Case Study: Bluestream pipeline project, “wet-buckle” contingency and precommissioning services for dual 24 inch 239 mile (382km) pipelines in 7,035 feet (2,144m) water

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Introduction, Project Details and Challenges/Solutions:

Introduction:

During recent years, technology has allowed the exploitation of oil and gas reserves in increasingly deeper waters. In addition to floating production facilities and tanker transportation, pipeline construction companies have also developed their services to facilitate pipeline transportation of oil and gas reserves from deepwater installations. As a result, some construction companies have been required to obtain a real time solution for a "wet-buckle" scenario. In an ideal world, construction of offshore pipelines should be completed without any incidents. However, in the real world, and for a variety of reasons, sections of a pipeline can sometimes become damaged or even flooded during the laying process. Such an occurrence of unplanned flooding of the pipeline is known as "wet-buckling". Since a pipeline is most likely to buckle during deepwater installation, it is important to have detection and correction methods in place at this stage. While few deepwater projects ultimately require a "wet-buckle" contingency during pipe lay, construction companies agree on the benefits of providing it as an insurance. If any buckling escapes detection during the installation, and is only discovered post installation, then the costs to correct the situation can be huge.

Figure 1: Bluestream route

Project Details:

The Black Sea project known as "Bluestream" comprised the world's deepest natural gas pipelines running 239 miles (385km) from Dzhubga, Russia, to Samsun, Turkey (Fig. 1). The dual 24 inch diameter gas lines lie in water depths of up to 7,035 feet (2,150m) with line pressures of up to 3,675psi (250bar). Installing the pipelines in these water depths posed a serious risk of "wet-buckling", so a contingency was specified at all times during installation. Weatherford's proposal in the case of a "wet-buckle" was to provide sufficient compressed air capacity onsite and on demand to be able to displace water out of any flooded pipe spools, enabling them to be retrieved. Central to this proposal was the use of the same compression spread for dewatering and drying activities during precommissioning of the pipelines.

Challenges/Solutions:

After the initial discussions with the client, Saipem, about the compression station, Weatherford's next step was to present a firm technical case. While some elements of the station had been used before on an individual basis, to assemble it into one Temporary Air Compression Station (TACS^{SM}) presented a unique challenge. Other demands on the proposal included budget guarantees, the promise of no downtime (and provision of total-

Figure 2: Main compressor unit

Challenges/Solutions:

redundancy), the training and employment of local personnel, and the mobilisation and installation of equipment within six months of contract award.

The solution ultimately selected by the client involved the construction of a fully stand alone compression station comprising 78 major components, requiring approximately 40% less space than conventional compressor units. These components consisted of 58 main combination compressors (Fig. 2), four feed compressors, eight high volume air dryers capable of dew points in excess of -76°F (-60°C), and eight boosters (Fig. 3). Each Weatherford engineered combination compressor unit consists of a rotary screw compressor and horizontal reciprocating compressor, each one capable of delivering 1,150scf/m (33 m^3/min) at 2,000psig (138barg). The entire station generates a total horsepower of 52,500bhp (39,400kW) on location. The eight high pressure boosters are designed around a two stage horizontal reciprocating compressor and provide an additional stage of compression to meet the 3,625psig (250barg) final discharge pressure. This overall design proved to be the answer for Saipem's requirement of maximising fuel efficiency and minimising footprint. The key milestone was to function test the TACS^{SM} on location and secure the client's acceptance. At the time of contract award, Weatherford had the design of the main combination compressor, but did not retain sufficient quantities to resource the project.

Figure 3: High pressure booster

The massive task of designing and building all the main compressor units, feed compressors, dryers, boosters, oil filtration units and auxiliary components had to commence without delay. Given the time constraints, it became quickly apparent that a dedicated experienced engineering team would be required to complete the design. SRC Engineers based in Lafayette (LA), were commissioned to design the station and ensure that not only would the components operate individually, but also that all the station components would operate as a synergised unit to produce the required flow rates and pressures. After discussion with a number of the fabrication companies, it was also apparent that not one company was able to produce all of the compressors alone, and so a number of contracts were awarded to produce the total quantity of compressors required to a common design specification.

In addition to the fabrication challenge described above, mobilisation of the vast amount of equipment from Houston to the Black Sea also posed a huge challenge. This required 150 containers, including 15 X 40 foot containers full of spares packed for every eventuality. Since the 58 main compressors were designed to meet the same specifications as a 20 foot sea container, it was easy to stack them on the vessel. Actually getting all the equipment into Russia proved to be very time consuming because every single piece of equipment, regardless of size or function, required a special permit and a passport, in order to enter and operate within Russian borders. With site preparation complete, transfer of the equipment from Novorossiysk, the port of arrival, to site also proved problematic. The single, steep, access road was also used by the construction companies installing the permanent gas compression station. This resulted in partial availability of the road during certain hours making transportation of the equipment a painful and frustrating process. Eventually, installation of the station was sufficiently advanced to commence the function testing.

Challenges/Solutions:

This was the first time the components had been operated as a station and although it became apparent that the dryers were unable to handle the total flow required, the TACS[SM] became operational and the key milestone had been met. Additional dryers were then quickly manufactured and mobilised to supplement the *TACS* for the precommissioning operations.

During both the installation and function testing, the site's location revealed new problems. Its remoteness meant that finding food and housing for the 30-40 personnel was not easy, and sourcing proper fuel (Fig. 4) to run the station was another project in itself. Requiring 55,000 gallons (208,000-liters) of fuel per day, and in a very remote, undeveloped area, the *TACS* required constant and intensive monitoring, and no downtime. When the purchase of local diesel fuel (during peak season) was finally negotiated, the team had to work with local refineries to ensure quality levels, and still had to filter it many times before use. Additives also had to be brought in from the USA to prevent the fuel from gelling during the cold operational months.

As a final test of the strength of the *TACS* and the will of the team, extremes of weather hit the remote site over the 18 month project period. Temperatures varied from –15°F (-26°C) onshore in the winter to 105°F (40°C) in the summer. A massive ice storm with hurricane force winds paralysed the region for about three weeks. With its own power generation, the station was not badly affected, although it took the team days to chip ice off much of the equipment (Fig. 5).

It took the Saipem 7000 about three to four months to J-lay each line, during which time the station was on full alert standby and ready to operate within 72 hours of a "wet-buckle" incident. During the standby periods there were six operations personnel on location everyday to maintain and run individual units every other day. During this pipe lay period, the site received two call outs for contingencies, both requiring the use of the station. In the case of an incident occurring, the onsite operations team was notified by the client, and an action plan formulated.

During the second call out, the entire team was mobilised within 24 hours, and 12 Russian team members already located on site, for maintenance duties purposes, were fortunately able to act immediately, providing instant cover. Since the entire station was tied into the programmable logic controller (PLC), the 12 men were able to operate the station safely and successfully for the first 24 hours until the remainder of the standby team arrived to take over.

Each phase of the project was different and required a change in operations. The dewatering phase took approximately 12 days and required the use of the entire station, along with 34 operations personnel on location for two 12 hour shifts. The drying phase utilised 40% of the main compressors and eight drying units, with the entire system designed to bypass the high pressure boosters and filtration during this phase.

Figure 4: Fuel storage tank

Figure 5: Ice covered equipment

Challenges/Solutions, Results/Benefits and Summary:

Challenges/Solutions:

Using an onsite (PLC) in a main station control room and unit PLCs on individual operating equipment, Weatherford monitored the equipment and provided real time data on engine parameters, injection line temperatures, flows and pressures to assist in the improvement of Saipem's flow modelling program. The station PLC was critical to the operational success of the project both for Weatherford and the client. The main function of the system was to monitor all operating aspects of the station, along with minimising personnel requirements and therefore costs. The information was fed into a main control room, which enabled the operations manager to make quick decisions and communicate directions to the team. This integration of systems information and operations insured no downtime during project operations and provided the client critical data for improving future projects.

Results/Benefits:

Despite never having deployed the TACS℠ as a complete unit before, Weatherford was able to provide Saipem with a dependable and durable compression station for contingency and precommissioning for the Bluestream project. Problems were faced, challenges overcome and the successful completion of the work scope was proof to both Saipem and Weatherford that the *TACS* and its completely self supporting inventory are an effective solution for this type of deepwater pipeline project. Although few deepwater projects ultimately require a "wet-buckle" contingency during pipelay, the benefits of having one in place become obvious compared to the costs incurred to correct the situation post installation.

Summary:

The *TACS* is a unique, mobile facility providing "comfort insurance" for pipelay construction companies operating in deep water where the cost of not retaining an immediate remedial solution for "wet-buckle" occurrence could be huge. It is a proven synergised package that can provide dewatering capability of up to 64,000scf/min (1,800m^3/min) and 3,625psig (250barg) without the uncertainty of operational capability of last minute multi fleet mobilisation. As offshore pipeline developments venture into deeper and deeper waters, the *TACS* and its capabilities and applications will continue to evolve, meeting new technical challenges and requirements.

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