

The Challenges Of Emergency Pipeline Repairs - Introducing New Rapid Pipeline Repair Methods

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Abstract:

Protection of critical pipeline assets against risk of physical and operational trauma should be of the highest priority to ensure uninterrupted energy supply. The Trans ASEAN Gas Pipeline forming the arteries of a vibrant economy would be a case in point. While the cause of trauma may vary from external events, such as impacts by ship anchors or natural hazards, to internal events like corrosion or operational blockages, the consequence is the same: sudden damage or inoperable pipelines. An important risk reduction measure is the establishment of an emergency pipeline repair system (EPRS) which is a planned, organized response capability to swiftly restore a damaged or inoperable pipeline, as it minimizes production downtime and cost and reduces extended exposure of people, asset and the environment. EPRS involves the identification and ranking of the potential problems using risk priority index, and defines the repair solutions and determines which essential pre-investments should be made in advance in order to be operationally ready before an emergency arises. Recent negative operating experiences from real pipeline downtime incidents are changing conventional wisdom from reactionary to proactive. EPRS is a complex system supporting multiple repair scenarios involving various players, technologies, materials, equipment and resources. Subsea pipeline isolation plays an important role in facilitating the pipeline repair. This paper shares some EPRS experience and new technology for a solution that allows the pipeline operator to restore flow significantly quicker than conventional repair methods. The paper addresses the criteria that will help make the right investment decisions which will save time, cost and money.

1. Introduction

This paper presents an overview of the challenges subsea pipeline operators face concerning Emergency Pipeline Repair Systems (EPRS) and discusses the main criteria for investment decisions to ensure operational readiness for a rapid reinstatement of a pipeline after an emergency event. The paper is presented against the backdrop of the continuing development of critical subsea pipeline assets delivering energy to end consumers such as the Trans ASEAN Gas Pipeline. These critical energy supply networks form the vital arteries to support vibrant regional economies. Protection of these critical subsea assets against the risk of physical and operational trauma should be of the highest priority to assure the uninterrupted flow through the pipeline network and the energy supply to the customer.

WHY EPRS?

1.1 Risk Management Options

At the centre of every subsea pipeline owner's operations there is a Pipeline Integrity Management Plan (PIM), the purpose of which is to ensure that the pipeline infrastructure remains "Fit for Purpose", with due regard for safety and the environment. The objective of a PIM Plan is to ensure that the pipeline network is able to perform the intended function for its design life, and one of its key elements is the management of known risks in order to prevent or mitigate any loss of pipeline integrity, leading to loss of production, customer interruption, and/or expensive repairs.

What are the risk management options available to an operator? In generic terms there are three (3) risk management options:

- i) Eliminate the risk through engineered solutions.

- However, total risk elimination is highly unlikely because of the high costs involved, the human factor and the uncertainty of environmental conditions.
- ii) Accept the risk. This is a reactive mode that will ultimately prove to be very costly, not only in dollar terms due to extended loss of production and unplanned repair, but also in terms of potential loss of customers and reputation. This approach is likely to lead to unmitigated exposure of people, assets, and the environment, under the undesirable glare of the media and, ultimately, may lead to possible legal actions against the operator and stakeholders alike.
 - iii) Reduce the risk, by reducing the probability of occurrence and/or the consequence of failure. In this regard, an Emergency Pipeline Repair System (EPRS) is a risk reduction measure because it reduces the consequence of failure.

EPRS is defined here as a comprehensive program aimed at creating awareness and understanding of possible subsea pipeline damage scenarios and subsequent response and repair requirements. The steps generally involved are:

- i) Risk Assessment, of various failure modes, leading to risk priority ranking of the pipelines;
- ii) Damage Consequence analysis, to identify the likely severity of failure;
- iii) Repair Scenario development, identifying the key repair methods;
- iv) Essential pre-investments, in long lead items, critical repair equipment and in securing marine spreads and other specialized resources, to enable an expeditious response and restoration of the pipeline flow after an incident.

An EPRS is a proactive measure, akin to buying Builders Risk Insurance for a new pipeline being laid or production facility being installed, as it anticipates the bandwidth of potential risk exposures and provides coverage for same. In the case of EPRS it provides the upfront mitigating solutions to respond and repair the damage in the shortest time possible. At its core, the EPRS, if fully implemented, minimizes the downtime following a subsea pipeline damage event. Minimizing downtime converts into real economies of substantial “cost savings” to the operator in terms of:

- i) Business interruption and its financial and credibility consequences;
- ii) Share value impact through missed earnings;
- iii) Reactive versus proactive costs – it is estimated to cost at least 3 to 5 times more to react than “pro-act” through an existing EPRS program as premiums are paid to contractors and suppliers called upon in an emergency

- state versus pre-established fees or pre-arranged Frame Agreements;
- iv) Higher costs of subsequent insurance coverage following a reactive event; and,
- v) Regulator intervention and potentially fines and/or future operating restrictions.

Although the EPRS does not reduce the probability of occurrence of a failure, it does reduce the consequence of failure, and is therefore an important risk reduction measure. The challenges a subsea pipeline operator faces are many in deciding, implementing, and investing in EPRS, given it is planning and spending for a future event that may never occur. But as the saying goes, “an ounce of prevention is worth a pound of cure”.

WHERE IS THE RISK?

1.2 Risk Assessment

The risk of damage lies in the well known modes and mechanisms of subsea pipeline failure which are: corrosion, natural hazards (hurricane/typhoon related, mudslides, earthquakes, seabed current erosion, etc), impact (dropped objects, anchor snags), structural (thermal or pressure expansion or contraction), material (cracks, fatigue), operations (line plugging, deep water SC Riser dynamics) and others. Instinct tells us that corrosion is probably the most frequent and widely occurring failure on the one hand, whereas anchor snag likely causes the most severe damage on the other. Recent experience in the North Sea reveals that anchor drag incidents result in not only physical damage to the pipeline, but also in production shut-in of adjoining fields tied in to the affected pipeline causing huge impact and interruption to many operators for an extended period of time. In another incident the damage to the pipeline was only detected months after it occurred thus jeopardizing the PIM plan. These experiences show that the consequential losses and likelihood of detection are other important factors to be considered in the assessment of risk and planning around an EPRS.

One way of looking at risk is by ranking the failure events as the product of three (3) factors:

- i) The **Severity Index** defines how hazardous a failure is likely to be. Ranked from 1 (no discernible effect on product or subsequent processes) to 10 (hazardous effect, safety compromised, noncompliance with government regulations).
- ii) The **Occurrence Index** defines the likelihood of a failure. Ranked from 1 (failure unlikely, history shows no failures) to 10 (failure almost certain)
- iii) The **Detection Index** defines the difficulty of detection of a failure. Ranked from 1 (almost certain detection) to 10 (almost impossible to detect failure).

A Risk Priority Index (RPI) defined as $Severity \times Occurrence \times Detection$ and its value – varying from 1 to 1000 – determines the overall ranking of a failure mode.

Interestingly, the RPI also shows that the most frequent causes of incidents are not necessarily the highest ranked ones. Statistics for the Gulf of Mexico see Figure 1 shows that the highest number of incidents for pipelines and risers over the last decade is dominated by Internal Corrosion at 33% of all incidents, followed by Natural Hazards at 17% and Impact at 12%. A further breakdown of potential causes of failure is shown in Figure 2.

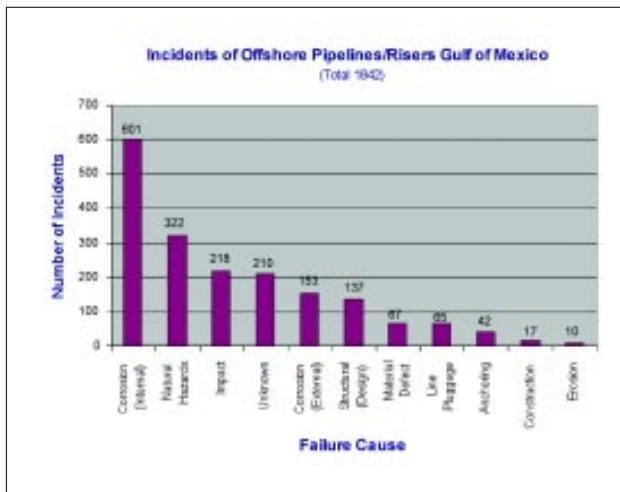


Figure 1 – Incidents of Offshore Pipelines/Risers in the Gulf of Mexico



Figure 2 – Potential Causes of Failure

However, a Failure Mode and Effect Analysis conducted for the Gulf of Mexico incorporating the occurrence, severity as well as detection indices, revealed that the highest RPI is calculated for anchor snag (wet buckle) with 450 points followed by anchor snag (dry buckle) with 360 points. See Figure 3. This is not in the least because of the significant contribution to the RPI made by the high severity index of and high difficulty in detecting an anchor drag event.

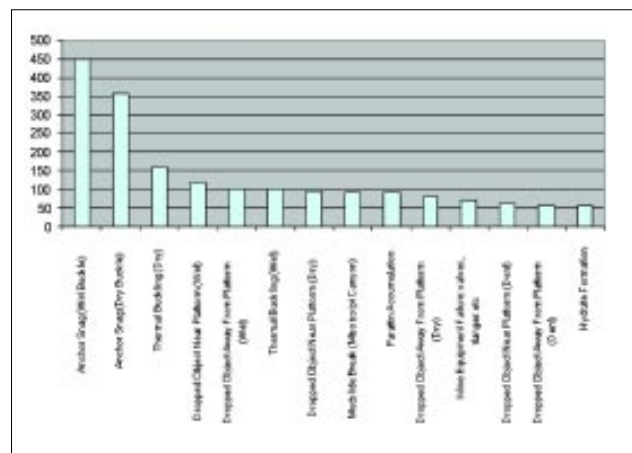


Figure 3 – Risk Priority Index (Operational) - Gulf of Mexico

The RPI is an important parameter as it tells which failure events can be anticipated and which repair methods need to be developed to recover from such an unplanned event. In other words, the RPI is one of the key criteria in the decision making process of what to pre-invest in an Emergency Repair Plan. A fully developed RPI for an operator's specific subsea pipeline assets will determine what causes of failure and failure modes will likely impact their system, and will provide insight and guidance as to what damage consequence, response, and repair scenarios need to be considered for their network.

WHAT KIND OF DAMAGE AND WHICH REPAIR SCENARIO?

2. Damage and Repair Scenarios

After an incident has occurred, a sequence of activities will have to take place as a swift, organized response to restore the integrity of the pipeline, as illustrated in Figure 4:

- Find the damage
- Assess the damage
- Control the pipeline content
- Decommissioning and Re-commissioning
- Fabricate/install the replacement pipe
- Repair the pipeline.
- Return pipeline to safe operation

2.1 Find the Damage

Damage can be located based on information provided by intelligent pigging devices such as geometry pigs which locate and quantify dents or ovalities or MFL tools that detect metal loss from gouges. However, the damage itself could rule out the use of intelligent pigs because pipeline flow may already be interrupted for pressure reduction safety reasons or because there could be a real risk of getting them stuck due to unknown pipeline restrictions at

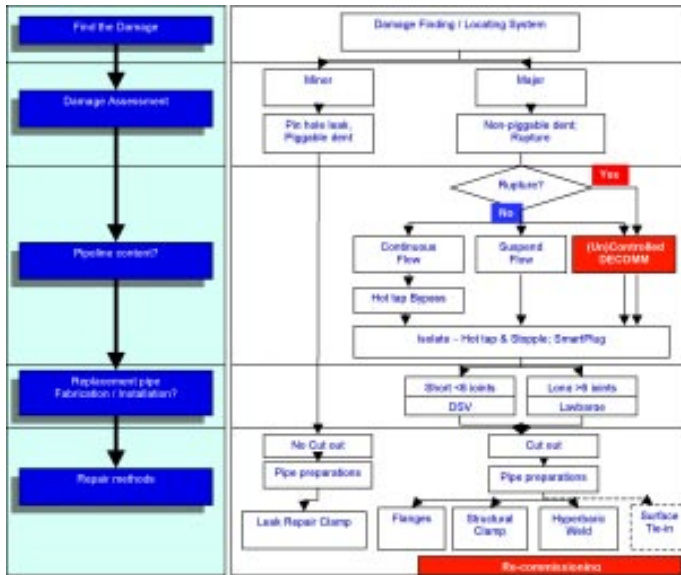


Figure 4 – Damage repair sequence & decision tree

the damage site. In this case the primary way to find the location of the damage is by external means, i.e. with vessels towing an ROV sporting all necessary video camera and other equipment, acoustic or side scan survey equipment, supplemented by an aerial survey to detect visual evidence of the damage, such as bubbles and/or oil slicks emanating from the damaged pipeline. Extensive subsea pipeline networks can easily consist of many critical subsea pipelines of long lengths and they are spread over a large geographical area. This calls for the design and deployment of effective protocols for damage-finding and survey systems comprising aerial and marine surveys, supported by well developed procedures to quickly find the damage. Given the size of the ASEAN region the early establishment of a number of coordinated “search hubs” may be needed for the Trans ASEAN Gas Pipeline, each with a dedicated framework agreement with aerial and marine service providers. The key in such search and find surveys is to have quick, ready access to current and accurate pipeline route coordinate and as-built information.

2.2 Damage Assessment

Damage assessment is carried out to decide exactly what needs to be done to the pipeline to return it to safe operation. The obvious objective for any assessment is to find a permanent solution, however, due to the complexity of issues involved, it may be necessary to use a phased approach wherein a temporary interim solution is deployed to safely stabilize the situation first, and then a follow-up phase to engineer and deploy the permanent repair solution. In the meantime, the goal of the temporary solution is to enable the pipeline to return to safe operation, either at reduced pressure or, optimally, full pressure and flow. Decisions that could be involved include whether the damaged section needs to be cut out and, if so, how much

of the line must be replaced. The decision rests on fit-for-purpose criteria as stipulated in the operator’s PIM plan, in compliance with international pipeline codes and local regulatory requirements. Damage assessment can only be accomplished with accurate pipeline condition and physical data that can be modeled so as to provide the basis around which reparation solutions can be designed and practically implemented. Therefore, having existing as-built design and installation information, and accurate physical assessment, metrology, preferably internal and external views of the pipeline are essential. The quicker this information can be accessed, assimilated and applied towards solution options, the sooner the pipeline can return to operation. Typically, there are two main categories of subsea pipeline damage categorization or characterization:

- i) Minor damage, such as small piggable dents and pin hole leaks, which generally do not require a cut-out but only a leak/reinforcement clamp; and,
- ii) Major damage which does require a cut out and replacement, such as non-piggable dents, metal gouges in the pipeline, long snaking displacements due to anchor snag, or a rupture of the pipeline.

The difficulty in assessing damage lies in the fact that, without the aid of internally launched devices, it relies primarily on visual details or measurements obtained by divers or ROV based equipment; however, the information provided is of limited accuracy for a finite element stress analysis. It is believed that there is still some work to do by the industry in this important area of response to come up with more accurate external damage assessment tools and methodologies in order to arrive at the right reparation decisions and optimal cut-out lengths in the shortest timeframe.

2.3 Control of the Pipeline Contents

This is about managing the precious commodity inside the pipeline – the gas or the oil/liquid products being transported. What does one do to limit the losses during the emergency response and repair? Stabilization (applying a clamp), bypass, temporary isolation and prompt de-/re-commissioning are the means to either keep the product flowing, or retain its value during the repair or to get it flowing again in the shortest possible time. From the chart in Figure 4, it follows that pipeline inventory management depends on whether the pipeline is ruptured or not.

Non-Ruptured pipeline.

If the pipeline is not ruptured, there are three (3) basic ways to deal with its content before isolating and cutting out the damaged section:

- i) Maintain the flow, sometimes involving lowering operating flow rates and pressure, and by creating a temporary bypass around the damaged area;
- ii) Suspend the flow, by closing the valves at the pipeline ends, or
- iii) Controlled depressurization and/or decommissioning of the line. This may be required in case the MOP must be lowered, or if it is desired to repair the line under decommissioned conditions.

The hot tap process and isolation methods facilitate the inventory management and they are addressed below.

Bypass – by Hot Tapping

The process of creating a bypass without shutting down the pipeline using hot tap technology is well known in the pipeline industry and has been used in many applications both onshore as well as offshore for decades. A hot tap fitting, one located on each side of the damaged section, is sleeved around the pipeline after cleaning of the pipe surface and is bolted in place, and the hot tap is executed. The hot tap machine is then removed and the bypass is installed, using the temporary sandwich valves to control the product flow through the bypass. An example of a hot tap set up is shown in Figure 5.

Isolation – by Pipeline Plugging Machine

The conventional method to isolate a pipeline is by plugging the line, for instance using the TDW **STOPPLE® Plugging Machine**, as illustrated in Figure 6. The Stopples plugging head donned with the sealing element is inserted into a hole which is hot tapped in the line, thus sealing off the pipeline and allowing the pipeline to be cut. For diver safety reasons most diving contractors and pipeline operators require the installation of two Stopples in tandem to establish a double-block-and-bleed arrangement. Figure 7 shows the general arrangement of a Bypass and Stopples plugging set up. Eventually, a single Stopples system can be applied using the TDW STOPPLE® Train system that incorporates two



Figure 5 – Typical Hot tap set up



Figure 6 – Typical STOPPLE set up

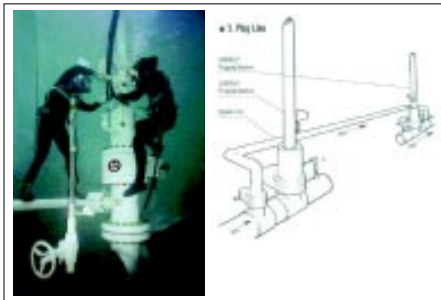


Figure 7 – Bypass and STOPPLE Plugging set up.

plugging heads acting as a double-block.

Before cutting, the damaged section is depressurized and flushed with seawater and chemicals or nitrogen applied from the surface support vessel through two vent valves tapped into the line. The cut can then be performed safely and without polluting the environment.

Isolation – by Plugging Pig

A novel method to isolate a pipeline in a very fast way is the **TDW SmartPlug®**. A SmartPlug® is a remotely controlled and operated (umbilical-less) pipeline isolation system, which has been applied in oil and gas pipelines with diameters ranging from 8” to 42” and pressure differentials up to 240 bar. See Figure 8.

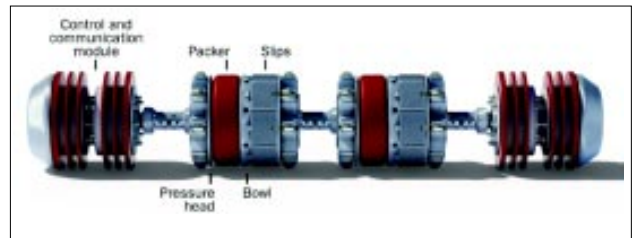


Figure 8 – TDW SmartPlug®

The SmartPlug® is launched from the pig launcher and is pushed by the product flow and upon arrival at a pre-established location, is set (sealing packers are energized to seal against the internal pipe wall) and is locked in place until it is deactivated. The system is a fail safe, double block sealing system type approved by DnV. See Figure 9. The SmartPlug® is operated by through-the-wall wireless communications using Extremely Low Frequency (ELF) electromagnetic waves from an external SmartTrack® subsea communications system. Control of the SmartPlug® enables the operator to monitor pipeline pressure on both sides of the seal and if appropriate, command the SmartPlug® battery power into hibernation mode to preserve battery life during extended isolation applications. The longest duration a SmartPlug® has been in position and subsequently and successfully awakened, exceeds 400 days.

The SmartPlug® is by far the fastest deployable isolation device and does not require pipeline intervention; there are no hot taps, no heavy steel fittings and no other pipeline preparations. That said, as with any device inserted into the bore of a pipeline, confirmation of the piggability of the pipeline is critical to configuring the SmartPlug® for the application and ensuring it can be readily pigged to its set location. Finding out in the midst of a

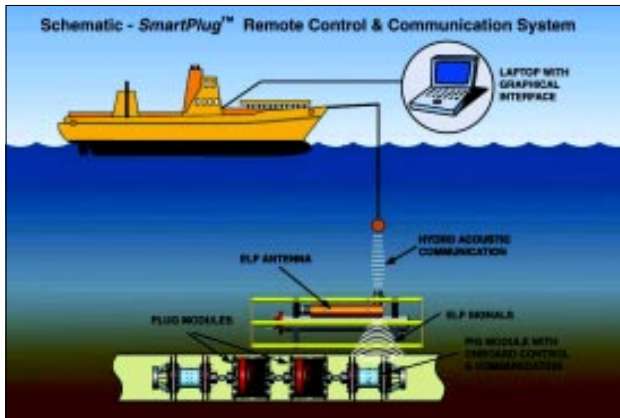


Figure 9 – SmartPlug® remote control & communication system

pipeline emergency that the pipeline has differing OD's or ID's, tight bends, insufficient launching or receiving facilities, or that pipeline flow cannot be achieved is not a desirable situation. Pre-engineering and piggability studies BEFORE the need arises can then help ensure a speedier response and better outcome. One must also understand that there is, however, a temporary disruption to the product flow since the SmartPlug® must be slowed down and stopped by the product flow once in position, which is achieved by the pipeline operators manipulating the upstream and downstream process flow valves. Once the SmartPlug® is in position and has been set, flow can be resumed if a bypass has been installed, as presently there is no bypass through the SmartPlug® itself.

VERSATILITY OF SMARTPLUG ISOLATION TECHNOLOGY

Figure 10 demonstrates the versatility of the SmartPlug® as it can be applied for various sizes of damage:

- For dents less than 5% the codes generally do not require a cut out, only a leak repair/reinforcement clamp, so no isolation is required;
- For dents between 5% and 10%, a train of two SmartPlugs® with a slug of glycol in-between can be launched into position on either side of the dent and activated in place, allowing for immediate cut out of the damaged section;
- For dents larger than 10%, which the SmartPlug® cannot pass through, the upstream SmartPlug® is launched from the pig launcher up to the damage, while on the downstream side the Smartplug® can be installed in-situ, by inserting it using a coiled tubing injection head through a hot tap and subsea launcher in a post-installed wye-piece;
- For ruptured gas pipelines, the SmartPlug® can potentially be launched from each end of the pipeline

towards the damage, depending on the engineered decommissioning process. This is discussed in the next paragraph. This method, however, is not applicable for oil lines as the oil content will be pushed ahead of the SmartPlug® into the sea through the rupture, causing unacceptable environmental pollution.

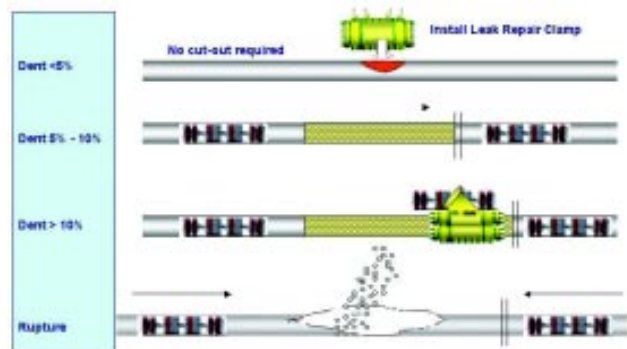


Figure 10 – SmartPlug® launching for various damage sizes.

In conclusion, while both the Stopple and the SmartPlug® methods can be used for isolation purposes, the SmartPlug® is by far the fastest isolation method providing that pre-engineering of the pipeline system has been accomplished, and is superior to Stopples in terms of material usage, marine spread and execution time, safety, schedule, cost and future integrity of the repair.

2.4 Decommissioning / Re-commissioning

The subject and application of decommissioning and subsequent re-commissioning of the pipeline is of great importance and must have a prominent place in any EPRS for it to be comprehensive and effective. DECOMM/ RECOMM can be and is oftentimes overlooked and is brought in as an after-thought in terms of planning and preparation. However, it has a significant influence on the speed of recovery, return to operation, and the overall integrity of the pipeline. Extensive pre-engineering efforts should be undertaken as part of the EPRS studies in order to have a full grasp of the decommissioning process, in particular in a rupture event, and to decide which necessary spreads, resources, and procedures should be prepared for in advance to ensure a rapid decommissioning and re-commissioning of the pipeline when the time comes. Many times the commissioning spreads used during the installation of the pipeline, which can be sizeable in surface area footprint for set up of numerous sets of equipment packages (pumps and/or compressors), could be under much tighter constraints post pipeline start-up and operation. For example, safe work areas may be limited, access to water may be limited, areal footprint may be reduced, along with

restrictions on noise, release of gas and other constraints. Some of these constraints may be difficult if not impossible to change during an emergency response and the time to be working through these constraints is not during the emergency itself.

Ruptured Pipeline

In the unfortunate event of a rupture of a gas pipeline, the following scenario unfolds: the gas is released into the sea until the pipeline is depressurized down to seabed ambient, and seawater, possibly contaminated with surrounding seabed soil, will flood uncontrollably into the line until it is stabilized in accordance with the local pipeline topography profile. Small ruptures are almost more difficult than large ruptures particularly if the pipeline continues to release product slowly into the water. Accessing the worksite becomes a safety matter as surface vessels and divers must carefully weigh the safety implications of approaching a slow leaking pipeline. Calculations can be performed as part of the EPRS engineering studies to assess the depressurization duration and the flooding volumes as a function of the size of the rupture, its location along the pipeline route and elevation relative to surrounding profile. The outcome of the calculations will define the basis for the decommissioning and re-commissioning requirements, such as the minimum pumping spread, compression, nitrogen, air drying and vacuum drying equipment, pigging products and services. From this outcome, early Framework Agreements with potential response vendors and contractors can be made.

In the above paragraph – Isolation by SmartPlug® – one scenario pertains to the launching of SmartPlugs® from each end of the pipeline in case of a rupture. In this scenario, one could consider running a combined decommissioning and isolation train from each end. The decommissioning train consists of various pigs with batches of nitrogen and glycol pushing the gas, seawater and debris out of the rupture; the last pig is the SmartPlug® isolation pig. Pushing the train is done by dry air, so the process of decommissioning is performed while simultaneously positioning the SmartPlug® isolation devices. This process is complex and requires a good bit of engineering effort but is worth considering in case it would result in significant savings in repair time. Again, the emphasis is on pre-planning and pre-engineering a “knowable” event. One can anticipate and model scenarios that could befall the pipeline before the bell rings, not after.

2.5 Fabricate/Install the Replacement Pipe Spool

The replacement pipe section or spool is usually prepared and lowered to the seabed by the Diving Support Vessel (DSV). However, there is a limit in length that can be

comfortably handled by these vessels, typically up to a maximum of 4 to 6 pipe joints. Unusually long pipeline replacements in case of extensive damage caused by anchor drag, will need to be installed by a heavy lift marine vessel or pipelay barge installation method. Irrespective of which type marine spread is employed, access to the right equipment at the right time is critical to the speed with which the response and reparation work can be completed and pre-planning and pre-screening such capabilities is important to the overall success of the EPRS.

2.6 Repair the Pipeline

There are generally two different repair solutions depending on the size of the damage:

- i) No cut-out: or minor damage such as piggable dents and pin-hole leaks; the damaged section does not need to be cut out. The repair consists of simply installing a leak repair/reinforcement clamp around the small damaged part, after cleaning of the pipe surface. The key determinants for not having to cut out the section are generally future operational piggability and operator permanent PIM and pipeline repair philosophy.
- ii) Cut-out: For major damage such as non-piggable dents or rupture, the damaged section must be cut out and replaced by a new pipe. In this case all the aspects discussed above can take place: hot tapping, isolation, decommissioning and re-commissioning. A repair of this nature involves quite a number of activities both subsea and on the surface, involving a marine spread consisting of a DSV, diving spread, survey vessels and transportation barges, specialized pipeline preparations and repair equipment and pipeline connection equipment.

To illustrate the complexity of the offshore operations, here are a few of the steps that may be required in a typical subsea pipeline repair sequence, each requiring specialized equipment and/or tools and trained and available crews:

- find and uncover (if applicable) the pipeline and the damage site
- perform visual inspections and metrology
- perform desktop engineering analysis and assessment
- develop response and repair plans and procedures including DECOMM if appropriate
- lift the pipeline to gain full round access
- temporarily support the pipeline
- remove the concrete & corrosion coating
- option - install interim/temporary repair clamp
- install fitting and perform hot tap
- install bypass
- install isolation Stopples and/or SmartPlug®
- flush out the hydrocarbons & perform cut out

- perform metrology
- prepare replacement spool
- prepare pipe-end
- lower the replacement spool
- connect the pipe ends
- RECOMM the pipeline
- return pipeline to operation

Many of the above activities are the bread-and-butter business of many offshore contractors. We will not go into details here but we will highlight the connection method because it is of considerable importance.

There are four generic connection methods available in the market:

- Flanges: a mechanical end connector complete with flange on the subsea pipe end, aligned with a ball-flange cum swivel flange welded on the replacement pipe-end. Bolting by divers;
- Structural clamps, simply placed over and gripping the connection at the point where the replacement pipe-end is aligned with the existing subsea pipe end. Can be diver-assisted or diver-less using ROV and running tools;

- Hyperbaric welding, by lowering a specially designed welding chamber over the connection point, displacing the water with air and performing a full penetration, butt weld in a dry environment;
- Surface welding, by lifting the two subsea pipe-ends to the surface and welding the replacement joint in between them, and relaying the pipeline.

The latter two methods by welding are the most expensive ones and are not usually applied. Most companies use the flanged connection method or the structural clamp method, which is the fastest and easiest. The structural clamp connection is also the method that is adopted by the Deep Water Response to Underwater Pipeline Emergencies – DWRUPE – the “EPRS club” of the Gulf of Mexico offshore industry. The structural clamp can also be used as a leak repair clamp, so the spare inventory requirements for an EPRS can be minimized.

3. Investment in Emergency Repair

From the above description it becomes clear that an actual repair requires the mobilization of a lot of products,

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services, equipment and intellectual property which we could summarize into the following groups:

Group 0: EPRS Scenario and Response Engineering – problem definition & solution; compliance to codes, regulations and operators philosophy.

Group I: Pipeline Preparation and Handling Tools – for pipeline preparations (lifting, cleaning, cutting etc).

Group II: Connection and Clamping – flanges, misalignment flanges, pressure or structural clamps.

Group III: Intervention, Isolation and Recovery – Bypass, isolation, hot tap, SmartPlug®, DECOMM/RECOMM.

Group IV: Marine Survey, Construction & Support – marine spreads, DP vessels, dive support, ROV, surveys.

Generally Group 0 is developed by the operator in conjunction with specialized engineering companies/EPRS providers. Group I and IV are typically part of an offshore contractor's spread, whilst Group II will be free issued by the company, and Group III may be a combination of Free Issue materials and specialist vendor/subcontractor services.

WHICH ESSENTIAL ITEMS SHOULD BE ACQUIRED?

3.1 Essential Pre-investments

None of the items in these groups are off-the-shelf items that can be easily and quickly mobilized in case of an emergency. One can imagine the sense of bewilderment or panic in a real emergency if one does not have any of these items within reach or under one's immediate control. This is where the real value of an Emergency Pipeline Repair System comes into plain view. As explained in the Introduction, the last step of an EPRS process is to determine which essential investments must be made in advance. With these essential items at his disposal, the operator can confidently face nearly any emergency occurring in the future and be reasonably assured that he can restore his pipeline to operation in the shortest possible time and in the safest manner.

Decision criteria & Essential Pre-investments

Which items does an operator essentially need? It is not necessary that all the items in each group are acquired in advance and stored in the operator's premises. The following criteria may help to decide which pre-investments may be required as a minimum:

Risk – What are the main risks?

Risk comes in many forms and modes. Knowing the relevant risks will help focus upon the most realistic emergency response scenarios. Therefore:

- Establish the Risk Priority Index impacting the pipeline network.
- Clearly identify the risk scenarios and conceptualize

the response scenarios

Time – Which EPRS equipment investments and specialty service Frame Agreements will result in time saving in an emergency response?

Time is a factor in damage-finding & damage-assessment, and in the delivery of long lead items, such as flanged connections and structural clamps etc. which can take anywhere from 6 to 9 months, sometimes longer particularly dependent on pipeline size, service (sour or sweet for example), and pressure rating. To save time, the following actions are recommended:

- Establish Framework Agreements for aerial & subsea surveys.
- Build up a spares inventory of Long Lead Items. For example:
 - o Sufficient line pipe for each critical pipeline.
 - o Minimum 2 Structural Clamps (=Leak Repair Clamp) per line.

Cost – Where are the main costs in an emergency repair and how can pre-investment contribute to overall cost savings? High cost is to be expected in the intensive offshore repair operations involving subsea diving and other marine spread, specialized equipment and services. Upfront engagement with marine service providers would be an effective cost saving measure. Therefore:

- Establish detail procedures for relevant repair scenarios, and
- Based on the established scenarios, establish Framework Agreements for marine spread & specialist equipment with selected marine contractor(s).

Money – Where is the money in the operations and how to save it?

Money is in the pipeline content, the better the inventory is managed with a swift bypass and isolation and a speedy re-commissioning, the more money will be saved.

- Establish Framework Agreement for hot tap & plugging and SmartPlug services.
- Establish Framework Agreement for DECOMM/RECOMM services and
- Build up an inventory of critical DECOMM/RECOMM spreads.

A Framework Agreement can take many forms and shapes depending on the particular needs at hand and whether the company is to own none of the equipment, or some or all of it. The Agreement could be a full commercial contract, a price agreement, a call-off contract, a retention contract, Blanket Purchase Order, etc. It could be in a Lump Sum format, or time & material, day rates or any combination thereof. Of course the practicalities of fulfilling

relatively unknown response and repair circumstances make lump sum contracting difficult to employ in practice.

All the above can be worked out in detail in a **comprehensive EPRS engineering and GAP analysis study.**

3.2 EPRS is a Lifetime Commitment for a Pipeline Network

In a way, pipeline incidents are reasonably knowable in advance, like decommissioning of an old production platform. Pipeline operators contemplating investment in new pipeline assets should include EPRS in the CAPEX and OPEX budgeting of their projects over the expected life of the pipeline asset. While EPRS is a relatively new concept in the world of subsea pipelines, recent pipeline incidents occurring around the globe, and the relatively disorganized responses and lack of preparedness to them along with extended downtimes suggest that a new way of thinking and planning is called for in operators' investment, operating planning and decision-making. With the immediacy and speed of stock and commodities market rattling news events, the shareholders and stakeholders of pipeline operating companies are under increasing pressure to reasonably plan what is knowable and to be prepared to mitigate incidents occurring to their assets over the lifetime

of that asset.

An EPRS engineering study is not the end of a full EPRS but it is only Phase I of the process, it merely identifies the gaps in the essential needs. A full Emergency Pipeline Repair System looks as follows:

- **Phase I – Definition:** Define the scenarios and essential EPRS needs, from risk assessment to shopping list.
- **Phase II – Mobilization:** Buy the essential items. Purchase the long lead items, service contracts, JVs; procedures; DECOMM/RECOMM spreads; set up the organization & training plans; set up the Base Location.
- **Phase III – Maintenance:** Maintain the essential items. Maintenance & repair contracts; storage facilities; regular training & readiness drills.
- **Phase IV – Intervention:** Use the essential items. Develop the right kit system to go out and find the damage and repair it swiftly every time, all the time.

The operator's real challenges is between what he wants, i.e. to be well prepared to respond and to reinstate the supply to his customers, and what he gets, i.e. to invest heavily into equipment and resources, getting no returns



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for it, and no desire to manage it as a business. Pre-planning, preparation and Partnership with innovative pipeline service providers will help ease the burden of the operator in overcoming these challenges.

3.3 What is Driving EPRS in Today's Business Environment?

Despite the seemingly daunting tasks and deep investments called for in a comprehensive EPRS, the trend among operators is the realization of the need for an emergency response system for the following common reasons:

- Business interruption insurance/underwriting is either going away or premiums are skyrocketing – risk management criteria are tightening;
- Negative operating experience from real pipeline downtime is changing conventional wisdom from reactionary to proactive;
- Good business practice suggests that critical pipeline assets need planned EPRS response;
- The interconnectivity of pipeline assets means the consequences of interruption can have wide spread impact;
- Long lead times to respond.

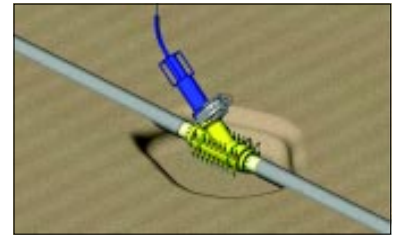
3.4 What Are Others Doing?

- A major North Sea player maintains the most sophisticated arsenal of EPRS equipment in the world, along with ~ 30 full time, trained responders;
- An operator in the Gulf of Mexico is customizing an EPRS for its own use in the Deepwater, around its specific critical assets. So are a few others.
- Major gas hub operator was idle for 2 months due to a leaking Flex-joint and is expected to be considering an EPRS now.
- EPRS Clubs are in place in some offshore markets, and they can be effective, but more so in areas where the response is to one failure event, not a multiple loss scenario like a typhoon or hurricane affecting a large offshore area.
- Owners of critical pipelines are increasingly studying and investing in EPRS to various degrees and in various geographical areas (North Sea, Asia Pacific etc).
- Persian Gulf offshore operators of a critical gas gathering and supply pipelines are planning to implement world class EPRS programs with anchor drag focus.
- The concept solution centers on the use of rapid isolation by SmartPlug including the injection through a post-installed wye-piece for a 48" 900# ANSI class pipeline.

4. Summary

There is a growing trend among pipeline operators in the

global offshore pipeline industry to move away from reactive response to pipeline emergencies and proactively develop or participate in an emergency response system or club driven by recent negative experiences and



real downtime pipeline incidents. People learn by watching others live through experiences that could happen to them.

For the most expedient response to pipeline emergencies, planning and essential investments must be made in advance – in long lead items, critical repair equipment and marine spread availability to name a few – as these are not necessarily standing ready or off-the-shelf items that can be easily and quickly mobilized in an emergency, let alone cost effectively. It is not always necessary to stock up on all the emergency repair gear and kits; an EPRS engineering study can establish an optimal pre-investment shopping list and procurement strategy.

Focusing on realistic pipeline emergency scenarios; on investments that cut long response times; on pre-engagement with marine contractors to control high offshore execution costs; on effective management of pipeline content through investments in bypass and isolation equipment and decommissioning/re-commissioning spreads are increasingly the right approaches to mitigation of pipeline downtime.

Proven capabilities and novel technologies exist today that can be combined into the most responsive repair solutions to match almost any pipeline damage scenario in shallow and deep water, the latter being a field of know-how immaturity concerning EPRS.

EPRS is a lifetime commitment that should start in the initial investment stage for any new, critical pipeline. Increasingly subsea pipeline operators are joining the industry leaders in understanding EPRS and the long term benefits that such an investment can have. **PP**



PetroMin PipeLiner would like to show appreciation to Mr. George Lim for this paper which was presented at the 5th Asian Pipelines Conference & Exhibition 2009, in Kota Kinabalu, Sabah, Malaysia. As the Offshore Business

Strategy Manager for T. D. Williamson, Mr. George K. Lim is responsible for the development of the company's offshore businesses in the Asian, Indian and Australian regions. This forms part of the corporate strategic initiatives to expand TD Williamson's pipeline and subsea intervention and integrity services in the offshore business arena. With extensive profit & loss (P&L) experience in the engineering and construction business and the oil & gas industries Mr. Lim has been with the company since 2004 when he first joined as the Managing Director.

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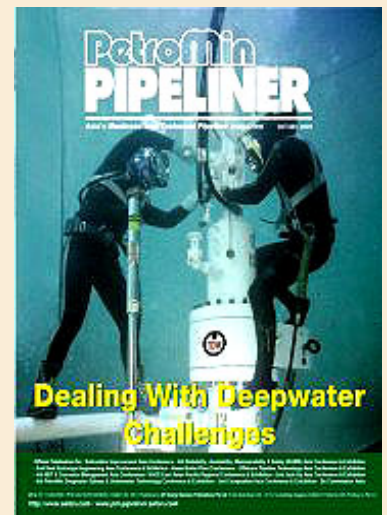
Oct-Dec 2009 Vol 05 No 04

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