

Pipelines exposed

Dr Sjef Beaujean, Eurospiraal BV, The Netherlands, discusses the transportation of prefabricated pipelines as floating spirals.

Pipelines can be prefabricated onshore with relative ease, meeting high quality standards. This is particularly true of the following systems:

- Complex pipelines such as for 'pipe in pipe' systems.
- Pipelines made of special materials, such as Cr-13 or Duplex steel.
- Pipelines to be installed as a bundle, or in combination with optic/power cables.

The manufacture of these may be relatively easy in terms of prefabrication, but the principal hurdle is their transportation. By its nature, a long pipeline, transported over sea, is much exposed. It is exposed to traffic when floating on the waves, exposed to subsea structures when drawn along the seabed or towed at controlled depth, and exposed to lateral currents. A 20 km floating pipeline, subjected to a lateral current of 0.5 m/s (1 knot) is loaded by a lateral force of 2.5 million N. This requires a pulling force of 12.5 million N at both ends to keep the pipeline straight (at a 500 m deviation).

A bollard pull of 1250 t is a substantial force for the tugboats at either end of the linear tow. However, at the end of the firing line onshore, this load is unacceptable (even less acceptable at the point of touchdown). As a result of unacceptable exposure and large holding forces at the pipe ends, it is better to wind the pipes and transport them as floating spirals wide enough to keep the steel and the concrete coating within their elastic limits.

Figure 1 shows the 120 m diameter floating spiral of an 8 in. pipeline for transportation along the coast of The Netherlands. It is pulled by a tugboat at 10 t bollard pull, and reached a speed of 4 knots (equivalent to 100 miles every day).

Making and towing a floating spiral is not particularly difficult in itself. Before a pipeline is pushed/pulled from the firing line onto the sea, EuroSpiraal's sister company, Spiralling Services, applies floats to it. These pipe floats are long, multi-cell, air filled bodies, connected to the pipeline by a safety net that envelops the pipe as well as the float.

At sea, the floating pipeline will be pulled around eight

floating bending wheels anchored to the seabed (Figure 2). When the first winding has been completed, the pipe end is cable connected to a winch on a so-called drive unit. The winch closes the first winding, and this is then used as a reel for the following windings. The drive unit keeps the reel rotating; winding the pipe coming from the firing line. The winding speed will not limit the production rate of the firing line.

The spiral is towed from the spiral base to the installation site, and this can be performed by a locally available tugboat. Before the tugboat arrives, the shape of the spiral is secured by some crisscross cables. They prevent ovalisation of the spiral due to drag forces. The tugboat is connected by cable to three of the bending wheels, which are themselves interconnected by a stiff beam for the purpose of transportation. The beam is typically made of the same pipe elements and the same floats as are used for the pipeline. The beam takes the centrally oriented forces of the tugboat cables exerted during the tow.

Floating spirals in a storm

The principal question in the development of the floating spiral concerned its ability to survive a severe storm. In order to ascertain this, a spiral was tested in a storm tank (Figure 3). Note that no crisscross cables are installed.

It can be observed that without such cables the spiral is stretched by the drag forces, and also that the spiral sways easily on the waves, with no tendency of windings climbing over one another. Such tests were performed at significant wave heights (of 11.5 m), with the spiral staying fully intact.

This may seem odd at first sight. However, short waves



Figure 1. 120 m floating spiral for an 8 in. pipeline.

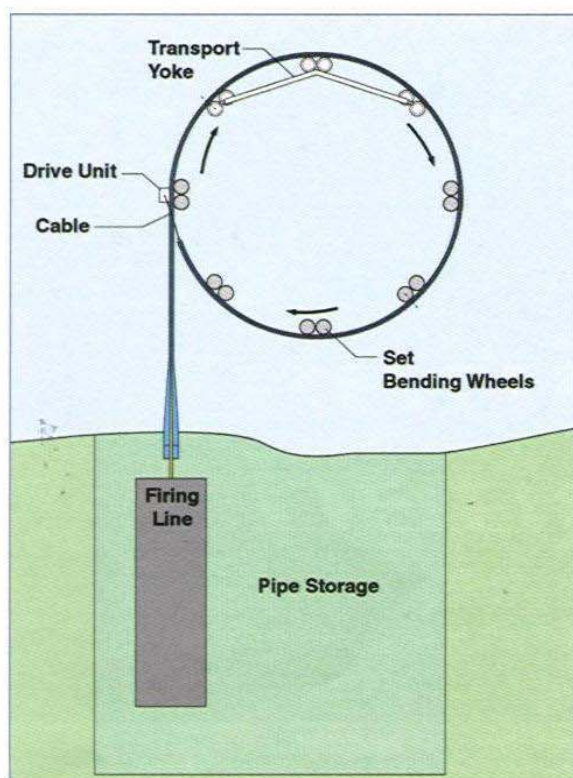


Figure 2. The pulling of the floating pipelines around the bending wheels.

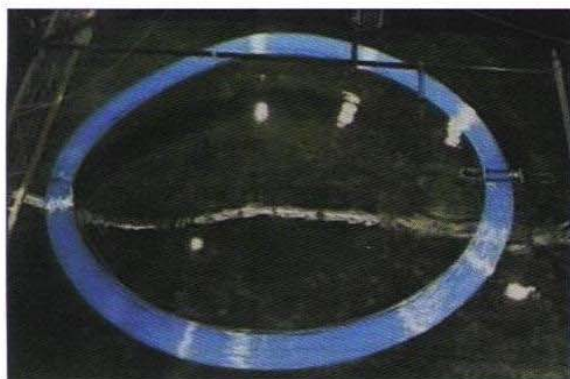


Figure 3. Floating spiral in a storm tank.

have absolutely no effect on a large floating pipe. In short, they do not have enough power to make a large pipe move over or under its neighbouring winding, and long sea waves carry pipe windings equal distances. The consecutive windings swing synchronously with the curvature of the waves. Adjacent pipelines move up and down together, keeping the texture of the spiral intact.

Pipe installation

At the installation site, the floating pipe can be fed into either a lay barge or a lay vessel via a front stinger. This allows pre-fabrication to be combined with conventional pipelaying techniques. However, lay vessels and lay barges are not fully on a par with the potential speed of the elastic unwinding of a floating spiral. The following discusses how the pipe installation could be accelerated, considering three situations: a landfall operation, a deepwater installation and pipe laying in very deep water.

Landfall operations

In a landfall operation, the floating spiral is anchored close to the shore. The crisscross cables are removed, and the end of the pipeline is connected to a winch onshore by a cable. The drive unit at the spiral and the onshore winch co-operate to bring the head of the pipeline to the shore. Once the coast has been reached, the floats are gradually removed in order to launch the pipe to the seabed. The landfall operation is therefore relatively simple in the case of a pipeline unwound from a spiral while floating.

The landfall installation is more time consuming if a trench has to be made in the seabed to protect the pipeline and keep it out of view. This trenching procedure, executed by dredgers or backhoe excavators, takes more time than the unwinding of the spiral. At a typical speed of 1 km/hr, unwinding can last as little as a matter of hours, whereas the trenching may take weeks. In the case of long landfalls, a trencher roller is currently being designed to serve as an alternative to making trenches at a speed in line with the potential of a floating spiral.

Conceptually, the Trencher Roller is a large road roller with profiled wheels. Figure 4 shows a 500 t Roller, with wheels of 12 m in diameter. By its sheer weight, the profile of the wheels is impressed in the soft soil of the seabed. Merely by rolling along, a trench can be created at considerable speed; 10 - 20 km/d. The softness of the soil determines how fast a trench can be made and how much weight will be needed.

The design aims to achieve this in water as deep as 5 m. The roller moves from the shore to the spiral, and picks up the unwound floating pipe. Once it has reached the coast again, the pipeline has been sunk into the trench by gradually removing the pipe floats. Alternatively, if the water is deep enough, the floats can just be collapsed.

In this way, the trenching and pipe installation is a fast procedure, with minimal environmental impact. This would be a particularly important feature if the landfall happens to be close to a beach resort or in an environmentally protected area.

Minimising environmental impact was a particular concern when the design of the Trencher Roller was initiated for the installation of the Kashagan pipelines in the northern sector of the Caspian Sea. The maximum water depth is just 4 m over the full 71 km trajectory of these pipelines. Three large pipelines have to be laid individually, and then trenched one metre in the soft soil over their full length. The installation area is environmentally protected, with a zero disposal regime. Finally, the area is only open for operations for 75 days/yr. Systems used in short landfall operations, such as dredgers and backhoe excavators, are not up to the challenge. The design was initiated with this job in mind.

After the 'Big Wheel' has completed its job, it can be put into service to trench pipelines in marshlands, tundras or other landfall operations, anywhere in the world. The mobilisation/demobilisation time can be as short as the operational time, and the design aims to assemble or disassemble the roller within two days; thereby allowing the modules to be transported as standard 40 ft containers.

Deepwater

In shallow water, the pipe can be laid directly from the spiral. In deepwater, however, it cannot. The pipe needs support when it bends from sea level to seabed. Rollers are needed to give this support, and floats to give these rollers their upward thrust. A chain of such floats and rollers have been termed a Compliant Stinger (Figure 5). Unlike lay vessels or barges, they do not require a long, stiff cantilever structure to

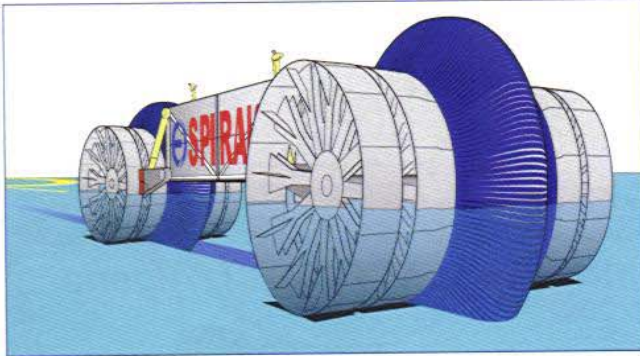


Figure 4. 'Big Wheel' Trencher Roller.

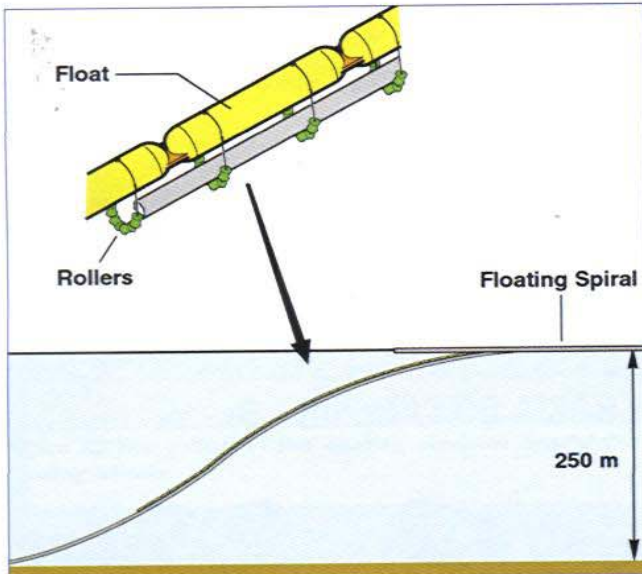


Figure 5. Compliant Stinger.

connect the rollers to a floating body. The Compliant Stinger puts the float directly in contact with the load.

In order to install the pipeline, the Stinger must be shifted over the free end of the unwinding spiral until it connects to the drive unit used at the spiral base to wind the spiral. That drive unit now acts as a tensioner; controlling the speed of the pipeline and rolling downwards over the Stinger.

The lower end of the Stinger can be cable connected to the survey vessel and a pilot vessel (Figure 6). A sensor platform can be towed between these two vessels, with a D-GPS device for accurate positioning and sensors to detect the relative position and the shape of the Stinger via sonar. By combining data from the D-GPS device and the beacons, the pilot onboard the survey vessel can monitor the absolute position and shape of the pipe over the full length from sea level down to the point of touchdown. The screen also shows the tension in the pipe.

This system of monitoring and controlling the Compliant Stinger would facilitate a safe pipe installation in deepwater, and at high potential speeds: up to 1 m/sec, 80 km/day.

Ultra deepwater

In ultra deepwater, the speed of the pipelaying is hampered by the drag force. This would be aggravated by the drag resistance, exerted by the Stinger's floats. Moreover, the weight of the pipe hanging from sea level to seabed is too great a load for a tensioner/drive unit dimensioned for

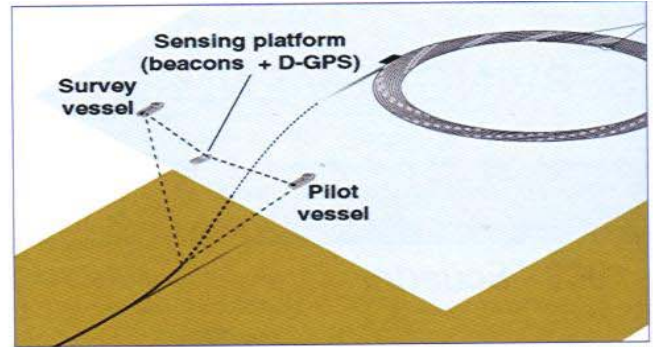


Figure 6. Stinger connected to a surveying vessel and a pilot vessel.

the winding procedure. One might accept these hindrances of weight and drag forces, and decide to reduce the speed of installation and use a stronger tensioner. However, another alternative would be to choose to overcome these limitations more directly by introducing a fairing float: a chain of floats, each mounted in a wing shaped fairing. The structure grips around the pipe by bellows filled with seawater. By allowing seawater to enter the bellows, the hydrostatic pressure inside the bellows is the same as that outside. This means that overpressure in one bellow will give the same effective overpressure in each of the interlinked bellows.

This effect is used to control the vertical position of the chain of fairing floats. Overpressure clamps the floats around the pipe when the pipe starts to move down to the seabed. A water column overpressure of approximately 20 cm allows sufficient grip on the pipe. When a predefined water depth has been reached, the overpressure is reduced and the clamping force released. 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 a 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 weight reduction relieves the load carrying exerted by the tensioner.

The same bellows ensure that the fairing float can pivot around the pipe by rolling over its circumference. The rolling bellow allows the floats to follow the direction of the local water current. The fairing floats wind-vane around the pipe.

With 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 may otherwise have raised the drag force and induced a fatigue load. The fairing floats thus allow the floating spiral to install a pipeline at a high speed, even in ultra deepwater; thus helping to reduce the loads on the tensioner and tugboat. It is worth noting that the fairing float may also reduce weight and vibrations for floating platforms' riser pipes and tensioning cables.

Conclusion

Each of these methods is designed for laying a pipeline from a floating spiral at high speed and low stress, under well controlled, constantly monitored conditions. By combining the floating spiral with any of these installation methods, the offshore operational OPEX and CAPEX costs could be dramatically lower than those typically accrued with lay barges or vessels. This applies to all water depths in all seas.