre-heating**

Figure Pre-heating

Before placing the wraparound sleeve, the bare steel surface shall be preheated either with a torch moved back and forth over the surface. The steel surface and the adjacent PE line coating are preheated to temperature around 70ºC**.** This is very important to bond properly to the PE line coating. The pre-heat temperature is checked by means of contact type temperature-recording thermometer at minimum four (4) locations uniformly spaced around the pipe circumference. Pre-heat temperature shall be checked on every joint. Care shall be taken to ensure that the entire circumference of the pipe is heated evenly. In windy conditions a wind shield, or during rain, a ventilated tent should be used to assist in the application of the coating.

➢ **Primer Application**

Figure Priming

Upon pre-heating, the pipe surface shall be applied with two pack epoxy primer which is already mixed in the ratio 3:1. Apply the S1301M epoxy on the steel surface and 10 mm on chamfered polyethylene edges, in order to cover all bare metal. Apply the S1301M epoxy primer over the girth weld seam first and then on the body to a wet film thickness of 200

microns. S1301M epoxy primer should not be applied on the adjacent PE line coating. The wet film thickness of the primer shall be checked on every joint with a wet film thickness gauge prior to installation of sleeve.

➢ Sleeve Application

Figure Coating

Immediately after application of epoxy primer, the wraparound sleeve shall be entirely wrapped around the pipe within the stipulated time recommended by the Manufacturer. Sleeve shall be positioned such that the closure patch is located on one side of the pipe at 10 or 2 O'clock position, with the edge of the undergoing layer facing upward and an overlap of minimum 50 mm. Gently heat by appropriate torch the backing and the adhesive of the closure and press it firmly into place. A heat shrinking procedure using heating torch or induction heaters shall be applied to shrink the sleeve in such a manner to start shrinkage of the sleeve beginning from the centre of the sleeve and heat circumferentially around the pipe. Continue heating from the centre towards one end of the sleeve until recovery is completed. In a similar manner, heat and shrink the remaining side. Shrinking has been completed when the adhesive begins to ooze at the sleeve edges all around the circumference and change in the visual indicator / other means provided on the backing material, to signify proper shrinkage, shall be complete and uniform. The complete shrinking of the entire sleeves shall be obtained without undue heating of existing pipe coating and providing due bonding between pipe, sleeve and pipe coating. The installed sleeve shall not be disturbed until the adhesive has solidified.

➢ Visual Inspection

The inspection of the joint shall be done after the cool down of the sleeve and the substrate to ambient temperature. The sleeve shall be visually inspected for the following:

- ✓ The weld bead profile contour shall be visible through the sleeve.
- ✓ The ends of the sleeve shall be firmly bonded to the mill coating.
- ✓ There shall be no upstanding edges.
- ✓ Adhesive flow shall be evident at both edges of sleeve around entire circumference of pipe sleeve.
- ✓ The sleeve shall be smooth; there will be no dimples, cold spots, bubbles, punctures, burn holes or any signs of holidays.
- ✓ There shall be no signs of entrapment of foreign materials in the underlying adhesive.
- ✓ Sleeve shall overlap minimum 50mm onto the adjacent PE line coating on each side of joint.

➢ Holiday Testing

Metal objects such as pipelines, reinforcing bar (rebar), storage tanks or structural steel are normally covered with a protective coating to prevent corrosion. Holiday detectors are used to inspect these coatings for pin holes, scratches or other coating faults. They work by generating a voltage high enough to jump a gap that is longer than the thickness of the coating. A holiday detector simply applies a voltage to the outside of the coating. With the pipe connected to ground and with the holiday detector connected to ground, a hole in the coating will cause a spark to jump or ―arc‖ from the electrode to the pipe to complete the circuit. When a complete circuit is formed, a signal is activated on the Holiday Detector.

Figure Holiday

Figure Holiday Testing

The entire surface of each joint shall be inspected by means of a full circle holiday detector set to the DC voltage of 25KV.Inspection of the sleeves shall be carried out only after the joint has cooled below 50ºC and prior to lowering-in operations. The holiday detector shall be calibrated using a DC voltmeter. Calibration shall be performed at the commencement of each operational day and then again after a maximum of 4 hours during the shift.

2.4 Coating Thickness Testing

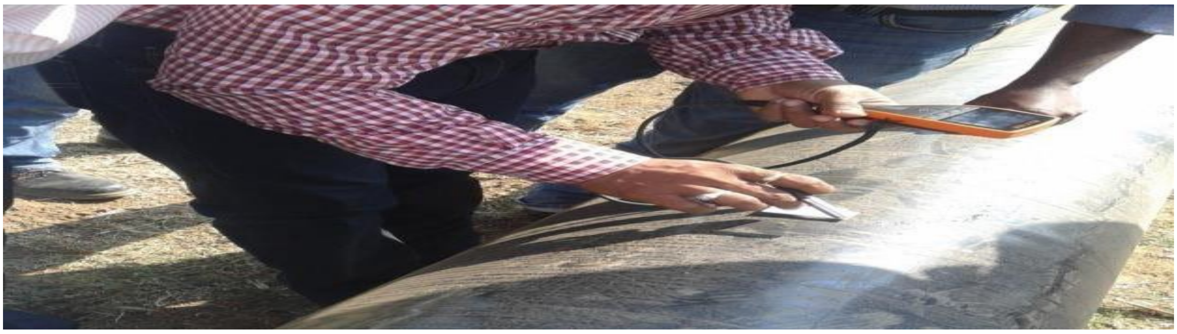

Figure Coating Thickness test

Coating thickness shall be checked by non-destructive methods for each field joint. Average thickness of the as-applied coating on pipe body shall be established based on measurements at minimum eight locations i.e. four measurements on either sides of the girth weld at 3, 6, 9 and 12 O'clock positions. To establish the minimum thickness on the girth weld, four measurements shall be taken on apex of the weld.

2.5 Adhesion Peel Strength Test

One out of every 50 joint coating or one joint coating out of every day's production, whichever is stringent shall be tested to establish the peel strength on steel and factory applied coating. From each test sleeve selected as above, one or more strips of size 25 mm x 200 mm each for peel strength on steel and factory applied coating, shall be cut perpendicular to the pipe axis. Manually remove the first 20-30 mm of the leading edge of the strip by using a screwdriver or chisel, make sure that the initial adhesive bond line cut is essentially centered within the adhesive layer or towards the epoxy primer layer. Attach the peel gauge to the leading edge of the test strip and fasten clamp. Holding the peel test gauge with both hands, peel at angle of 90° to the circumference of the pipe. Note the pull value on the Peel test gauge.

Figure Peel Test

The peel strength of the coating in N / mm is the pull value in Kg x 9.81/ 25. The peel strength value shall meet the requirements of this specification as applicable for 23ºC or 60ºC whichever is feasible. The table below indicates the Peel Values of HTLP 80 HP Heat Shrinkable Sleeves at various temperatures.

After removal of the strip, bulk of the adhesive shall remain adhered to the pipe showing no bare metal. The adhesive layer that remains on the pipe surface shall be free of voids resulting from air or gas inclusion. A void is considered as an air bubble in the adhesive where the substrate (steel or overlapped factory coating) has been exposed or where the underside of the PE backing on the pulled strip is exposed. In the event of failure of any test, two sleeves immediately preceding the failed sleeve shall be destructively tested.

- Should both sleeves pass, the test rate be increased to one out of every twenty-five sleeves until Engineer-In-charge is satisfied and subsequently the test rate can be restored to one out of fifty sleeves as above.

- Should either or both sleeve fail, coating activities shall cease and testing shall continue until the subject sleeve passes the test and the investigation is satisfactorily concluded.

2.6 COATING DEFECTS

2.6.1 Disbondment from Edges.

Figure 15 Coating defect

- Insufficient heating of the sleeves on the pipe overlapping. Action to be taken: Extra heating to be done on these areas for 5-10 sec and finger test to be done on each joint to ensure the sufficient heating.
- Insufficient/Excess blasting on factory coating. Action to be taken: only Sweep blasting to be done on factory coating with minimum on 1 inch overlap on both sides of sleeve.

2.6.2 Adhesion Failure

Figure Adhesive failure

Adhesion is a measure of the degree of attachment between the coating and the pipeline steel with which it is in contact. The adhesion is a force that keeps the coating on the steel surface. Adhesion may be caused by chemical, physical, and mechanical interactions. When

these interactions are diminished, the coating loses its adhesion. It is caused by coating applied to a contaminated surface, wrong surface preparation specified, failure to inspect surface preparation, insufficient surface profile, exceeding the topcoat window, application of incompatible coatings, applying a coating to a glossy surface.

2.7 REPAIR TO DAMAGED 3LPE

2.7.1 Criteria for Repair

➢ Damages caused to coating during handling such as Scratches, cuts, dents, gouges, even if not picked up during holiday test and having a total reduced thickness on damaged position not less than 2.0mm and an area not exceeding 20cm2 can be rebuild by Heat Shrink Patch without exposing to bare metal.

➢ Damages of size exceeding above mentioned area or holidays of width less than 300mm can be replaced with Heat Shrinkable Repair patch by exposing the bare metal surface

- Defects exceeding the above and in number not exceeding 2 per pipe and linear length not exceeding 500mm can be replaced using Heat Shrinkable sleeves.

2.7.2 Repair Material

- The repair can be carried out using Repair patch made of radiation cross linked Polyolefin backing, coated on the inside with Semi-Crystalline thermoplastic adhesive and Filler mastic. Expired, Deteriorated materials cannot be used for repairing. Materials are stored in sheltered storage and in manufactures original packing away from direct sunlight.

2.7.3 Repair Procedure

- Repair of defects resulting in Holiday Test
  - Coating from defect area should be removed using a Knife, scraper, or power brush. Area should be cleaned to remove oil, grease, rust and moisture

CHAPTER-3

HYDROSTATIC TESTING

The section of the pipelines shall be tested as a single string. All welded joint shall be exposed and should be cleaned properly from rust and other foreign materials. The section of the pipeline section for the crossings shall be tested as a single string. The minimum hydrostatic test pressure shall be 1.4 times of the design pressure for gas pipeline. The combined equivalent stress in the pipeline due to bending and test pressure shall not exceed 90% of the SMYS of the pipe material. The test section shall be visually examined for leaks/ defects etc.

3.1 EQUIPMENT FOR HYDROTESTING

- Water Feeling Pump
- Tank
- DG Set
- Boring Pump
- Dozing Pump
- High Pressure Hydraulic Plunger Pump
- Thermocouple

3.2 Inhibitors

- The pH value of the test water shall be adjusted to a value of between 6.5 and 7.5 by the addition of suitable chemicals. No other inhibitor shall be added to the test water provided the water does not remain in the pipeline longer than 1 month.
- Inhibitors shall be uniformly mixed with the test water in the dosage recommended by the Manufacturer, and in sufficient concentration to ensure the inhibitor remains active for the duration of the test, and any possible delays to testing.

➢ An oxygen scavenger chemical and a biocide chemical shall also be added.

Figure Inhibitor

3.3 HYDROTESTING

- A hydrostatic pressure test of entire pipeline and the attachment to the pipeline using fresh Potable water or close with adequate quantities of corrosion inhibitors depend upon quality of water. The entire pipeline shall be hydrostatically tested at minimum 168.0 bar (g) test Pressure. The maximum test pressure shall not be higher than the one resulting in a hoop stress corresponding to 95% of SMYS of pipe material based on the minimum wall thickness in the test section.
- Gauge plate of 95% ID and 10 mm thickness shall be passed through the section after cleaning of the pipe.
- Gauge plate with < 2 mm scratch on side wall and with no dent is acceptable.
- Checking the condition and sequence of pigs in the hydrostatic header.
- Instrument and equipment to be used are with valid calibration and of required rating.
- Water testing certificate and corrosion inhibitor dosage recommendation available.

- Only qualified welder is allowed to performed welding of header.
- Check rating and condition of header fittings.
- Use the feeling water from tested water source only.
- Fill 500 mtr. Of water before first pig and 1000 mtr water between first and second pig.
- Final feeling shall be done with fill rate of 2 km/hrs.
- After receipt of pig at receiver minimum 2 hrs. Water flushing shall be ensured.
- Turbine meter reading recording shall be preserved.
- Thermal stabilization for 24 hrs. shall be done and section is said to be thermally stabilized if discrepancy not higher than 1 degree is attained between the average value of soil temperature readings.
- Pressurize the section not more than 2 bar/min rate

Following Sequence mention below

a) Pressure the pipe section to 50% hold for I hr.

b) Drop 0.5 bar do air volume calculation.

c) Drop pressure to static +1 bar.

d) Follow b & c for 75% pressurization.

e) If air volume calculation value is between 1 to 1.06, then filling is accepted.

- Pressure the pipe (depending upon pipe section profile) and hold it for 24 hrs.
- Use DWT and recording system during testing.
- The test is considered acceptable if discrepancy is less or equal to 0.3 bar in case of doubt testing period shall be extended.

= **Theoretical Quality of Water (V_p)** = $(0.884 \times R_i/t_i + A) \times 10^{-6} \times V \times \Delta P \times K$

3.5 Thermal stabilization

- After a check has been made to confirm if the pressure has attained at least 1 bar (g) at the highest section, the thermal stabilization can be started.
- Thermal equilibrium between the pipeline and environment shall be checked through the thermocouples installed on the pipeline.
- Temperature readings shall be made at every 2 hours interval. When a discrepancy not higher than 10C is attained between the average values of the last two readings, thermal stabilization shall be considered as achieved.

Figure Thermo- couple

3.6 Air Volume Calculation

- In order to check the presence of air in the pipeline, two separate consecutive pressure lowering of 0.5 bar shall be carried out after pressurising to 50% & 75% of test pressure.
- For calculation of air in the pipeline, the second pressure lowering shall be used and the relevant drained water shall be accurately measured (V1). This amount measured shall be compared to the theoretical amount (VP) corresponding to the pressure lowering that has been carried out.
- If no air is present in the length under test, then V1 / VP = 1
- In order that the above ratio is acceptable, it shall not differ by more than 6% (i.e. 1.06). If the air found in the pipeline is within above established tolerance, then the pressurising can continue. If the ratio of VI / VP exceeds 1.06, the hydrostatic testing cannot go on and additional pig passages shall be performed to remove the air pockets.
- The test shall be repeated as per the above procedure until above estimated tolerances are satisfied. The pressurising can then continue to reach the test pressure.

Figure Lowering of water

3.7 Pressurisation

- The pressurization shall be performed at a moderate and constant rate not exceeding 2 bars/min
- One pressure-recording gauge shall be installed in parallel with the dead weight tester.
- Volume required to reach the test pressure shall be recorded using a dead weight tester periodically throughout the pressurization as follows.

➢ Each 5 bar increments up to 80% of test pressure

➢ Each 2 bar increments between 80% to 90% of test pressure

➢ Each 0.2 bar increments between 90% of the test pressure to full test pressure;

The pressurisation shall be cycled according to the following sequence

- pressurisation shall be cycled according to the following sequence:

➢ Pressurise to 50% of test pressure, hold for 1 hour,

➢ Drop pressure to static head of test section at test head

➢ Pressurise to 75% of test pressure, hold for 1 hour

➢ Drop pressure to static head of test section at the test head

➢ Pressurise to test pressure

During the pressurization to each test pressure, two tests shall be carried out for the calculation of air volume in the pipeline under test. Air volume shall be calculated as detailed subsequently. In case, during the hold periods, a decrease in pressure is observed, the above operations shall not be repeated more than twice, after which the line shall not be considered capable of test, until the reason for that is sorted out.

Figure Crystal gauge

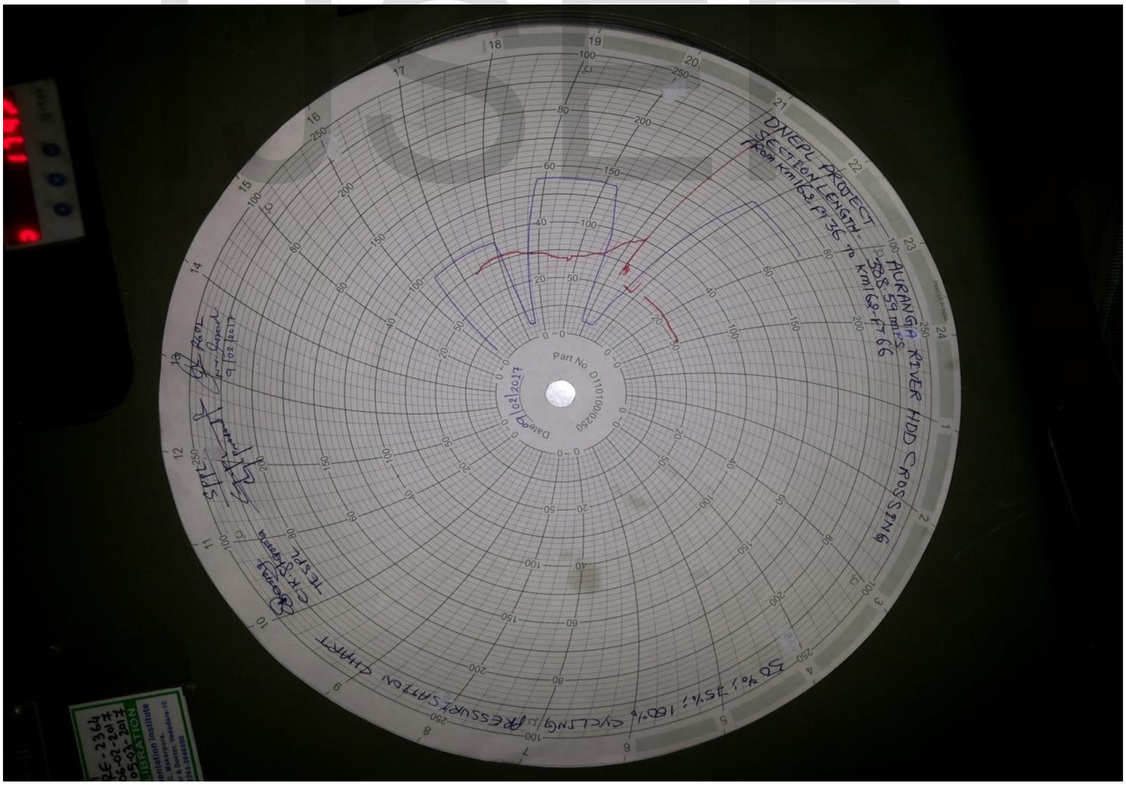

Figure Recording Graph

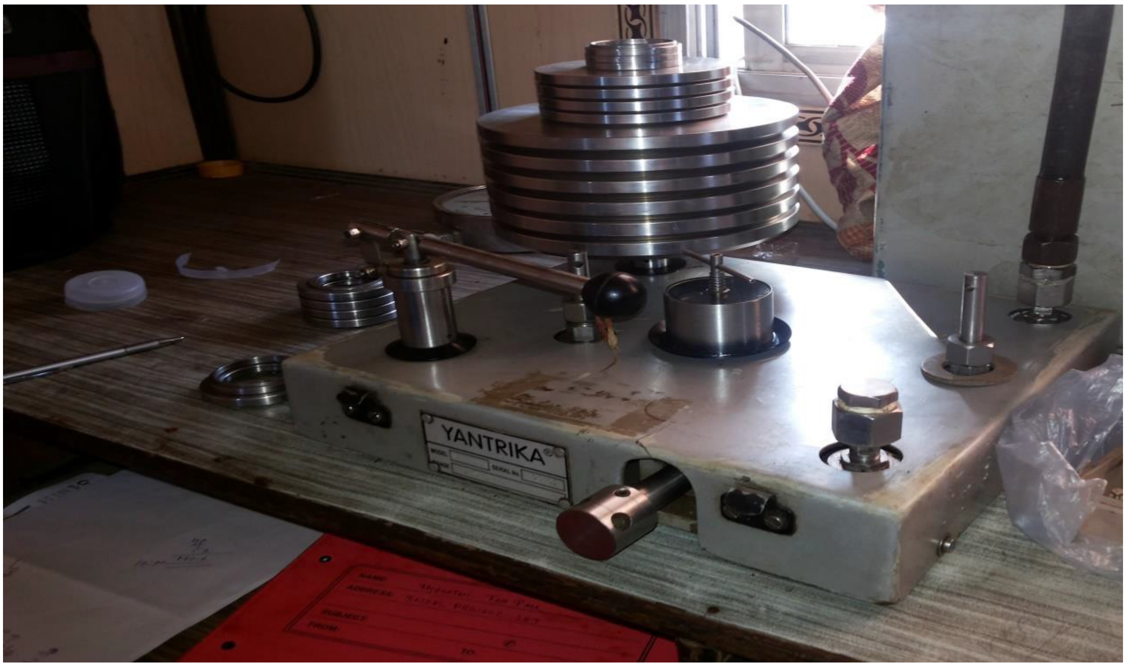

Figure Dead weight tester

Dead weight testers with an accuracy of 0.01 bar, measuring in increment of 0.05 bar and provided with a calibration certificate not older than one month.

3.8 SAFETY PRECAUTIONS DURING THE HYDROTEST

Safety requirement is very important as the line tested is at high pressure during testing. As a minimum, the following shall be taken during the hydrostatic test:-

- Such areas shall be suitably fenced in such a way as to prevent access of unauthorized personnel and no unauthorized personnel shall be closer than 40 m to the testing equipment or pipeline under test.
- Warning signs stating ‖PIPELINE UNDER TEST-KEEP OFF‖ with local language translation shall be placed where the pipeline is uncovered.
- Warning tapes and signboards shall also be placed near the crossings and regular intervals along the route to warn the public around those areas.

- Provisional scraper traps shall be installed in compliance with methods and suitable location so that their rupture cannot cause any injuries to the personnel or third parties.
- The test station shall be placed in such a location as to prevent it from being affected by a catastrophic failure in the test head.

CHAPTER-4

4.CROSSING

4.1 Types of Crossing

Various types of crossings are mentioned below: -

Foreign Pipeline Crossings

A plastic grating / mat/ concrete slab shall be laid between the existing and proposed pipeline at minimum 200 mm from proposed pipeline.

- Buried Pipeline
- Above Ground Pipeline
- Road Crossings

Water Body Crossings

- Nala / Stream crossing – single sag
- Nala / Stream crossing – double sag
- Major Water course crossing

Road Crossings

4.2 Method of crossings

Crossings are done by the following methods:-

- Open Cut Crossings -not good, traffic disturb, bypass, layer backfilling.
- Bored Crossing - Auger boring method, Usually cased crossing, Casing pipe-conduit 6 inch larger installed while boring, shaft of auger inside, casing insulators Vent & drain Pipe are also provided.

LITERATURE REVIEW

4.3 Description of HDD

Horizontal directional drilling is a trenchless construction method utilizing equipment and techniques from horizontal oil well drilling technology and conventional road boring. HDD construction is used to install Petroleum pipelines (Steel or plastic), fiber optic and electric cables, and water and waste water pipelines where conventional open trench construction is not feasible or will cause adverse disturbances to environmental features, land use or physical obstacles.

HDD technology is used in many situations, including, the following:

Lake crossings;

Wetland crossings;

Canal and watercourse crossings;

Valley crossings;

Sensitive wildlife habitat;

Road and railway crossings

HDD installation involves four main steps:

1. Pre-site planning;
2. Drilling a pilot hole;
3. Expanding the pilot hole by reaming; and
4. Pull back of pre-fabricated pipe.

The following summarizes the main activities that take place during each phase of an HDD. Drilling of the Pilot hole and pipe string pull hack are illustrated on.

4.3.1 Pre-Site Planning:

A determination is made as to whether an HDD is technically and geotechnical feasible by studying existing geological data and conducting field investigations to assess the subsurface. Conditions and characteristics likely to be encountered during the drill. If an HDD is determined to be feasible, a drill path is designed to meet the requirements of the crossing and appropriate drill entry and exit locations are selected An allowance is made in the design of the drill path for any potential changes in the obstacle (i.e., stream migration or cutoff development) to be drilled under and the drill entry and exit points are refined.

4.3.2 Drilling the Pilot Hole:

An HDD drill rig and supporting equipment are set-up at the drill entry location determined during the pre-site planning phase, A pilot hole is drilled along the predetermined drill path. Periodic readings from a probe situated close to the drill bit are used to determine the horizontal and vertical coordinates along the pilot hole in relation to the initial entry point; the pilot hole, path may also be tracked using a surface monitoring system that determines the down hole probe location by taking measurements from a surface point. Drilling fluid is injected under pressure ahead of the drill bit to provide hydraulic power to the down hole mud motor (if used), transport drill cuttings to the surface, clean buildup on the drill bit, cool the drill bit, reduce the friction between the drill and bore wall, and stabilize the bore hole.

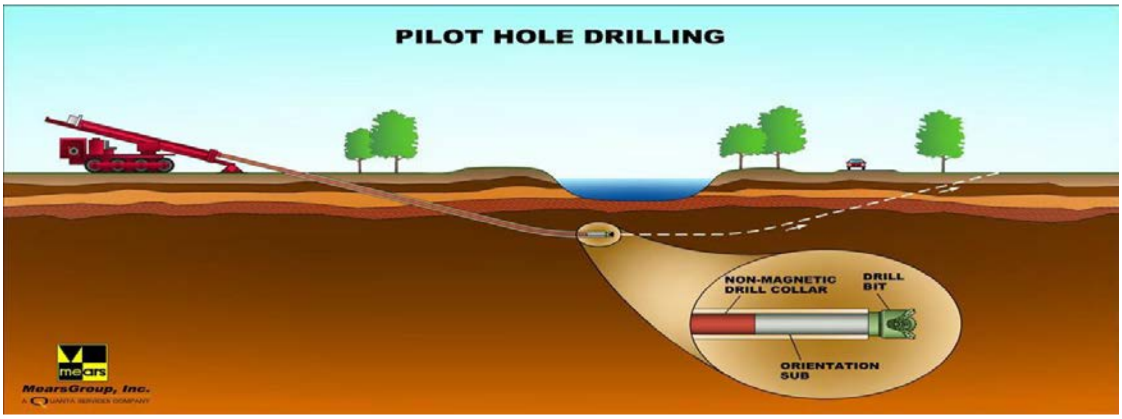

Figure Drilling Pilot hole

4.3.3 Reaming of the Pilot Hole:

The down hole assembly is removed from the drill string upon breaking the ground surface at the exit location and is replaced with a back reamer: The drill string is pulled back through the bore hole and the back reamer enlarges the diameter of the drill hole; The reamer may be pulled from the pipe side of the HDD crossing if additional passes with the reamer are required to achieve the desired bore hole diameter; and The reaming stage may not be necessary during HDDs for small diameter pipelines where the bore hole created by the pilot hole drill is of adequate size to pull back the pipe string.

4.3.4 Pipe String Pull back:

Pipe is welded into a pipe string or drag section, that is slightly longer than the length of the drill, on the exit side of the bore hole. The pipe is typically coated with a corrosion and abrasion resistant covering, and is commonly hydrostatically pretested to ensure pipeline integrity. The pipe string is pulled over rollers into the exit hole and the pullback continues until the entire pipe string has been pulled into the bore hole. The external coating of the pipe string visible at the entry point is inspected for damage upon completion of the pull back. An internal inspection of the pipe string is performed to identify any damage done to the pipeline during the pull back. Upon successful pull back of the pipe string, the drilling equipment is dismantled and demobilized. The pipe string is connected to the conventionally laid pipeline and work areas are reclaimed with the rest of the pipeline right-of-way.

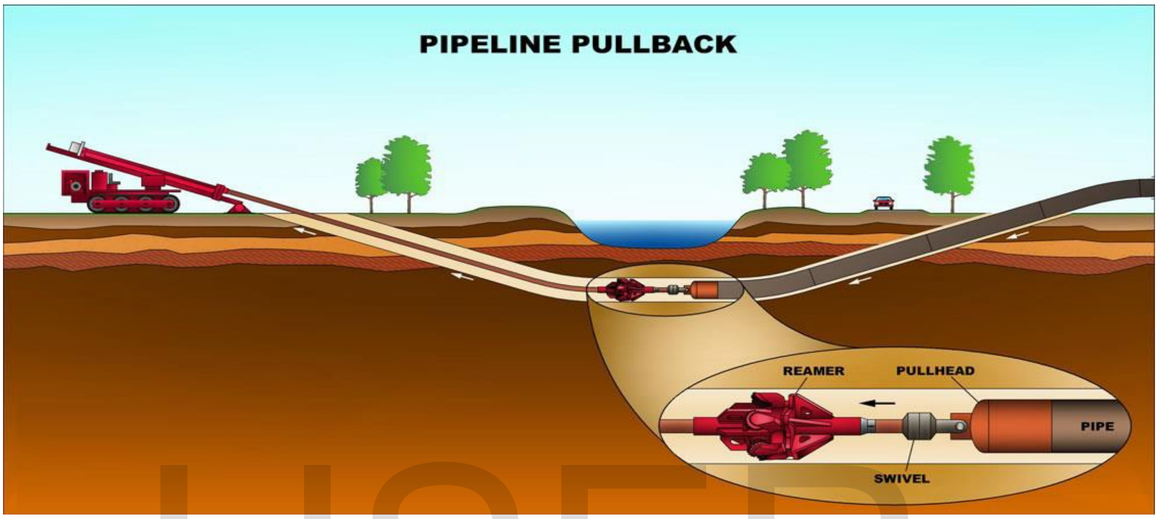

Figure Pipe string Pull back

4.3.5 Factors influencing HDD as the Preferred Crossing Method:

The decision to install an HDD crossing at a specific location is the result of a process that addresses the following issues like:

4.3.6 Pipeline Route Selection:

The selection of a preferred crossing location based on an overland pipeline routing assessment should also consider the method of crossing, alignment and access for the HDD construction. The pipeline routing should allow for layout areas, entry/exit pads, access routes, and minimal points of inflection in the design drill path and the pipe string layout area.

4.3.7 Crossing Location Selection:

The selection of the crossing should be undertaken in conjunction with the route selection to allow the following:

- Flexibility in using various crossing methods, especially if the HDD fails and an alternative crossing technique is required
- Flexibility to use various accesses or vehicle crossing methods
- Flexibility in refining the exact crossing location in the event that constraints prevent certain alignments.

4.3.8 Crossing Method Selection:

In selecting a pipeline crossing method many factors must be taken into consideration. These include, among others:

- Pipeline diameter
- Project schedule
- Watercourse crossing width, depth and flow
- Environmental sensitivity and associated constraints
- Geotechnical concerns
- Substrate composition
- Hydrological data
- Costs of the various alternatives
- Navigation
- Amount of working space
- Regulatory requirements and conditions including timing constraints
- Equipment availability
- Contractor expertise
- Downstream water users

- Landowner and community issues
- Engineering constraints
- Construction season.

The selection of a crossing method is an exercise in striking, a balance among the considerations listed above to derive the most practical solution. The method that is preferred is usually that which is geotechnical feasible and offers the required level of environmental protection for the lowest cost. Selection of an HDD crossing when other methods are more cost effective, technically feasible and offer sufficient environmental protection may be inappropriate. If an HDD is the strongly preferred method by regulators and this method is considered to have a low likelihood of success or is otherwise impractical, the regulators should be provided detailed information on the crossing method selection process and the rationale for the rejection of the HDD method.

4.4 Other Selection Issues:

Assuming that HDD has been selected as the preferred crossing method, the following other selection issues must be evaluated

4.4.1 Access:

Pipeline routing and drilling execution planning should consider that access to both sides of the drill will be required during the HDD construction process. If adequate access to the crossing cannot be provided on both sides of the watercourse and the watercourse is suitable for the installation of a crossing structure, a temporary crossing structure may need to be installed for vehicle and equipment traffic. As with the selection of the crossing method, selection of the vehicle crossing technique also involves striking a balance between many of the same considerations listed above for crossing method selection to derive the most practical solution. The technique that is preferred is usually one which offers the required level of environmental protection for the lowest cost. Access will also be required:

- To a water Source during the installation of the HDD
- For monitoring of the drill path
- During clean-up operations in the event of a drilling fluid release to surface.

Sediment and erosion control protection plans may be warranted to ensure that access creation or use do not result in adverse effects.

4.4.2 Drill Entry and Exit Site Selection

The selection of the drill entry and exit locations will need to consider the following:

- The terrain must be cleared leveled and suitable for the work (sites with negligible longitudinal or side slopes are preferred)
- Entry and exit location should be of sufficient size and configuration to undertake the work safely : this should include consideration of
- Drill rig entry and points (note that generally the entry point should ideally be at an equal or lower elevation than the exit point)
- Rig size and layout requirements
- Pipe lay down area or false night-of-way (note that a straight approach to the exit point is preferred to avoid the need for false right-of-way)

4.4.3 No Drill Zone:

A No Drill Zone can be identified that addresses geotechnical issues and concerns at the proposed crossing site. As defined by the -geotechnical engineer, the No Drill Zone is the upper limit of potential drill paths between specified entry and exit locations, intended to ensure that the bore is maintained within geological materials suitable for an HDD while providing sufficient cover to mitigate potential inadvertent return concerns.

As detailed in next section, definition of the No Drill Zone for a proposed HDD crossing is influenced by a number of factors, including:

- Crossing area terrain conditions, in terms of the discrepancy in elevation between entry and exit locations and along the HDD alignment, that determine, in large part, the minimum recommended depth of cover
- Subsurface soil and bedrock stratigraphic conditions, and the suitability of the various units for directional drilling
- River engineering considerations, including depth of scour during the design flood event and potential for bank/meander migration and cut of development.

The presence of active, inactive and potential landslide features, and other geotechnical ―problem‖ areas, which should be avoided by the design drill path. All potential drill paths should be designed to pass outside of the No Drill Zone. While the No Drill Zone is typically defined in terms of geotechnical considerations, it may also be influenced by environmental and socio-economic concerns, such as wildlife concerns, rare plant occurrences, social resources (e.g. land use) and Cultural resources (e.g., archaeological sites) etc. Specific studies may be necessary to identify the presence of these environmental and cultural features. Relocation of the entry and/or exit point, thereby altering the length of the design drill path, may provide a means of mitigating some of these non-geotechnical concerns.

4.4.4 Water Source:

The availability of a water supply to the HDD site should also be considered during the planning stage of the project, Water will be required for the following:

- Initial drilling fluid make-up
- Additional drilling fluid as the drill progresses.

- Replacement fluid for drilling fluid escaping into the formation due to seepage or hydraulic fracture
- Pretesting, where warranted, of the pipe string.

Hydraulic fractures can greatly increase the water requirements during an HDD project. Water can be pumped from a water body to the drill site or hauled to storage tanks onsite.

Factors to be considered in selecting a water supply are:

- Access to the water body
- Flow restrictions
- Regulatory approval
- Construction schedule (i.e., air temperature, anticipated stream flow/volume and water quality).
- Physical limitations such as the distance or elevation of the entry point from the water body.

4.5 Engineering Design Considerations:

Various factors to be considered before doing a HDD crossing are:

4.5.1 Geotechnical Study

The most important aspect of a HDD crossing is the degree of effort taken to study the geotechnical aspects of the planned crossing. A comprehensive assessment of the underground conditions such as soil type, rock type, and their location relative to the planned drill crossing is required in order to properly design the crossing and ensure its success. Air photos, topographical maps, geological maps, previous job histories (road cuts, bridges, and other crossings), hydrology, and geological analysis are some of the tools used to study the intended crossing. Typically vertical exploration holes are made to retrieve core samples which are used to assess the extent and depth.

underground conditions.1 It is important that the depth of the exploration holes is at least 10-15m below the intended drill path and that a sufficient number of holes are made to adequately define the underground conditions.

4.5.2 Design of Drill Path:

The design of the drill path should consider all of the information gathered from the crossing area. The physical limitations of the site as well as geotechnical, environmental (fish. wildlife. vegetation, land use, cultural and hydrological information should be considered in the preparation of the drill path design.

4.5.3 Radius of Curvature

The design of the drill path and selection of pipe must consider the following:

- The radius of the curves in the drill path.
- The exit and entry angle.
- The radius of the arc of the drill path should consider the diameter of the pipe to be installed.

The diameter of the pipe to be installed in meters multiplied by 1200; or The pipe diameter in inches multiplied by 100 to obtain a radius of curvature in feet. This formula is used of the ensure a conservative radius of curvature that will allow for the easy installation of the pipe and minimize the bending stress on the pipe. If the pipe is smaller than the drill string, the larger pipe size shall be used in the minimum radius calculations. This will ensure that the drill pipe will not be overstressed and the drill can proceed as planned. In most applications, the radius of curvature will not be lower than 250 m.

Depth of Cover:

Depth of cover requirements are dependent upon a number of factors such as subsurface conditions, type of drilling equipment, mud pressure (which is a function of the mud pump capacity) and the discrepancy in elevation between the entry and exit points. Depth of cover is a factor used in the development of the No Drill Zone in above section and should be determined by the HDD project team.

Alignment:

Angles in the easement/right-of-way alignment adjacent to an HDD crossing should be minimized. If difficulties are encountered during an HDD, it may be necessary to increase the drill length. Therefore, the entry and/or exit points would need to be moved farther back from the location being crossed. The approach alignment to the HDD crossing needs to allow for the potential need for lengthening of the crossing.

Right-of-Way:

The drill path should be aligned to lie within the right-of-way boundaries. If this is not feasible, new right-of-way must be acquired at a prior to commencement of the HDD. Temporary workspace is typically required at a crossing above and beyond that necessary for conventional pipeline construction. The pipe string will require additional workspace and, where the alignment on the exit side is not straight, additional workspace, typically referred to as false right-of-way, and may be required. This area should be of sufficient length and width to allow the pipe to be welded up and tested along the full length of the pipe string. It is highly recommended that the pipe string be fabricated in one complete section since any stoppage in pulling of the pipe string adds significant risk to the success of the project

Land Issues:

The land issues listed below should be considered during the planning phase of an HDD project;

- Landowner consultation during the routing, and crossing selection process, and when determining a water source for drilling activities.
- Landowner consultation when determining access to the water source.
- Landowner consultation to avoid Conflict with land use practices (e.g., drill in pasture when cattle have been rotated to another pasture or during the winter to avoid the crop year).
- Informing the landowner of HDD processes and applications to avoid potential issues.
- Landowner consent for access across lands not on the right-of-way for monitoring purpose and potential reclamation of inadvertent returns.
- Spills on the entry side and the pipe side of the drill may require reclamation and remediation as well as compensation to landowner and compensation for any habitats lost.
- Trespass off the right-of-way due to inadequate marking of designated work areas or inadequate location or amount of workspace.

4.6 Casing:

Contractors often use a short section of casing that is „dug in" at the start of construction. This casing is intended to prevent inadvertent near-surface returns, and allows for easy monitoring of drilling mud return levels. However, where unconsolidated deposits represent a risk of inadvertent returns on the entry side, the casing may need to be more extensive. The casing can either be driven in with a large hydraulic hammer or possibly, in softer soils, pushed in with the drill rig.

Casing should be of sufficient length to seal into a suitable competent formation such as bedrock or cohesive stiff clay. The casing diameter should be greater than the final reaming pass to ensure down hole tools can easily enter the bottom of the casing throughout the entire drilling operation and pull back. It is preferable to remove any casing at the end of the crossing construction since it will shield the pipeline within the crossing from cathodic protection.

4.7 Coating

Anti-corrosion

An anti-corrosion coating is applied to the pipeline, including any sections to be used for a HDD crossing. The anticorrosion coating is used in conjunction with cathodic protection to provide a corrosion protection system for the steel line pipe. In most cases the anti-corrosion coating has been designed to have some degree of flexibility, impact resistance, good adhesion to the steel substrate, some degree of moisture permeation resistance, and compatibility with the cathodic protection system. The anti-corrosion coating system is applied in a coating plant using an industry standard such as CSA Z245.20- 98.6 Where as a number of coatings will meet the necessary requirements to provide external corrosion protection for the pipeline, they do not necessarily have the mechanical properties to withstand the rigors of a HDD crossing.

Antiabrasion

A variety of anti-abrasion coatings have been developed specifically to protect the anticorrosion coating from mechanical damage. In addition to gouge and wear resistance, it is important to have good adhesion between the anticorrosion coating and the anti-abrasion coating. Flexibility and impact resistance are less of a concern as the pipe is not bent to any significant degree and the coating is not subjected to the same degree of potential impact damage as that encountered by the main line in an open ditch installation. These coating systems and methods for testing their properties will be discussed in more detail later in this project.

CHAPTER-5

Construction Considerations:

5.1 Workspace Requirements:

Workspace for an HDD may require clearing and grading, depending on the entry and exit sites selected for the drill. Since the drill entry location or entry side accommodates the drill rig and supporting equipment, the entry side location requires satisfactory access as well as stable ground conditions to support heavy equipment. Equipment typically found on the entry side of a HDD includes:

- The rig unit;
- Power unit and generators;
- Drill pipe rack and drill pipe;
- Water pump;
- Drill mud supply;
- Drill mud mixing tank;
- Drill mud pump;
- Mud handling and cleaning system

Since the drill exit side is the location for the fabrication of the pipe string as well as where the pipe string is inserted into the bore hole, the workspace required is typically longer to accommodate the pipe string and may require extra temporary work space outside of the right-of-way known as ―false right-of-way‖.

Equipment typically found on the exit or pipe side of the HDD includes:

- Exit mud containment tanks/pits;
- Cuttings settlement tanks/pits;

- Pipe racks and product pipe
- Rollers and pipeline handling equipment;
- Side booms and other heavy equipment; and
- Pipelines, welding.
- Coating and testing equipment.

5.2 Site Preparation:

1. Prior to any alterations to work-site, Contractor shall photograph or video tape entire work area. One copy of which shall be given to CLIENT/RGPL representative and one copy to remain with Contractor for a period of following the completion of the project

2. Contractor shall abide by the common ground alliance, best practices version 1.0 or most recent, unless exceptions are specifically agreed to by CLIENT. Once the locate service has field marked all utilities, the contractor shall verify each utility (including any service laterals, i.e. water, sewer, cable, gas, electric, phone etc) and those within each paved area. Verification may be performed utilizing ground Penetrating Radar, hand dig, or vacuum excavation. Prior to initiating drilling, the contractor shall record on the drawing both the horizontal and vertical location of the utilities off of a predetermined baseline. The Contractor shall utilize the Ground Penetrating Radar over the projected bore path whether utilities are located in the horizontal drill pathway or not, in order to reduce the opportunity of conflicting with any unforeseen obstructions.

3. Work site shall be graded and filled to provide a level working area. No alternations beyond what is required for operations are to be made. Contractor shall confine all activities to designated work areas.

4. Following drilling operations. Contractor will de-mobilize equipment and restore the work-site to original condition. All excavation will be backfilled and compacted to 95% of original density (at a minimum).

5.3 Equipment requirements:

The directional drilling equipment shall consists of a directional drilling rig of sufficient capacity to perform the bore and pullback the pipe, a drilling fluid mixing, delivery and recovery system of sufficient capacity to successfully complete the drill, a drilling fluid recycling system to remove solids from the drilling fluid so that the fluid can be re-used, a guidance system to accurately guide boring operations, a vacuum truck of sufficient capacity to handle the drilling fluid volume, trained and competent personal to operate the system. All equipment shall be in good, safety operating condition with sufficient supplies, materials and spare parts on hand to maintain the system in good working order for the duration of this project.

5.3.1 Drilling Rig:

The directional drilling machine shall consist of a power system to rotate, push and pull hollow drill pipe into the ground at a variable angle while delivering a pressurized fluid mixture to a guidable drill (bore) head. The power system shall be self-contained with sufficient pressure and volume to power drilling operations. Hydraulic system shall be free of leaks. Rig shall have a system to monitor and record maximum pull-back pressure during pull-back operations. The rig shall be grounded during drilling and pull-back operations. There shall be a system to detect electrical current from the drilling string and an audible alarm which automatically sounds when an electrical current is detected.

Figure Drilling Rig

5.3.2 DRILLING FLUIDS RECYCLING SYSTEM

Drilling fluids recycling system is also a mixing system, and includes a centrifugal mixing pump, mixing hopper and mixing jets located on the bottom of the tanks/compartments to keep the drilling fluid agitated. As clean drilling fluid is returned to the drill via a centrifugal charge pump during drilling operations, drilling fluids return from the entry and/or exit pit are picked up via a trash pump and discharged over a scalping shaker that makes the initial coarse cut, removing large drill solids that can either settle to the bottom of the tanks or cause plugging problems with hydrocyclone.

Drilling fluid from the scalping shaker drop into a compartment under the scalping shaker and is picked up by a centrifugal pump and fed into a series of hydrocyclones that utilize the centrifugal force of spinning fluid to remove finer cuttings.

The hydrocyclone underflow discharge of fine cuttings also include a significant amount of liquid, therefore, the material is discharged on to a vibratory screening deck (shaker) equipped with ultra-fine screens in order to facilitate the recovery of additional drilling fluid and provide a dry discharge of drill cuttings. The combination of hydrocyclones mounted over a shaker is commonly referred to as a mud cleaner.

Drilling fluids recycling systems should be sized to handle at least one and a half times the maximum pumping rate of a drill‘s circulating system in order to maintain a clean drilling fluid and to minimize wear on the rigs drilling fluids circulating equipment (especially the reciprocating pump). When in operation, drilling fluid from the clean compartment should cascade back into previous compartments (lower bypass gates should always be closed during recycling).

5.3.3 Main System Components

1. Linear Motion Shakers

   a 1-Double deck shakers

   b 2-Mud Cleaners

2. Desander 2 – 12‖ Cones

3. Desilter 12 – 5‖ Cones

4. Centrifugal Pumps

a. 30HP Desilter

b. 30HP Hopper/Mud Gun

c. 30HP Transfer

5. 3-Mud Mixers

6. Mud Hopper

7. Main Control Panel

8. Low & High Level Alarm &Lamps

9. Auto Transfer Function

10. 2-175 Watt area lights

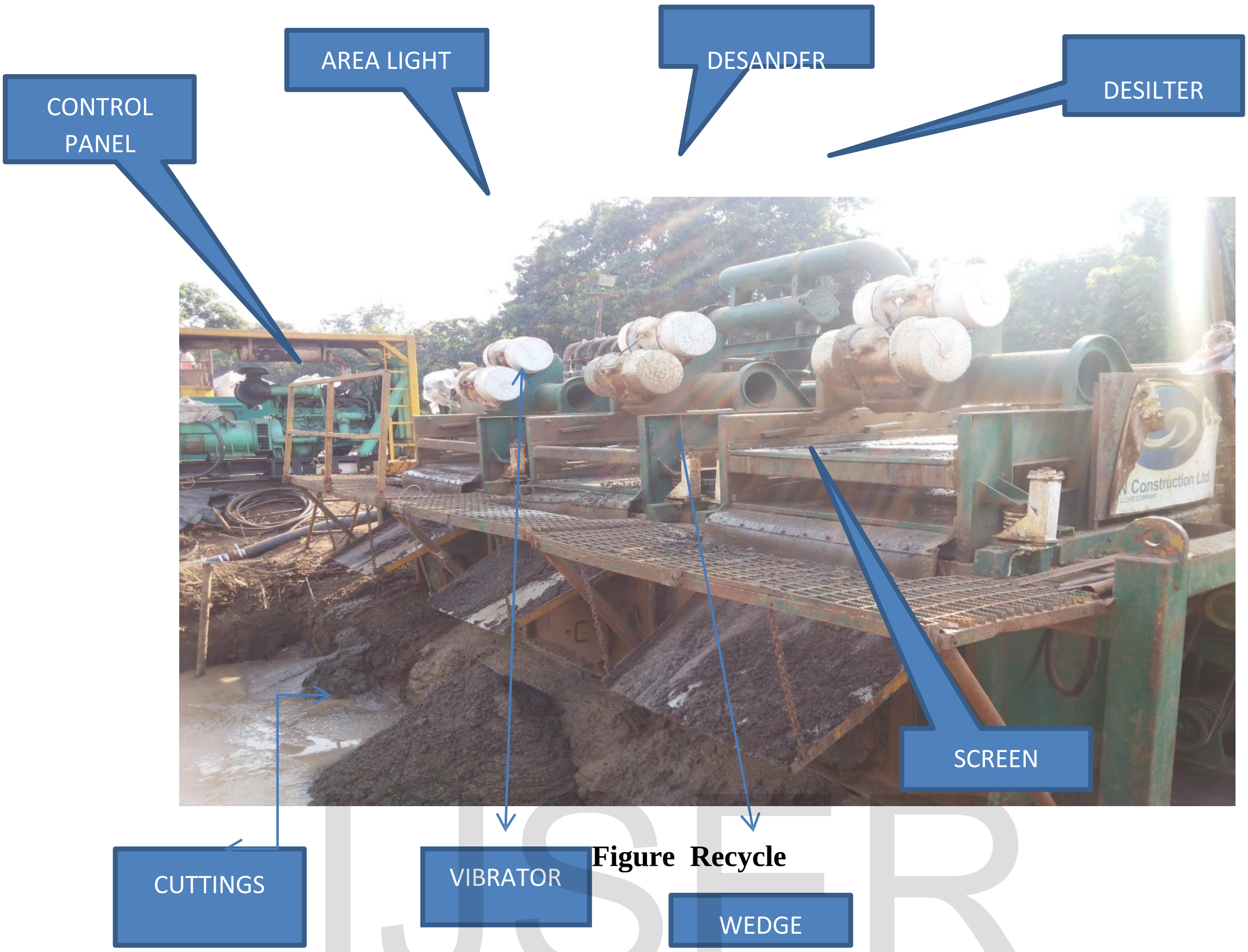

Figure Recycle

The following flow description

1. Fluid from the pit is pumped over the upper decks of Flow Line Shaker Desander Shaker 2, and Desilter Shaker 3 multi-functional linear motion shakers

2. The underflow from the shakers, by way of a central trough,is diverted into compartment 1 Dirty Tank 1.

3. The overflow from Tank 1 flows into Tank 2.

4. The fluid from Tank 1 is pumped to the Desander mounted over the Desander Shaker 2 (Mud Cleaner) via Desander Pump.

5. The Desander overflow is diverted into Tank 3.

6. The Desander underflow goes over the deck of the Desander Shaker 2 and its underflow is diverted to tank 3.

7. Fluid from Tank 2 is pumped through the Desilter that is mounted over the Desilter Shaker 3 (Tango Mud Cleaner) via Desilter Pump.

8. The overflow from the Desilter is diverted into Tank 2.

9. The overflow from Tank 2 flows into Tank 3.

10. The Desilter underflow flows over the deck of the Desilter Shaker 3 and its underflow is diverted to tank 1.

11. The solids from all the shakers are discharged out over the side to a solids pit.

12. Clean fluid from Tank 3 is pumped via the Transfer Pump to a separate storage tank or to the triplexpump.

13. A high and Low-Level switch in tank 3 provides a selectable Auto control of the fluid in tank 3 allowing fluid to be transferred when the high-level switch is activated and stop when the low-level switch is activated.

14. Also, the High and Low-Level switches activate high and low-level alert lights and an audible alarm that can be manually silenced.

15. Mud mixers are provided in each tank compartment to agitate the solids and maintain a uniform fluid mixture in each tank.

16. Tank equalizer valves are provided between tanks 1-2 and 2-3. These are normally closed but can be used during various operations.

ISSN 2229-5518

Mixer

They are used to mix water + bentonite powder and polymer. The mixing principle is done either by impeller or by venturi throttle, in both cases the aim is to generate enough shear to end up in a colloidal.

5.3.4 MEASURING PERCENTAGE OF SAND

Figure Sand Measure

The percentage of sand should less than 2

5.3.5 MEASURING VISCOSITY OF MUD

Figure Viscosity Measuring

5.3.6 MEASURING MUD WEIGHT

Figure Mud Weight

5.3.7 MUD MOTOR WORK

Mud motors are powered by drilling fluid referred to as ―drilling mud‖ within the oil industry. The fluid consists of water mixed with bentonite or polymer additives designed to match various soil conditions. The fluid is pumped down through the drill string to the downhole motor, which converts the flow to rotary speed and torque.

Steering a mud motor through rocky strata is achieved with a slight bend in the motor‘s housing in combination with the capability to rotate the downhole motor separate from the drill strings. In order to bore straight, the drill stem is rotated as the drill bit, powered by the mud motor, fractures and breaks the rock. To switch directions, the operator simply stops the rotation of the drill string and positions the bend so the bit is aligned in another desired direction. Thrust is then applied, causing the bore path to change in the direction of the bend. Because the bend angles on a mud motor are fairly small, directional changes are made very gradually.

Figure Mud Motor

5.4 Step by Step Procedure for a HDD Installation:

HDD is a trenchless construction method that involves drilling small pilot hole, using technology that allows the drill to be steered and tracked from the surface. The pilot bore is launched from the surface at an angle between 8 and 20 degrees to the horizontal, and transitions to horizontal as-the required depth is reached. A bore path of very gradual curvature or near-straight alignment is normally followed to minimize friction and to stay within the allowable joint deflection and the allowable curve radius for the pipe. This minimizes the chance of getting the pipeline ―hung up‖ in the soil or damaging the pipe. The pilot hole is enlarged (usually approximately1.5 times the largest outside diameter of the new pipe) by pulling back increasing larger reamers, or reaming heads, from the pipe insertion point to the rig side.

To achieve the appropriate bore path size, it may be necessary to perform several reaming operations. Generally, all reaming procedures prior to the actual product installation are referred to as pre-reams, and the final ream to the product pipe is attached is referred to a, the back ream. After the pre-reams, the pulling head and connecting product pipe attached to the reamer using a swivel, a device that isolates the product pipe from the rotation of the HDD drill pipe. The product pipe is then pulled behind the final reamer back through the horizontal directional drill path to the exit pit on the rig side.

5.4.1 Pilot Hole:

The pilot hole shall he drilled along the path shown on the plans and profile drawings or as directed by the client/RGPL Representative in the field. Unless approved otherwise by CLIENT, the pilot-hole tolerance shall be as follows:

Elevation:

As shown on the plan.

Alignment:

+3 feet and within 1 feet of right-of-way or easement boundary.

Curve Radius:

The pilot hole radius shall be no less than 80% of the maximum bending radius as recommended by the pipe manufacturer of the pipe being installed. In no case shall the bending radius be less than 30 pipe diameters, unless approved otherwise by CLIENT/RGPL.

5.4.2 Entry Point Location:

The exact pilot hole entry point shall be within +5 feet of the location shown on the drawing or as directed by the CLIENT/RGPL Representative in the field.

5.4.3 Exit Point Location:

The exit point location shall be within +5 feet of the location shown on the drawing or as directed by the CLIENT/RGPL Representative in the held.

5.4.4 Limitations on Depth:

If not noted on the plans, 6" steel pipe and smaller shall be installed with a depth of 3 to 5 feet and 8‘‘-steel pipe thru 12" pipe shall be installed with a depth of 3 to 6 feet unless it is required to install the pipe deeper due to utility conflicts. Steel pipe larger than 12" shall be specifically designed by the engineer and approved by CLIENT/RGPL. Where utilities cross under DOT roads, the depth of cover shall comply with applicable DOT permit.

5.5 Water Main and Non-Water Main Separation Requirements:

The minimum separation requirements between steel water main and a non-water main shall be as outlined as per the standard procedure.

5.5.1 Reaming process:

The general ―rule of thumb‖ is to ream the drill hole to 1.5 times the outside diameter including coating and insulation of the pipe to be installed. This diameter will generally provide for an adequate allowance for the installation of the pipe. The multiplier may be reduced for large pipe diameters (>36‖/914 mm O.D.) The number of reaming passes that will be determined by the hardness of the material being reamed and the ability to remove cuttings from the hole .

Consider product pipe and reamer diameter requirements:

Product Diameter Reamer Diameter

- <8‖ Product+4‖
- 8‖to24‖ Product *1.5
- >24‖ Product +12‖
- (2.6.10) Pull Back:

After successfully reaming bore hole to the required diameter, Contractor will pull the pipe through the bore hole. In front of the pipe will be a swivel and reamer to compact bore hole walls. Once pull-back operations have commenced, operations must continue without interruption until pipe is completely pulled into bore hole. During pull-back operations Contractor will not apply more than the maximum safe pipe pull pressure at any time. Maximum allowable tensile force imposed on the pull section shall be equal to 80% of the pipe manufacturer‘s safety pull (or tensile) strength.

1. Torsional stress shall be minimized by using a swivel to connect a pull section to reaming assembly.

2. The pullback section of the pipeline shall be supported during pullback operations so that it moves freely and the pipe is not damaged.

3. External pressure shall be minimized during installation of the pullback section in the reamed hole. Damaged pipe resulting from external pressure shall be replaced at no cost to the CLIENT/RGPL.

4. Buoyancy modification shall be at the discretion of the Contractor and shall be approved by the CLIENT/RGPL Representative. The Contractor shall be responsible for any damage to the pull section resulting from such modifications.

5. In the event that pipe becomes stuck. Contractor will cease pulling operations to allow any potential hydro-lock to subside and will commence pulling operations. If pipe remains stuck, Contractor will notify CLIENT/RGPL Representative. CLIENT Representative and Contractor will discuss options and then work will proceed accordingly.

6. Contractor shall provide a break-away link between the swivel and the pipe or a combination swivel and break link. Break-away link shall be rated at 80% of pipe manufacturer‘s safe pull (tensile) strength. Break pins shall be color coded for easy identification. Contractor shall provide rated break-away link for each material and pipe size(s) for the project.

5.6 Buoyancy Control:

When a drag section is pulled back through the bore, the buoyant weight of the pipe as well as the resulting drag forces between the pipe (pipe coatings) and the walls of the bore will act as resisting forces. The drag force can be severe enough to damage pipe coatings as well as collapse the pipe. Therefore, it is important to determine during the planning phase whether buoyancy control is needed. If buoyancy control is necessary (i.e., for some long and large diameter drills), a buoyancy control plan needs to be implemented.

Typically, buoyancy control is applied by adding water to the drag section during the pullback phase.

5.7 Monitoring and Documentation of HDD Construction:

Monitoring and reporting are critical during an HDD since they provide a log of activities during the process to:

- Provide early identification of issue
- Make appropriate changes
- Provide a basis for mitigation
- Provide a record of decisions and actions to demonstrate due diligence.

It is important to ensure that sufficient records are maintained before, during and after construction to support subsequent reports prepared to satisfy contractor, owner or government reporting requirements. This should include detailed notes and photographs of al l areas monitored.

The following monitoring and reporting activities should be reviewed for appropriateness for the size and complexity of the HDD crossing;

- Inspector daily records - a day-to-day account of the entire construction of the project
- Steering report
- Drilling fluid volume balance report
- Drilling fluid parameters

- Drilling fluid additives list
- Annular pressure modeling and reporting
- Turbidity monitoring report
- Surface monitoring report
- Pull force monitoring
- Inadvertent return report.

5.8 Work site restoration:

1. Access pits and excavation shall be backfield with suitable material, and in a method approved by the owner‘s Engineer/Inspector.

2. The disturbed grass-surface area shall be top soiled, seeded, fertilized, mulched and anchored according the owner‘s specification for construction, Slopes steeper than 1-on-3, shall be sodded. If a final site restoration is not completed within 5 days after completion of the operation, the installation of temporary soil erosion and sedimentation control measures shall be required.

3. Upon completion of the work, the contractors shall remove and properly dispose of all excess materials and equipment from the work site.

4. The permit, including the surety requirements, shall remain in effect for a minimum of one year after completing the work to monitor for settlements of the pavements and or slope.

CHAPTER-6

RISK CONSIDERATION AND LIMITATION

6.1 Risk Considerations:

As with all construction techniques, a degree of risk and unpredictability is associated with the use of HDD applications. It is recommended that a project team be assembled early in the planning and design process in order to identify and assess potential risk, as well as develop plans to-minimize the risks. Although HDD projects vary widely in complexity, most encounter site-specific characteristics that differ from previous projects. The project team may be composed of the proponent: engineering, geotechnical and environmental consultants; the HDD contractor and the pipeline contractor. Close consultation with regulators and land authorities can assist in the acquisition of initial approvals as well as ensure that alternate plans can be readily implemented if insurmountable problems arise. Risk can generally be divided into three types: regulatory risks: construction risks: and operations risks.

Here we will discuss only construction and operation risks.

6.2 Construction Risk

Success of an HDD installation is dependent upon the ability of the project team to minimize the causes of failure. Tile risks associated with each crossing will vary according to many factors. These include but are not limited to:

- Inadequate planning
- Lack of contingency planning
- Inexperienced field personnel
- Overestimation by the contractor in the firm‟s abilities

- Insufficient quantity and size of equipment onsite
- Inadequate knowledge of subsurface conditions

Construction risk on a project can be minimized by ensuring that sufficient planning is conducted and an adequate geotechnical investigation is carried out. Another means of addressing risk on a project is through the type of contract that is used in next section.

6.2.1 Operations Risk:

The risks associated with an HDD installation during operations are generally considerable less than those of a traditional trenched crossing. In particular, the risk of the following problems is minimized or eliminated:

- Maintenance of disturbed banks or stream bed
- Exposure of pipe during peak flow events or due to ice scour
- Damage of pipe due to anchors or other third-party activities.

6.2.2 Increased risks include:

- Pipe is inaccessible for repairs due to depth of cover
- Corrosion due to undetected damage to pipe coating
- Subsidence at entry and exit points
- Visual leak detection is not possible.

6.3 Environmental Considerations:

HDD crossings are often undertaken to minimize the adverse environmental effects at watercourse crossings. Nevertheless, an HDD does not guarantee that all adverse environmental effects will be prevented. Common adverse effects are the result of: Inadvertent returns of drilling fluids into the aquatic, terrestrial or social/cultural environments; and, to a lesser extent, Disturbance of soils, vegetation, wildlife and social/cultural elements arising, from either construction of drill sites, exit areas- access roads and temporary vehicle crossings, or the HDD activity.

6.4 Environmental Protection Plan:

An environmental protection plan (EPP) should be developed by the owner to address mitigate measures to be implemented during execution of the HDD. Environmental protection planning should cover all aspects of the execution of the HDD including land, water and access needs.

The EPP should address the following aspects and be closely linked to the drilling execution plan:

- Notification and approvals
- Identification of environmental exclusion areas to be incorporated into No Drill Zones
- Environmental and social timing constraints
- Equipment inspection and servicing
- Clearing and grading of HDD sites and access
- Erosion and sediment controls
- Monitoring.

In addition to having an EPP, it is essential to have qualified onsite to enact the plan, to handle deviations to the plan and to report events properly to the authorities. Having an environmental specialties or biologist onsite to liaise directly with the DFO habitat biologist or other similar authority can prove useful. Effective communication of unintended events and subsequent mitigation action to the authorities may reduce delays or unwarranted enforcement actions contingency planning, e.g., inadvertent returns, and reclamation.

Contingency Plans:

A site-specific contingency plan should be prepared by the project team for each HDD. A well-designed contingency plan should address the following:

- Equipment and personnel needs for containment and clean-up.
- Emergency response procedures.
- Plans for continuance of drilling or alternative plan.
- Time lines of acceptable response and notification.
- Clean-up methods and plans.
- Regulatory and stakeholder contacts.
- Monitoring plans
- Disposal plans.

Selection of Alternatives:

Alternatives that may be available to allow continued use of an HDD method following an initial failure include:

Down hole cementing to either seal off the problem zone for redrilling or seal off a large portion of the existing bore hole to a point where a new drill path (generally at a lower elevation) call be attempted; note that if reaming is necessary this method may not be successful since any reaming will remove localized cementing. A new drill can be attempted at a steeper entry angle in an attempt to get below the problem area

• The drill can be moved and an attempt made to redrill from a new location (the revised drill path should be reviewed and revised accordingly prior to drilling); and

• The feasibility of conventional (i.e., trenched) crossing methods should be considered if the drill fails; Consult the appropriate protect staff as well as regulatory authorities.

Clean-up and Remediation:

An important decision may be required when developing plans to clean-up an inadvertent release of drilling mud. The decision can involve determination of, whether not clean-up and reclamation of a site will incur greater adverse effects oil the environment than leaving the mud in situ and allow natural processes to reclaim the area. In some situations, a combination of minimal intervention and letting nature take its course can also be appropriate (e.g., re-establishing a channel in a blocked wetland while leaving the wetland to reclaim itself). The determination as to whether to clean-up or not must be made in conjunction with appropriate regulatory and land authorities. In many cases, this decision will be contrary to traditional practices and must be made after thorough examination of the advantages of each.

Clean-up of Returns:

The impacts from „clean-up activities in sensitive environments are dependent upon the level of activity and equipment required to remove the residual drilling mud, terrain and aquatic conditions and season.

Containment:

Several containment measures are commonly used for the uncontrolled release of inadvertent returns . The measure(s) chosen to be used depend upon;

- The anticipated volume to be contained
- Existing access to the site
- Environmental sensitivity of the area contaminated and adjacent areas
- Soil and weather conditions.

Clean-up:

It is important for the owner, contractor, appropriate environmental specialist(s), if warranted, and appropriate regulatory agency to discuss the clean-up goals for a site subjected to an inadvertent release of drilling fluids prior to commencement of cleanup activities. If a net gain is not anticipated as a result of clean-up, alternative measures may need to be implemented.

Limitations of HDD:

The soil mixed with heavy boulders is very difficult to make a bore hole and pull a pipe string because nobody can drill through boulders and make a constant bore. The boulders may move to anywhere to upstream, downstream or to both sides. The movement of the bolders may stop the reamers at reaming for a bore hole or the pipe string will be choke up due to the movement of bolders. In the fine sand conditions, the hole may collapse at the time of reaming or pipe string puling time. It may cause the failure of HDD. In India, the available capacity is maximum 600 tones. It can pull 18‖ diameter pipe upto 4.5km and 24‖ diameter pipe upto 2.5km safely. And if it is HDPE 18‖ pipe it can be pulled upto 7km and for 24‖ upto 5km. All pulling length may vary and it depends upon profile drawing and design calculation.

CHAPTER-7

ECONOMIC CONSIDERATION

7.1 Potential Economic Advantages of HDD:

The development of guidance systems specifically for HDD use has made HDD technology increasingly efficient and, productive. Experience acquired by HDD contractors and operators during the early period of HDD use has resulted in more competent operating directional equipment as well as more knowledgeable contractors. There are several potential economic advantages of employing, HDD construction techniques as opposed to conventional pipeline installation techniques including:

- Increased use of HDD technology has resulted in associated equipment and labour costs being spread over multiple projects, making individual projects more affordable
- High installation performance
- No additional expense arising from closed streets, irrigation canals or railways
- Minimal to non-existent reclamation costs to the obstacle crossed since surface disruption along the alignment drilled is minimized (inadvertent drilling mud release still requires mitigation)
- The need for removal, restoration, monitoring, maintenance mud other long-term costs associated with trench settlement is eliminated through the use of HDD crossings
- Road cuts, which are expensive to restore, are minimized
- HDDs are possible year-round (instream timing restrictions may apply to conventional construction methods)
- HDD can be faster than conventional crossing methods.

7.2 Costs of HDD

The costs associated with an HDD are influenced by;

- Location
- Access
- Environmental setting Geological characteristics
- Obstacle to be crossed
- Required rig size to complete the drill
- Total length of the drill
- Pipe diameter(s) to be installed.

The types of costs associated with HDDs, as with any construction activity, are direct costs, indirect costs and potential risks to the public. Operating and maintenance costs of completed projects should also be considered for HDD Projects.

7.2.1 Direct Costs and Benefits of HDD Applications:

Direct costs are readily identified within the scope of a project and are paid for directly from the budget of a project (i.e., the cost of the project itself). Considerable direct costs are often associated with conventional pipeline construction installation methods. Common costs related to conventional construction methods include:

- Excavating equipment required for trenching
- Labour
- Topsoil and spoil handling
- Backfill costs
- Reclamation and restoration costs.

Where conventional construction impacts traffic volumes, water bodies or environmentally sensitive areas, direct costs are often substantially increased. HDD technology can be used to avoid environmentally sensitive areas, areas of large traffic volumes and water bodies, and minimizes the requirements for moving and handling large quantities of topsoil, spoil and backfill. Consequently, there are often some costs saving advantages over conventional installation techniques. In addition, the costs of using trenchless technology do not increase with depth of cover as dramatically as with conventional construction methods, thereby reducing overall costs.

7.2.2 Indirect Costs and Benefits of HDD Applications:

Indirect costs are tangible and intangible costs which cannot be included in the project costs. Indirect costs accumulated by the proponent on n project depend upon the work site and the issues present or encountered. Factors affecting indirect costs include:

- Traffic obstruction
- Road damage
- Environmental damage
- Air and noise pollution
- Project delay 's
- Social costs.

With the potential to reduce the approval period and construction duration, and as old or reduce overall disturbance, HDD applications appeal to indirect cost reduction by minimizing interference with community activities and operations, and adverse environmental effects. Air and noise pollution may also be minimized due to the often reduced installation time. Traffic obstruction and road damage are avoided, since the roads are not affected on the surface by construction. Safely issues and costs associated with HDD applications may also be less that those related to conventional construction techniques (i.e., open excavation), and fewer people are required onsite of HDDs, reducing the chancing the chance of injury in the workplace.

7.3 Comparison over other trenchless construction methods and Open-Cut construction method:

HDD offers several advantages when compared to other trenchless, construction methods:

- Complicated crossings can be quickly and economically accomplished with a great degree of accuracy since it is possible to monitor and control the drilling operation
- Sufficient depth can be accomplished to avoid other utilities
- In river crossing applications, danger of river bed erosion and possible damage from river traffic is eliminated.
- Requires only a small construction footprint.

7.3.1 Comparison over Open-Cut construction methods:

On the basis of the following points HDD can be compared with open-cut construction methods.

1. Three of the nine cost factors considered indicated open cut to be slightly cheaper than HDD. The averages of the respondents indicate that contractors spend approximately nine percent more on equipment operational costs for HDD than open cut. Material costs more also found to be nearly three percent higher. The engineering service costs on a project are generally expected to be similar for HDD as open cut.

2. The following table indicates that HDD has a significant reduction on the environmental factors. Dust pollution oil an open cut project was found to be almost three times the impact than on an HDD project. Travel effect on the public, effect on business sales, and the impact on the ecological system have considerable advantages when HDD is utilized- It should be noted that HDD scored higher for removal of waste materials. This is due in large part to the fact that it can be difficult to find waste sites

that accept drilling fluid. On open cut projects; however, if soils are removed, disposal of waste materials is usually non-problematic.

3. The next table, which indicates that having a detailed understanding of the soil conditions, is much more critical for HDD. Also, having, the proper information and quantity of existing utilities in the construction area is as important for open cut as it is for HDD. As would be expected, the ground water table and the weather conditions are much more critical oil an open cut project. The impact of surface obstructions for open cut is much important however buried obstructions such as timber and concrete have a greater importance for HDD. Safety issues for both types of construction were surprisingly similar, even though HDD was expected to have a lower rating due to a significant reduction of open trenching and reduction of fatalities.

Advantages

- Significantly reduced construction time:

With the elimination of costly and time-consuming excavation and restoration associated with open trenching, installations can be performed in less time. Additionally, the mobility and quick times of the directional drill reduce costs as well.

- Saves expensive or historic landscapes and structures:

Directional drilling minimizes the need to remove expensive landscaping or endanger historic structures with excavation.

- Eliminates unsightly excavation and trenching activity:

Conventional trenching, operations require many pieces of equipment, all of which contribute to noise and sight pollution on site, as well as litter the environment with spoil pipes and trenches. Only the drill, with a minimal amount of support equipment, is required on horizontal directional drilling projects - and trenches are eliminated.

- Reduced impact on residents and business around construction site:

There is no need to close roads or redirect traffic around the construction site, thus maintaining normal traffic patterns and access to business and residential property

- Reduction in long-term costs associates with settlements:

Installations utilizing directional drilling reduce and in some cases eliminate settlements above the new pipe or conduit. This is particularly advantageous when installations are conducted beneath roads, highways, rail lines and foundations.

- Minimum disruption to road, rail and other service users.
- Minimum reinstatement costs

International Journal of Scientific & Engineering Research Volume 9, Issue 5, May-2018
978
ISSN 2229-5518

CHAPTER-8

CASE STUDY

Kharera River Crossing

Outside Diameter, Do – 323.9mm

Inside diameter, Di – 304.05mm

Wall thickness, T – 9.9mm

Moment of inertia, I - 0.0009 m4 (Calculated)

Weight of pipe in air, Wt -80.37Kg/m

Cross section of pipe, As – 72612.01082/mm2

Modulus of Elasticity, E - 210000 N/m2

Radius of Curvature, – 800 m

Co-efficient of drag, μd – 239N/m2

Mud density, dm -1200 Kg/m3

Proposed length, L -345.42m

Entry angle – 12-degree

Exit angle - 10 degree

Hydro test Pressure, P – 168 bar

Design Pressure, p -114.128Kg/cm2

Weight of drill pipe (9.6m length) – 350Kg

Rig pull back capacity – 400 ton

Co-efficient of friction between soil and pipe, μ- 0.2

Maximum longitudinal stress during installation

- Buoyancy of steel pipe in down hole:

= π/4*Do2* Density of drilling fluid

= .785*(0.3239)^2*997 (Density of drilling fluid= 997 Kg/m3)

Wb = 82.10 Kg/m

- **Total weight of steel pipe in down hole:**

= (Weight of pipe)-(Buoyancy of pipe in down hole)

= 80.37-82.10

= -1.73 Kg/m

- **Buoyancy Force:**

= μF*N

=μ (Buoyancy factor* Proposed length) * g (Where g=9.81, μ=0.2)

=0.2*(1.73*345.42) *9.81

=1172.445 N

- Bending moment:

= EI/R

= 225000Nm

Pulling Force Calculation

- Due to Buoyancy force:

F1= μF*N

= μ(Buoyancy factor * Proposed length) * N

= 0.2*(1.73*345.42) *9.81

= 1172.445 N

- Due to cohesion:

F3= μd*π/2*Do*L

= 239*1.57*0.3239*345.42

= 42002.603 N

- **Pulling force :**

=F1+F2+F3

=1172.445 +858.496 +42002.603

=44033.544N

- **Considering safety factor, drill pipe & Reamer weight**

= 1.5 * pulling force + drill pipe weight + Reamer weight

= 1.5* 44033.544N +350+750

=67700.316 N

= 67700.316 / (9.81*1000) = 6.90 ton

400 ton rig is safe

Stress Calculations

- Allowable Stress :

S= 95% of SMYS

= 0.95*482.185

= 458.185 N/mm2

- **Bending Stress :**

= ED/2R

= 85.02375 N/mm2

- Tensile Stress

International Journal of Scientific & Engineering Research Volume 9, Issue 5, May-2018
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ISSN 2229-5518

=
=0.60459 N/mm2

- Longitudinal stress during installation

Allowable stress > Tensile stress + bending Stress

458.185 > 85.02375 +0.60459

458.185 >85.6275 N/mm2

Which is very much lower than allowable stress, thus safe?

Maximum Equivalent Stress during Final Hydrostatic Test

- **Hydro test pressure :**

=1.5   Design Pressure

=1.5
= 168 bar

= 16.8 N/mm2

Bending Stress = 85.02375 N/mm2

- **Post Installation**

Allowable Stress > Bending Stress + Hydrotest stress

340.6> 85.02375 +16.8

340.52> 101.823 N/mm2

This is very much less than allowable stress, thus safe

Conclusion:

Horizontal Directional Drilling is a useful tool that is available for the installation of Pipeline crossings across Rivers, Canals, Railways, Roads, and Sewers etc., given the correct conditions.

By the design calculation, we seen that the pipeline used in this project can withstand the all type of stresses, which act on pipe section during construction and operation period. It is important to realize that an HDD may represent the critical on the overall project schedule. In addition, an HDD may have the highest risk of failure risk of failure of any activities on a project. Therefore, all aspect, of planning, design and construction for an HDD need to be assigned a high priority or importance value to their potential effect on the overall project.

CONCLUSION

Pipeline construction involves many activities of which all are equally important with quality and safety perspective.

Oil and gas pipelines are found across the globe. Pipelines can run above ground, underground or they can be immersed in fresh or salt water. Coatings designed for external pipeline applications must be engineered to withstand this wide variety of environmental conditions. Soil stress, soil born chemicals and salt water present formidable challenges to the performance of external pipeline coatings. External coatings also need to be resistant to indigenous bacteria, other flora, and waste water and to the chemicals and solvents used in the processing of the hydrocarbons. Pipelines can be found in the hot desert where temperatures often exceed 100°F or where temperature can reach as low as -76°F. Ground conditions in the permafrost regions, where ground temperature rarely exceeds 32°F, make subterranean application of pipe very difficult and almost mandate above ground pipeline installations

Hydro testing proves the structural soundness of the installed pipelines & its capability to safely fulfill the function for which it is designed. It is the ultimate Quality Control check before the owner takes over the line .It is very essential for the proper & safe working of pipeline.

After a test, a pipeline can be expected to safely contain its intended operating pressure. The confidence level that a pipeline is fit for safe service increases as the ratio of test pressure to operating pressure increases. This highly beneficial aspect of hydrostatic testing applies not only to a new component to be placed in service for the first time. A similar benefit accrues to an in-service component if that component is taken out of service after a period of time and subjected to a hydrostatic test.

Overall it was a productive experience for us, doing internship under Sanmarg Projects Pvt Ltd. I have acquired an amount of knowledge in a practical way from about what I actually understood in theory during my M.Tech - Pipeline engineering and also once again thank Sanmarg for providing this golden opportunity to improve myself in my career and as a person.

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