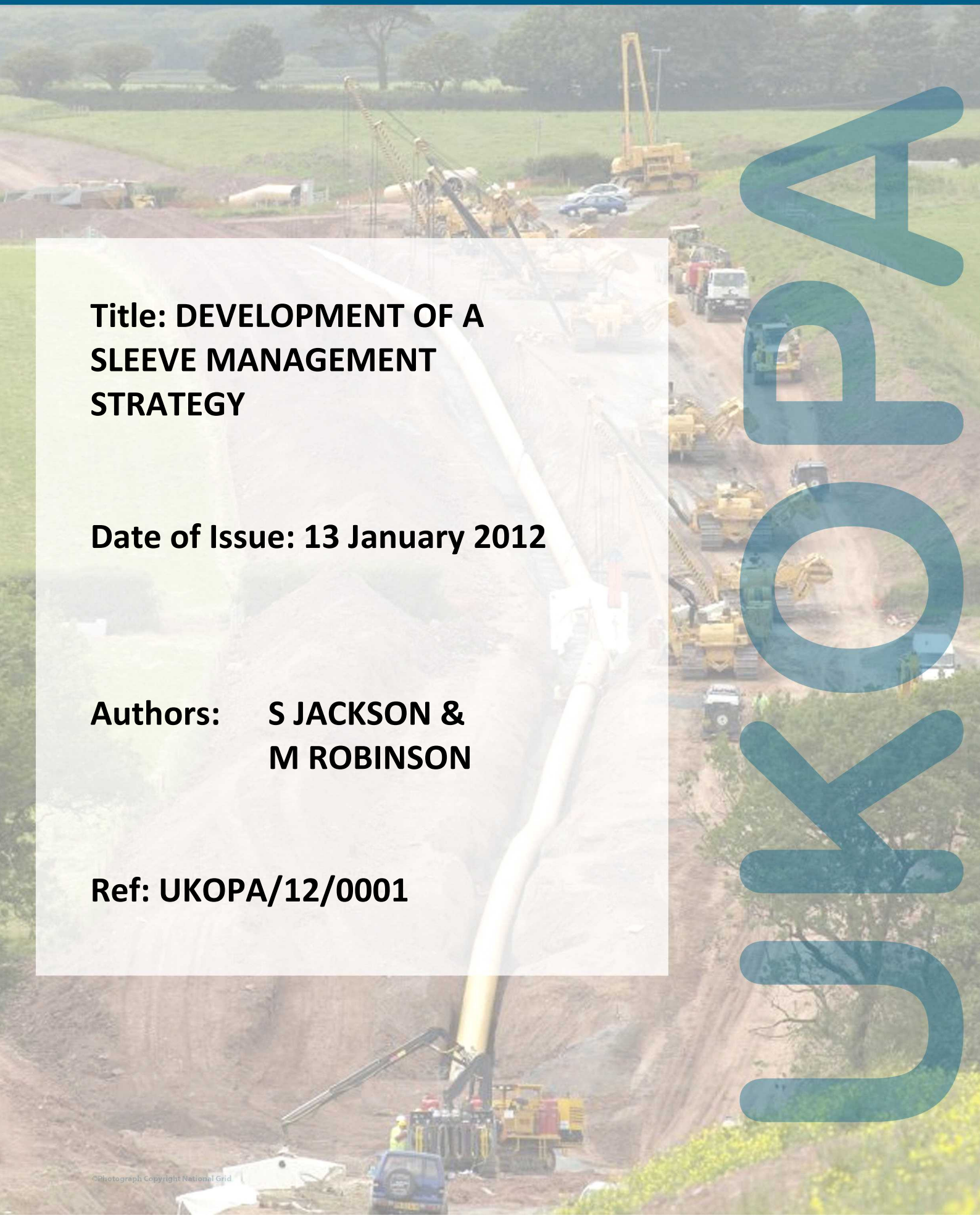
UKOPA

United Kingdom Onshore Pipeline Operators' Association



Title: DEVELOPMENT OF A SLEEVE MANAGEMENT STRATEGY

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DEVELOPMENT OF A SLEEVE MANAGEMENT STRATEGY

1 Introduction

Sleeves have historically been installed to provide additional protection for pipelines that cross traffic routes (including roads, railways, and water courses) or traverse areas with high population densities. Sleeves were predominantly constructed from steel or concrete, and incorporated various designs of end seal and annular fill materials.

Due to issues concerning the integrity management of sleeves, and the pipelines within sleeved sections, the United Kingdom Onshore Pipeline Operators' Association (UKOPA) risk assessment working group have begun an initiative to develop a consistent sleeve management strategy.

GL Noble Denton facilitated two workshops from which the following sleeve maintenance algorithms were developed on behalf of the UKOPA risk assessment working group.

2 Development of New Maintenance Algorithms

Discussions during the workshops identified that multiple algorithms were required to fully consider the various configurations of sleeves installed. To this end, two algorithms were developed focussing on nitrogen charged sleeves and non-nitrogen charged sleeves respectively. The algorithms developed by the UKOPA risk assessment working group members are presented in the following sections.

2.1 Nitrogen Charged Sleeves

The algorithm developed for nitrogen charged sleeves, applicable to both piggable and un-piggable pipelines, is presented in Figure 1.

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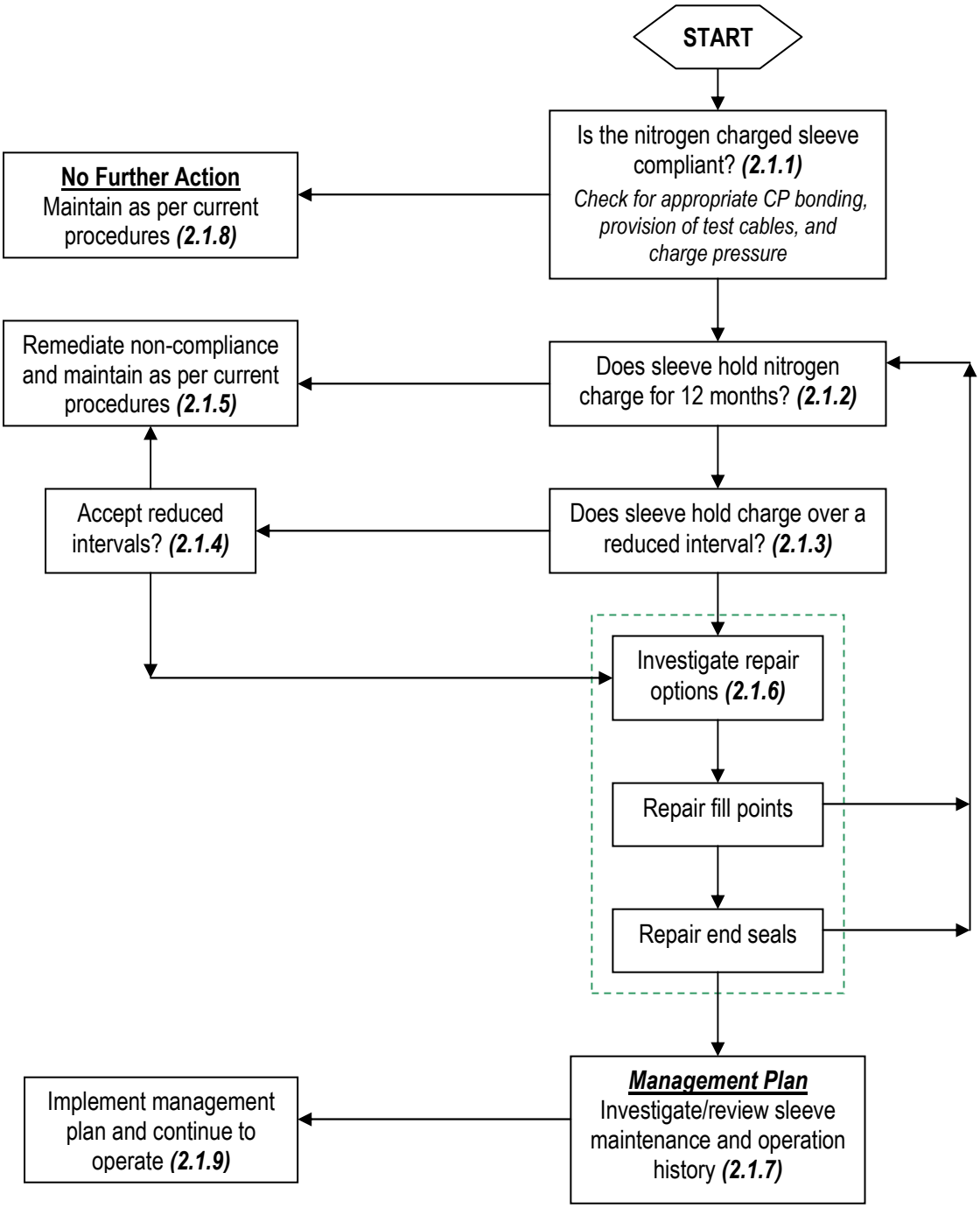
2.1.1 Is the Nitrogen Charged Sleeve Compliant?

The condition of the nitrogen charged sleeve should be reviewed for compliance against company management procedures. Compliance is likely to be judged against pressure retaining capability, provision of cathodic protection (CP), and the presence of non-nitrogen gases within the sleeve annulus (such as hydrogen or methane).

All nitrogen filled sleeves should be cathodically protected to prevent loss of nitrogen through corrosion damage. It is recommended that CP of nitrogen filled sleeves be provided by the pipeline protection system by virtue of forged/welded end seals, or by the use of a direct cable bond between the sleeve and carrier pipe where non-welded end seals (e.g. epoxy end seals) are in place. It is further recommended that all metallic sleeves have CP test facilities installed [1].

If the sleeve is judged to be compliant progress to 2.1.8 and continue to maintain the sleeve as per company management procedures. If the sleeve is judged to be non-compliant, progress to 2.1.2.

Figure 1 – Maintenance algorithm for nitrogen charged sleeves



2.1.2 Does the sleeve hold charge for 12 months?

Nitrogen charged sleeves should maintain positive nitrogen pressure within the annulus for a minimum period of 12 months. If a 12 month charge is maintained progress to 2.1.5. If the sleeve does not hold pressure for 12 months, progress to 2.1.3.

2.1.3 Does the sleeve hold charge over a reduced interval?

Where it is not possible to maintain a positive charge pressure for the full 12 month period the capability of the sleeve to hold pressure over a reduced interval (i.e. 3 or 6 months) should be assessed. Where the sleeve experiences rapid discharge of nitrogen, such that even reduced intervals cannot be maintained, progress to 2.1.6 and investigate repair options. If nitrogen pressure is maintained over the reduced period, progress to 2.1.4.

2.1.4 Accept reduced intervals

Where the sleeve can be shown to hold nitrogen pressure over a reduced interval it is necessary to review the costs associated with frequent recharging against the costs associated with investigating and undertaking repair work required for reinstating 12 month charge capability. If the reduced intervals are acceptable, progress to 2.1.5. If the reduced intervals are deemed to be unacceptable then progress to 2.1.6 and investigate repair options.

2.1.5 Remediate non-compliance

In the situation where the sleeve holds nitrogen pressure over the required interval but other non-compliances exist, for example missing CP test cables or lack of sleeve bonding (for sleeves with epoxy end seals), then these non-compliances should be addressed at the next opportunity, and the sleeve should continue to be maintained in accordance with company procedures.

2.1.6 Investigate repair options

Where the sleeve is incapable of maintaining positive nitrogen pressure it is necessary to determine the cause of the leak, implement repair solutions, and reinstate the nitrogen charge. The provision of an inert atmosphere within the sleeve is of significant importance to the corrosion protection of the carrier pipe.

Operational experience suggests that the two most likely origins of nitrogen release are the nitrogen fill/test points and the sleeve end seals. It is proposed these items are investigated in order of least difficulty, thus reviewing the condition of fill/test points initially, followed by the condition of the end seals. Where repairs can be successfully made, the nitrogen charge should be reinstated and the hold capability re-assessed (2.1.2). If it is not possible to successfully reinstate the nitrogen charge through fill/test point and end seal repairs, then progress to 2.1.7.

2.1.7 Sleeve management plan

Where it has not been possible to re-instate or maintain a positive nitrogen pressure within the sleeve annulus then a thorough review of the sleeve maintenance and operational history should be conducted, and a sleeve management plan produced.

Piggable pipelines:

For piggable pipelines the in-line inspection data should form a basis for this review. The date and results from the most recent pig run should be reviewed to determine

the presence of any known corrosion wall loss and to form an opinion whether there is a possibility any corrosion could have occurred since the most recent inspection.

Nitrogen monitoring records should also be reviewed, which should identify the period of time the sleeve annulus may have been exposed to a corrosive environment, and should also identify if any corrosion products, such as CO_2, have previously been detected.

Un-piggable pipelines:

For sleeves installed on un-piggable sections of pipeline it is difficult to ascertain whether any corrosion could exist within the sleeve. In such cases reliance is placed upon nitrogen monitoring records to determine how long the sleeve annulus may have been exposed to a corrosive environment.

Direct bonding of nitrogen filled sleeves results in the carrier pipe within the sleeved section not being protected by the pipeline CP system, and as such, in cases where nitrogen pressure has diminished, carrier pipe protection is limited to the pipeline coating. Construction records should be reviewed to identify the type and quality of coating system installed within the sleeve, and to identify whether any past repair or modification works have been implemented on the sleeve.

Emphasis should be placed on determining the condition of the carrier pipe where a sleeve is not able to retain nitrogen pressure. Here the configuration of the pipeline should be reviewed to determine whether it would be practicable to make the line piggable, compared to the alternative solution of conducting direct assessment of individual sleeves, for example by deploying emerging technologies such as robotic inspection or guided wave ultra sonic testing.

Management Plan:

A sleeve management plan should then be formulated based on the findings from this review and an assessment of the risks to integrity. Depending on the outcome of the review, the sleeve management plan could conclude changes to the inspection intervals (piggable pipelines), introduction of alternate fill materials (e.g. waxes or gel inhibitors), sleeve cut out, or diversion.

2.1.8 No further action

Where the sleeve has been determined to be compliant to company policy, and it can be shown that a positive nitrogen pressure can be maintained, then no further remedial action is required. In this case the sleeve should be maintained in line with company management procedures.

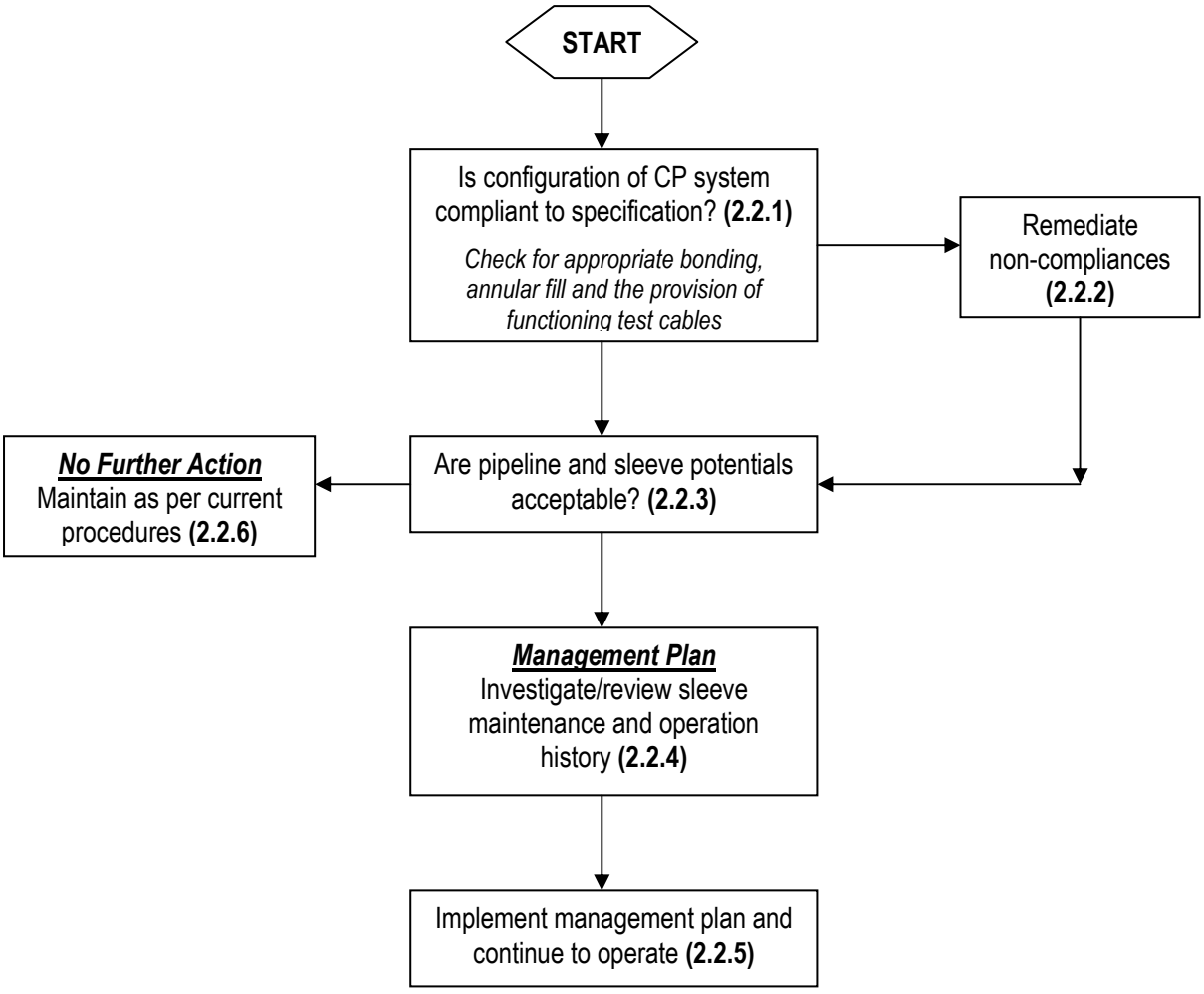
2.1.9 Implement sleeve management plan

If a thorough assessment of the sleeve has been conducted and it can be demonstrated that the sleeve can be managed through the implementation of a robust management plan, then the sleeve should be maintained as per the methodology outlined in the sleeve management plan.

2.2 Non-nitrogen Charged Sleeves

The maintenance algorithm developed during the workshop for sleeves containing fills other than nitrogen is presented in Figure 2, and is applicable to metallic and prefabricated concrete sleeves.

Figure 2 – Maintenance algorithm for sleeve containing annular fills other than nitrogen



2.2.1 Compliance of CP system

The configuration of the CP system should be reviewed for compliance to applicable design standards. For sleeves containing fills other than nitrogen it is essential that the sleeve is maintained such that it does not interfere with the pipeline CP system. For the carrier pipe to be effectively protected it is necessary that the annulus is completely filled with a conductive material, and that there are no inadvertent electrical shorts (metallic bridging of steel sleeves) between the sleeve and carrier pipe.

For steel sleeves installed in high density locations (i.e. those to Class 1 of IGEM/TD/1[1]) it is recommended that the sleeve is also protected by the pipeline CP system. In some cases this may be achieved as the current flows radially through the sleeve towards the carrier pipe. Where current flows in this manner it is expected that protection will be provided to the outer surface of the sleeve only, and metal loss could occur at the inner sleeve surface due to current transfer. In such cases the extent of metal loss is expected to be very small due to the large area of bare metal

within the sleeve and the low magnitude of current involved. In any case, the onus should be placed on ensuring the carrier pipe is adequately protected.

Where sleeve protection does not occur in this manner it is recommended that a resistive bond be installed between the sleeve and carrier pipe. The installation of a resistive bond will also help to minimise the effects of metal loss associated with current transfer from the sleeve to the carrier pipe. The resistive bond should be configured with an appropriate resistance to create a balanced current drain between the sleeve and pipe sufficient to generate a sleeve to soil polarised potential in the range -0.85 V to -0.95 V, with a pipeline to soil polarised potential 0.1 V more negative than the sleeve to soil polarised potential[1]. Lower class steel sleeves (i.e. Class 2 and 3) are not required to be cathodically protected, but should be maintained such that they do not interfere with the carrier pipe protection.

All sleeves should be completely filled with an appropriate conductive material, and all metallic sleeves should have CP test facilities attached to the sleeve and carrier pipe. As indicated in Clause 12.7.5.3 of IGEM/TD/1 Edition 5 only the external surface of the sleeve will be protected by CP.

If the CP system is deemed to be compliant, then proceed to 2.2.3 and obtain sleeve/pipe potential readings. If the CP system is non-compliant then remediation must be undertaken.

2.2.2 CP remediation

Where the CP system is deemed to be non-compliant, for example there are insufficient test cables or the steel sleeve is not resistance bonded (where applicable), then remediation should be undertaken. Once the non-compliance has been resolved, progress to 2.2.3 and obtain sleeve/pipe potential readings.

2.2.3 Are pipeline and sleeve potentials acceptable?

Pipeline and sleeve (for metallic sleeves) potential readings taken at both ends of the sleeve should indicate any localised pipe to sleeve shorting. Where there is no indication of shorting or reduced effectiveness of the CP system it is reasonable to assume that the pipe and sleeve are adequately protected and no further action is required (2.2.6).

Where the pipe and sleeve potentials indicate a short or reduced effectiveness of the CP system further investigation should be undertaken (2.2.4). It should be noted that the absence or deterioration of a conductive annular material could lead to reduced current flow to the carrier pipe.

2.2.4 Sleeve management plan

Where it has not been possible to prove sleeve/pipe isolation such that the impressed current CP system may not be effective then a thorough review of the sleeve maintenance and operational history should be conducted, and a sleeve management plan implemented.

Piggable pipelines:

For piggable pipelines the in-line inspection data should form a basis for this review. The date and results from the most recent pig run should be reviewed to determine the presence of any known corrosion wall loss and to form an opinion whether there is a possibility any corrosion could have occurred since the most recent inspection.

Un-piggable pipelines:

For sleeves installed on un-piggable sections of pipeline it is difficult to ascertain whether any corrosion could exist within the sleeve. The configuration of the sleeve and the nature of the CP fault should be reviewed to determine whether the CP system is, or has been, likely to provide any level of protection.

Where the pipeline CP system is found to be ineffective at a non-nitrogen filled sleeve corrosion protection is limited to the pipeline coating within the sleeve. Construction records should be reviewed to identify the type of coating installed within the sleeved section which may identify any potential concerns with respect to the quality of coating.

Emphasis should be placed on determining the condition of the carrier pipe within sleeved sections where the effectiveness of CP systems is known to be reduced. Here the configuration of the pipeline should be reviewed to determine whether it would be practicable to make the line piggable, compared to the alternative solution of conducting direct assessment of individual sleeves, for example by deploying emerging technologies such as robotic inspection or guided wave ultra sonic testing.

Management plan:

A sleeve management plan should be formulated based on the findings from this review and an assessment of the risks. Depending on the outcome of the review, the sleeve management plan could recommend changes to the inspection intervals (piggable pipelines), introduction of alternate fill materials where appropriate, or sleeve cut out or diversion.

2.2.5 Implement management plan

If a thorough assessment of the sleeve has been conducted and it can be demonstrated that the sleeve can be managed through the implementation of a robust management plan, then the sleeve should be maintained as per the methodology outlined in the sleeve management plan.

2.2.6 No further action

Where it has been shown that the configuration of the sleeve is compliant to company specification, and it is determined that the pipeline and sleeve (where applicable) are receiving acceptable levels of protection from the pipeline CP system, then no further action is required and the sleeve should continue to be maintained inline with company management procedures.

3 References

[1] 'Steel pipelines for high pressure gas transmission'. IGEM/TD/1, Edition 5. The Institution of Gas Engineers and Managers. December 2008