UKOPA

UK ONSHORE PIPELINE OPERATORS' ASSOCIATION - INDUSTRY GOOD PRACTICE GUIDE

MANAGING PIPELINE SLEEVES

Guidance Issued by UKOPA:

The guidance in this document represents what is considered by UKOPA to represent current UK pipeline industry good practices within the defined scope of the guide. The document does not specify prescriptive requirements, should be considered guidance and should not be considered obligatory against the judgement of the Pipeline Owner/Operator. Where new and better techniques are developed and proved, they should be adopted without waiting for modification to the guidance in this document. The term 'shall' has been used to identify any requirement of UK law in Great Britain at the time of publication.

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Disclaimer

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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 (air, cementitious grout, pulverized fly ash, nitrogen, bentonite etc). The vast majority of pipeline sleeves are present in the natural gas pipeline industry, so this document reflects much of the guidance historically used for natural gas pipelines.

For natural gas pipelines designed to IGE/TD/1 Editions 1 and 2, the following sleeve classifications were used:

- Class 1 - Sleeves required to protect the public, or judged desirable to protect some other installation, from the consequences of failure of the carrier pipe. Also serve to protect the carrier pipe from outside interference;
- Class 2 - Sleeves provided in order to protect the carrier pipe from outside interference;
- Class 3 - Sleeves installed only to facilitate the construction of the carrier pipe.

IGE/TD/1 Edition 2 allowed Class 1 sleeves to be used on any pipeline that was crossing, or running within the boundary of high density traffic routes (e.g. motorways, dual carriageway roads, rail routes as defined in IGE/TD/1). Pipelines crossing or running within the boundaries of other traffic routes could utilise sleeves to Class 2.

For natural gas pipelines designed to IGE/TD/1 Edition 3 onwards, heavy wall pipe was the recommended practice for crossings, and sleeves were only recommended to facilitate construction. Where these sleeves are steel, they need to be maintained depending on their type.

It should be noted that audits are carried out periodically to reaffirm the MOP and the edition of IGEM/TD/1 to which pipelines operate (see clause 12.4.2.1 of IGEM/TD/1 edition 5); sleeve classification may be re-designated as part of these surveys.

For pipelines designed to ASME codes (e.g. ASME B31.4 or 8), no sleeve classification is given. However, ASME B31.4 Para 403.1 states 'the design shall provide reasonable protection to prevent damage to the pipeline from unusual external conditions that may be encountered in river crossings, offshore and inland coastal water areas, bridges, areas of heavy traffic, long self-supported spans, unstable ground, vibration, weight of special attachments, or forces resulting from abnormal thermal conditions. Some of the protective measures that the design may provide are encasing with steel pipe of larger diameter...'. Therefore, for the purpose of this document, sleeves on ASME B31.4 pipework can be viewed as analogous to Class 2 sleeves in IGE/TD/1.

This good practice document has been developed to support UKOPA members in assessing the condition of existing pipeline sleeves and pipelines within sleeved sections. Appendix A provides guidance on suitable maintenance, inspection and monitoring strategies to ensure the future integrity of pipeline sleeves.

A draft document (ISO/CD 16440) is available from ISO (International Organization for Standardization) entitled 'Petroleum and natural gas industries -- Pipeline transportation systems -- Design, construction and maintenance of steel cased pipelines'. Once this document is accepted as an ISO standard, it should be reviewed by UKOPA and if appropriate referenced in the 'Good Practice Guide'.

2 SCOPE AND APPLICATION

2.1 Scope

The guidance in this document is applicable to sleeves located on all buried steel pipelines operated by the UKOPA member companies. These pipelines can be categorised as:

- Natural gas transmission and distribution pipelines;
- Petrochemical liquids and gas pipelines;
- Oil and refined liquid pipelines.

For gas pipelines, the guidance is generally applicable to steel pipelines with maximum operating pressures above 7 barg, however the principles of the document can be equally applied to gas steel pipelines operating at lower pressures.

The document contains guidance for nitrogen charged sleeves and non-nitrogen charged sleeves and good practice for maintenance.

2.2 Application

The guidance in this document is considered by UKOPA to represent current UK pipeline industry good practice within the defined scope of the document. All requirements should be considered to be guidance and should not be considered to be obligatory against the judgement of the Pipeline Owner/Operator. Where new and better techniques are developed and proved, they should be adopted without waiting for modifications to the guidance in this document.

3 Maintenance Algorithms

The algorithm used to determine maintenance depends upon whether the sleeve is filled with nitrogen (section 3.1) or another fill (section 3.2).

A methodology for prioritizing the inspection of pipeline sleeves is presented in GL Noble Denton report 13065. Historical incident data and engineering construction data have been used to propose criteria that can be used to estimate the importance of inspecting the condition of pipelines within sleeves on piggable and un-piggable pipelines.

3.1 Nitrogen Charged Sleeves

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

3.1.1 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 3.1.8 and continue to maintain the sleeve as per company management procedures. If the sleeve is judged to be non-compliant, progress to 3.1.2.

3.1.2 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 3.1.5. If the sleeve does not hold pressure for 12 months, progress to 3.1.3.

3.1.3 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 3.1.5. If the reduced intervals are deemed to be unacceptable then progress to 3.1.6 and investigate repair options.

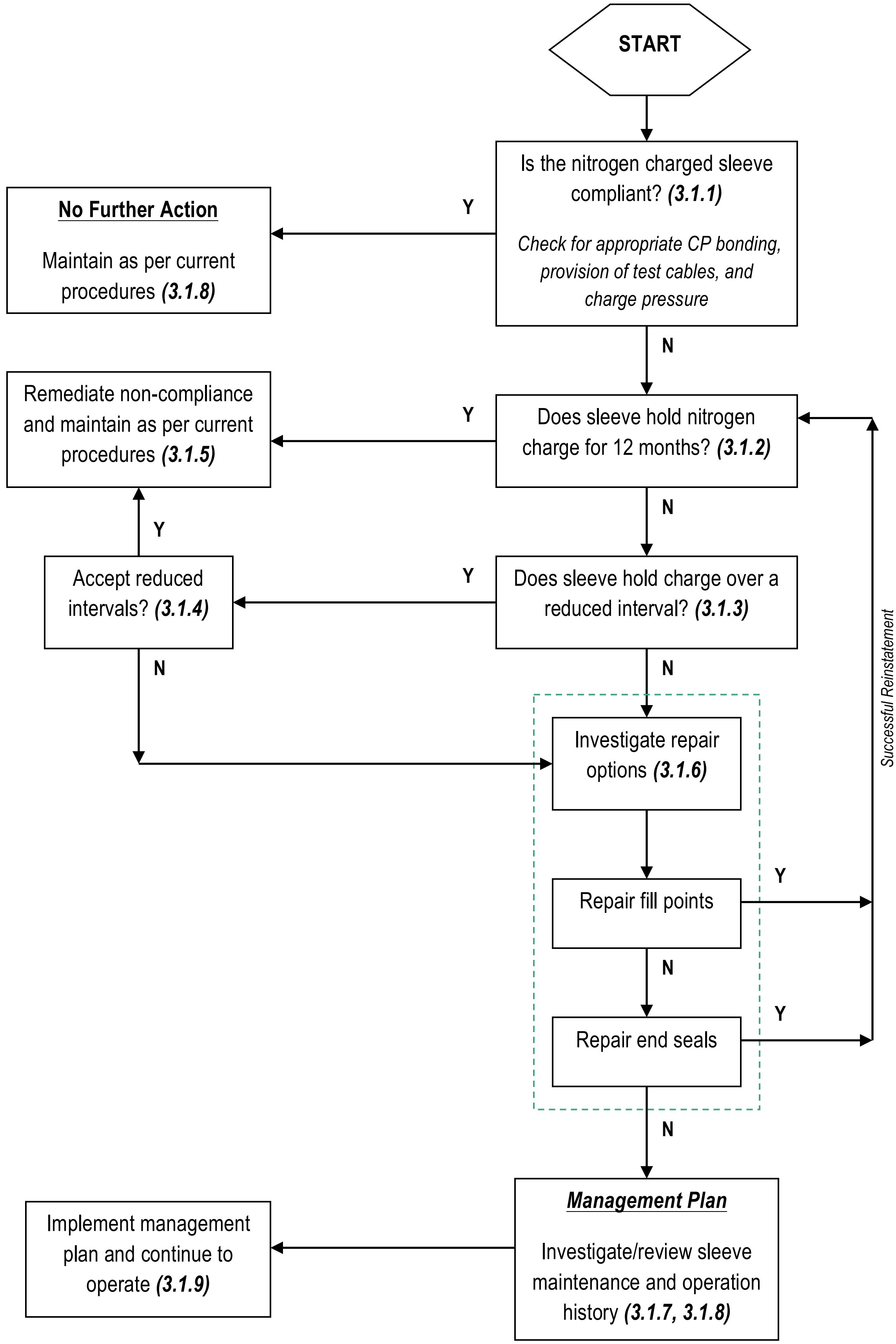

Figure 1 – Maintenance algorithm for nitrogen charged sleeves

3.1.4 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.

3.1.5 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 three most likely origins of nitrogen release are the nitrogen fill/test points, the high pressure rubber connecting hoses 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 (3.1.2). If it is not possible to successfully reinstate the nitrogen charge through fill/test point and end seal repairs, then progress to 3.1.7.

3.1.6 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 ultrasonic 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.

3.1.7 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.

3.1.8 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.

3.2 Non-nitrogen Charged Sleeves

The maintenance algorithm developed for sleeves containing fills other than nitrogen, including non-conducting fillings and air filled sleeves, is presented in Figure 2, and is applicable to metallic and prefabricated concrete sleeves.

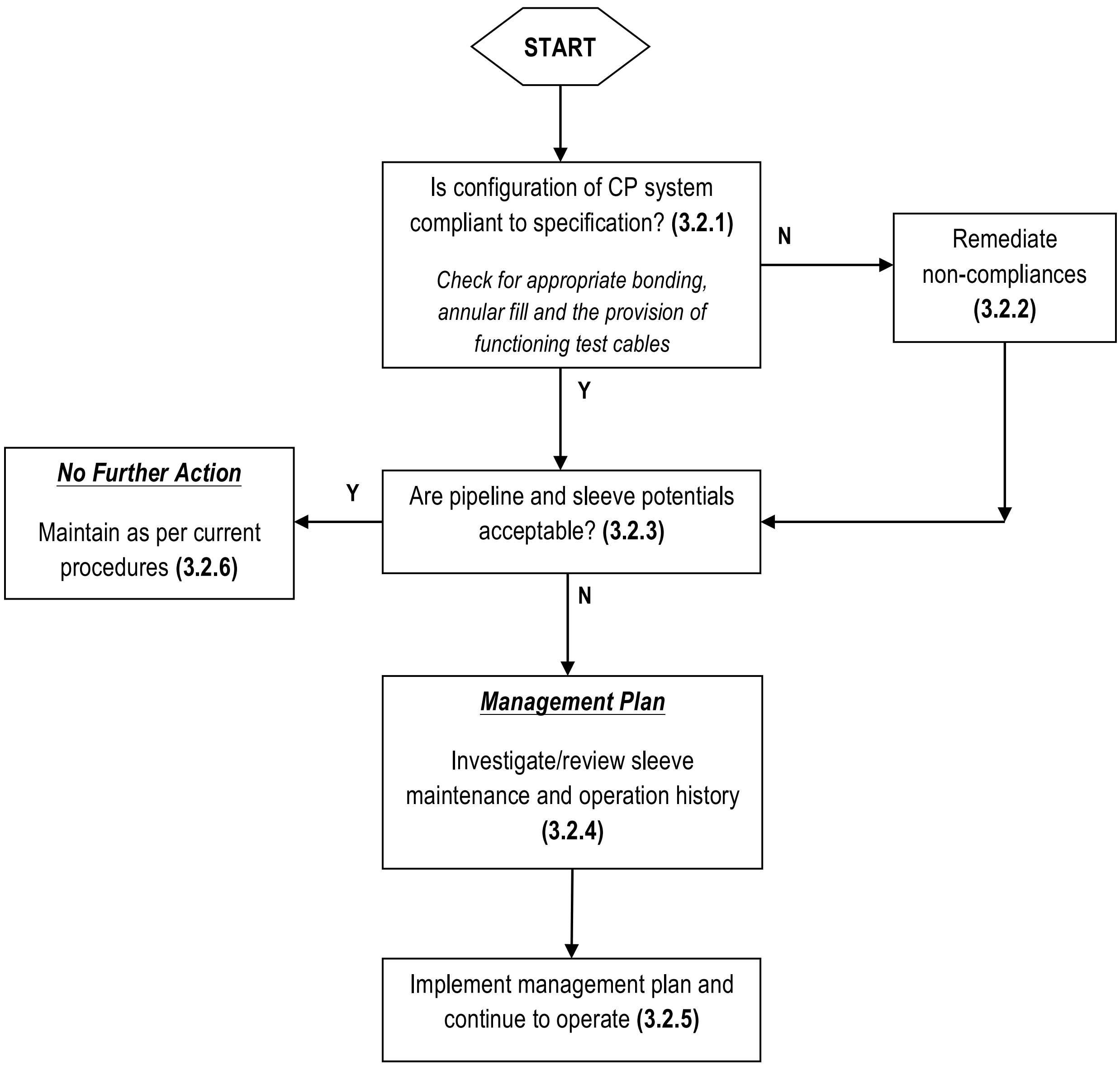

Figure 2 – Maintenance algorithm for sleeve containing annular fills other than nitrogen

3.2.1 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. 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 an external or internal coating (or both) is applied to the sleeve, this will not conduct CP current to the carrier pipe even if conductive annular fills are present in the annulus.

For steel sleeves installed in high density traffic routes (i.e. such as those to Class 1 of IGE/TD/1 Editions 1 and 2), 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 that is typically 0.1V more positive than the pipe to soil potential, to ensure that the majority of the CP is effective on the carrier pipe rather than the sleeve.

Lower class steel sleeves (i.e. Class 2 and 3 in IGE/TD/1 Editions 1 and 2) are not required to be cathodically protected, but should be maintained such that they do not interfere with the carrier pipe protection.

Construction sleeves (i.e. Class 3 in IGE/TD/1 Editions 1 and 2), which are generally bare, uncoated and not sealed, are not subject to future maintenance and are not protected by the CP system. However, they should have a CP connection to monitor the sleeve potential to identify any pipe/sleeve shorts.

If the CP system is deemed to be compliant, then proceed to 3.2.3 and obtain sleeve/pipe potential readings. If the CP system is non-compliant then remediation must be undertaken.

3.2.2 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 3.2.3 and obtain sleeve/pipe potential readings.

3.2.3 Are pipeline and sleeve potentials acceptable?

Pipeline and sleeve (for metallic sleeves) potential readings taken on 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 (3.2.6).

Where the pipe and sleeve potentials indicate a short or reduced effectiveness of the CP system, further investigation should be undertaken (3.2.4). It should be noted that the absence or deterioration of a conductive annular material could lead to reduced current flow to the carrier pipe.

3.2.4 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. Particular attention should be given to the effectiveness of the CP system in the vicinity of the sleeved section.

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 ultrasonic 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.

3.2.5 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.

3.2.6 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 in-line with company management procedures.

4 References

1. Steel pipelines for high pressure gas transmission. IGE/TD/1, Edition 1. The Institute of Gas Engineers. 1970.

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3. Steel pipelines for high pressure gas transmission. IGE/TD/1, Edition 3. The Institute of Gas Engineers. 1993.

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5. Pipeline Transportation Systems for Liquids and Slurries. ASME B31.4 – 2012.

6. Gas Transmission and Distribution Piping Systems. ASME B31.8 – 2014.

7. Risk ranking scheme for prioritising the inspection of pipeline sleeves. GL Noble Denton (now DNV GL) report 13065, August 2013.

8. Petroleum and natural gas industries - Pipeline transportation systems - Design, construction and maintenance of steel cased pipelines. ISO/TC 67/SC 2 N 827. Draft document, May 2012.

Appendix A - Maintenance, Inspection and Monitoring of Pipeline Sleeves

The following good practice is suitable for maintenance, inspection and monitoring of sleeves.

A.1 Clearing of Sleeve Shorts

Metallic contact between the carrier pipe and the sleeve (such as contact with the metallic portions of end seals, isolating spacers, bond wires or straps, test leads, debris, or the sleeve itself) should be removed.

Established construction techniques shall be used to realign the carrier pipe or sleeve to eliminate metallic contact.

Note: Equipment typically used in this situation includes hydraulic jacks, tripods, air bags, side-boom slings and belts.

The carrier pipe and sleeve shall be permanently maintained in the realigned position by the use of supports such as compacted earth, sandbags or concrete piers. If the sleeve and carrier pipe cannot be realigned, elimination of a metallic contact may be accomplished by removing a portion of the sleeve. Once metallic contact is eliminated, spacing materials, end seals, fill / purge points and test leads should be reinstalled as necessary.

A.2 Integrity inspection of carrier pipe

If available, integrity inspection data, such as from In-Line Inspection data, Long Range Ultrasonics etc, should be used to determine the presence or absence of defects (corrosion damage, etc.) in the carrier pipe.

Note: Some in-line inspection techniques are capable of detecting the presence of a sleeve around a carrier pipe but are unable to accurately detect metal-to-metal contact between the sleeve and carrier pipe as well as carrier pipe metal loss.

Note: Long range Ultrasonic inspections are primarily used as a 'screening tool', as it cannot give a quantitative metal loss value. It is also attenuated by some pipe coatings and at spacers or where the sleeve touches the carrier pipe.

A.3 Monitoring of carrier pipe and sleeve

Carrier pipe and sleeve shall be monitored on a periodic basis to determine condition and electrical status using one or more of the following methods:

a) potential survey

b) internal resistance test

c) interrupting the transformer rectifier

d) sleeve depolarization test

e) pipe / cable locator

Details of test methods are given below.

Note: Where cathodic protection is applied to the sleeve, the cathodic protection system shall be disconnected from the sleeve and allowed to depolarize before any tests are conducted.

Note: Direct-connected galvanic anodes on the sleeve should be disconnected and a resistive bond installed in their place to protect the sleeve.

A.3.1 Potential survey

Purpose

Potential surveys of steel cased pipelines are made to monitor the effectiveness of the cathodic protection and are the initial tests to identify shorted sleeves. The presence of a metallic contact can also be evaluated by measuring both the pipe-to-electrolyte and sleeve-to-electrolyte potentials with respect to a reference electrode placed in the soil.

Procedure

Potential measurements (surveys) of pipelines and sleeves are made using a voltmeter and a reference electrode (usually a copper-copper sulphate electrode [CSE]).

More definitive results are obtained if the cathodic protection current source is cycled on/off while the carrier pipe and sleeve potentials are recorded.

Measuring carrier pipe potential

One lead of the voltmeter shall be connected to the carrier pipe by way of the test lead (T1) or direct connection. The other lead of the voltmeter shall be connected to the reference electrode, which is placed on the ground directly over the pipeline and near the end of the sleeve (see Fig 1).

Measuring sleeve potential

One lead of the voltmeter shall be connected to the sleeve by way of the fill / purge / vent pipe, test lead, or direct connection. The other lead of the voltmeter shall be connected to the reference electrode, which shall be placed at the same location as where the carrier pipe potential was taken (see Fig 1).

Note: The reference electrode shall not be placed directly over the sleeve. The location of the end of the sleeve can usually be verified with a pipe locator.

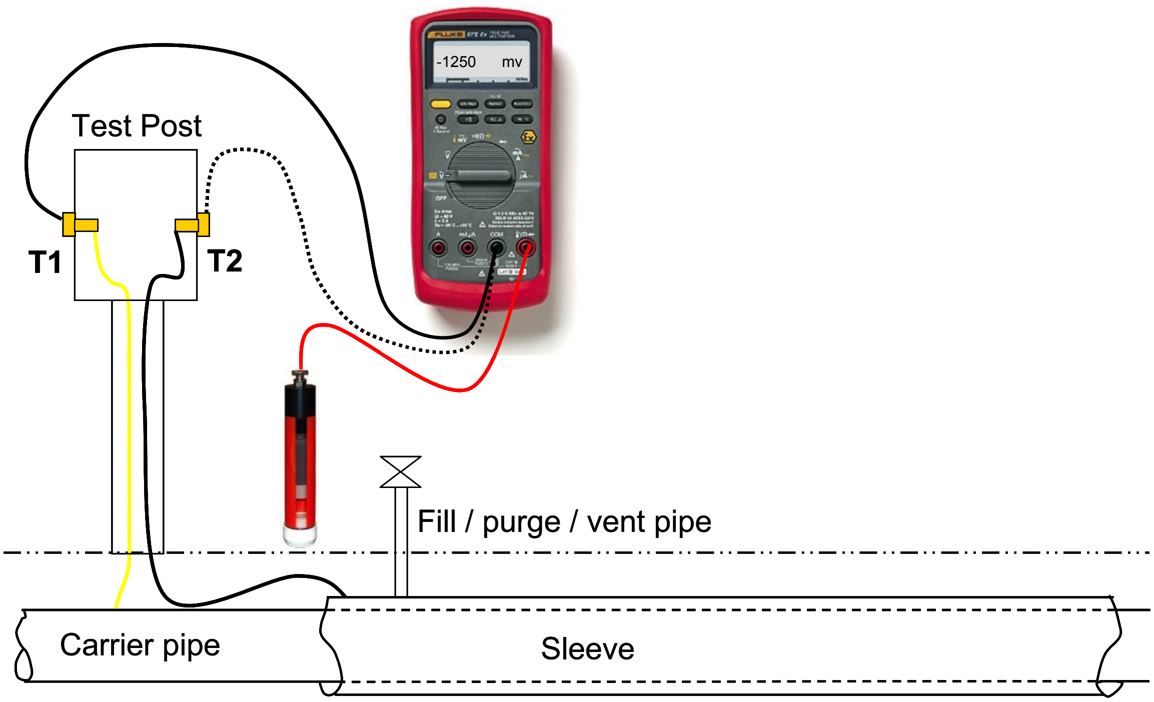

Figure A.1

Analysis

A clear or not shorted sleeve is indicated by a potential difference between the sleeve and the carrier pipe. For example, a pipe-to-soil potential of -1200 mV CSE and a sleeve potential of -650 mV CSE has a potential difference of 550 mV and would indicate the sleeve is clear.

A shorted sleeve may exist if a small potential difference exists between the pipeline potential and the sleeve potential. This is typically less than 100 mV. Additional testing should be conducted if the difference in potential is 100 mV or less.

Note: If operator data and experience indicate that it is appropriate, a difference in potential as small as 20 mV, or as large as 200 mV, may be considered a criterion indicating that the sleeve under test requires further examination.

A.3.2 Internal resistance test

Purpose

This technique may indicate whether direct metal-to-metal contact exists between a carrier pipe and a sleeve by measuring electrical resistance. It is a useful method of determining if a full or partial sleeve to pipe short is existing following a potential survey indicating a small difference between the carrier pipe and sleeve.

Procedure

This procedure requires a 4 wire resistance measuring device such as a Megger or similar.

a The pipe-to-sleeve potential shall be measured at terminals T1 and T2

b The 4 wire resistance measuring device shall be connected to the sleeve as per fig. 2

c The 4 wire resistance measuring device shall be operated as per manufacturers instructions and the resistance read directly from the device

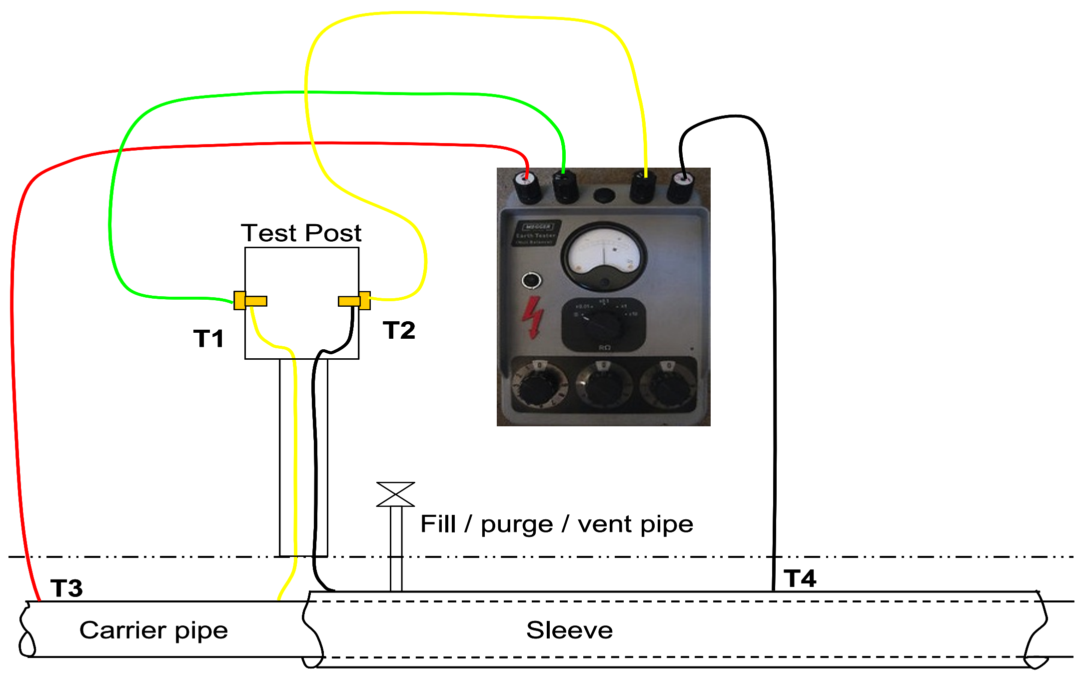

Figure A.2

Analysis

A sleeve-to-pipe (metal-to-metal) contact may exist if the value obtained is less than 0.01Ω

Note: While a pipe to sleeve resistance of less than 0.01Ω is indicative of a metallic short, a resistance of greater than 0.01Ω does not necessarily indicate that a metallic short does not exist. Depending on the nature of the carrier pipe to sleeve contact, a metallic short could have a contact resistance of much more than 0.01Ω, although the likelihood of a metallic short decreases as the measured resistance increases. For example a relatively low carrier pipe to sleeve resistance of 0.12Ω would suggest that further testing may be required to determine the status of the sleeve.

A.3.3 Interrupting the transformer rectifier (T/R)

Purpose

Measurement of structure-to-earth potentials under steady-state conditions of applied cathodic protection may not provide conclusive evidence regarding the state of electrical isolation between sleeve and pipeline. The same potential measurement, if taken while the cathodic protection T/R is being cycled, can provide additional information for evaluation of sleeve isolation conditions.

Procedure

This technique may be applied to a pipeline survey using an interrupter in the most influential cathodic protection rectifier unit. The location of the cycling rectifier selected shall be sufficiently remote from the sleeve under test so that anode bed voltage gradients do not influence the measurement.

1. Pipeline and sleeve potentials shall be measured with the cathodic protection current applied.
2. Measurements made for 1 shall be repeated at the same instant that the cathodic protection current is switched off.

Analysis

If the on and off potentials from the sleeve are close in magnitude to the on and off potentials of the carrier pipe, the presence of a metallic short may be indicated.

Note: If water or soil is present in the sleeve, this test procedure does not give a conclusive result. In such situations, additional testing techniques should be employed.

A.3.4 Sleeve depolarization test

Purpose

Isolation may be verified by discharging D.C. from the sleeve. If the two structures are not metallically connected, a significant potential difference occurs between the sleeve and carrier pipe.

Procedure

1. A temporary metallic structure (anode bed) shall be constructed laterally to, and spaced an appropriate distance from, the carrier pipe and sleeve (a spacing of 15 m is usually an adequate distance). Steel rods (road pins) driven into the earth may provide an adequate temporary structure.
2. The negative terminal of a variable D.C. power source (such as a current drain test unit) shall be connected to the temporary metallic structure.
3. The positive terminal of the same variable D.C. power source shall be connected to the sleeve.
4. A reference electrode shall be positioned over the carrier pipe near the sleeve end (see Fig.1).
5. An appropriate D.C. voltmeter shall be used to measure and record the carrier pipe and sleeve potentials.
6. A small increment of current (0.1 A is a satisfactory first increment of current) shall be discharged from the sleeve for a short period of time, such as one or two minutes.

7. The current shall be interrupted; then the carrier pipe and sleeve instant-off potentials shall be measured and recorded to determine the effect of the applied current; the increment of current shall also be recorded.
8. Steps 6 and 7 shall be repeated using additional increments of current (e.g., 0.2 A, 0.3 A).

   A minimum of three different values of test current and measurement of the effects should be taken. The amount of current required for an effective evaluation varies due to the size of the structure and condition of any coating present. A maximum of 10 A of D.C. should adequately develop significant potential shifts.

Analysis

Sleeve shorted

If the sleeve is shorted, the sleeve-to-soil potential shifts in a positive direction. The pipe-to-soil potential also shifts in a positive direction, usually by about the same magnitude as the sleeve. As subsequent steps are taken, the pipe-to-soil potential largely tracks the positively shifting potentials of the sleeve.

Sleeve clear

If there is no metallic short, the pipe-to-soil potential may shift in a positive direction by only a few millivolts, whereas there will be a dramatic shift in the sleeve-to-soil potential. In some cases, the pipe-to-soil potential may shift in a negative direction by a few millivolts.

If the sleeve potential shifts in a positive direction and the carrier pipe potential remains near normal, electrical isolation is indicated. If the sleeve and pipeline potentials both shift in the positive direction, a shorted condition is indicated. Tables A.1 and A.2 illustrate examples of values that indicate electrical isolation (sleeve clear), and Table A.3 illustrates example of values that indicate an electrically shorted condition (sleeve short).

	V	A	P/S Potential	S/S Potential	Potential differential
Initial Readings			-0.975	-0.850	0.125
Step 1	6.0	0.25	-0.974	-0.710	0.264
Step 2	18	0.68	-0.975	-0.505	0.470
Step 3	45	1.0	-0.981	-0.210	0.771
Step 4	65	1.8	-0.986	+0.01	0.996

Table A.1 - Sleeve is clear (not shorted)

	V	A	P/S Potential	S/S Potential	Potential differential
Initial Readings			-1.250	-1.21	0.04
Step 1	6.0	0.086	-1.139	-0.7	0.439
Step 2	18	0.258	-1.104	-0.140	0.964
Step 3	30	0.413	-1.06	-0.24	1.3
Step 4	42	0.566	-1.022	+0.49	1.512

Table A.2 - Sleeve is clear (not shorted)

	V	A	P/S Potential	S/S Potential	Potential differential
Initial Readings			-1.246	-1.242	0.004
Step 1	6.0	0.234	-1.211	-1.195	0.016
Step 2	18	0.594	-1.05	-0.98	0.07
Step 3	30	1.0	-0.796	-0.71	0.086
Step 4	45	1.2	-0.61	-0.54	0.07
Step 5	75	2.0	-0.135	-0.1	0.035

Table A.3 - Sleeve is shorted

Note: During this test, current is being discharged from the sleeve and this could result in creating an interference condition with other structures.

A.3.5 Use of pipe / cable locator

The presence and location of a pipe-to-sleeve metallic contact may be approximated by following a low power audio or radio signal (pipe locator trace) set between the carrier pipe and the sleeve. The signal returns at the point of contact, which should be verified from the opposite end.