Pipeline Emergency Repairs
Combining ILI Data Analysis with Field Assessment

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Introduction
Overview

Weather and outside force are a threat to pipelines worldwide.

Pipelines can experience external forces from many different events including:

• landslides
• flooding
• earthquakes
• human activity

The effect can be immediate. In other cases the progressive increase in loading can occur over time.
Introduction

In 2014 APA Group found a pressure loss on a 10” natural gas transmission pipeline. A leak was identified and a full investigation of the cause was initiated.

At the time of the incident the 10” pipeline system was in the process of being inspected using a magnetic flux leakage (MFL) combination vehicle including caliper (geometry) and an inertial measurement unit (IMU).

Only a few days earlier, the leaking pipeline section had been inspected and the data collected from this inspection was still in the initial analysis phase.

The issue was highlighted to PII who fast-tracked the analysis review to initially focus on the leak site.
Investigation:
In-Line-Inspection Data
Magnetics Data at Leak Site showing Metal Loss and a Dent
IMU Data

Mapping data can be used to determine even very small deviations from a pipeline’s original position.

Due to the light bending indications on the caliper gyros the IMU curvature data was also reviewed in the area of the failure.

Significant Peak in Horizontal Bending Strain at Leak Site
Investigation: In-Field
In-Field Challenges

Leak site was located on a steep slope downstream from a railway crossing.
Narrow Circumferential Crack-like Feature Identified at Failure Site
Investigation:
Geotechnical and Other Factors
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In-Field Findings

Rainfall data was reviewed. While no single major rainfall event or landslide had occurred, a number of recent years indicated wetter than average conditions. These could have contributed to ground movement affecting the pipeline.

- Geotechnical observations
- Spatial surveys
- LiDAR scans

Indicated that the area of high strain correlated with an area of creep-type landslide ground movement.
Investigation:
Findings
Findings

• The circumferential metal loss seen by the MFL vehicle at the leak site was in fact a circumferential crack. For MFL technology to detect a part-wall crack, the crack faces must be open (gap > 0.1mm) at the time of the ILI run.

• The leak site showed signs of non-construction bending indicating external loading on the pipeline. Deflection occurred when the pipeline section was cut out and permanent curvature was observed in the removed sections, indicating the pipeline had experienced stresses beyond the yield strength.

• The in-field investigations and the ILI data review showed that the leak site was in the tensile zone of the applied bending loading.

• Geotechnical investigation and field observations indicated that the area was subject to creep-type landslide ground movement.
Further Investigation:

Aims
Further Investigations

• Identify any other areas of the pipeline showing **similar attributes** to the leak site

• Determine all areas where the pipe had **changed shape**, potentially indicating external loading

• Carry out **further in-field investigation** on other identified subcritical sites and remediate
Further Investigation: Bending Strain Comparison
Bending Strain Comparison

Intentional Bends

Strain Change

Leak Site

Peak Strain
Bending Strain Comparison

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- Bending Strain data showed **change in strain** between the 2008, 2011 and 2014 inspections.
- Strain Comparison plots indicate that there was a change in strain, indicating **ongoing movement**.
- Data suggests that the external loading on the pipeline had been **present** at least since 2008.

### Inspection Year Summary

<table>
<thead>
<tr>
<th>Year</th>
<th>Horizontal Strain at Peak</th>
<th>Vertical Strain at Peak</th>
<th>Total Strain Magnitude at Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>0.511%</td>
<td>0.113%</td>
<td>0.523%</td>
</tr>
<tr>
<td>2011</td>
<td>0.548%</td>
<td>0.129%</td>
<td>0.563%</td>
</tr>
<tr>
<td>2014</td>
<td>0.566%</td>
<td>0.158%</td>
<td>0.587%</td>
</tr>
</tbody>
</table>
Complementary Techniques

- IMU curvature analysis can effectively locate and measure pipeline bending strain due to ground movement or external loading.
- Other techniques are used to assess direct axial tension and to monitor pipeline and ground movement in between ILI runs.
- Ground surface changes: Pipeline patrols; conventional survey; LiDAR.
- Subsurface movement/depth analysis: Geotechnical inclinometers; geophysical or seismic survey.
- Pipeline strain: Vibrating wire strain gauges; fibre optics.
Further Investigation:
Conclusions
Conclusions

• This study highlights the importance of on-going monitoring of pipeline systems for multiple threats especially on lines that may be subjected to external loading due to the effects of weather and outside force

• ILI investigations can help identify sub-critical threats to pipeline integrity and identify areas previously not thought to be a risk

• Combining multiple inspection technologies can effectively build a picture of pipeline condition and behaviour in-situ and how this changes over time

• Regular inspection and monitoring combined with effective in-field operator expertise to investigate locations presenting combined integrity risks can be utilised to address this threat to pipeline integrity
Conclusions

• For this pipeline, strain events > 0.3% peak magnitude were considered significant and have been incorporated in the ongoing excavation and repair programme

• Pipeline curvature strain analysis from IMU data is an effective means of identifying potential locations of circumferential damage

• Ground patrolling and monitoring using LiDAR, survey, and similar provide complementary data for short term monitoring of at-risk locations in between ILI runs

• Integrity management of ageing pipelines should incorporate ground movement and external loading threats, in terms of detection, assessment and repair