Blue Stream

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SAIPEM


7000

Blue Stream


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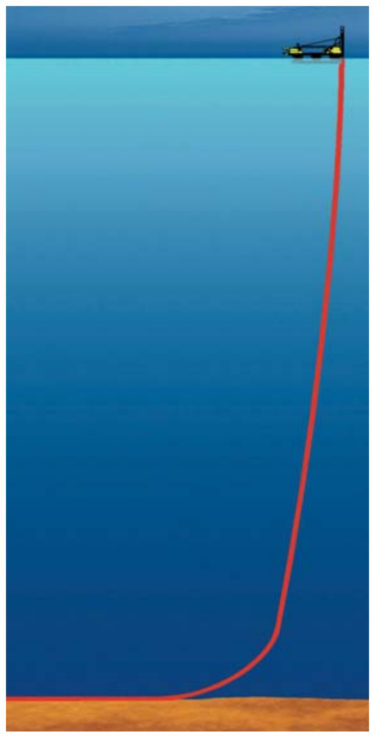
Blue Stream

As the international gas sector expands to ever deeper waters for production and international export, Saipem has built on the success of the Hoover Diana project and reached a major milestone in its successful completion of the Blue Stream project. Providing a conduit for export of Russian gas direct to Turkey, execution of the Blue Stream project is viewed as a major political achievement, in addition to the well-documented technological achievements emanating from it. Using Saipem's SSCV S7000, in tandem with the DLV Castoro Otto, installation of twin 24-inch diameter pipelines crossing the Black Sea between Russia and Turkey at a water depth in excess of 2150 metres is the most significant and challenging deep water pipeline project ever completed.



PROJECT CONCEPTION & IMPLEMENTATION

Award of the Blue Stream project to Saipem was preceded by more than one year of intensive technical feasibility evaluation of the Client's proposed scheme.
Having confirmed that it was possible for a pipeline system to be installed across the Black Sea, and having demonstrated to the Client Saipem's capability for performing such a task, the basic and detail design phases of the project were awarded to, and performed by, Saipem within an EPCI environment.
Performing the work in this manner ensures rigid control of all quality aspects of the project, from procurement and production of linepipe, through transportation, fabrication and installation to eventual commissioning and handover to the Client.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SCOPE OF WORK

Saipem was hired by BSPC (Blue Stream Pipeline Company, a partnership between Gazprom, the Russian National Hydrocarbon Company, and Snam of the ENI Group) as General Contractor for the compressor facilities in Beregovaya, and for the Black Sea crossing. The offshore part of the project was installed by Saipem, and the onshore compressor station was built by Bouygues Offshore, now part of the Saipem group following its acquisition in October 2002.

Det Norske Veritas was the Project Certifying Party that reviewed and verified the Blue Stream Pipeline Project for certification purposes.

Saipem's scope of work for the project consisted of the design, detailed engineering, management, procurement, construction, installation, testing, dewatering and drying of the following:

- Russian Onshore Section: 2 no. 24" OD, 31.8mm thick pipelines between the ESD Valves and the Russian LTE (ESD Valves excluded).
- Submarine Pipelines: 2 no. 24" OD, 31.8mm thick pipelines between the Russian and Turkish LTE's.
- Turkish Onshore Section: 2 no. 24" OD, 31.8mm thick pipelines between the Turkish LTE and the ESD Valve (ESD Valves excluded).

The two pipelines were installed parallel to each other at a nominal separation distance of between 5 and 100 metres, except along the Russian continental slope where two different routes were selected.

The two pipeline routes were termed Route W2 (the westward route) and Route E1 (the eastward route).

Their lengths are about 389km and 382km respectively.

The lengths of the onshore pipelines are about 1200m and 480m onshore from the Russian and Turkish landfall points respectively up to the ESD valves.

Installation of the two submarine pipeline sections involved shore approach works at the Russian and Turkish landfalls, and laying of the pipelines across the Black Sea.

The shore approach (or landfall pipeline installation) works were preceded by pre-trenching activities.

Pre-trenches were excavated between the beach and approximately 10m water depth on both the Russian and Turkish sides. Trenching work was carried out using a combination of onshore excavators and sea-going dredging equipment. For shallow water installation, standard pipe joints of 12.2m length were used. Some of the pipe joints used for the shore pull (for the shore approach works) are also weight coated with 45mm thick concrete.

The deep water sections, up to more than 2150m WD, were installed using the J-lay method (S7000), whilst the shallow water sections, up to more than 380m, were installed using the conventional S-lay method (Castoro Otto). The S7000 J-lay system utilises pipe strings of 48.8m average length (called quadruple joints or quadjoints). Four no. 12.2m long standard pipe joints are welded together to form the quadjoint. Pipe carrier vessels transported the quadjoints from the onshore base to the vessel. The quadjoints were first stacked in a container near the quay. The container was then loaded aboard the vessel.


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LOGISTICS AND COMPLEXITY OF THE CONTRACT

In addition to the geotechnical, geomorphological and bathymetric characteristics of the regions to be traversed by the pipelines, i.e. ultra deep water, H2S environment, steepness of subsea slopes and geohazard risks, the magnitude of the Blue Stream project necessitated procurement and fabrication of items from many countries worldwide. This raised many interface and logistics issues.

Quadruple Joints

A purpose-built Quadruple Joint (QJ) fabrication plant, occupying 90,000 sq.m, was constructed adjacent to Industrial Quay, in the Commercial Port of Samsun in Turkey. Location of the plant close to the Commercial Port and Industrial Quay facilitated the logistics operations that the base provided for the receipt, storage, transportation and loadout of single joint linepipe, insulating joints, combi-joints, anodes, anchor flanges and QJ's. Fabrication and loadout of 14,557 quad joints was performed at the plant. As well as the 43,671 girth welds and associated field joint coating, 8673 anodes were installed.

Linepipe & Buckle Arrestor Supply and Coating

A major element of the project was the procurement of linepipe and buckle

arrestors associated transportation and coating, involving sub-contractors based in Japan, UK and Malaysia.

Due to the large quantity of SAWL I 448 SF grade linepipe and buckle arrestors (more than 800km of 24" linepipe and 17km of 652mm OD x 52.7mm WT buckle arrestors) required for the project, and in order to ensure delivery of high quality finished articles within the critical schedule deadlines, it was necessary to procure linepipe from both Japan and the UK. A Japanese Consortium of Nippon Steel Corporation, Sumitomo Metal Industries, NKK and the Kawasaki Steel Corporation supplied a total of 690km of linepipe from Japan, whilst Corus UK supplied 89km of 5km of concrete-coated linepipe from UK.

Buckle arrestor manufacture was awarded to the Japanese Consortium and Marubeni UK, both of whom passed the manufacture to the Japanese mills of NKK and OTK.

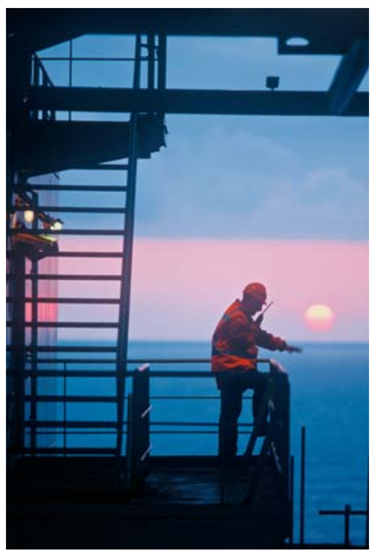
Linepipe produced by the Japanese Consortium was coated (both internally and externally) by Bredero Price and PPSC Industries at Kuantan in Malaysia, and by Bredero Price at Leith in Scotland.

Linepipe produced by Corus UK was coated by BSR Pipeline Services in Hartlepool, England, and at Price Coaters Ltd of Leith in Scotland for concrete coating.

Miscellaneous Items

In addition to linepipe and buckle arrestors, the following miscellaneous items were also supplied from various locations:

- 20 no. 7D Bends – mother pipe from Germany, Belgium for bending, and UK for coating;
- 6 no. Insulating Joints – forging and manufacture in Italy;
- 6 no. Anchor Flanges – forging and manufacture in Italy;
- 10,438 no. Offshore Bracelet Anodes – 5,662 half shells from UK, 15,032 half shells from Singapore;
- 71 no. overweight concrete mattresses – manufactured in UK;
- 2 no. HDPE pipeline crossing supports – raw materials from Finland, fabrication in UK;
- 20 no. cable crossing concrete mattresses – manufactured in UK.

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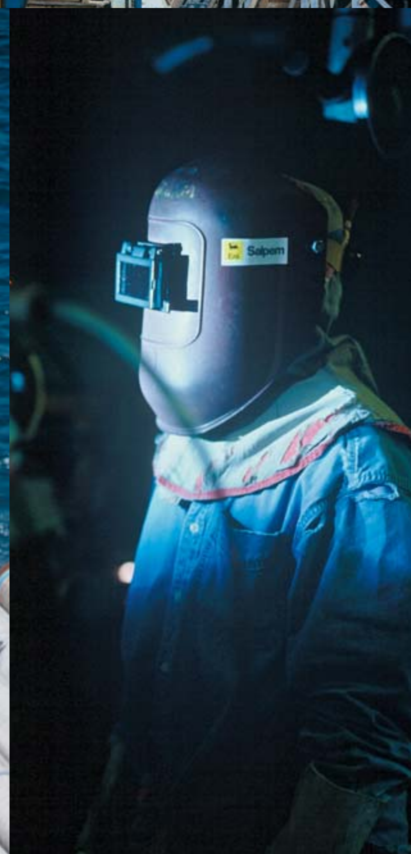
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Testing & Qualification

Testing of materials was performed both in-situ and under simulated laboratory conditions. As an example, considerable laboratory tests were performed prior to selection of the anode material.

Following completion of the design, and prior to commencement of fabrication activities, an exhaustive series of Pre-Production Tests (PPT) and Procedure Qualification Tests (PQT) were performed, as necessary, to ensure that all the procedures adopted guaranteed that the technical requirements defined during the detailed design were maintained.

Qualification Tests

Qualification tests were performed on the following equipment, systems and vessels:

- Welding and Automatic Ultrasonic Testing (AUT)
- Field Joint Coating (FJC) and Field Coating Repair (FCR)
- Quadjoint fabrication plant (Samsun Base)
- Anode Installation System
- Post Trenching Machine
- Wet Buckle Recovery System (WBRS)
- J-lay vessel (S-7000) and associated equipment
- Stress monitoring equipment (DP Pipe)
- Topas System
- Micro Wave Buckle Detector (MWBD)
- Emergency Recovery System (ERS)
- Reverse Stinger (RS)
- S-lay vessel (Castoro Otto) and associated equipment

Welding and NDT

When pipelaying in J-lay mode, quadjoints are welded into the pipeline in the J-lay tower. Saipem developed and tested, in-house, a new welding method consisting of a purpose-made welding system comprising 3 no. Presto Twin Torch Welding Units mounted on a purpose made rotating platform (carousel). While the core elements of the welding system have been used extensively in the past, (PRESTO is based on the well known PASSO system and both have been used on numerous pipelines in S-lay mode), the system proposed for Blue Stream contained some previously unused features.

In accordance with DNV requirements, the new welding system had to be qualified prior to use. This was achieved by performing a number of sea trials.


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The sea trials were divided into two phases. In the first phase Saipem set up the various S7000 systems and conducted in-house trials with straightforward J-lay with tower angle set 7° from vertical. The second phase was conducted in the presence of the Client, BSPC and DNV, the Certifying Authority. During the second phase, J-lay was performed with tower angles set at 20°, 10° and 7° from vertical. Both trial phases were concluded successfully.

Stress Monitoring

Special equipment was specifically developed by Saipem to ensure that pipelaying was performed in compliance with the requirements of the DNV

design code, especially in terms of stress monitoring. The J-lay system was implemented on the basis of the experience gained on the Hoover Diana project in the Gulf of Mexico. Special attention was paid to safety aspects during laying in terms of personnel and pipeline integrity. Consequently, a number of HAZOP, FMEA and "What-if" analyses were performed.

New equipment was designed and installed onboard S7000, such as a reverse stinger and new rollers c/w load monitoring instrumentation. Stress monitoring was performed using conventional methods such as top tension and touch down point monitoring. Additional equipment was developed to complement these conventional methods, and was qualified for future purposes via a number of sea trials performed in Norway during 2000 - 2001.

A microwave buckle detector was developed, built and installed on S7000 to detect buckles during laying so as to avoid the use of a conventional cable-pulled buckle detector in such deep water. An acoustic system was also developed and installed to monitor the pipeline catenary during laying.

This complemented the purpose-developed stress monitoring software capable of assimilating data from several systems and presenting it in graphical form on the vessel bridge.

A remote controlled robot was also designed and built for emergency recovery of any dropped object in the pipeline. The robot can be launched into the pipeline from within the vessel J-lay tower.

Coatings

A three layer polypropylene coating consisting of a first layer of fusion bonded epoxy, a second layer of polypropylene adhesive and an outer layer of polypropylene was selected as anti-corrosion coating of the Blue Stream pipelines. The selection was the result of extensive testing performed during the feasibility study in the aggressive environment of the Black Sea containing H2S.

The application technology was not sufficiently developed at the time, and the existing international codes did not completely cover the Blue Stream requirements.

An extensive qualification program was therefore undertaken involving several potential Subcontractors to qualify materials and application processes. The processes had to be adapted to the following operating scenarios:

- field joint coating during laying in deep waters performed by S7000,
- field joint coating during laying in shallow waters performed by Castoro Otto,
- field joint coating during fabrication of the quadruple joints performed at Samsun base,


POLAR PRINCE

- field joint coating for the onshore sections of the pipelines in Russia and in Turkey.

The process for the field joint coating activities onboard S7000 and in Samsun was based on the application of the outer layer by means of polypropylene injected in a mould closed around the field joint. The process for the field joint coating onboard Castoro Otto was based on the application of a polypropylene film as outer layer. Both processes were fully computer-controlled.

Great effort was spent to ensure quality during production since it was not possible to perform destructive tests during production. This was achieved by an extensive qualification program, where the number and ranges of the process parameters governing the field joint coating quality were identified. During production, computer control ensured that the process parameters were kept within range. A special plant was installed for this purpose in Samsun, whilst dedicated machines were installed onboard the laying vessels. Field joint coating for the onshore sections of the pipelines was based on the application of polypropylene heat shrinkable sleeves.

Wet Buckle Recovery System (WBRS)

Although highly unlikely, Saipem has developed a diverless WBRS specifically as a contingency for deep water repair of a wet buckle during J-lay operations. The WBRS comprises the following main components:

- H-Frame,
- Pipe Cutting Tool,
- Lifting Clamps,
- Pipeline Recovery Head Insertion Tool (PRHIT),
- Buoys and clump weights.

The system has been tested and approved, and is deployed from a DSV under ROV guidance.

OPERATIONS

Installation operations commenced with trench excavation at the Russian side (up to 10m water depth) followed by trench excavation at the Turkish side (up to 10m water depth).

The works were performed by SIDRA using a Cutter Suction Dredger, floating pipeline and outlet spreader pontoon. Castoro Otto, without stinger, commenced shore pulling at the Russian side. Line W2 was pulled ashore first, followed by normal laying and abandonment at 22m water depth, then Line E1 was pulled ashore followed by normal laying and abandonment at 22m water depth. Both lines were pulled ashore via a 300 tonne capacity return sheave installed on the beach.

The stinger was then attached to Castoro Otto, which recovered and laid Line W2 up to 382m WD, then recovered Line E1 and laid up to 355m WD. Castoro Otto then proceeded to the Turkish side, where a trench had been prepared, and a linear winch installed on the beach for shore pulling of the pipelines from Castoro Otto. Line E1 was pulled first followed by normal laying and abandonment in 12m water depth, then Line W2 was pulled, followed by normal laying and abandonment in 33m water depth. Castoro Otto then recovered and laid Line E1 up to 33m WD and demobilised from the field.

S7000 was then mobilised to the field via the Bosphorus Strait.

The A-frames of the cranes on


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board had to be lowered during passage through the Strait to avoid contact with the various bridges and high voltage cables traversing the route.

In addition to conventional pipelaying requirements, detailed engineering activities identified specific requirements concerning certain aspects of pipelaying activities along the route.

These particular requirements were:

- Limitations to applied tensions during pipelay,
- Restrictions to pipelay tolerances,
- Touchdown point monitoring to avoid boulders,
- Assessment of free spans detected during pipelay.

Very specific procedures had to be produced in order to overcome these imposed conditions.

S7000 commenced installation activities by recovering Line W2 abandoned in 382m water depth on the Russian slope and laying towards Turkey.

Line W2 was abandoned in approximately 155m water depth on the Turkish shelf.

S7000 then returned to the Russian side, recovered line E1 abandoned in 355m water depth on the Russian slope, and started deepwater laying towards Turkey.

During laying of Line E1 by S7000, Castoro Otto was re-mobilised on the Turkish side, recovered Line W2 abandoned by S7000 in approximately 155m water depth, and laid towards the Turkish shore up to 33.5m water depth, abandoning the pipeline in readiness for the above water tie-in.

Following completion of the above water tie-in of Line W2, Castoro Otto was again demobilised. Flooding, pigging and testing of Line W2 was then performed.

Following completion of deep water installation of Line E1 in the same manner as Line W2, S7000 was demobilised.

Castoro Otto was then re-mobilised and completed laying of Line E1 in shallow water followed by the above water tie-in in the same manner as that for Line W2.

Flooding, pigging and testing of the Line E1 was then performed.

Flooding and pigging was performed from the Russian side.

In addition to the conventional hydrotesting spread, a contingency flooding and de-watering station was also set up to cover any contingency situation arising during installation activities.

A number of surveys were performed by the Akademick Golitsyn survey vessel prior to, during, and after installation activities to assess seabed and pipeline conditions.

The vessel was equipped with 1 no. Innovator ROV (3500m rating) and surface and underwater positioning systems.

ROV AND SUBSEA OPERATIONS

DP DSV Polar Prince, with two Innovator work-class ROV's on board, was used for essential intervention works, survey (when required) and any required repair works. Main works performed by Polar Prince on the Blue Stream project were as follows:

- ITUR West Crossing installation,
- BSFOCS West Crossing installation,
- BSFOCS East Crossing installation,
- Installation of Topas Reflectors,
- ITUR East Crossing installation,
- Offshore verification operations for Beluga trenching machine,
- Free span intervention works W2 pipeline,
- Overweight mattresses installation,
- S7000 J-lay Support E1 Critical lay (Russian slope),
- Provide support to S7000 as required during deep water lay operations,
- Above-water tie-in surveys.

Post-trenching intervention works were performed using the Beluga post-lay trenching machine.

This machine was specifically upgraded for the Blue Stream project mainly to cope with the extreme water depths, steep subsea slopes and trench depths up to 5m.

S7000 also has 2 no. dedicated Innovator ROV's onboard enabling continuous touchdown monitoring operations.


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