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United Kingdom Onshore Pipeline Operators' Association

UKOPA Good Practice Guide

Type A Repair Guidance

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1. EXECUTIVE SUMMARY

This document is the output of a high level review of available standard and non-standard Type A repairs. The information has been collated from repair vendors through the completion of a technical questionnaire issued by ROSEN (UK). The intention of the document is to allow the operator to identify the most appropriate repair system for the given defect. Both, the Type A Repair Guidance document (GPG-33-8) and Repair Management Procedure (GPG-33) should be used together to help identify Type A repair options that are readily available.

The review has considered both standard and non-standard Type A repairs and compared them against one another to highlight the potential benefits of using a non-standard repair. The repairs are reviewed against typical Type A repair design guidance provided in the Pipeline Repair Manual, ASME B31.4 and ASME PCC-2.

Non-Standard Type A repairs typically cover a greater defect applicability. Additionally, measured performance of the repairs are sometimes beyond the typical recommendations of a Type A repair. For instance, crack defects can be repaired if dressed and then placed under compression by the steel sleeve, this would not be achievable by a standard Type A repair. Generally, most of the non-standard repairs are of a proprietary design which makes it difficult to verify their capability with specifications alone, therefore an in-depth repair management procedure is required to verify the Vendors claims regarding their product.

2. INTRODUCTION

2.1 Background

This guidance report is the output of a high level review of available Type A pipeline repair sleeves. Typically a Type A repair sleeve is described as a non-pressure containing full encirclement steel sleeve which acts as reinforcement for a defective area. Guidance for performing standard Type A repairs is provided in ASME PCC-2 (Ref [1]), ASME B31.4 (Ref [2]) and the Pipeline Repair Manual (Ref [3]).

Developments in the pipeline repair industry have led to a number of non-standard Type A repairs being used, which generally have an increased defect applicability. These non-standard repairs tend to be system and vendor specific with proprietary guidance documentation, making it increasingly difficult for operators to independently assess the available technical information against the defect requiring repair.

2.2 Scope

The aim of this review is to compare the functionality and defect applicability of a standard Type A repair against a number of non-standard Type A repair designs.

To enable a fair comparison between the repairs the review has been performed through a desk study and a questionnaire, completed by each repair vendor.

The guidance report considers the following and should be used supplementary to the management procedure (Ref [4]) to allow the operator to identify the most appropriate repair system for the given defect:

- Technology Qualification – Specification Guidance
- Vendor Selection
- Defect Applicability
- Repair Compatibility Matrix
- Repair Comparison
- Description of Repair Systems

3. TECHNOLOGY QUALIFICATION – SPECIFICATION GUIDANCE

In developing an approach for the management procedure, current specification (from ASME B31.4 and ISO 24817) guidance for the qualification of new technology was reviewed to provide the high level process for developing the procedure document.

ASME B31.4 provides guidance on how to complete a pipeline design activity where the standard does not provide explicit guidance. Additionally, ISO 24817 (Ref [6]), provides a clear process from taking a “new” repair technology and the stages it goes through to qualify, design and install in accordance with the qualification.

3.1 ASME B31.4

Section 404.10 details the approach to validation of a design for pressure containing components where the code does not present recommendations on how to complete the design. Although Type A repairs alone are not pressure containing, the complete repair system (pipe, defect and repair combined) is required to contain pressure.

Where a repair has little in-service history, the pressure design should be based on analysis and supplemented by one of the following:

(a) proof tests (as described in UG-101 of Section VIII, Division 1, of the ASME Boiler and Pressure Vessel Code)

(b) experimental stress analysis (as described in Appendix 6 of Section VIII, Division 2, of the ASME Boiler and Pressure Vessel Code)

(c) engineering calculations

3.2 ASME PCC-2

ASME PCC-2 does not specifically provide guidance on how to qualify a non-standard repair design, however it does detail cautions and limitations of a standard Type A design within Article 2.6. Sufficient information is provided for the reader to determine that a non-standard Type A repair lies outside of the specification and that further qualification is required.

3.3 ISO 24817

The procedure for the use of composite repairs sets out guidance for qualification, design, installation, inspection and testing. It recognises that a successful repair requires the process for qualification through to life extension or end of life to be managed.

The standard does provide closed form equations to design repairs for metal loss features, and recognises that additional engineering calculations and testing are required to extend the scope of the repairs beyond metal loss.

4. VENDOR SELECTION

The review has considered non-standard Type A repair systems which embody all or part of a standard Type A design philosophy as described in ASME PCC-2 or ASME B31.4. Although the repair systems are somewhat hybrid they still embody the main characteristics of a Type A repair:

- Type A repairs are welded longitudinally only and do not require welding to the carrier pipe
- Provides reinforcement for the defective area. The repair cannot contain pressure and is used only for non-leaking defects
- Type A sleeves shall be fabricated from steel meeting the material specifications of the construction code, and should have a thickness equal to at least two thirds the thickness of the carrier pipe. Thinner sleeves are permissible if the strength of the material can compensate for the thickness being less.
- Intimate contact between the pipe and the sleeve at the location of the defect being repaired and an appropriate filler material should be used to ensure that the sleeve provides the desired pressure load reinforcement.

The vendors approached for inclusion in the study and questionnaire include:

- National Grid : Pipeline Management Centre
- Petrosleeve
- Western Specialties
- Ram 100

5. REPAIR SYSTEM OVERVIEW

5.1 Defect Applicability

The scope of applicability of a Type A repair is detailed within the pipeline construction code ASME B31.4 and the Pipeline Repair Manual, the defect types are summarised in Table 1.

For the purpose of producing this procedure the descriptions used in National Grids P11 to describe the different defect types will be adopted to provide consistency across the UKOPA member documents.

In providing the comparison in Table 1, it should be noted that the applicability between the Type A repair and the Epoxy Sleeve Repair seems similar. It should be noted that the options highlighted in red require removal of the crack or the stress concentration for the repair to be acceptable. This may be limited by the Company’s guidance on grinding of cracks for in-service pipelines.

DEFECT TYPE P11 [1]	DEFECT TYPE PRCI	TYPE A REPAIR	EPOXY SLEEVE FROM NATIONAL GRID P11
General Corrosion & Pitting Corrosion	Leak (from any cause) or Defect >0.8t	No	
General Corrosion & Pitting Corrosion	Shallow to Moderate Pitting < 0.8t	Yes	Yes
General Corrosion & Pitting Corrosion	Deep Pitting ≥ 0.8t	No	Yes [2]
General Corrosion & Pitting Corrosion	Internal Defect or Corrosion	Yes [3]	N/A
Welding Arc Strikes	No Ref	Yes	
No Ref	Blisters or HIC	Yes	Yes
Cracks or Spalling	Shallow Crack < 0.4t Deep Crack >0.4t and not more than 0.8t	Yes [4]	Yes
Smooth Dent	Smooth Dent	Yes [5]	Yes
Smooth Dent plus cracks or smooth dent plus spalling	Smooth Dent with stress concentrator on seam weld or pipe body	Yes [4,5,6]	Yes
Smooth dent plus gouge	Smooth Dent with stress concentrator on seam weld or pipe body	Yes [4,5,6]	Yes
Kinked Dent	Wrinkle bend, Buckle or Coupling	No	Yes
Gouge	Gouge or other metal loss on pipe body	Yes [4]	Yes
Stress Corrosion Cracking	Shallow Crack < 0.4t Deep Crack >0.4t and not more than 0.8t	Yes [4]	Yes

Notes:
[1] National Grid T/PM/P/11 excludes leaking defects from its scope
[2] National Grid T/PM/P/11 does not specify a maximum depth for the application of the ESR
[3] Internal defects or corrosion should not continue to grow beyond acceptable limits
[4] Repair ay be used for defects less than 0.8t deep, provided that damaged material has been removed by grinding and removal has been confirmed by inspection
[5] Use of filler material in dent and engineering assessment of fatigue are recommended
[6] Code and regulatory restrictions on maximum dent size should be followed

Table 1: Comparison of repair options for differing types of defect

5.2 Qualifying Factors

The selection of a suitable repair method for given defects presented in Table 1 considers a pipe line without constraints. National Grid and the PRCI Pipeline Repair Manual state additional considerations applicable to defect assessment and repair selection.

5.2.1 National Grid T/PM/P/11

- Bending stresses due to subsidence or land slip
- Tensile or compressible axial stresses as a result of temperature differential or the presence of nearby fixtures or valves which have the potential to constrain movement of the pipeline

5.2.2 PRCI Repair Manual

As the Pipeline Repair Manual provides recommendations on the suitability of repair methods for differing defect types. It also details specific considerations, where a repair type may be unsuitable or require additional considerations in its use.

	Qualifying Factor	Type A Sleeve
1	Onshore	Yes
2	Offshore	No
3	Straight Pipe	Yes
4	Gradual Bend	Yes [1]
5	Sharp Bend	Yes [1]
6	Fitting	No
7	Heat Sink	Yes
8	High Carbon Equivalence	Yes
Notes: [1] A Special sleeve configuration is required		

Table 2: Summary of qualifying factors for various repair options from PRCI Repair Manual

The application to bends (gradual and sharp) can be made with a special configuration sleeve. This approach may reduce the effectiveness of the load transfer and a more detailed design process or selection of an alternative repair method may then be recommended.

5.2.3 Defect – Repair Compatibility Matrix

Table 3 is unique with regards to materials, construction and application to the defect site. The repair matrix has been developed in-line with vendors responses to the questionnaire (Appendix A) and readily available repair data sheets.

The repair capabilities have been aligned with the defect types discussed in T/PM/P/11, the Management Procedure for Inspection, Assessment and Repair of Damaged Steel Pipelines (Ref [5]). The repairs suitability for the defect type will need to be considered together with a range of pipeline construction and operating conditions which are provided to the vendor in the form of a design basis (Ref [6]). Options highlighted in green show where the non-standard defects offer a defect applicability above what the standard Type A can repair.

DEFECT TYPE	REPAIR TYPES				
	Standard	Non-Standard			
	Typical Type A Repair	**British Gas** Epoxy Sleeve Repair	**Petrosleeve** Steel Compression Sleeve	**Western Specialities** Composi-Sleeve	**Ram 100**[4] Ramfill A
External Corrosion < 80%	YES	YES	YES	YES	YES
External Corrosion > 80%	NO	YES	YES [1]	Temporary	YES
Internal Corrosion < 80%	Limited	YES[5]	YES[5]	Limited	NO
Internal Corrosion > 80%	NO	NO	NO	Limited	NO
Welding Arc Strikes	YES	YES	YES	YES	YES
Cracks or Spalling	YES[2]	YES [1][2]	YES	YES[2]	YES[2]
Smooth Dent	YES[3]	YES[3]	YES[3]	YES[3]	YES
Smooth Dent plus cracks or spalling	YES[2][3]	YES[2][3]	YES[3]	YES[2][3]	YES[2]
Smooth dent plus gouge	YES[2][3]	YES[2][3]	YES[3]	YES[2][3]	YES[2]
Kinked Dent	NO	NO	NO	NO	YES
Gouge	YES[2]	YES[2]	YES	YES[2]	YES
Stress Corrosion Cracking	YES[2]	NO	YES	Limited	Limited

Notes:
[1] Can repair, provided the site conditions are safe and the product is not leaking
[2] Repair may be used for defects less than 0.8t deep, provided that damaged material has been removed by grinding and removal has been confirmed by inspection
[3] Use of filler material in dent and engineering assessment of fatigue are recommended
[4] Ramfill A repair is based on information attained from marketing material only, no questionnaire was returned from Ram 100
[5] A limit of repairable internal corrosion is capped at 80%

Table 3: Repair comparison – defect matrix

5.3 Repair Comparison

Table 4 provides a summary comparison of the repairs included within this review. The comparison considers design and construction of the repair only, defect applicability is only considered in Table 3.

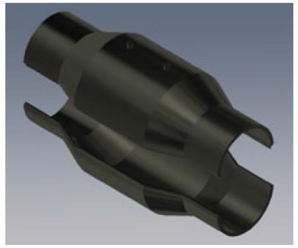
	Type A Repair	Epoxy Filled Sleeve	Compression Sleeve	Composi-Sleeve	Ramfill-A+E
					
Welding Required	Longitudinal Only	Longitudinal or clamp Arrangement	Longitudinal Only	No Welding (chemically bonded)	Longitudinal Only
Internal Filler	Epoxy filler at defect site	Epoxy Filler on the ends then in the annulus	Epoxy used as lubrication and load transfer	Adhesive on the internal and external surface	Ram-100 Epoxy Resin
Fit Up	Close Fit Up	Oversized Half Shells	Close Fit Up – Mechanically loaded	Close Fit Up – Mechanically loaded	Stand Off Shell
Pressure Reduction	It should be installed at a pressure level below that at which the area of the line pipe with the defect might be expected to fail	May be necessary to reduce pipeline pressure for 24hrs while grout cures. Pressure level should be below that at which the defect might fail. A reduction of at least 15% of MOAP is recommended	Recommended that pipe pressure be reduced to at least 80% MAOP. A trial fit-up and pressure reduction is recommended	Reduced for personnel safety Assumed reduction of 80% MAOP	Information not provided
Installation Method	Close fit full encirclement steel sleeve halves welded longitudinally. Epoxy filler is used at the defect site to ensure pressure load reinforcement	Welded or mechanically joined to fully encircle damaged section. Annulus is then sealed at both ends prior to injecting with epoxy Grout	Two sleeve halves are installed over the defect area , drawn together mechanically. The sleeve is then heated to induce expansion, the halves are then welded. Once cooled the sleeve contracts and puts the defect into compression	Military grade adhesive is used to chemically bond the steel sleeve onto the pipe. A composite overwrap goes over the top to provide additional support and protect the sleeve from future corrosion	Custom made full encirclement sleeve with concentric reductions, welded longitudinally and annulus filled with Ram-100 epoxy resin
Qualification Testing	ASME PCC-2	Short Term testing programme (Hydrotest, Pressurised with bending moment, Fatigue test)	Pressure testing and fatigue testing of crack defect	Full scale testing with a deep corrosion feature. The tests involved both burst testing and pressure cycle fatigue	Burst and Hydrotesting

Table 4: Comparison of Standard and Non-standard Type A Repairs

6. DESCTRIPTION OF REPAIR SYSTEMS

6.1 Standard Type A Repair

As described in ASME B31.4 (Ref [2]) and the Pipeline Repair Manual (Ref [3]), full encirclement steel sleeves consist of a cylindrical shell placed around the pipe section to be repaired, and welded along the two longitudinal seams as shown in Figure 6-1.

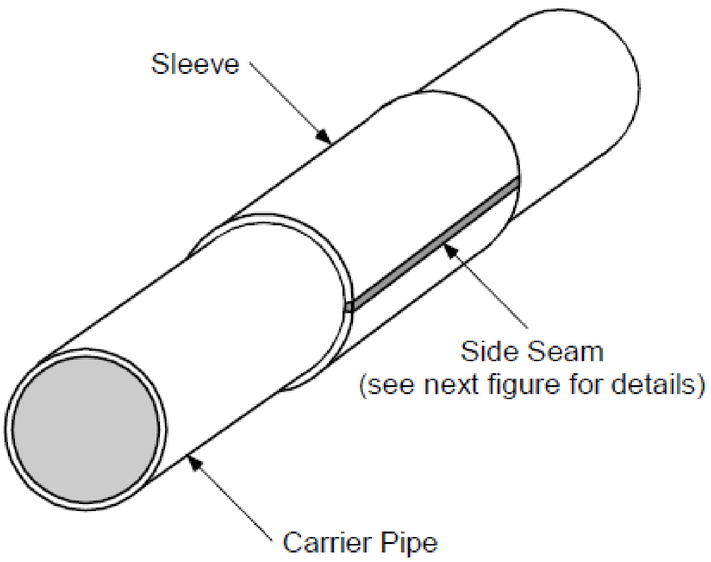


Figure 6-1: Illustration of Type A (reinforcing Sleeve) Ref [3]

Type A sleeve ends are not welded circumferentially to the carrier pipe, therefore it is not capable of containing internal pressure, but functions as reinforcement for a defective area.

It is only used for repair of defects that are not leaking and that are not expected to grow during service, or when the damage mechanism and growth rate are fully understood.

6.1.1 Limitations

- Type A sleeves may not be appropriate for the repair of circumferentially orientated defects because they will not resist axial loads on the pipe.
- Measures shall be taken to prevent corrosion due to the mitigation of moisture through the unwelded ends into the space between the pipe and sleeve. Such measures may include the use of sealant or coating for the operating environment.
- The presence of a girth weld or longitudinal seam weld having prominent weld reinforcement may interfere with achieving a tight fit-up of the sleeve.

6.1.2 Design

A Type A sleeve should be designed using guidance from all three relevant construction codes: Pipeline repair Manual (Ref [3]), ASME 31.4 (Ref [2]) and ASME PCC-2 (Ref [1]).

A typical configuration and weld details of a type A sleeve are shown in Figure 6-1 and Figure 6-2. The seams may be single V-butt welds or overlapping steel strips fillet welded to both halves. Additional sleeve wall thickness maybe required where the sleeve is ground to accommodate a seam weld or has a rebate for a backing strip.

If the side seams are to be butt welded and the sleeve halves are to be made from the same diameter pipe as the carrier pipe, then each half should be more than half the circumference of the piece of pipe. With the overlapping joint, it is not essential that each half be more than half of the circumference because the gap can be easily bridged and is considered to have a joint factor of 0.8.

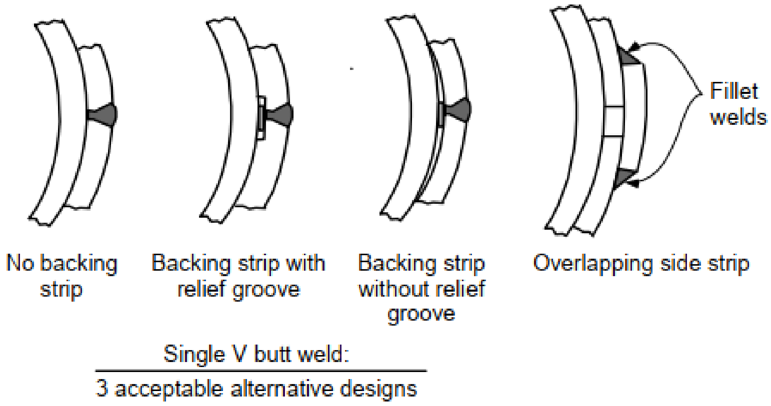


Figure 6-2: Weld details for Type A sleeve

As described in PRCI (Ref [3]), one major advantage of a Type A sleeve over other types of repairs is that for relatively short flaws it can function effectively without itself necessarily being a high integrity structural member. (short flaws $\leq \sqrt{20Dt}$). For such flaws, the sleeves role is limited to restraining bulging of the defective area. As a result, it can be fabricated simply and requires no rigorous non-destructive inspection to ensure its effectiveness.

As a rule of thumb, the thickness of the sleeve should not be less than two-thirds of the thickness of the carrier pipe when used to repair short flaws as described in ASME PCC-2 (Ref [1]), assuming that the sleeve is at least as strong as the carrier pipe.

With flaws $> \sqrt{20DT}$, the sleeve thickness should be at least as great as that of the carrier pipe, again assuming that the sleeve is at least as strong as the carrier pipe.

It is permissible to use sleeves thinner than the carrier pipe if their strength is increased by an amount sufficient to compensate for their thickness being less than that of the carrier pipe. Likewise, the sleeve could be of an acceptable material with lower strength than that of the carrier pipe if its thickness is increased to compensate for the difference in strength

To assure that adequate restraint exists and that the sleeve will indeed prevent a rupture, the sleeve should be extended onto sound, full-thickness pipe at least 50 mm (Ref [2]) beyond the ends of the defect.

For type A sleeves, it is necessary to achieve intimate contact between the pipe and the sleeve at the location of the defect being repaired and an appropriate filler material should be used to ensure that the sleeve provides the desired pressure load reinforcement.

Additionally if the sleeve has a less than optimum fit up then the load transfer co-efficient can be greatly affected.

- for ideal case of perfect fit-up, which is never approached in practice without mechanical loading
- 0.50 for a strong highly compressed epoxy filler, such as that used in tight fitting compression sleeves
- 0.25 for typical tight fitting sleeves with epoxy filler
- 0.15 for typical tight-fitting sleeve with epoxy filler only in the defect area

Realistically, a standard Type A repair may only achieve a 0.15 co-efficient, whereas the non-standard repairs may be able to achieve closer to 1.0 if the correct compression and mechanical loading has been applied. The variability in load transfer greatly relies on the vendors installation procedure.

6.1.3 Pressure Reduction

Pressure reduction is essential if the defect being repaired is at or near its predicted failure pressure at the start of the repair operation. If the pressure is not reduced in such a case, the repaired defect could begin leaking during the sleeve installation process. In contrast, when the pressure is reduced, the radial bulging at the defect location is reduced and can be prevented from recurring during re-pressurisation by using a tightly fitting sleeve.

As stated in the pipeline repair manual (Ref [3]), research results indicate that a pressure reduction of 33% from the predicted failure pressure was adequate for the application of Type A sleeves. Typically, a pressure reduction is not necessary if it can be shown that the defect is not at or near its predicted failure pressure.

Reinforcing sleeves usually do not share much of the hoop stress that is acting on the carrier pipe unless special application techniques are used. Even if the sleeve fits perfectly, it will at most carry one-half of the hoop stress recovered after pressure reduction if the sleeve is the same thickness as the carrier pipe. In spite of this, a properly fabricated sleeve can restore the strength of a defective piece of pipe to at least 100% of SMYS.

For features categorised as severe or extreme damage, it is unlikely that the remaining strength can be accurately determined without detailed measurement and analysis of the feature. However there is a significant likelihood that due to the damage, the strength of the pipeline has been reduced. Consequently, it is recommended that where possible a pressure reduction is carried out to the guidance in Figure 6-3.

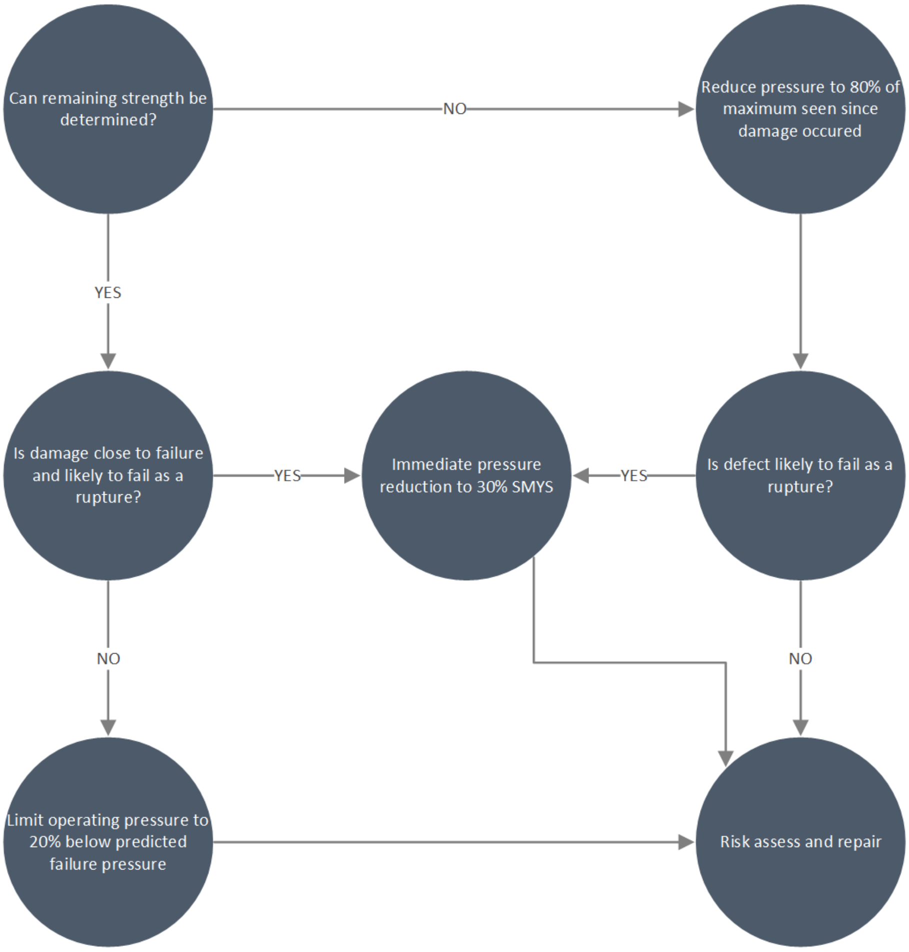


Figure 6-3: Pressure reduction guidance following detection of anomaly

As well as this generic guidance, the operator must take account of the circumstances around any specific excavation and put in place relevant mitigation measures to ensure safety; this could include further pressure reduction.

6.1.4 Mechanical Loading

To improve the fit-up of the sleeve against the carrier pipe, the two halves can be drawn together mechanically (using clamps, lugs or chains). A significant preload can enhance the effectiveness of a Type A sleeve in the same manner as a pressure reduction in the carrier pipe, repair vendor Petrosleeve apply a preload technique to place the carrier pipe and ultimately the defect into compression. However, preload should not be substituted for pressure reduction in cases where a reduction of pressure is necessary for safety prior to the start of repair operations.

6.1.5 Hardenable Fillers

Compounds such as epoxy or polyester are frequently used in Type A repairs to ensure that no gaps exist between the sleeve and carrier pipe. Commonly, the fillers are used prior to installation of the sleeve to restore the outside diameter of the pipe by trowelling the compound into depressions, such as metal loss or dents. Alternatively, excess filler can be used around the entire pipe circumference and excess squeezed out when the two steel halves are drawn together. Ultimately, effective use of hardenable fillers should aid in efficient load transfer between the sleeve and carrier pipe.

6.2 Epoxy Filled Shells (British Gas)

The epoxy filled half shell repair comprises two steel half shells which are joined to encircle the defect leaving an annular gap between 3mm and 40mm (a wide tolerance on the annular gap ensures that severe defects can be repaired).

The shells are designed to have the same thickness as the pipeline and extend at least one half diameter past the defect location. The shells can be joined either by a flanged clamp design or by welding, the annulus is sealed with a fast curing putty and the enclosed annular cavity filled with a high stiffness epoxy grout administered at low pressure. Bonding between the epoxy, sleeve and the pipe permits the transfer of longitudinal stress and provides hoop restraint.

The repair reduces stresses and strains in the vicinity of the damage. This is achieved by:

- Preventing the radial bulging associated with failure of the defect
- Transferring some stress into the shell, and hence reducing both the static and cyclic stress near the defect site.
- A fluid epoxy putty ensures immediate contact and efficiently fills the annulus enable effective load transfer once cured

These factors contribute greatly to the increase in strength and fatigue life of the defect after repair. A secondary function of the repair is to enclose the damage and limit the consequence of failure (i.e. leak not rupture)

6.2.1 Range of Recommended Defects

As detailed in the Gas Exhibition Conference paper (Ref [8]), an extensive full scale test programme confirmed many types of major damage could be repaired to a high standard, these included:

- Metal loss damage or cracking of any length, with a maximum depth up to 90% of the pipeline wall thickness and an average depth up to 80%
- Dents up to 9% of the pipeline diameter with metal loss or cracking up to 12% of the pipeline wall thickness
- Girth weld damage of length up to 60% of the pipe circumference

It also confirmed that damage which, if not repaired, would fail as a rupture can only fail as a minor leak after repair. This is an important factor for some types of internal damage.

6.2.2 Advantages of the repair

- It is a simple, rapid, proven and safe repair method
- The damage is restrained regardless of its surface topography or the deformed shape of the pipeline
- Welding directly onto live pipe is not required
- The annular gap between the pipeline and shell is large which simplifies manufacture of the shells and eliminates fit-up problems during installation

- The shells are easily produced since they have the same wall thickness and grade as the pipeline to be repaired.
- Repair can completely negate the need for welding by utilising a flanged half shell design

6.2.3 Supplier Information

British Gas originally developed the epoxy filled shell repair method for pipeline damage. The repair is now widely available through different vendors, these include GE PII and National Grid PMC. National Grid PMC has completed ROSEN's Vendor Questionnaire and is appended in Appendix A.

6.2.4 Qualification Testing

Information sourced from the Gas Exhibition Conference Paper (Ref [8]) states that qualification testing of the epoxy sleeve has included:

- Static Strength Test – effectiveness of the repair method against internal pressure loading is demonstrated by comparing the unrepaired failure pressure of a damaged test vessel with the maximum pressure applied. None of the repairs were found to repair, the maximum test pressure was limited by yielding of the test vessel.
- Fatigue Strength – effectiveness of the repair against variations in internal pressure is demonstrated by comparing fatigue life without the repair to fatigue life with the repair.
- Axial Strength – effectiveness of girth weld repair is demonstrated by the results of six tests on vessels ranging from 324 mm diameter to 610 mm diameter, with full circumferential defects 60% of the pipe wall deep which all survived the following loading:
    - Bending stress up to the yield strength of the pipeline
    - Internal pressure loading in excess of yield
    - Internal pressure fatigue loading for 140,000 cycles

A final axial pull test on these vessels has shown residual axial strength to be in excess of half yield strength.

6.3 Steel Compression Sleeves (Petrosleeve)

Petrosleeve is a commercial product that was developed to combine pressure reduction with thermal shrinkage of the sleeve achieving full compression in the carrier pipe.

They are designed, fabricated, and applied so that the repaired section of the carrier pipe is maintained under compressive hoop stress during subsequent operation. This approach is attractive for repairing longitudinal orientated crack-like defects because without a tensile hoop stress there is no driving force for crack growth.

Steel compression sleeves involve installing two sleeve halves over the defect area and drawing them together using clamps, jacks and chains, or lugs and bolts. The sleeve is then heated while in the clamped position to induce material expansion, the steel halves are then welded together. Once cooled, the steel sleeve contracts and puts the defect into compression. The thermal element and contraction of the sleeve material is the dominant mechanism within the repairs success. The forces generated as a result of the interference fit cause the steel repair sleeve to be put into tension and the pipe material to be put into compression.

Epoxy filler is used between the carrier pipe and sleeve to achieve the transfer of stresses and to aid in fit up of the sleeve.

Several factors influence the degree of stress reduction in the carrier pipe. These include the fit of the sleeve, the pipe wall thickness and diameter, the sleeve wall thickness, the internal pressure during installation, and the installation temperature.

6.3.1 Range of Recommended Defects

To date, 26,000+ installations have been completed in Canada, USA, Mexico, France, Australia and the Dominican Republic, repairing defects such as corrosion, cracking SCC, denting, arc burns and weld defects.

6.3.2 Advantages of the Repair

- No welding is required directly onto the live pipeline
- Not susceptible to disbondment between the sleeve and parent pipe
- The shells are easily produced and quick to manufacture
- Places pipe into compression, therefore can arrest crack growth

6.3.3 Supplier information

Petrosleeve design, manufacture and markets the Petrosleeve repair system, headquarters are based in Alberta Canada. Petrosleeve have completed ROSEN’s Vendor questionnaire, this can be found in Appendix A.

6.3.4 Qualification Testing

All testing has been completed at pipeline pressures.

The test involved putting a 50% crack into a section of 862 mm diameter, 9.5 mm wall thickness grade 448 pipe. Then a compression sleeve was installed while the pipe was pressurised to 3800 kPa (38% SMYS).

Following sleeve installation, the test vessel was subjected to 9000 cycles and 7880 to 2960 kPa (80% to 30% SMYS); 200 cycles 7800 to 0 kPa (80%-90% SMYS), hold pressures of 8870 kPa (90% SMYS) for 4 hours and 10840 kPa (110% SMYS) for 2 hours.

Following pressure cycle and sleeve removal, the crack was inspected by phased array inspection technique.

The technique can effectively supress fatigue crack growth of an axial flaw (100 mm long x 50% WT deep) in 34” API X65 pipe.

None of the test samples showed evidence of disbondment, the repaired section of pipeline remained in compression.

6.4 Composite Sleeve (Composi-sleeve) – Western Specialties

Composi sleeve is the only industry non-welded anomaly repair solution that uses a combination of steel sleeves and composite overwrap (water activated E-glass composite system).

The repair utilised a military grade adhesive to 'chemically weld' the steel sleeve onto the pipe without the need of typical hot welding. A composite overwrap goes over the top to give additional support as well as to protect the steel sleeve from future corrosion.

6.5 Range of Recommended Defects

Composi-sleeve has been tested and used for structural reinforcement for spans, crossings and overburden scenarios. It has been used to repair pipeline anomalies such as cracks, dents corrosion and even small diameter holes. Since there is no hot welding it is ideal for thin wall pipe and defects.

6.5.1 Advantages of the Repair

- No welding is required directly onto the live pipeline or to join the repair
- Composite wrap supports the repair and protects the defect area from future corrosion
- The shells are easily produced and quick to manufacture

6.5.2 Supplier Information

Western Specialties is a technology company that specialises in composite repairs and reinforcements for pipelines and storage tanks. All products meet the requirements of ASME PCC-2. Since the initial Composi-sleeve system was invented, Western specialties has continued to develop other reinforcement and repair solutions for the oil and gas market. Western Specialities have completed and returned ROSEN's Vendor questionnaire, this can be found in Appendix A.

6.5.3 Qualification Testing

The evaluation process involved full-scale testing verified by stress engineering services (Ref [9],Ref [10] & Ref [11]) where Composi-sleeve repaired a test sample fabricated using 12.75 inch x 0.375 Inch, Grade X42 pipe having a 75% deep corrosion section. The tests involved both burst testing and pressure cycle to failure testing.

Bend testing – The testing programme consisted of comparing the moment bearing capacity of an unreinforced pipeline relative to 2 different configurations of reinforced pipelines. To better represent in service conditions, the pipelines were tested while pressurised to the maximum operating pressure (MAOP) or 72% of the minimum specified yield strength (SMYS) and then subjected to bending loads.

Other tests performed have included external corrosion > 80% and < 80%, through wall holes, dents, bending, overburden, cyclic fatigue, cathodic Disbondment, axial tensioning loads, girth weld reinforcement, vintage weld repairs, cracks within LF ERW seams.

Testing has been certified by a 3rd party: ASME PCC-2 and ISO 24817 from Stress Engineering Services

6.6 RAMFILL A – Ram 100

RAMFILL-A+RE, is a full encirclement pumpkin steel sleeve, welded together at the longitudinal seams. RAM-100 liquid epoxy resin is then injected into the annulus of the sleeve to promote the transfer of stress from the pipe to the sleeve. The sleeve is custom made with concentric reductions, the main advantage of this sleeve type is that it is tolerant of pipe out-of-straightness, fixtures and pipe surface deformities such as dents or wrinkles.

6.6.1 Range of Recommended Defects

On review of Ram-100 marketing material, the repair can be used for the following : dents, stress concentrations, corrosion > 80%, cracking, internal corrosion and flaws in welded sections.

6.6.2 Advantages of the Repair

- The damage is restrained regardless of its surface topography or the deformed shape of the pipeline can encompass large dents, wrinkles, stress, joints and pipe reductions
- No welding is required directly onto the live pipeline
- The annular gap between the pipeline and shell is large which simplifies manufacture of the shells and eliminates fit-up problems during installation

6.6.3 Supplier Information

Ram 100 international provide repair solutions to the oil and gas industry for challenging anti-corrosion pipeline repair, rehabilitation, and maintenance projects. ROSEN's vendor questionnaire was unable to be completed by Ram 100, therefore information contained in this report regarding their repair has been sourced from their website and marketing material only.

6.6.4 Qualification Testing

The Ramfill A+RE repairs have been burst tested to failure

7. REFERENCES

Ref [1] *ASME PCC-2 (2015) Repair Pressure Equipment and Piping. Issued 23rd February 2015*

Ref [2] *ASME B31.4 (2016) Pipeline Transportation Systems for Liquids and Slurries. ASME code for pressure pipeline , B31. Issued 31st March 2016.*

Ref [3] *PRCI (2006) Pipeline Repair Manual. Rev 6. Issued 28th August 2006.*

Ref [4] *ROSEN (UK) (2018) Management Procedure for Pipeline Repair: Grout Filled Steel Sleeves. 10520-RPT-001 Rev 01. Issued September 2018.*

Ref [5] *National Grid (2012) Management Procedure for Inspection, Assessment and Repair of Damaged (Non-Leaking) Steel Pipelines Above 150 mm Nominal Diameter and Designed to Operate at Pressures Greater Than 2 bar. T/PM/P/11 Rev 02. Issued February 2012*

Ref [6] *ROSEN (UK) (2018) 10520 – TN – Design Basis. Rev 01. Issued September 2018.*

Ref [7] *ISO 24817(2015) Composite Repairs for Pipework, Qualification and Design, Installation, Inspection and Testing.*

Ref [8] *British Gas Plc (1992) 58th Autumn meeting and Gas 92 Exhibition, Wembley Conference Centre, November 1992. Repairing Transmission Pipelines by Epoxy-Filled Shells. Issued November 1992.*

Ref [9] *Stress Engineering Services (2011) Evaluation of the ComposiSleeve™ Pipeline Repair System. PN1151033CRA. Issued June 2011*

Ref [10] *Stress Engineering Services (2016) ASME PCC-2 Qualification Testing for the ComposiSleeve™ Repair System. Issued 10th June 2016*

Ref [11] *Stress Engineering Services (2008) Bend Testing of the Western Specialities ComposiSleeve™ Reinforcement System. PN117847CRA. Issued November 2008.*

APPENDIX A

REPAIR VENDOR QUESTIONNAIRES

Repair Vendor Questionnaire

UKOPA Repair Management Procedure
Reinforcement Sleeve - Type A

Ambergate PMC

Questionniare Purpose

UKOPA have identified a subject area of the management of grout filled pipeline repair sleeves where improvements in process and guidance to operators will provide a benefit to its members

Currently, guidance is available within ASME PCC-2, ASME B31.4 and the Pipeline Repair Manual, on how to perform Type A rep[airs, but the increased defect applicability and performance identified in alternative Type A repairs is system and vendor specific, therefore an updated guidance document is being produced to cover these proprietary methods.

The information collated from repair vendors shall be included within the management procedure to allow the operator to identify the most appropriate repair system for the given defect and perform a technical review and management of change to be able to implement the repair.

Where possible please append any supporting documentation to clarify the response to the below tables and questions.

Please return the completed questionnaire to:

Lauren Guest
lguest@rosen-group.com

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1. REPAIR COMPATIBILITY

REPAIR DETAILS	VALUE	COMMENT
Carrier Pipe Diameter Range (mm)	9/16" (14 mm) to 48" (1200 mm)	P/11 & P20 dictates
Carrier Pipe Wall Thickness Range (mm)	3 mm -28.7 mm WT	
Maximum Repair Length (mm)	As dictated by P11 & P20	Consolation with DNVGL on individual assessments have allowed increased epoxy sleeve lengths & multiple sleeves.

Table 1: Repair Details

Table 2 should be used to identify the defects that can be repaired by your proprietary repair, comments should be made to illustrate the repairs full capability, i.e. can repair cracking (weld cracks, SSC, etc).

DEFECT TYPE		COMMENT
✔	External Corrosion < 80%	P/11 & P/20 dictates, epoxy repair sleeve option
✔	External Corrosion > 80%	P/11 & P/20 dictates, epoxy repair sleeve option
✔	Internal Corrosion < 80%	Epoxy sleeve repair previously used on oil lines to extend asset life (5 years)
✔	Internal Corrosion > 80%	Epoxy sleeve repair previously used on oil lines to extend asset life (5 years)
✔	Grooving, selective or preferential corrosion of ERW, EFW seam	P/11 & P/20 dictates, epoxy repair sleeve option
✔	Gouge, groove or arc burn	P/11 & P/20 dictates, epoxy repair sleeve option
✔	Crack	P/11 & P/20 dictates, epoxy repair sleeve option non-leaking
✔	Hard Spot	P/11 & P/20 dictates, epoxy repair sleeve option

DEFECT TYPE		COMMENT
	Blisters	Not covered under P/11 & P/20
✔	Defective Girth Weld	P/11 & P/20 dictates, epoxy repair sleeve option
✔	Lamination	P/11 & P/20 dictates, epoxy repair sleeve option
✔	Dents ≤ 6% of the diameter of the pipe containing gouge, groove, or crack	P/11 & P/20 dictates, epoxy repair sleeve option
✔	Dents ≤ 6% of the diameter of the pipe containing seam or girth weld	P/11 & P/20 dictates, epoxy repair sleeve option
✔	Dent exceeding 6% of the diameter of the pipe	P/11 & P/20 dictates, epoxy repair sleeve option-increased annuals to accommodate ovality
	Buckles, ripples, or wrinkles	N/A
	Leaking coupling	N/A
	Defective sleeve from prior repair	Not experienced
	Small diameter holes	Encapsulation with epoxy tee or Plidco temporary repair clamp
✔	Circumferential defects	P/11 & P/20 dictates, epoxy repair sleeve option-increased annuals to accommodate ovality

Table 2: Compatible Details

Where applicable, please identify which of the below the repair can be used with, additionally, please state any 'limited' compatibility or other constraints.

PIPELINE CONSTRAINTS		COMMENT
✔	Pipeline Bends (hot, mitre, field bend)	P/11 & P/20 dictates, epoxy repair sleeve option-special flanges type
	Expansion Loops	N/A
	Ovality	N/A
✔	Ground Movement	Anchor points previously attached to epoxy shell used to prevent pipeline movement
	External Loading (Axial or Bending)	N/A
✔	Pressure cycles	Encapsulation used in high frequency vibration areas
✔	High Temperature Servuce > 60 °C	Namco solutions newly approved grout installation range 20-35 (degC) operating range -40 to 100 (degC)
✔	Low Temperature Servuce < 5 °C	Namco solutions newly approved grout installation range 5-20 (degC) operating range -40 to 70 (degC)
✔	Temperature Cycles	125 (degC) 1000 hours

Table 3: Pipeline Constraints & Repair Compatability

2. DESIGN

1. What design code does the repair comply with? And what are the sizing/design rules?

ASME B31.4
ASME PCC-2
Other

If other then please specify:

F/15 & P/22

2. Is the repair system approved by a 3rd party?

DNV
Lloyd's Register
Other

If other then please specify:

Namco

3. What fit-up does the sleeve have against the pipe?

Stand-off
Close fit
Other

If other then please specify:

As per F/15 & P/22

4. How are the epoxy fillers mechanical properties used in the repair design process?

Class as outside of the reinforcing area

5. Can the sleeve be made with flanged halves or can it only be welded?

Flanged Halves
Welded
Both

If other then please specify:

3. INSTALLATION

1. How is the pipe prepared prior to installing the sleeve?

Grit blast to 60-80 profile MMP SA2.5 cleanliness

2. For near critical defects how is the pressure reduction determined for the fit up of Type A sleeves?

Per P/11 & P/20 specialist advise

3. How are the two halves of the sleeve drawn together and secured for welding activities?

The sleeves are drawn together with Deman butt clamps and ratchet straps

4. What welding technique is used to perform the longitudinal seam welds? Is there any visual examination or NDT performed to verify weld quality?

P2 & P8 welding techniques, MPI, UT, X-ray to circumferential welds and MPI to longitudinal welds

5. Can the integrity of the repair be inspected once fully installed?

Inspected by ILI only

4. QUALIFICATION TESTING

1. Has the repair undergone any long or short term testing to qualify the repair for use with the suggested defects in Table 1? If yes, please expand on the following where possible?

    - Tests performed
    - Test duration
    - Defect type
    - Defect types qualified
    - Static or Cyclic

Repair Vendor Questionnaire

UKOPA Repair Management Procedure
Reinforcement Sleeve - Type A

Petrosleeve

Questionniare Purpose

UKOPA have identified a subject area of the management of grout filled pipeline repair sleeves where improvements in process and guidance to operators will provide a benefit to its members

Currently, guidance is available within ASME PCC-2, ASME B31.4 and the Pipeline Repair Manual, on how to perform Type A rep[airs, but the increased defect applicability and performance identified in alternative Type A repairs is system and vendor specific, therefore an updated guidance document is being produced to cover these proprietary methods.

The information collated from repair vendors shall be included within the management procedure to allow the operator to identify the most appropriate repair system for the given defect and perform a technical review and management of change to be able to implement the repair.

Where possible please append any supporting documentation to clarify the response to the below tables and questions.

Please return the completed questionnaire to:

Lauren Guest
lguest@rosen-group.com

ROSEN
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1. REPAIR COMPATIBILITY

REPAIR DETAILS	VALUE	COMMENT
Carrier Pipe Diameter Range (mm)	60-1220 mm	The PetroSleeve repair technology has been used on all pipe sizes utilized in the oil and gas industry.
Carrier Pipe Wall Thickness Range (mm)	N/A	Wall thickness is taken into account when designing the repair installation.
Maximum Repair Length (mm)	914 cm / sleeve	When undertaking a repair, sleeves can be installed adjacent to each other. Whole pipe joints have been repaired with multiple sleeves

Table 1: Repair Details

Table 2 should be used to identify the defects that can be repaired by your proprietary repair, comments should be made to illustrate the repairs full capability, i.e. can repair cracking (weld cracks, SSC, etc).

DEFECT TYPE		COMMENT
✔	External Corrosion < 80%	No limitation
✔	External Corrosion > 80%	As Per CSA Code, this is an acceptable repair, provided the site conditions are safe and product is not leaking.
✔	Internal Corrosion < 80%	No limitation. However, additional action should be taken to arrest the internal active corrosion.
✔	Internal Corrosion > 80%	As Per CSA Code, this is an acceptable repair, provided the site conditions are safe and product is not leaking.
✔	Grooving, selective or preferential corrosion of ERW, EFW seam	No limitation
✔	Gouge, groove or arc burn	No limitation
✔	Crack	Arrests crack extension. The pipe is put into compression, thus eliminating all future crack growth.
✔	Hard Spot	No limitation

DEFECT TYPE		COMMENT
✔	Blisters	No limitation
✔	Defective Girth Weld	Sleeving adds support to the weld.
✔	Lamination	No limitation
✔	Dents ≤ 6% of the diameter of the pipe containing gouge, groove, or crack	No limitation as long as the sleeve fit around the pipe is acceptable.
✔	Dents ≤ 6% of the diameter of the pipe containing seam or girth weld	No limitation as long as the sleeve fit around the pipe is acceptable.
✔	Dent exceeding 6% of the diameter of the pipe	No limitation as long as the sleeve fit around the pipe is acceptable.
	Buckles, ripples, or wrinkles	Not applicable due to fit
	Leaking coupling	Not applicable
	Defective sleeve from prior repair	Not applicable
	Small diameter holes	If leaking, not applicable.
✔	Circumferential defects	Acceptable, except for cracking in the circumferential direction

Table 2: Compatible Details

Where applicable, please identify which of the below the repair can be used with, additionally, please state any 'limited' compatibility or other constraints.

PIPELINE CONSTRAINTS		COMMENT
✔	Pipeline Bends (hot, mitre, field bend)	Acceptable for field bends, with trial installation confirmation, tight radius bends not acceptable
	Expansion Loops	Not applicable
✔	Ovality	With all the 26,000+ installations completed, ovality has not been a concern.
✔	Ground Movement	The sleeving has a reinforcing affect on the section of pipe repaired.
✔	External Loading (Axial or Bending)	The sleeving has a reinforcing affect on the section of pipe repaired
✔	Pressure cycles	Testing has confirmed that pressure cycles are not a concern. After installation at pipeline operating pressure, disbondment between the sleeve and pipe does not occur.
	High Temperature Servuce > 60 °C	Temperature service up to 40 C is acceptable
✔	Low Temperature Servuce < 5 °C	Low temperature not a concern as long as the installation temperature is in the 20 C range
✔	Temperature Cycles	Not a concern, as long as the temperature does not exceed 40 C

Table 3: Pipeline Constraints & Repair Compatability

2. DESIGN

1. What design code does the repair comply with? And what are the sizing/design rules?

ASME B31.4
ASME PCC-2
Other

If other then please specify:

The PetroSleeve technology is recognized in the CSA Z662 Code, as well as being "allowed to be used" by the US Office of Pipeline Safety. It recently was accepted in France, and has been used in Mexico and Australia.

2. Is the repair system approved by a 3rd party?

DNV
Lloyd's Register
Other

If other then please specify:

Refer to the above reply. Lloyd's Register has been involved in PetroSleeve installations in Mexico. Some users of the system have completed independent testing and study for their application situations.

3. What fit-up does the sleeve have against the pipe?

Stand-off
Close fit
Other

If other then please specify:

There is metal-to-metal contact between the sleeve and pipe. The cathodic protection on the pipe is transmitted to the sleeve.

4. How are the epoxy fillers mechanical properties used in the repair design process?

The epoxy acts as a sealant between the metal-to-metal contact of the pipe and sleeve.
Also, for dent cavities, the epoxy supports the pipe.

5. Can the sleeve be made with flanged halves or can it only be welded?

Flanged Halves
Welded
Both

If other then please specify:

When installed, the two sleeve halves are welded together. No welding is performed onto the carrier pipe.

3. INSTALLATION

1. How is the pipe prepared prior to installing the sleeve?

The pipe is grit blasted.

2. For near critical defects how is the pressure reduction determined for the fit up of Type A sleeves?

For all repairs, it is recommended that the pipe pressure be reduced, to at least 80% of the usual operating pressure, if not lower, prior to personnel entering the ditch and the sleeve halves being trial fitted. The trial fit is important to determine if the repair can successfully be completed. This is a safety guideline we encourage.

3. How are the two halves of the sleeve drawn together and secured for welding activities?

The assembly is secured using a custom jacking system.

4. What welding technique is used to perform the longitudinal seam welds? Is there any visual examination or NDT performed to verify weld quality?

A suggested welding procedure is provided to the operator. However, the operator is required to provide a welding procedure. Standard NDT welding inspection procedures can be used to inspect the weld.

5. Can the integrity of the repair be inspected once fully installed?

In addition to inspecting the welding, an engineering assessment is undertaken with proprietary software to determine, after sleeve installation, the stresses in the pipe under the sleeve and stresses in the sleeve. This analysis confirms that, based on the generated stresses, the pipe under the sleeve has been put into compression for all operating ranges. The engineering report is available/provided to the operator with the software.

4. QUALIFICATION TESTING

1. Has the repair undergone any long or short term testing to qualify the repair for use with the suggested defects in Table 1? If yes, please expand on the following where possible?

   - Tests performed
   - Test duration
   - Defect type
   - Defect types qualified
   - Static or Cyclic

Various testing has been completed that has shown that after a sleeve has been installed at operating pipe pressure, the pipe is placed into compression, the sleeve in tension. This testing has shown that the pipe under the sleeve remains in compression for all pressure ranges. This in turn, has confirmed that pressure cycling does not cause disbondment between the pipe and sleeve. Not having disbondment means that environmental interaction (water) after the installation can not enter between the sleeve and pipe, thus causing additional defect growth.

All our testing has been completed at pipeline pressures. Following installation, the sleeve has remained “tight” on the pipe, even though the internal pressure varied from e.g. 10,000 kPa during installation to zero. This aspect is very important to prevent disbondment between the sleeve and pipe.

Severe Cyclic testing has shown that cracking in the pipe, after sleeve installation, has not extended. This testing included 36,500 pressure cycles, 700-8300 kPa, which would represent a daily shutdown for 100 years.

Various internal pipe inspection runs have illustrated that after sleeve installation, previously identified SCC has not grown.

Petrosleeve installations have been completed (26,000+ to date), in Canada, USA, Mexico, France, Australia, and the Dominican Republic, repairing defects such as corrosion, cracking, SCC, and denting.

Repair Vendor Questionnaire

UKOPA Repair Management Procedure Reinforcement Sleeve - Type A

Western Specialities

Questionniare Purpose

UKOPA have identified a subject area of the management of grout filled pipeline repair sleeves where improvements in process and guidance to operators will provide a benefit to its members

Currently, guidance is available within ASME PCC-2, ASME B31.4 and the Pipeline Repair Manual, on how to perform Type A rep[airs, but the increased defect applicability and performance identified in alternative Type A repairs is system and vendor specific, therefore an updated guidance document is being produced to cover these proprietary methods.

The information collated from repair vendors shall be included within the management procedure to allow the operator to identify the most appropriate repair system for the given defect and perform a technical review and management of change to be able to implement the repair.

Where possible please append any supporting documentation to clarify the response to the below tables and questions.

Please return the completed questionnaire to:

Lauren Guest
lguest@rosen-group.com

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1. REPAIR COMPATIBILITY

REPAIR DETAILS	VALUE	COMMENT
Carrier Pipe Diameter Range (mm)	114 - 1524	
Carrier Pipe Wall Thickness Range (mm)	4 - 50.8	
Maximum Repair Length (mm)	N/A	Multiple repairs can be "butted" up next to each other for endless length

Table 1: Repair Details

Table 2 should be used to identify the defects that can be repaired by your proprietary repair, comments should be made to illustrate the repairs full capability, i.e. can repair cracking (weld cracks, SSC, etc).

DEFECT TYPE		COMMENT
✔	External Corrosion < 80%	
✔	External Corrosion > 80%	Used as "temporary" repairs and have lasted more than 2 years thus far. Currently testing full scale with 3rd party to justify a permanent repair now or calculate a design life.
✔	Internal Corrosion < 80%	Can be used to repair area, but will not stop the internal corrosion.
✔	Internal Corrosion > 80%	Can be used to repair area, but will not stop the internal corrosion.
✔	Grooving, selective or preferential corrosion of ERW, EFW seam	Testing reports can be supplied.
✔	Gouge, groove or arc burn	
✔	Crack	Testing reports can be supplied.
✔	Hard Spot	

DEFECT TYPE		COMMENT
✔	Blisters	
✔	Defective Girth Weld	Testing report can be supplied.
✔	Lamination	No hot welding is necessary to attach sleeves so can be applied to lamination areas.
✔	Dents ≤ 6% of the diameter of the pipe containing gouge, groove, or crack	
✔	Dents ≤ 6% of the diameter of the pipe containing seam or girth weld	
	Dent exceeding 6% of the diameter of the pipe	
✔	Buckles, ripples, or wrinkles	Custom sleeves can be made.
✔	Leaking coupling	Custom sleeves can be made.
✔	Defective sleeve from prior repair	Custom sleeves can be made.
✔	Small diameter holes	Testing report.
✔	Circumferential defects	Testing report.

Table 2: Compatible Details

Where applicable, please identify which of the below the repair can be used with, additionally, please state any 'limited' compatibility or other constraints.

PIPELINE CONSTRAINTS		COMMENT
✔	Pipeline Bends (hot, mitre, field bend)	Custom sleeves can be made
	Expansion Loops	
✔	Ovality	ComposiClamps conform sleeve to fit ovality of pipe
✔	Ground Movement	Test report
✔	External Loading (Axial or Bending)	Test report
✔	Pressure cycles	Test report
✔	High Temperature Servuce > 60 °C	Adhesive selection
✔	Low Temperature Servuce < 5 °C	Adhesive selection
✔	Temperature Cycles	

Table 3: Pipeline Constraints & Repair Compatability

2. DESIGN

1. What design code does the repair comply with? And what are the sizing/design rules?

ASME B31.4
ASME PCC-2
Other

If other then please specify:

2. Is the repair system approved by a 3rd party?

DNV
Lloyd's Register
Other

If other then please specify:

Stress Engineering Services certification of ASME and ISO standards
Currently working with Lloyd's Register integrating fiber optics into steel sleeve

3. What fit-up does the sleeve have against the pipe?

Stand-off
Close fit
Other

If other then please specify:

Sleeves are tightened down to a uniform thickness utilizing small glass beads that is in the adhesive used to attached sleeves to carrier pipe.

4. How are the epoxy fillers mechanical properties used in the repair design process?

High compression strength epoxy was chosen to transfer load to repair system only. Mechanical properties are not used in the specific calculation, but is dependent on the temperature.

5. Can the sleeve be made with flanged halves or can it only be welded?

Flanged Halves
Welded
Both

If other then please specify:

We can custom make sleeves with flanged halves welded before or after installation.

3. INSTALLATION

1. How is the pipe prepared prior to installing the sleeve?

Minimum NACE #3 and 2.5 mil profile is ideal. This can an be achieved by various methods. We have also used non-motorized equipment such as sandpaper and files to achieve pipe prep.

2. For near critical defects how is the pressure reduction determined for the fit up of Type A sleeves?

Pressure reduction for ComposiSleeve system is not necessary and only needed when their is a safety issue.

3. How are the two halves of the sleeve drawn together and secured for welding activities?

ComposiSleeve uses ComposiClamps that are torqued down to draw sleeves onto the carrier pipe.

4. What welding technique is used to perform the longitudinal seam welds? Is there any visual examination or NDT performed to verify weld quality?

N/A - no hot welding needed to attach sleeves

5. Can the integrity of the repair be inspected once fully installed?

Yes - it is also detected in future smart pig runs.

4. QUALIFICATION TESTING

1. Has the repair undergone any long or short term testing to qualify the repair for use with the suggested defects in Table 1? If yes, please expand on the following where possible?

    - Tests performed
    - Test duration
    - Defect type
    - Defect types qualified
    - Static or Cyclic

Tests performed: external corrosion >80% and <80%, through wall holes, dents, bending, overburden, cyclic fatigue, cathodic disbondment, axial tensioning loads, girth weld reinforcement, vintage welds repairs, cracks within LF ERW seams.

Testing certifications by 3rd party: ASME PCC-2 and ISO 24817 from Stress Engineering Services