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INSTALLING PIPELINES
FROM A FLOATING SPIRAL

ABSTRACT

Prefabrication allows for optimal control of costs and quality in pipeline manufacturing. Transport limitations have hindered to make full use of those advantages for long and wide pipelines. The Floating Spiral method lifts those limitations. The pipe is made afloat and wound elastically to form a large flat spiral, ready to be towed to the installation site by standard tugboats.

Laying a pipeline, unwound elastically from a Floating Spiral, can be done conventionally, via a layvessel or a laybarge, be it at a lower speed than the unwinding of a Spiral allows for. This paper describes alternative methods that might be used in the three typical situations:

- a landfall operation
- a deep water installation
- pipe installations in very deep water

For all three situations options are described for reducing both installation time and installation costs, while minimizing pipe stresses and maximizing process control.

INTRODUCTION

This presentation is about installing prefabricated pipelines offshore.

Pipelines can be prefabricated very well onshore. In particular this is true for complex pipelines such as for pipe-in-pipe systems. Or for pipelines made of special materials like Cr-13 or Duplex steel. Or for pipelines to be installed as a bundle, or in combination with optic cables or power cables. All these pipeline systems can be prefabricated onshore with relative ease, answering high quality standards.

Manufacturing of these pipeline systems may be relatively easy in prefabrication, their transport has been the hurdle. By nature a long pipeline, transported over sea is very much exposed. Exposed to traffic when floating on the waves. Exposed to subsea structures when drawn along the seabed or towed at controlled depth. And the elongated pipeline is exposed to lateral currents as well. A floating pipeline of 20 kilometres length, subjected to a lateral current of 0.5 metres/second (1knot) 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 500 metre deviation.

Such bollard pull of 1250 tonnes is a substantial force for the tugboats at either end of the linear tow. But at the end of the firing line onshore, such load is unacceptable. And such force is even less acceptable at the point of touchdown. For those two reasons, unacceptable exposure and large holding forces at the pipe ends, it is better to wind the pipes and to transport them as floating spirals. As spirals, wide enough to keep the steel and the concrete coating within their elastic limits.

TRANSPORTING PREFABRICATED PIPELINES AS FLOATING SPIRALS

Figure 1 shows a Floating Spiral of 120 metres diameter of an 8” pipeline during transport along the coast of Holland. It is pulled by a tugboat at 10 tonnes bollard pull and reached a speed of 4 knots, equivalent to 100 miles a day.

Making such a Floating Spiral and towing it is not too difficult. Before your pipeline is push/pulled from the firing line onto the sea, our sister company Spiralling Services will apply floats to it. These pipe-floats are long, multi-cell air-filled bodies, connected to the pipeline by a kind of safety net, enveloping 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 illustrates this procedure. 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, which 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.

From the Spiral Base the Spiral is towed to the installation site. This can be done by a locally available tugboat. Before the tugboat arrives, the shape of the Spiral is secured by some criss-cross cables. They prevent ovalization of the Spiral due to drag forces. The tugboat is cable connected to three of the Bending Wheels. For the transport those Wheels have been interconnected by a stiff beam. This beam is typically made of the same pipe elements and the same floats as 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 prime question in the Floating Spiral development concerned the ability of a Spiral to survive a severe storm. To test this, a Spiral was tested in a storm tank, as shown in Fig. 3. This picture shows the situation that no criss-cross cables are installed.

You see that, indeed, without such cables the Spiral gets stretched by the drag forces. You may see, as well, that the Spiral sways easily on the waves, without a tendency of windings climbing over each other. We did such tests at significant wave heights of 11.5 metres and after this pretty severe storm the Spiral was fully intact.

That may look odd, at first sight. But on second thoughts it is not so odd. Short waves have no effect at all on a big floating pipe: those small waves just do not have enough power to make a big pipe move over or under its neighbouring winding. And long sea waves just carry the pipe windings, one as much as its neighbours. The consecutive windings swing synchronously on the curvature of the waves. Adjacent pipelines move up and down together, keeping the texture of the Spiral intact.

PIPE INSTALLATION FROM A FLOATING SPIRAL

At the installation site the floating pipe can be fed into a laybarge or a layvessel, via a front stinger. This approach allows to combine prefabrication with conventional pipe laying techniques. But lay vessels and lay barges are not fully at par with the potential speed of unwinding a Floating Spiral elastically. Below we discuss how the pipe installation could be accelerated. We will consider three situations: a landfall operation, a deep-water installation and pipe laying in very deep water.

1 Landfall operations

In a landfall operation, the Floating Spiral is anchored close to the shore. The criss-cross cables are removed. The end of the pipeline is connected by a cable to a winch onshore. And then the Drive Unit at the Spiral and the winch onshore cooperate to bring the head of the pipeline onshore. When the coast has been reached, the Floats are gradually removed, to launch the pipe to the seabed. The landfall operation is thus relatively easy for a pipeline, unwound from a Spiral while it is floating.

The landfall installation is more time consuming when 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 by backhoe excavators, takes more time than the unwinding of the Spiral. Unwinding can be a matter of hours, at a speed of –typically- one kilometre an hour, whereas the trenching may take weeks. For long landfalls a Trencher Roller is currently under design as an alternative to make trenches at a speed in line with the potential of a Floating Spiral.

Conceptually, the Trencher Roller (figure 4) is a big road roller with profiled wheels. The figure shows a 500 tonnes Roller with wheels of 12 metres 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, 10-20 kilometres 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 aims to do so in water as deep as five metres. 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 sunk 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 a beach resort, or in an environmentally protected 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. Over the 71 kilometres long trajectory of these pipelines the maximum water depth is just 4 metres. 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. Last but not least: 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 design of theTrencher Roller was initiated with that Kashagan job in mind.

After the Big Wheel would have completed its job, 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.

2 Installing pipelines in deep water

In shallow water the pipe could be laid directly from the Spiral. In deep water, however, it cannot. The pipe needs support where it bends from sea level to seabed. Rollers are needed to give this support, with floats to give these rollers their upward thrust. A chain of such floats and rollers we have called a Compliant Stinger (figure 5). You may note that this Compliant Stinger does not need a long, stiff cantilever structure to connect the rollers to a floating body, as is the case for lay vessels or lay barges. The Compliant Stinger puts the float directly where the load is.

For the pipeline installation the Compliant Stinger is to be shifted over the free end of the unwinding Spiral, till it connects to the Drive Unit having been used at the Spiral Base to wind the Spiral. That 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 (figure 6). In between these two vessels a sensor platform can be towed. This platform has 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 of 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 screen also shows him the tension in the pipe, represented in false colours.

This system of monitoring and controlling the Compliant Stinger would facilitate a safe pipe installation in deep sea, with high potential speeds: up to one metre per second, 80 kilometres a day.

3 Very deep water installations

In very deep water the speed of the pipe laying gets hampered by the drag force. This would be 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 dimensioned for the winding procedure. One may accept these hindrances of weight and drag forces, and decide to reduce the speed of installation and to use a stronger Tensioner. But we may choose to overcome these limitations more directly by introducing a Fairing Float.

A Fairing Float is a chain of floats, each mounted in a wing shaped fairing (figure 7). The structure grips around the pipe by bellows, filled with sea water. By letting sea water inside the bellows, the hydrostatic pressure inside the bellows is the same as outside, at all water depths. This means that overpressure in one bellow will give the same effective overpressure in each of all 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 downward to the seabed. An overpressure of about 20 centimetres water column gives sufficient grip on the pipe. When a predefined water depth has been reached, 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. This is shown in picture 7b. The rolling bellow 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 thus 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.

Note: the Fairing Float might reduce weight and vibrations as well for riser pipes and for tensioning cables of floating platforms.

SUMMARY

We have seen that the Floating Spiral may be used to transport prefabricated pipelines. This is especially relevant when the pipeline is a complex one, either a pipe-in-pipe system, or a pipeline made of special steel, or used as a bundle with other pipelines or in combination with optical cables and power cables.

At the installation site, the pipe can be fed onto a lay vessel or a laybarge. This allows for combining the advantages of prefabricated pipelines with those of conventional pipe laying techniques. Alternatives were discussed for three situations: laying in shallow water, in deep water and in very deep water.

For very shallow water, 0-25 times the pipe diameter, we discussed the use of a large Trencher Roller. It would allow pipe pulling and trench making in water as deep as five metres, and it could do so at high speed: 10-20 kilometres per day.

For deeper water, 25-250 times the pipe diameter, the pipeline may be supported by a Compliant Stinger and controlled by the Tensioner, being the Drive Unit that was used before in the Spiral winding process. The position of the launching end of the Compliant Stinger can be monitored and controlled at high precision by the survey vessel and a pilot vessel.

For very deep water, more than 250 times the pipe diameter, the effective weight of the pipe and its drag resistance could be reduced drastically by using Fairing Floats in between the Compliant Stinger and the seabed.

Each of these methods is designed for laying a pipeline from a Floating Spiral at high speed and low stress, under well-controlled conditions, constantly monitored.

Finally, it may be said that by combining the Floating Spiral with any of these installation methods the offshore operational OPEX and CAPEX costs would be dramatically lower than those typical for using laybarges or lay vessels. This applies for all water depths, for all seas.

Sjef Beaujean
Managing Director
Eurospiraal BV
Spiralling Services BV

P.O. Box 3006
NL- 5902 RA Venlo
www.eurospiraal.com
e-mail: beaujean@home.nl

Figures

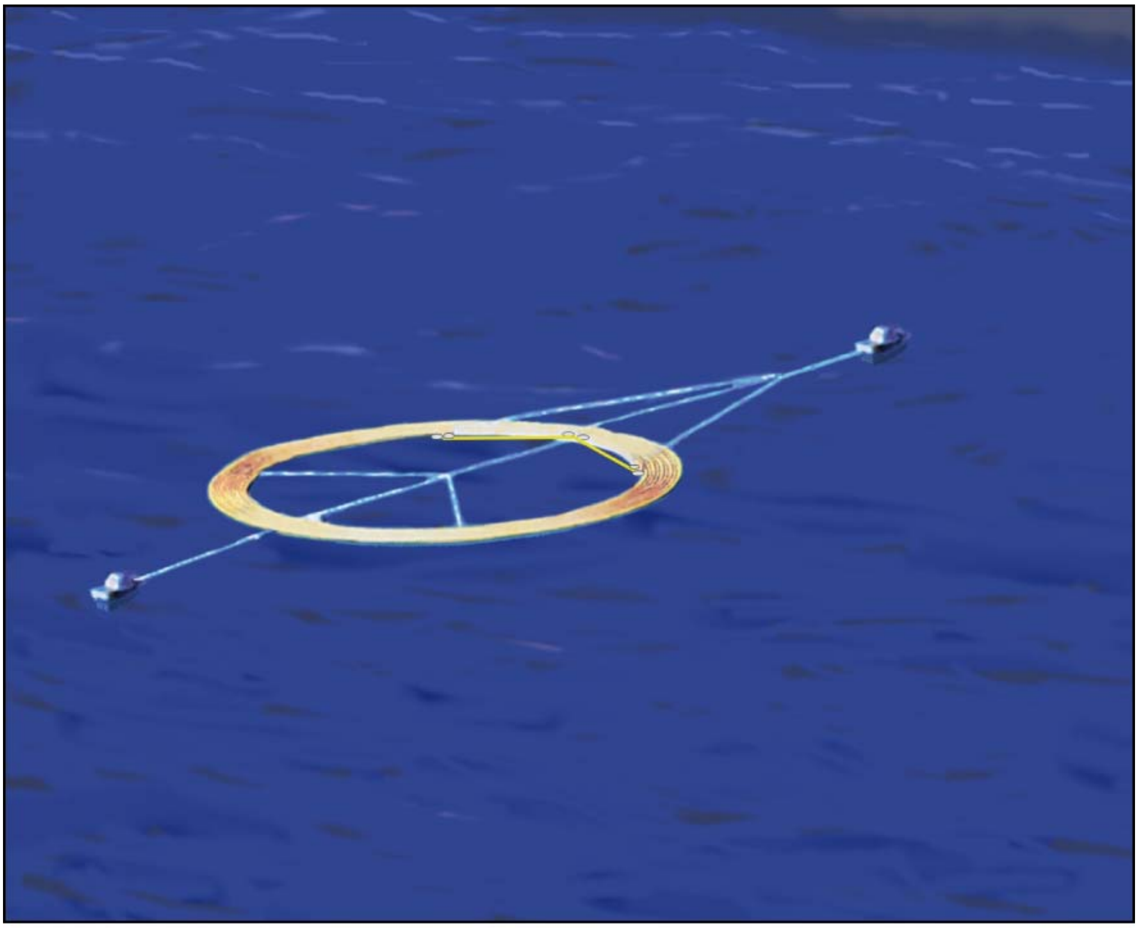

Figure 1

Floating Spiral on NorthSea

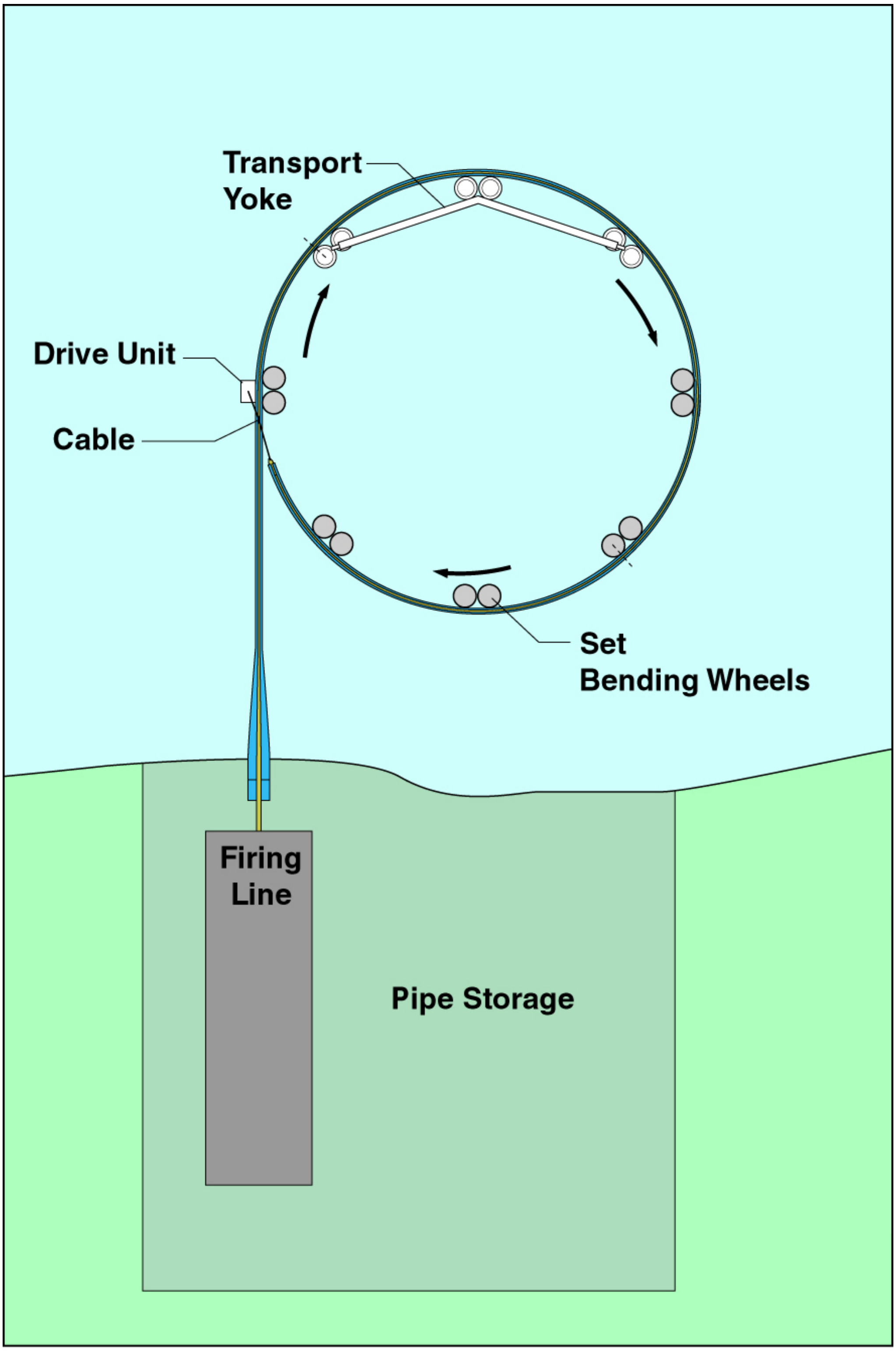

Figure 2

***Winding of floating pipeline
Spiral Base***

Figure 3

Floating Spiral in storm tank

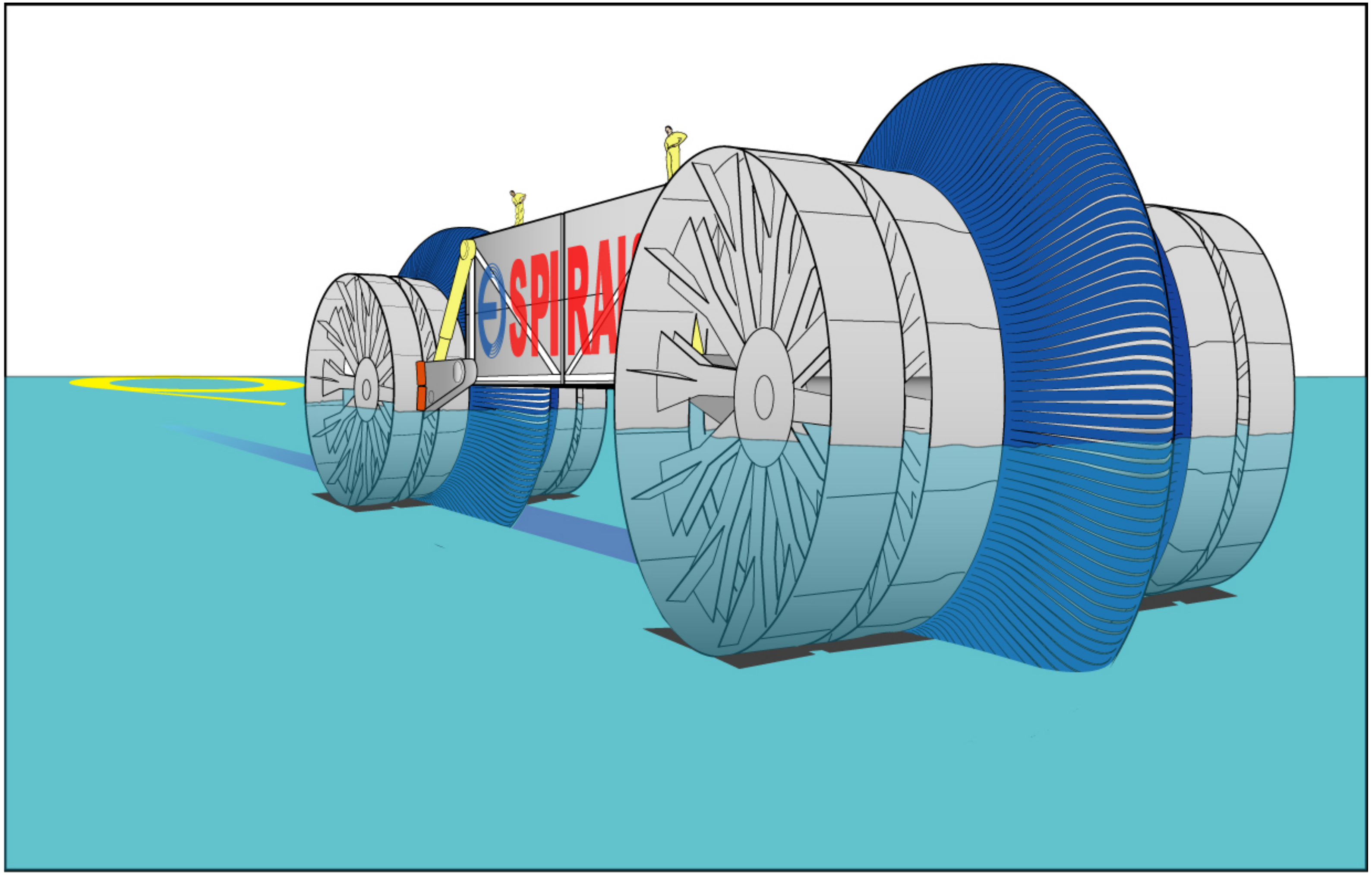

Figure 4

"Big Wheel" Trencher Roller

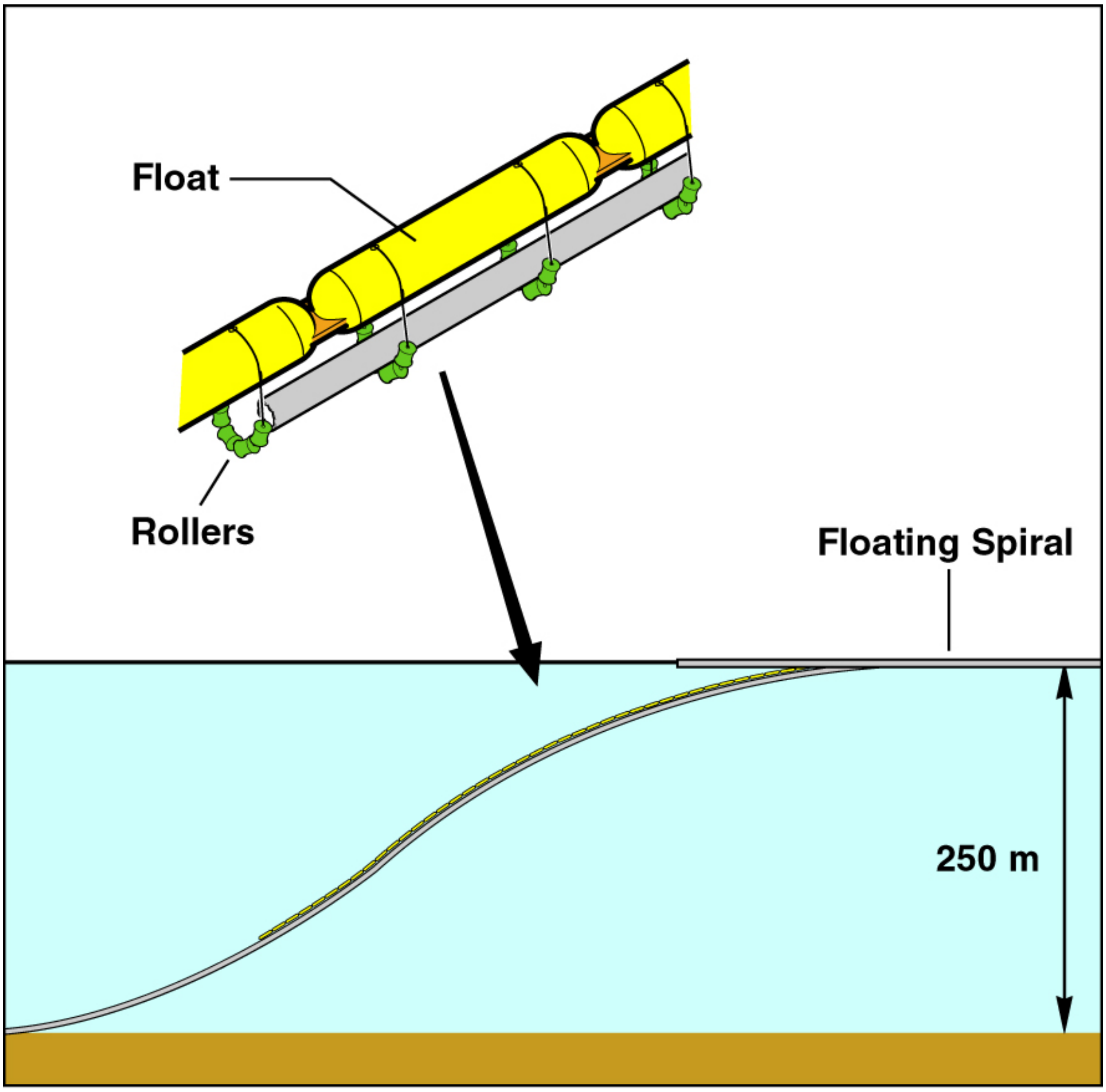

Figure 5

Compliant Stinger

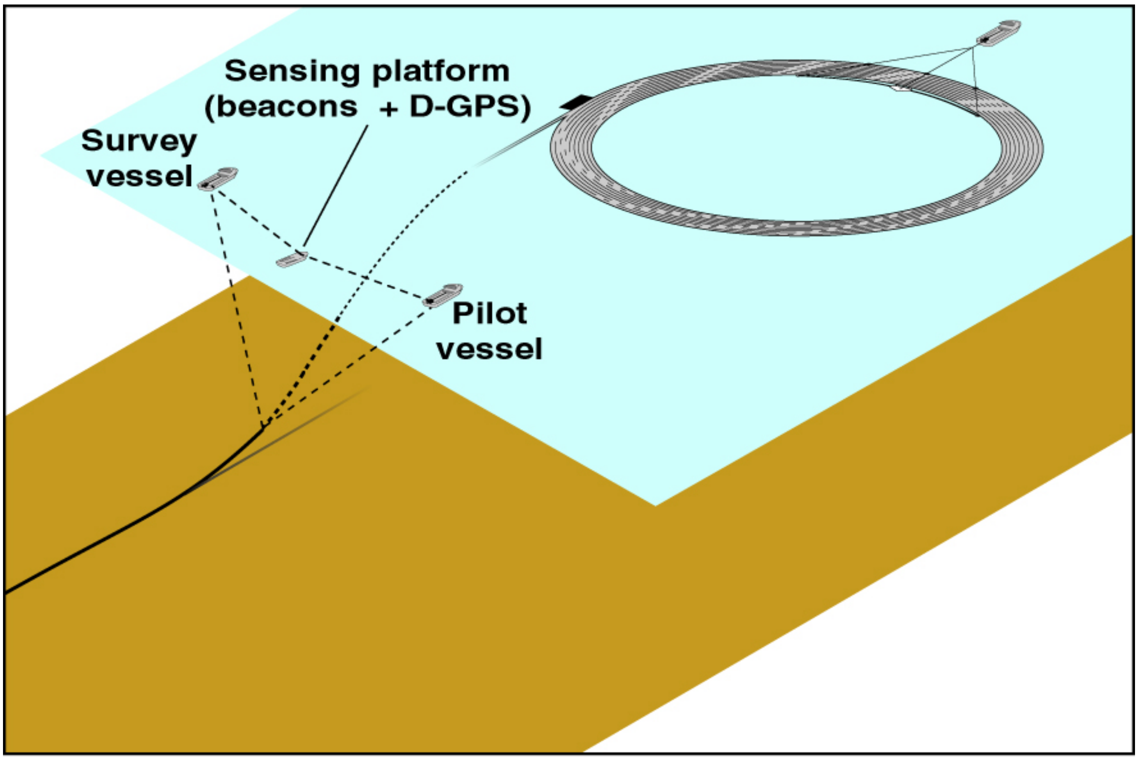

Figure 6

Stinger connected to surveying vessel and pilot vessel

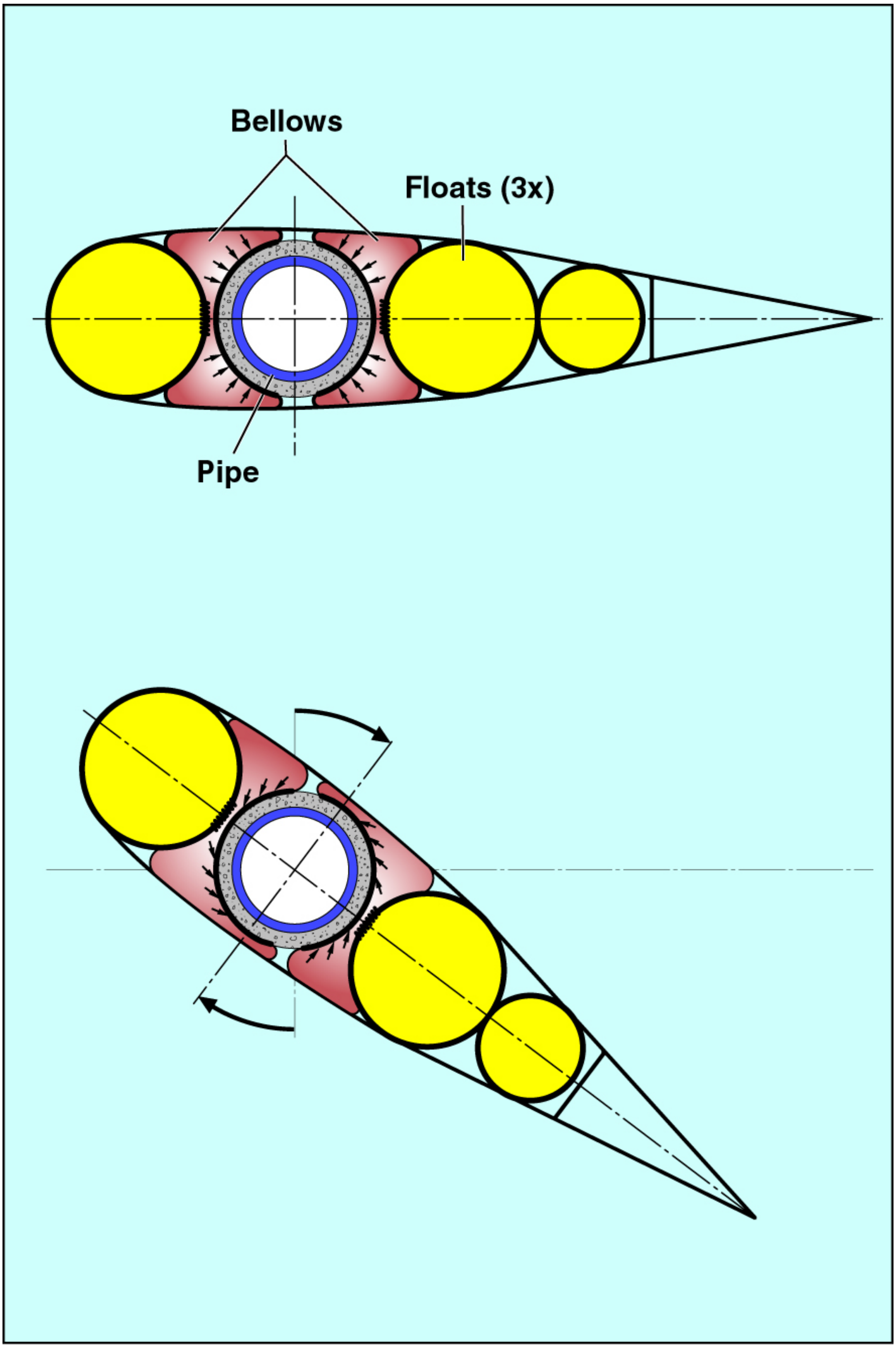

Figure 7

Fairing Float