OPERATIONAL PIGGING PROGRAMS AND STUCK PIG RECOVERY FROM GAS EXPORT PIPELINE

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Abstract

Pigging is one of the many production maintenance activities available to pipeline operators. Part of integrity management, pigging is a standard operational activity performed regularly throughout a pipeline network's lifecycle. Pigs are run successfully every day. However, every so often a pig becomes stuck, stalled or damaged inside the pipeline.

This was the case during operational pigging of the PTTEP International Limited (PTTEPI) 28-inch gas export line in the Southeast Asian Gulf of Martaban. A third-party subsea, bi-directional (Bi-Di) 28-inch pig was scheduled to run between the offshore platform and onshore operation center. However, it stalled halfway into the barred production tee located immediately beyond the pig launcher isolation valves. Its position meant the pig was not entirely obstructing product flow. The operator was concerned, however, that pressure and flow bypassing the pig could easily move it farther into the pipeline, blocking the line and leading to production shut down.

To avoid this costly challenge, the operator evaluated multiple pig recovery options, including using another Bi-Di pig to push the stalled one to the onshore end. Ultimately, they decided to rescue the stalled pig by pulling it back to the launcher. Because all of the standard pig-rescue solutions would involve blowing down the entire pipeline, the operator required a 100 percent engineered solution. T.D. Williamson (TDW) designed, manufactured, tested and mobilized a special recovery tool that successfully extricated the stalled offshore pig and returned it to the platform.

This white paper describes the key steps in the pig recovery operation, including planning, site visit, engineering, tool manufacturing and execution.

Nomenclature

Bi-Di:	Bi-directional
ESDV:	Emergency Shutdown Valve
ILI:	In-line Inspection
PTTEPI:	PTT Exploration and Production International
PU:	Polyurethane – used as pig disc material
PPE:	Personal Protective Equipment
QOC:	Quick Opening Closure
TDW:	T.D. Williamson

Introduction

Pigging is a routine part of pipeline integrity management and flow assurance. Common applications include pre-commissioning, line-proving, cleaning, liquid removal, batching, in-line inspection (ILI), in-line isolation and decommissioning. Pipeline product and transportation conditions, including pressure and temperature, will often dictate the type and frequency of pigging.

Pipeline operators have been running pigs successfully for years. However, occasionally a problem occurs, and one becomes stuck, stalled or damaged in the pipeline. There are several reasons why this happens: mechanical obstacles in the pipeline stopping the pig, volume deposit build-up in front of the pig, unintentional bypass leading

to a stuck pig with product flowing past it instead of driving it, excessive wear leading to failure of the pig's disc seals and loss of drive, and other failures.

During operational pigging of the 28-inch gas export line in the PTTEPI gas field development in Southeast Asia, the 28-inch Bi-Di pig stalled and could not negotiate the barred production tee located immediately beyond the pig launcher isolation valves (See Figure 1). Because the pig was stuck halfway into the tee, it was not blocking the production flow entirely. However, the operator was concerned that, over time, the discs on the pig could lose force or a change in internal pressure could lead to the pig moving farther into the tee or line, blocking the flow completely. If the pig blocked the line, it could lead to shut down of production (See Figure 2) costing millions of dollars in lost production and serious impact on operations.

Figure 1: Gas Export Pipeline

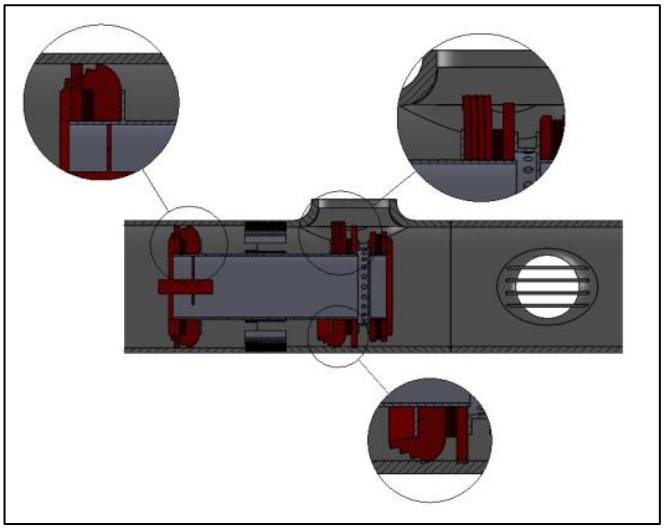

Figure 2: Bi-Di pig stuck in the barred Production Tee

Understanding Why the Pig Stalled and Became Stuck

PTTEPI anticipated that the pipeline had a lot of debris that would collect in front of the pig during the pigging operation. When such debris is expected, it is normal to build some bypass into the pig to allow a portion of the gas flow to pass through it. As the flow passes ahead of the pig, it causes turbulence that will either flush debris ahead of it or allow the debris to be held in suspension in front of it. This avoids too much build-up in front of the pig that could eventually cause it to stall in the pipeline. (Figure 3)

Figure 3: Effect of bypass on debris

PTTEPI attempted to allow enough bypass to create turbulent flow but not so much that the pig loses the drive. However, there were several factors that complicated the effort.

First, they used a Bi-Di pig designed with a large bypass that allowed a portion of the gas flow to pass through it, (Figure 3). Although some bypass is necessary, too much bypass means there won't be enough differential pressure to drive the pig.

In addition, because of its heavy polyurethane (PU) disc stack up, this Bi-Di pig required more differential pressure to move it than a conventional Bi-Di pig would. However, there was insufficient pressure to push the pig through the launcher and into the pipeline.

Finally, as the pig entered the barred production tee a portion of the front disc package disengaged, and the bypass was even larger. Without enough drive on the discs to push the pig through, it simply stalled.

Evaluating Alternative Solutions and Risks

The operator considered multiple options for recovering the pig, including using another Bi-Di pig to push the stalled pig back to the onshore receiver. However, this approach was too risky as it was possible the pig would get stuck further into the line - for example, in one of the many bends in the subsea tie-in spool connection the subsea pipeline to the platform riser - which could potentially create an even more challenging subsea rescue operation.

The only viable option was to recover the Bi-Di pig back to the launcher. First, PTTEPI and TDW evaluated whether to attempt pigging the Bi-Di pig back to the launcher by installing a sealing cap at the rear of the pig to block the large bypass. (Figure 4) or to attach some sort of a pulling arrangement to the pig so it could be pulled back to the launcher using a hydraulic cylinder attached to a strong hold behind the launcher to provide the necessary pull force.

Because of the stalled pig's large bypass, not enough differential pressure could be built up to pig it back to the launcher. Installing an end cap would essentially block the bypass, enabling higher differential pressure to build up across the pig. By bleeding pressure on the launcher side, the differential pressure would push the pig back to the launcher. The only viable option was to recover the Bi-Di pig back to the launcher

Regardless of the choice, two things would be necessary. First, a secure strong hold or gripping tool had to be installed at the end of the pig so that either a sealing cap or pulling arrangement could be securely attached to the pig. (Figure 5). Second, production would have to be shut down briefly, so crews could purge hydrocarbons from the topside portion of the pipeline to gain safe access through the launcher quick-opening closure (QOC).

After the TDW project team and operator agreed that pulling the pig back to the launcher was the most suitable recovery method, the next step was determining how to proceed. With no standard solution available—or at least none that could be implemented without blowing down the entire pipeline first—recovery would require the development of a unique, 100 percent engineered to order tool.

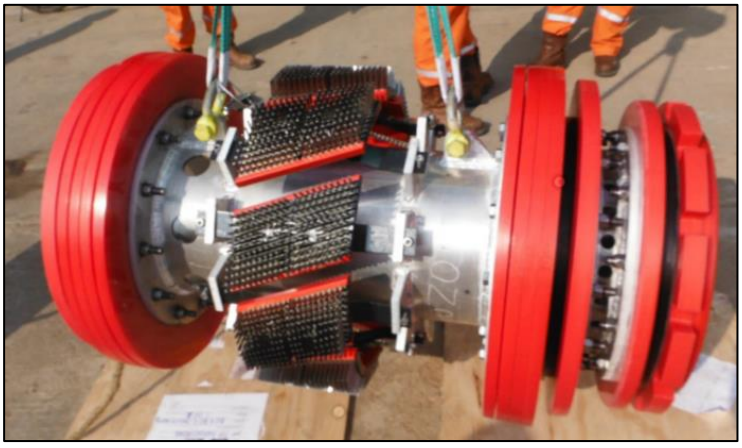

Figure 4: Bi-Di pig

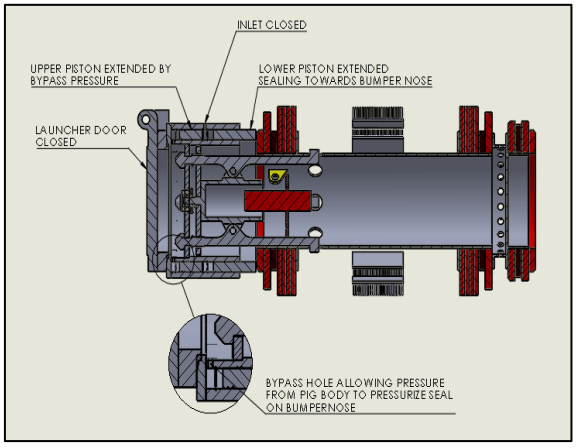

Figure 5: Gripping Tool with option of using sealing cap

Scope of Work and Timeline

The scope of work was to engineer, design, manufacture and test a special recovery tool that would hook onto a strong hold in the pig body; a wire and hydraulic cylinder attached to a strong hold prepared by PTTEPI and located behind the launcher would pull the pig out of the pipeline. (Figure 6). TDW:

- Completed pre-engineering in July 2018.
- Performed detailed design and engineering in August and September.
- Manufactured the customer recovery tool at the Global Solutions Center in Norway in October and November.
- Performed factory acceptance testing (FAT) in December.

Once testing was complete, TDW personnel and the recovery tool was mobilized to the offshore platform the second week of January 2019. It took just three days to complete the recovery operation. PTTEPI representatives provided on-site support during the pig retrieval.

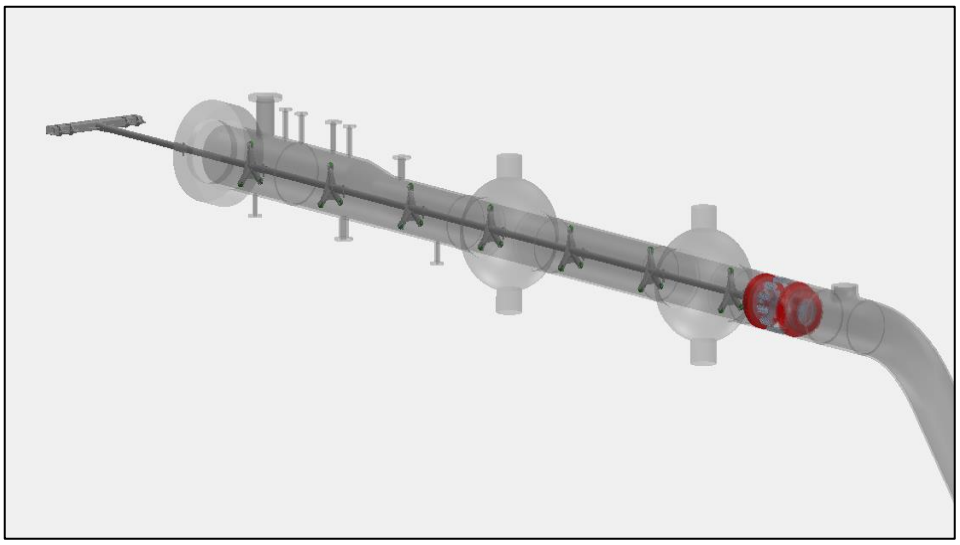

Figure 6: Pulling lance to install gripping tool on the pig body

Pre-engineering, Engineering and Equipment Design

Conducting a pre-engineering study involves looking first at alternatives before zooming in on the right approach to solve the problem. As previously noted, TDW considered multiple options during pre-engineering before deciding upon the method of pulling the pig back to the launcher.

Before TDW could design the recovery tool, they first had to determine how much recovery force it would take to flip the sealing discs on the Bi-Di pig and pull it back to the launcher.

During pigging, the outer edge of the PU discs are backwards-folding and parabolically shaped. To reverse the pig, the discs must first be flipped so they fold the opposite direction. Otherwise, the pig can't move or it takes a very high force to move it. The pressure it takes to flip the discs is often referred to as "flipping pressure."
To accurately test the effect of various differential pressures on the sealing discs, TDW built a replica test rig of the offshore pipeline, including the barred production tee, at its Global Solutions Center in Stavanger, Norway. PTTEPI furnished a Bi-Di pig identical to the one used offshore.

TDW loaded the test pig into a straight section of the replica pipeline pressurized to approximately 3 bar (43 psi), the expected offshore pressurization, using water as the pigging medium. This pig also stalled when it entered the barred tee, just as it had offshore. (Figure 7) TDW then pressurized the pig from the barred tee blind flange to 3.5 – 4 bar (50.7 – 58 psi). However, instead of the disc packs flipping, they partially burst. There was significant water leakage across the outer disc perimeter and the pig did not move at all.

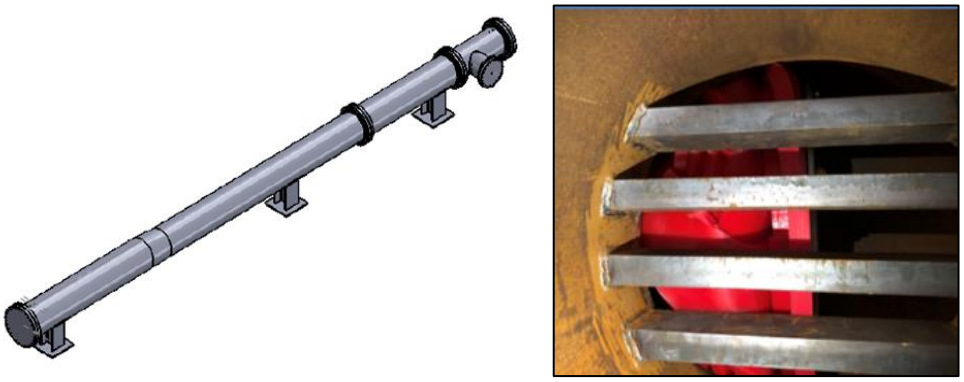

Figure 7: Test rig assembly Pig stuck in the bared Tee

After removing the blind flange to visually inspect the front disc pack, TDW re-pressurized the test pipe to 3.5 – 4 bar (50.7 – 58 psi). The pig moved approximately 1m (3.2 ft) before stalling; again, water leaked across the outer disc perimeter. The front seal disc flipped but the rear disc pack, which was closest to the launcher, did not. A hydraulic cylinder pushed the pig to recover it from the test rig. All the discs flipped upon recovery; however, they were partly torn radially due to high stress and damage on the rear disc pack. With such large leakage across the disc perimeter making the build-up of enough differential pressure to push the pig unlikely, TDW decided to eliminate the recovery option of installing a sealing cap at the rear of the pig and pigging it out.

For the next recovery force test, the first of the four PU discs was stretched over the next three to reduce friction. This time, the reverse pigging test was successful: all four discs flipped at a recovery force of 13 tons, without touching the pipeline wall or getting damaged. (Figure 8)

Figure 8: Reverse pigging test

With the recovery force determined, TDW had the necessary information to complete the design of the recovery tool. It was configured with:

- A gripping tool with spring-loaded pulling arms. (Figure 9) The arms were spring loaded to engage or “click in place” once they reached the bypass holes of the pig body.
- An installation with locking mechanism lance (shown in red in Figure 10) to install the gripping tool onto the pig body.
- Lance support wheel assemblies to centralize the lance in the pipe. (Figure 10)
- A pulling wire arrangement.
- A hydraulic pulling cylinder (furnished by TDW) with a “strong hold” anchor point operation (supplied by PTTEPI).
- A camera system to ensure the gripping tool engaged inside the launcher, where visibility was very poor (Figure 13).

Gripping Tool

The next task was designing a tool to grasp onto the pig body. TDW decided that the bypass holes were the only strong point in the pig body to grip onto. The pig that was stalled offshore had a pinger used for tracking purposes assembled in its center. Although the pinger could have been an obstacle to securely inserting the gripping tool, TDW decided to use the pinger receptacle as a guide post, which worked quite well. Once the gripping arms entered the bypass holes, the spring-loaded arms were “clicking” in place into the bypass holes. (Figure 12)

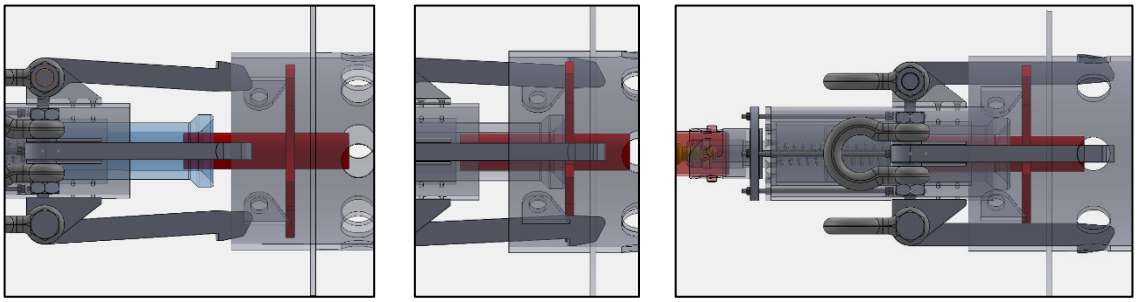

Figure 9: Gripping tool grasping onto the pig body using pinger as guide.

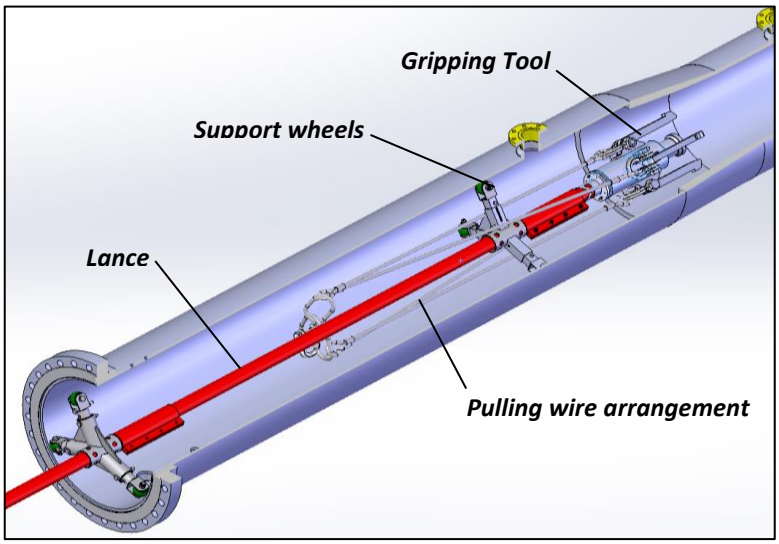

Figure 10: Lance with support and wheel assembly attached to Gripping Tool

Factory Acceptance Testing
After the recovery tool was manufactured, it was time to conduct a retrieval test in the pipe replica, using a Bi-Di pig identical to the one that had become stuck offshore. This allowed the engineering team to:

- Monitor the force required for the recovery tool to overcome inertia.
- Visually inspect and ensure integrity of the retrieval tool and pig body.
- Plan for offshore operations by recording the time it took to assemble the lance, engage the tool/pig and retrieve the pig.

The maximum encountered pulling force on the pig was measured at 15.4 tons or 360 bar (5221 psi) of hydraulic pressure in the pulling cylinder.

In order to minimize the platform shut down time, the recovery operation was very critical to PTTEPI. During the testing phase, TDW timed how long it was going to take to recover the pig. The testing phase provided valuable practice and optimization of procedures, and as a result, the recovery time improved. This provided confidence that TDW could recover the pig on an acceptable timeline. (Figure 11)

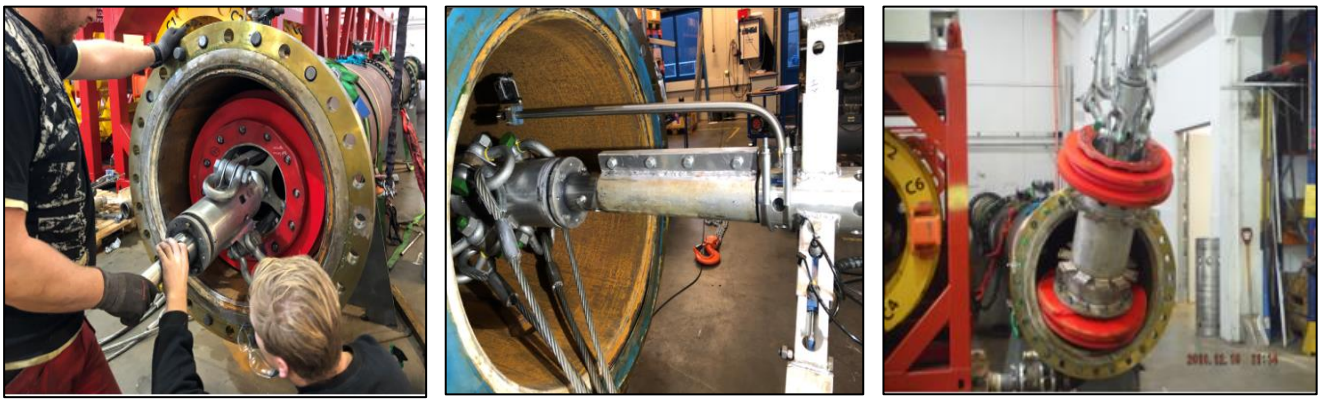

Figure 11: Factory Acceptance Test

Safety
Safety is always a top priority. In this operation, two key risks were identified and mitigated:

Internally leaking emergency shut-down valve (ESDV): Reaching the stalled pig required process isolation. However, two downstream isolation valves that blocked high pressure export gas at about 130 bar (1885 psi), were severely leaking internally which could have resulted exposing work crews to hydrocarbon gas. To mitigate this risk, PTTEPI installed an additional vent point at an annular between the isolation valves and the pig. The pressure alarm set point at each location was temporarily set at 0.1 bar (1.4 psi) in order to monitor and alert workers to pressure build-up.

Toxic gas: In any oil and gas operation, toxic gases continuously flow to the platform, making pipeline contamination with mercury, hydrogen sulfide and benzene unavoidable. TDW measured all levels prior to executing the recovery and applied full personal protective equipment (PPE) when values exceed acceptable limits.

Mobilization and Offshore Recovery Operation

Following the successful factory acceptance test, the equipment package was shipped to the onshore supply base in Thailand and from there to the offshore platform. The offshore team mobilized to the worksite for the retrieval operation. Crews opened the launcher QOC at 9:20 on January 20 and successfully performed the following steps between 11:15 and 16:15:

- Assembled the lance and gripping tool and inserted them into the pipeline.
- Locked the pig gripping tool in place in the bypass holes in the pig.
- Hooked up the pulling wire
- Started the pulling recovery operation
- Retrieved the pig from the launcher

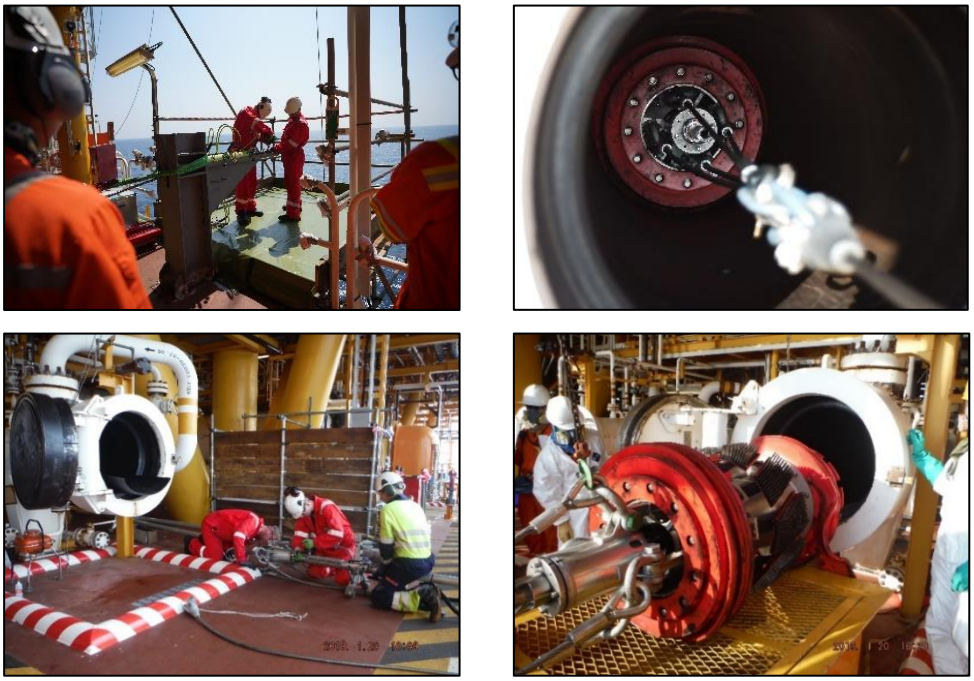

Figure 12: Recovery operation offshore

Figure 13: Camera monitor showing tool connected to the pig

Results and Conclusions

The pig recovery operation was 100 percent successful and was conducted without any safety incidents. However, the solution was not necessarily the obvious choice at first. During pre-engineering, it was important for TDW and PTTEPI to consider multiple options and evaluate risk. Only then could they feel confident in their decision to pull the pig back to the launcher.

Close cooperation between TDW and PTTEPI was critical to the success of the operation at every step, in fact, beginning with a pre-engineering client workshop at PTTEPI's Yangon facilities. TDW visited the offshore platform to get a thorough understanding of the site and conducted design review meetings with PTTEPI where the solution was challenged, and the tool and recovery procedure optimized.

Gas export pipelines like these transport millions of dollars in product every day, making reliable throughput essential. Properly evaluating pig design through piggability studies can mitigate the risk of launching a pig into a critical pipeline and avoid pipeline shutdown and product loss. In this case, if the stuck pig had moved farther into the line, it could have blocked production completely, leading to a much larger recovery operation and significantly longer shutdown. Acting on the problem as soon as possible avoided those losses.

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