8in pipeline being pulled out to form the floating spiral during sea trial.

A new way to launch, transport and lay offshore pipelines has been developed in The Netherlands, promising to make pipeline installation easier and cheaper. **Terry Knott** takes a closer look.

Inspired by spirals

Building long lengths of pipeline onshore, then launching and towing them on the sea surface to the offshore installation site, might appear to be a relatively straightforward operation for an industry well versed in handling large structures at sea. But in practice, the limitations are such that this occurs infrequently, leading to the more costly route of offshore welding and lay vessels.

So says Eurospiraal, a joint venture technology provider formed in The Netherlands to develop an alternative method, which last autumn saw its first full scale sea trial.

The underlying concept for the new technique is to wind the pipeline into a giant floating spiral and tow this to the installation site, where the spiral is then unwound and lowered to the seabed in one operation (*artist's impression above*).

'The idea was sparked by discusions on a different subject – laser welding – with the leading pipeline installation contractors,' says Sjef Beaujean, originator of the concept and now head of Spiralling Services based in Venlo. 'Prefabricating pipelines onshore offers certain quality advantages, but when a pipeline is reeled for offshore transportation, the pipe goes beyond the elastic limit and then has to be straightened out when it is unreeled. Reeling a 40km long, 20in diameter pipeline elastically would require a 300m diameter reel, which is clearly not practical for ship transportation. However, this started the train of thought of winding up the pipeline into a spiral and floating it to the site, gaining the advantages of onshore fabrication and avoiding the limitations of reel ships.'

There followed three years of design and development work leading up to the recent sea trail, with support and research effort coming from leading pipe manufacturer Mannesmann/Europipe in Germany, input from Shell, and extensive model testing at the Maritime Institute of The Netherlands (Marin). The Eurospiraal joint venture – a combination of Beaujean and NOM, a semi-government organisation promoting industry in the northern part of The Netherlands – was formed to co-ordinate the work. The Dutch Ministry of Economic Affairs has also acted as a key sponsor for the \$2 million programme, which has led to the patented Floating Spiral Method and the development of tools to carry out the job.

According to Beaujean, the advantages of using a spiral rather than a straight length of pipe are many.

'Finding a suitable launch site for long pipelines presents the first obstacle,' he explains. 'Side currents can create large forces on a straight pipeline, the launch ramp and the tugs – a one knot current acting on a cross sectional area of $0.5m^2/m$ (equivalent to a 12in diameter pipeline with coating) for a 10km long pipe generates 44t of force. If the tug pulling out the line is working at a towing angle of 1:10 with relation to the launch ramp, this results in a longitudinal force of 220t, too much for most tugboats. There are very few sheltered areas suitable for long pipeline launching.'

By spiralling the floating pipe as it comes off the launch ramp, its exposed length and the resultant forces can be reduced significantly. For example, a 10km long, 8in diameter pipeline can be spiralled at an inner diameter of 120m and an outer diameter of 135m. Adding to this the length of pipeline stretching from the ramp to the floating spiral, the overall exposed length will be only 200m, producing 50 times less current load on the pipe, possibly less as the operation is closer to shore.

Flotation for the pipeline is normally achieved through soft polyethylene foam. For the 8in diameter line used in the trial, the foam was applied in 28mm thick strips by Eupec in Mullheim, a Europipe subsidiary. As a part of normal fabrication, the pipe receives a polyethylene anticorrosion coating involving heat treatment – while this layer is still hot, the polyethylene flotation foam is placed on top and becomes thermally bonded. In water, the buoyancy of the foam changes with hydrostatic pressure as it becomes compressed – a depth of about 10m is the turning point: above this the pipe floats, below this the pipe will sink, enabling the line to be lowered to the seabed during the installation phase, where the foam remains as a thin layer adding to the protection of the pipe.

The tools required to produce the spiral – which Spiralling Services leases out, along with tugboats and crew – consist of bending buoys, a yoke and a floating triangle, chain-anchored to the seabed (*see figure*).

The pipe is pulled from the launch ramp by the tug or support vessel – only a light boat is required – and guided around the bending buoys to begin the first winding, a pipe-curving technique used by dredging vessels.

'The inner diameter is chosen to be 500 times the outer diameter of the pipe, producing only very low bending strain and allowing the pipe to remain elastic so that it will straighten when unwound,' says Beaujean. 'For the 8in pipe the bending force was just 250kg. The bending moment is far below the level that could induce local buckling, even with the relatively thin 10mm wall thickness we used in the trial.'

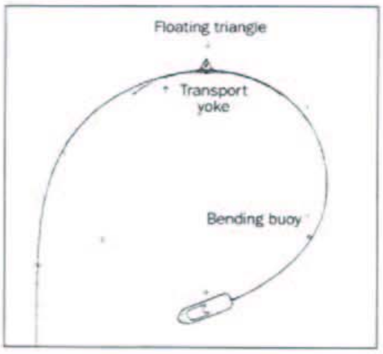
The yoke and floating triangle are attached to the curving pipe, to sandwich it between driving wheels. The first winding is completed by pulling the pipe leader to the end of the yoke using a winch, where it is attached. Once the first winding is made, the driving wheels then draw the remainder of the pipeline out from the ramp, creating a spiral as the windings build up. The rate of driving is around 360m per hour, which means the speed of the operation is actually controlled by the rate at which the pipe can be assembled onshore.

Towing the pipe offshore as a spiral reduces the risk of towing a long straight pipe among other sea traffic, and reduces the movement experienced by the line.

'The conventional method of attaching buoys at intervals to a straight pipe to be towed just below the sea surface causes flexing along the pipe as the buoys follow the waves,' Beaujean points out. 'By contrast, the spiral is evenly supported by the water, with only a small percentage of the pipe exposed in the wave troughs. This reduces wave-induced stress and greatly improves fatigue life of the pipe.'

Extensive testing in the storm and towing tanks at Marin on a 1:60 scale up to sea state 8 have shown that the spiral sways on the waves much like seaweed and will survive a storm. The windings did not rub together and no 'pipe spaghetti' was created.

Once on station the spiral can be unwound for installation – positioning accuracy is said to be enhanced by the relative ease of manoeuvring a 120m spiral compared to a 10km long pipeline. The free end of the spiral is pulled down to the seabed using a cable passing through an anchor on the seabed. The driving wheels

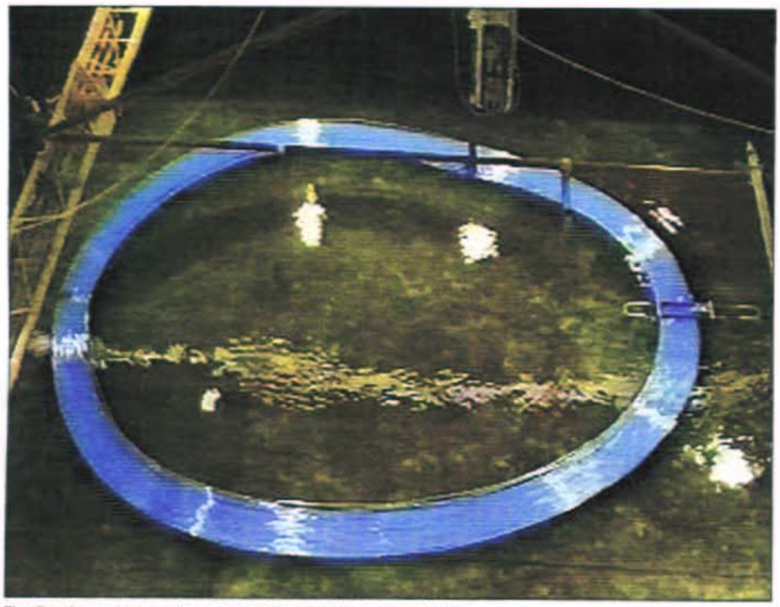


in the yoke and triangle then take over to unwind the coils, while the tug moves the spiral along the laying corridor.

'At a speed of 1m/s, a 10km pipeline could be laid in an afternoon,' notes Beaujean. 'And this with an accuracy of 5m, perhaps twice as accurate as trying to get a straight pipe into place.'

As the tug nears the shore line in water around 8m deep, the remainder of the spiral is unwound and a winch pulls the floating pipe to shore, this section being trenched or rock dumped.

At present, the tools and technology are available to wind up and install pipelines up to 16in in diameter, but larger lines could be handled in future, says Eurospiraal. By way of illustration, a desk study of the 1100km long Oman to India pipeline, 20in in diameter, indicated that spirals of 950m in diameter could be used and that laying could be achieved in two weeks – but realistically, Beaujean is quick to point out that a project on this scale would not be the first he would like to tackle.


The floating spiral method undergoing tank testing at Marin.

Adaptations to the flotation method will be required for very shallow waters where the buoyancy of the polyethylene foam will not be sufficiently reduced. In this case floating cradles made from reinforced polymer sheet would be used, forming a line of compartments along each side of the pipe, designed to pass through the wheels of the yoke. During installation the cradles can be stripped off and reeled for reuse, or have their air content reduced in a controlled manner to lower the floats with the pipe. On the seabed the floats act as an artificial reef, promoting sand deposition around and on the pipe.

In very deep waters a tensioner and stinger arrangement would be needed to control the laying of the pipeline. However, unlike conventional rear-mounted J-lay or S-lay stingers, the stinger proposed is a suspended stinger hanging below the centre of the laying vessel, which could be of the size of an anchor handler or supply boat, eliminating the need for a large specialised pipelaying ship.

The sea trial took place offshore the northern part of Holland last September. During the summer, the 8in diameter foam-coated pipe sections were shipped from Germany to Delfzijl where Hak welded them into three strings, each 420m long. The strings were moved out to the launch site on wheeled dollies and pulled out to sea, the three strings being welded into a 1260m long pipeline in the process. As the water depth was very shallow, the strings were pulled out some 200m from shore for the winding process, producing the windings of 120m diameter at a rate of about 0.1m/s.

'While the spiralling process in itself was successful, the operation was let down by the seabed anchor blocks, which moved during a storm and allowed the spiral to be pushed onto the inshore wetlands,' Beaujean explains. 'The line became covered in mud and made it hard to detect at sea, so we had to clean it and start again. We made the spiral three times in all.'

Unfortunately this caused the project to slip to September, missing its weather window, which meant the planned tow and installation into the North Sea could not be carried out. Instead a one-day tow around the Dutch and German coast was made, before the pipeline was returned to base and unwound.

Despite this disappointment, Beaujean remains upbeat, pointing to the major cost advantages of the technique.

'When compared to present pipeline laying methods, the floating spiral method offers ten times less capital investment in equipment, ten times less labour at sea, and potentially could deliver ten times faster lay rates.'

Eurospiraal is currently preparing FEED studies for prospective pipeline projects and is taking the development work further for pipe-in-pipes, bundles, and laying in ultra-shallow and ultra-deep waters. OE