Pipeline failure in the Mediterranean Sea

Figure 1. The line has been dewatered and the winch is connected to the PRT, pulling the pipeline onto the vessel.

Mark Sim, T.D. Williamson, Inc., explains how engineering, isolation and innovative technology helped to restore a severed high-pressure subsea gas pipeline.

While pipeline operators prepare to respond should a line be damaged by a hurricane or dragging anchor, it is rare that a line is completely severed. Against the odds, this is what took place in December 2008 when an anchor sliced through a 26 in. high pressure subsea gas pipeline in the Mediterranean Sea, resulting in failure of the line and a simultaneous l4% reduction in a parallel 20 in. subsea high pressure pipeline (Figure 2) However, because these lines were part of a common system featuring parallel lines, gas deliveries were maintained. Fortunately, response time was not as critical as it might have been had deliveries come to a standstill. This made it possible for the operator to implement a more planned and measured response.

After the incident, the operator's pipeline repair contractor retained TDW Offshore Services (TDW) to isolate the damaged sections so that they could be removed and replaced. TDW developed a plan to use a combination of its pipeline recovery tools (PRTs), SmartTrack™ remote tracking and pressure-monitoring system, and SmartPlug® pipeline pressure isolation tools to isolate the affected pipeline sections.

This operation featured two common emergency scenarios that TDW needed to address: a piggable dent and a wet buckle. A 'wet buckle' describes a condition whereby the pipeline is breached and damaged, allowing water to enter, making the pipeline 'wet'. A 'piggable dent' is where there is limited pipeline damage so that a pig can still pass through the 'dent' or obstruction.

When an anchor comes into contact with a pipeline, it normally deflects the anchor, as was the situation with the 20 in. pipeline. Although TDW had been involved in the repair of pipelines that had been damaged by dragging anchors, this was a first. Never before had the company been called to facilitate repair of a pipeline that had been completely severed by an anchor, as was the 26 in. line.

Assessment

The impact of the anchor drag damage could have been much worse. For example, water depth drops to below 600 m on one side of the pipeline. Had the line been totally flooded in this location, the de-commissioning, repair and re-commissioning would have been a more daunting and complicated operation.

Thankfully, the damaged pipeline was located in just 70 m of water, with a favourable topography, meaning the full line did not flood. As a result, a far greater range of repair options could be considered. Regardless of the solution selected, it would require the use of remotely operated diver-less technology.

Figure 2. When a 26 in. pipeline was completely severed by a dragging anchor, it resulted in catastrophic failure of the line. The recovered pipe was severely deformed.

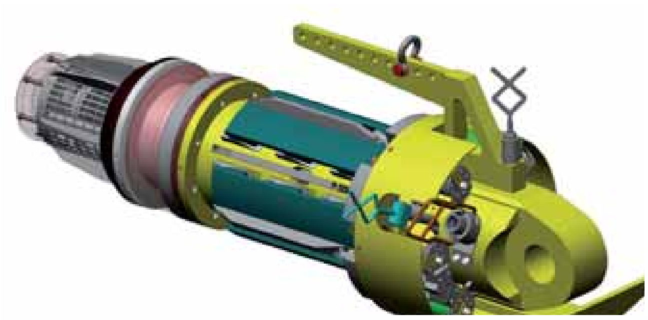

Figure 3. Customised SmartLift™ PRT.

Potential solutions for de-commissioning

During brainstorming sessions with the pipeline repair contractor, TDW assessed options to decommission and repair the two lines. TDW had previously designed and manufactured a custom SmartLift™ pipeline recovery tool (PRT) for a project carried out subsea in much deeper water (Figure 3). By using the SmartLift™ PRT, it would be possible to recover and dewater the recovered pipe. The PRT's internal gripping function is hydraulically activated by a remotely operated vehicle (ROV) or diver, and self-locks mechanically after it is set. At the same time, packers are activated, providing a seal. Dewatering is carried out by running a dewatering pig either from a launcher or to a receiver attached to the PRT. During the early planning stages, it was agreed that PRTs would be used, with delivery and design the primary issues.

Tracking pigs with through-wall communications technology

With the 26 in. pipeline blown down, a standard bi-directional pig was chosen for use in conjunction with TDW's SmartTrack system. By doing so, the pipeline repair contractor would be able to accurately track the pigs from each end of the line through to the damaged section. As an added benefit, in addition to tracking the pig as it travelled through the 120 km and 30 km lines, the SmartTrack system served as back-up to the pig detector on the PRT, confirming positioning within +/- 5 cm. The SmartTrack system's ability to communicate 'through-wall' also allowed technicians to read the pressure inside the pipe prior to removing the PRT.

Because the 20 in. pipeline was still flowing at operational pressures, a different approach was necessary. As planning progressed, it became increasingly clear that the optimal solution was to isolate using specially designed pigs to prevent major seawater ingress during cutting operations. It would also make it possible to insert the PRT and to carry out the dewatering process.

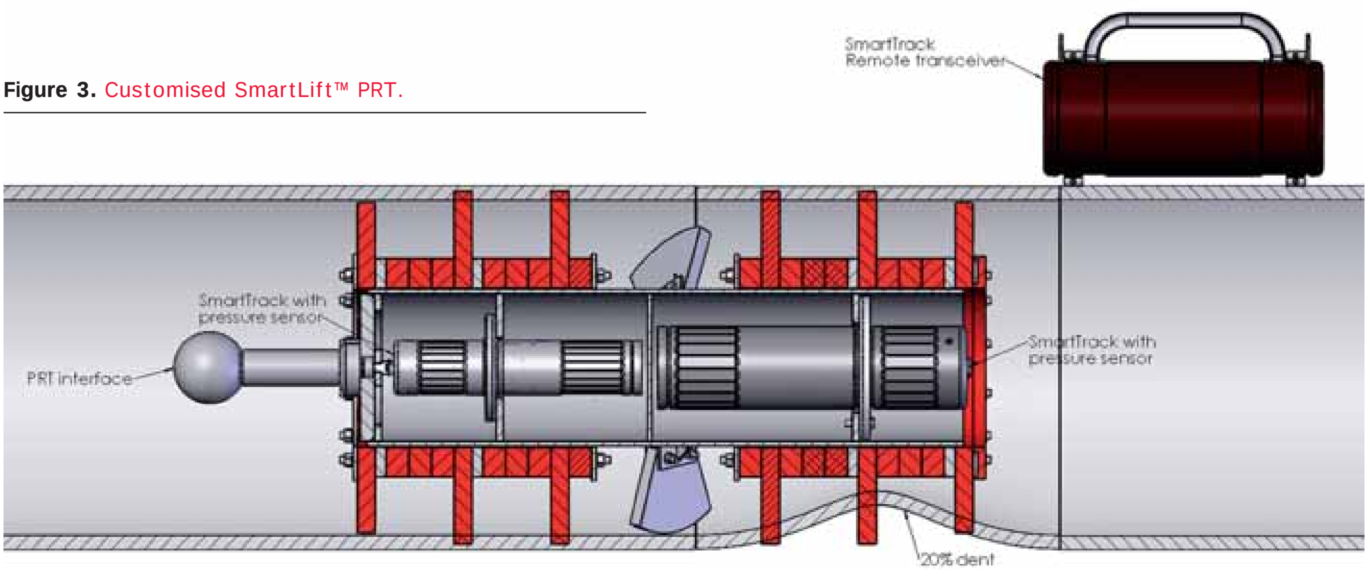

Figure 4. Custom pig set-up.

Figure 5. The custom SmartLift™ PRT is deployed from the lay vessel.

Figure 6. The PRT recovers the pipe by drawing it up the stinger.

TDW had to make certain that the line was safely isolated so that the damaged section could be removed, and the pipeline could be recovered and repaired. Although the recovery and repair process was identical to that used for the 26 in. pipeline, in this case, proper isolation and depressurisation were critical.

A custom pig was to play a central role in the operation, so TDW developed a design with the requisite parameters. The strategy was to send two multi-diameter, bi-directional pigs that could provide a sufficient barrier so as to allow the damaged section to be cut and removed without the risk of uncontrolled seawater ingress. The two pigs would be positioned on each side of the damaged section.

Custom test rig simulates subsea conditions

At its facility in Stavanger, Norway, TDW designed and built a test rig with a built-in dent in excess of the 14% actual deformation (Figure 4). In essence, a 16 – 20 in. dual diameter pig was required. A range of configurations were tested to simulate the conditions subsea. Flip pressures, launch pressures, holding pressures, and pigging pressure across the dent were measured and optimised during the test to ensure optimal performance offshore.

The aim of the trials was to verify tracking signals and pressure readings through the pipe at the site of the dent. A range of delta-Pressure (ΔP) measurements were taken while running in straight pipe, through the dent, restarting in the dent, and flipping of the dent-passing pig in straight pipe. ΔP measurements were also taken while running in straight pipe for the second pig and combined pig train.

Carrying out the plan

Following thoughtful assessment, surveys to detect water and analyse oil characteristics were carried out, along with an inspection of the subsea 26 in. line to determine where seawater flooding had taken place and to collect soil data along parallel routes. To prepare the 26 in. line for isolation, the main contractor cut it, installed PRTs at both ends, and removed the damaged sections.

After the 20 in. line was de-commissioned by shutting it down, de-pressurising and venting it, the 26 in. line was dewatered and purged, and the 20 in. line purged and isolated. Pigging was performed from terminals located onshore. Preparatory work and isolation of the 20 in. line was successfully achieved, including purging of all remaining pipeline sections. Damaged sections of the 20 in. line were cut and removed, as were remaining sections of the 26 in. line. The pipeline repair contractor then installed PRTs at both ends of the line.

The pipeline repair contractor proceeded to repair the 26 in. line. The pipe ends were recovered, and an above water tie-in performed, prior to laydown. The line was then re-commissioned by drying, filling with nitrogen, and packing with gas before being re-started, allowing production to resume. This was followed by repair of the 20 in. line by the pipeline repair contractor, who employed the same process. The line was re-commissioned by drying, filling with nitrogen, and packing it with gas before it was re-started, allowing production to resume.

The operation proceeded smoothly, and was completed on schedule. "We believe that the SmartTrack system played a critical role, particularly due to its ability to function as both a tracking and pressure monitoring system," said Roar Kvame, Commercial Service Manager for TDW. "The fact that we were able to accurately track positioning allowed the pipeline repair contractor to feed back information to the northern pump site. This provided better control as the pig train approached. Plus, each pig is equipped with a unique identifier system so there was no confusion when placing one pig on either side of the damaged section. Finally, pressure was read through the pipe wall, ensuring pressure equilibrium and providing a safe environment in which to make the cuts," he added. After the cuts were made, TDW inserted the PRTs, and pumped air/nitrogen from either end to push the pigs to the PRT pig catcher, while simultaneously removing the water via the PRT dewatering ports.

By taking a disciplined approach to planning, engineering custom pigs, and conducting trials on the test rig, TDW successfully completed the pipeline pressure isolation operation. The operation paved the way for safe, efficient repair of this pipeline, which plays a vital role in the supply of natural gas to countries that border the Mediterranean Sea. WP