OPERATIONAL PIPELINE PIGGING—CONGO RIVER CROSSING (CRX) PRE-COMMISSIONING

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Abstract
The Congo River crossing (CRX) pipeline system was built to bring associated gases from various fields to a liquefied natural gas (LNG) processing plant in Soyo, Angola. The pipeline system runs a distance of approximately 140 km from the processing plant to the South Nemba platform located offshore Cabinda via two satellite pigging platforms [north pigging platform (NPP) and south pigging platform (SPP)], which provide the location for a drilled conduit that crosses the Congo River.

The pipeline system comprises four segments (A, B, C, and W), running from the South Nemba platform to the Angola LNG (ALNG) terminal in Soyo.

A service company was contracted to perform pre-commissioning services on each segment independently (flood, clean, gauge, caliper survey, hydrotest) before the close-in spools and subsea structures were installed.

Once all segments were completed and tied in, a global leak test was conducted before commencing dewatering operations. Each segment was bulk dewatered followed by final dewatering and vacuum drying before being packed with nitrogen in preparation for first gas.

During the various campaigns, each segment experienced incidents/problems, ranging from stuck centraliser tools, leaking hot stabs, vessel delays, etc., resulting in major delays to the overall project. The pre-commissioning work was successfully completed in early 2016.

Introduction and Field Overview
The operator, an affiliate of a major exploration and production company, is responsible for transporting gas from Blocks 0 and 14 located north of the Congo River to the LNG plant. Gas from Blocks 0 and 14 is gathered at the South Nemba and Sanha auxiliary platforms and then exported via the CRX pipeline to the LNG terminal.

The overall ALNG pipeline network consists of a gathering system for associated gas from the oilfield developments in Blocks 0, 14, 15, 17, 18, and future fields offshore Angola. The collected gas is gathered through offshore facilities and transported through an offshore pipeline system to the onshore LNG plant near Soyo, Angola.

The reliability of the section of pipeline crossing the Congo River canyon and continuing to the LNG plant presented a major challenge to the CRX pipeline project. Over time, the water stream of the Congo River has incised a large submarine canyon that ranges in size from 3 km wide and 400 m deep near the mouth of the river to 15 km wide and 1300 m deep near the continental shelf break.

The pipeline was divided into various segments and pre-commissioned separately. Segment C ties into the B0/14 PLEM that had been installed, pre-commissioned, and packed with N2 previously. It runs approximately 14.9 km to the SPP situated on the edge of the Congo River canyon. The line from the LNG plant situated in Soyo is 38 km with an inner diameter ranging from 20 to 25 in. and a maximum water depth of 40 m at SPP.

Segment W is a 12-in. drilled conduit that runs from the SPP on one side of the Congo River canyon to the NPP on the other side. It extends 1400 m under the seabed and is approximately 7 km in length.

Segments A and B are 20- and 22-in. lines, respectively, running 95 km from NPP to the South Nemba platform with water depths ranging from 40 to 117 m. They are connected by a subsea bypass (SBP) close to the Sanha auxiliary platform to allow for future tie-in with the Malfumeria Sul pipeline at the platform.

Scope of Work—Segment C

Operations on Segment C commenced in March 2013. The scope was to run a series of pigs to flood, clean, and gauge 22-in. production pipeline from the LNG pig launcher/receiver (PLR) to the temporary subsea receiver head installed at the end of the pipeline at SPP. The pig train consisted of the following (Figure 2):

- One bidirectional (bi-di) brush pig
- One combined bi-di brush/gauge pig
- One bi-di gauge pig

Figure 1—Segment C 22-in. bi-di pigs

All pigs were separated by 500 linear meters of seawater filtered to 50 microns, and the final gauge pig slug was treated with a chemical cocktail consisting of biocides and oxygen scavenger at 500 ppm to provide protection to the line for 24 months.

After successful completion of the flooding, cleaning, and gauging run, the pipeline was tied into the platform riser, and a temporary topside PLR was installed. A caliper tool was then run from the LNG plant to the temporary PLR to provide a baseline survey. On receipt of a preliminary report, the inspection was completed, and a hydrostatic strength test was performed. The line was then depressurised to 1 bar more than subsea ambient pressure.

During the detailed inspection, an anomaly was discovered approximately 4.5 km from the SPP platform that was greater than the acceptable 5% deformation (Figure 2). After further analysis and discussion with the operator, it was determined that a centralising welding shoe had come loose and secured itself to the pipeline.

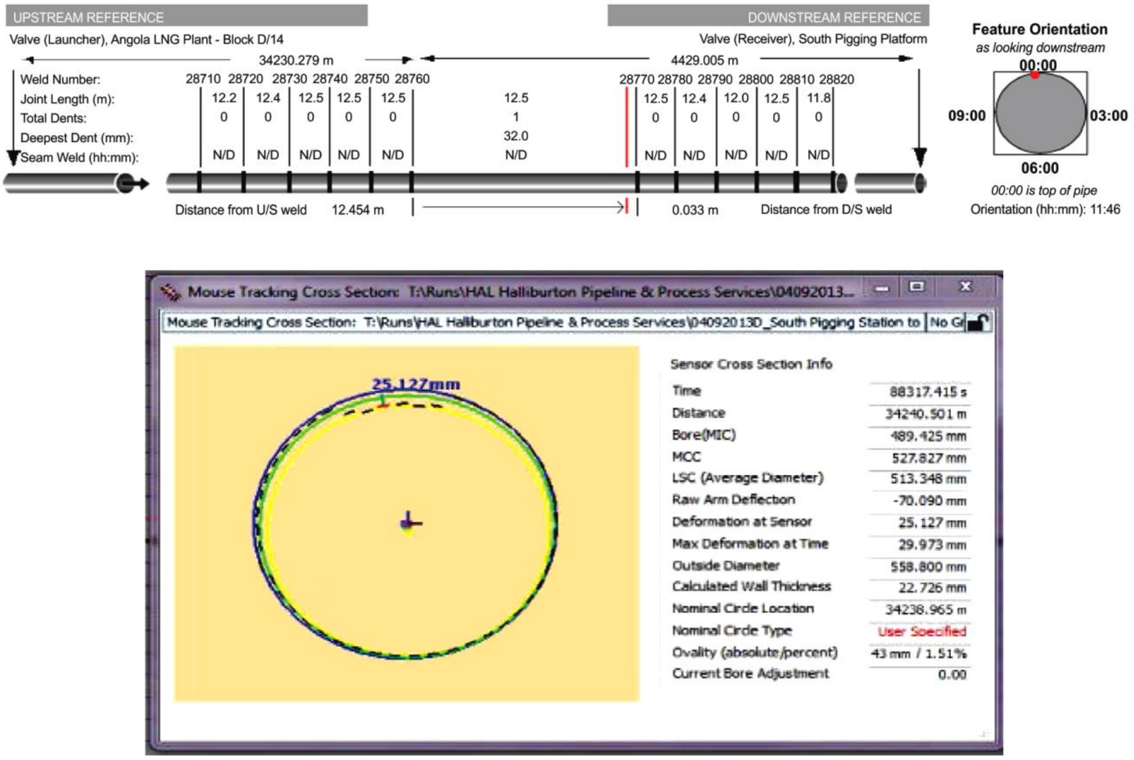

Figure 2—Data received from caliper survey of anomaly on Segment C

A secondary campaign was planned to replace the section of pipeline with a flanged spool. The spool was gauged and subjected to a hydrostatic strength test before installation. Following completion, the system was refilled from the LNG terminal to the SPP riser to help ensure no pockets of air remained; it was then leak tested. Operations were completed in July 2015.

Scope of Work—Segment W

After completion of the Segment C initial campaign, the well conduit crossing the Congo River was completed. Jack-up drill rigs were located at SPP and NPP and drilled 1400 m under the seabed to meet in the middle.

The service company flooded and cleaned the line and ran an inspection tool followed by a hydrostatic strength test. An initial pre-flood of the line was completed using three medium-density foam pigs (Figure 3).

Figure 3—Segment W 12-in. foam pigs

The purpose of the pre-flood was to help eliminate the possibility of trapped air at hydrostatic pressure residing in the line because at -1400 m the air could be compressed by the hydrostatic conditions to 140bar. As this air travels through the conduit and ascends the NPP riser, it could expand, and depending on the volume, it could pressurise the conduit to pressures possibly attaining 140 bar.

This operation is based on the theory that if the column of water did break, it could create a void comprised of water vapour above the water column, which could then collapse back to water as the pigs approached the NPP side of the conduit. The pressure level could then be such that the water vapour voids could no longer exist. This process can help ensure that the line is air free.

Once all of the foam pigs were received, they were taken out of the SPP receiver, and the following bi-di pig train (Figure 4) was launched without risk:

- One bi-di pig
- One bi-di brush pig
- One bi-di gauge pig

Figure 4—Segment W 12-in. bi-di pigs

Following completion of the flooding operation, a caliper pig (Figure 5) was scheduled to be run to provide a baseline survey. Unfortunately, the pre-commissioning of Segment W was cancelled because of unforeseen events.

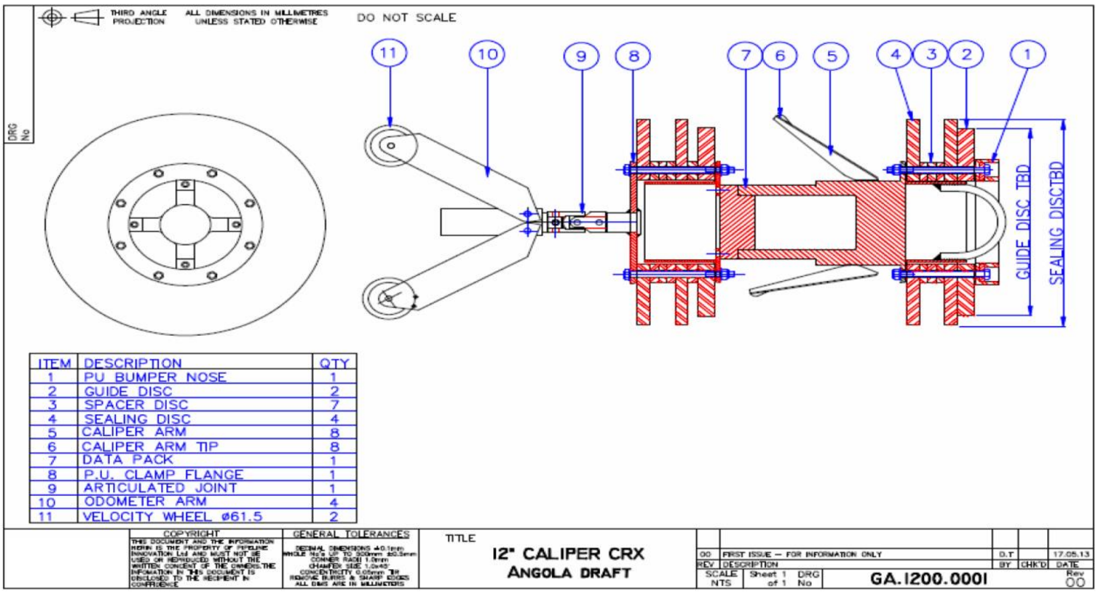

Figure 5—Segment W 12-in. caliper pig

Scope of Work—Segments A and B

Operations for Segments A and B began in November 2013 with the two sections being flooded, cleaned, and gauged with a pig train comprising two bi-di brush pigs and a bi-di gauge pig. Per the previous work scopes, the pigs were separated by 500 linear meters of seawater filtered to 50 microns, with the gauge pig slug treated with a combination of biocides and oxygen scavenger at 500 ppm.

Following completion of the pigging campaign, there was a planned 6- to 8-week break to allow the installation of the SBP and subsea structures. Because of vessel scheduling, this was delayed until 2014.

When the subsea structures were prepared for installation in 2014, the subsea PLRs on Segment A and B pipelines were recovered, and the pigs were removed (Figure 6). There was an unexpected volume of dirt collected by the pigs, necessitating a fast-tracked pigging operation before the installation of the subsea structures.

Figure 6—A 20-in. bi-di pig recovered from Segment A

Following the installation of the subsea structures, a caliper tool was planned to be run from the NPP platform to South Nemba to provide a baseline survey of the pipeline; however, during hydrotest operations, it was apparent that there were possible leak paths in the line.

A series of tests was performed to isolate various subsea structures of Segments A and B to attempt to isolate the leak paths and identify the problems. This involved a second campaign to individually isolate each group of hot stabs, flush through, and pressurise the system. Once the leak locations were identified, the system was depressurised and rectified. Once completed, Segments A and B were subjected to a hydrotest and a caliper survey. Operations were completed in October 2015.

Scope of Work—Full System Commissioning

Operations for commissioning began in November 2015 when the topside pipework at SPP, NPP, and South Nemba auxiliary (SNA) platform were completed and tied into the pipeline. The system was topped up and tested with fresh water before dewatering operations began. Each segment was bulk dewatered separately before final dewatering. The line was then vacuum dried and packed with N2 to 51.8 barg.

Segment C was bulk dewatered using two high-seal bi-di dewatering pigs. The pigs were separated with 250 m3 of fresh water to desalinate the line and then propelled with dry air. The discharge from Segment C was diverted through Segment W and discharged to sea at NPP. The freshwater slug was used to desalinate Segment W.

On receipt at SPP, the pigs were removed from the receiver, and Segment C was isolated. It was then pressurised to 150 barg to create a reservoir of air to bulk dewater Segment W and overcome the hydrostatic head created during dewatering of the drilled conduit.

Once Segment C was packed to 150 barg, a high-seal bi-di pig was launched into Segment W behind the freshwater slug and run using compressed air from Segment C. Discharge was once again routed overboard at NPP and controlled with a choke valve to maintain pig speed and pigging pressure.

Once both Segments C and W were bulk dewatered, they were subjected to a final dewatering pig train. Beginning with Segment C, five high-seal bi-di dewatering pigs were launched from ALNG to SPP. They were separated by 1 km of dry air and removed upon receipt at SPP. This operation was then completed for Segment W with the same number of pigs. On completion, both segments were packed to 150 barg to act as a reservoir to dewater Segments A and B.

To reduce the schedule, Segments A and B were bulk dewatered and final dewatered in one campaign rather than two separate ones.

A vessel was mobilized to NPP with a flooding spread, which was used to launch the first high-seal bi-di dewatering pig with a 200 m3 slug of fresh water. An additional five high-seal bi-di dewatering pigs were loaded and launched separately by 1 km of dry air.

The first pig arrived at SNA as expected; however, the remainder of the pigs did not. It was believed they had caught up with each other and become stuck somewhere in the line. To bring the final pigs home, the line was vented down in front of the pigs, and Segments C and W were packed to 90 barg. The plan was to shock the pigs with a pressure differential to dislodge them. Eventually, all remaining pigs arrived at SNA, and the line was depressurised.

On completion of the dewatering campaign, the entire system from ALNG to SNA was vacuum dried to a dew point of -20°C or better using specially built units located at both ends of the pipeline system. Once dried, the pipeline system was packed to 51.8 barg with nitrogen produced from the air/membrane spread located at ALNG.

This final operation allowed the platform to bring the pipeline system online and transfer first gas to the ALNG plant at the end of February 2016, therefore completing the project successfully.

Summary and Conclusions

In conclusion, it is important to fully engineer and plan complex projects such as CRX to help ensure all possibilities and contingencies are considered. Working in remote locations can hinder fast-acting support should any issues occur. This can create delays in completing operations and can increase the final project costs beyond their original estimates.

Pre-commissioning is an important step in a pipeline construction project—the final step in the critical path before product is introduced into the line. It is imperative that oil and gas pipelines are properly pigged to help ensure they are clean, conditioned, and fit for purpose. Inadequate pipeline pre-commissioning can increase the risk of debris build up, cause creation of hydrates or waxes, and result in reduced bore and restricted flow or even blockage and loss of production. Performing a baseline survey of pipeline systems as part of a pre-commissioning operation allows the pipeline operator to have comparable data for future pigging campaigns and surveys. Without proper maintenance, the pipelines are at risk of future shutdowns and reduced production.