CROSSING THE ELBE RIVER IN GERMANY RESULTS IN RECORD PROJECT

By Gerald Hoogveld

A recent horizontal directional drilling crossing under the Elbe River in Germany resulted in what is believed to be a world-record crossing by German contractor LMR Drilling, Oldenburg, Germany, as part of a project to install an ethylene pipeline to two chemical plants. The record-setting crossing, according LMR officials, was 2,626 m in length and involved installing 14-in pipe. The project is detailed below:

A 55-km long ethylene pipeline must connect the chemical plant of Sasol, Brünsbuttel with the plant of DOW in Stade. For this, the Elbe River needed to be crossed by horizontal directional drilling (HDD), in accordance with the following requirements:

- Reduction of impact on the nature reserve areas at the river sides near the dykes. The entry and exit point were chosen outside of the river dykes. This resulted in a crossing length of 2,626 m.
- Heavy shipping traffic on the Elbe River. This did not allow measuring and steering cables in the shipping lanes.
- Cobble layers at the river's sides, endangering the stability of the drilled hole.
- The project team consisted of: project owner, chemical company Sasol; the feasibility study was made by bureau Dr. Kögler; primary contractor was Vorwerk; and the HDD contractor was LMR Drilling.

Feasibility Study

Because of the gravel and cobble layers at either side of the river, it was proposed to install 48-in. sleeve pipes at both sides of the crossing prior to the commencement of drilling. A general methodology was devised to:

- Mobilize two drill rigs, each with a pull capacity exceeding 567,000 lbs to sites on either side of the Elbe River.
- Drill 48-in. sleeve pipes at each side.
- Commence drilling at the north side to a target area some 2,000 m away.
- Commence drilling at the south side and intercept the other drilled hole within the target area.

In the engineering phase, LMR further developed this general methodology to determine the best technical solution for final installation.

Soil Investigation

Due to the extreme length (aproximately 2,700 m) and depth (45 m) of this crossing, it was extremely important to have extensive and reliable soil information. Despite the considerable expense, this was essential to ensure that the crossing could be done and could be engineered to the best standards. In particular, the corings under the Elbe River involved some extra but well spent soil investigation costs. Next to these geotechnical field investigations, geophysical and laboratory tests were executed.

It was in every party's interest to have this reliable soil information available in order to let LMR Drilling find the optimal engineering solution.

Contract

Despite the considerable soil information, the length of the crossing and the depth at which the drill intercept had to be made meant that it was still conceivable that the ground conditions might make the crossing impossible. As such, the contract protected LMR Drilling against this risk during the early stages of the drilling operation. Beyond this point, the contractor had to continue at its own risk on the basis of the ground conditions that had been discovered to date. Only after a certain period, would more compensation be provided, which means extra days times a day rate. Still a maximum limit was set to the total cost for the project.

Meeting in the Middle

The pilot hole was executed with a 2 7/8-in. drill pipe, which subsequently was washed-over with a 6 5/8-in. wash-pipe. Because of this and a perfectly drilled hole, the push forces and torques were kept to a minimum. Special, heavy-duty, 13 3/8-in. drill pipes were used. The "Meeting in the Middle" went as follows:

Due to the successful drilling from the north, the north pilot bore was drilled to 2,100 m and the wash-over some 100 m behind. The south pilot bore was drilled in to the target area. The pilot pipe from the south side was successfully steered into the wash-over pipe from the north. This activity was executed at a depth of more than 40 m and some 2 km from the north side. The survey equipment indicated that the pilot heads had initially approached each other 4 m apart and with a 1 m difference in elevation. The angle from the one hole to the second hole was less than 1 degree. The south pilot was then pulled back and re-routed so as to intercept the north pilot hole and produce a continuous, 2,626-m long hole beneath the Elbe River.

This approach of the two drill strings was assisted by sensors in the drill heads combined with an additional magnet sub at the end of one of the strings. The sensors could detect the other string when the magnets were activated (by way of rotation). Furthermore, this project also used "benchmarks" complementing the modern Paratrack II system. Benchmarks act as "magnetic lighthouses" for the measuring sensors in the pilot string. They were temporarily placed on the bottom of the Elbe River.

Upon completion of the pilot hole, the hole was reamed to a diameter of 18 in. in order to pull in the 14-in. diameter product pipe. During this process, both drill rigs were engaged in order to operate the reamer and pump the drilling fluid. In this way, fluid transports and return pipelines can be eliminated. The measured push forces and torques stayed under 500 kN and 50 kNm, respectively. In order to reduce the risk of hitting the edge of the casing at the exit side, a customized swivel from Boretech Holland was used.

On July 11, drilling of the first pilot hole started from the north side. On July 29, the second pilot hole commenced from the south. The pullback happened on Aug. 25. The net drill time amounted to six weeks. To minimize the influence of the drill activity on the environment, the work was executed in double shifts and during seven days of the week.

The success of this project, which has extended the limits of horizontal directional drilling, was only possible with the full understanding of all parties of directional drilling and acceptance of all parties of the remaining risks. This risk had been limited by an extensive, costly and reliable soil survey. In addition the remaining risk had been fairly distributed over the parties.

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Pressure Balance Swivel: AN IMPORTANT COMPONENT IN THE RECORD-BREAKING ELBE RIVER CROSSING

A long reach horizontal directional boring followed by back reaming the utility pipe more than 2,626 m demands much from both personnel and materials. All equipment for the proposed crossing had to be engineered to the highest standards to reduce risks that could lead to failure. One important component was the connection between the utility being installed (12-in. steel pipe) and the reamer.

The demands for the swivel were clear:
- Failsafe construction
- Swivel connection with no lateral play
- Smooth outer surface
- Compact design

The conventional shackle connection between swivel and product pipe was deemed unsatisfactory due to the lateral play, which could offset the product pipe and allow it to hang-up whilst entering the casings that were used at both entrance and exit point. The design solution was engineered by BoreTech Holland and connected the pipe directly to the swivel by means of a universal joint, which kept the pipe in line and prevented these lateral movements.

It was also a major concern that there should be no risk of the reamer itself nor any connections between the towing head and the swivel that could cause a hang-up especially when the assembly enters the spud casings.

The reamer component is a solid steel ring with a diameter of 18 in. with nozzles and cutting surfaces. This reamer adaptation slides over the 6 5/8-in. FH connection and is mounted directly on the swivel, making it an integral part of the swivel. The bentonite is pumped through canals in the front part of the swivel to the reamer. This design allows BoreTech to build any size of reamer onto the swivel, ensuring proper mud distribution onto the cutting face of the reamer. At the rear end a double clevis universal joint is attached directly to the shaft and product pipe.

The triple bearing arrangement of the swivel allows severe radial and axial loads in any direction. The bearings are lubricated with heavy-duty oil, which has far better lubricating and thermal distribution properties than grease. The oil lubrication also made it possible to use the unique pressure-balance seal, mainly used in large HDD swivels in Europe since 1991. This pressure-balance seal equalizes the pressure difference between the mud down hole and the lubricant inside the swivel, preventing any pollution to enter the bearing area. This seal is based on the simple principle that fluids will not move unless there is a pressure differential.

Pressure balance also means that the seal can withstand almost any pressure, regardless of down hole mud pressure or drilling depth. A rock guard with a returns separation seal and a labyrinth seal protects the pressure-balance seal.

This construction forms a multi-stage barrier between the bentonite and lubricant. The simple construction of the rock guard and outer seal makes it easy to check and service the seal on the jobsite without dismantling the swivel.

This sidebar was submitted by Boretech Holland.