

Figure 1. Because of the possibility that unknown obstacles could prevent the pigs from reaching their destination, each of the three pigs used to isolate the riser section was equipped with its own transponder as part of a subsea remote tracking and pressure-monitoring system.

George Lim, Eirik Trane and Jan Eyolf Bjørnsen, TDW Offshore Services, reveal the advances in pig tracking technology that redefine integrity verification and pressure monitoring.

KEEPING TABS

Pipeline pigs made their first appearance more than 60 years ago, and ever since, there has been a need to accurately track their movements. The reason is obvious enough: if a pig stops or gets stuck in a line, knowing its precise location will be the first requirement for addressing the situation.

In basic terms, pig tracking refers to the science (some might even say art) of following a pig's progress within a line. This can be either a continuous process, or it can be accomplished by locating the pig at sequential predetermined points along the trajectory of the pipeline. Either way, the goal is to be able to know with a high degree of accuracy where a pig is along its intended route at any given point in time.

As pigs have become more sophisticated, so too have the methods used to track them. In the early days, the human ear or a hand on the pipe were the first tracking devices. Later, geophones placed on or near lines routed pig noises to amplifiers and speakers. Even more recently, transmitters have come into wide use, particularly in conjunction with inline inspection (ILI) tools (smart pigs) and in subsea applications.

Increasingly, the ability to track pigs from remote locations has played a key role in numerous offshore projects. For

example, when a major operator needed to repair a damaged export pipeline riser in the North Sea, a remote pig tracking and pressure monitoring system played a critical role in ensuring the repairs were completed safely and successfully.

The damage was caused when a passing cargo vessel weighing 2000 t collided with the southeast face of a satellite platform jacket, damaging the 12 in. export riser. Production from the platform was immediately shut-in via the emergency shutdown valves, leaving the pressure in the pipeline at approximately 4 bar. Before production could resume, the operator needed to remove and replace the damaged riser section and associated topside pipework production system.

Communication as key

To facilitate this process, TDW Offshore Services (TDW) was retained to formulate a low pressure isolation solution that would effectively and efficiently isolate the damaged section of the riser from the export pipeline gas inventory (Figure 2). Following intensive analysis, engineering and testing, TDW implemented a solution that drew upon a range of specialised pipeline pigging, pig tracking and remote communications technology.

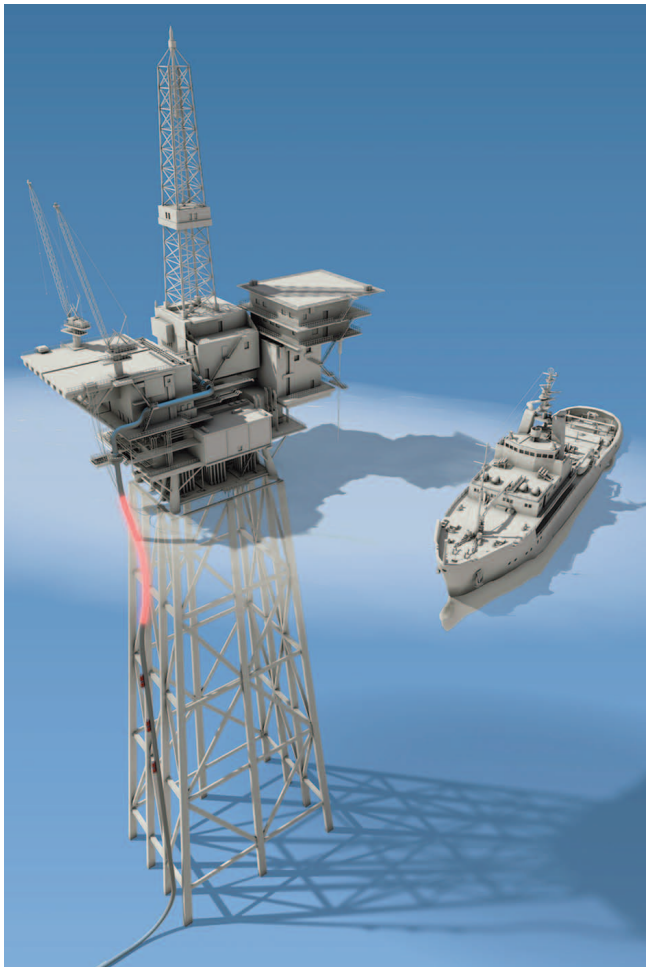


Figure 2. A major operator needed a low pressure isolation solution that would effectively and efficiently isolate a damaged section of a riser from the export pipeline gas inventory.

The first step was to verify and record the pipeline inventory gas pressure, and then close and isolate the appropriate emergency shutdown valve (ESDV). The redundant topside pipework located upstream of the ESDV was removed, and a temporary spool with 12 in. isolation ball valve was installed upstream of the ESDV. Leakage over the ESDV was monitored closely, with a view to minimise pressure build-up in the spool.

Using a custom-designed pig trap and pumping spread, a high friction isolation pig train (HF IPT) was launched and pigged with water to the pre-determined isolation position within a straight spool section of the vertical riser. As shown in Figure 1, the three high friction pigs would isolate the damaged riser section from the gas inventory in the export pipeline without venting or flooding the pipeline, or displacing the pipeline inventory. Once isolated, replacement would be possible.

The use of high friction pigs to create the isolation was not unique. Due to their extremely efficient sealing capabilities, high friction pigs are regularly used during pipeline repair and modification projects for isolation with low pressure differential; the inline gas pressure was 4 bar for this particular project. In this case, however, the pigs had to traverse 1.5 D bends, and the full extent of the damage to the export riser was unknown, making it difficult to determine the internal diameter anomalies the pigs might encounter en route to the proposed set location.

Because of the possibility that unknown obstacles could prevent the pigs from reaching their destination, each of the three pigs in the train was equipped with its own transponder as part of a SmartTrack™ subsea remote tracking and pressure-monitoring system. Designed for use on oil and gas pipelines and based on electromagnetic technology using extremely low frequency (ELF), the SmartTrack system creates two-way (bidirectional), through-wall communication between transponders and transceivers (Figure 3).

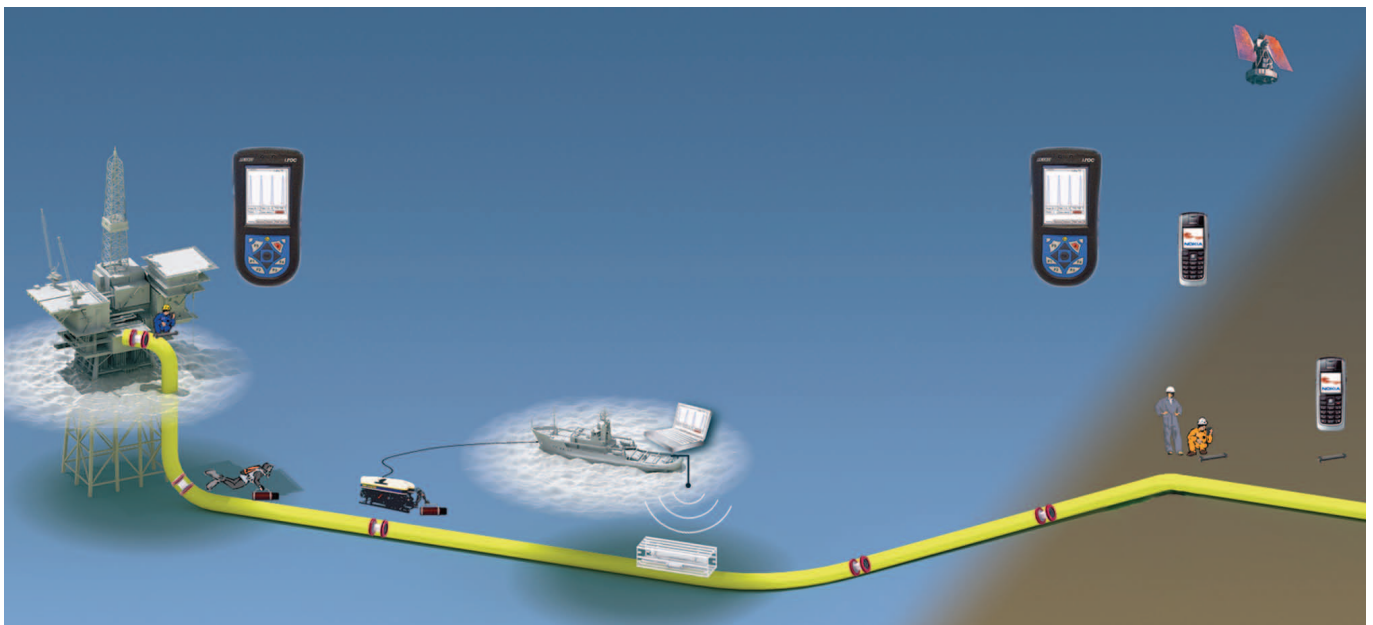


Figure 3. Designed for use on oil and gas pipelines, and based on electromagnetic technology using extremely low frequency (ELF), the SmartTrack™ system creates two-way (bidirectional), through-wall communication between transponders and transceivers.



Figure 4. The skid containing the remote logger was placed parallel to the pipeline, close to the subsea pig receiver.

Because both the receivers and transmitters can receive and transmit information, they are known as transceivers and transponders. Transponders are typically mounted on a pipeline pig, given an identification code, and transmit a unique signal pattern so that the location of each individual pig in a multiple pig train can be readily identified. The transceivers are placed on or near the pipeline, and receive the transmitted signals. The SmartTrack system tracks pigs, whether they are subsea, topside or inside underground pipelines located onshore. The strength, frequency and identification of each signal can even be changed, or the signal transmission can be paused to conserve power, while the transponder is in the pipeline.

Continuous monitoring

Once mounted on a pig and given an identification code, each transponder emitted a unique signal so that its precise location could be tracked. With the help of these transmitted signals, technicians onboard the dive support vessel (DSV) tracked the position of each pig to verify that the HFIPT was located below the damaged section of riser designated for replacement. SmartTrack remote transceivers were positioned over the three pigs and connected to the pig monitoring system. By doing so, technicians were able to monitor the downstream pressure of each isolation pig continuously throughout the operation and at the same time verify that there was no movement of the pig. The through-wall communication technology made it possible to send isolation integrity data by SmartTrack radio link to the DSV.

The existing topside pipework was removed and replaced with new pipework. Divers were deployed from the DSV. The section was successfully cut and removed using a crane onboard the DSV and a mechanical connector was locked onto the existing riser. The new riser was attached to a crane on the platform and lowered down to rope access workers who installed it on the topside pipework above the HFIPT.

Following installation of the new riser section, technicians verified that the ESDV and new 12 in. valve were operating properly and fully open. After purging the riser and topside

pipework, TDW technicians used a pigging pump to slowly increase the water pressure to begin pigging the HFIPT downstream away from the platform to the launcher. The ESDV and 12 in. valve were then closed, and the pipeline gas inventory pressure was increased to keep the HFIPT moving forward. After all pigs were recovered in the temporary pig trap, the ESDV and new valve were closed. Using the platform crane and a remotely-operated vehicle (ROV), all pigging equipment was removed and the TDW crew demobilised. All offshore operations were carried out in about 10 weeks.

This project was the first commercial low pressure isolation to incorporate the SmartTrack pressure monitoring capabilities. Available for pig body sizes 6 in. and above, standard SmartTrack transponders are designed for pipeline pressures up to 300 bar (4350 psi). In this case, the system provided through-wall pressure monitoring on a low inline gas pressure of just 4 bar (58 psi). Not only did technicians isolate the affected riser section effectively and efficiently, the innovative solution meant that the operator experienced reduced downtime.

Atmosphères explosibles

In some cases, the use of sophisticated electronic equipment for pig tracking and pressure monitoring must adhere to the requirements of directives adopted by the European Union (EU). These directives - known as ATEX, after the French phrase 'atmosphères explosibles' (explosive atmospheres) - govern the production and use of equipment in potentially explosive situations. The first directive (94/9/EC) applies to equipment; the second (99/92/EC) applies to workplace practices. Both directives seek to prevent explosions. A piece of equipment that contains electronics, for example, must be reviewed to make sure it will not serve as an ignition source should an explosive atmosphere exist. An explosive atmosphere is one that could become explosive as the result of a change in atmospheric or operating conditions. ATEX is rigorous but specific to Europe; other regions (such as the United States) rely on other certification standards to help control sources of ignition.

The need for ATEX compliance was important on a recent project in which TDW Offshore Services supplied a series of four pigs for use in the flooding, cleaning and gauging of a 36 in., 63 km long gas export pipeline system installed between a permanent pig launcher and subsea pig receiver (laydown head, or LDH) located near a gas processing plant in Kollsnes, Norway. The pigging sequence utilised a set of cleaning/magnetic pigs, followed by a set of cleaning/gauging/magnetic pigs.

Each 36 in. pig was equipped with a SmartTrack D116 ATEX-compliant transponder. The plan called for use of the ATEX-certified SmartTrack topside transceiver with handheld personal digital assistant (PDA) at the launch location for pig tracking topside. The topside transceiver and PDA are intrinsically safe (Ex i), while the transponder D116 uses flameproof enclosure protection (Ex d). All three are ATEX-certified for use in Zone 1, gas group B.

Under normal circumstances, a remotely-operated vehicle (ROV) would carry a SmartTrack remote transceiver that

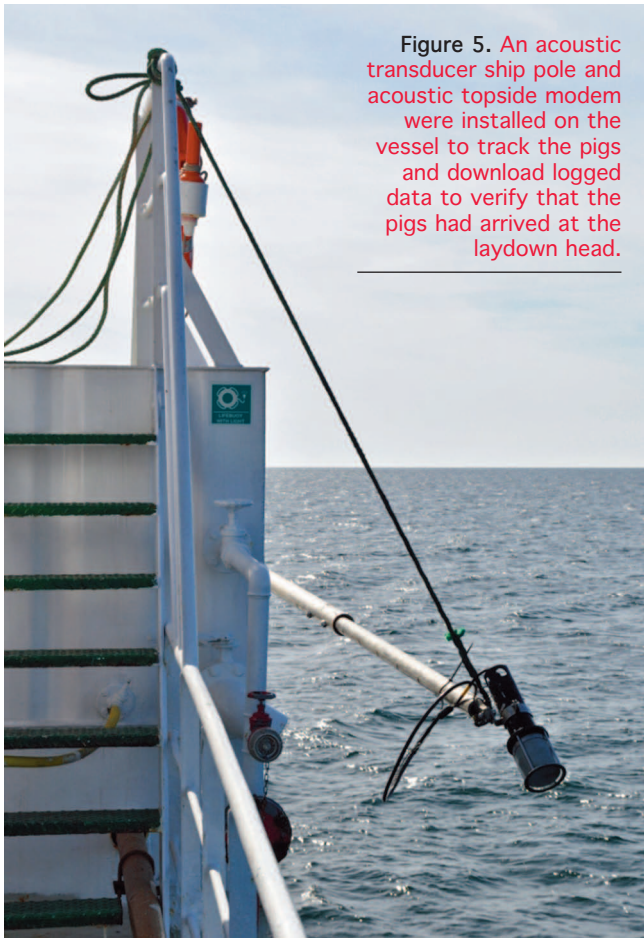


Figure 5. An acoustic transducer ship pole and acoustic topside modem were installed on the vessel to track the pigs and download logged data to verify that the pigs had arrived at the laydown head.

would be used to verify that all four pigs arrived at the subsea receiver. However, no ROV was available at the subsea receiver location, so another method had to be devised. Consideration was given to placing a subsea skid equipped with a remote transceiver and acoustic modem at the pipeline near the subsea pig receiver. Since it was uncertain whether a vessel equipped with acoustic modem topside equipment would be available at the receiver location when the pigs would arrive, the decision was made to integrate a SmartTrack remote logger in the subsea skid.

This approach required that the skid be placed parallel to the pipeline, close to the subsea pig receiver (Figure 4). The

remote logger would create a data log containing all recorded ELF-signals and a summary of detected transponders. This data could be retrieved using the acoustic modem when a ship was within communication range, or it could be retrieved when the subsea skid was retrieved.

Logging the data

This solution allowed live subsea pig tracking via an acoustic link using computer software displaying the ELF-signal and detected transponder IDs. It also allowed downloading logged ELF-data and detected transponder IDs via the acoustic link if a vessel with acoustic modem was not present at all times. The downloaded data could be used to check the date and time of detected transponder IDs and to re-play recorded ELF-signals in the computer software.

To this end, TDW trained client personnel to activate the transponders and to use a topside transceiver for topside tracking and pinpointing at the launch location. A marine support vessel (MSV) installed two stabs (each incorporating a non return valve assembly) at the LDH. The same MSV also installed the subsea communication skid under supervision of TDW personnel.

The air-filled pipeline was free-flooded, and the pipeline system was then re-flooded, cleaned and gauged from the launch location to the LDH using the four bidirectional transponder-equipped pigs propelled by the client's pumping equipment and seawater. The total distance from the launcher to the LDH is 62.6 km, which is at 165 m below mean sea level.

A guard vessel was present at the LDH location during the entire operation. As shown in Figure 5, an acoustic transducer ship pole and acoustic topside modem were installed on the vessel to track the pigs and download logged data to verify that the pigs had arrived at the LDH. It was confirmed that all four pigs had arrived and the LDH was later safely disconnected from the pipeline and retrieved.

This project and the previously discussed riser isolation are just two examples of projects that benefitted from the ability to track pigs (and monitor pressure) using sophisticated electronic equipment. As companies continue to invest in pigs of all types – and particularly in highly engineered isolation and inspection devices – the need to accurately and reliably track the locations of these devices while in service will only increase. **WIP**