Effective Use of In-line Inspection Technologies to Support Pipeline Integrity Management

PPSA Annual Seminar
Ardoe House Hotel and Spa, Aberdeen, UK
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INTRODUCTION

- MACAW Engineering has been supporting Chevron North Sea Ltd (CNSL) with the implementation of their integrity management process since 2006.

- Support has focussed on ensuring that CNSL maximise the value from their in-line inspection (ILI) campaigns:
  - Pre-inspection support (ILI tool selection and timing of ILI).
  - Post-inspection support (‘verification’ of ILI report, integrity assessment of ILI results, comparison of repeat ILI data, recommended updates to corrosion management strategy).

- Key to the success of the ILI campaigns has been combining corrosion knowledge with an understanding of the capabilities and limitations of available ILI technology.

- This paper aims to share some key learning points in order to improve the input that ILI has into an overall pipeline integrity management programme.

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CNSL’S UK OPERATIONS

CNSL operates more than 25 pipelines across three operated assets in the UK North Sea, Alba, Captain and Erskine, with pipelines service life of up to 20 years.

The pipelines are required to transport:

- Produced hydrocarbon fluids
- Gas import/export
- Injection water for enhanced hydrocarbon recovery
- Chemicals/hydraulic fluids for flow assurance, asset integrity and subsea equipment controls

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CNSL INTEGRITY MANAGEMENT PROCESS

- IM Process developed in-line with industry best practice (e.g. DNV RP F116)
- Processes adopted by CNSL for effective management of pipeline integrity and reliability follow the UK HSE recommended practice, HSG65
- Overall objectives of IMP:
  - Prevent hydrocarbon release
  - Make effective use of available integrity management resources
  - Identify and effectively manage all integrity threats
  - Ensure effective, regular monitoring to confirm the ongoing condition of the assets and verify the effectiveness of the corrosion management strategy
  - Drive continuous improvement in integrity management
THE ROLE OF ILI IN INTEGRITY MANAGEMENT

- Confirm Current Condition of the Pipeline
- Quantify Corrosion Growth Rates
- Confirm Effectiveness of Corrosion Prevention Strategy
- Encourage Compliance with Performance Standards

Requirements
- Knowledge of pipeline history and required future use
- Understanding of active corrosion threats and likely corrosion mechanisms present in pipeline
- Knowledge of capabilities and limitations of ILI tools
- Sound integrity knowledge to be able to combine corrosion management experience with ILI data to estimate remaining life
PRE-INSPECTION

- Cleaning Requirements

- ILI Tool Selection:
  - Detection capabilities (metal loss size and shape)
  - Sizing accuracies
  - Compatibility / Repeatability compared to previous inspection data
  - Product used for propulsion
  - Pipeline cleanliness
  - Tool availability
  - Requirement for use of combined technology

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CASE STUDY 1: ILI TECHNOLOGY SELECTION

• Background:
  • 12” Alba Water Injection Pipeline, commissioned in 1998
  • Previously inspected using MFL technology on two occasions (2006 & 2009)
  • Inspections both reported internal corrosion throughout the pipeline, thought to have been caused by elevated O₂ levels
  • Corrosion risk assessment indicated potential for channelling corrosion
  • MFL tools known to be relatively insensitive to smooth channelling corrosion
  • No channelling corrosion reported by MFL inspections but indirect evidence (features at girth welds and increased magnetisation at the 6 o’clock position) supported potential for channelling

Channelling corrosion in Strathspey W.I. pipeline which was operated under similar conditions
Image used with Permission from Chevron 2014
CASE STUDY 1: ILI TECHNOLOGY SELECTION

- Approach for next ILI:
  - Pipeline was re-inspected in 2010 using both MFL and UT technology
  - MFL was used to enable a direct comparison against the previous data
  - UT was used to improve detection capability with reference to channelling
  - UT reported significant channelling corrosion in the bottom of the pipeline
  - Comparison of 2009 and 2010 data highlights significant differences in depths and lengths of reported features
CASE STUDY 1: ILI TECHNOLOGY SELECTION

- Key Learning Points:
  - Limitations of ILI technology must be understood and considered: distribution of reported corrosion may not be reliable
  - Findings from a corrosion risk assessment should be considered when selecting ILI technology
  - Lessons learnt from other pipelines (e.g. Strathspey W.I. pipeline) should be communicated effectively throughout the organisation
  - If channelling corrosion is suspected, an alternative / supplementary technology should be considered (UT or high resolution calliper)
POST-INSPECTION INTEGRITY ASSESSMENT

ILI Data ‘Verification’

Corrosion Diagnosis based on ILI Results

Integrity Assessment of Reported Features

Corrosion Growth Rate Estimation

Application of Corrosion Rates to Estimate Remaining Life

Develop / Modify Corrosion Management Strategy
ILI DATA VERIFICATION

• Requirement to determine the quality of the ILI data and, where possible, confirm ILI performance specifications have been met

• Verification performed directly and / or indirectly

• Direct verification
  • Typical approach for onshore pipelines
  • Direct verification methodology outlined in standards such as API 1163, In-line inspection systems qualification standard

• Indirect verification
  • Review run speed and acceleration, sensor malfunction / data loss, magnetisation (for MFL tools) and echo loss (for UT tools)
  • Sense check of results against what was expected from CRA
  • Comparison of results against previous ILI or ILI data from alternative technology
ILI DATA REVIEW AND CORROSION DIAGNOSIS

- Review of the reported **distribution** of corrosion features to diagnose cause of corrosion
- Diagnosis of **internal** corrosion is reliant on reviewing the distribution throughout the length and around the circumference of the pipeline
- Diagnosis of **external** corrosion on offshore pipelines is normally reliant on accurate alignment of ILI data with as-built riser drawings
CASE STUDY 2: EXTERNAL CORROSION DIAGNOSIS

- 16” Captain Oil Export riser
- GVI reported an area of corrosion immediately above the neoprene splash zone coating. Corrosion was subsequently repaired.
- Although records of repair (including photographs) were retained, it was not clear if and how far the neoprene coating was stripped back
- Following the repair, the pipeline was internally inspected and external corrosion was reported at various locations on the riser
- Comparison of repeat ILI data indicated some features had grown since previous inspection
- Initial comparison between ILI data and riser drawings were inconclusive and there was uncertainty whether all active corrosion had already been repaired
CASE STUDY 2: EXTERNAL CORROSION DIAGNOSIS

- ILI data aligned with riser schematic
- Alignment used ILI signals to increase accuracy
- Based on alignment, clear guidance was given to investigation team to enable positive identification of riser corrosion
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• **Corrosion rates** estimated from comparison of repeat ILI data, supported by corrosion modelling (e.g. NORSOK) where feasible (i.e. dominant mechanism is sweet corrosion)

• **Future** corrosion rates critically dependent on effectiveness of corrosion management and compliance with performance targets (e.g. C.I. injection)

• Two primary requirements from remaining life analysis:

  1. To determine a suitable timeframe for re-inspection based on a conservative estimate of corrosion growth rate

  2. To estimate the potential remaining life of the pipeline based on a less conservative / more representative corrosion growth rate

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**Note:** Remaining life for offshore pipelines normally defined as the time until the most significant defect is predicted to exceed critical dimensions
REMAINING LIFE ANALYSIS

![Graph showing remaining wall thickness over service life]

- **Nominal WT**
- **First ILI**
- **MAWT**

The graph illustrates the remaining wall thickness over the service life, with key points indicating the nominal wall thickness, the first indication of internal lining (ILI), and the minimum allowable wall thickness (MAWT).
REMAINING LIFE ANALYSIS
REMAINING LIFE ANALYSIS

![Graph showing the remaining wall thickness over service life](image)

- **Nominal WT**
- **Corrosion Rate Estimation (P90 Confidence)**
- **MAWT**

- **Timing Allows for Data Analysis and Potential Repair / Rehabilitation**
- **Recommended Timing for Next ILI Run**
REMAINING LIFE ANALYSIS

![Diagram showing remaining wall thickness over service life with annotations for Nominal WT, MAWT, Third ILI, and Potential Remaining Life.]
SELECTION OF RE-INSPECTION INTERVAL

Conservative estimate of CGR assuming no change to corrosion management

Time to Exceed Critical Dimensions (Years)

Corrosion Growth Rate (mm/year)

- 26.2 bar
- 0.71 mm/year
- 0.52 mm/year
- 0.23 mm/year
SELECTION OF RE-INSPECTION INTERVAL

Conservative estimate of CGR assuming recommendations are implemented and full compliance with performance targets.
SELECTION OF RE-INSPECTION INTERVAL

Best estimate of CGR assuming recommendations are implemented and full compliance with performance targets

Multiple ILIs to monitor growth and manage risk
SUMMARY

• Extending the safe remaining life of a pipeline requires effective integrity management. ILI plays a critical role by confirming the condition of the asset and the effectiveness of the applied mitigation.

• Direct and indirect costs and operational impact of running inspections can be significant so it is important that the value of the inspection be maximised.

• Combining corrosion knowledge with ILI experience is a fundamental requirement:
  • Understand active corrosion mechanisms
  • Be aware of ILI technology limitations and select a tool / tools capable of detecting all active mechanisms
Thank you for your attention

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