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THE DEVELOPMENT OF AN EMERGENCY REPAIR SYSTEM, AND A CASE STUDY FOR A REMOTE GAS PIPELINE

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ABSTRACT

Large diameter long distance gas pipelines are high value assets which have to be kept operating. When damage occurs, or the pipeline fails, a rapid repair is critical to allow full operation to re-start. Suitable equipment and skilled personnel are required to ensure a repair can be completed for the range of damage that can occur.

Many locations around the world can be remote or hostile creating an absence of both available skills (such as welders) and equipment for emergency repairs. Consequently, some operators need comprehensive repair systems and skills that can be mobilised quickly and easily.

This paper presents an overview of the options for the emergency repair of different types of pipeline damage, and provides a strategy, and a case study of the process used to define the equipment and support contracts needed by the operator of a gas pipeline in a remote area to ensure that they could complete a repair to any credible damage or failure within just 7 days.

KEYWORDS: *Pipeline, repair, emergency, EPRS.*

1 INTRODUCTION

"Be prepared" is the motto of the Boy Scout movement. For a scout this can mean carrying a Swiss Army pocket knife that will enable them to remove a stone from a horses hoof where ever they may be. For the operator of a large diameter high pressure gas pipeline it means being ready to respond to any damage as quickly as practicable and getting the pipeline back into operation. The effects of pipeline failure can be dramatic, and the costs high; for example, a gas pipeline shutdown may result in power stations shutting down, heating going off, or, as in the case study presented here, a Liquefied Natural Gas (LNG) plant shutting down.

Consequently, it is important to be prepared, have appropriate equipment available, have access to trained staff, and have suitable procedures in place.

Pipeline design codes, and integrity management guidance[1, 2, 3], include a great deal of useful guidance on the identification of defects in pipeline systems, and the selection of repairs. They do not, however, provide clear guidance on how to set up all elements of an Emergency Pipeline Repair System (EPRS), or the procedures required to complete different repairs.

This paper:

- Lists the key elements of an EPRS;
- Considers the circumstances under which an emergency repair may be required;
- Reviews a selection of repair methods for onshore pipelines that could be used in the case on an emergency;
- Suggests a strategy for developing an EPRS.

The paper concludes with a case study of the development of an EPRS for a 320 km long, 38 inch diameter, 134 bar, LNG pipeline supplying gas from the interior of Yemen to a LNG plant on the coast at Bal Haf (see **Figure 1**).

2 NOMENCLATURE

3LPE	Three Layer Polyethylene
API	American Petroleum Institute

BVS	Block Valve Station
EPRS	Emergency Pipeline Repair System
FBE	Fusion Bonded Epoxy
LNG	Liquefied Natural Gas
NDT	Non Destructive Testing

3 KEY ELEMENTS OF AN EMERGENCY PIPELINE REPAIR SYSTEM

An EPRS has the following key elements:

- Procedures
- Parts
- Equipment
- Staff

These are briefly discussed in this section.

3.1 Procedures

The procedures required for an EPRS range from the identification of damage that requires emergency repair, to the detailed procedures for welding on a live pipeline. There are many procedures required including safe excavation, and gas concentration monitoring etc..

3.2 Parts

The parts needed for an EPRS will include line pipe, bends, steel sleeves, composite wraps, and repair clamps. Special parts such as hot tap tees, mechanical connectors, and prefabricated bypass pipe work may also be needed.

3.3 Equipment

An extensive range of equipment will be needed for an emergency repair. An EPRS may also require trucks, excavators, welding kit, hot tap tools, stopples, NDT systems, and site facilities such as offices and rest rooms.

3.4 Staff

Staff who are familiar with the pipeline and with pipeline repair methods, company procedures, the available parts, and equipment are vital for an efficient repair. On extensive pipeline systems there will be regular modification work, and general rehabilitation activities. These will allow teams to use the systems that will be needed in an emergency, practice the procedures and train them in team working. The operator will need to develop some in house expertise, but, for smaller systems should also consider making use of a contracting company familiar with pipeline intervention work.

4 EMERGENCY REPAIR CASES

Pipelines can be damaged: The major causes of damage are generally accepted to be corrosion and third party damage (damage to the pipeline by someone not working for or contracted by the pipeline operator). Modern pipelines are very resistant to damage by mechanisms such as corrosion, due to good design and the use of high quality materials. Failure rates for onshore gas pipelines in Europe have fallen from 0.79 incidents per 1000 km years in the 1970s to 0.21 incidents per km year in the late 1990s[4]. Consequently, most anomalies found in service are superficial.

4.1 Emergency Repair Assessment

Occasionally damage is severe: in these cases (e.g. a rupture) an emergency repair is required. In other cases the situation is less clear; for example a corrosion defect 50 mm long and 70% through the pipe wall may seem severe, but imminent failure is unlikely (for example see **Figure 18**, and consider a defect 50 mm long, by 11 mm deep), and if a failure did occur it would probably be a leak rather than a rupture. A dent depth of 5% of the pipe diameter, with some evidence of abrasion, may look innocuous, but could fail by rupture at a very low stress, or after just a few pressure cycles[8]. Hence it is important to have a defect assessment procedure that will allow the operator to correctly identify defects that require rapid response.

4.2 Pressure Control and Reductions

When severe defects are identified (or there is the possibility of a severe defect) it is vital to control the pressure (to prevent any increases), and a reduction in the pressure is highly recommended. For some defects the complete depressurisation of the line may be required.

5 EMERGENCY PIPELINE REPAIR METHODS

There are many pipeline repair methods which may be suitable for use in an emergency. The options that will be described in this paper are ‘classic’ methods:

- Pipeline section replacement
- Welded steel sleeve
- Composite wrap
- Pin hole leak clamp
- Bolted clamp
- Temporary bypass.

5.1 Section Replacement

Replacing a damaged section of pipeline with new pipe is the most involved form of repair, but is it also the preferred form of repair. The replacement pipe section will be a permanent repair as good as, or better than, the original pipeline, provided the replacement works have been carried out to a high standard.

Replacement can be used for any damage, but it is most likely to be required in the event of severe damage such as a rupture or a landslide. **Figure 2** shows a typical gas pipeline rupture site[5].

A schematic representation of the major activities involved in the isolation, and replacement, of a damaged section, are shown in **Figure 3**. Replacing a section of a large diameter pipeline is a major project. A significant amount of equipment is required, similar to the facilities required for pipeline construction. The damaged section must be isolated and vented, excavation equipment is required, welding equipment and crews will be needed, as will NDT facilities. The time required to mobilise equipment and personnel will prevent a very rapid repair: as a minimum a few days will be required. Additional time will be needed for re-commissioning the pipeline.

5.2 Welded Steel Sleeves

Welded steel sleeves are commonly used for pipeline repair and can be used for a wide variety of damage[6]. A welded steel sleeve provides a permanent repair, and tests have demonstrated excellent performance[7].

There are a variety of types of welded sleeve repair including:

- Close-fitting reinforcement (commonly known as ‘type A’);
- Close-fitting, pressure-containing (commonly known as ‘type B’)
- Epoxy grout filled,
- Pre-stressed.

These different designs have various advantages and disadvantages[6]. The close fitting pressure containing (or type B) sleeve and the epoxy grout filled sleeve are considered suitable for emergency repairs.

The type B sleeve is installed by clamping 2 half shells tightly to the pipeline, welding them together and then fillet welding the sleeve to the pipeline. Consequently it is suitable for damage such as internal corrosion that may become a leak, or damage that is already leaking. An example of a close-fitting pressure-containing sleeve is shown in **Figure 4**.

The epoxy grout filled sleeve is installed by loosely assembling 2 half shells around the pipeline, with an annular gap of up to 40 mm, and welding them together. The annulus is then filled with an epoxy based grout with a very high compressive strength. The primary advantages of the epoxy grout filled sleeve are that it is not welded to the pipeline, and it is relatively easy to fit if the pipeline surface is uneven or if there is some deformation. An example of an epoxy grout filled sleeve is shown in **Figure 5**.

Both repairs are more effective if installed with the pipeline operating at a reduced pressure. Any pressure reduction is good practice when working on a live pipeline, but may have an impact on operability.

An installation time of less than 24 hours is achievable for welded and epoxy filled sleeves.

5.3 Composite Wrap

Composite wrap repairs are light and easy to mobilise. They are quick to install, but they are not proven for leaking damage, or severe damage such as combined dents and gouges.

A composite wrap repair is generally installed by wrapping several layers of a composite material around the damaged area. The composite, and any adhesive, will take a short time to cure, and then the repair is complete.

The main advantages of composite wraps for emergency repair are the speed of installation, and the limited working space required, which reduces the time required to excavate the damage site. An example of a composite wrap repair is shown in **Figure 6**.

An installation time of less than 5 hours is achievable.

5.4 Pin Hole Leak Clamp

A pin hole leak clamp can be installed quickly over a small leaking defect to provide a temporary repair. The repair can be installed while the pipeline is leaking, provided appropriate safety precautions are taken to prevent ignition, asphyxiation, or other hazards. Short term disruption of pipeline operation will be minimised; however, in the long term a permanent repair will be required.

Pin hole leak clamps are relatively light weight and easy to mobilise, and only require a relatively small excavation. Two examples of a pin hole leak clamp are shown in **Figure 7**.

5.5 Bolted Leak Clamp

Bolted leak clamps are commonly used for emergency repair. The clamps tend to be large and heavy due to the high bolting forces required to prevent flange separation. They will provide a temporary repair, and a permanent repair will be required in the future. Many bolted clamps can be made into permanent repairs by welding them to the pipeline.

The size and weight, particularly for large diameter clamps, makes mobilisation more difficult, and means that a large excavation may be required.

Bolted clamps can be installed over leaking damage. It may be possible to temporarily seal the leak with a non metallic plug, or to use a valve attached to the clamp body to allow the leaking product to be diverted away from the repair site while the clamp is being installed.

Clamp installation may be difficult if the pipe has been deformed, for example by impact damage. Clamps can typically be installed over high quality coatings such as FBE and 3 layer polyethylenes: this reduces installation time.

Bolted clamps generally use elastomer seals, which can degrade over time. If the clamp is being kept for contingency repair purposes the seals should be kept under appropriate conditions and replaced if required.

An example of a bolted leak clamp repair is shown in **Figure 8**.

5.6 Temporary Bypass

A temporary bypass may be installed while the pipeline is operating to allow a damaged section to be removed. Alternatively a temporary bypass could be installed after a major incident to allow service to be resumed as quickly as possible and to give time for a permanent repair to be completed (**Figure 9**, and **Figure 10**).

A temporary bypass will require tees to be fitted to the pipeline and bypass pipe work to be assembled. For rapid installation mechanical connectors or couplings (**Figure 11**, and **Figure 12**) can be used to connect the main pipe sections together. A selection of flanged pieces can be used to create the connections to the main line at each end of the bypass. In addition to the bypass, isolation will be required. This is most likely to take the form of a plug inserted into the pipeline (**Figure 13**), but isolation pigs could be used (**Figure 14**).

6 STRATEGY FOR THE DEVELOPMENT OF AN EPRS

The setting up of an effective emergency pipeline repair system requires a strategic approach. A proposed strategy is:

- Review the pipeline system design and operation
- Identify hazards that may result in damage or failure to the system.
- Evaluate damage that may be caused by different hazards, and any associated pipeline failure modes.
- Prepare guidance to identify severe damage.
- Prepare guidance for selecting a repair option for particular types of damage, or failures. Preferred repair options for different types of damage should be selected based on industry practice and experience. Alternatives should also be identified to allow flexibility.
- Develop a high level activity list, ranging from damage identification to re-commissioning. These activity lists can also be used as a basic scope of work for repair contractors.
- Develop a strategy to cover tasks to be covered by the operator, long term maintenance contractors, and other contractors such as civil works contractors, and specialist pipeline intervention companies.
- Identify and purchase critical parts and equipment required and purchase parts and equipment
- Set up support contracts with required contractors.
- Prepare detailed procedures. This should be done by the companies that will be responsible for implementing them.
- Test the repair system

7 CASE STUDY

Yemen LNG Company Ltd. (YLNG) is constructing a new liquefied natural gas (LNG) facility at Bal Haf in the Republic of Yemen, fed by a 25 km transfer pipeline, and a 320 km main line from producing fields in Marib. YLNG have a target of seven days to complete a repair of the pipeline, in the event of a failure or severe damage incident. The seven days must include all activities from depressurising to re-commissioning. Penspen working closely with YLNG have developed an EPRS strategy which is intended to ensure that the EPRS will be capable of completing a repair as quickly as practicable. In the unlikely event of a very severe failure in an area where access is difficult, completing a repair within the seven day target may not be possible.

7.1 Pipeline System

The basic pipeline system parameters are summarised in Table 7-1.

Parameter	Main Line	Transfer Line
Design code	ASME B31.8	ASME B31.8
Design Pressure (barg)	117.83 to 134.5	130
Diameter (mm)	930.4 (internal)	762.0 (external)
Wall Thickness (mm)	16.2, 18.0 and 23.7	15.9 and 19.1
Grade	API 5L X70	API 5L X70
Coating	3.5 mm 3LPE	3.5 mm 3LPE
Maximum Design Temperature (°C)	80	80
Minimum Design Temperature (°C)	0	0
Cathodic Protection	Impressed current	Impressed current
Pipeline Length (km)	320	25
Terrain	Flat sandy desert (large dunes), mountainous, coastal plain.	Flat sandy desert
Maximum Slope	30 degrees	5 degrees

Table 7-1 Pipeline Parameters

An important point to note is the constant internal diameter of the 38 inch pipeline: the external diameter varies with wall thickness. This will require different sizes of tee fittings, and clamps, but is an advantage for stopple plugs as only one size will be needed.

Another key issue is the terrain crossed by the main pipeline. In the sand dune areas vehicle access can be difficult (see **Figure 15**), and specialist vehicles are needed. In the mountainous areas there are some very steep slopes (see **Figure 16**), which will make any repair work difficult.

7.2 Hazard Identification

Having reviewed the pipeline route and basic design parameters the first stage of the EPRS development was to identify credible hazards. The key hazards identified were:

- Malicious damage to the pipeline;
- Malicious damage to a block valve station;
- Wash out at steep slopes;
- Wash out at Wadi-crossing.

Corrosion was included in the study for completeness, together with weld defects, displacement (due to ground movement), and loss of support (due to sand dune migration)[1]. The potential for an emergency repair to be required for corrosion damage is considered to be low. Significant external corrosion damage is not expected as the pipeline:

- has a good quality (three layer polyethylene) coating,
- a modern impressed current cathodic protection system,
- has a relatively thick wall (> 16 mm),
- will be subject to regular surveys of the cathodic protection system, and
- will be inspected regularly using intelligent pigs.

7.3 Damage and Failure Types

The type of damage most likely to require an emergency repair was considered to be:

- A dent and gouge caused by bullet impact;
- A puncture due to bullet impact, but a rupture is unlikely;
- Damage to the pipeline from explosives; which, could result in a rupture.

These three credible cases require a comprehensive emergency repair system to be in place. Such as repair system will also be suitable for dealing with a wide range of other damage scenarios; consequently, the following failure and damage types were identified for inclusion in the study:

1. Rupture
2. Leak
3. External and Internal Corrosion
4. Gouges
5. Dents (including buckling), and dents with gouges
6. Weld Defects
7. Displacement (e.g. Landslide)
8. Loss of Support (e.g. Washout / Sand Movement)
9. Block Valve Station Damage

It is considered unlikely that corrosion, or loss of support would result in an emergency repair. In addition major displacement is also considered unlikely as the terrain is understood to be stable.

It should be noted that a long rupture (more than two pipe lengths, 24 m) is very unlikely with modern line pipe having good toughness; however, YLNG considered that a rupture of up to 10 pipe lengths (120 m) should be considered.

7.4 Damage Assessment

A rupture will require emergency repair, but other severe damage requires assessment before implementing a repair. Penspen have developed the Pipeline Defect Assessment Manual [8]. This document is based on a comprehensive review of pipeline defect assessment methods, and identifies best practice in defect assessment. The guidance in PDAM was used to develop a procedure that would allow the rapid identification of critical defects, and ensure that over-reaction to less severe defects is avoided. The guidance document provides an overall procedure for defect categorization (see **Figure 17**), and provides bespoke charts that can be used to identify critical defects (see example in **Figure 18**).

7.5 Selection of Repair Options

An emergency repair system must have flexible options for repair that cover the full range of possible damage and failure scenarios, but creating too many options may result in confusion, indecision, and a delay in the repair process. A high level procedure was developed to allow the identification of suitable repair methods for different damage scenarios.

The basic repair strategy developed is:

Leaking Damage

1. **Rupture:** Following a rupture the pipeline will be shut down and repaired with a section of pre-tested pipe.
2. **Leak**: Following a leak the pipeline will be shut down and repaired using: a welded sleeve; or by cutting out the damaged section. The use of a leak clamp as a temporary repair may be considered to minimise the time out of service and allow a permanent repair to be scheduled for convenient time.

[1] Incidents of pipeline exposure and sections becoming unsupported were found even just a few months after construction had been completed and before the pipeline was commissioned.

Non Leaking Damage That Exceeds Acceptance Limits

3. **Corrosion**: Pipe wall damage will be repaired using a welded sleeve, a composite wrap, or by cutting out the damaged section. A pressure reduction may be required before applying the sleeves to ensure safe working in the vicinity, and this may lead to a requirement to shut down the pipeline.
4. **Mechanical Damage:** Mechanical damage will be repaired using a welded sleeve or by cutting out the damaged section.
5. **Displacement**: Pipeline displacement requires expert advice and the damaged section (which it is assumed to be up to 40 pipe lengths) must be cut out and replaced. This will require a pipeline shutdown.
6. **Loss of Support**: Where the pipeline has lost support, new support must be installed. If bending has resulted in local buckling then a cut-out will be required. This will require a pipeline shutdown.
7. **Block Valve (BV) Station Damage**: BV station damage will be repaired by capping off the bypass pipework and returning the pipeline to service. The damaged pipework, valves and actuators will then be replaced at a convenient time.

For each scenario a flow chart was prepared guiding the user through the repair selection process, and identifying options. The strategy is illustrated in **Figure 19** for a leaking defect, as an example.

The repair strategy also has to consider issues such as safety isolation; for example, does the operator require "double block and bleed" isolation between any work site and pressurised gas. Will isolation be provided by existing block valves, or can alternatives be used? Can the operator afford to vent long pipeline sections to de-pressurise?

7.6 Repair Activities

A high level listing of the activities required to complete a repair was prepared for each type of repair. These lists provide a basic scope of work for potential repair contractors, and help to ensure that all the manpower, equipment and spare parts required to complete a repair have been identified. An example activity list for the installation of a welded pressure containing (type B) sleeve is given in **Figure 20**.

7.7 Spare Part and Equipment Requirements

The key spare parts and equipment required for emergency repair can be identified from the repair activity listing. Where local suppliers or service companies are available it may be possible to limit the contingency repair stock to items such as hot tap tees, and pre-tested pipe. In areas where there are limited facilities, or for systems that operate at particularly high pressures getting specialist equipment such as a hot tap machine, or stopple, at short notice may be very difficult, or impossible. For YLNG the pipeline is remote from existing service centers in Europe and North America, so mobilizing equipment would add considerably to repair time. The temporary import of large expensive equipment can be difficult. In addition, the operating pressures exceed the ratings of much standard equipment. This combination of factors means that if a temporary bypass is required at short notice a comprehensive set of bespoke equipment must be kept on site, together with the necessary spare parts (pipe, sleeves, tees, etc.). This equipment would be costly to purchase and maintain. The detailed hazard assessment carried out, and the review of damage and failure types (see sections 7.2and 7.3), demonstrate that a scenario where a temporary bypass would be required at short notice is very unlikely for this pipeline. Consequently, the emergency repair contingency equipment can justifiably be focussed on those items that will provide the greatest benefit. These are:

- Temporary leak clamps that will fit the different external diameters, and can be fitted over the coating to minimise the installation time;
- Steel sleeves to fit the different external diameters;
- Composite wrap repairs;
- Pre-tested spare pipe (including a selection of bends);
- Spare weld neck flanges and valves for Block Valve bypass pipe work isolation.

Other, less obvious, equipment is also needed. For example, pay welders and NDT kit, and trucks capable of crossing desert terrain to transport the tools and spares to site. Site facilities are also needed, as there is very little local infrastructure.

The purchasing of this specific pipeline repair equipment, and the required support equipment, has now commenced, to ensure that a comprehensive emergency repair system is in place before the pipeline is put into full service supplying gas to the new Bal Haf LNG plant.

7.8 Contracting Strategy

A contracting strategy is required to define which organizations will be responsible for different activities during a repair. The contracting strategy will identify those tasks that must remain the responsibility of the operator of the pipeline, those tasks that should be taken on by a permanent maintenance contractor (likely to be employed in the maintenance of the LNG plant), and tasks that should be outsourced to other contractors. For YLNG the strategy outlined in Table 7-2 was selected. The key task not included in this table is civil works (excavations, construction of temporary access, etc.). Civil works will be the responsibility of the right of way maintenance contractor.

Tasks	YLNG	Maintenance Contractor	Local (Yemen) Contractor	Middle East Contractor	International Contractor
Defect Assessment	✓				
Site Supervision	✓				
Clamp Installation		✓			
Sleeve Welding & NDT		✓			
BV Isolation		✓			
Section Replacement			✓	✓	
Temporary Bypass					✓

Table 7-2 Contract Strategy

Based on this contracting strategy, suitable potential contractors can be identified, and scopes of work developed for call off contracts. YLNG can ensure that their staff, and maintenance contractors, have the required training to assess damage, and install temporary leak clamps.

8 CONCLUSIONS

The repair of a large diameter high pressure gas pipeline that has failed, or suffered severe damage, is complex. The repair must be of the highest standard, to ensure safety and integrity; however, completing a complex project, under severe time pressure, to the high standard required, and with limited practical experience, is extremely difficult.

Thorough preparation, including a combination of, training of key staff, a comprehensive set of parts, equipment and procedures, and setting up call out contracts with qualified companies will put YLNG in a position to start operations safe in the knowledge that they have a system that can respond to any emergency quickly and efficiently. This will ensure that disruption is minimised and the flow of LNG from the Yemen to customers around the world is maintained.

9 ACKNOWLEDGMENTS

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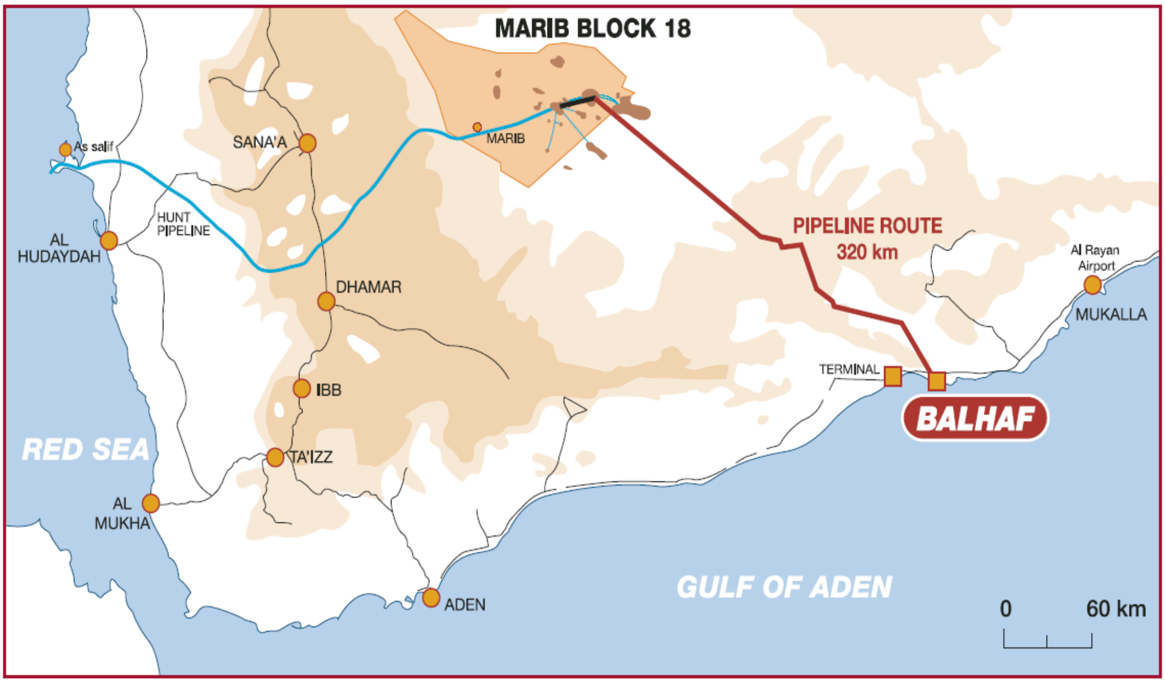

Figure 1 Yemen LNG Pipeline Overview

Figure 2 Rupture Site[1]

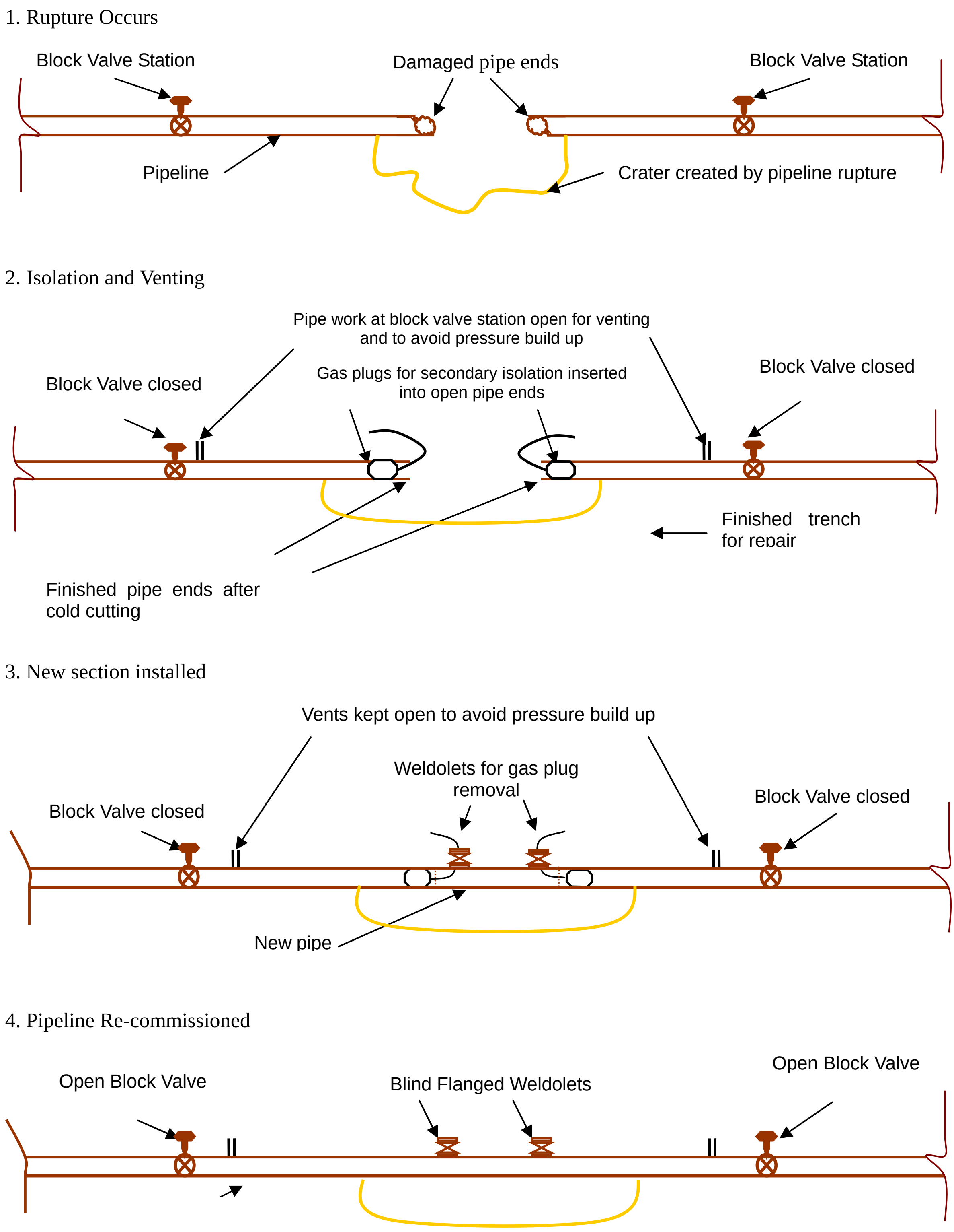

Figure 3 Pipe Section Replacement

Figure 4 Close Fitting (Type B) Welded Sleeve

Figure 5 Epoxy Grout Filled Sleeve

Figure 6 Composite Wrap Repair

Figure 7 Pin Hole Leak Clamps (www.statsgroup.com), (www.3xengineering.com).

Figure 8 Bolted Clamp Repairs

Figure 9 Stopple and Bypass (www.tdwilliamson.com)

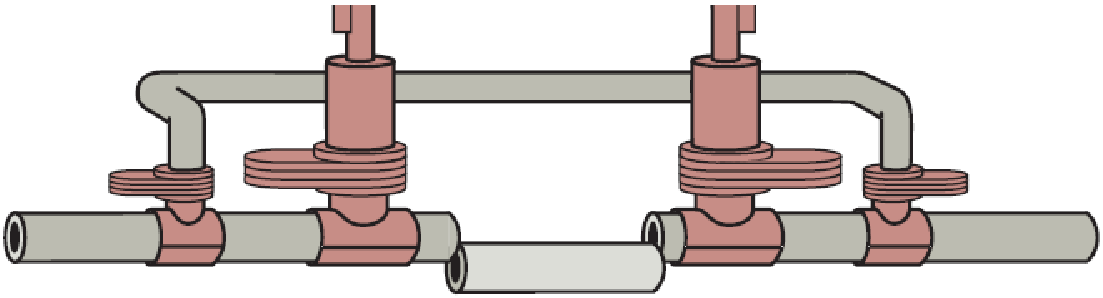

Figure 10 Stopple and Bypass Schematic (www.tdwilliamson.com)

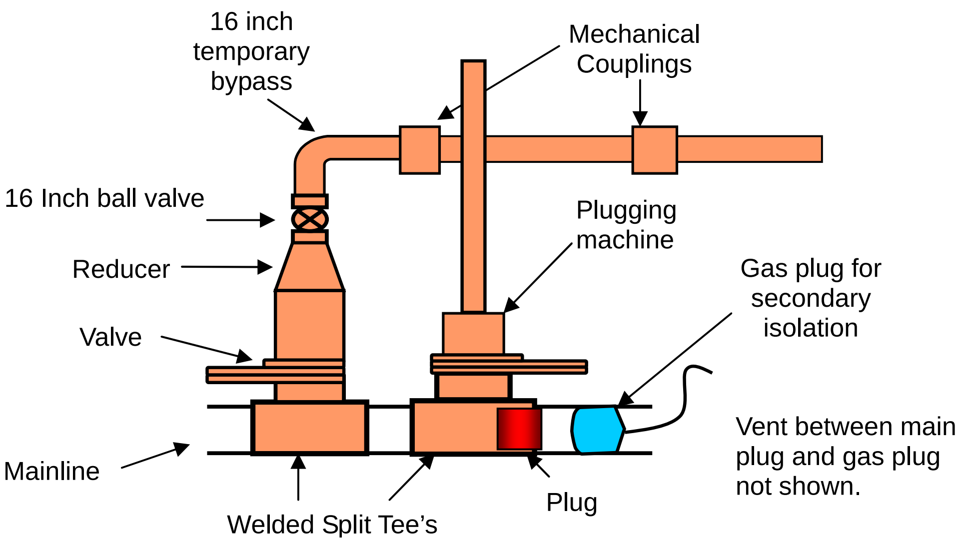

Figure 11 Temporary Bypass Schematic

Figure 12 Pipe Connector/Coupling (www.furnanite.com)

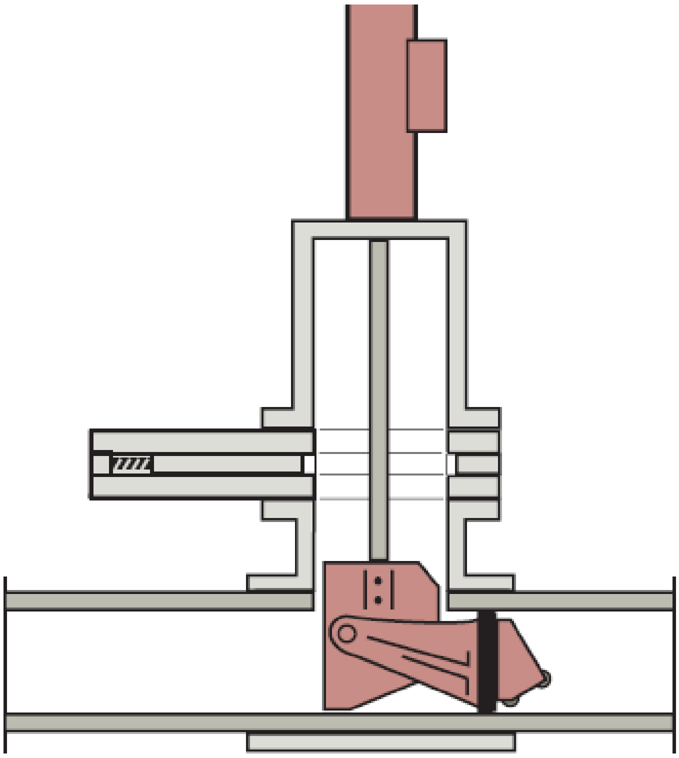

Figure 13 Stopple™ Line Plug (www.tdwilliamson.com)

Figure 14 Remote Setting Isolation Pig (www.statsgroup.com)

Figure 15 Desert Terrain

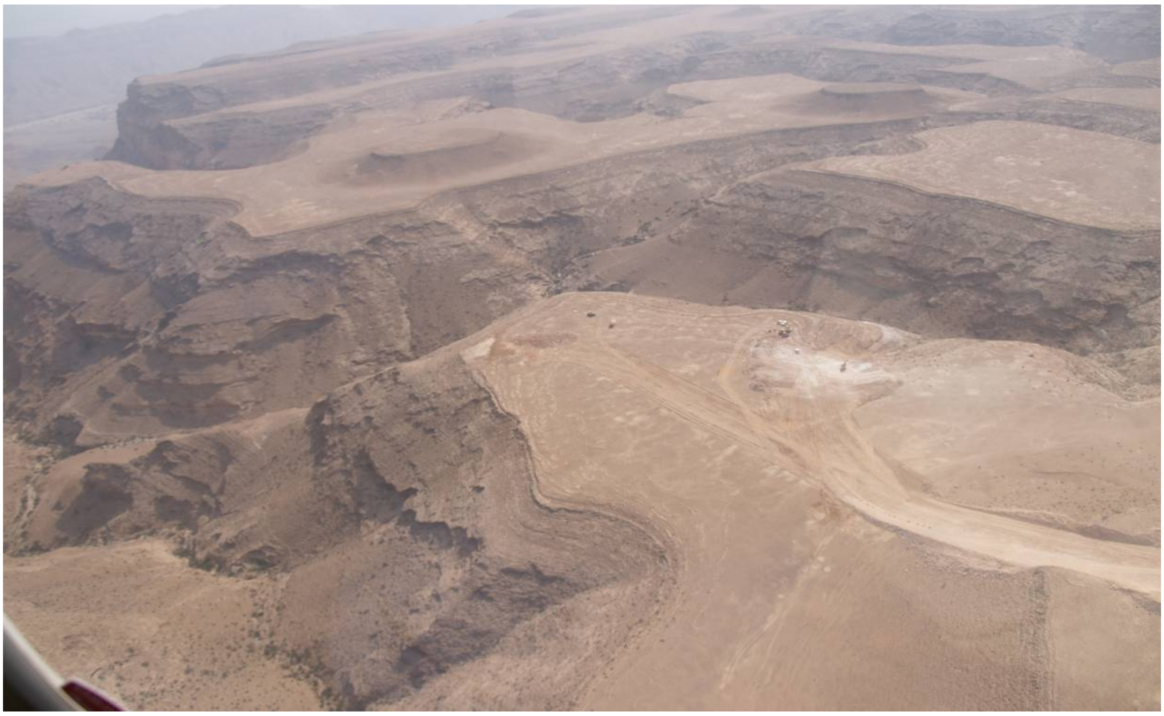

Figure 16 Mountainous Terrain

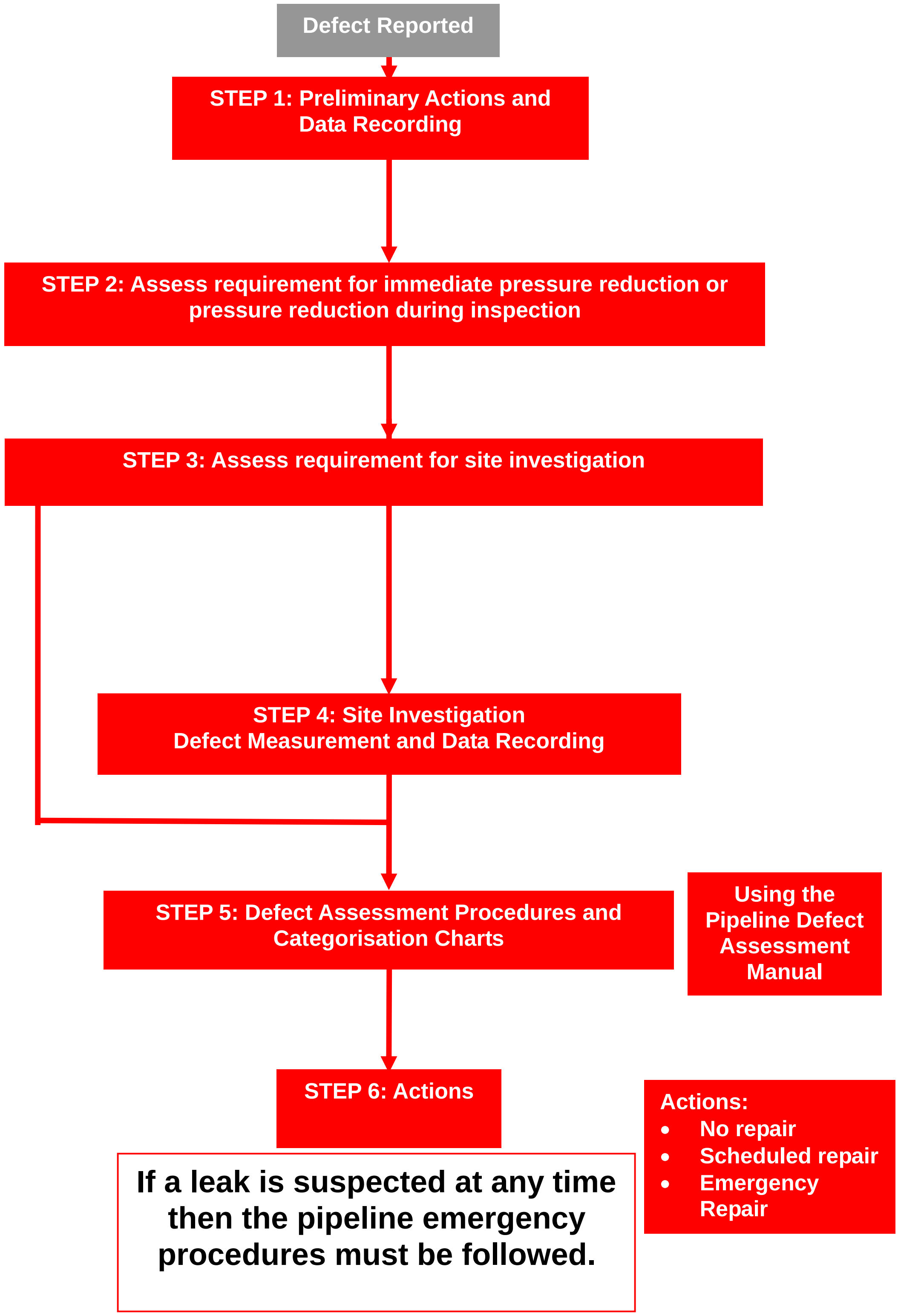

Figure 17 Summary of a Pipeline Defect Classification Procedure

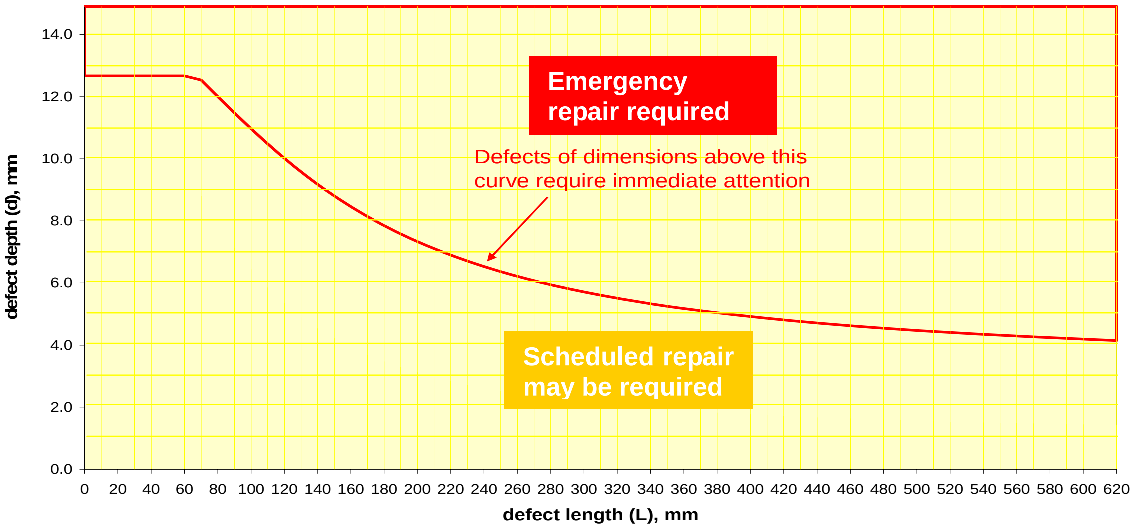

Figure 18 38 inch Main Line, 16.2 mm line pipe: Axial corrosion defect chart. Assessment of depth and length.

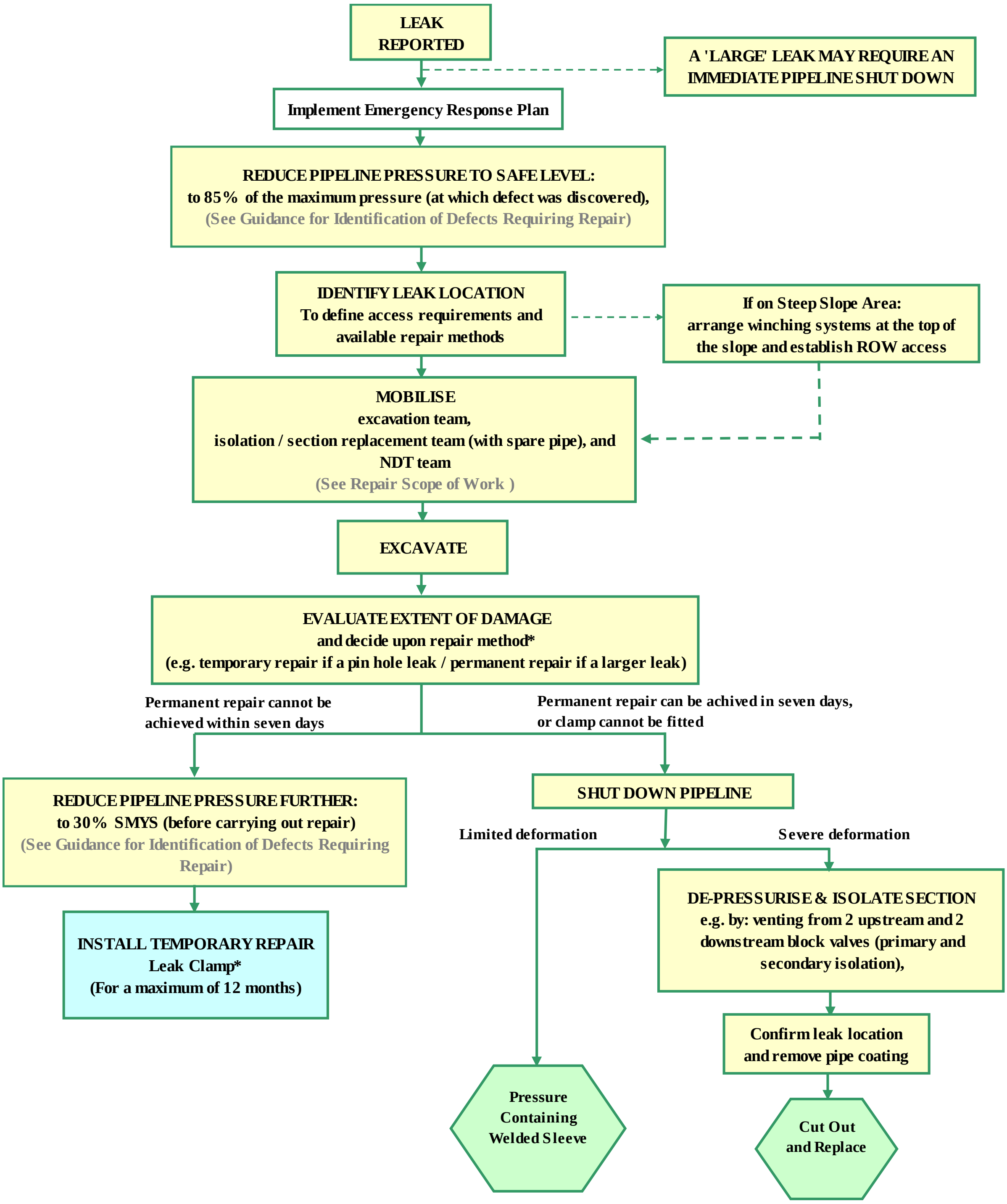

Figure 19 Repair Strategy for Leaking Defects

No	Pressure Containing Welded Sleeve Installation Description of Key Activities	Standard Access			Steep Slopes		
		Target Duration (hours)	Start	End	Target Duration (hours)	Start	End
1	Contact control room and arrange pressure reduction.	6	Day 1	Day 1	6	Day 1	Day 1
2	To minimise the time for ground patrol, vehicles should be mobilised from upstream and downstream if available, the main response team will be mobilised from Balhaf. Included in the ground patrol will be a responsible person from Balhaf or Sana'a Inspection Team.	12	Day 1	Day 1	12	Day 1	Day 1
3	Mobilise excavation team.	18	Day 1	Day 1	18	Day 1	Day 1
4	Mobilise repair installation team with close fitting sleeves of required size (matching to outer diameter of damaged line pipe) needed for 38 inch or 30 inch line plus a leak clamp, as a clamp may need to be installed as a temporary repair. Also consider Clockspring™ repair as a contingency.	24	Day 1	Day 2	36	Day 1	Day 2
5	Review location, monitor gas levels (Lower explosive limit - LEL) and gas dilution.	6	Day 1	Day 1	6	Day 1	Day 1
6	Site access - if location is remote from existing roads, then some form of access track will be required.	24-72	Day 1	Day 3	96	Day 2	Day 5
7	Setting up winching arrangement, if required.	n/a	n/a	n/a	24	Day 3	Day 3
8	Survey to confirm pipe location.	6	Day 2	Day 2	6	Day 2	Day 2
9	Worksite preparation - prepare space for parking, portacabins, compressors, generators etc. as required.	36	Day 2	Day 3	36	Day 3	Day 4
10	Initial excavation to each side of the pipeline with mechanical excavator, Careful excavation is required while pipeline is under pressure (no mechanical excavation is to be conducted within 0.5 m of the pipeline, see Section 2 for guidance).	24	Day 2	Day 3	48	Day 3	Day 4
11	Final manual excavation.	12	Day 3	Day 3	12	Day 5	Day 5
12	Coating removal, of a length sufficient for repair installation.	4	Day 4	Day 4	4	Day 5	Day 5
13	Install welded sleeve (see specific guidance in Appendix A, Section A.3). If repairing mechanical damage such as a dent and gouge it is good practice to remove the gouge by dressing, guidance on dressing is given in (Appendix A, Section A.1).	16	Day 4	Day 4	36	Day 5	Day 6
14	Initiate gassing up (Re-Pressurisation) of section[4].	36	Day 5	Day 6	36	Day 6	Day 7
15	Coating (time varies depending on curing time).	48	Day 5	Day 7	48	Day 6	Day 8
16	After a few days of observation, conduct backfilling and restoration of the repair site.	48	Day 9	Day 10	72	Day 10	Day 13

Figure 20 Major activities: Welded pressure-containing sleeve installation