Figure 1. TDW designed and delivered this 44 t subsea clamp as part of a custom pipeline repair solution for StatoilHydro.

Mark Sim, T.D. Williamson, North Europe, reveals how to reduce risk by using an Emergency Pipeline Repair System.

BE PREPARED

To ensure that energy supplies flow without interruption, operators need to protect pipelines from damage. They must respond effectively when the unexpected occurs to their subsea lines, whether it is caused by a passing ship's anchor, corrosion or a blockage. Today's operators can substantially reduce risk by establishing an Emergency Pipeline Repair System (EPRS).

An EPRS is an organised plan whose sole objective is to swiftly restore a damaged or inoperable pipeline in order to minimise production downtime. To establish an effective EPRS, potential problems are identified and ranked using a Risk Priority Index (RPI). Optimal repair solutions are set forth that determine the types of investments that must be made in order to fully prepare the operator well in advance of an emergency. Because pipeline isolation facilitates pipeline repair, it is critical that this process features in an EPRS. The following offers guidance on formulating an effective EPRS, highlighting the critical role that technology plays.

Managing risk

A plan for Pipeline Integrity Management (PIM) is integral to every pipeline owner's operation. To achieve this, known risks must be managed to prevent loss of pipeline integrity, leading to production loss, interruption or costly repairs.

As with the PIM, an EPRS is designed to create awareness and understanding of potential subsea pipeline damage scenarios, and subsequent response and repair requirements.

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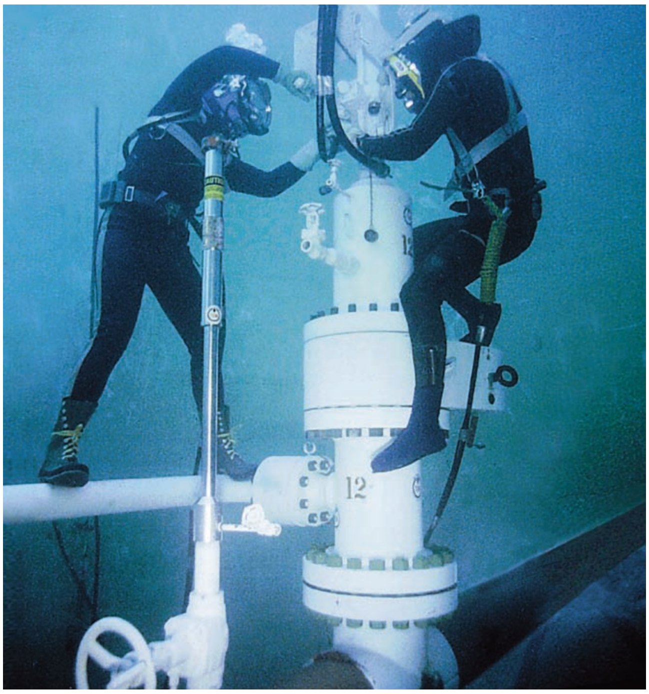

Figure 2. TDW divers carrying out a bypass operation.

The steps are:

1. Assess the risk of potential failure modes, leading to risk priority ranking of the pipelines.
2. Analyse the impact of the damage to identify the likely severity of failure.
3. Develop repair scenarios.
4. Identify essential pre-investments, including repair equipment, marine spreads and other resources.

An EPRS provides a plan to repair damage with care and speed. When fully implemented, it reduces downtime after a pipeline is damaged, which translates into real cost-savings. For example, an EPRS plan can help reduce:

- Regulatory intervention, fines and operating restrictions.
- Negative impact upon share value as a result of lost earnings.
- Costs. It is up to five times more expensive to react when unprepared than to 'pro-act' while relying on an EPRS. For example, premiums paid to contractors called upon during an emergency are higher than fees arranged previously as part of an EPRS.
- Higher cost of insurance following a reactive event.
- Impact on financial standing and reputation caused by business interruption.

Although the EPRS does not reduce the probability of a failure, it minimises the negative impact.

Identifying risks

Risks that can lead to pipeline failure are familiar: corrosion, natural hazards, impact, structural shifts, material defects, and operational errors, among others. Recent experience in the North Sea reveals that an anchor drag incident can cause not only physical damage, but potentially shut down production in adjoining fields tied into the affected pipeline. This would have had a dramatic impact, resulting in long-term interruption for many operators. Losses suffered as a consequence of a failure and the likelihood that failure could be detected are key factors when assessing risk for EPRS planning. Risk can be approached by ranking failure events as the product of three factors:

- Severity Index - potential severity of a failure.
- Occurrence Index - likelihood of a failure.
- Detection Index - difficulty of detecting a failure.

The RPI is central to an EPRS. It identifies failure events that can be anticipated, and repair methods that must to be developed to recover from an unexpected event. It is one of the criteria used when deciding which types of equipment and services must be invested in to support an Emergency Repair Plan.

Plan of action

As soon as word of an incident is received, a swift, organised response is key to restoring pipeline integrity.

- Locate and assess the damage.
- Control pipeline content.
- Decommission and recommission.
- Fabricate/install the replacement pipe.
- Repair the pipeline.
- Return pipeline to safe operation.

Assess the damage

By using intelligent pigs to gather information, damage can often be easily located. Unfortunately, the actual damage could prevent this when pipeline flow is interrupted or when the pig becomes stuck due to unknown pipeline restrictions at the damage site. In this case, using a remotely-operated vehicle (ROV) with video camera, acoustic or side scan survey equipment can pinpoint the damage.

Damage must be assessed to develop a strategy as to how to return the pipeline to safe operation. Ideally, it is best to create a permanent solution. At times, the situation must be stabilised, first with a temporary solution that returns the pipeline to safe operation at reduced or full pressure and flow. Damage can only be assessed with accurate pipeline condition and physical data that can be modelled. This model will provide the basis upon

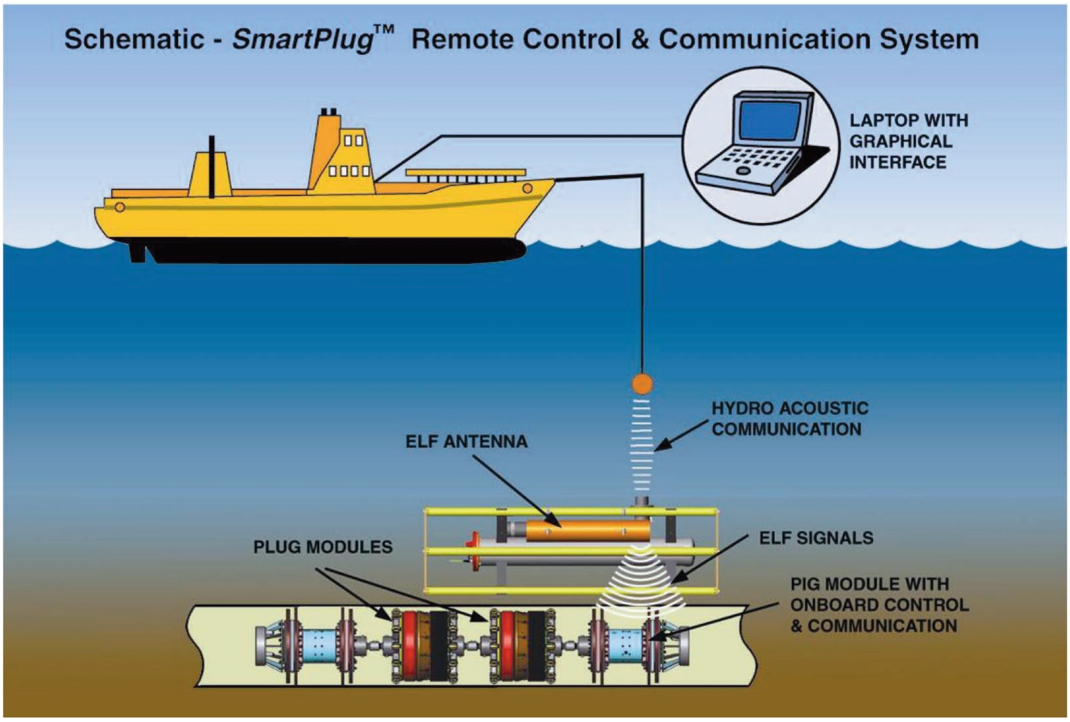

Figure 3. SmartPlug® remote control and communication system.

which repairs can be designed and implemented. This is why having access to original design and installation information, accurate physical assessment, metrology, and internal and external views of the pipeline are critical. Types of damage include:

- Minor: small piggable dents and pinhole leaks that require a leak/reinforcement clamp, not a cut-out.
- Major: non-piggable dents and metal gouges that require a cut-out and replacement.

Minimising loss

To minimise loss while repairs are made, pipeline content must be controlled. To protect, maintain or restart flow quickly, this may be achieved by applying a clamp, creating a bypass or temporary isolation. If not ruptured, content may be protected before the damaged section is isolated and removed, as follows:

- Maintain flow by creating a temporary bypass around the damaged section.
- Suspend flow by closing valves at the pipeline ends.
- Depressurise and/or decommission the line.

Hot tap to create a bypass

Hot tapping is a straightforward way to provide a bypass. A clamp is placed on each side of the damaged section, sleeved around the pipeline and bolted into place. The hot tap is executed, and the bypass is installed using temporary SANDWICH® valves to control the product flow (Figure 2).

Isolate the pipeline: plugging machine vs. plugging pig

A pipeline is often isolated by plugging the line using a system such as TDW's STOPPLE® plugging machine. The STOPPLE plugging head, with the sealing element, is inserted into a hole that is hot tapped into the line. This seals off the pipeline for safe cutting.

When time is of the essence, TDW's SmartPlug® isolation tool is ideal. It does not require pipeline intervention, hot taps, steel fittings or other preparations. SmartPlug technology includes a remote-controlled tool that isolates pipelines ranging 8 – 48 in. in diameter with pressures of up to 240 bar. It is launched from the pig launcher, and pushed by the product flow through the pipeline. Upon arrival at its destination, it is set by way of sealing packers that seal against the internal pipe wall. The SmartPlug tool is a failsafe, double-block sealing system, which is operated by through-wall wireless communications using extremely low frequency electromagnetic waves, making it possible to monitor pipeline pressure on both sides of the seal (Figure 3).

Decommissioning and recommissioning

Although often overlooked, pipeline decommissioning and recommissioning directly affect the speed of recovery, return to operation, and integrity of the pipeline. Extensive pre-engineering efforts should be undertaken so that emergency responders understand the decommissioning process, especially in the event of a rupture. Necessary spreads, resources and procedures must be prepared in advance.

Preparing for the worst: a ruptured pipeline

When a gas pipeline ruptures, gas is released into the sea and seawater floods the line. Responders must weigh the safety implications of approaching a leaking pipeline. For this reason, calculations are made as part of the EPRS studies to assess the depressurisation and flooding volumes, as an indication of the size of the rupture, its location and elevation. These calculations define the requirements for decommissioning and recommissioning, and dictate the size of the pumping spread, compression equipment, and other equipment and services. Armed with this information, agreements with contractors can be secured.

To repair major damage caused by a rupture, the damaged section must be removed. A combination of hot tapping, isolation, decommissioning and recommissioning will help to resolve the situation. For some ruptures, running a combined decommissioning-isolation train from each end is effective. The decommissioning train consists of various pigs, with nitrogen and glycol pushing the gas, seawater and debris out of the rupture. The final pig in the train is a SmartPlug tool. The train is propelled by dry air, so the process of decommissioning is performed while simultaneously positioning the SmartPlug tool. Although complex, this approach is worth considering, given the significant reduction in repair time.

Identifying essential pre-investments

Because none of the items required for effective emergency response are readily available, they must be selected and prepared in advance. The final step of the EPRS planning process is to determine which essential investments must be made. This guide will assist in determining minimum requirements.

- Risk: establish an RPI, identify risks and conceptualise response scenarios.
- Time: affects damage location and assessment, and delivery of long-lead items. To save time, establish framework agreements for aerial and subsea surveys and create an inventory of 'spare' long-lead items, such as sufficient line pipe for each pipeline and two structural clamps per line for repair purposes.
- Costs: consider the primary costs involved in emergency repair and how pre-investment can reduce overall costs. Fees for intensive offshore repair services and equipment are high. Engaging marine service providers in advance will minimise costs. To ensure that agreements are tailored to meet specific needs, create detailed procedures for repair scenarios and enter into framework agreements with contractors for marine spreads and specialised equipment for these scenarios.
- Value: protect the value of the pipeline content. By carrying out bypass, isolation and recommissioning procedures immediately, losses will be reduced and value will be greater. To optimise response, establish framework agreements for hot tap and plugging, SmartPlug isolation, decommissioning and recommissioning services. An inventory of decommissioning and recommissioning equipment spreads should be created.

EPRS: an essential expenditure

Pipeline operators must anticipate events that could damage a pipeline or interrupt flow. They should be prepared to mitigate incidents that might occur throughout the lifetime of each asset. As operators consider investing in additional pipelines, they should include EPRS that extend over the pipeline's life expectancy in their capital expenditures and operating expenditures budgets.

The EPRS engineering study is Phase I of the process. It identifies gaps in the essential needs. A comprehensive EPRS consists of four phases:

- Phase I – define: define scenarios and essential needs.
- Phase II – mobilise: purchase essential and long-lead items, enter into service contracts and frame agreements for decommissioning/recommissioning spreads, develop procedures, organise training plans and prepare the base.
- Phase III – maintain: maintain essential items and storage facilities, establish maintenance and repair contracts, and adhere to a schedule of regular training and readiness drills.
- Phase IV – intervene: organise the appropriate response package, and use it to locate and repair damage.

Is the industry responding?

Preparing for potential subsea pipeline disruption as a part of a prudent operations contingency plan is gathering momentum. In the North Sea, a major operator maintains a sophisticated arsenal of EPRS equipment and a staff of 30 full-time trained responders. Elsewhere, an operator is customising an EPRS to protect its assets in the Gulf of Mexico, and operators of offshore gas pipelines in the Persian Gulf are planning to implement world-class EPRS programmes that focus on anchor drag. EPRS Clubs are springing up in offshore markets where they must respond to one failure event, as opposed to a multiple loss scenario caused, for example, by a hurricane that affects one area.

A common sense approach

To mitigate pipeline downtime in the wake of an emergency, operators must identify emergency scenarios, and appreciate the value of investments that will dramatically reduce lengthy response times. By investing in critical equipment, pipeline content can be managed with minimal loss or disruption of flow. Exorbitant costs of emergency marine services can be reined in by simply entering into agreements in advance. These are the essential elements of an EPRS, which aims to reduce loss inflicted by the unexpected.

EPRS in and of itself is not difficult. In fact, it is a matter of common sense. It does, however, represent change, and change can be daunting. However, as more and more operators prepare themselves for a safe and prosperous future, they will embrace emergency preparedness as a matter of course. It is only a matter of time. WP