

## Quality Control for Weathered Rock Directional Drilling Pilot Hole Construction

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Received 5 May 2014; accepted 25 June 2014.  
 Published online 29 June 2014

### Abstract

Directional Drilling Technology originated from the oil drilling industry, combining industrial and public utility construction technology, after the evolution of modern horizontal directional drilling technology, which is widely used in the construction of municipal pipelines, oil and gas pipeline industry, and is a kind of trenchless surface through the construction technology. At present, there is more weathering rock to pass through in the oil and gas pipeline construction, so a higher requirements for the construction of directional drilling mud. The weathering degree of heterogeneity of the rock at the same time and also caused great difficulties to construction, and the guide hole construction in the construction of directional drilling is the key control to the key working procedure, after the guide hole is dragged back reaming and pipe at all levels, the basis of the guide hole quality directly affects the pipeline back to success, is the most important factor in engineering which can be successfully completed, so how to control the construction quality of directional drill guide hole is particularly important.

**Table 1**  
**The Categories of Weathered Rock**

Category	Characteristics of the wild	The weathering degree parameter index		Note
		Wave velocity ratio ( $K_v$ )	Coefficient of weathering ( $K_f$ )	
Unweathered	Accidentally see traces of weathering	0.9 - 1.0	0.9 - 1.0	Wave velocity ratio ( $K_v$ ) is weathered rock and the ratio of fresh rock compressional wave velocity; Coefficient of wathering ( $K_f$ ) is weathered rock wathering coefficient and the ratio of the fresh rock saturated uniaxial compressive strength
The breeze	Joint surface has a slightly discolored or rendering	0.8 - 0.9	0.8 - 0.9	
Medium weathering	Joint surface with secondary mineral	0.6 - 0.8	0.4 - 0.8	
Strong weathering	Most of the damage structure, good weathering fracture	0.4 - 0.6	< 0.4	
The weathering	Basic structure failure, the residual strength	0.2 - 0.4	—	
Residual soil	Most weathered to form earthy, dry drilling drilling, have plasticity	< 0.2	—	

**Key words:** Weathered rock; Directional drilling; Pilot hole; Mud

Zhao, P., Zhang, Y. Z., & Zhang, H. Y. (2014). Quality control for weathered rock directional drilling pilot hole construction. *Advances in Petroleum Exploration and Development*, 7(2), 110-115. Available from: URL: <http://www.cscanada.net/index.php/aped/article/view/5158> DOI: <http://dx.doi.org/10.3968/5158>

### INTRODUCTION

Fresh rock, formed under the action of weathering of the products, and is generally called weathered rock. According to the degree of weathering, it can be divided into unweathered, breeze, medium, strong weathering and whole weathering, and residual soil. Strong weathering and whole weathering intensity is relatively low, but medium weathering intensity is relatively high with the breeze. According to construction experience based on some geological data, the general location of weathering rock thickness is about 9-12 m. Weathered rock can be divided into the following categories by the degree of weathering, as shown in the Table 1.

## 2. THREE DIFFICULTIES FOR WEATHERED ROCK DIRECTIONAL DRILLING GUIDE HOLE CONSTRUCTION

### 2.1 Measuring Unreeling

The unearthed and the grave can't see through caused by the horizontal directional drilling and the characteristics of construction, which belongs to the special location of measuring unreeling, especially long distance measuring unreeling directional drilling crossing section of weathered strata, more difficult.

### 2.2 Poor Guide Blastholes Hole Ability

Weathered rock weathering degree is different, which leads to the the great difference in the mud needed for the formation of each layer, It is of great difficulty for the suitable configuration of mud, so a higher requirements of mud. Directional drilling during the construction of the guide hole, hole of weathering rock horizon direction blastholes ability is poor.

### 2.3 Big Interference From Outside Magnetic Field, and the Great Deflection From Pilot Hole Track

Based on years of experience in directional drilling crossing the oriented hole construction, external magnetic field is mainly composed of underground pipes, cables, power lines, such as the external magnetic field influence new magnetic intensity and magnetic angle, influence to magnetic azimuth control, however, which leads to the magnetic azimuth measurement deviation, and the magnetic azimuth inaccuracy results in guide hole in construction of drilling direction control, which seriously affects the actual trajectory guide hole.

## 3. WEATHERED ROCK DIRECTIONAL DRILLING PILOT HOLE CONSTRUCTION

### 3.1 Geology Exploration

According to the report from the geological exploration unit field exploration on construction area, there are mainly three aspects<sup>[1]</sup>: a) The structure of the ground of illness, such as pole, large buildings, and so forth; b) To screen underground industrial facilities, such as city heat supply, gas pipeline, such as national defense optical fiber cable; c) Due to the weathering degree of rock weathering rock, directional drilling to drill pilot hole through the formation of geological structure change is relatively obvious, the directional drill pilot hole has caused some difficulties in construction. In addition, because of its environment and different regions, various facilities may not be perfect, the limits of the construction site, the influence of climate, so the cross section of geology to do scientific analysis is very important.

## 3.2 Measuring Unreeling

### 3.2.1 Cross Section Measurement

In the process of measuring unreeling, the control the measuring unreeling is mainly based on the design drawings and parameters, It brings the great difficulty to the measurements due to the block between the earth and the grave unearthed. First of all, to fix the directional drilling, and locate the place for the grave to take back and forth pour point measurement using coordinate control, put between the grave unearthed, straight line at the scene of the construction area marked by white; Secondly, according to the directional crossing construction characteristics, higher requirements on accuracy of measuring unreeling, in order to reduce the artificial measurement error in the measurement process, in the fixed pile orientation when measured in the bar, logo on pile intersection, for many times to reduce the measurement error. Requirements for unearthed the grave Angle, Angle, azimuth Angle precisely, gradient measurement, the measurement data after finishing, using computer simulation technology directional drilling guide hole trajectory simulation.

### 3.2.2 To Strengthen Magnetic Azimuth Measurement

Magnetic azimuth directional drilling guide hole is the key point to the data. The guide hole is the original numerical value, which is to ensure that the guide hole through the crucial factors of curve is smooth. So, before the pilot hole drilling, one must calculate accurately the magnetic azimuth measurement section across the centerline, to guarantee the accuracy of the data. Because the theconstruction equipment will disturb themagnetic azimuth measurement, the controlling and measuring personnel must go to the grave in front of the equipment in the point of measuring magnetic azimuth. When measuring, one should avoid large structures which has larger electric current magnetic field on the earth's surface, power lines and other large steel industrial objects and underground pipelines, etc., to avoid the probe affected by the magnetic disturbance, and the great data deviation. Using total station to sonde along its axial line direction accurately, one should place in the center line of the pipeline crossing the lead, combine along the radial sonde in 0°, 45°, 90°, 135°, 180°, 225°, 270° and 315°cross section of the magnetic azimuth measurement. Every turn, pass the total station to reposition determine whether the sonde accurate positioning on the centerline of the cross section of the wire. On the section through the centerline, shangdi surface of multi-point measurement in out, two points from each side of the grave, then compare each measurement data analysis, determined to eliminate errors due to magnetic interference measurements, accurate magnetic azimuth value are obtained. If each set of measurements data values differ over 0.2°, the need to increase 2 - 4 points, to ensure the accuracy of the magnetic bearing numerical, and the optimum parameters

of the original point to the record, is advantageous for the guide hole drilling.

In directional drilling during the construction of the guide hole, one should base bit drilling direction control on field measurement of magnetic azimuth. Under the circumstance of no interference of external magnetic field, the azimuth angle and point to the azimuth of the actual measurement are small; But when the point to the azimuth abnormally, the drilling direction of trajectory deviation will happen<sup>[2]</sup>. To control the direction of the guide hole drilling at the same time, the control of each tool offset in the permissible range, the drilling practice is needed, but each time to avoid adjusting offset in a too fast and large manner.

### 3.3 Ground Leveling

Directional drilling construction covers an area of drilling site, pipeline site, reservoir, mud floor, pipeline welding covers. Equipment installation area should be solid, and the corresponding foundation reinforcement measures should be taken. The selection of the drilling rig is based on directional drilling rig installation site models. The size of the mud pools and reservoir covers depends on the size of the pipe diameter, sites and geological conditions, so as to make economical use of land as much as possible. When it gets unearthed according to the pipe axis center, the area of the width and length (to add 50 m) through the design curve length, discharge pipe, mud pools, covers an area of the site, and pipe welding line, and mark the car pulling in and out of the ground line and place.

### 3.4 The Configuration and Control of Mud

#### 3.4.1 The Overview of Track Mud

In directional drilling crossing engineering, the quality of mud greatly affect the quality of the guide hole construction. Ordinary mud is mainly composed of bentonite, water and additives, according to the actual situation of crossing section of the geology, it is necessary to adjust the proportion of mud composition. If the geological structure lacks uniformity, and the crossing length and diameter is larger, there will be a high requirements for the mud performance index. Certain measures need to be taken to ensure the quality of the mud and drilling through the guidance of blastholes Kong Liang well<sup>[3-4]</sup>.

(a) Mud has strong viscosity and liquidity, which can carry drilling cuttings into weathered rock strata, making cuttings in a suspended state in the bottom of a guide hole, weathered rock cuttings will get out of the ground as the mud circulates.

(b) The mud should have a stronger power in protecting the walls, improving the stability of borehole wall of hole, especially for weathered rock strata formation heterogeneity is easy to collapse.

(c) Mud has a stronger function of lubrication and cooling performance, providing effective lubrication for drilling tools, especially when getting through the

weathering rock formation, due to large friction between tool and formation, it will produce a larger quantity of heat, mud need to be cooled down, protecting the drill to ensure the smooth construction.

(e) Based on each layer of the weathering rock weathering degree is different, it is necessary to adjust the pressure and flow rate of slurry, meeting the needs of the drill guide hole construction.

#### 3.4.2 Hole Formation: the Key to the Success

To ensure the formation of a curve, to prevent the hole collapse, in all, to solve the problem of hole forming. First of all, to formulate the plan for guiding hole mud proportion, choose different mud formula before drill pilot hole according to the situation of the geological structure, and the inequality of the formation, During the long construction of the guide hole, the melted soil is easy to coat tool, so the general preparation for the preventing pasting hole through the formation fluid is to reduce the friction coefficient in the pilot hole, and also to reduce the resistance between drill pipe and formation, so as to improve the drilling hole rate<sup>[5]</sup>. Judging from the surface, the geology is commonly covered with filled soil, clay, but there are strong weathered rocks, fracture shape quartzite worn by the breeze on the bottom, weathering rhyolitic porphyry, weathered rock under the sand. When there are great changes in soil area, efficient bentonite and other auxiliary additives should be prepared on the spot. Also, considering the moisture content and the bearing capacity of the construction area the different state of the geological and geotechnical structure, fault or variable layer, on the basis of geological mechanics and the theory of structural mechanics, construction equipment, the force applied on the machine axis or the deviation of the elevation accidents frequently occur in some turning points during the actual installation of pipeline. The difference in groundwater and the formation of moisture content of liquidity has a great impact on the mud viscosity, and in the crossing construction after the operation, the tightness and the lifespan of the pipeline will be greatly affected. The most important key of the influencing the surrounding environment geology has changed greatly, if not valued highly in the construction plan, there will be a great hidden safety trouble.

#### 3.4.3 Configuration of the Weathering Rock Slurry

(a) Pretreatment: to have water from the river to the precipitation in the sedimentation tank, then to add the softening  $\text{Na}_2\text{CO}_3$  into the precipitation of water, in order to reduce the quantity of the  $\text{Ca}^{2+}$   $\text{Mg}^{2+}$  in the sedimentation to adjust the PH of the water to 9 - 10, to ensure that the bentonite hydration thoroughly.

(b) The experience in recent years for directional drill pilot hole construction found that weathering layers requires a relatively large mud viscosity value. Based on the requirement for stratum situation the mud viscosity is shown in Table 2.

**Table 2**  
**The Mud Viscosity Based on the Requirement for Stratum Situation**

Geological properties	Parameter									
	Density	Funnel viscosity	Water loss	Plastic viscosity	Yield value	Specific value	Liquidity index	Consistency coefficient	Power of hydrogen	Friction coefficient
	D	FV	FL	PV	YP	YP/PV	n	k	PH	f
	g/cm <sup>3</sup>	s	ML	MPas	Pa	1/S		pas		
Silty clay	1.04 - 1.05	30 - 35	6	18 - 24	10 - 15	0.4 - 0.5	0.6 - 0.7	100 - 350	8 - 10	< 0.07
The pebble gravel	1.04 - 1.06	40 - 45	8	25 - 35	20 - 25	0.6 - 0.75	0.6 - 0.65	320 - 650	9 - 11	< 0.06
Weathered rock	1.05 - 1.08	45 - 55	8	20 - 35	15 - 25	0.5 - 0.65	0.5 - 0.65	500 - 1,300	9 - 11	< 0.06

(c) The general Na-CMC (carboxymethyl cellulose sodium) mud. This is one of the most common type of the sticky mud, and Na-CMC can have the effect of further stick and drop water loss Ingredients: 1 m<sup>3</sup> of water, high quality mud for making clay 60 - 80 kg, soda ash 3 - 5 kg, Na-CMC 10 - 20 kg; Mud performance: the density of 1.03 - 1.03, the viscosity of 25 - 60 s, about loss less than 30 min, 12 ml/pH 9.5.

#### 3.4.4 Mud Control

By using two sets of feed proportion system, increasing the appropriate mud cycle, prolonging hydration of bentonite, that the performance of the mud can be ensured. To test regularly the pH value of slurry mud in the process of recycling, so as to ensure the pH in 9 - 10. The quality of the mud can be ensured by adding the following ingredients to prevent the loss of water, to strengthen wall agent, to promote the disperse of the clay, etc. According to the formation conditions of the crossing section in the drill guide hole phase, the maximum of the mud viscosity should be in 45 s and 50 s; When there is strong weathered rock in the process of construction, mud viscosity should be improved by 5 - 10 s, namely to 50 - 55 s.

### 3.5 Using Artificial Magnetic Field Guide Hole Curve Shifts

To understand the cross section of the geomagnetic field with the aid of the bit at the back of the probe and the computer when the Guide hole drilling is working. Because of the weakness in the earth's magnetic field, vulnerable to the interference of external magnetic field, the magnetic azimuth data collected is not so accurate, which affects the subsequent quality of pilot hole track. Artificial magnetic field is in the closed section across the center line on both sides of the setting current coil, coupled with strong large direct current (dc), and its magnetic field is far larger than the earth's magnetic field and other objects of the magnetic field strength, and the impact of other magnetic field can be ignored. Artificial magnetic field layout is simple<sup>[6-7]</sup>, but effective and low-cost in the directional drilling construction Directional drilling can accurately monitor the location of the bit located around, crossing point elevation and the offset. When the probe in the range of

the artificial closing coil to closing coil with dc current to produce artificial magnetic field, on the basis of the magnetic field around elevation and section can be obtained through the axis through migration. Based on the comparative analysis between the artificial magnetic field and the magnetic field around the deviation analysis, it can accurately determine the current drilling azimuth and then determine the next drill pipe drilling azimuth. Practice has proved that under the condition of the earth's magnetic field interference, with the aid of artificial magnetic field it can judge the section through the azimuth accurately; If the earth's magnetic field is not interfered, it can also control the correctness of the magnetic azimuth correction, and control accurately and effectively the trajectory of drilling pilot hole and design the migration across the curve to ensure that the section through the curve has good smoothness.

### 3.6 Guide Hole Construction

Guide hole trajectory control curve is directly related to the quality of the directional drilling construction. Based on the working experience for many years in the weathered rock strata directional drilling construction, we usually use the power drill, tricone bit, core sampler room, compound pipe, non-magnetic drill collar, such as ordinary drill pipe drilling tool combination. The following is a weathered rock guide hole construction quality control measures:

(a) there is a weathered rock strata, drill guide Kong Ma resistance coefficient is larger, drill bit power is hard to arrive, adopting compound pipe and casing drilling technical measures, to prevent drill pipe due to the long distance at wellhead and clay layer part deformation, instability, and improve drilling efficiency.

(b) According to the weathering of rock strata geological drill guide hole drilling difficulties, power tool for mud motors, mud drive mud motor running. Fast drilling process, the rate of flow, pressure, and constantly to the insulation of the wire connector contraction scour control set, increase the drill pipe wall friction, friction repeatedly will burst, causing circuit open circuit or short circuit, the interrupt signal. In guiding hole drilling process, through the drill pipe in adding retaining ring can

reduce the impact of the mud to control to the line, and can avoid interruption due to point to the line breakage detection signal.

(c) Guide hole drill ground equipment operation situation analysis. Weathered rock stratigraphic guide hole construction after in homogeneity, cutting and drilling pressure, torque, mechanical drilling rate, pressure instrument can directly reflect the downhole conditions on the ground, such as pilot hole should be keeping a close eye on, especially the torque and pump pressure, mechanical drilling rate and cuttings, important data records in the process of orientation, analyze and judge the change of formation.

(d) According to the weathered rock, mixture of mud (fluid) is made suitable for formation of earth when the drill guide hole is working, to control strictly the viscosity and specific gravity of slurry and the size of the displacement, pressure. Mud being the auxiliary coordinate system, to adjust the mud mixture proportion, which plays an important role in the control to the slurry, and to make the curve “flat, smooth, round, slow”.

(e) When the weathered rock guide hole drilling is in progress, the adjustment of every drill pipe, drilling speed the signal change lag using mud motor orientation at the same time the adjustment of each drill pipe to control parameters of minimum deviation between the each drill pipe is needed due to the change of the structure of the rock. If the guide hole deviation is too big, in the spare part or all of the drill rod back into action, the tool is hard to get out of the original drill new holes, even to new hole drilling, the large curve will be formed in the original and the new form the angle of the intersection, so it cannot satisfy the requirement of the pipeline crossing the radius of curvature.

### 3.7 Wireless Controlling Line Monitoring System

Upon the guide hole construction, the use of wireless monitoring system to monitor can ensure energy emission probe and tracking device on a vertical line, and the timely data comparison with the pipeline crossing project design drawings the designed trajectory parameters control, and to ensure the directional drilling to conform to the requirements of the design of pilot hole track.

**Table 3**  
**Guide Hole Curve Deviation**

Project	Lateral deviation (m)	Upper and lower deviation (m)
Allowable deviation	-3 - +3	-1 - +2
Control before	-5	+3
After the control	-1.5	+1.2

### 3.8 The Actual Controlling Situation for the Directional Drilling Guidance Trajectory Deviation

For directional drilling weathered strata, to control strictly the measuring unreeling, mud compatibility, and the interference of outside magnetic field and so on, so the good effects have been obtained, and fully meet the standard of GB 50424-2007 in the guide hole to curve and design curve deviation less than 1% in real terms.

## CONCLUSIONS AND SUGGESTIONS

(a) When directional drilling crosses weathering rock, the preparation before the construction include: a careful analysis of the cross section of the geological condition, completing the measuring unreeling, gathering of controlling the parameter, designing of pilot hole trajectory control, developing the practical and feasible construction scheme, computer simulation.

(b) Guided-via-curve should be “flat, smooth, round, slow”. To control strictly each of the drill pipe for the controlling parameters when guide hole drilling gets through, drill pipe; When guide hole deviation is too big, the spare part deviation, bore in the original, the new form the angle of the intersection of the curve of the large, cannot satisfy the requirement of the pipeline crossing the radius of curvature.

(c) In the process of the guiding hole drilling, the data for controlling parameters, mud property, displacement parameters, drilling drag force, torque, etc should be collected promptly. According to the data comparison, the drilling progress can be judged, so reasonable adjustment will be made in time to ensure the quality of construction and improve the directional drilling pilot hole drilling success rate.

(d) Because the weathered rock strata adopts combining equipments, when drilled rock formation on the unearthed end get into the soil, power tool weight is bigger, formation heterogeneity, bit has difficulty in being raised. so the unearthed process will be lagged. The Suggest is that we need to increase the bit tilt angle to 2° or so in advance for drilling rock, so as to control bit drilling soil layer angle decrease unearthed much impact.

(e) To make high-quality fluid according to the weathering rock geological situation. For some complicated geological conditions, adopt high viscosity mud, to adjust the ratio of composition of mud in the process of drilling, mud flow rate and drilling pressure, to ensure that the mud with lithology can get through smoothly.

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