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Ultra Short Radius Drilling Trials in PDO

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Abstract

Productivity from thin reservoir layers and thin oil rims can be enhanced by short laterals, fully contained within the layers. Ultra short radius system will be required to kick off and drill these lateral within the reservoir. Now days, these system are available as Rotary Steerable system 4-8 m and jetting system (0.5 m). This paper will discuss the flexible pipe rotary system, in particular the Torch drilling services (TDS) system and the implementation of this system in PDO.

This system has been tried two times last year in Lekhwair field. In both wells a dual lateral have been drill and completed as open hole injector. The paper will discuss this the technology concept, describe the tool and drilling procedure and will summarize the operational aspect of the trial. Couple of trials will be planed this year (2003) to complete the evaluation of the system.

Introduction

It is well known that in most cases the production from the horizontal wells is more then from vertical wells on the same reservoir depend on the horizontal and vertical permeability. This was demonstrated during the last decade by the dramatic increase in the number of the horizontal wells. As an example, the Analytical models (Ref.1) for Barik field, PDO Oman, indicate that sidetracks increase the well productivity by a factor of 1.8 to 2.4 and hence accelerate the field production. A new well design emerged from the various "Drilling the Limit" workshop while preparing for the Barik FDP suggested Short radius horizontal sidetracks of 100-200 m to be drilled from vertical slim monobore well targeting well developed sands around the well to overcome traditional, relatively low

well potentials (175 m³/d). Planning for a new horizontal well or converting a vertical into horizontal well is not always achievable either due to the technology limitation or economic justification.

The New Technology Section in PDO's Well Engineering department was allocated to search for the suitable technology to drill 4m to 8m radius wells in the Barik field. Several options were screened out of which Terra (Previously called Torch) Ultra Short Radius Drilling System was chosen for different reasons.

Prior to embarking on a full commercial application of drilling Ultra short radius implementation, five trials were planned to prove the ability of the tool to complete the objectives and to evaluate the production result compared with the typical vertical wells and to prove the economic gains of USR wells. At the time of writing this paper, two duel lateral wells were drilled successfully in Lekhwair as part of this trial.

History of the Terra USR technology

In 1989, Amoco initiated a project to develop a short radius lateral drilling system. The development criteria consisted of four main objectives:

- (1) Develop a system low in cost to manufacture, repair and operate;
- (2) Develop a system that will drill a predictable and consistent radius of curvature in a desired direction;
- (3) Develop a system capable of operating from a service rig using a power swivel; and
- (4) Develop a system capable of working inside 4.5" casing.

Following development of the prototype tools, more than 200 test wells were drilled at Amoco's Catoosa Test Facility near Tulsa, Oklahoma. Following testing, the technology was taken to the field where it was used to drill several wells at Amoco's Level land Unit. These initial test wells proved the basic capability to install lateral drain holes at a reasonable cost with a top drive power swivel and workover rig.

Since the first quarter of 1995, more than 160 wells have been drilled with the same USR System.

Concept of Terra USR System

The system is purely mechanical. There are no mud motors or expensive electronics down hole. The tool has a bit with a diameter, D, that is the same as the wellbore diameter. For a tool with Outer diameter, d, and length, L, contacting the borehole wall at point, P, there is one and only one curve

radius R where the bit face centerline is exactly pointing along the curve centerline at the bit face (Fig-1).

If the bit drills in the direction that it is pointed, it will continue to drill along a curved path of radius R as long as the upper end of the tool is positioned along the outside wall of the curve. If the tool is perturbed so that it is in a shorter radius curve, the bit will point to the outside of the curve and the radius will increase to R. If for some reason the radius is longer than R (as is always the case during a kickoff) the bit will be pointed to the inside of the curve, decreasing the radius to R. The tool is self stabilizing as it drills along the desired radius of curvature.

USR BHA

The USR system consist of two drilling assembly, one for the curve drilling (CDA) and one for the lateral drilling (LDA).

Curve Drilling Assembly

The Curve Drilling Assembly ("CDA") (Fig-2) is very simple in design. Key features of the CDA include an Amoco-patented anti-whirl, bi-center PDC bit, bit sub, signal ring, non-rotating deflection sleeve, lower torque shell, ball pin and upper torque shell.

Design of the anti-whirl bit provides for a consistent and reliable angle build. Directional control is a result of stabilizing the bit to continually point along a curve path. Cutters are positioned so that they direct a lateral force to a smooth pad on the gauge of the bit. This pad contacts the borehole and acts as a bearing by transmitting a restoring force to the bit. This force rotates with the bit and continually pushes the smooth or bearing side of the bit against the borehole wall. This design minimizes the side cutting action that is typically observed with PDC bits and results in a consistent wellbore diameter.

The CDA drills a curved path by continually pointing the bit along a tangent to the curved path. Contact points on the bit and the wear pad at the base of the deflection sleeve control the bit tilt. The desired radius of curvature is obtained by utilizing a bit sub to alter the distance between the two contact points.

The deflection sleeve is an eccentric sleeve constantly keeps the upper end of the rotating mandrel pushed off-center in the hole an amount determined by the eccentricity of the bore through it. In order to keep the mandrel pushed toward the outside of the curve, the eccentric sleeve must be oriented with the eccentricity positioned toward the outside of the curve. The deflection sleeve (Figure 3) houses blades which, during right hand rotation, engage the wellbore to maintain toolface direction. Left hand rotation allows the driller to reposition the toolface in the event of slippage.

Initial toolface positioning to the target azimuth is established by gyro orientation. A protractor plate is used on

the rig floor to orient toolface and reference target direction. A scribe line is placed on the work string coinciding with target direction on the protractor plate. Once oriented to the desired direction, the toolface is monitored by pump pressure signals at surface. These signals are monitored throughout the curve drilling process to maintain directional control.

The mandrel/deflection sleeve assembly also contains a Fluid Port and Signal Ring. The fluid port, which is machined into the mandrel, has a matching port on the signal ring. The signal ring is held in place by a tang which engages the deflection sleeve. As the mandrel and drill bit rotate to the right, these two ports will open and close with each rotation creating a pressure drop at the BHA. This signal is transferred to the mud pump gauge and monitored on the rig floor. The position of the scribe line mentioned previously is checked when these two ports are in alignment. When curve drilling commences, the pressure signal and scribe line are the key elements used to monitor toolface position. This position is a positive indication of tool face direction.

A Ball Pin that acts as a fulcrum connects the upper and lower torque shells. The ball pin is the hinge point that allows the upper and lower torque shells to rotate at independent angles to each other. The lower and upper torque shells along with the drill pipe become one unit and are driven by drill pipe rotation. The upper shell has no additional components attached to it.

Lateral Drilling Assembly (LDA)

Lateral drilling is strictly a rotary process. The lateral assembly consists of an anti-whirl bit, two stabilizers and two articulated subs connected to a flexible drill string of composite, titanium or steel pipe. The lateral assembly is essentially a point and shoot technology - the bit goes where it is pointed. Over a 500 lateral, the azimuth change is 3 degrees or less. At the present time, there are two assemblies. The "Gentle Riser" is engineered for a build rate of approximately 10 degrees per 30m. The "Straight Shooter" is for maintaining inclination and produces near neutral responses of -2 to +2 degrees per 30m.

Surveying is done with a tri-axial steering tool probe. The probe contains specially designed miniaturized instrumentation that can negotiate doglegs approaching 2 degrees per foot inside 1.5" ID pipe. Electronics consist of flux-gate magnetometers and accelerometers. All data is real time and transmitted to surface via 5/16" single conductor wireline. Survey data includes inclination, azimuth, magnetic field, gravity toolface, magnetic toolface and temperature. Following a drilled segment, probes are run in the hole and if needed, the mud pump is engaged to deliver the probe to bottom. Because of the high build rates to drill a 9m to 18m radius and the small margin of error in hitting TVD targets within ± 60 cm and at the desired angle, surveys are pulled in 60cm (2 foot) stations. Typically, 2-3 surveys are run in the curve drilling process. Survey data is then used to project inclination at the bit. Probes are tripped out before drilling resumes.

In the lateral, surveys are usually run every 30m. However, this may vary depending on dip rates, target thickness, rock hardness and knowledge of the formation being drilled.

Wellbore Preparation

Wellbore preparation is a critical process. Two key steps that must be executed properly are sectioning the production casing (in case of workover well) and spotting the cement kickoff plug.

The interval to be sectioned depends on the dimensions of the curve and the number of laterals to be drilled. Usually a minimum of 7 to 8m is cut to accommodate one 9m to 18m radius curve. For larger radii and/or multiple curves, a larger section is required. It is important that the sectioned interval be located at the exact depth called for in the wellplan. If there is any doubt as to the location and/or the quality of the section, the interval should be under-reamed.

Following the sectioning procedure, a cement plug is set at total depth ("TD") or just below the sectioned interval. Cement is brought up through the section and to a depth where at least 60m of cement is inside casing. In certain cases, a cast iron bridge plug ("CIBP") must be set just below the sectioned interval and immediately above the top perforation. The CIBP will help isolate the cement plug from possible hydrocarbon contamination. The cement plug is multi-purpose providing zone isolation for the original completion, mechanical strength for the curve drilling assembly to kickoff and toughness to remain intact throughout the rotary drilling process. A period of 48-72 hours should be allowed for the plug to cure. The plug is then dressed off to a depth 2.5m to 4.5m above the projected kickoff point.

Drilling Operations

Following dress off of the cement plug, a pilot hole of approximately 2.5m to 4.5m is drilled to the kickoff point using a packed hole assembly and the anti-whirl PDC bit. The hole is then circulated clean and the pilot assembly tripped out.

Drilling the Curve

Following the scribe procedure and mule shoe alignment at surface, the CDA is tripped in the hole to approximately 1.5m from the kickoff point. A function test of the tools is performed by checking the pump pressure signals at surface. Next, the toolface is oriented with a gyro and the pipe scribed to the protractor plate. Curve drilling commences and re-alignment of the toolface is made after each foot drilled in the following manner:

1. Drill string rotation is stopped.
2. The assembly is picked up off bottom.
3. The drill string is rotated to the left until a pressure port on the deflection sleeve opens; a

pressure drop at surface will indicate that the deflection sleeve is locked and moving with the assembly.

4. The drillstring is rotated farther to the left until the surface scribe line is pointed in the target direction referenced on the protractor plate.
5. The drillstring is then reciprocated to remove drillstring twist and bring the deflection sleeve in line with the surface scribe line.

The frequency of the re-alignment maneuvers may be decreased to every 60 to 90 cm drilled if pressure signals appear constant. After drilling approximately 9m, a survey is run to check build rates and direction. Based on survey data, drilling may continue or the toolface may be repositioned to correct for any slippage. A second and possibly third survey will be run to fine tune the inclination at the terminus of the curve. When the curve is complete, the CDA is tripped out. The total curve drilling process usually takes 8-24 hours to complete depending on depth, rate of penetration and radius drilled.

Drilling the Lateral

The "Straight Shooter" is run the majority of the time to drill the lateral. The bottom hole assembly ("BHA") consists of the Straight Shooter and the required footage of flexible drill pipe. Prior to drilling the lateral, the curve must be gradually reamed. Once on bottom, drilling resumes with emphasis placed on torque, RPM's and weight on bit. Surveys are usually taken every 30m or as needed. When TD is achieved, the hole is circulated clean and the pipe tripped.

PDO USR experience

Barik filed with very light oil in the upper and middle Ghariff is contained in oilrems of varying thickness 4-57m. To have both the window in the 4 1/2" completion and the lateral in the sand channel, an ultra short radius system is required. Based on existing data, 4 m radius could capture 65-70% of the total oil sand intersection where 6 m system could capture only 35-40% of the total oil sand intersection thus the requirement for USR system is a must. The USR technology was brought in first place to complete wells on Barik field however due to drilling sequences and other reasons the system will be tried in other filed before Barik.

To the date of writing this paper, two trials were performed successfully in Lekhwair 365 & 366. The Lekhwair Field is in the north-western portion of the Petroleum Development Oman (PDO) concession area. The field produces light, low viscosity oil from two low-permeability (1 to 10 md) limestone reservoirs, the Lower Shuaiba and the KharaiB. The L. Shuaiba is about 100 ft (30 m) thick while the KharaiB is about 60 ft (18 m) thick, with 16 ft (5 m) of shale between the two intervals. The objectives of the two trials is utilize USR technology to drill dual laterals targeting lower Shuaiba B1.2 and KharaiB 5 reservoir in the northern western part of the Lekhwair "A" North in order to provide injection support in the Shuaiba and KharaiB reservoir

In both trials the well designed called for 9 5/8" casing set into Dammam formation at 527m and 7" casing set into the top of the upper Shuaiba at 1218m. A 6 1/8" pilot hole was then drilled to 1297m and then logged. A class G cement kickoff plug was then set in the 6 1/8" hole and brought up inside the 7" casing to a depth of 1165m.

Lekhwaier 365 Trial

Cement Kickoff Plug and Dress-off

After completing the logging operation of the pilot hole, the hole was plugged back with class G cement. Setting of a competent kick off plug, which can stand the drilling stresses and injection pressures during the life cycle of the well, was one of the critical success factors. In order to achieve this, 0.35 % of fiber was added to the cement recipe to increase the tension strength of the plug especially that it is planned to drill dual laterals above each other which eliminate the risk of having the cement to collapse and packing off the BHA while drilling the second lateral. 6 1/8" bit with scrapper was used to dress off the top of the cement plug to 1234.6m.

Drilling 4 1/2" Pilot hole

The Pilot Hole Assembly consists of a 4 1/2" BP-Amoco patented anti-whirl, bi-center; low friction PDC bit, one 4 15/32" near bit stabilizer, one 4 15/32" string stabilizer and a 3 3/8", 7' long DC sub. This assembly drills a true gauge pilot hole of 4 1/2" which is required for accurate toolface orientation of the Curve Drilling Assembly.

A pilot hole of approximately 3m was drilled to the first KOP at 1237.2m.

Drilling Curve Section of H-1

The Curve Drilling Assembly (CDA) (see figure 2) consists of the following: 4 1/2" PDC anti-whirl bi-center bit, bit sub, mandrel with 4 1/2" eccentric stabilizer sleeve and, lower and upper torque shell.

The BHA for the curve-drilling segment was comprised of the CDA, three joints of composite drillpipe and an adjustable mule shoe (UBHO Sub). The BHA then crossed over to the 3 1/2" drillpipe.

Following a scribing procedure to align the toolface with an adjustable key housed in the mule shoe the CDA was lowered inside the pilot hole and the toolface oriented to 124 degrees azimuth, the curve drilling procedure commenced at 1237.2m. The first segment of curve was drilled to 1246.6m and an initial survey was run on tri-axial survey tool. Curve drilling continued to 1252.6 and a second survey then taken. After tying in survey data from these two surveys it was projected that the desired sail angle of 88.5 degrees would be achieved at 1253m. The remaining 0.4m was drilled and the CDA POOH.

The tri-axial tool seats into the upper torque shell of the CDA, which is slightly less than a meter from the bit. The survey

tool housing is run on wireline and pumped down until it is seated in the CDA resulting in a pressure increase and confirmation that the tool is seated. The depth counter is then corrected for depth and two-foot stations are pulled up through the KOP to record inclination and azimuth

The survey taken for the vertical hole before kick off point shows that the well had a horizontal displacement of 8m with a hole direction of 334 which required steering the bit back to the desired azimuth of 122 degrees.

Due to the dogleg severity of these USR wells no steering tools can be run while drilling. The toolface is monitored by the use of scribe lines on the drillpipe which is used as a reference for toolface position and by pressure drops at surface transmitted by a port. The toolface position is checked every two feet and corrected as necessary by slight rotation to the left. Accuracy is affected by the width of a chalk line and the driller's recognition of pressure drops as and where they occur.

The first curve drilled resulted in landing the curve at the desired 88.5 degree inclination, less than 8 degrees off target azimuth and 0.5 m from desired TVD.

Drilling Lateral H-1

Lateral assembly consists of the following: anti-whirl, bi-center, PDC bit, near bit stabilizer, wobble sub (articulated sub), string stabilizer and wobble sub.

Unlike the CDA which can be used to adjust course direction, the LDA is strictly a point and shoot technology. Control drilling is used to either drop or build angle to make subtle changes in the well path trajectory. The LDA was very responsive in the Shuaiba 1.2 to adjustments to WOB, RPM's and pump pressure. Less weight, higher RPM's and lower pump pressures resulted in the bit slightly dropping angle. Increased weight, lower RPM's and lower pump pressure resulted in building angle.

The LDA was RIH to the KOP at 1237.2. Each curve has to be reamed to get back to bottom before actual drilling can begin. It is critical that constant weight is applied to prevent bypassing the curve. A 4 1/2" lateral was drilled from 1253m to 1437m. A third survey was taken after drilling 8m of lateral hole to confirm the sail angle (EOC inclination).

The lateral was drilled in two stages to minimize the buckling of the composite pipe inside the 7" casing and 6 1/8" open hole to extend the life of the composite. A total of 11 joints of composite were run to drill Stage 1 from 1253m to 1333m. An additional 13 joints were picked up to drill Stage 2 from 1333m to TD at 1437m. Drilling conditions at TD indicated additional lateral could be achieved as torques was running smoothly at 1200 ft-lb. It is believed that H-1 has achieved a new world record for lateral length from a 34' radius.

Stimulation of H-1

After reaching TD of H-1 the composite was left in the hole to be used as the stimulation string. Drilling mud was displaced with DHW. Following acidizing the lateral with 15% HCL the composite was pulled back inside casing and a period of 2 hours was given for the acid to spend. The composite was then run back to bottom and the acid displaced with a polymer (Duo - Vis pill) to prevent cuttings from entering the wellbore while drilling the second curve and lateral. The Duo-Vis pill was designed to self-break after 5 days.

Lab tests were conducted at PDO to test the pipe for reaction to several fluids including 15% HCL. Results indicated that the outer coating of resin was slightly affected by the acid. The report raised no concerns about the possible affects of acidizing through the composite. However, following stimulation of the H-1 it was observed that one joint had restricted ID due to a collapsed or damaged liner. Additional joints showed acid still spending on resin at surface. The resin acts as the bonding agent which holds the fibers together and which gives the matrix of the composite its tensile and torsional strength.

Following a discussion with the Drilling Team it was decided that steel pipe of 1.9 Hydril CS should be used on stimulation of laterals following the observations on the H-1.

Drilling the Bypass and Curve Section of H-2

The bypass assembly consisted of the Pilot Hole Assembly with a second string stabilizer placed above the 7' DC Sub to add more stabilization. Four 3 5/8" DC's were run above the Pilot Hole assembly and crossed over to the 3 1/2" drillpipe. The bypass commenced at the first KOP at 1237.2 and continued to the second KOP at 1263.7m. After drilling just a few meters no cement was observed in the samples. New formation was drilled to the second KOP.

Drilling Kickoff was initiated from formation rather than cement at 1263.7m. The first segment of the H-2 curve was drilled from 1263.7m to 1269.7m before running Survey #1. This was a shorter hole length than on the first segment of the curve on H-1 and also shorter than what it is preferred, hence did not provide enough survey information to establish tool performance. The survey at 1268.5 showed an azimuth of 124.7 and did not indicate any severe slippage of the toolface. Drilling several more meters on a second joint would have provided more data, but required the rig hand to work much higher and be at more risk.

This can be avoided on subsequent wells by drilling a longer segment before running the first survey. Despite the almost 26 degree miss on azimuth the end of curve still landed at the desired sail angle.

Drilling Lateral Section of H-2

As was the case with H-1 a survey was taken after drilling 8 meters to confirm the sail angle. It was at this point that we

received an inclination of 91.4 degrees at 1283.8m which indicated the LDA had built approximately 2.6 degrees over the first 8 meters of lateral. Control drilling to drop angle by reducing weight from 1.5-2 tons to 0.5 to 1 ton and increasing RPM's from 70 to 45 and pump pressures. After drilling 5 meters the pipe was worked back through the drilled segment to trough out the low side of the hole in order to drop angle. This procedure continued one joint to 1295m. Survey # 4 was run and inclination at 1293m read 89.8 degrees. It was decided to continue to drop angle and the same procedure was followed on the next joint to 1314m. While dropping angle was successful more angle drop was created than what it was necessary due to bogus surveys. As a result of this discrepancy, the wellpath dropped lower into the K-5 than was planned. Building angle was then required by increasing weight, reducing RPM and cutting back on pumps to keep the wellpath into K-5. However, due to the inclination of 80 degrees there was not enough room to correct and build angle quickly enough before exiting the K-5. The decision was made to run the Gentle Riser to build angle more quickly. Once the GR got into a pattern it built from 79 degrees to 91 degrees at TD of 1386m. Even though this was an unplanned trajectory it was in line with the desired wellpath for the injection profile.

The survey procedure entails a pump down wireline conveyed tool that seats into the BHA and creates a pressure increase to confirm it is at bottom. Survey intervals in the curve are every two feet, which may not exact station due to wireline stretch. Tool joints also affect azimuth readings and slightly affect inclination readings as well. While it may seem primitive it is the only tool on the market that can negotiate the dogleg severity of USR wellbores. The survey data may vary from tool to tool as much as two degrees due to calibration and running procedure. Each tool is calibrated prior to shipment and cannot be calibrated in the field due to the microelectronics housed in the sonde.

The lateral was then stimulated using 1.9" CS Hydril as the acid string. No damage was observed to the tool joints or pipe body.

Lekhwait 366 trial

Drilling 4 1/2" Pilot hole

A pilot hole of approximately 3m was drilled to the first KOP at 1232.2m.

No problems were encountered during the drilling of the pilot hole.

Drilling Curve Section of H-1

The same procedure in Lekhwait 365 was followed again in this well and a curve is drilled from 1232.2m to 1246.72 with sail angle of 87.5 degrees. The curve was landed 87.5 degrees inclination, 16.4 degrees off target azimuth and 0.8m higher than desired TVD.

Drilling Lateral H-1

The LDA was RIH to the KOP at 1232.2. Each curve has to be reamed to get back to bottom before actual drilling can begin. It is critical that constant weight is applied to prevent bypassing the curve. A 4 1/2" lateral was drilled from 1246.72m to 1398m. A third survey was taken after drilling 8m of lateral hole to confirm the sail angle (EOC inclination).

Drilling the Bypass and Drilling Curve Section of H-2

The bypass commenced at the first KOP at 1232.2 and continued to the second KOP at 1258.8m. The hardness of the plug and soft formation combined with the aggressive kickoff at 1232.2 caused a subtle deflection of the bit resulting in the BHA deviating from the original hole. Despite the fact the bit tracked off the plug no problems were encountered when initiating the second kickoff.

As was the case with H-1 the target azimuth was 300 degrees. However, due to toolface slippage on H-1 and on H-2 on well # L-365 it was decided to set the toolface at 288 degrees to allow for anticipated slippage. In addition, toolface checks and corrections were made every foot rather than every two feet as was the case with the two curves on 365 and H-1 on this well. The first segment of the H-2 curve was drilled from 1258.8m to 1266.14 m before running Survey #1. Survey #1 reflected toolface slippage and walk to the right of some 20 degrees over the first 7m from 287 to 317 degrees. The second segment of hole was drilled from 1266.14m to 1269.19m. Between survey#3 the build rates were altered dramatically at 1272.24m which showed 70.7 degrees and Survey #4 at 1274.68m which showed 90.9 degrees. Build rates had increased from 4.43 degrees per meter to 8.28 degrees per meter and resulted in over shooting the desired sail angle of 87.5 degrees.

When the LDA run to drill the lateral, the assembly continued to build from 97.6 to 100.8 degrees in the first joint. The well was TD at that point due to high angle.

H-1 Re-entry Attempt

It was felt that due to the losses and cleaning issues of H-1 following stimulation that an attempt should be made to re-enter the H-1. The only known available technology that can work through this tight Radius was tested by BP-Amoco for use in the re-entry of USR wellbores. Drawings were secured from BP-Amoco by Torch personnel to fabricate a multi-lateral USR re-entry sub (See Figure 6). This sub uses hydraulics to kick the sub over and allow it re-enter the top of the curve. Tests at BP-Amoco research showed a very high success rate at shallower depths.

The first field attempt on L-365 failed, but based on additional communication with BP-Amoco more equipment (articulated drill collars) was ordered and shipped from the US for use on L-366. Following resetting the highside 90 degrees out from the initial attempt the sub was lowered to a depth of 1247m. The survey tool was run to a depth of 1235m and obtained an inclination reading of 16 degrees. The survey tool was

retrieved and the re-entry assembly was run successfully to bottom.

Acknowledgments

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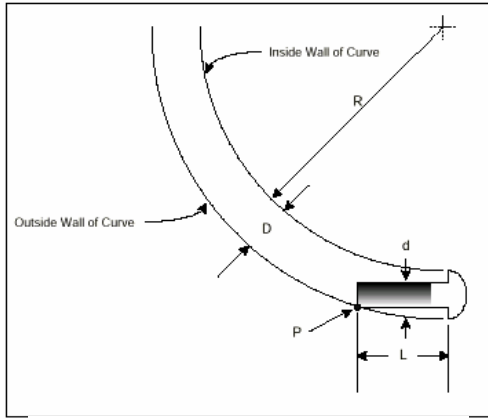


Fig-1 Concept of USR

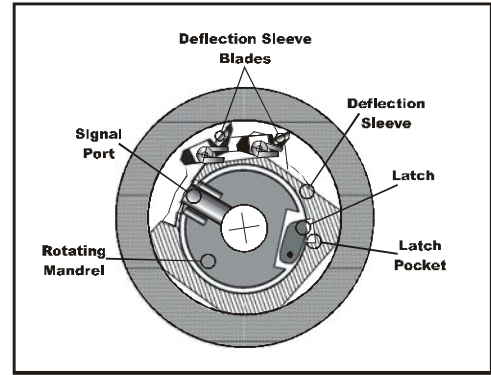


Fig-3 Deflection Sleeve

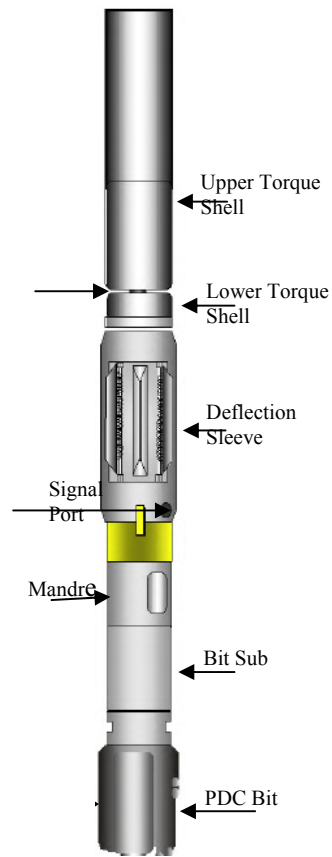


Fig-2 CDA

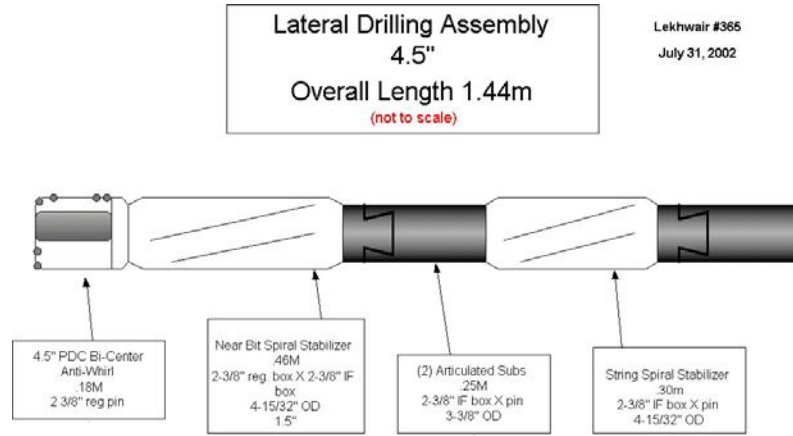


Fig-4 Lateral Drilling Assembly

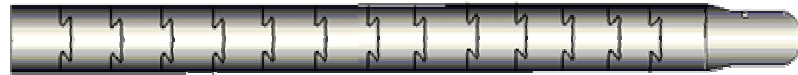


Fig-5 Re-entry Assembly

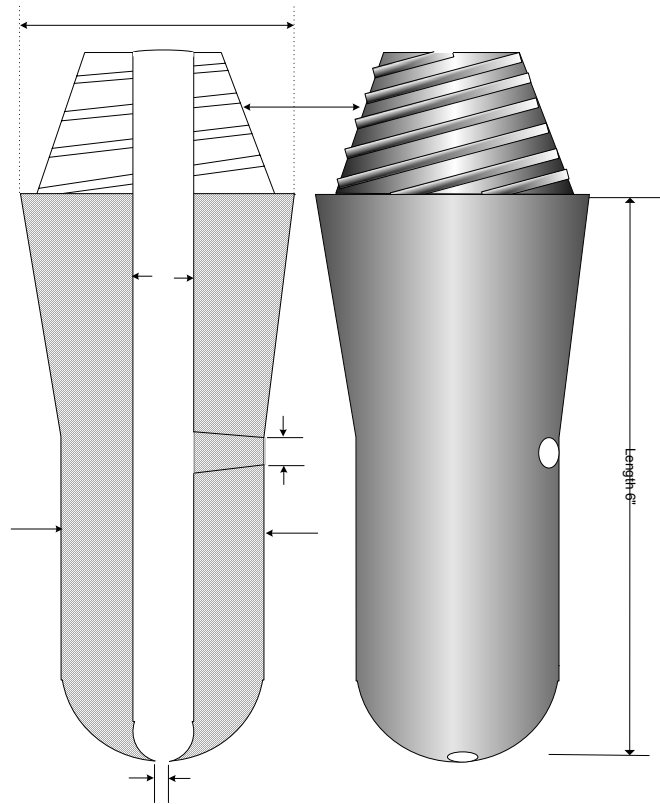


Fig-6 Re-entry sub

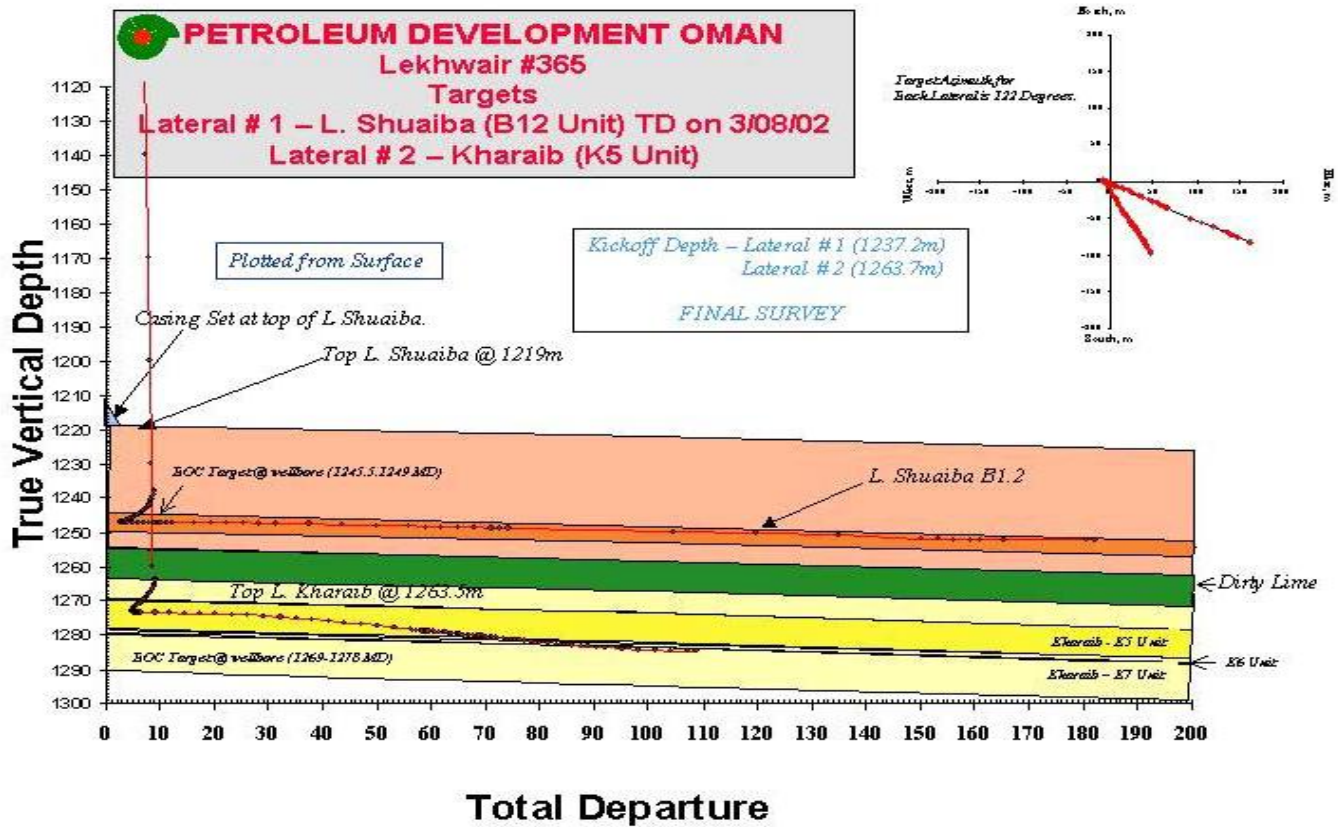


Fig-7 Lekhwair 365 Well Plot

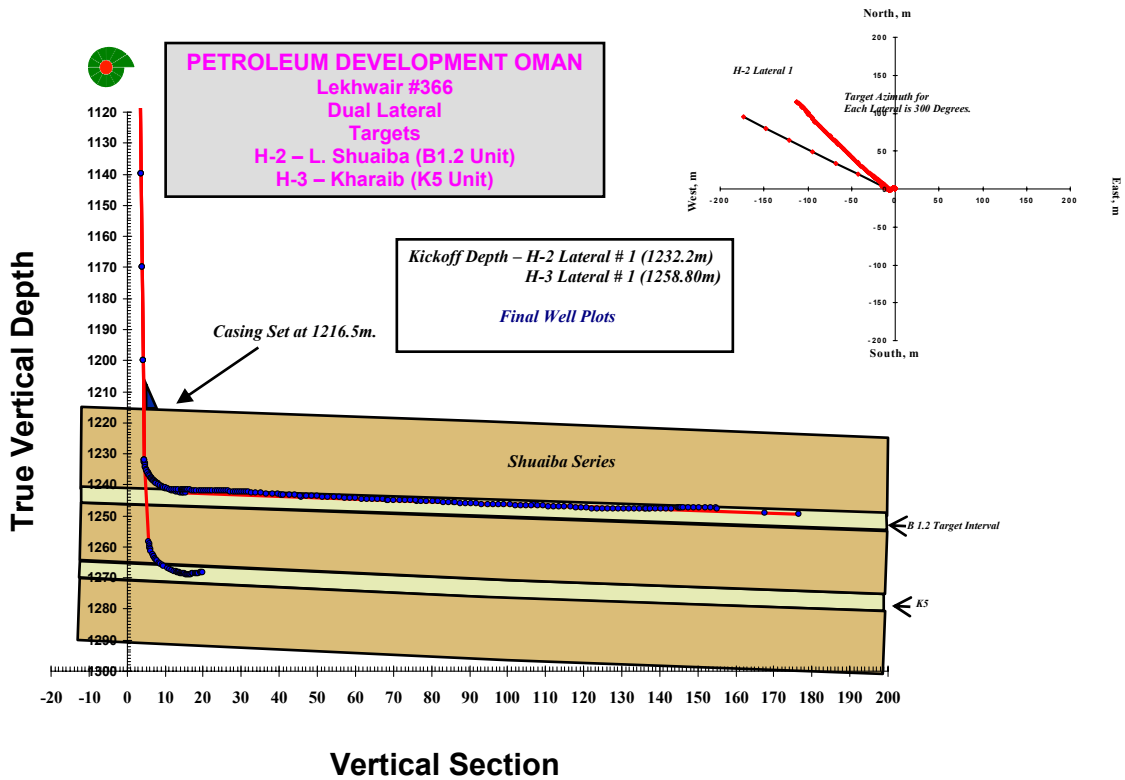


Fig-8 Lekhwair 366 Well Plot



Fig-9 Surface test of the re-entry sub