DESIGN AND PROJECT MANAGEMENT CONSIDERATIONS INVOLVED WITH DIRECTIONALLY CONTROLLED HORIZONTAL DRILLING

by

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ABSTRACT

Utilization of Directionally Controlled Horizontal Drilling for the trenchless installation of buried utilities continues to grow. This process presents designers and contractors with significant advantages in installing pipelines beneath a wide range of surface obstacles. In order for these advantages to be realized, creative engineering efforts must be properly applied in advance of, and during, construction. In this paper, the author describes the fundamentals involved in designing a drilled installation as well as contractual and construction monitoring considerations. Topics covered include site investigation requirements, drilled path design, construction activity impact, pipe specification, and contractual considerations including allocation of unknown subsurface condition risks.

INTRODUCTION

Presented in this paper is a discussion of design and project management considerations involved with installation of a buried conduit by the trenchless excavation process known alternately as Horizontal Directional Drilling (HDD) or Directionally Controlled Horizontal Drilling (DCHD). This process has primarily been utilized in constructing river crossings for high pressure cross country pipelines and this paper; has been drafted in the context of that application. Nevertheless, the process, as well as the concepts presented herein, are generally applicable wherever installation by DCHD is merited.

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GENERAL PROCESS DESCRIPTION

Installation of a pipeline by Directionally Controlled Horizontal Drilling is a two-stage process. The first stage consists of drilling a small diameter pilot hole along a designed directional path. The second stage involves enlarging this pilot hole to a diameter which will accommodate the pipeline and pulling the pipeline back into the enlarged hole.

Pilot Hole

Pilot hole directional capability is accomplished by using a non-rotating drill string with an asymmetrical leading edge. A steering bias is created by the asymmetry of the leading edge. If a change in direction is required, the drill string is rolled so that the direction of bias is the same as the desired change in direction. Drilling progress is normally achieved by hydraulic cutting action with a jet nozzle. Mechanical cutting action, when required, is provided by a downhole positive displacement mud motor.

The actual path of the pilot hole is monitored during drilling by taking periodic readings of the inclination and azimuth of the leading edge. These readings, in conjunction with measurements of the distance drilled since the last survey, are used to calculate the horizontal and vertical coordinates along the pilot hole relative to the initial entry point on the surface.

In some cases, a larger diameter wash pipe may be rotated concentrically over the non-rotating drill string. This serves to prevent sticking of the non-rotating string and allows its drilling bias to be freely oriented. It also maintains the pilot hole if it becomes necessary to withdraw the steerable string.

When the steerable string penetrates the surface at the exit point opposite the horizontal drill rig, the pilot hole is complete.

Ream & Pull Back

Enlarging the pilot hole is accomplished using either prereaming passes prior to pull back or simultaneously during pull back.

Prereaming tools are typically attached to the drill pipe at the exit point. The reamers are then rotated and drawn to the drilling rig thus enlarging the pilot hole. Drill pipe is added behind the reamers as they progress toward the drill rig. This insures that a string of pipe is always maintained in the drilled hole. It is also possible to ream away from the drill rig. In this case, reamers fitted into the drill string at the rig are rotated and thrust away from it.

Reaming tools typically consist of a circular array of cutters and drilling fluid jets. Drilling fluid is pumped through the reamers to aid in cutting, support the reamed hole, and lubricate the trailing pipe.

For smaller diameter lines in soft soils, prereaming passes may be omitted and the final installation pass is undertaken upon completion of the pilot hole. In this case, the prefabricated pipeline pull section, or sections, is attached behind the reaming assembly instead of more drill pipe and follows the reamers to the drill rig. A swivel is utilized to connect the pull section to the leading reamers to minimize torsion transmitted to the pipeline.

SITE INVESTIGATION

The first step in accomplishing a DCHD installation is to investigate the site at which the work will be undertaken. An appropriate site investigation will consist of both surface and subsurface surveys. Although each survey may be performed by different specialized engineering consultants, it is important that the results be integrated onto a single plan and profile drawing which will form the basis of any contract and be used to price, plan and execute the crossing. Since this drawing will also be used to make the working profile which will be the basis for downhole navigation, accurate measurements are essential.

Surface Survey

A topographic survey should be conducted to accurately describe the working areas where construction activities will take place. Both horizontal and vertical control must be established for use in referencing hydrographic and geotechnical data. A typical survey should include overbank profiles on the centerline extending from approximately 150 feet (46m) landward of the entry point to the length of the prefabricated pull section(s) landward of the exit point. Survey ties should also be made to topographic features in the vicinity of the crossing.

For significant waterways, a hydrographic survey will be required to accurately describe the bottom contours. Typically, it should consist of fathometer readings along the centerline and approximately 200 feet (60m) upstream and downstream. This scope can be expanded to include more upstream and/or downstream ranges if this data is required to analyze future river activity.

Subsurface Survey

A subsurface survey program for a drilled river crossing should involve the artful application of technology to define the characteristics and engineering properties of the subsurface material through which the drilled path will pass. It should include both the review, in office, of existing geological information and the assembly of site specific data through field sampling. It should be conducted by engineers knowledgeable in the state of the art. The extent of the program should be governed by practical economic limits.

Existing geological data should be reviewed to determine what conditions may be encountered during installation of the crossing at the specified location. The results of this review should be presented in a geotechnical report describing the probable geologic cross section beneath the river extending from the surface to either bedrock or a depth substantially below the anticipated crossing penetration depth. This report may then be used to design a preliminary drilled path for the crossing.

A site specific geotechnical survey should be conducted to confirm the probable subsurface conditions through which the crossing will be installed. The number and location of borings, as well as the use of other exploratory techniques, will be based on site specific conditions taking into account the preliminary drilled path design produced using the data developed by the geological review. Borings should be located approximately 50 feet (15m) off of the crossing centerline and should extend to approximately 30 feet (9m) below the deepest crossing penetration depth.

Sampling interval and technique will be based on site specific conditions and be designed to accurately describe the subsurface material. If rock is encountered, the borings should at least penetrate the rock to a depth sufficient to confirm that it is bedrock. The following data is required from the borings:

* Standard classification of soils
* Gradation curves on granular soils

* SPT values where applicable
* Cored samples of rock with Rock Quality Designation and Percent Recovery
* Unconfined compressive strength for rock samples
* Moh's Hardness for rock samples

In some locations, samples should be reviewed to determine the presence of any hazardous wastes.

The results of the geotechnical survey should be presented in the form of a geotechnical report containing engineering analysis, boring logs, test results and a geotechnical profile of the subsurface conditions beneath the river.

DRILLED PATH DESIGN

To maximize the advantages offered by directionally controlled horizontal drilling, primary design consideration should be given to defining the obstacle to be crossed. For example, a river is a dynamic entity. Not only should the water's width and depth be considered, the potential for bank migration and scour should also be taken into account. It should always be remembered that flexibility in locating a pipeline to be installed by DCHD exists not only in the horizontal plane but in the vertical plane as well.

For the majority of drilled installations, there are six parameters which define the location and configuration of the drilled path. These are listed below:

* Entry Point
* Exit Point
* Entry Angle
* Exit Angle
* P.I. Elevation
* Radius of Curvature

These parameters, or their limiting values, should be specified on the contract plan & profile drawing.

Entry and Exit Angles

Entry angles should be held to between 8 degrees and 20 degrees with horizontal. These boundaries are due chiefly to equipment limitations. Exit angles should be designed to allow easy breakover support. That is, the exit angle should not be so steep that the pull section must be severely elevated in order to guide it into the drilled hole. This will generally be less than 10 degrees for larger diameter lines.

P.I. Elevation

The P.I. elevation simply defines the depth of cover the installation will have. Typically, a minimum depth of cover of 15 feet (5m) should be maintained in designing drilled profiles. This provides a margin of safety against downhole "blowout." A "blowout" can cause the drill string to seek the ground surface and force redrilling of the pilot hole.

Radius of Curvature

The radius of curvature for bends used in DCHD installations is determined by the following formula:

$$R = 100(ND)$$

Where: R = Radius of curvature of circular sagbends in feet
ND = Nominal diameter of the pipe in inches

This relationship has been developed over a period of years in the horizontal drilling industry and is based on experience with constructability as opposed to any theoretical analysis.

RIGHTS OF WAY AND WORK SPACE

Directional Accuracy and Tolerances

The instrument used to survey the pilot hole during drilling is magnetic and therefore subject to some inaccuracy. Additionally, some deviation from the designed drilled path may be experienced due to soil reaction. Therefore, it is desirable to allow contractors as much tolerance as possible in actual versus designed pilot hole course. Error can be largely eliminated by redrilling after "punch out" but this will increase the cost of the installation. This should be considered when purchasing easements.

Construction Activity

A horizontal drilling rig and its ancillary equipment typically require a temporary workspace of approximately 150 feet (45 m) by 250 feet (75 m). The addition of water storage may increase this area. For a welded steel pull section, it is desirable to provide enough workspace on the bank opposite the drill rig to allow fabrication in one continuous length. Rights of ingress and egress are also required. A typical horizontal drilling spread can be moved onto the site in approximately 10 tractor loads. Where marine access is available, barges can be used for site access, to move and store drilling fluids, and to augment land based workspace.

DRILLING FLUIDS

Mixing Water

It is standard practice on a river crossing to draw water from the waterway for use in mixing drilling fluid. Where surface water proves too brackish, contractors may opt for fresh water from a municipal source or may use a combination of the two. Substantial amounts of water are required.

Disposal of Excess Drilling Fluids

From a contractor's point of view, it is desirable to discharge excess drilling fluid back into the river or on the adjacent banks. Permission to discharge excess fluid at the site will reduce cost. Hauling these fluids to an offsite disposal location is a costly procedure.

In some cases, it is unwise to leave the disposal method to the sole discretion of contractors. They generally cannot estimate offsite disposal cost accurately in the time given for bidding and will add a contingency factor to cover it resulting in a higher bid price. Nevertheless, in actual operations, they may employ a "midnight disposal" method which can result in bad publicity for the owner if discovered.

The primary component of drilling fluid is fresh water found at the location. In most cases, it is necessary to add bentonite to the water to increase its viscosity, stabilize the drilled hole and provide lubricity during pipe installation. Bentonite is a naturally occurring clay composed primarily of sodium montmorillonite. The product used by horizontal drilling contractors is mined from deposits in South Dakota, Wyoming, Texas and Mississippi. It is not a hazardous material as defined by the U.S. Environmental Protection Agency characteristics of ignitability, corrosivity, reactivity or commercial chemicals. It is also used to seal earth structures such as ponds or dams and as a suspending component in livestock feeds.

Inadvertent Returns

DCHD involves the uncontrolled subsurface discharge of drilling fluids. Under ideal circumstances, drilling fluid exhausted at the leading edge of the drill string will flow back to the surface through the annulus between the outside of the drill pipe and the drilled hole. This will allow the fluid to be reused and thus reduce costs. Under actual conditions, this happens inconsistently. Drilling fluid downhole will flow in the path of least resistance. This can mean dispersal into the surrounding soils or discharge to the surface at some random location. When random flow to the surface occurs, it is called inadvertent drilling fluid returns.

This is not a critical problem in a typical installation. Returns on the river bottom are rarely noticed and returns on the banks in undeveloped areas have a very minor impact. However, in an urban environment, or in a highly visible recreational area, inadvertent returns can be a major problem. In addition to the obvious public nuisance, drilling fluid flow can buckle streets or wash out embankments. A skilled contractor can adjust his drilling program to minimize the risk of inadvertent returns. Nonetheless, the possibility of their occurrence cannot be eliminated altogether. Contingency plans addressing possible remedial action should be made in advance of construction and regulatory bodies should be informed.

Recirculation

Drilling mud purchases and disposal costs may be minimized by recirculating drilling fluid returns. This is a common practice which involves pumping collected returns through cleaning equipment and back into the fluid storage/mixing tank. Unfortunately, substantial returns may occur at the exit point on the other side of the river from the drilling rig where the drilling fluid system is located. This requires either two drilling fluid systems to be utilized or transportation of returns from the exit point to the drilling rig location. Drilling fluid returns transportation should be left to the contractor and can be accomplished by truck, barge or a temporary recirculation line placed on the bottom of the waterway. Which system is most advantageous will be determined by site specific conditions. However, if a temporary recirculation line is utilized, the contractor's design of the line should be checked to insure that it is adequate to prevent failure and the resulting discharge of drilling fluid into the waterway.

PIPE SPECIFICATION

The specification of the pipe to be installed by DCHD will generally be governed by its service and applicable regulations and codes. However, stresses or loads imposed by the installation method should be reviewed and, where prudent, analyzed in combination with the operating stresses to insure that acceptable limits are not exceeded. A discussion of operating and construction loads typical to a liquid petroleum products pipeline river crossing is presented in the following paragraphs.

The definitions of the general symbols used in the relationships shown are as follows:

P = Internal pressure in pounds per square inch
D = Pipe outside diameter in inches
t = Pipe wall thickness in inches
S = Stress in pounds per square inch
SMYS = Specified Minimum Yield Strength for pipe steel in pounds per square inch
E = Modulus of elasticity for steel
R = Radius of curvature for circular elastic bends in feet
k = linear coefficient of thermal expansion, inches per inch per degree F
T1 = Installation temperature, degrees F
T2 = Operating temperature, degrees F
n = Poisson's ratio
Wm = Mud density in pounds per gallon
Ww = Water density in pounds per gallon
Hm = Depth of mud column in feet
Hw = Depth of water column in feet

Operating Loads

The operating loads imposed on a horizontally drilled pipeline river crossing and the corresponding stress relationships are listed below.

Internal Pressure

A pipeline river crossing is subjected to internal pressure from the fluid flowing in it. This pressure results in a circumferential (hoop) tensile stress defined by the relationship shown below:

$$S = PD/2t$$

Bending

A drilled river crossing will contain elastic bends. These bends are approximate circular curves and induce a flexural stress in the pipe. This stress is defined as follows:

$$S = ED/2R(12)$$

Thermal

A drilled pipeline river crossing is considered to be fully restrained by the surrounding soil. Although this may not be completely true for all cases, it is a valid assumption for the majority of soil conditions. Therefore, stress will be induced by a change in temperature from that existing when the line was constructed (locked in) to that present during operations. This stress is defined as follows:

$$S = Ek(T1-T2)$$

This assumption bears further consideration since a drilled pipeline is pulled into an oversized horizontal hole. Obviously, the line is not restrained by the soil during installation. However, the fact that the soil tends to return to its natural state after installation is demonstrated by the fact that a line may become stuck during pull back if movement and mud flow are not maintained. The degree to which the line will be restrained after installation is probably a function of subsurface soil conditions and behavior. These are very difficult to predict and the possibility of longitudinal displacement due to thermal expansion or contraction should be recognized. It should also be noted at this point that this same uncertainty exits with a crossing installed by cut and cover methods.

Dynamic

Dynamic effects such as impact, earthquake, vibration and subsidence apply to specific systems in specific locations. Discussion of these effects is beyond the scope of this presentation.

External Pressure

A pipeline river crossing will be subjected to external pressure resulting from hydrostatic head and possibly overburden. For a high pressure welded steel line in operation, these loads are not considered significant. However, external loads can be critical during installation and should be carefully analyzed.

Construction Loads

During installation, a horizontally drilled pipeline will be subjected to tension, torsion, bending and external pressure.

Tension

The pipeline pull section is placed in tension as it is pulled back through the drilled hole. Theoretically, the pull section is surrounded by an annulus of drilling mud which reduces soil friction and allows it to move freely. This is the basis on which a pull section can be pulled in a long drilled hole. The tensile forces developed by a horizontal drilling rig during pull back will generally be around 100,000 to 200,000 pounds. A significant portion of this force is applied to the cutting face of the reaming assembly which precedes the pull section into the hole. It is very difficult to determine what magnitude of the rig tension is transmitted to the pipeline pull section. Nevertheless, overstressing the pipe due to tension is unlikely under normal circumstances. For example, a 5L X42, 6-inch schedule 40 line has a calculated tensile capacity of 234,402 pounds at 100% of SMYS. The capacity is greater for larger lines.

Torsion

A swivel is typically used to separate the rotating reaming assembly from the pipeline pull section. Therefore, the pull section should not be subjected to torsion. Swivels are not one hundred percent efficient, however, and some torsion will be transmitted to the pull section. Nonetheless, this torsion is not significant and does not merit any special analysis.

Bending

As it is guided into the drilled hole, the pull section will be subjected to bending in a similar manner to a pipeline being lowered into a ditch or pulled into a dredged crossing. Control of this operation generally falls under the responsibility of the contractor and need only be subject to field inspection unless special circumstances warrant an engineering analysis. A restricted work area requiring tight construction bends to thread the pull section into the drilled hole can be a special circumstance. In this case, an analysis of the bending stresses imposed on the line due to the geometry of construction bends should be conducted.

External Pressure

External pressure on a pipe during installation by directionally controlled horizontal drilling results from the following loads:

* Hydrostatic pressure produced by the weight of the drilling mud column extending from the surface to the location being analyzed. This pressure is defined as follows:

$$P = W_m H_m / 19.25$$

* Hydrokinetic pressure required to produce drilling mud flow from the reaming assembly through the reamed annulus surrounding the pipe to the surface. An indication of this pressure can be calculated using annular flow pressure loss formulae borrowed from the oil well drilling industry. These results are dependent on detailed mud properties, flow rates and hole configuration. For simplicity, the relative formulae are not reproduced here.

* Hydrokinetic pressure produced by surge or plunger action involved with pulling the pipe into the reamed hole. This load cannot be calculated reliably. The maximum value should be indicated by soil properties.

* Bearing pressure of the pipe against the hole wall forces the pipe to conform to the drilled path. As with surge or plunger pressure, it cannot be calculated reliably. Once again, its maximum value should be indicated by soil properties.

Pipe External Pressure Capacity

The external pressure at which a circular steel pipe is subject to elastic collapse is defined as follows:

$$P = (2Et^3)/D^3$$

However, this capacity is subject to reduction for a steel pipe being installed by directionally controlled horizontal drilling. The cross section of the pipe will tend to become elliptical as a result of the bending stresses induced by the drilled path. Sound engineering judgement should be employed to insure an adequate factor of safety exists.

External Coating

The general practice for the past ten years has been to install pipe coated with corrosion coating only in drilled crossings. Weight coating is generally not required. Typically, the coating used has been thin film fusion bonded epoxy in thickness ranging from 14 mils to 22 mils. This is due not only to the fact that it is a highly durable system, but also that the field joints can be coated using a fusion bonded epoxy method.

Pipe coated with extruded coatings has also been installed using shrink sleeves on field joints. This system is equally acceptable from a construction standpoint as long as care is taken to insure that the shrink sleeves are properly applied and suitably bonded. To date, these systems have been satisfactory.

However, the vast majority of crossings installed during the past ten years have been in soils consisting of silts, sands or clays, not rock. Use of directionally controlled horizontal drilling for crossings founded in rock is a relatively new development. Therefore, it is a good idea on crossings involving rock to reinforce the coating to provide the maximum practicable resistance to abrasion during installation.

CONTRACTUAL CONSIDERATIONS

Qualifications

It is generally more effective to have drilled river crossings installed under an independent contract and bid directly to directional drilling contractors. Each contractor's qualifications should be evaluated before being included on the bidder's list. This is difficult to do if the drilling contractor is a subcontractor to a local prime.

Contract Form

In most cases, drilled river crossings should be bid using standard lump sum contracts. Nevertheless, there can be instances where a day work contract will offer benefits to the owner. State of the art installations involving conditions which make it next to impossible to accurately estimate costs are an example of instances where day work contracts are applicable. However, a day work contract requires much greater oversight by the owner than a typical lump sum or production unit contract. Significant misunderstandings are possible when a standard lump sum contract form is used for a day rate contract applied to a state of the art drilled river crossing.

Bonding

Generally, drilled river crossings bid on a lump sum basis should be bonded in the full amount. Bonding has three benefits. First, the ability to obtain bonding is a good indication of the financial strength of the contractor. Second, the presence of a bond helps insure that a contractor will use his "best efforts" to execute the contract. Third, the bond provides a source of funds for the owner to draw on should the contractor default.

Unknown Subsurface Condition Risk

A subsurface survey program for a drilled crossing, appropriately designed and executed, will result in a definition of the subsurface which, while reasonable, will still contain a degree of uncertainty. The state of the art in engineering subsurface survey methods does not allow, within practical economic limits, the detailed definition of every area of a broad subsurface space.

In installation of a pipeline by DCHD, there is a risk of operational problems occurring due to this uncertainty. This risk is assumed by the contractor in a standard lump sum contract. It is incumbent upon the contractor to calculate his bid with the appropriate contingency cost included to offset this risk. In order to do this with some success, he must have the results of the subsurface survey program previously described. He should be able to base his bid on all of the information gathered by the owner or his engineer.

Under these circumstances, a contractor should not be entitled to extra compensation on the basis of changed conditions unless there is an extreme deviation from the conditions indicated by the survey (i.e., bedrock where only alluvial deposits were encountered). With a properly conducted subsurface survey, this is a remote possibility. On the other hand, changes such as encountering gravel where borings indicated coarse sand is not a changed condition. The presence of gravel in a formation containing coarse sand is not unforeseen. A more significant example would be encountering cobbles or boulders in a strata described by general geologic data as glacial in nature. Although site specific borings may not have penetrated a boulder, random cobbles and boulders can be a characteristic of glacially deposited soils.

A competently executed subsurface survey program may serve as the benchmark from which to judge whether conditions are materially different from those indicated in the contract. It is important to remember that, unlike an open excavation, the conditions along a drilled path will never be visible. It will not be possible to look at, touch, or feel the soil encountered.

CONSTRUCTION MONITORING

Specialized construction monitoring effort involved with a DCHD installation should be focused on two major areas, the drilled path and drilling fluid flow. It is important for the inspector to document his observations and actions. Should a question or dispute arise after the installation is complete, the inspector's notes will provide the only source of confirming data. Since a drilled installation is typically buried with deep cover under an inaccessible obstacle, its installed condition cannot be confirmed by visual examination.

Drilled Path

Construction Staking

The contractor will rely on the owner's staking to locate the drilled segment. Two locations, the entry point and exit point, must be staked. The elevation of these locations, as well as the distance between them, should be measured as accurately as possible by the owner. The accuracy of the contractor's pilot hole is directly dependent on the accuracy of the relative location, both horizontally and vertically, of these two points. It is also necessary for the contractor to have a line of site between the entry and exit points. This is required to establish a crossing bearing for orientation of the downhole survey instrument. If it is not possible to have a clear line of site, then the owner should stake points which define the drilled path alignment.

Directional Performance

The inspector should be concerned with two basic performance areas, position and curvature. First, the contractor must provide the drilled length and penetration depth specified by the contract. Second, the contractor must not curve the drilled path in such a way that the codes and specifications governing pipeline design are violated. The actual position of the drilled profile cannot be readily confirmed by an independent survey. Therefore, it is necessary for the inspector to have a basic understanding of the downhole survey system being used by the contractor and be able to interpret its readings. It is not necessary for the inspector to observe and approve the drilling of each joint, however, progress should be monitored on a daily basis and problems addressed so that remedial action can be taken as soon as possible. Pilot hole curvature is monitored by reviewing the change in inclination or azimuth on each joint. The inspector should insure that bends are not drilled which have a radius of curvature less than the minimum allowable. For example, if the minimum radius of curvature for bends has been set at 1500 feet, a change in inclination of 1.2 degrees over a course length of 30 feet is too tight. If this occurs, the joint should be redrilled or reviewed with the design engineers as soon as possible to insure that the codes and specifications governing design of the pipeline are not violated.

As-built Error Distribution

The downhole survey instrument used to track the pilot hole contains error. This error is indicated by comparing the actual exit point location with the anticipated exit point location. The owner's inspector should make an independent comparison of these two points. If the topographical survey is accurate and the downhole survey calculations are correct, then the observed difference in the two points results from inaccuracies in the downhole tool itself. This error should be distributed over the drilled path to yield an "as-built" profile and the "as-built" profile compared against the contract requirements.

Drilling Fluid Flow

The inspector should always bear in mind the possibility of inadvertent drilling fluid returns. The right-of-way should be examined regularly for the location of inadvertent returns. Particular attention should be paid to locations of underground utilities (mud may migrate along a perpendicular pipeline) and pile foundations. If returns are found, they should be cleaned up immediately and their locations monitored for continuing problems (particularly during pull back). If problems persist, engineering assistance should be called upon to review the contractor's drilling program and institute preventive measures.

Pipe Installation

Pull Section Handling

The inspector should review the contractor's operations to insure that the pull section is adequately supported during pull back. Roller stands should be provided as well as lifting equipment capable of moving the string into the drilled hole. The section should not be dragged on the ground. All break over bends should be made with a radius long enough to insure that the pipe is not overstressed.

Coating Integrity

The coating should be inspected with a holiday detector immediately prior to entering the drilled hole. Additionally, field joints should be closely inspected. Damage to a yard-applied pipe coating imposed by drilled installation in most soils will be negligible if the hole has been properly drilled and reamed. However, loosely bonded field-coated joints may be subject to peeling off during pull back.