SPIRAL PIPELINE TRANSPORT

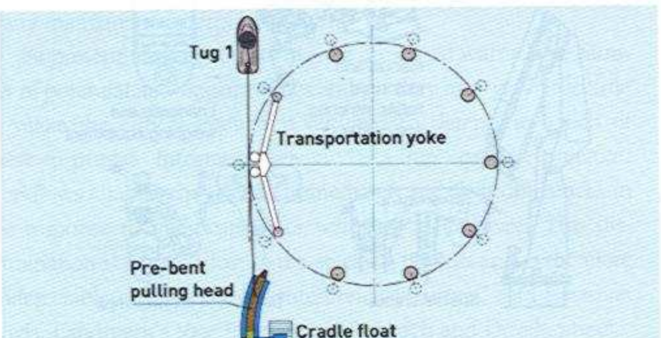
Transporting prefabricated pipe to its location can be considerably more cost effective than making the individual units up offshore

The pipeline company Eurospiraal is currently looking for new applications for its Floating Spiral pipe transport and laying concept. The design has been technically verified and Eurospiraal are currently looking at strategic areas which they recognise as particularly suitable for the system.

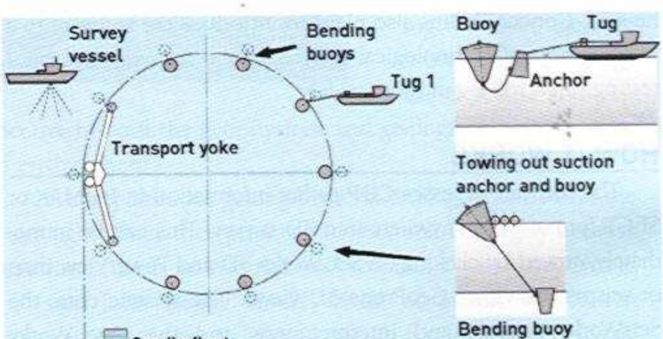
'One such application concerns developments that are located remotely from established infrastructure,' said Eurospiraal's Managing Director, Dr Sjef Beaujean. 'It becomes particularly applicable where the 'local content' of the project is important. Most countries with an offshore industry have some sort of port-based facility that can manufacture such a pipeline. The pipe can be assembled without sophisticated equipment and using domestic labour. Another possible application of the technology to lay cables, which can exhibit very similar characteristics to thin pipe.'

The idea of prefabricating pipe onshore and then taking if offshore, is not uncommon in the offshore sector. This is particularly true for complex arrangements such as pipe-in-pipe systems, lines composed of special materials eg, Cr-13 or Duplex steel, lines to be installed as a bundle, or those to be installed in combination with fibre optic or power cables.

Towing straight, floating pipelines has several attractions over welding the pipe joints together at an offshore location. Prefabrication allows for optimal control of costs and quality in pipeline manufacturing. A further advantage is that it obviates the need for lay barges or reeling vessels, which can be very expensive when compared with the capital and operational expenses of towing the floating pipelines.



The transport yoke and bending buoys are positioned

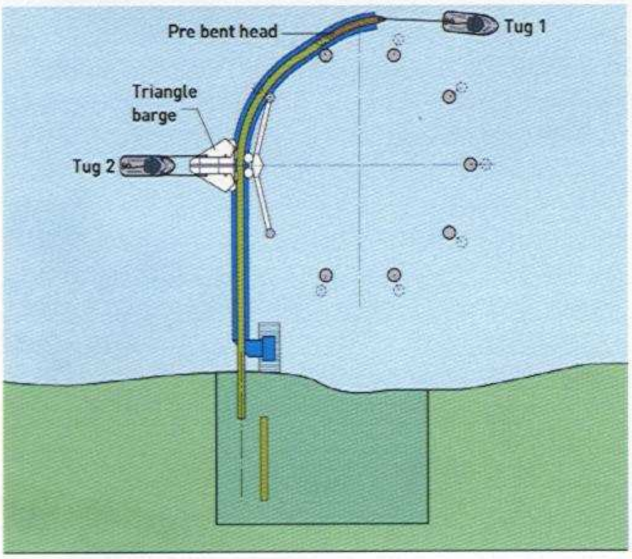


A tug pulls the pipe and towing head to the yoke

The technique, however, does have a number of disadvantages; not least, the requirement for special conditions at the yard – principally a long, open strip in which to fabricate and store the pipe strings. In order to launch the pipe safely, this site has to be ideally located at a well-protected coastline.

A further disadvantage is the exposure of the long pipelines during transport and installation to a variety of problems. It can be subject to potential collision with sea traffic when floating on the waves or to the subsea structures when drawn along the seabed or towed at controlled depth.

The elongated pipeline is also suspect to lateral currents as well. A floating pipeline, say, 20km in length, subjected to a lateral current of 0.5m/sec (1kt), is loaded by a lateral force of 2 500 000N. Such a lateral force requires a pulling force at both ends of 12 500 000N to keep the pipeline straight, at 500m deviation.



The tug pulls the pipe around the bending buoys while another applies tension

'Such bollard pull of 1250t is a substantial force for the tugboats at either end of the linear tow,' said Sjef Beaujean. 'At the end of the firing line onshore however, such load is unacceptable.

OVERCOMING DISADVANTAGES

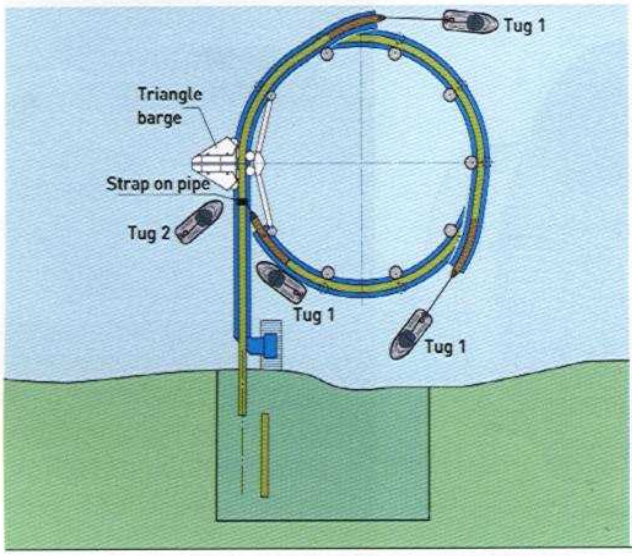
The concept eliminating these disadvantages was discussed between pipeline manufacturers, contractors and operators, who began to examine a number of concepts to reinforce the many fundamental advantages of using floating pipes for offshore pipeline installations.

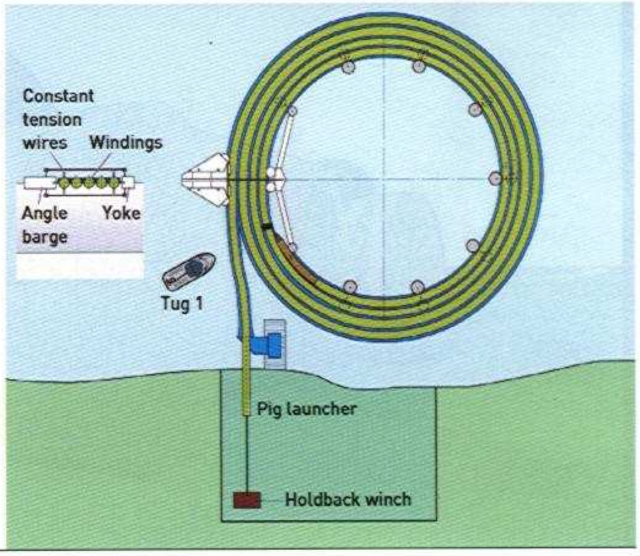
There were three main conclusions. It was deemed to be advantageous from a production viewpoint, to produce the pipeline continuously as seen on a lay barge, but to shift the pipeline directly from the firing line and inspection operations, into the sea. This essentially removed the requirement for long open strips at the yard.

In order to solve the unacceptable exposure and large holding forces at the pipe, the designers also decided that a better solution would be to wind the pipe string elastically while it was floating on sea, ideally around some in-shore guiding structure, to form a flat floating pipe spiral and then to transport in that form. The diameter of the spiral would be governed by keeping the steel and the concrete coating within their elastic limits.

At the offshore site, the pipeline would be unwound elastically from the floating spiral. This can be carried out using a conventional layvessel or a laybarge.

Companies interested in this proposal decided to initiate a detailed development programme, starting with scale tests and numerical analyses, to be followed by real scale tests on full sea, to link the theory to the practical experience in handling floating pipes. Governing its progress was Eurospiraal, a company supported by Dutch and German pipeline groups and by the Dutch Ministry of Economic Affairs. Monitored by Det Norske Veritas in Oslo, the development lasted about four years and cost about US$3M.





The tug wraps the pipe round the floating bending wheels to form the spiral. After the first winding, the pipe is cable-connected to a winch on a drive unit , allowing it to be used as a reel for subsequent windings.

SPIRAL CONSTRUCTION

'The concept is simple and cost-effective,' explained Sjef Beaujean. 'As the pipeline progresses along the firing line and out to sea, floats are applied to it. In practice, this would be carried out by a sister company called Spiralling Services. These pipe-floats are long, multi-cell air-filled bodies, connected to the pipeline by a net system which envelops the pipe as well as the float. This pipe is then fed around a set of eight floating bending wheels, anchored to the seabed.'

When the first winding has been completed, the pipe end is cable-connected to a winch on a drive unit. The winch closes the first winding, allowing it to be used as a reel for subsequent windings. The drive unit keeps the reel rotating, winding the pipe coming from the firing line. The winding speed does not therefore limit the production rate of the firing line. From the spiral base, the spiral is towed to the installation site by tug.

'A typical 120m diameter of an 8in pipeline spiral could be pulled by a tugboat with a bollard pull of 10t and reach a speed of 4kt, equivalent to 100 miles a day,' said Sjef Beaujean. 'Before the tugboat arrives however, the shape of the spiral would have to be secured by an arrangement of criss-cross cables, in order to prevent any ovalisation due to drag forces.'

The tugboat would be cable-connected to three of the bending wheels. For the transport, those wheels would be interconnected by a stiff beam, typically composed of the same pipe elements and the same floats as used for the pipeline. The beam

KASHAGAN ROLLER

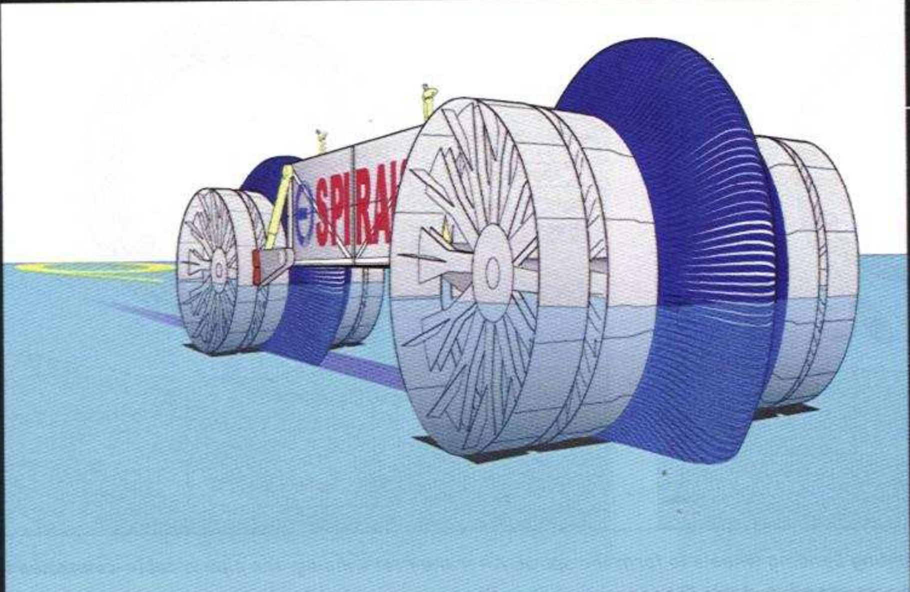
In order to expedite laying line in shallow waters, Eurospiraal has designed a trencher system. The design of the Trencher Roller was developed as a specific trenching on the Kashagan project in Kazakhstan, although at present, the project has been considerably delayed.

Conceptually, the 500t trencher roller is a conventional large road roller with profiled wheels 12m in diameter. By its sheer weight, the profile of the wheels is impressed in the soft soil of the seabed. Just by rolling along, a trench is created at a considerable speed; possibly up to 10-20km a day. The softness of the soil determines how fast a trench can be made and how much weight is needed.

The design of the Roller is aimed at operating in waters as deep as 5m. In operation, the Roller moves from the shore to the spiral, and picks up the unwound floating pipe. When the Roller has reached the coast again, the pipeline is laid into the trench by gradually removing the pipe floats. In this way, the trenching and the pipe installation is a fast procedure, with minimal impact on the environment. This would be an important feature when the landfall happens to be close to an environmentally sensitive area.

'Minimising impact on the environment was in focus when the design of the Trencher Roller was initiated for the installation of the Kashagan pipelines in the Northern Caspian Sea' said Sjef Beaujean. 'Over the 71km long trajectory of these pipelines, the maximum water depth is just 4m. Three big pipelines have to be laid individually, trenched in the soft soil one metre over the top over their full length. The installation area is environmentally protected, with a zero disposal regime,' he said

'Lastly, the area is only open for operations during a 75 days time window per year. Systems used in short landfall operations, like dredgers and backhoe excavators, are hardly up to that challenge.'



The Trencher Roller designed for use on Kashagan

After Kashagan, it was suggested that the Roller might be put in service anywhere in the world, to trench pipelines in marshlands and in tundras, or in other landfall operations. The mobilisation/demobilisation time could be as short as the operational time. The design aims to assemble or disassemble the Roller within two days and to allow that the modules can be transported as standard 40 ft containers.

would take the centrally-oriented forces of the tugboat cables exerted during the tow.

One question the designers voiced initially, concerned the ability of the floating spiral to survive a severe storm. To assess this, a spiral was tested in a wave tank. It was seen that without the criss-cross cables, the spiral was elongated by the drag forces, but in general, the structure swayed easily on the waves. Tests were carried out at significant wave heights of 11.5m, with the spiral structure fully intact after this severe storm simulation.

'The behaviour was not particularly surprising,' said Sjef Beaujean. 'Short waves had no effect at all on a big floating pipe as they do not have enough power to make a big pipe move over or under its neighbouring winding. The long sea waves however, do not seem to react adversely either. The consecutive windings swing synchronously on the curvature of the waves, with adjacent pipelines moving up and down together, keeping the texture of the spiral intact.

INSTALLATION SITE

At the installation site, the floating pipe would be fed into a laybarge or a layvessel, via a front stinger. This approach combines prefabrication with conventional pipe laying techniques. The reception speed of the lay vessels however, is not fully equal to the potential speed of unwinding a floating spiral.

In a landfall operation therefore, the floating spiral would be anchored close to the shore and the criss-cross cables would be removed. The end of the pipeline would be then connected by a cable to a winch onshore. The drive unit at the spiral and the winch onshore would then work in harmony to bring the head of the pipeline onshore. When the coast has been reached, the floats would be gradually removed, allowing the pipe to reach the seabed.

The landfall installation is more time-consuming when a trench, to protect the pipeline and keep it out of view, has to be excavated in the seabed. This trenching procedure, executed by dredgers or by backhoe excavators, would take more time than the unwinding of the spiral. Typically unwinding can be a matter of hours whereas the trenching may take weeks. For long landfalls therefore, a trencher roller has been designed.

DEEP AND VERY DEEP WATER

In shallow water, the pipe may be laid directly from the spiral, however in deep water, this cannot occur as the line needs support where it bends from sea level to seabed. Rollers would therefore be used to give this support, with floats to give these rollers their upward thrust. Eurospiraal has therefore designed a 'compliant stinger' arrangement — essentially a chain of floats and rollers. In contrast to lay barges however, this does not need to be a long, stiff cantilever structure to connect the rollers to a floating body. Instead, it places the float directly where the load is.

For the pipeline installation, the compliant stinger is placed over the free end of the unwinding spiral, until it connects to the drive unit. The drive unit now acts as a tensioner, controlling the speed of the pipeline, rolling downward over the compliant stinger.

The lower end of the stinger can be cable-connected to the survey vessel and a pilot vessel. A sensor platform can be towed in between these two vessels. This platform incorporates a D-GPS device for accurate positioning and it has sensors to detect the relative position and the shape of the stinger, via sonar beacons attached to the stinger.

By combining data from the D-GPS device and from the beacons, the pilot on board the survey vessel can monitor the absolute position and the shape of the pipe over its full length from sea level down to the point of touchdown. The monitor screen also shows the tension in the pipe. This system of monitoring and controlling the compliant stinger would also be necessary to facilitate a safe pipe installation in deep waters, associated with high potential speeds up to one metre per second, 80km/d.

In very deep water, the speed of the pipe laying gets hampered by drag force, aggravated by the drag resistance exerted by the floats of the compliant stinger. Moreover, the weight of the pipe hanging down from sea level to seabed is too much of a load for a tensioner/drive unit. One answer may be to accept these weight and drag forces hindrances, and decide to reduce the speed of installation while using a stronger tensioner.

'It has been proposed therefore, to use a fairing float to overcome these limitations,' said Sjef Beaujean. 'This is essentially a chain of floats, each mounted in a wing shaped fairing. The structure grips around the pipe by bellows filled with seawater. By letting seawater flow inside the bellows, the hydrostatic pressure inside and outside bellows equalises at all water depths. This means that overpressure in one bellow will give the same effective overpressure in each of all interlinked bellows,' he said.

The effect of this, is to control the vertical position of the chain of fairing floats. Overpressure clamps the floats around the pipe when the pipe starts to move downward to the seabed. An overpressure of about 20cms (water column) gives sufficient grip on the pipe. At a predefined water depth, the overpressure is reduced, releasing the clamping force. By controlling the pressure, the chain of fairing floats is kept at a given depth, while the pipe slides down.

As the floats stay at constant depth, they transfer their upward thrust to the sliding pipe. Effectively, the weight of the pipe is reduced to the extent of the total buoyancy of the floats. This effective weight reduction relieves the load carrying force to be exerted by the tensioner. The same bellows ensure that the fairing float can pivot around the pipe, by rolling over its circumferential. The rolling bellows allows the floats to easily follow the direction of the local water current. The fairing floats wind-vane around the pipe.

'By their wing-shape, the fairing floats suppress vortices otherwise created by water currents passing the pipe. By preventing vortices, the fairings prevent vortex-induced-vibrations that might otherwise have raised the drag force, and might have induced a fatigue load. The fairing floats therefore allow the floating spiral to install a pipeline at a high speed, even in very deep waters and they help to reduce the loads on the tensioner and on the tugboat,' he concluded.