Rhone Valley HDD Intersect

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France

Location: River Rhone near Bellegarde, France
Pipeline Owner : Gas de France
Drilling Contractor : NACAP
Directional Guidance : Prime Horizontal, Vector Magnetics and Nacap Engineers
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Project Brief:

Installation of a 24” steel gas line through heavy gravels on both sides of the river by means of horizontal directional drilling (HDD). Total length of the river crossing was 1036m. The gravel density precluded reaming operations through the gravels. NACAP proposed a technical solution including installation of 48" casing to seal off the gravel sections on both sides of the river. They would then centralize another 16" casing string inside the 48” and drill a pilot hole to a planned intersection point near exit, and using another rig, drill an intersection hole from the exit point. After intersection, the pipe would be pushed through the entry side hole into the 16” casing to the rig at entry. Once a complete drill string was established from entry to exit, normal reaming operations would commence and the 24” product line installed.

NACAP carried out the project using their 200-Ton purpose built rig and a Hütte 60-Ton Rig.

Planned Method

- Install 48” Casing on Side 'B' (Pipe Side) using a microtunnelling machine for 100 meters
- Install a ParaTrack guidewire on centerline all the way from entry to exit
- Install 16” Casing centralized inside the 48” casing
- Drill 12 1/4” pilot hole from entry point to a point near exit about 40 meters below surface.
- Using ParaTrack and Calculated Position data, Install Side A, 48" Casing once again using a microtunnelling machine for 100 meters.
- From Side A using the Hutte 60T rig, drill pilot hole to intersect the primary bore using a combination of ParaTrack Surface guidewire cable and ParaTrack Rotating Magnetic technology.
- Trip Side B drill string out of entry hole
- Trip Side A drill string towards the entry side casing.

- Enter 16” casing and push to the Side B Rig.
- Begin stage-reaming operations
- Install 24” Product Line

Site Preparation

It was necessary for Nacap to undertake considerable civil work on both sides of the Rhone valley to construct sites level enough to install the drilling rigs and site support facilities. Weather in late winter and spring was expected to be a problem. The crews were not disappointed. Water running downhill during rain created a muddy and slippery environment. An entrance and exit pit was excavated to an elevation near the rock and sheet piling installed. Pumps were supported in the pit in case their use was required later. 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. 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 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 steerable microtunnelling machine.

Casing Program

Before starting the installation of the 48” casing pipes NACAP engineers designed the drill profile taking into account the allowed product line radius. An entry angle of 25 degrees was required since the angle of the hillside was excessive and it was necessary to drill into the rock as quickly as possible to get through the gravel. The microtunnelling machine was set up with laser guidance and was to drill the planned angle. NACAP engineers did the required surveying to ensure the planned direction was vectored to the bottom of the pit where the machine began work. Once the tunnelling machine reached the planned depth at rock head, it was withdrawn through the inside of the 48" casing by the Nacap 200T rig.

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 could need to be moved, causing delays and high costs of reinstallation. Therefore, it was planned for the exit side casing to be started only after the pilot hole was drilled to planned intersect point.

In fact, the pilot hole position at the replanned intersect point was nearly on centreline in angle and direction. The positional uncertainty calculation showed a possible position from 40cm left to 40cm right. ParaTrack positions were being measured from the surface cable at this point located 95 meters above the probe on the surface of the hillside. Once the position had been measured and established, the microtunnelling operation could once again start.

Once again, after the machine was withdrawn, their laser guidance was confirmed by the ParaTrack inclination sensors to be exactly where planned.

ParaTrack Guidance

The Rhone crossing was planned to be drilled from casing to casing using an underground intersect at a point about 40 meters 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 head 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 preplanned 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 meters 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 meters 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 meters 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 one meter. While very good 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 down hole 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 their service business in the oilfield and in coal bed methane drilling 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 Rhone. Prior topo survey information gave the bottom profile at centreline. The elevation drop to the river of nearly 100 meters from entry and 100 meters 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.

While drilling the pilot hole using the surface guidewire, only a few cable problems were noted. The road crossing of the cables produced two or three breakages due to wear against the road surface. There was one situation where a farmer burned the weeds in his field - unknown to the drilling crew until the cable burned in half. Since we thought the breakage would be elsewhere, possibly inaccessible, the burned field was discovered with relief.

Drilling commenced with 8" motors and a 12 1/4" TCI bit after installation of the 16" 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" string was installed and the microtunneller withdrawn, the 16" centralised casing was installed. The Hutte 60T rig was set up in place 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 always giving the engineers clear data for drilling decisions.

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

At 30 meters it indicated we were high and right of the other bore but we were unable to determine a proper signal strength which would give us distance. We oriented the motor for intersect. The next drilled joint, the signal strength was higher but indicated we were 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 we needed to rethink the software and our technique since we obviously needed to have positive information. 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.

We used considerable time doing this rethink and in the final analysis determined that our 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 used 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, we continued to confuse ourselves about which side we were measuring from. Add to this the fact that there were four guidance engineers on site and a considerable number of interested spectators --- we even threatened to install a raised seating platform at one point.

At this point, an input form was made up which allowed us to do the proper input exactly right each time. We also constructed a travelling cylinder drawing, which depicts the location of the two bores in relation to each other. See, Fig. 2. When we drilled ahead after this, we knew where we were and what we needed to do to effect the intersect.

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

This meant we needed to pull the RM sub back from Side B and continue drilling towards it from Side A. Once we were far enough ahead, we could push the RM behind the ParaTrack steering tool and further fine tune positions 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, we brought the two holes together on an approach angle of less than a degree. When intersect occurred, we stopped push and rotated the high side to line up with our expectation of the geometry of the other bore. We push and rocked ahead a meter. We began rotation, carefully watching for torque. Finding none, we pushed another meter and began rotation, looking for torque. After working through an entire joint of pipe, we rotated top to bottom. We made another connection and worked forward until the hole was totally free. We then pulled back again looking for any point of high torque. We found none. Whatever dog leg existed, it was completely reamed free.

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

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

Conclusion

The tools exist today to make planned intersect drilling a commercial reality. Preplanning and professional execution make this possible. Intersect drilling requires forward thinking drilling contractors willing to venture into uncharted waters and rely on highly specialised outside contractors.

Each problem when encountered was discussed and solved with application of sound reasoning.

Positive guidance made the Rhone Intersect possible. Positive guidance will bring other specialised drilling opportunities into line with future needs. The 3000-meter crossing is now not only possible but already being planned - from each side. Additional projects will highlight future needs and companies like Nacap and Prime Horizontal intends to be on site to implement or assist.