First Operational Experiences

Laying of 17 km Steel-Cased Pipe-in-Pipe in the Ijsselmeer

A power plant in Diemen provides district heating to the Dutch City of Almere. The special thing about that: The district heating pipeline runs through the Ijsselmeer. Altogether 17 km of steel-in-steel pipe 500/70/700 was delivered by FW-Fernwärme-Technik GmbH – 16 km of which were laid in the Ijsselmeer. Technical challenges were the mechanical prestressing of the pipes with hydraulic cylinders on pipe-laying pontoons as well as the crossing of the dykes and a shipping channel with horizontal directional drilling (HDD). The first operation year has now been completed successfully.

The power plant of Diemen in the southeast of Amsterdam provides nearly 290,000 households with electricity and annually produces about 400 GWh of heat that contribute to the supply of the cities of Utrecht, Amsterdam-Zuidoost and Ijburg. With the construction of the cogeneration plant Diemen 34, as from 2012 the site has new district heating capacities. These had to be connected to the Almere district heating network as efficiently and cost-effectively as possible. Normally, an 8.5 km long connection is not a major challenge, but in this case, the Ijsselmeer is between the cogeneration plant and the transfer station in Almere-Poort, i.e. the southernmost bay of the largest Dutch lake area of Ijsselmeer and Markermeer. The shortest possible connection between the power station Diemen and Almere-Poort was the direct pipe laying through the Ijsselmeer (*figure 1*). With a route length of 13 km, the same connection over land would have been 4.5 km longer; 9 km less heating pipes lead to a considerable cost saving.

With a depth of about 2 m, the Ijsselmeer (freshwater) is not very deep. At the bottom a trench, 2.2 m deep, was excavated, so that the encasing pipes DN 700 would have a coverage of approximately 1.5 m. A 19 m deep shipping channel in the route area (Gooimeer) was crossed under just like the dykes, both at the beginning and at the end of the pipeline by horizontal directional drilling (HDD). Dykes in Holland, anyway, may not be crossed in an open trench (*figure 2*). Although gas pipelines there had been already laid in the Ijsselmeer, the laying of district heating pipelines – axially expanding due to temperature variations – was new in this length. From the pipeline length of 17 km, 16 km are laid in the Ijsselmeer. Similar projects are not known worldwide.

After thorough soil investigations on the total length of the route and after evaluation of risk analyses and requirements of environmental protection and nature conservation as well as of the demands with regard to reliability and durability of the district heating pipelines, a steel-in-steel pipe was taken as planning basis for the heat transport. In a single planning, the Dutch engineering company Tebodin Netherlands B. V. coordinated the demands of the route, the requirements to the encasing pipe system and the laying works. In the tender phase the competing companies were free to develop concepts in terms of installation, expansion and pre-stressing.

In coordination with the system manufacturer, the flow and return pipelines were divided into twelve


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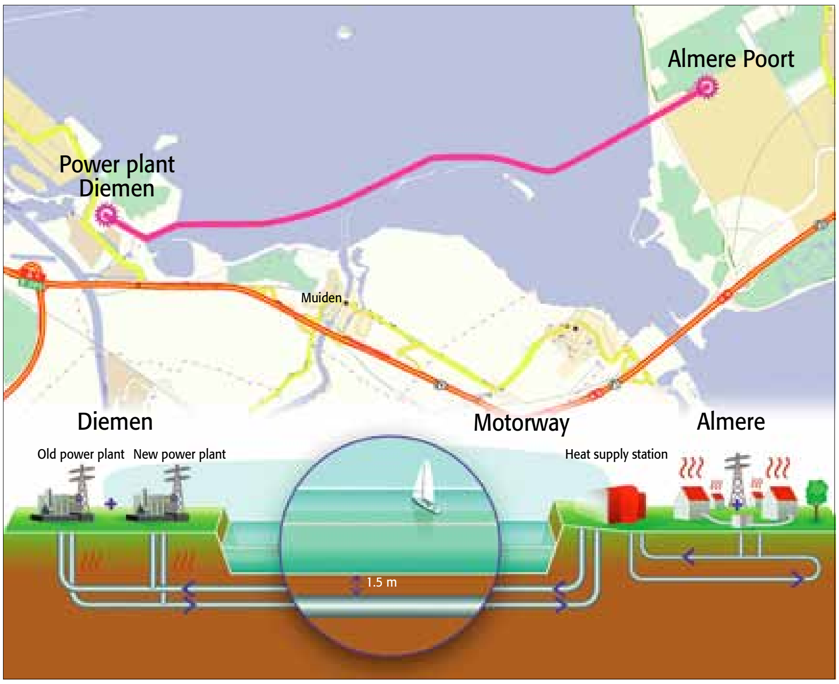

Figure 1. Route through the Ijsselmeer

Figure 2. Dyke-crossing with horizontal directional drilling (HDD)

pre-stress sections with lengths of up to 1.5 km. Today, it is state of the art to pre-stress the inner pipe thermally against the encasing pipe with steam. However, since the inner pipe was filled with water for lowering, this technique could not be applied. The pipe was mechanically pre-stressed by means of hydraulic cylinders.

With a design temperature of 135 °C, an expansion coefficient of 1.62 mm/m and a total length of the flow and return pipelines of 17 km, the inner pipes would extend by 27.540 mm in total. This expansion was hindered in the axial movement by using the allowable tension.

On site, the prefabricated 16-m-units DN 500/70/700 were welded together to partial lengths of 500 to 700 m, tested, sealed at the ends, and lowered into the water (*figure 3*). The welding of the partial lengths was carried out on a pipe-laying pontoon (*figure 4*), on which a pre-stressing device, consisting of eight hydraulic cylinders, was generating a pre-stressing force of up to 3,200 kN. In order to achieve a more equal distribution of stresses in the pipe, the pre-stress process took place in several stages of pull and release.

The pre-stressing parameters and the pre-stress procedure were planned and calculated individually subject to the trench position, the pre-stressing distance, the pre-stressing force to be applied and the position of the pre-stress points for each section. With regard to the horizontal and vertical radiuses in the course of the pipeline, it was not possible to pre-stress 8.5 km of FW-steel-cased pipe-in-pipe in one single operation.

In early January 2011, FW-Fernwärme-Technik GmbH started with the pre-fabrication at factory. In close coordination between the site management and the manufacturing plant, the delivery of about 1,116 pieces of site units took place. In the period from January to September 2011, the welding and pipe-laying works on-site had been completed.

The crossing of the dyke on the Almere-side was a technical challenge for the HDD-drillings. The water level on this side is about 3 m higher than the land lying behind the dam. The six HDD-drillings

Figure 3. »Parking lot« of the pipelines, which are welded together to partial lengths of 500 to 700 m and sealed at the ends

Figure 4. Pipe-laying pontoon with hydraulic pre-stressing device

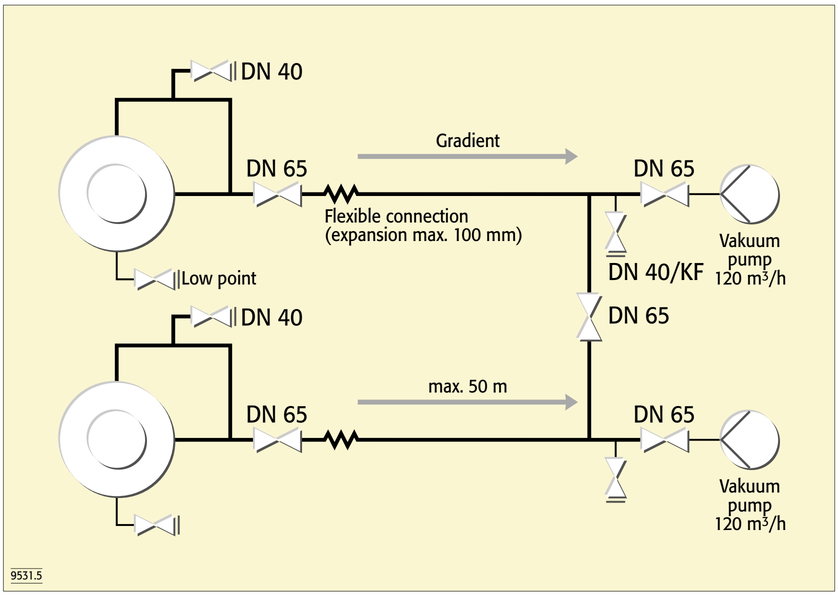

Figure 5. Principal Sketch: vacuum connection at the end of the pipelines

Involved project partners

System operator:	Nuon Energy, Amsterdam/the Netherlands
Planning:	Tebodin Netherlands B. V.
General contractor:	A. Hak Leidingbouw B. V.
Civil engineering:	Martens en Van Oord, BS Oosterhout
Construction planning:	FW-Fernwärme-Technik GmbH, Celle/Germany
Production and supply:	FW-Fernwärme-Technik GmbH, Celle/Germany, via Logstor Nederland B. V.
Planning and execution of the vacuum system:	FW-Fernwärme-Technik GmbH, Celle/Germany
Planning and execution of the cathodic corrosion protection system:	Van der Heide Kathodische Bescherming & Corrosie Engineering B. V., Kollum/the Netherlands

in a length of 400 to 600 m – two of them were below the shipping channel in the Ijsselmeer – required different surface roughness of the passive corrosion protection of the encasing pipes. In the standard laid pipeline sections, smooth PE was used, below the horizontal directional drillings PP white with a very small surface roughness was applied. The latter resulted in a lower friction between the encasing pipe and the bentonite. At the pipeline ends, where a bigger static friction between the encasing pipe and the surrounding soil was required, PE rough was used.

The structural engineer had in particular to pay attention to:

- allowable horizontal and vertical radiuses of the routes,
- allowable horizontal and vertical radiuses when flooding, lowering and pre-stressing,
- coverage and encasing pipe friction during pre-stressing and operation,
- filling of the inner pipe when lowering,
- buoyancy effects and deflection forces caused by the radiuses,
- positioning of the supports, as no binding »up«-position was ensured,
- longitudinal stresses in the pipes after the pre-stressing.

The encasing pipe ring space of the flow and return pipeline of the FW-steel-cased pipe-in-pipes is kept under permanent vacuum of 1 to 3 mbar.

For the first evacuation right after the pipe-laying (drying of insulation, final tightness testing of the inner and encasing pipes) the operator of the pipeline system had heated the pipeline to about 70 °C to support the evacuation operations. With a gradual increase of this temperature, the first evacuation was completed after three months. Pressure rising tests with measurements of the leak rate followed.

The excellent vacuum values which were measured give an idea of the high welding quality in the pipe manufacturing plants in Salzgitter and in Siegen, at FW-Fernwärme-Technik, the pre-fabricator, and the A. Hak company as the pipe-laying company on-site. On each of the four pipeline ends, a vacuum pump was installed (*figure 5*).

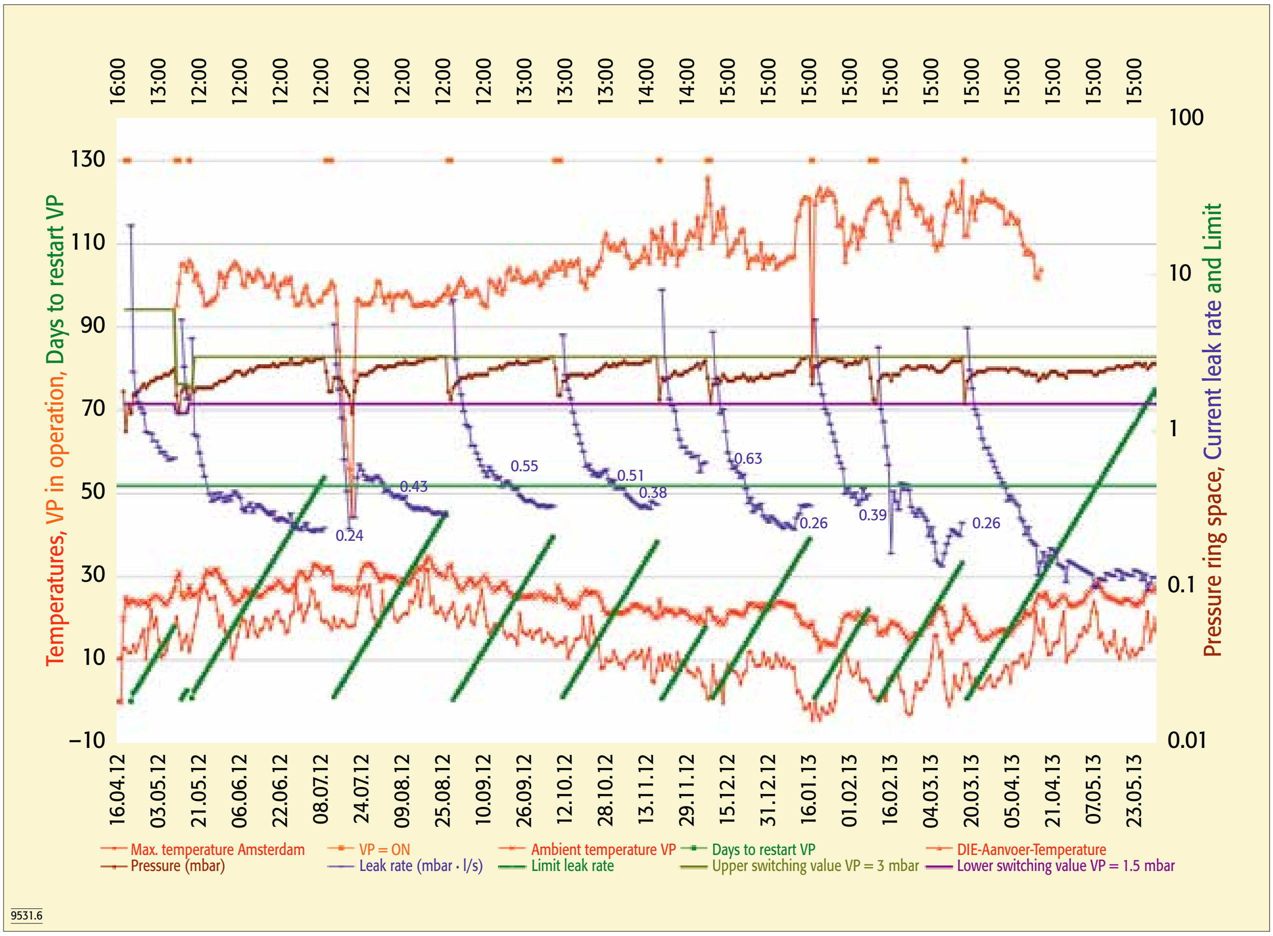

Figure 6. Heat losses, temperatures of the casing pipe for DN 500/70/700, 135 °C, Rockwool R 880; 1,013 mbar, without vacuum, 120 W/m, 38 °C; 1 mbar, 79 W/m, 27 °C; that means 40% less heat losses
VP vacuum pump

The evacuated pipe sections have annular ring spaces of 700 to 750 m^3. Two vacuum pumps were switched off due to the high vacuum tightness of the system. Two of the operating pumps run 3.8 to 4.2%. The diagonal green lines in the vacuum pump records indicate the idleness times of the pumps (*figure 6*). On the Diemen return pipeline section the vacuum value increased from 0.8 to 1.8 mbar during 250 days from September 2012 to June 2013. The leak rate here is 0.04 mbar l/s – compared to the requirements of the AGFW (the German District Heating Association) ≤ 0.43 mbar l/s – indeed, an excellent value.

Over the entire length, the flow and return pipeline are cathodically protected against corrosion. The ends of the pipelines are electrically disconnected from the continuing system components by means of insulating pieces FW-/Dr. Schnabel. After the first year of operation, a service life of the pipeline of at least 50 years is expected by the system manufacturer FW-Fernwärme-Technik. ■

Technical Data

Design temperature:	135 °C
Design pressure:	35 bar absolute
Inner pipe:	DN 500 (508 × 8.0) of material P355NH according to DIN EN 10217-3
Manufacturer:	Salzgitter Mannesmann Line Pipe GmbH, Siegen/Germany
Encasing pipe:	DN 700 (711 × 10.0 or 14.0) and DN 800 (813 × 14.0) of material P355NH according to DIN EN 10217-3
Manufacturer:	Salzgitter Mannesmann Großrohr GmbH, Salzgitter/Germany
Approving authority:	Lloyd's Register Nederland B. V.
Encasing pipe coating:	PE according to DIN 30670, special layer thickness 5 mm, partially with roughened surface PP according to DIN 30678 with a minimum thickness of 6 mm
Inner pipe bend:	DN 500 (508 × 8.0), radius 2,500 mm, hot bent, of material P355NH

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