Meeting under the river

US-based Prime Horizontal reports on a record-setting, 2.45km HDD intersect crossing of the Qiantang River that will take gas to China's Zhejiang Province

Workers use boats to deploy the coil in the Qiantang River

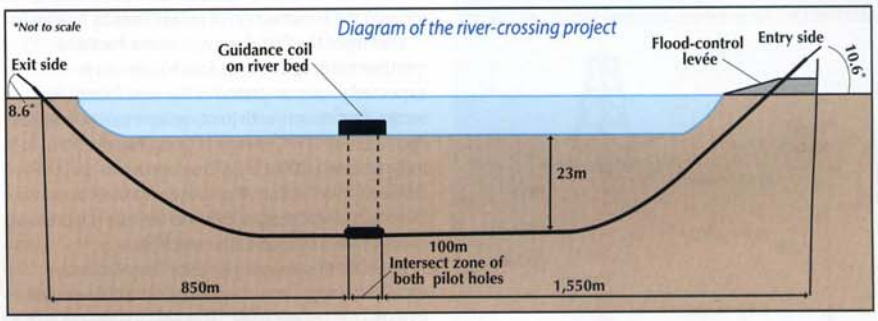
HANGZHOU, the capital city of East China's Zhejiang Province, is located about two hours north of Shanghai. The city has a 2,200-year history as a political and cultural centre. During the Yuan Dynasty (1254-1324), Marco Polo said of Hangzhou that it "is the finest and noblest city in the world". With a population exceeding six million, Hangzhou continues to enjoy a strong economy and vigorous growth.

In 2006, CNPC CPP Crossing Company, on behalf of the Zhejiang Province Natural Gas Development Company (ZPNGDC), started the construction of an 812mm (32in) natural gas pipeline and a 150mm optical fibre conduit for pipeline operations across the Qiantang River near the No 9 QTJ Bridge – which is under construction about 50km from Hangzhou.

CNPC CPP Crossing Company is part of the China Petroleum Pipeline Bureau (CPP), which, in turn, is part of China National Petroleum Corporation (CNPC).

Around five years ago, a similar crossing of the Qiantang was completed several kilometres down river, but due to the length of the crossing and the soft sediments encountered, the drilling rig ran out of push force at 2,200m.

While CPP has experience of crossings, an intersect crossing had not been previously attempted since the technology was still new. However, based on a series of planning discussions with Prime Horizontal, which has completed more than 25 intersect projects, CPP opted to try the underground intersect method – the first time it had been used in China.



CPP and ZPNGDC agreed the intersect method was the best solution for this long-distance crossing in alluvial ground. They planned and specified the rig sizes and locations, and used Prime Horizontal to learn how to execute this type of intersect project.

They provided field navigation and drilling staff, engineers and the labour force necessary to complete this project, as well as an energetic and knowledgeable management team. Prime Horizontal's role was one of training and project oversight, together with CPP management. Prime also provided two on-site, senior field engineers.

The project plan was placed on a large billboard sign near the entry point (see diagram), which shows the entry point on the right side atop a flood control levee running alongside the river.

The guidance coil is straightened at the exit site in front of the 100t exit-side drilling rig

The exit point is shown on the left, and the point of intersection of both pilot holes is shown at a horizontal distance of 1,550m from the entry point. The depth of the drill pipe is almost a constant 23m beneath the river bottom, although this varied: water depths were deeper than 5m from 0-900m, as measured from the entry point, and ranged to less than 2m from the 900-2,450m marks.

Since the Qiantang River empties into the South China Sea, these shallow waters cause large daily tidal surges – called Soaring tides – of 0.5-2m.

PILOT HOLE DRILLING

CNPC CPP carried out extensive geological reports of near-surface conditions and produced CAD drawings of the layout in Chinese. The formations consisted of alluvial sands and clays covered by very soft surface sands. Drilling therefore used jetting assemblies with mill tooth bits.

The basic entry parameters of the pilot hole were:

- **Planned angle:** 10.6°;
- **Elevation:** +5m;
- **Horizontal distance:** 0m.

The basic exit parameters of the pilot hole were:

- **Planned angle:** 8.6°;
- **Elevation:** +5m;
- **Horizontal distance:** 2,450m;
- **Total depth below sea level:** 23m.

In order to maintain the entry and exit angles within tolerance, casing was run on the entry side to 300m to case off the build area and to 350m on the exit side. vIntersect drilling requires the use of two drilling rigs targeting a planned, underground intersection point; one drilling from the entry point and the other drilling from the exit point.

Pilot-hole navigation was performed in two stages: a conventional coil stage for drilling most of the pilot holes and an axial magnet stage for making the actual underground intersect.

The first stage used a water coil deployed on the river bottom from the exit point to a horizontal distance of about 1,650m into the river. This meant that drilling from the exit point was under the guidewire all the way. The first 800m of drilling from the entry side was performed without guidewire, while the last 750m was performed under the guidewire.

The guidewire was 6mm² of drill wire in a rectangular loop of 1,500m x 90m. Both pilot holes were located along the centreline of the coil.

The second stage of pilot-hole drilling consisted of making the actual intersect using the axial magnet source. The axial magnet is an assembly of rare-earth magnets placed in a non-magnetic bit sub behind the bit. It is used when the two approaching drill holes are about two metres from each other to make the actual intersection.

The magnetic field strength of the axial magnet is smaller than the field strength from the coil, but is much more precise, so the location of the two drill bits relative to each other can be measured with centimetre accuracy.

During the intersection process, radio modems were used to control both rigs from the exit site. As the exit-side drill approaches the point of intersection the drill pipe is marked on a quality-control display, so the driller knows precisely how the drill pipe is progressing to the point of intersection.

OPERATIONAL ISSUES

The guidance coil had to be placed near the river bottom to remain out of the way of surface craft and weather. Weights of 25kg were initially used, but daily tidal surges were very strong. After the installation of the first 200m of coil, the tide displaced the weights from 45m to 90m away from their designed positions.

Changing the weights to 40kg solved the problem, but the locations needed to be checked every two to three days, and repositioned when necessary. The weights were placed every 100m until they were within the vicinity of the planned point of intersection, when the spacing was changed to 50m.

After pilot hole drilling commenced, circulation was lost several times due to the soft formations, which required tripping out to clean the hole in order to maintain circulation. During later operations, similar problems occurred that were harder to overcome. The total time (including mobilisation) to complete both pilot holes was two months. The difficulties encountered with reaming for a 812mm product pipe caused a three-month delay in project completion.

Even so, using the underground-intersect method was an unqualified success with the new technology paying off handsomely. Prime's on-site field engineer, Alexandru Randunica, says: "In my opinion the guidance and drilling operation was a total success. No sidetrack was necessary and everything was OK from the first hour in the hole. I will always be happy to perform more intersects with CNPC CPP Crossing Company."

"The location of the two drill bits relative to each other can be measured with centimetre accuracy"

EQUIPMENT

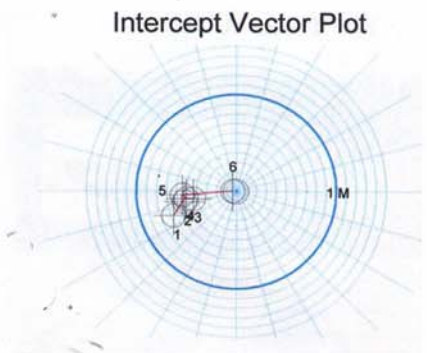
- Rig, entry site: American Augers 600T 80 series
- Rig, exit site: American Augers 100T
- Mud system: made in China
- Downhole tools: 2 x ParaTrack-II Kit, supplied by Prime Horizontal to CPP; 2 x axial magnet, supplied by Prime Horizontal
- Drill bits: jetting assemblies, with mill tooth bits, made in China
- Product pipe: 812mm (32in) steel, made in China; 150mm steel, made in China

CNPC CPP was the sole supplier of all equipment and supplies. The specifications of the equipment made in China are unknown, but no problems were encountered with the equipment, as all was of high quality and fit for its intended purpose

PROJECT TIMING

- Project start: October 19, 2006
- Drilling start: 150mm pilot hole – October 28, 2006
- First intercept finished: pilot hole for 150mm product pipe – November 20, 2006.
- Second intercept finished: pilot hole for 812mm product pipe – December 13, 2006
- Project completed: pulling the 812mm product pipe – March 8, 2007

A worker marks the drill pipe to enable its progression to the intersection point to be tracked precisely



A quality control display is used to make the intersection. The axial magnet is located at the centre of the target. The bold blue circle 1m radius from the centre, and the other points are successive measurements as the last 2m are drilled. Point 6 is the point of intersection.

DOING BUSINESS IN CHINA

Doing business in China is no different from doing business in Western countries once language barriers are overcome and a few differences between Western and Chinese culture are understood.

No one spoke English on this project, so interpreters were needed for all communications. This slowed down operations considerably since one of Prime Horizontal's primary obligations to CNPC CPP was to provide training in how to execute intercept crossings with water coils and magnetic sources. Since the vocabulary of interpreters often does not include the technical jargon of the HDD or drilling industry, quite a bit of backtracking and explanation was necessary.

One significant business difference focuses on training. In general, contracts for the purchase of hardware or software must include a strong component of training that is usually included in the contract price.

It is becoming less common for CNPC to grant service-only contracts and this project was no exception. CNPC CPP purchased the ParaTrack-II system, the specialised hardware and software needed for the HDD intersects. It then hired Prime Horizontal to train its staff in how to execute intersect jobs. Prime Horizontal's role was that of consultant, rather than as a supplier of services, and the company's role plus the sale of the systems was dealt with in the same contract.

Since these first two intersects performed on the Qiantang River in 2007, CNPC CPP Crossing Company and Prime Horizontal have partnered on more projects. They are currently involved in another two complex intersects drilling across the Chinese and Russian borders.

Acknowledgments: many people made the project a success. From the beginning, Mr Sun Bohua, general manager of CNPC CPP Crossing Co, supported the use of the HDD intersect drilling method. Tang Xuefeng, project manager of the QTJ project and deputy general manager of the CNPC CPP Crossing Company, and Mr Yin Gangqian, deputy project manager of the QTJ project, could always be found at the job site. However, we are sure these gentlemen would prefer to praise the work of their very competent staff for the success of the project. Alexandru Randunica and Thoralf Kray were Prime Horizontal's primary on-site senior field engineers