



Good Practice Guide – Managing Pipeline Sleeves (UKOPA/GP/05)

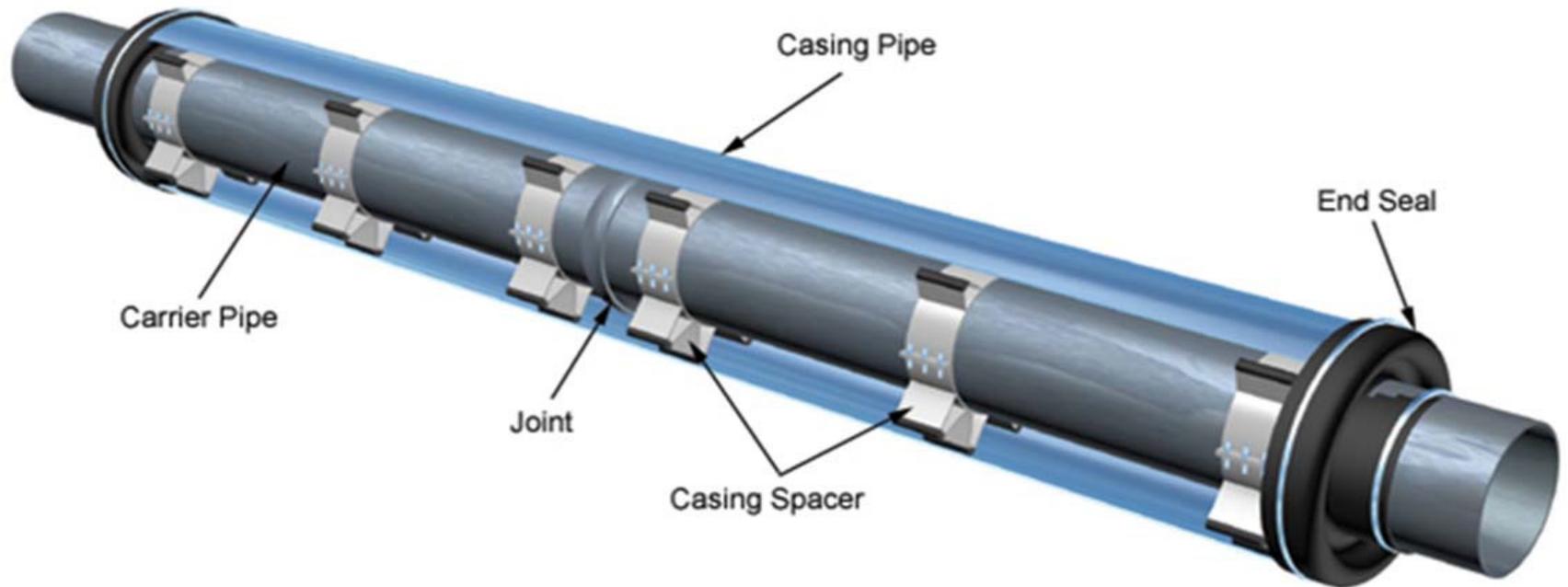
UKOPA Technical Seminar
Robert Owen, National Grid
12 May 2016

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- ❑ Background
- ❑ Historical use of sleeves
- ❑ UKOPA initiatives
 - ❑ **Development of Good Practice Guide**
 - ❑ Risk ranking study
 - ❑ ILI study
- ❑ Summary



Overview of a sleeve or casing



Background

- ❑ The integrity management of pipeline sleeves is an issue for all pipeline operators and the HSE suggested this could be a topic for an industry initiative.
- ❑ Main threat is integrity of the carrier pipe in the sleeve.
- ❑ Pipeline sleeves, of different types and annular fills, have historically been used.
- ❑ **Aim was to develop a UKOPA strategy for managing pipeline sleeves – now a Good Practice Guide.**

The use of sleeves

- ❑ Sleeves were installed to:
 - ❑ Protect the public or nearby installations from the consequences of pipeline failure
 - ❑ Protect the pipeline from outside interference
 - ❑ Facilitate construction processes



Example of concrete sleeve



Maintenance of nitrogen filled sleeve

Historical use of sleeves

- ❑ Sleeves (or casings) have been installed to provide additional protection for pipelines that
 - ❑ cross traffic routes – roads, railways, watercourses
 - ❑ 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, pulverised fly ash, nitrogen, bentonite etc).

What did UKOPA do?

- ❑ Workshops held with support from DNV GL
- ❑ Review of industry designs and issues
 - ❑ Large number of pipeline sleeves, many on unpiggable pipelines, of different configurations, different fill materials etc
 - ❑ Main concern - what is the condition of the carrier pipe?
- ❑ Review of previous incidents
 - ❑ Record to date has been good, but these are aging assets – a few incidents have occurred in the US
- ❑ What is best practice for maintenance, inspection, remediation?

Topics raised at workshops

- Establish sleeve populations
- Develop sleeve algorithm to reflect best practice
- Review new and emerging technologies for inspecting sleeves
- Validation of ILI in sleeved sections
- Annular fill for concrete construction sleeves
- Share experience on maintenance and remedial works on sleeves
- Review of findings from ILIs undertaken
- Establish best practice with sleeve crossing designs
- Research using decommissioned sleeves

Outputs from workshops

- Historical sleeving practices
- Overview of design standards
- Review of incidents
- What are current issues and challenges
- A common strategy for managing the integrity of sleeves
- Presentation on nitrogen sleeve remote monitoring

UKOPA initiatives

- ❑ Development of sleeve maintenance algorithms – now in Good Practice Guide
 - Nitrogen filled sleeve
 - Sleeve containing annular fill other than nitrogen

- ❑ Prioritisation of sleeves for assessment and remediation – DNV GL study complete

- ❑ Study of ILI results – MACAW study in progress

Incidents on sleeves

- ❑ Colonial Pipeline Company – 1980
 - ❑ 32” diameter liquid (aviation kerosene) pipeline
 - ❑ Failure occurred at an area near the bottom of the pipe thinned by corrosion
 - ❑ Corrosion caused by ground water leaking into the annular space between the carrier pipe and sleeve
 - ❑ Sleeve had been electrically shorted to the carrier pipe for 10-12 years
 - ❑ No fatalities but significant environmental damage

Incidents on sleeves

- ❑ Texas Eastern Gas Pipeline Company – 1985
 - ❑ 30” diameter natural gas pipeline
 - ❑ Failure occurred due to thinning of the pipe wall by corrosion
 - ❑ Sleeved crossing located 2 miles downstream of a compressor station
 - ❑ Pipeline temperature 70°C and coating damage was noted
 - ❑ Water condensing on carrier pipe provided an electrolyte for atmospheric corrosion
 - ❑ Escaping gas ignited and burned
 - ❑ Five fatalities and extensive damage to property

Incidents on sleeves

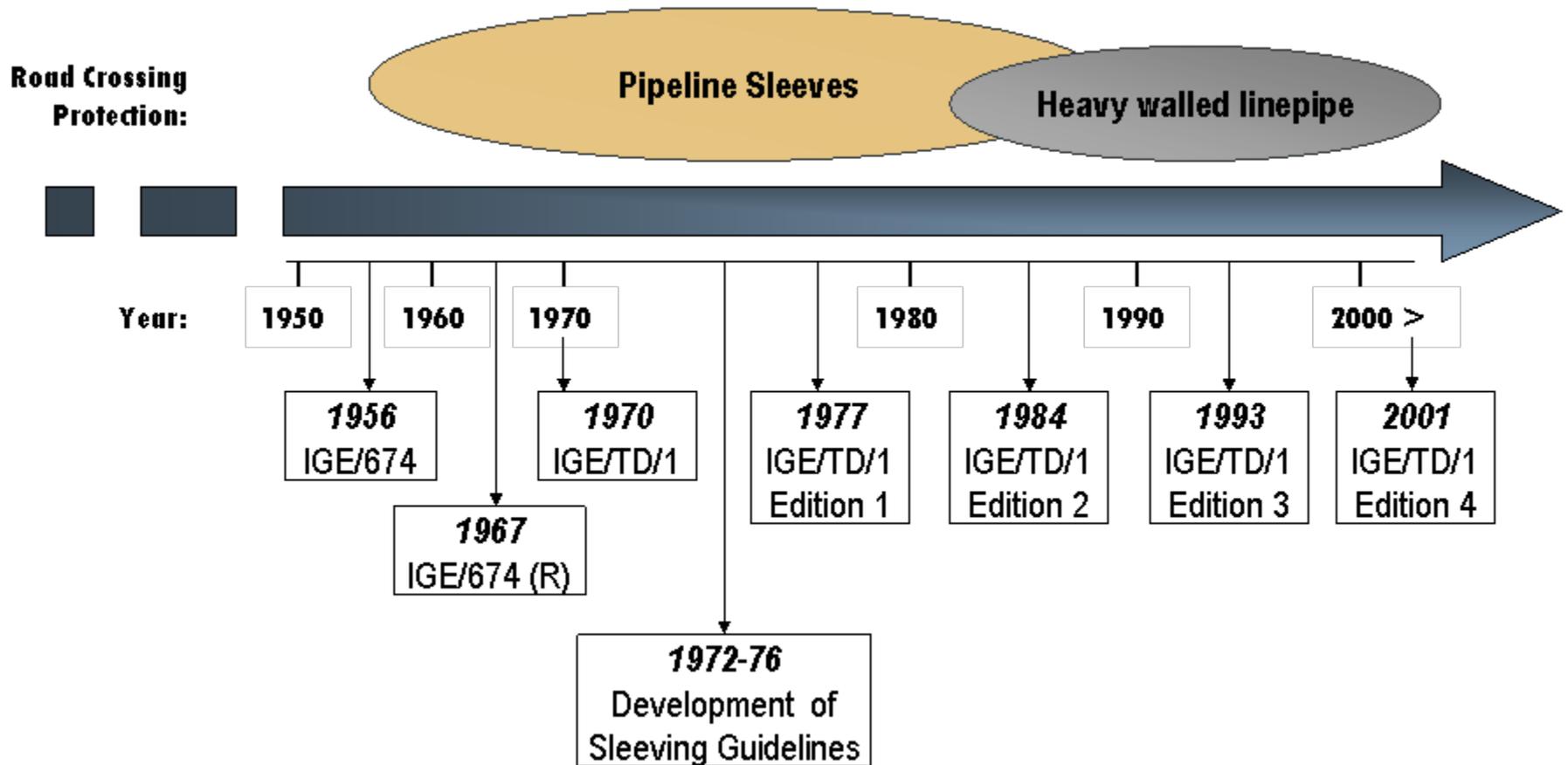
- ❑ Columbia Gulf Transmission Company – 2007
 - ❑ 30” diameter natural gas pipeline
 - ❑ Failure occurred at or near the sleeve crossing under a motorway
 - ❑ Operating pressure at time of failure ~64 barg
 - ❑ Failure due to external corrosion of the carrier pipe
 - ❑ Failure resulted in a undetermined release of natural gas, an explosion and fire
 - ❑ One fatality and one injury
 - ❑ Some damage to property



Development of sleeve practices

- ❑ Sleeve technology developed along with the development and construction of the pipeline network – many designs/types in service.
- ❑ Vast majority of pipelines sleeves are present in the natural gas industry, so this is reflected in the Good Practice Guide.
- ❑ For natural gas pipelines, this development is included in the various editions of IGE/TD/1, the latest version being IGEM/TD/1 Edition 5.

IGE/TD/1 historical sleeving practices



1950s – 1960s

- ❑ **1956 - IGE/674:** Recommendations Concerning the Installation of High Pressure Pipelines
 - ❑ *When the pipeline has to cross a carriageway, railway, or watercourse the method adopted is a matter for individual design, after consultation with all the authorities concerned. When a pipe is protected by sleeving it with a large size tube, the annular space should be vented and fitted with a flame arrestor.*

- ❑ **1967 - IGE/674 Re-Print:** Recommendations Concerning the Installation of High Pressure Pipelines
 - ❑ *Crossings of railways, roads, rivers, streams, can be sleeved in pre-cast concrete or steel pipe or other materials. The annular space should be filled with a suitable material or sealed and vented to atmosphere*

1970s

- ❑ **1970 – IGE/TD/1: Steel Pipelines for High Pressure Gas Transmission**
 - ❑ *For working pressures above 350 lbf/in², pipelines laid in roads should be sleeved; where such pipelines are laid in close proximity to roads or railways, consideration should be given to sleeving, having regard to the density of traffic. All crossings of roads and railways should be steel sleeved for working pressures exceeding 350 lbf/in². The sleeve should extend for a suitable distance either side.*

- ❑ 1972 – Provisional Section on Pipeline Sleeving (Addition to TD/1)

- ❑ 1976 – Section S: Pipeline Sleeving

Section S: Pipeline sleeving

- ❑ Introduced sleeve design classes:
 - ❑ **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

Historical sleeving practices adopted in the UK

R = Recommended System (*NB* The table should be read from left to right to find the recommended system in each set of circumstances.)
 A = Alternative System only to be used if recommended system cannot reasonably be applied.
 X = Unacceptable System.

Sleeve Class	Application (S.2.2)	Sleeve Material (S.4.1)					
		Steel			Concrete		
		End Seal Type (S.4.7)					
		Rigid	Flexible	Shuttering	Rigid	Flexible	Shuttering
1	To meet the requirements of 5.5.1, 5.5.2.1 or 5.7 to give protection against consequences of carrier pipe failure. Also to protect carrier pipe against outside interference.	R	A	A	X	X	X
2	To meet the requirements of 5.5.2.2 to protect the carrier pipe against outside interference.	R	A	A	X	X	A
3	Required only to facilitate construction of the carrier pipe.	A*	A	A	X	X	R
Method of Corrosion Control (S.7)		Annular Fill (S.3.3)					
Inert Environment Only		Nitrogen (S.3.3.3) (S.7.2)					
Combination of: Coating Environmental control Cathodic protection		Cementitious (S.3.3.4) (S.7.3)					
		Others (S.3.3.5), eg Bentonite (S.7.4), grease/oil, foam plastics					

* Where a steel sleeve is used it should preferably have rigid end seals and nitrogen fill.

Section S: Pipeline sleeving

- Sleeving of existing pipelines
- Sleeve construction
- Pipe spacers
- Annular fill and corrosion control
- Maintenance of sleeved lengths

1980s

□ 1984 – IGE/TD/1 Edition 2

□ High Density Traffic Routes

- a. Utilise pipe with a nominal wall thickness of not less than 11.91 mm, OR
- b. Be steel sleeved in accordance with Class 1

□ Other Traffic Routes

- a. Utilise pipe with a nominal wall thickness not less than 9.52 mm, or be provided with impact protection, OR
- b. Be steel sleeved in accordance with Class 2

1990s

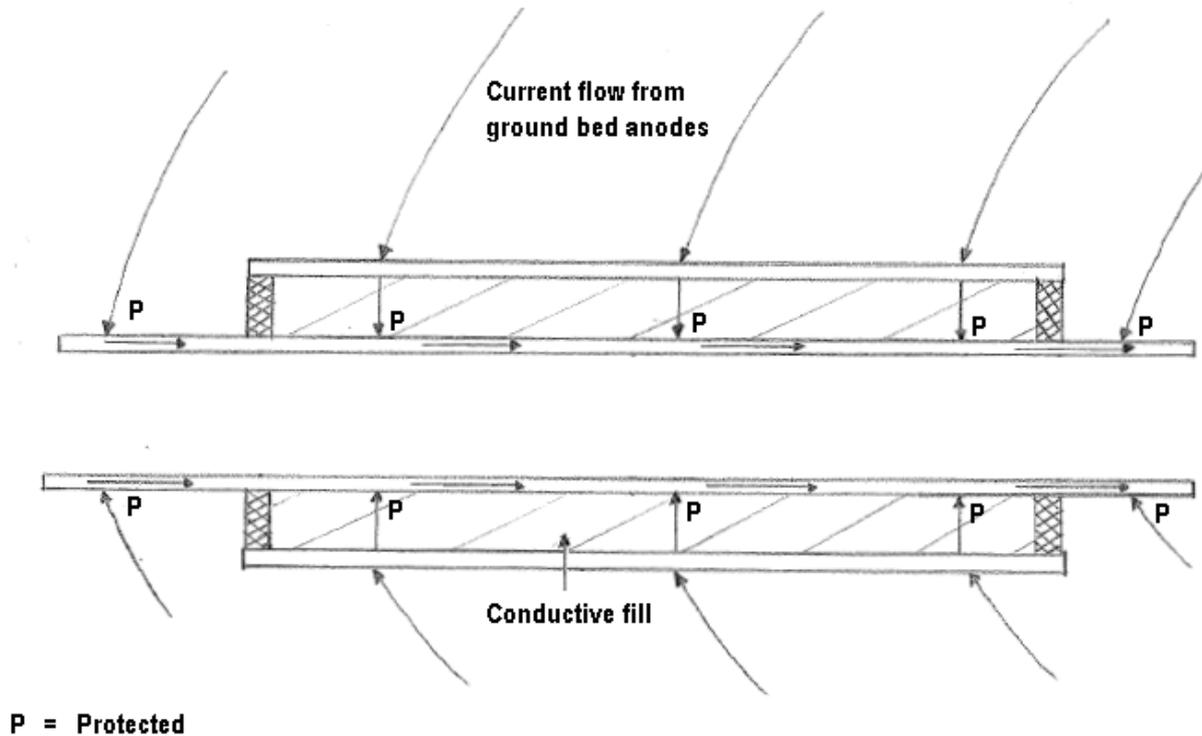
❑ IGE/TD/1 Editions 3 (1993) and 4 (2001)

- ❑ Heavy walled pipeline is recommended for crossings, sleeves should only be used to facilitate construction
- ❑ Construction sleeves should be concrete, however a steel sleeve may be implemented designed to incorporate a nitrogen fill with the use of forged end seals
- ❑ Existing sleeves that meet Class 1 or 2 of Edition 2 may continue to be used to allow the pipeline to operate up to its original design factor

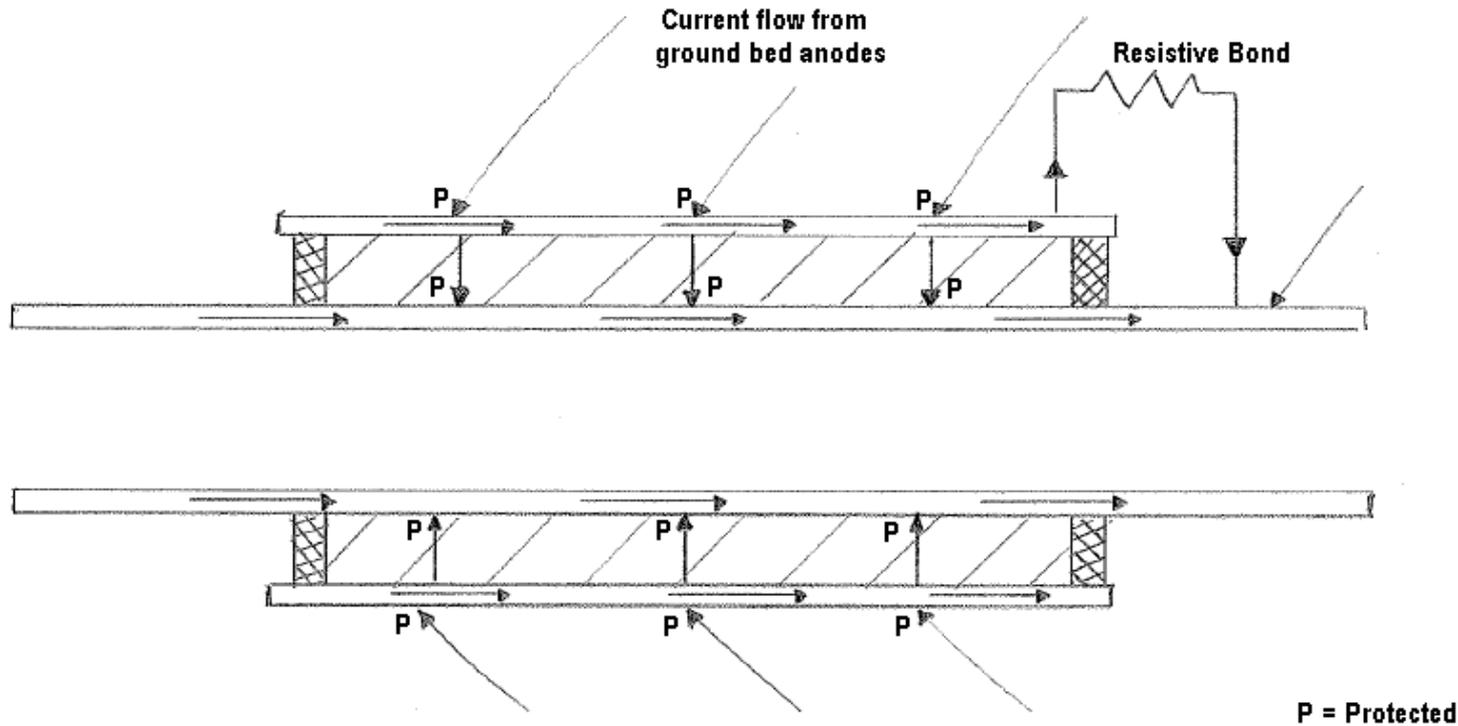
Other design standards and guidance

- ❑ BSI PD 8010-1 Code of Practice for Pipelines – Part 1: Steel Pipelines on Land
- ❑ ASME B31.8 – Gas Transmission and Distribution Piping Systems
- ❑ API RP 1102 – Steel Pipelines Crossing Railroads and Highways
- ❑ NACE SP0200 – Steel Cased Pipeline Practice
- ❑ PHMSA Guidelines for Integrity Assessment of Cased Pipe for Gas Transmission Pipelines in HCAs
- ❑ Draft ISO/TC67/SC 2 N 827 – Petroleum and natural gas industries – Pipeline transportation systems - Design, construction and maintenance of steel cased pipelines.

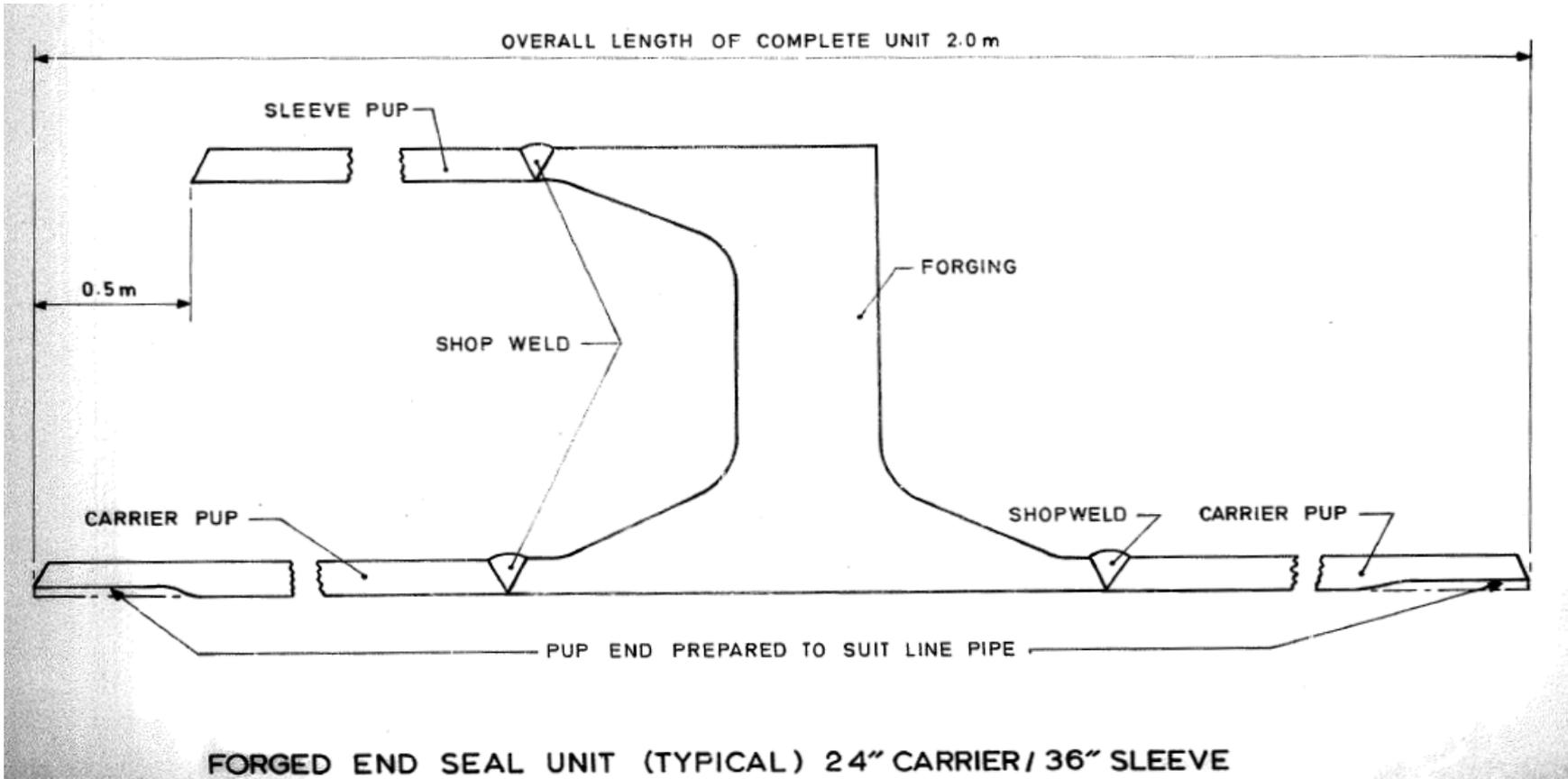
CP of sleeved pipeline



CP of sleeved pipeline

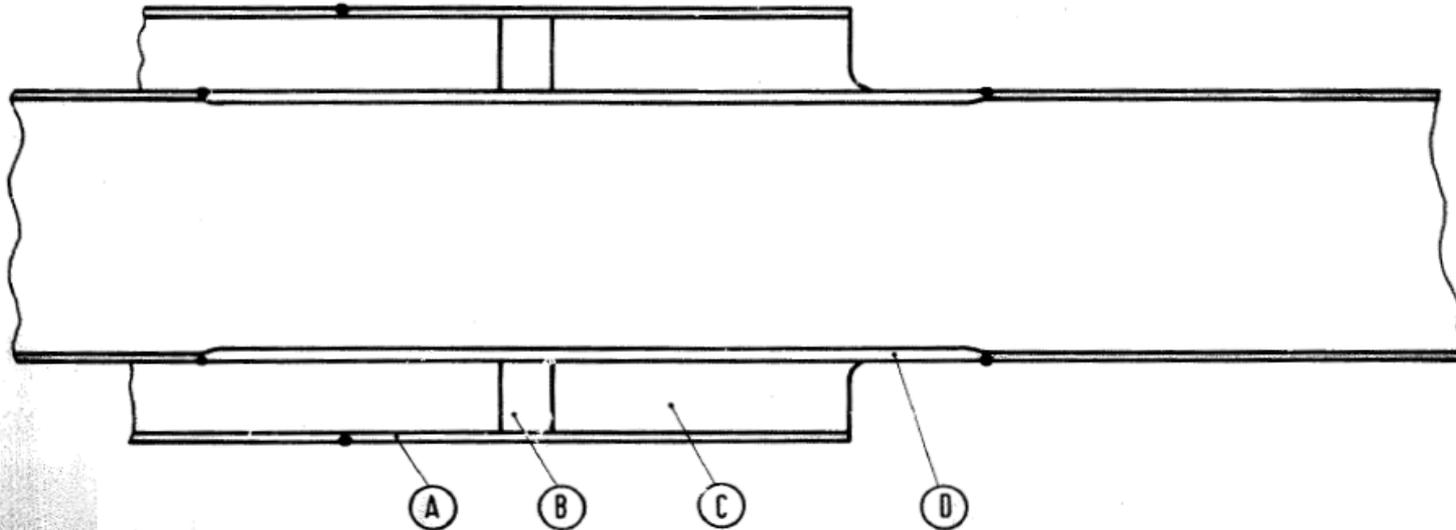


Forged end seal



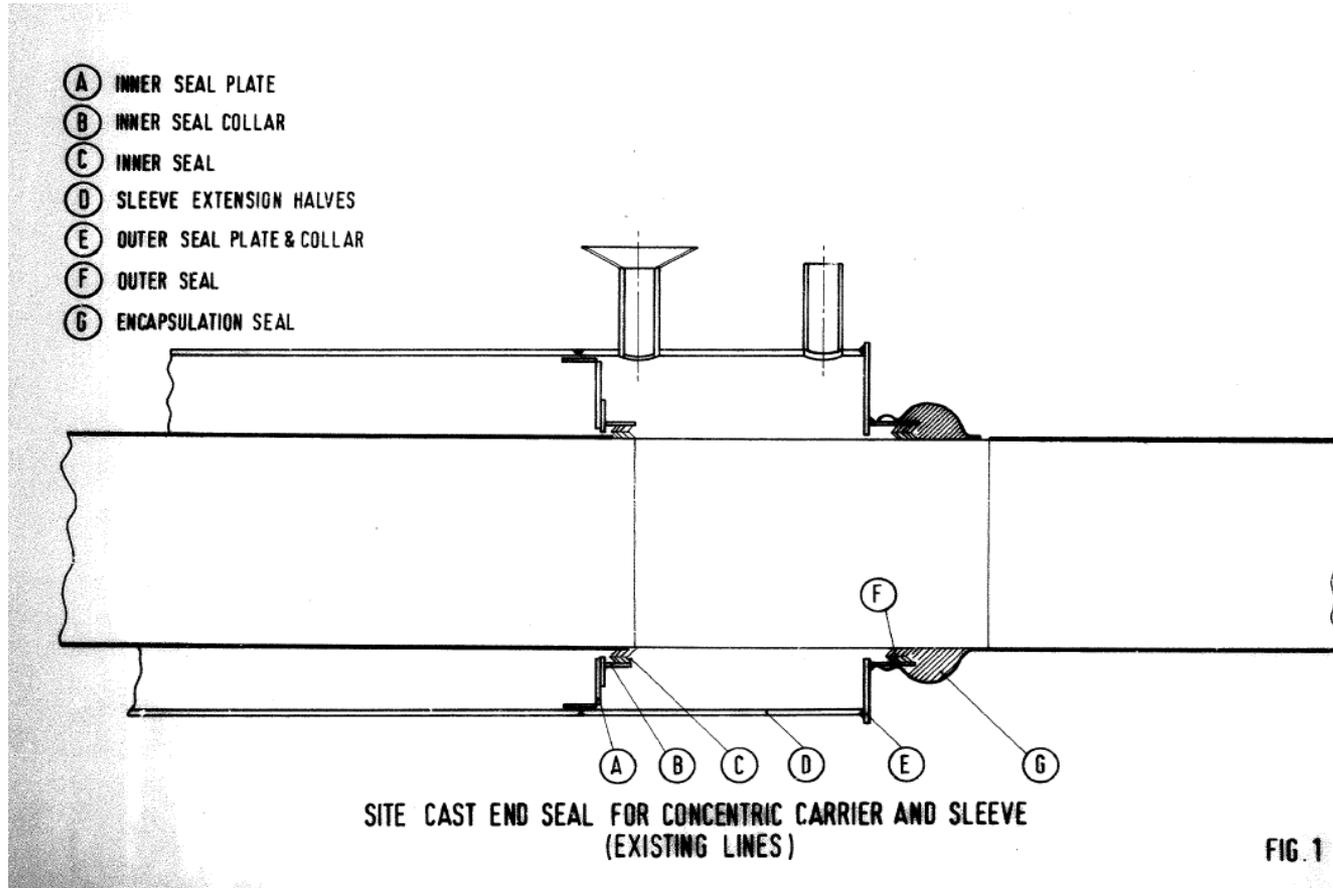
Pre-cast epoxy end seal

- (A) SLEEVE PUP
- (B) SEALANT GROUTING MATERIAL
- (C) LOAD CARRYING GROUT
- (D) CARRIER PUP



PRECAST END SEAL (NEW LINE CONSTRUCTION)

Site cast epoxy end seal



New design of epoxy end seal



New design epoxy end seal
based on epoxy repair sleeve
technology



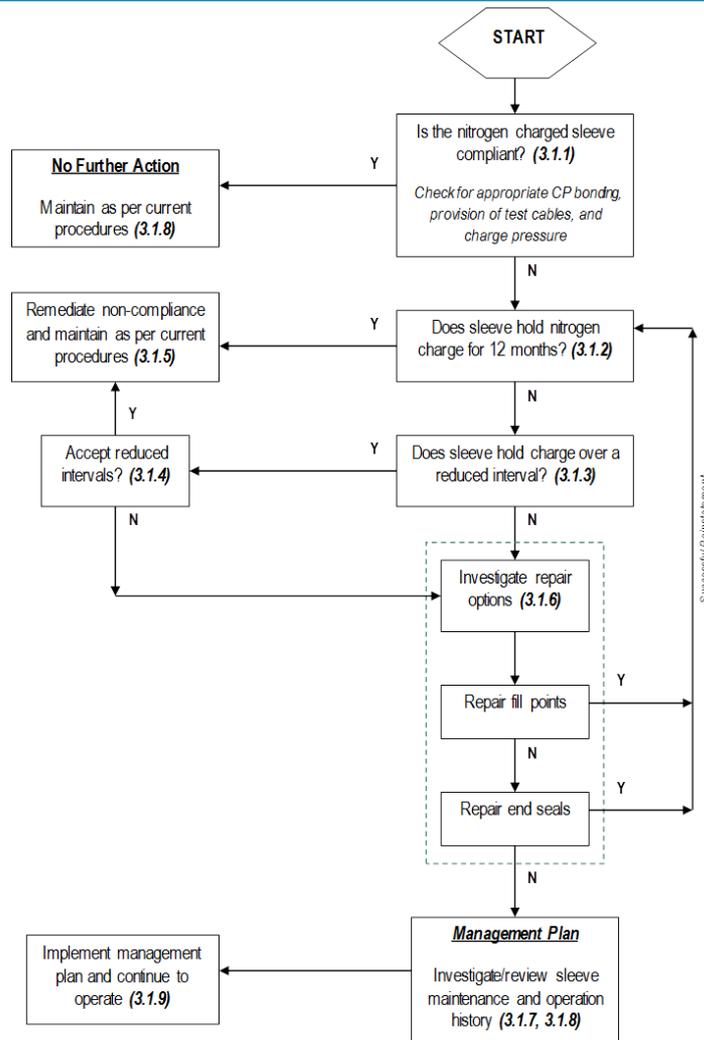
Development of Good Practice Guide

- Development of sleeve maintenance algorithms
 - Nitrogen filled sleeve
 - Sleeve containing annular fill other than nitrogen

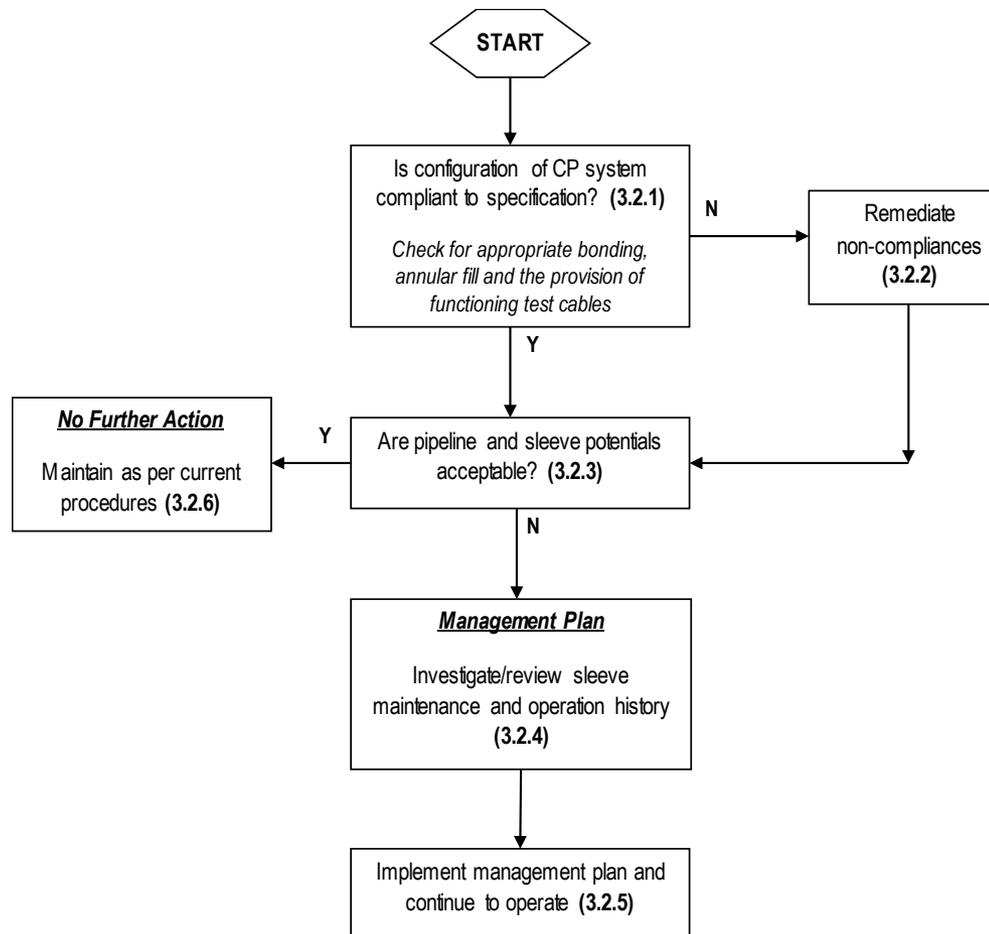
- Commentary on algorithms considers
 - Compliant?
 - Remediation
 - Management plan - considers whether subject to ILI

- Maintenance, inspection and monitoring

Maintenance algorithm for nitrogen charged sleeves



Maintenance algorithm for sleeve containing annular fills other than nitrogen



Maintenance, inspection and monitoring

- Clearing of sleeve shorts
- Integrity inspection of carrier pipe
- Monitoring of carrier pipe and sleeve
 - Potential survey
 - Internal resistance test
 - Interrupting the transformer rectifier
 - Sleeve depolarisation test
 - Pipe/cable locator



Review process for document

- ❑ Good Practice Guide based on ‘UKOPA Sleeve Management Strategy’ document’, which had been produced by DNV GL after the workshops, and had been reviewed by the HSE.
- ❑ Draft Good Practice Guide circulated for comment to working group members.
- ❑ Comments collated, documented and reviewed.
- ❑ Peer review by Ian Thompson of DNV GL.

Prioritisation of sleeves for assessment and remediation – DNV GL study

- ❑ Sleeve inspection scoring scheme that
 - ❑ Uses the engineering characteristics to differentiate between the different sleeve configurations in use
 - ❑ Indicates those sleeves that have higher likelihoods of failing and thereby resulting in an escape of gas that could lead to multiple fatalities
 - ❑ Indicates those sleeves that are a low likelihood of failing in such a way as to produce multiple fatalities

- ❑ Sleeve ranking incorporated into a spreadsheet

Sleeve ranking - factors included

Pipeline characteristics

- Pipeline installation date
- Operating pressure
- Pipeline wall thickness
- Pipeline diameter
- Pipe coating
- Piggable (Y/N)

Sleeve characteristics

- Protection reason (i.e. road, rail, or water)
- Sleeve location (R or S or T)
- Sleeve installation date
- Sleeve length
- Sleeve material
- Sleeve end-seal
- Annular fill material
- Inspection and monitoring data

Date of last in-line inspection

- Cathodic protection
- Status of nitrogen fill in annulus

Overall Sleeves Risk Ranking

- ❑ The different factors are given scores indicative of how likely that factor is to increase the risk associated with the sleeve.
- ❑ The scores for the individual factors are then combined together to give an empirical number within a non-linear ranking scheme that has been designed to identify those sleeves most at risk of housing a leaking pipeline within a high consequence area.
- ❑ Three general zones:
 - ❑ High scores for sleeves that are a high priority for inspection
 - ❑ Low scores for sleeves that are a low priority for inspection
 - ❑ An intermediate region
- ❑ N.B. The scoring scheme is an estimate of relative likelihood of a failure - not that the pipe with a higher score will fail before a pipe with a lower score.

ILI study – MACAW study

- ❑ Reviewing the ILI results on pipelines containing pipeline sleeves.
- ❑ Aim to develop an understanding of the relationship that may exist between the location and type of sleeves and corrosion features that occur in close proximity.
- ❑ Investigate and compare the depth distribution of corrosion features that are directly under sleeves, with those in close proximity to sleeve (upstream/downstream) and in general along the pipeline.
- ❑ This will provide an in-sight into the performance of sleeves on pipelines not subject to ILI.

ILI study – progress

- ❑ Successfully demonstrated the feasibility of extracting information relating to sleeves from the In-Line Inspection data.
- ❑ Feasibility study completed for a small number of pipelines but intention is to consider a much larger population of pipelines.
- ❑ Feasible to evaluate external corrosion reported from ILI in an effective manner and identify those features related to sleeves.
- ❑ For some of the pipelines, the number and depth of features within 12 m of a sleeve is higher than for the remainder of the pipeline.
- ❑ Particular attention should be given to the effectiveness of the CP system in the vicinity of the sleeved section.
- ❑ Highlights importance of having good data on the sleeves attributes.

Concluding remarks

- ❑ Pipeline sleeves represent a potential integrity threat, particularly on pipelines not subject to ILI.
- ❑ UKOPA has developed a Good Practice Guide for managing pipelines sleeves.
- ❑ Sleeve risk ranking has been developed and a study looking ILI results is in progress.
- ❑ ILI study highlights importance of having good quality data on sleeve attributes.