

## **Wet–Buckle Contingency and Pre-Commissioning of Deepwater Pipelines**

Troy Dilzell

Weatherford Pipeline & Specialty  
Services

1101 Winters Ave., Unit C

Grand Junction CO 81501

Tel: 713-693-4000

Email: [troy.dilzell@weatherford.com](mailto:troy.dilzell@weatherford.com)

Ross Coleman

Weatherford Pipeline & Specialty  
Services

Phase 1 Kirkton Drive, Dyce

Aberdeen AB21 0BG, Scotland

Tel: +44 (0)1224 767015

Email:

[ross.coleman@eu.weatherford.com](mailto:ross.coleman@eu.weatherford.com)

Helen O'Connor

Weatherford Pipeline & Specialty Services

Unit 3, Newhailes Industrial Estate

Musselburgh EH21 6SY, Scotland

Tel: +44 (0)131 653 3700

Email: [helen.oconnor@eu.weatherford.com](mailto:helen.oconnor@eu.weatherford.com)

### **Abstract**

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. Moreover, pipeline construction technology has allowed for the length of transmission pipelines to be significantly reduced with the successful navigation of previously un-charted waters. This technology has in many cases been the catalyst for new distribution systems and markets previously considered unviable.

As part of the development programme for deepwater pipelines, construction companies were forced to consider the 'wet-buckle' scenario and pipeline pre-commissioning operations for gas transportation pipelines. It was recognized that in the event of water entering large diameter pipelines as an unplanned event in deepwater (wet-buckling), then significant construction delays and costs would be incurred. In addition, it was identified that the facilities required to provide a wet-

buckle contingency could also be allocated to the pipeline pre-commissioning operations required prior to the introduction of hydrocarbons.

This paper explores some of the challenges encountered by Weatherford's Pipeline & Specialty Services in deepwater pipeline pre-commissioning operations. In particular, this paper considers the purpose built, Temporary Air Compression Station (TACS) used for wet-buckle contingency and pipeline pre-commissioning operations of twin 24" pipelines running under the Black Sea. The continued application of the air compression station is also reviewed.

### **Nomenclature**

BSP	Blue Stream Project
PLC	Programmable Logic Controller
TACS	Temporary Air Compression Station

### **Introduction**

In an ideal world, all dry offshore pipelay operations would run smoothly, with no incidents of pipeline flooding. However, in the real world, and for a variety of reasons, sections of pipeline can sometimes become damaged or even flooded during pipelay. The most significant 'unplanned' flooding occurrence 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. Whilst few deepwater projects ultimately require wet-buckle "contingency" during pipelay, 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 [1].

Once pipeline installation is complete, then pre-commissioning activities will follow. For deepwater gas lines, this will include the statutory hydrostatic testing to prove the integrity of the line, plus dewatering, cleaning, drying and nitrogen purging to make ready the pipeline to accept hydrocarbons. During the dewatering phase or indeed during water evacuation during post wet-buckle recovery, significant additional equipment is required to overcome the hydrostatic heads with deepwater pipelines.

### **The Black Sea Project**

In 1999, Saipem S.p.A. advised Weatherford that it would be looking for a very specific kind of compression spread for a new pipeline project in the Black Sea (Fig. 1). The major design criterion for the station was that it should have as small a footprint as possible and be as fuel efficient to meet the operational specs of 64,000scfm (1800nm<sup>3</sup>/hr), 3,625psig (250 barg), -76°F (-60°C) dewpoint and .001 ppm oil content. (The original reason for this is they wanted to see if they could place the station on a vessel offshore and pump to land, but it became clear very quickly in the design phase that this would be impossible).

Weatherford recognised that its unique Combination compressors design could be easily transferred to pipeline use, and it was from this point that the planning and negotiations began.

The Black Sea project known as “Blue Stream” comprised the world’s deepest natural gas pipelines running 239 mile (385km) from Dzhubga, Russia, to Samsun, Turkey. The dual 24” 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 pipeline 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 on-site 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 pre-commissioning of the pipelines.



**Figure 1: Blue Stream route**

After the initial discussions with Saipem about the compression station, Weatherford’s next step was to present a firm technical case. Whilst some elements of the station had been used before on an individual basis, to assemble it into one Temporary Air Compression Station (TACS) presented a unique challenge. Other demands on the proposal included budget guarantees, the promise of no downtime (and provision of total redundancy), the training and employment of local personnel, and the mobilisation and installation of equipment within six months of contract award.

### **The Temporary Air Compression Station**

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), 4 feed compressors, 8 high volume air dryers capable of dew points in excess of -76°F (-60°C), and 8 boosters (Fig. 3). Each Weatherford-engineered combination compressor unit consists of a rotary screw compressor and horizontal reciprocating compressor, each one capable of delivering 1,150scfm @2,000psig. The entire station generates a total horsepower of 52,500 bhp on location. The 8 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 maximized fuel efficiency and minimized footprint.



**Figure 2: Main compressor unit**



**Figure 3: High pressure booster**

Following award of contract, the key milestone was to function test the TACS 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. The massive task of designing and building all the main compressor units, feed compressors, dryers, boosters, oil filtrations 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 synergized 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.

### **Mobilisation**

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 fifteen 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' 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. 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 became operational and the key milestone had been met. Additional dryers were then quickly manufactured and mobilised to supplement the TACS for the pre-commissioning operations.

### Remote Location

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 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  $-15^{\circ}\text{F}$  ( $-26^{\circ}\text{C}$ ) onshore in the winter to  $105^{\circ}\text{F}$  ( $40^{\circ}\text{C}$ ) in the summer. A massive ice storm with hurricane-force winds paralyzed 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).



Figure 4: Fuel storage tank



Figure 5: Ice-covered equipment

### Operations

It took the *Saipem 7000* about 3-4 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 6 operations personnel on location everyday to maintain and run individual units every other day. During this pipelay 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 mobilized within 24 hours, and twelve Russian team members already located on site on maintenance duties were fortunately able to act immediately, providing instant cover. Since the entire station was tied into the PLC (see below), the twelve 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 utilized 40% of the main compressors and 8 drying units, with the entire system designed to bypass the HP boosters and filtration during this phase.

### **Control and Monitoring of the Station**

Using an on site Programmable Logic Controller (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 minimizing 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.

### **The Mediterranean Project**

Within six months of finishing the Blue Stream Project (BSP), Weatherford re-mobilised the TACS for the same work scope, but for a different project, at a different location (Fig. 6). The 322 mile (518km) Trans-Mediterranean pipeline known as the Libya Gas Transmission System (LGTS) or "Greenstream", runs from Melitah, Libya to Gela, Sicily in water depths exceeding 3,600 feet (1,100 meters), and was constructed by Saipem S.p.A. using the *Castoro Sei*. The new onshore site was Gela, and installation of the TACS from availability of the site to mechanical completeness took only sixteen days (Fig. 7). Having undergone and overcome all possible challenges and problems on site in Russia, the contingency situations and the dewatering and drying of the 32" diameter gas line all ran smoothly.



**Figure 6: Aerial view of Gela site**



**Figure 7: Aerial view of TACS**

The TACS comprised the same 78 major components, plus 18 coalescing and carbon bed oil removal filters (an addition from BSP), flow meters, centralized remote monitoring system, fuel pumping and distribution system and all support facilities (electrical generation, lighting, etc.). The same PLC was used to ensure the smooth running, monitoring and control of the station.

For various reasons, not all of the same personnel could be transferred to the new project. As a result, many key strategic personnel from BSP had to be replaced with other personnel for Greenstream. Unlike the Russian TACS operators, who transferred directly to Gela, the new personnel did not have the luxury of experience from BSP, and had to learn quickly how to manage such a huge project.

During performance of installation and pre-commissioning activities, the site received two call-outs for contingency, both requiring the use of the station. Once the contingency was resolved, Saipem could complete the pre-commissioning operations. The pipeline was then dried up to the required acceptance criterion for pipeline dryness, allowing the pipeline to be finally purged and packed with Nitrogen. Hydrocarbon gas was introduced into the pipeline soon after the commissioning process was completed.

## **Results**

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 pre-commissioning for the Blue Stream project. Problems were faced and 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.

Work on the subsequent Greenstream project has proven the mobility of the TACS. It has improved Weatherford's knowledge and experience of the station, providing greater installation, operational and maintenance know-how. Lessons were learned from the Bluestream project that were implemented in the Gela site.

During certain ambient conditions in the Black Sea site (e.g. hot weather), the 'used' cooling air from some units was being drawn in by adjacent units, resulting in some

cooling difficulties. Consequently the station layout design was changed for Greenstream with the units being spaced further apart to allow access to additional cooling air.

During BSP, although non-recoverable oil injection from the boosters was minimal, consistent removal to the specification of 0.01 ppmw proved difficult using standard coalescing filters. Subsequently, additional carbon absorption filtration towers were added to the Gela site in order to obtain improved results.

### **Conclusions**

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 synergized package that can provide dewatering capability of up to 64,000scf/min (1,800nm<sup>3</sup>/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, so the TACS and its capabilities and applications will continue to evolve, meeting new technical challenges and requirements.

### **Acknowledgements**

Saipem S.p.A.  
SRC Engineers

### **References**

[1] Venas, Asle and Collberg, Leif. *Damned if we do, damned if we don't – A paper about buckle detection during deepwater pipeline installation*. OPT04, Feb Amsterdam.