Saltwater Transport Line - Germany

In 2001, NOV Fiber Glass Systems B.V. secured the contract for an 18 inch GRE brine transport line with a working pressure of 20 bar with a total length of 54 km. Leading energy supply company EWE (Elbe Weser Ems) planned to create four caverns, at a depth of 1200 meters, 450 meters high and 100 meters in diameter, with a volume up to 700.000 m^3 each in the underground salt layers of Rüdersdorf, located some 30 km east of Berlin. The caverns were created for storage of natural gas.

The gas is stored at high pressure up to 180 bar. This allows EWE to store gas during summer to create a buffer for the winter period. The advantage is that EWE will be able to receive a consistent quantity of gas throughout the year yet can meet increased seasonal demands. These underground salt layers provide excellent conditions for this type of storage.

The caverns are shaped by controlled water injection. The salt water that is produced during this process is transported over a distance of 54 km, running through developed and rural areas with various landscapes and obstacles, to Heckelberg, where it is injected in the underground rock layers at 1000 m depth.

- Over 6.000.000 metric tons of brine with a density of 1200 kg/m^3 will be pumped through this line,
- Salt content is 300 kg/m^3,
- Working temperature ranges 2°C to 60°C,
- Besides the salt, additional chemicals are added such as HCl (950 metric tons per year) and citric acid (95 tons per ear). The very corrosive nature of this fluid was one of the selection criteria EWE used to select Bondstrand corrosion-resistant GRE pipe.

Project

Saltwater Transport

Client

EWE (Ems Weser Elbegebiet)
Oldenburg, Germany

Pipe system

Bondstrand 3400 18" (450 mm) Pipe
With Taper/Taper Adhesive Bonded Joint

Operating conditions

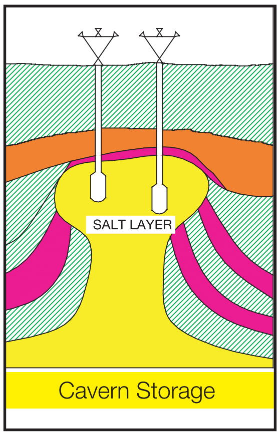
Operating Pressure: 17 Bar
Operating Temperature: Ambient
Design Pressure: 20 Bar
Test Pressure: 26 Bar
Design Temperature: 60°C

Installation date

Fall 2002

Editors Note: Bondstrand 2400 pipe is now available in place of Bondstrand 3400 pipe. It is equal to or superior to all properties of Bondstrand 3400.

Due to environmental restrictions, a leak detection cable was buried underneath the pipe. It is the first leak detection system in the world of this size. The system is designed to detect a 0.5 litre/ minute leakage. The cable consists of a small bore PE line containing a number of glass fibres. This way a local change in temperature resulting from leakage can be detected.



- Plecon controlled construction of the pipeline during the entire installation period, on behalf of the client: EWE.
- ECB was responsible for the survey and marking of the route.
- GESO supplied the leak detection system.
- FINKE, specialists in long length pipe transport, transported the pipes from the various off loading locations to the actual installation site.
- TÜV from Munich (Germany) reviewed all calculations, material specifications and procedures. A TÜV representative supervised the entire installation, in collaboration with NOV Fiber Glass Systems B.V. field service engineers and the NOV Fiber Glass Systems B.V. related material manager.

There were many companies involved in this project:

- NOV Fiber Glass Systems B.V. was chosen as pipe supplier and is also responsible for the installation.
- Kusimex GmbH, NOV Fiber Glass Systems' representative for Germany, proved to be an important intermediary during the preparation and execution stages of this project. The Germany based contractor Bohlen & Doyen was selected as contractor.
- Bohlen & Doyen is a Wiesmoor (North West Germany) based company experienced with large pipe line installation projects.

EWE selected Bondstrand pipe and fittings due to the corrosive nature of the fluid and the following considerations:

- Select higher alloyed steel (e.g. 13CR, Duplex)
- Glassfiber Reinforced Epoxy (GRE)
- Thermoplastic lined carbon steel

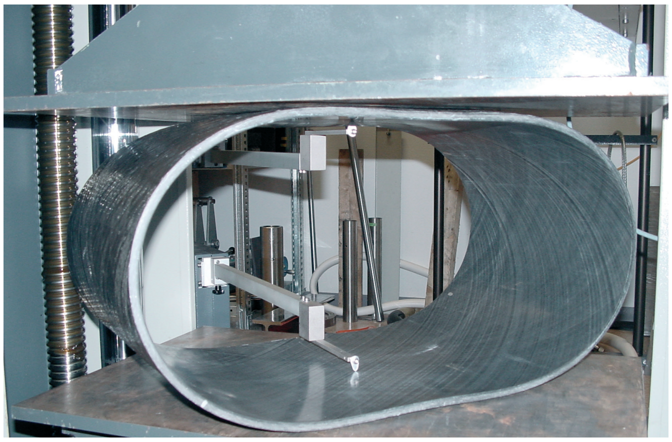
One of the largest advantages of GRE pipe is that it is corrosion resistant to a wide range of fluids and chemicals.

***Table 1**. Overview project requirement EWE versus tailor made solution.*

Advantages	Disadvantages
• Light weight (density 15% till 25% of steel) • Corrosion resistant • Reduced pump cost, internal roughness of the pipe does not change over time • Durable (fatigue resistant) Above statements are valid in general.	• Damage susceptible • Limited range in pressure ratings/diamters (although continually improving) • Limited temperature range (<120°C).

When focusing on the EWE project, the following project requirements can be extracted.

Requirement	Value
Design pressure:	20 bar
Diameter:	18”
Temperature range:	2-60 °C
Medium:	Water + 300 kg salt/m^3
Lifetime:	20 years
Environment:	For environmental reasons, no leakage permitted nor regular maintenance is allowed.
Solution:	• Optimized wall thickness for this application, approved by TÜV, 7.3 mm structural wall and a liner of 0.5 mm. This pipe can be custom-made because of the winding techniques. This is possible for applications in general. • An adhesive bonded joint (Taper/Taper) for maximum integrity for the pressure of 20 bar and insurance for zero leakage and leak tight performance. • Corrosion and temperature is not an issue of any importance for GRE pipe in this case. Internal roughness of the pipe will not be affected. The inner surface of the pipe will remain smooth over time. This has a positive impact on the pipe flow, less turbulence and less friction. These properties are by far superior when compared to steel.



Before technical approval could be obtained from TUV, external loading capacity testing was performed:

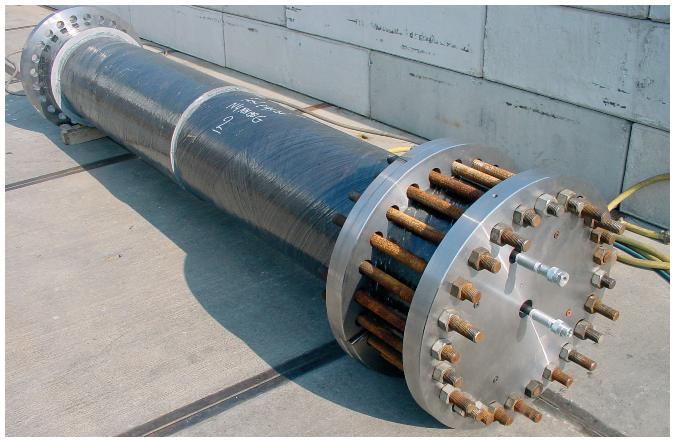
To determine the influence of a wheel load on the pipe, a calculation should first be made. In this calculation the value of the pipe stiffness is important. Therefore an ASTM D-2412-87 test was executed on three samples of 18” pipe sections to determine this value.

In order to understand the wording in the tables a brief explanation of the build-up of the pipe is provided Figure 2. Results of the test performed at TNO-industry, are shown in Table 2. The calculated values by TÜV are shown in Table 3.

Table 2: *Stiffness test results TNO*

Test acc. ASTM D-2412-87		Specimen number		
		1	2	3
Average diameter d_i	[mm]	434	434	434
Average wall thickness s_w	[mm]	7.9	8.0	7.9
Specimen length l	[mm]	298	298	298
Specimen weight	[g]	6440	6444	6430
PS as received				
5% deflection (Δy = 21.7 mm)	[kPa]	619	610	610
10% deflection (Δy = 43.4 mm)	[kPa]	564	558	559

Because the above values could not be used as presented in the ATV calculation, the E-modulus was calculated on basis of these test by TÜV acc. DIN 53769 T3. Using DIN 16869 T2 the “Nennsteifigkeit” is determined to be >SN10000.



Hydraulic design verification was conducted to prove that the configuration as proposed by NOV Fiber Glass Systems B.V. is suitable for this project. It is widely accepted to perform a 1000 hour test according to ASTM D-1598 (20 bar design pressure). This test is conducted at 66°C and at a pressure of 2.5 times design pressure with water as the medium. Photo 4 and Figure 3 show the specimens, including the Taper/Taper adhesive-bonded joint. The entire configuration was tested at Becetel in Belgium. The configurations tested were: pipe with Taper/Taper joint and a pipe spool including elbow and reducing Tee.

Based on the above tests, review of calculations, material specifications, test and inspection plan and procedures, TÜV could give the ‘go ahead’.

Table 3: *Stiffness calculations TÜV*

Specimen	Stiffness acc. Din 53769 T3 [N/mm²]	E-modulus acc. Din 53769 T3 [N/mm²]	Nennsteifigkeit acc. Din 16869 T2
1	0.0901	22794	SN10000
2	0.0940	23785	SN10000
3	0.0979	24776	SN10000

Based on these tests, the pipe was accepted for this application.

During the installation, a TUV representative checked NOV Fiber Glass Systems B.V. procedures to assure the layout, trenching and backfilling were completed properly. TUV also witnessed hydro testing of the line.

NOV Fiber Glass Systems B.V. checked bonding procedures, handling of the pipe, trenching (sand bedding, curvatures, elevations, backfilling, and hydro testing. An important issue related to the bonding procedure is that a pipe fitter also takes care of the traceability of the joint. This was checked by TUV.

The items for traceability are as follows:

- During curing, registration of temperature and heating up of blanket;
- Starting time of the cure;
- Pipe fitter number;
- Batch number. Adhesive/ heating blanket number;
- Measured temperature;
- Temperature surrounding;
- Date;
- End time of the curing.

It took several years to establish routing of the pipeline. Permission had to be obtained from many landowners to cross their property as the pipeline runs over several rural areas. The permissions involved church yards, railroad companies, and local communities. When possible the pipeline routing followed the borders of the properties. Since most properties are rectangle, it wasn't always possible and the flexibility of the pipe allowed directional changes.

The directional changes required the use of more than 250 elbows, which many were custom made (mitered) pushing manufacturing to the limit to produce these on time.

Due to the terrain, many elevation changes were involved. Without the use of special techniques, it would be impossible to drain the line in case of an emergency. To accommodate a potential emergency situation, vent valves were installed at high points and drain valves at low points.

Each of the 114 vents and drain valves were installed in a concrete pit. In addition to the 2" and 4" vent and drain valves, a total of five remote controlled isolation valves (18" gate valves) were installed.

The flexibility of the pipe overcame elevation changes. To reduce the number of the costly "high and deep points," the trenches were dug in such a way that there was always a minimum slope. Slopes of 1 cm per joint (12 meters) were realized with the aid of laser-guided excavators. This approach of trench preparation often resulted in trench depths of more than 5 meters.

Natural and man-made obstacles such as rivers, ditches and roads were crossed by means of thrust-boring techniques. Steel casing was not required for all crossings. Bondstrand pipe was directly pushed/pulled through the borings when casing was not required. When steel casing was required, the Bondstrand pipe was inserted into the steel casing then the casing was pushed through the bore hole, avoiding hidden rocks and sharp objects.

Much effort was required to cross the Muhlenflies and the Sophienflies streams. Areas next to the streams were very swampy and had to be drained, requiring special drain techniques, to dig the trench and install the crossing pipe sections

Two biologists surveyed the pipeline routing prior to activities beginning and the monitored all activities during construction. A 1.5 km right of way was cleared through forest and the trees were covered with protective material. Thrust boring was used in sensitive areas and biodegradable hydraulic oil was used in equipment and all types of waste were disposed of properly.

A battleground where the Soviet Union army fought to take Berlin in the last days of World War II was the area in which the pipeline was installed. Before excavation work could begin, the route was checked for live ammunition to ensure a safe installation. Several pieces of World War II scrap were found.

This area is known for archaeological findings of historical interest. It was necessary to examine the known sites to avoid destroying any relic of historical value prior to beginning installation work. A large prehistoric settlement was found that was over 400 meters in length. Many remains of building and fireplaces were found including a nearly finished and polished stone axe.

Part of the route survey was to map groundwater levels. Before trench excavation started, a small hole was dug every 100 meters to determine if groundwater was present at a depth of 1.8 meters. Despite these surveys, groundwater was found in unexpected locations and even on hilltops. To fight the water, additional measures had to be taken to manage the water by means of pumps and drainage tubing. At times over 40 diesel powered pump units were in use, divided over several locations.

Over the entire route the soil contained large amounts of stones ranging from the size of an egg to the size of a minivan. The risk of damage by falling stones and the fact the trench could not be left open for a long period of time in an inhabited area, demanded the trenches be closed immediately after the pipe was lowered into the trench.

Self-propelled screening plants had to be hired to produce the first layer of clean backfill material. Despite these actions, several impact damages due to falling stones had to be repaired.

The pipe was transported by truck from the factory in Holland to the off-load areas near the job site. Each truck could haul 25 pipe per trip. A total of 4700 pipe were transported by 188 truckloads.

Upon arrival, a German company named FINKE unloaded the pipe. This company specializes in pipe transport and handling by using a four-axle, all terrain truck equipped with a vacuum device to lift the pipe. The pipe were picked up with a large saddle that was vacuumized, holding the pipe with the assistance of one person. FINKE was able to unload five truckloads of 25 pipe per day. They transported and strung the pipe on site with one truck and a two-man crew, with one person handling the wooden sleepers.

The final route was first clearly marked by the surveyors. Next, the fertile top layer was removed over the full width of the right of way and stored separately.

Three installation crews were active. The first crew made double pipe joints. The second crew then followed bonding the remaining joints and creating a pipe string of 1000 meter.

The third crew, after trenching, installed the leak detection cable in the sand bed at the bottom of the trench and covered with about an inch of sand. Then the pipe string was lowered by means of three excavators equipped with cradles.

A pipe line padder first backfilled the trench at the sides of the pipe. This first part of the backfill was compacted with a hydraulic driven compactor attached to an excavator. Before continuation of the backfill, a 2 inch polyethylene pipe with communication cable was laid next to the GRE pipeline followed by the final backfill.

Bohlen & Doyen, the contractor, was a reliable partner, working closely with NOV Fiber Glass Systems B.V. and other companies involved.

There were many lessons learned by overcoming obstacles:

- A mix of the correct people,
- Proper equipment for the installation,
- Reliable bonded joints,
- Maintaining installation speed in adverse weather and terrain conditions.

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