City of Lufkin
TCSS Manual

HORIZONTAL DIRECTIONAL DRILLING

SECTION 02767
HORIZONTAL DIRECTIONAL DRILLING
CITY OF LUFKIN

PART 1 - GENERAL

1.1 Work Included

The work specified in this section consists of furnishing and installing waterlines, gravity sewer mains and force mains using the horizontal directional drilling (HDD) method of installation, also commonly referred to as directional boring or guided horizontal boring. This work shall include all necessary services, equipment, materials, and labor for the complete and proper installation, testing, all surface restoration and replacement of any damaged utilities and environmental protection and traffic control.

1.2 Measurement and Payment

Directional Drilling Pipe:

The quantity to be paid for will be the length in linear feet of each size of pipe furnished and installed. Measurement shall be made along the horizontal centerline of the pipe installed as shown on the plans. (The Contractor shall include in the Contract Unit Price its allowance for horizontal deflection, vertical deflection and all wastage). Payment for installed pipe will be at the item of work completed, including horizontal directional drilling, all pits including excavation, bedding and backfill, surface restoration including pavement removal and replacement, laying and jointing pipe; post construction TV inspection and mandrel testing; pressure and leakage testing; flushing, locating and protecting existing structures, utilities and property both public and private regardless of whether shown on plans or not; cleaning up the site; furnishing all material, labor, tools, and equipment; and all incidental and related work required to complete the installation including entry/back reaming pits, dewatering, Record Drawings (As-Builts), placing and removing all traffic signs and barriers, maintaining traffic, site preparation, and all restoration. Contractor shall be responsible for removal and disposal of drill fluid breakouts. Damage to roadways; existing utilities, property, both public and private, occurring due to the work shall require complete restoration to the satisfaction of the City. Any adaptors or coupling necessary for placement of fittings and valves shall not be paid for separately. No separate payment will be made for cleanup or restoration due to damage caused by Contractor's operations.

Compounds:

ASTM D2122 Standard Method of Determining Dimensions of Thermoplastics Pipe and Fittings.
ASTM D2290 Standard Test Method for Apparent Tensile Strength or Tubular Plastics and Reinforced Plastics by Split Disk Method.
ASTM D2683 Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
ASTM D2837 Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials.
ASTM D2839 Standard Practice for Use of a Melt-Index Strand for Determining Density of Polyethylene.
ASTM D3035 Standard Specification for Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Controlled Outside Diameter.
ASTM E3261 Standard Specification for Butt Heat Fusion Polyethylene Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.

ASTM D3350 Standard Specification for Polyethylene Plastic Pipe and Fittings Materials.
ASTM D4219 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
ASTM D4218 Standard Test Method for Determination of Carbon Black Content in Polyethylene Compounds by the Muffle-Furnace Technique.
ASTM F412 Standard Terminology Relating to Plastic Piping Systems.
ASTM D3139 Standard Specification for Joints for Plastic Pipes Using Flexible Elastometric Seals.
ASTM F477 Standard Specification for Elastometric Seals (Gaskets) for Jointing Plastic Pipe.

National Sanitation Foundation (NSF)
NSF14: Plastic Pipe System Components and Related Materials
NSF 61: Drinking Water System Components - Health Effects

Underwriters Laboratories (UL)
Quick burst test
Million cycle test
1000 hour sustained pressure test
Deflection leakage test
Factory Mutual Research (FM)
Underground fire protection approval

1.6 Permits

The Contractor is responsible for obtaining all permits necessary for the project before commencing any work on the project.

1.7 Submittals

1.7.1 Work Plan: Prior to beginning work, the Contractor must submit to the Engineer a work plan detailing the procedure and schedule to be used to execute the project. The work plan should include a description of all equipment to be used, down-hole tools, a list per personnel and their qualifications and experience (including back-up personnel in the event that an individual is unavailable), list of subcontractors, a schedule of work activity, a safety plan (including MSDS of any potentially hazardous substances to be used), traffic control plan (if applicable), an environmental protection plan and contingency plans for possible problems. Work plan should be comprehensive, realistic and based on actual working conditions for this particular project. Plan should document the thoughtful planning required to successfully complete the project.

1.7.2 Material: Specifications on material to be used shall be submitted to Engineer for approval. Material shall include the pipe, fittings and any other item, which is to be an installed component of the project.

1.7.3 Certification: The Contractor shall submit a notarized certification from the pipe manufacturer that the pipe and fittings supplied are new, have been manufactured at their plant, have been inspected at the plant and meet the requirements of these specifications.

1.7.4 Record Drawing: Submit as-built records in duplicate to the Engineer within five days after completing the pull back. The as-built records shall include a plan, profile, and all information recorded during the progress of the work. **Record Drawings are a condition of the Contract. The Project will NOT be accepted without Record Drawings.**

1.8 Notification

The Project Representative must be notified 48 hours in advance of starting work. The Directional Bore shall not begin until the Project Representative is present at the job site and agrees that proper preparations for the operation have been made. The Project Representative's approval for beginning the installation shall in no way relieve the Contractor of the ultimate responsibility for the satisfactory completion of the work as authorized under the Contract.

1.9 Site Preparation

1.9.1 Prior to moving to work-site, Contractor shall photograph or videotape entire work area in conformance with the specifications. One copy of which shall be given to project representative and done copy to remain with Contractor for a period of one year following the completion of the project.

1.9.2 The Contractor is responsible for contracting and coordinating with all utility companies prior to commencing work in the area. The Contractor is responsible for verification of all utilities including, but not limited to gas, electric, telephone, fiber optic, cable television, pipelines, storm sewer, sanitary sewer and water main and associated laterals prior to commencing work. All the existing utilities shall be located in the field (horizontal and vertical) prior to commencing work. Prior to initiating drilling, the Contractor shall record on the drawings both the horizontal and vertical location of the utilities off of a predetermined baseline.

1.9.3 Work site as indicated on drawings shall be graded and filled provide a level working area. No alterations beyond what is required for operations are to be made. Contractor shall confine all activities to designated work areas.

1.9.4 Following drilling operations, Contractor will de-mobilize equipment and restore the work-site to original condition. All excavations will be backfilled and compacted in conformance with project specifications.

1.10 Environmental Protection

Contractor shall place silt fence between all drilling operations and any drainage, wetland, waterway or other area designated for such protection by contract documents, state, federal and local regulations. Contractor shall place hay bales or approved protection to limit intrusion upon project area. Additional environmental protection necessary to contain any hydraulic or drilling fluid spills shall be put in place, including berms, liners, turbidity curtains and other measures. Contractor shall adhere to all applicable environmental regulations. Fuel may not be stored in bulk containers within 200-feet of any water-body or wetland.

1.11 Safety

Contractor shall adhere to all applicable state, federal and local safety regulations and all operations shall be conducted in a safe manner. Safety meetings shall be conducted at least weekly with a written record of attendance and topic submitted to Project Representative.

1.12 Personnel Qualifications Certification

1.12.1 Directional Boring**:** General contractor should have a minimum of 5-years experience in installing municipal water systems.

General Contractor should have completed a minimum of 250,000-linear feet of municipal distribution/collection and transmission water mains and/or sanitary sewer force mains.

General Contractor should have completed a minimum of 125,000-linear feet of municipal distribution/collection and transmission water mains and/or sanitary sewer force mains by either augering, boring, or pipe jacking.

General Contractor should have completed a minimum of 10,000-linear feet of municipal distribution/collection and transmission water mains and/or sanitary sewer force mains by HDD, horizontal directional drilling.

A list of project references is required prior to job commencement.

All personnel shall be fully trained in their respective duties as part of the directional drilling crew and in safety. (Each person must have been fully trained for over 1,000 hours on all facets of directional drilling, including, but not limited to machine operations, mud mixing, locating existing utilities and material fusion.) A responsible representative, who is thoroughly familiar with the equipment and type of work to be performed, must be in direct charge and control of the operation at all times. In all cases the supervisor must be continually present at the job site during the actual Directional Bore operation. The Contractor shall have a sufficient number of competent workers on the job at all times to insure the Directional Bore is made in a timely and satisfactory manner.

Personnel who are unqualified, incompetent otherwise not suitable for the performance of this project shall be removed from the job site and replaced with suitable personnel.

1.12.2 Pipe and Fitting Jointing**:**

1.12.3 Heat Fusion Joining**:** Joints between plain end pipes and pipe fittings shall be made by butt fusion when possible. Electrofusion welding may also be used tom complete when the location is not accessible to butt fusion-welding equipment. The Contractor shall ensure that persons making joints have received training in the Manufacturer's recommended procedure. The contractor shall provide copies of such certification to the Engineer. External and internal beads shall not be removed.

1.12.4 Heat Fusion Training Services: Upon request, the Manufacturer shall provide training and training materials in the Manufacturer's recommended butt fusion, saddle fusion and electrofusion procedures to the Contractor's installation personnel, and to Project Representative.

PART 2 - MATERIALS

2.1 High Density Polyethylene (HDPE, PE) Pipe and Fittings

2.1.1 Materials: Materials used for the manufacturer of polyethylene pipe and fittings shall be PE3408 high density polyethylene meeting cell classification 345464C per ASTM D3350; and meeting Type III, Class B or Class C, Category 5, Grade P34 per ASTM D1248; and shall be listed in the name of the pipe and fitting Manufacturer in PPI TR-4, Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Pipe and Fittings Compounds, with a standard grade rating of 1600 psi at 73□F. The Manufacturer shall certify that the materials used to manufacture pipe and fittings meet these requirements.

2.1.2 Polyethylene Pipe: HDPE Pipe shall conform to AWWA C906, SDR11, Ductile Iron Pipe (DIP) size and NSF 61 Standard. Polyethylene pipe shall be manufactured in accordance with ASTM F714, Polyethylene (PE) Plastic Pipe (SDR-PR) based on Controlled Outside Diameter and shall be so marked. Each production lot of pipe shall be tested for (from material or pipe) melt index, density, % carbon, dimensions and either quick burst or ring tensile strength (equipment permitting). Normal pipe sizes only are indicated o the drawings and bid form. Outside diameter of pipe is generally 1 to 2 inches greater than the nominal pipe diameter.

2.1.3. Service Identification: Permanent identification of piping service shall be provided by co-extruding multiple equally spaced color stripes into the pipe outside surface or by solid colored pipe shell. The striping material shall be the same material as the pipe material except for color. The following colors shall be used to identify piping service.

2.1.3.1 Blue - potable water

2.1.3.2 Green - non-potable water, wastewater, sewage

2.1.3.3 Purple - reuse water

2.1.3.4 Stripes printed on the pipe outside surface shall not be acceptable**.**

2.1.4 Polyethylene Fittings and Custom Fabrication: Polyethylene fittings and custom fabrications shall be molded or fabricated by the pipe manufacturer or trained personnel. Butt fusion outlets shall be made to the same outside diameter, wall thickness, and tolerances as the mating pipe. All fittings and custom fabrications shall be fully rated for the same internal pressure as the mating pipe. Pressure de-rated fabricated fittings are prohibited.

2.1.5 Molded fittings: Molded fittings shall be manufactured in accordance with ASTM D3261, Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing, and shall be so marked. Each production lot of molded fittings shall be subjected to the test required under ASTM D3261.

2.1.6 Fabricated Fittings: Fabricated fittings shall be made by heat fusion joining specially machined shapes cut from pipe, polyethylene sheet stock, or molded fittings. Fabricated fittings shall be rated for internal pressure service equivalent to the full service pressure rating of the mating pipe. Directional fittings 16" and larger such as elbows, tees, crosses, etc., shall have a plain end inlet for butt fusion and flanged directional outlets. Part drawings shall be submitted for the approval of the Engineer.

2.1.7 Polyethylene Flange Adapters: Flange adapter shall be made with sufficient throughbore length to be clamped in a butt fusion-joining machine without the use of a stubend holder**.** The sealing surface of the flange adapter shall be machined with a series of small v-shaped grooves to provide gasketless sealing, or to restrain the gasket against blow-out.

2.1.8 Back-up Rings and Flange Bolts: Flange adapters shall be fitted with lap joint flanges pressure rated equal to or greater than the mating pipe. The lap joint flange bore shall be chamfered to provide clearance to the flange adapter radius. Flange bolts and nuts shall be Grade 2 or higher.

2.1.9 Manufacturer's Quality Control: The pipe and fitting manufacturer shall have an established quality control program responsible for inspecting incoming and outgoing materials. Incoming polyethylene materials shall be inspected for density, melt flow rate, and contamination. The cell classification properties of the material shall be certified by the supplier, and verified by Manufacturer's Quality Control.

2.1.10 Polyethylene Mechanical Joint Adapters: Mechanical connections of HDPE pipe (4" through 24" diameter) to Ductile Iron or PVC piping, mechanical joint fittings, or valves shall be through a self-restraining, fusible mechanical joint adapter with an integral, internal stainless steel insert. Mechanical joint adapter shall be of the same SDR rating as the pipe. A separate, loose insert will not be allowed. Mechanical joint adapter shall be as manufactured by Central Plastics Company. The HDPE mechanical joint adapter shall be connected to the HDPE directional drilled piping via heat fusion joint. Provide the mechanical joint adapter, including but not limited to the heat fusion joint, longer tee bolts or all thread rods with nuts at the mechanical joint bell.

2.1.11 Electrofusion Couplings : Polyethylene pipe and fittings may be joined using approved electrofusion couplings. Fitting shall be PE3408 HDPE, Cell Class 345464C as determined by ASTM D3350-99. Electrofusion

fittings shall have a manufacturing standard of ASTM F1055. Fittings shall have a pressure rating equal to the pipe. All electrofusion fittings shall be suitable for use as pressure conduit per AWWA C906, and have nominal burst value of 3.5 times the working pressure of the fitting.

2.2 Polyethylene service line tubing shall conform to the specifications.

2.3 Service Connections: N/A

2.4 Drilling Fluids shall be a bentonite slurry.

2.5 Delivery, Storage and Handling of Materials

2.5.1 Inspect materials delivered to the site for damage. All materials found during inspection or during the progress of work to have cracks, flaws, cracked linings, or other defects shall be rejected and removed from the job site without delay.

2.5.2 Unload and store opposite or near the place where the work will proceed with minimum handling. Store material under cover out of direct sunlight. Do not store directly on the ground. Keep all materials free of dirt and debris.

2.5.3 Contractor is responsible for obtaining, transporting and sorting any fluids, including water, to the work site.

2.5.4 Disposal of fluids is the responsibility of the Contractor. Disposal of fluids shall be done in a manner that is in compliance with all permits and applicable federal, state, or local environmental regulations. The bentonite drilling slurry may be recycled for reuse in the hole opening operation, or shall be hauled by the Contractor to an approved location or landfill for proper disposal. Contractor shall thoroughly clean entire area of any fluid residue upon completion of installation, and replaces any and all plants and sod damaged, discolored or stained by drilling fluids.

2.6 Using HDPE pipe, the Contractor shall adhere to pipe manufacturer's most current data regarding tensile limitations for trenchless application. The Contractor shall adhere to the manufacturer's recommendations and shall not exceed the maximum valves recommended by the manufacturer. A copy of manufacturer's recommendations on the maximum pulling force and tensile limitations shall be provided to the Engineer prior to commencing work.

PART 3 - POLYVINYL CHLORIDE (PVC) PIPE

3.1 General: Products delivered under this specification shall be manufactured only from water distribution pipe and couplings conforming to AWWA C905. The restrained joint pipe system shall also meet all short and long term pressure test

requirements of AWWA C905. Pipe, couplings and locking splines shall be complete non-metallic to eliminate corrosion problems.

3.2 Materials: Pipe and couplings shall be made from unplasticized PVC compounds having a minimum cell classification of 12454-B, as defined in ASTM D1784. The compound shall qualify for a Hydrostatic Design Basis (HDB) of 4000 psi for water at 73.4 degrees F, in accordance with the requirements of ASTM D2837. Green pipe shall be supplied, unless otherwise agreed upon at time of purchase.

3.3 Approvals: Restrained joint PVC pipe products shall have been tested and approved by an independent third-party laboratory for continuous use at rated pressures. Copies of Agency approval reports or product listings shall be provided to the Engineer. Products intended for contact with potable water shall be evaluated, tested, and certified for conformance with NSF Standard 61 by an acceptable certifying organization.

3.4 Dimensions: Nominal outside diameters and wall thicknesses of thrust-restrained pipe shall conform to the requirements of AWWA C905. Thrust-restrained pipe shall be furnished in the size of 16" inside diameter, Class 165. Pipe shall be furnished in standard lengths of 20 feet.

3.5 Joints: Pipe shall be joined using non-metallic couplings, which, together, have been designed as an integral system for maximum reliability and interchangeability. High-strength flexible thermoplastic splines shall be inserted into mating precision-machined grooves in the pipe and coupling to provide full 360-degree restraint with evenly distributed loading.

Couplings shall be designed for use at or above the rated pressures of the pipe with which they are utilized, and shall incorporate twin elastomeric sealing gaskets meeting the requirements of ASTM F477. Joints shall be designed to meet the leakage test requirements of ASTM D3139.

3.6 Quality Control: Every pipe and machined coupling shall pass AWWA C905 hydrostatic proof test requirements (4X rated pressure for 5 seconds).

3.7 Marking: Pipe shall be legibly and permanently marked in ink with the following information:

- Manufacturer and Trade Name
- Nominal Size and DR Rating/Pressure Class
- Hydrostatic Proof Test Pressure
- (NSF-61)
- Manufacturing Date Code

Pipe and Couplings shall also bear the mark of the certifying agency (s), which have tested and approved the product for use in fire protection applications.

3.8 Workmanship: As defined in AWWA C905, pipe and couplings shall be homogeneous throughout and free from voids, cracks, inclusions, and other defects, and shall be as uniform as commercially practicable i color, density, and other physical characteristics.

3.9 Execution - Installation:

3.9.1 Meet Requirement of "Rules and Regulations for Public Water Systems" by Texas Natural Resource Conservation Commission.

3.9.2 Parallel Lines - Maintain clearance between lines as shown in plans.

3.9.3 Crossing Lines - Refer to plans.

PART 4 - EQUIPMENT REQUIREMENTS

4.1 General: The directional drilling equipment shall consist 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 a system to remove solids from the drilling fluid so that the fluid can be re-used, Magnetic Guidance System (MGS) or "walkover" system to accurately guide boring operations, a vacuum truck of sufficient capacity to handle the drilling fluid volume, and trained, certified and competent personnel to operate the system. All equipment shall be in good, safe 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.

4.2 Drilling System

4.2.1 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.

4.2.2 Drill Head: The drillhead shall be steerable by changing its rotation and shall provide the necessary cutting surfaces and drilling fluid jets.

4.2.3 Mud Motors (if required): Mud motors shall be of adequate power to turn the required drilling tools.

4.2.4 Drill Pipe: Shall be constructed of high quality 4130 seamless steel tubing, grade D or better with threaded box and pins. Tool joints should be hardened to 32-36 RC.

4.3 Guidance System: A Magnetic Guidance System (MGS) or proven gyroscopic system shall be used to provide a continuous and accurate determination of the location of the drill head during the drilling operation. The guidance shall be capable of tracking at all depths up to eighty feet and in any soil condition, including hard rock. It shall enable the driller to guide the drill head by providing immediate information on the tool face, azimuth (horizontal direction), and inclination (vertical direction). The guidance system shall be accurate to +/-2% of the vertical depth of the borehole at sensing position at depths up to one hundred feet and accurate within 1.5 meters horizontally. The Contractor shall supply all components and materials to install, operate and maintain the guidance system.

The Guidance System shall be of a proven type and shall be operated by personnel trained and experienced with this system. The Operator shall be aware of any magnetic anomalies on the surface of the drill path and shall consider such influences in the operation of the guidance system if using a magnetic system.

4.4 Drilling Fluid (Mud) System:

4.4.1 Mixing System: A self-contained, closed, drilling fluid mixing system shall be of sufficient size to mix and deliver drilling fluid composed of bentonite clay or other appropriate material approved by Engineer, potable water and appropriate additives. The mixing system shall be able to molecularly shear individual bentonite particles from the dry powder to avoid clumping and ensure thorough mixing. The drilling fluid reservoir tanks shall be a minimum of 1,000 gallons. Mixing system shall continually agitate the drilling fluid during drilling operations.

4.4.2 Drilling Fluid: Drilling fluid shall be approved by the Engineer. Water shall be from an authorized source with a pH of 6.0. Water of a lower pH or with excessive calcium shall be treated with the appropriate amount of sodium carbonate or equal. No additional material may be used in drilling fluid without prior approval from ENGINEER. The bentonite mixture used shall have the following minimum viscosities as measured by a Marsh funnel:

Rocky Clay	60 seconds
Hard Clay	40 seconds
Soft Clay	45 seconds

Sandy Clay 90 seconds

Stable Sand 80 seconds

Loose Sand 110 seconds

Wet Sand 110 seconds

4.4.3 Delivery System: The drilling fluid pumping system shall have an adequate capacity and should be capable of delivering the drilling fluid at a constant minimum pressure of 1200 psi. The delivery system shall have filters in-line to prevent solids from being pumped into drill pipe. Connections between the pump and drill pipe shall be leak free. Used drilling fluid and drilling fluid spilled during operations shall be contained and conveyed to the drilling fluid recycling system or shall be removed by vacuum trucks or other methods acceptable to ENGINEER and the CITY. A berm, minimum of 12-inches high, shall be maintained around drill rigs drilling fluid mixing environment. Pumping equipment and/or vacuum truck (s) of sufficient size shall be in place to convey drilling fluid from containment areas to storage and recycling facilities or disposal.

4.4.4 Drilling Fluid Recycling System: The drilling fluid recycling system shall separate sand, dirt and other solids from the drilling fluid to render the drilling fluid re-usable. Spoils separated from the drilling fluid will be stockpiled for later use or disposal.

4.5 Other Equipment: Pipe Rollers: Pipe rollers shall be of sufficient size to fully support the weight of the pipe while being hydro-tested and during pull-back operations. Sufficient number of rollers shall be used to prevent excess sagging of pipe.

4.5.1 Pipe Rammers: Hydraulic or pneumatic pipe rammers may only be used if necessary and with the authorization of Project Representative.

4.5.2 Restrictions: Other devices or utility placement systems for providing horizontal thrust other than those previously defined in the preceding sections shall not be used unless approved by the Project Representative prior to commencement of the work. Consideration for approval will be made on an individual basis for each specified location. The proposed device or system will be evaluated prior to approval or rejection on its potential ability to complete the utility placement satisfactorily without undue stoppage and to maintain line and grade within the tolerances prescribed by the particular conditions of the projects.

EXECUTION

PART 5 - DRILLING PROCEDURES

5.1 Drill Path: Prior to drilling, Contractor shall utilize all verified locate information to determine drill pathway. Marked up drawings shall be on site at all times, and referred to during the drill operation.

The CONTRACTOR shall provide all material, equipment, and facilities required for directional drilling. Proper alignment and elevation of the borehole shall be consistently maintained throughout the directional drilling operation. The method used to complete the directional drill shall conform to the requirements of all applicable permits.

The entire drill path shall be accurately surveyed by the CONTRACTOR with entry and exit stakes placed in the appropriate locations within the area indicated on drawings. If CONTRACTOR is using a magnetic guidance system, drill path shall be surveyed for any surface geo-magnetic variations or anomalies.

5.2 Guidance System: Contractor shall provide and maintain instrumentation necessary to accurately locate the pilot hole (both horizontal and vertical displacements), measure pilot string torsional and axial and measure drilling fluid discharge rate and pressure. The Project Representative shall have access to instrumentation and readings at all time during operation.

5.3 Pilot Hole: The pilot hole shall be drilled along the path shown on the plans and profile drawings. In the event the Contractor elects to drill the pilot hole along another alignment, the Contractor shall submit drawing showing the revised pilot hole location for concurrence by the Engineer.

5.3.1 Reading shall be recorded after advancement of each successive drill pipe (no more than 10') and the readings plotted on a scaled drawing of 1' = 2' vertical and 1" = 20' horizontal. Access to all recorded readings and plan and profile information shall be made available to the ENGINEER or his representative at all time. At no time shall the deflection radius of the drill pipe exceed the deflection limits of the carrier pipe as specified herein.

5.3.2 A complete list of all drilling fluid additives and mixtures to be used in the directional operation will be submitted to the ENGINEER, along with their respective Material Safety Data Sheets. All drilling fluids and loose cuttings shall be contained in pits or holding tanks for recycling or disposal, no fluids shall be allowed to enter any unapproved areas or natural waterways. Upon completion of the directional drill project, the drilling mud and cuttings shall be disposed of by the CONTRACTOR at an approved dumpsite.

5.3.3 The pilot hole shall be drilled on bore path with no deviations greater than 5% of depth over the length of the bore unless previously agreed to by the ENGINEER. In the event that pilot does deviate from the bore path more than 5% of depth over the length of the bore, CONTRACTOR will notify ENGINEER. Engineer may require CONTRACTOR to pull-back and re-drill from the location along bore path before the deviation. In the event of a drilling fluid fracture, inadvertent returns, or returns loss during pilot hole drilling operations, CONTRACTOR shall cease drilling, wait at least 30 minutes, inject a quantity of drilling fluid with a viscosity exceeding 120 seconds as measured by a Marsh funnel and wait another 30 minutes. If mud fracture or returns loss continues, CONTRACTOR will discuss additional options with the ENGINEER and work will then proceed as agreed.

5.3.4 Upon completion of pilot hole phase of the operation, a complete set of "as-built" records shall be submitted in duplicate to the ENGINEER. Theses records shall include copies of the pilot bore path plan and profile record drawing, as well as directional survey reports as recorded during the drilling operation.

5.3.5 Upon concurrence of the pilot hole location by the ENGINEER, the hole opening or enlarging phase of the installation shall begin. The bore hole diameter shall be increased to accommodate the pullback operation of the required size of carrier pipe. The type of hole opener or back reamer to be utilized in this phase shall be determined by the types of subsurface soil conditions that have been encountered during the pilot hole drilling operation. The CONTRACTOR shall select the proper reamer type with the final hole opening being a maximum of 1.5 times the largest outside diameter pipe system component to be installed in the bore hole.

5.3.6 Limitations on Depth: Maximum Depth of pipe shall not exceed 12-feet unless otherwise approved by the Engineer. Depths greater than 12-feet will be allowed to avoid conflicts with existing utilities.

5.3.7 The open bore hole shall be stabilized by means of bentonite drilling slurry pumped through the inside diameter of the drill rod and through openings in the reamer. The drilling slurry must be in a homogenous/flowable state serving as an agent to carry the loose cutting to the surface through the annulus of the borehole. The volume of bentonite mud required for each pullback shall be calculated based on soil conditions, largest diameter of the pipe system component, capacity of the bentonite mud pump, and the speed of pullback as recommended by the bentonite drilling fluid manufacturer. The bentonite slurry is to be contained at the exit or entry side of the directional bore pits or holding tanks. The slurry may be recycled at this time for reuse in the hole

opening operation, or shall be hauled by the CONTRACTOR to an approved dumpsite for proper disposal.

5.3.8 In the event, the Contractor Utilizes PVC pipe, the pipe section shall be joined together according to manufacturer's specifications. The gaskets and the ends of the pipe must be inspected and cleaned with a wet cloth prior to each joint assembly so they are free of any dirt or sand. The pipe must be free of any chips, scratches, or scrapes. A pulling eye will be attached to the Certa-Lok C900/RJ pulling head on the lead stick of pipe which in turn will be attached to a swivel on the end of the drill pipe. The product pipe shall be elevated to the approximate angle of entry and supported by means of a side boom with roller arm, or similar equipment, to allow for the "free stress" situation as the pipe is pulled into the exit hole towards the drill rig. The product pullback phase of the directional operation shall be carried out in a continuous manner until the pipe reaches the original entry side of the bore.

5.3.9 In the event the Contractor utilizes HDPE pipe, 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 90% of the pipe manufacturer's safety pull (or tensile) strength.

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

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

5.4.2 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 project.

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

5.4.4 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 Project Representative. Project Representative and Contractor

will discuss options and then work will proceed accordingly at no additional cost to the project.

PART 6 - PIPE ASSEMBLY/HANDLING

6.1 Pipe shall be welded/fused together in one length, if space permits. Pipe will be placed on pipe rollers before pulling into bore hole with rollers spaced close enough to prevent excessive sagging of pipe.

6.2 Butt Fusion Testing: When requested by the project representative, butt fusion testing will be performed. The test fusion shall be allowed to cool completely, and then fusion test straps shall be cut out. The test strap shall be 12" (min) or 1.5 times the wall thickness in width. Bend the test strap until the ends of the strap touch. If the fusion fails at the joint, a new test fusion shall be made, cooled completely and tested.

6.3 Mechanical Joining: Polyethylene pipe and fittings may be joined together or to the materials by means of flanged connections (flange adapters, electrofused couplings, and back-up rings) or mechanical couplings designed for joining polyethylene pipe or for joining polyethylene pipe to another material only with prior approval from the Engineer. Mechanical couplings shall be fully pressure rated and fully thrust restrained such that when installed in accordance with manufacturer's recommendations, a longitudinal load applied to the mechanical coupling will cause the pipe to yield before the mechanical coupling disjoins. External joint restraints shall not be used in lieu of fully restrained mechanical couplings.

6.4 Mechanical Joint and Flange Installation: Mechanical joints and flange connections shall be installed in accordance with the Manufacturer's recommended procedure. Flange faces shall be centered and aligned to each other before assembling and tightening bolts. In no case shall the flange bolts be used to draw the flanges into alignment. Bolt threads shall be lubricated, and flat washers shall be fitted under the flange nuts. Bolts shall be evenly tightened according to the tightening pattern and torque step recommendations of the Manufacturer. At least 1 hour after initial assembly, flange connections shall be re-tightened following the tightening pattern and torque step recommendations of the Manufacturer. The final tightening torque shall be 100 ft-lbs. or less as recommended by the Manufacturer.

6.5 Locate Wire System: N/A

6.6 PVC Pipe Handline

6.6.1 Care shall be taken during transportation of the pipe such that it will not be cut, kinked or otherwise damaged.

6.6.2 Ropes, fabrics or rubber protected slings and straps shall be used when handling pipes. Chains, cables or hooks inserted into the pipe ends shall not be used. Two slings spread apart shall be used for lifting each length of pipe. Pipe or fittings shall not be dropped into rocky or unprepared ground.

6.6.3 Pipe shall be stored on level ground, preferably turf or sand, free of sharp objects that could damage the pipe. Stacking of the pipe shall be limited to a height that will not cause excessive deformation of the bottom layers of pipes under anticipated temperature conditions. Where necessary due to ground conditions the pipe shall be stored on wooden sleepers, spaced suitably and of such width as not to allow deformation of the pipe at the point of contact with the sleeper or between supports.

6.6.4 The handling of the assembled pipeline shall be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. Slings for handling the pipeline shall not be positioned at pipe joints. Sections of the pipes with cuts a gouges or excessive deformation shall be removed and replaced.

PART 7 - TESTING

7.1 Leakage and Pressure Tests

7.1.1 Contractor shall test pipelines installed under this Contract in accordance with these specifications prior to acceptance of the pipeline by the City. All field tests shall be made in the presence of the Project Representative. Except as otherwise directed, all pipelines shall be tested. All piping to operate under liquid pressure shall be tested in sections of approved length. For these tests, the Contractor shall furnish clean water, suitable temporary testing plugs or caps, and other necessary equipment, and all labor required. The Contractor shall furnish suitable pressure gauges, calibrated by an approved testing laboratory with increments no greater than 2 psi. Gauges used shall be of such size that pressures tested will not register less than 10% nor more than 90% of the gauge capacity. All valved sections shall be hydrostatic tested to insure sealing (leak allowance) of all line valves.

7.1.2 Unless it has already been done, the section of pipe to be tested shall be filled with water of approved quality and air shall be expelled from the pipe. If blow offs or other outlets are not available at high points for releasing air, the Contractor shall make the necessary taps at such points and shall plug said holes after completion of the test.

7.1.3 Hydrostatic testing shall consist of a combined pressure test and leakage test. Specified 150 psig test pressures, based on the elevation

of the highest point of the line or section under test, and corrected to the elevation of the test gauge, shall be applied by means of a pump, pipe connection and all necessary apparatus shall be furnished by the Contractor and shall be subject to the approval of the Project Representative.

7.1.4 Maximum duration for any test including initial pressurization, initial expansion, and time at test pressure, must not exceed eight (8) hours. If the test is not completed due to leakage, equipment failure, etc., depressurize the test section, and then allow it to "relax" for at least eight (8) hours before bringing the test section up to test pressure again.

7.1.5 Monitored Make-Up Water Test: The test procedure consists of initial expansion, and test phase. During the initial expansion phase, the test section is pressurized to the test pressure (150 psig) and enough make-up liquid is added each hour for three (3) hours to return to test pressure.

The test phase follows immediately, and shall be two hours. At the end of the test time, the test section is returned to test pressure by add a measured amount of liquid. If the amount of make-up liquid added does not exceed the amount shown in Table 1 for the pipe size installed, leakage is not indicated.

Table 1: Test Phase Make Up Amount

Nominal Pipe Size (in.)	Make-up Water Allowance (U.S. Gallons/100 ft. of Pipe) 2-hour test
6	0.11
8	0.15
10	0.18
12	0.22
14	0.26
16	0.29

7.2 Mandrel Testing for Waterlines Installed by Horizontal Directional Drilling

7.2.1 Perform deflection testing on flexible and semi-ridge pipe to confirm pipe has no more than 5 percent deflection. Mandrel testing shall conform to ASTM D3034. Perform testing no sooner than 10 days after placing and backfilling of line segment, but prior to final acceptance testing of the line segment.

7.2.2 Pull the approved mandrel by hand through line sections. Replace any section line not passing the mandrel. Mandrel testing is not required for stubs.

7.2.3 Retest repaired or replaced line sections.

END OF SECTION