Denis Pellerin, Horizontal Directional International, France, talks about the Vashista Godavari pipeline project in India.

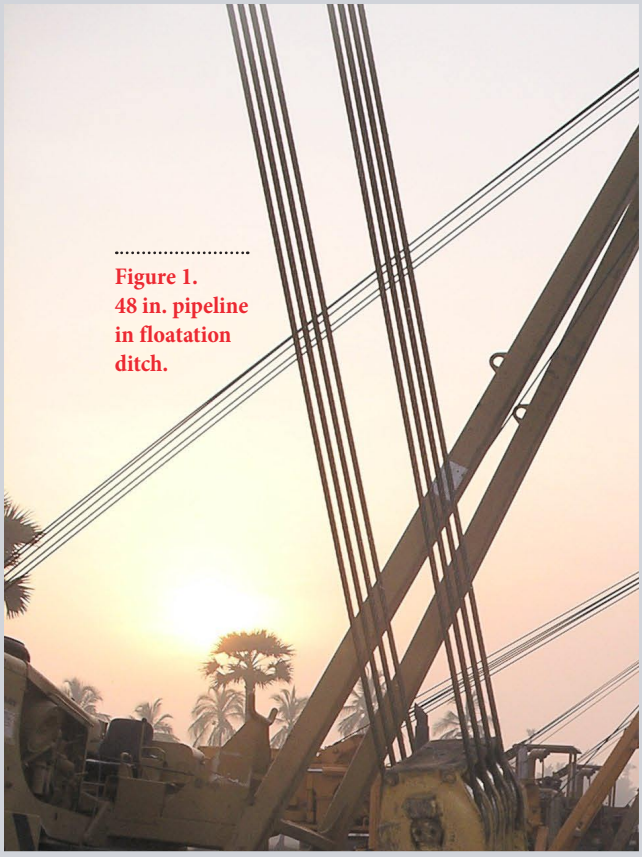
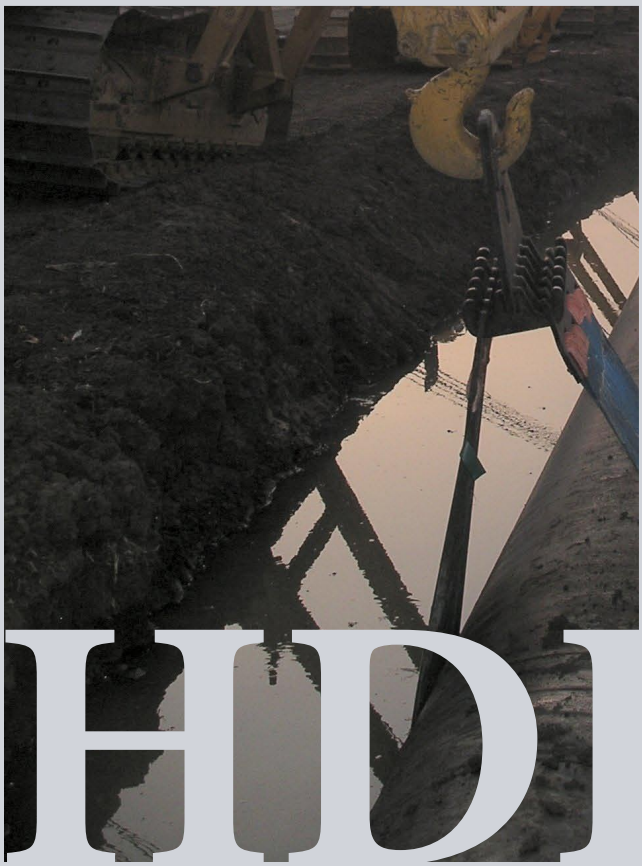
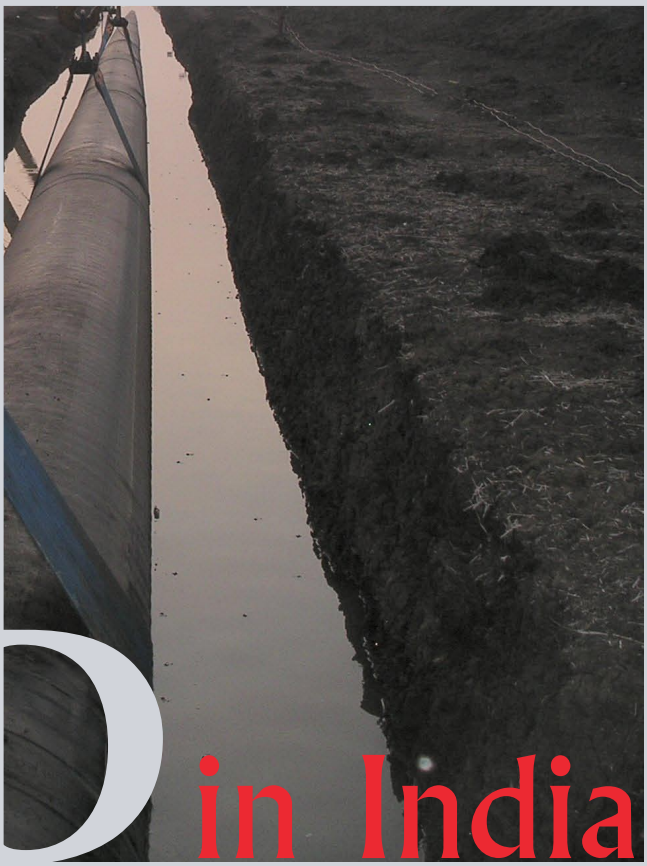


Figure 1.
48 in. pipeline in floatation ditch.





HDD in India

Early in 2006, one of the largest private Indian companies, Reliance, started construction of its first pipeline project across India. The pipeline has a diameter of 48 in. and is 1386 km long, linking the east coast near Kakinada to the west coast, at Bharuch in Gujarat, north of Mumbai. It will transport gas inland from offshore fields in the Indian sea.

Figure 2. 48 in. pipe tail during pulling.

Figure 3. 400 t rig set up on the Vashishta bank.

This pipeline crosses 10 major rivers, including one of the seven Goddess Indian rivers, the "Vashista Godavari", for which HDD technology was chosen. Reliance Gas Transportation Infrastructure Ltd (RGTIL), the company responsible for the project, entrusted Horizontal Drilling International (HDI) to construct this crossing. The combined dimensions, a 1760 m long drilling for a 48 in. product pipe, make the Vashista Godavari crossing the biggest horizontally drilled crossing ever attempted.

The Vashista Godavari project

For this project, HDI was in charge of the project engineering and all drilling works, and assisted Reliance with the supervision of Indian subcontractors for civil and pipeline works.

Since the area of the Vashista river is flooded by Monsoon waters between July and October, the crossing of the Vashista had to be performed between November and June. The actual construction took place between December 2006 and May 2007, over a total drilling works duration of 91 days.

The mobilisation started in September 2006, and a first drilling spread (250 t) reached the site two months later for starting the first pilot hole across the Vashista Godavari.

The drilling project was performed in three separated phases, each phase depending on the arrival of drilling equipments and drilling fluid products from Europe:

- First pilot hole for the 8 in. FOC line.
- Second pilot hole for the 48 in. gas line.
- Reaming in five progressive stages and pull back of the 48 in. product pipe.

Due to the width of the river, the entry and exit points were located inside the two flood banks, which protect the back lands from the flood periods.

During the dry season, the river is only approximately 100 m under, compared to more than 2400 m during flood season. The HDI drilling spreads, including one 400 t and one 250 t rig, were set up at entry and exit points after the second pilot hole was built, and therefore were located inside the floodable zone of the river.

The 1780 m long 48 in. product pipe was positioned at the exit side, but, since it was not allowed to open cut the flood bank because it is the last protection for the back lands, the product pipe was taken over the 5 m high flood bank by building two ramps of 200 m long.

For such a long pipe string, a trench filled with water was excavated to make the product pipe float behind the flood bank. The over-crossing from the floatation trench above the flood bank up to exit point was completed with heavy duty waste-built 80 t rollers.

The Vashista Godavari geology and design

The depth of the crossing was set below the scour line of the river, in order that the installed product pipe could not be exposed to the moving river bed during the Monsoon periods. In consequence, the design of the crossing called for a minimum cover of 37 m below the river bed. Because of the rigidity of this thick 48 in. steel pipe, the crossing profile was defined with a design radius of 2000 m for both entry and exit curves, and HDI drilling procedure allowed local radii never below the minimum of 1200 m over three drilled joints (a section of 29 m).

In practice, the smallest local radius achieved on the 48 in. pilot hole was above 1500 m, which is a remarkable performance.

The two pilot holes were drilled through a first section of 210 m of silty-sand layer at the entry curve, a second section of 1070 m of clay layer on the central horizontal section, and a final section of 480 m of silty-sand layer at the exit curve.

Figure 4. Launching roller 80 t.

Figure 5. Construction continues...

These are fairly favourable geological conditions for HDD works, but the interface between the silty-sand and clay layers hid some bad surprises, and large cobbles had to be removed during reaming phases (up to 300 mm large). Due to the quantity of cleaning passes and quality of the mud mix, made of bentonite and additives supplied by Süd Chemie and MI, these particular locations were crossed without major problems, only slowing down reaming operations.

Nevertheless, during the first pulling attempt, a twist off of the pulling assembly occurred at this gravel location and a second pull back attempt was successful two weeks later.

The HDD operation

Since the fine alluvial geological conditions foreseen for the crossing did not provide long term stability of the hole, all operations were performed on a 24 hour double shift basis, with crew changes on site. A total of 25 HDD specialists were deployed by HDI, including 10 technicians for day shift, nine technicians for night shift and six superintendent and managers.

The first pilot hole received an 8 in. steel casing pipe, to be later used for the fibre optic control cable of the pipeline. This first pilot hole was completed in 23 days including the pull back of the casing, which was to be used as a mud return line during reaming and pulling phases of the 48 in. crossing.

The second pilot hole, for the 48 in. line, was then performed in 16 days. For both pilot holes, HDI used entry casings 200 m and 12 in. diameter, inserted in the first sand layer at entry side in order to maintain the drill string in position while pushing on the long drill string. Both pilot holes were performed with the 250 t rig and 5 in. drill pipes grade S135.

The hole opening was then completed in 52 days with both 400 and 250 t rigs working in tandem, and using a brand new 5 in. $^1/_2$ grade S135 drill string. The operation was staged in five consecutive reaming passes with buoyant fly cutters up to a final size of 68 in. The 400 t rig was positioned at entry side, while the 250 t was connected to the drill string on the opposite exit side for any required assistance to the 400 t rig.

Between each reaming pass, a swabbing pass was systematically performed with barrel reamers to keep a reasonable torque on the drill string, up to the last final 62 in. swab prior to the pull back.

Unfortunately, during the first pull back attempt, a twist off of the pulling assembly occurred between the swivel joint and the pulling head, while pulling through the gravel interface at the exit curve. The product pipe was already inserted some 500 m inside the reamed hole; it was promptly removed with the assistance of a Taurus air hammer and side booms, which were already deployed at site by HDI and Reliance as part of the contingency plan devised during the engineering phase.

After reconditioning the product pipe and the reamed hole, the second and final pull back attempt was performed successfully, taking 72 hours and a maximum pull force of 320 t.

In parallel to the reaming stages, the product pipe had been prepared with a buoyancy system made of three HDPE pipes inserted in the 1760 m long product pipe. These three HDPE lines were filled with water during pull back phase in order to provide the adequate buoyant forces on the product pipe during the final pull back phase.

The equipment

The drilling spreads were made of two drilling rigs: a 400 t rig, with torque capacity of 120 kNm on the rig side, and a 250 t rig, with torque capacity of 90 kNm on pipe side. Still, even with so much torque resources, the torque was dutifully maintained down to a maximum of 25 KNm during reaming operations in order to avoid any twist of or breaking accident inside the reamed hole, thanks to systematic swabbing passes after each reaming sequence.

The downhole tools consisted of 2000 m of brand new 5 1/2 in. drill pipes grade S135 and 2000 m of 5 in. premium S135 drill pipes. Ten fly-cutters (largest sizes were buoyant to avoid over-digging) and nine barrel reamers were specially built for the five consecutive reaming stages.

The mud system equipment included two HDI mud mixing tanks and two recycling unit from PSD and Derrick dispatched on both sides of the crossing.

Three high pressure pumps, one Schäffer & Urbach and two Ellis Williams 446, provided the necessary pumping capacity of 2.5 m^3/min.

Thirteen transfer pumps and two mud return pumps with a pumping capacity of 150 m^3/hr were used for running the mud system in between mixing, recycling and pumping equipment.

A pneumatic hammer (Taurus) combined with two 30 t winches, were mobilised for this project, providing assistance to the 400 t rig at the tail of the product pipe during the pull back and contingency salvage phases.

A total of 600 t of THR bentonite and 50 t of additives (Pac R, Soda Ash, Lub) provided by Süd Chemie (Germany) and MI (India) were mobilised for this project, and dedicated mud engineers constantly monitored the quality of the drilling fluid through the entire operation.

A world record

The completion of this world record crossing proved that it is possible to further push the limits of the horizontal directional drilling technology and adapt current methods to the largest crossings.

Providing that the drilling methodology is well thought through and is implemented in a professional manner with competent personnel, the next world record could be bigger than the Vashista Godavari crossing and get closer to the performance of tunnelling technologies, for example.

Acknowledgements

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