RHONE VALLEY INTERSECT

Installation of a 24 in diameter steel gas line was required through heavy gravels on both sides of the river Rhone in France by means of horizontal directional drilling (HDD) over a total length of some 1,036 m. The gravel density precluded reaming operations through these horizons. The main contractor for the project, NACAP, proposed a technical solution which included installation of 48 in diameter casing to seal off the gravel sections on both sides of the river into which would be centralised another 16 in diameter casing string. A pilot hole would then be drilled to a planned intersection point near the exit side, and using another rig, a further bored intersection hole would be installed from the exit point. After intersection, the pipe would be pushed through the entry side hole into the 16 in diameter casing to the entry point. Once a complete drill string was established from entry to exit, normal reaming operations would commence and the 24 in diameter product line installed. The work was to be completed using a NACAP purpose-built 200 t rig and a Hütte 60 t Rig.

METHOD

The methodology of such an installation is quite complex. Initially the 48 in diameter casing would be installed over 100 m on Side ‘B’ (Pipe Side) using a Herrenknecht-manufactured microtunnelling machine. To guide the HDD operation a ParaTrack guidewire was established on the centreline of the bore route all the way from the entry side to the exit side. The 16 in diameter casing would then be centralised inside the 48 in diameter casing. A 12¼ in diameter pilot hole is then drilled from the entry point to a point near the exit at about 40 m below the surface. Using ParaTrack and calculated position data another 48 in diameter casing is installed, again using a microtunnelling machine over 100 m from Side A. Then from Side A, using the Hutte 60 t rig, a pilot hole is bored to intersect the primary bore using a combination of ParaTrack Surface guidewire cable and ParaTrack Rotating Magnetic technology for guidance. With the intersection made the Side B drill string is tripped out of the entry hole with Side A’s drill string tripped towards the entry side casing. The 16 in diameter casing is entered and the drill pipe is pushed to the Side B Rig. At this stage reaming operations begin and installation of the 24 in diameter product line follows.

Since the entry and exit positions were located on the sides of a steeply sloping hill, it was apparent from the beginning that the surface gravels located above the rock head would need to be cased off.

The NACAP 200 t drilling rig in operation.

Hole opening operations to the hole size required meant that drilling and reaming was not an option. It was thought that an attempt to ream to 36 in diameter in this size gravel would have immediately caused mud migration to the surface and a possible uncontrollable run off situation.

Once levelling operations and the Side B pit excavation were completed, Nacap mobilised the microtunnelling machine.

The laser guidance was confirmed exactly with the ParaTrack steering tool inclination sensors later when drilling operations began. Previous casing installations on other jobs had significant errors of guidance through use of other methods.

Microtunnelling operations on Side A were to begin only after the pilot hole had been drilled to the planned intersection point. Nacap planners reasoned that if drilling conditions forced the pilot hole away from the planned intersect position in relation to the exit side casing, the exit side casing would need to be moved, causing delays and high costs if reinstallation were needed.

In the event, the pilot hole position at the pre-planned intersect point was nearly on centreline in angle and direction. The positional uncertainty calculation showed a possible position from 400 mm left to 400 mm right. ParaTrack positions were being measured from the surface cable at this point located 95 m above the probe on the surface of the hillside. Once the position had been measured and established, the microtunnelling operation could again start.

PARATRACK

The Rhone crossing was planned to be drilled from casing to casing using an underground intersect at a point about 40 m from the surface. ParaTrack surface cable guidance was chosen for use due to the previous successful intersect in Holland. Surface geotechnical holes were drilled to define the location of the rock horizon so as to ensure the ability to seal the porous gravel formations from the mud flow and allow large diameter hole opening operations to be completed with little risk.

In fact, the pre-planned location of the intersect proved not to be geotechnically suitable causing a new plan to be required. The new plan required the intersect to be executed 95 m below the ParaTrack cable on centreline. Prime Horizontal was invited to visit the site locations in order to measure the ambient magnetic field throughout the axis of the crossing.

Since accuracy of any tracking system is based upon signal to noise ratios it is important to determine the ambient magnetic noise levels in order to project accuracy. On the exit side of the crossing within 100 m of centreline was a huge industrial incinerator. A small rail yard serviced the incinerator. Tracks ran perpendicular to the axis of the crossing on which the French TGV operated from Paris to Geneva every hour. Since the TGV tracks were located within 100 m of the planned intersect point, great care was taken to measure local fields in this area.

From the higher ambient magnetic fields noted in the intersect area, Prime recommended that total reliance not be placed on the centreline cable. The accuracy model indicated a spread in left/right and elevation positions to be in excess of 1 m. While very good, at 95 meters deep, it might not have been positive enough for a horizontal intersect.

The Vector Magnetics Rotating Magnetic System was mobilised. In this configuration, a number of rare earth magnets are installed into a sub to be located between the downhole motor and the drill bit. When rotated, the magnets produce an AC magnetic field, which is measured by the proprietary ParaTrack steering tool. Vector Magnetics, the owner of the RM technology and developer of ParaTrack, has used the system in its service business in the oilfield and in coal bed methane drilling sectors. These services involve the intersect of a vertical hole with a horizontal hole. The use of gyro systems was discussed but disregarded as much too inaccurate for the exacting requirements of the Rhone intersect.

Nacap survey/drilling engineers surveyed and installed the surface guidance cable from points at entry and exit. Nacap crews stretched the cable across the Rhone River and weighted it on centreline prior to managing its final position on the bottom of the river. Prior topographical survey information gave the bottom profile at centreline. The elevation drop to the river, of nearly 100 m from entry and 100 m back up to exit in heavily forested mountainous terrain, was difficult at best and the results are a testament to a group of dedicated professional engineers. Additionally, since Prime knew the Nacap engineers personally, it was decided that Prime would handle one 12-hour shift while a Nacap engineer could handle the other. ParaTrack is an easy system to grasp in a short time frame, especially since Nacap engineers already use AutoCAD while drilling. Within two shifts, Nacap was up to speed on the ParaTrack system.

DRILLING

Drilling commenced with 8 in diameter motors and a 12¼ in TCI bit after installation of the 16 in diameter casing. ParaTrack positional measurements were used to fine-tune the azimuth and inclinations measured by the ParaTrack steering tool.

Drilling progressed at a speed consistent with the rock strength and ParaTrack continued to perform well. Mud circulation was lost at various points while drilling the pilot hole causing considerable time loss. Each loss zone was isolated with open hole packers and a cementing job carried out. Cementing operations were continued until each loss zone held a specified pressure and pilot hole drilling could continue.

When drilling from Side B had progressed to the planned intercept point, drilling operations were suspended until the exit side casing could be installed.

Once the Side A 48 in diameter string was installed and the microtunneller withdrawn, the 16 in diameter centralised casing was installed. The Hutte 60 t rig was set up and drilling began.

The formations on Side A were quite a bit softer than Side B and drilling progressed rapidly. ParaTrack measurements from the surface cable once again performed well.

Installing the 48 in diameter casings with a microtunneller.

Meanwhile, the VM rotating magnet sub was run in hole from Side B to a position at bottom. Whilst drilling the approach from Side A and reaching a point about 70 m away, attempted measurements were made. The high ambient noise in the area, probably from the TGV tracks, made isolation of the RM signal too far down in the noise to read. The first indication of RM signal happened about 40 m away from the magnets but still too deeply embedded in background noise to make positive guidance decisions.

At 30 m it indicated the bore was high and right of the other bore but operators were unable to determine a proper signal strength which would give distance. The motor was orientated for intersect. With the next drilled joint, the signal strength was higher but indicated low and left? This was opposite to the first indication and opposite to the motor set just made. It was apparent that prior to drilling ahead a rethink of the software and technique was required since positive information was needed. The VM engineer was the developer of the RM system and fully able to trouble shoot not only the algorithms but the computer code as well. Since all previous intersects were made while approaching a vertical well bore from a horizontal bore, it was possible that a positive or negative sign might have been out of place.

Considerable time was used doing this rethink and in the final analysis determined that technique was more at fault that the software. The program needs relative positions of each point to be input in a specified format. For instance, the RM position in space is defined in terms of horizontal distance, elevation, left/right, azimuth and inclination. The drilling position also needs the same information to be input. Since this was the first planned RM intersect from two horizontal boreholes, confusion continued about which side measurements were from.

At this point, an input form was made up which allowed operators to do the proper input exactly right each time. A travelling cylinder drawing was also constructed, which depicts the location of the two bores in relation to each other. When drilling ahead after this, operators knew where they were and what needed to be done to effect the intersect.

At this point another problem emerged. Efforts had been focused on building a large magnet sub so as to be able to read it accurately from up to 70+ m in front. When moving to within 10 m of it, the magnetic sensors went into saturation and could no longer be read.

This meant the RM sub needed to be pulled back from Side B before continuing drilling towards it from Side A. Once far enough ahead, the RM could be pushed behind the ParaTrack steering tool and further define their relative trajectries with readings before and after the Side A bore. (The ParaTrack steering tool sensors can now be damped by surface to probe communication to ensure they no longer go into saturation when drilling alongside strong magnetic fields.)

The intersect was planned in hard rock and always of concern was the possible dogleg which might occur at intersect point. For this reason, the two holes were brought together on an approach angle of less than 1°. When intersect occurred, pushing stopped and the motor was rotated to the high side to line up with the expected geometry of the other bore. Pushing and advancing ahead 1 m operators carefully watched for torque on starting rotation. Finding none, the string was pushed another metre and rotation began, again looking for torque. After working through an entire joint of pipe, the motor was rotated top to bottom. Another connection was made and worked forward until the hole was totally free. This was then pulled back again looking for any point of high torque. None were found. Whatever dogleg existed, it was completely reamed free.

The plan was to approach the Side B target bore from a lower position and drill up into it. The purpose was simply that if this were achieved, pushing from either side would allow entry of the bore with the opposing pipe string. The Side A intersect string was pulled two joints behind the intersect point and stopped. The Side B target string was pushed ahead until it kissed the intersect string, rock bit to rock bit, proving both bores could be smoothly entered.

Once a complete drill string from entry to exit was achieved, hole opening would commence. In the meantime, guidance operations ceased, and the demobilisation began after champagne of course!

Positive guidance made the Rhone Intersect possible. Positive guidance will bring other specialised drilling opportunities into line with future needs. A 3,000 m crossing is now not only possible but already being planned – from each side.

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