Advisory – Corrosion in Pipelines

Corrosion Awareness Day, 2026

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LR Offshore Technical Support Offshore

Aims of presentation

- Introduction to Advisory
- Introduction to corrosion in pipelines
  - Corrosion mechanisms
- Corrosion defect assessment case study
  - Review of data
  - Assessment methodology
  - Results

Introduction to Advisory

A Trusted Advisor, partnering with clients to tackle business challenges

ASSET PERFORMANCE
Define actionable recommendations to optimise asset performance

MANAGEMENT CONSULTING
Prepare your business for future challenges

INNOVATION
De-risk and implement new technologies to future-proof your assets

OPERATIONAL SERVICES
Protect your assets throughout their lifecycle to deliver your contractual obligations and minimise risk

Advisory

ENERGY TRANSITION
Build and execute robust strategies to navigate the Energy Transition

ASSET & RISK MANAGEMENT
Creating a safer and more efficient operating environment

PROJECTS ADVISORY
Optimise the value of your project investments

HUMAN ELEMENT
Apply Human Factors specialist expertise to enhance operational performance

Introduction to Advisory

Asset performance

Aging Assets and Rising Maintenance Costs

Decarbonisation Imperative

Emissions Reporting Complexity

Regulatory Complexity

Uncertainty in Technology Performance

Noise and Vibration Risks

Lifetime Extension

Advisory

LR Advisory's structure comprises multidisciplinary experts who understand the intricacies of maritime and energy operations to provide client with evidence-based strategic advice on critical issues such as digitisation, energy transition, safety and commercial success

Corrosion in pipelines

Issues

Corrosion

↓

Reduced WT

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Reduced pressure capacity

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Increased risk of leaking or rupture

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Loss of fluid

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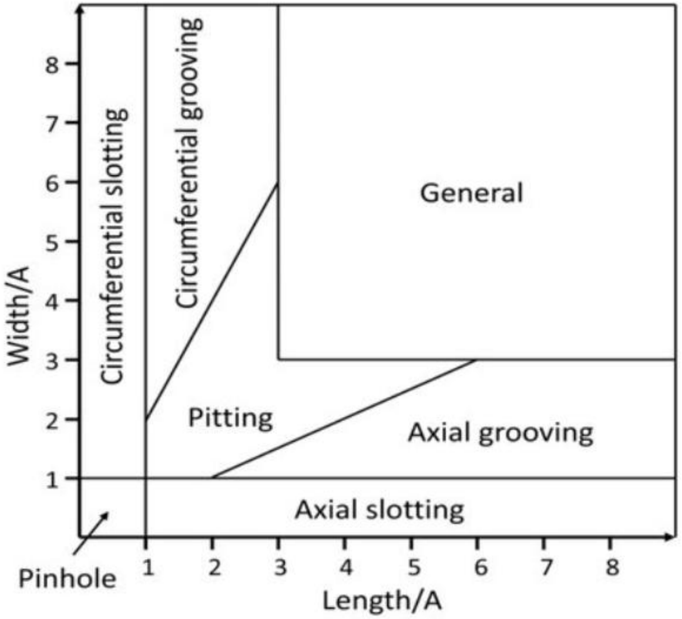
Corrosion in pipelines

Types of metal loss features

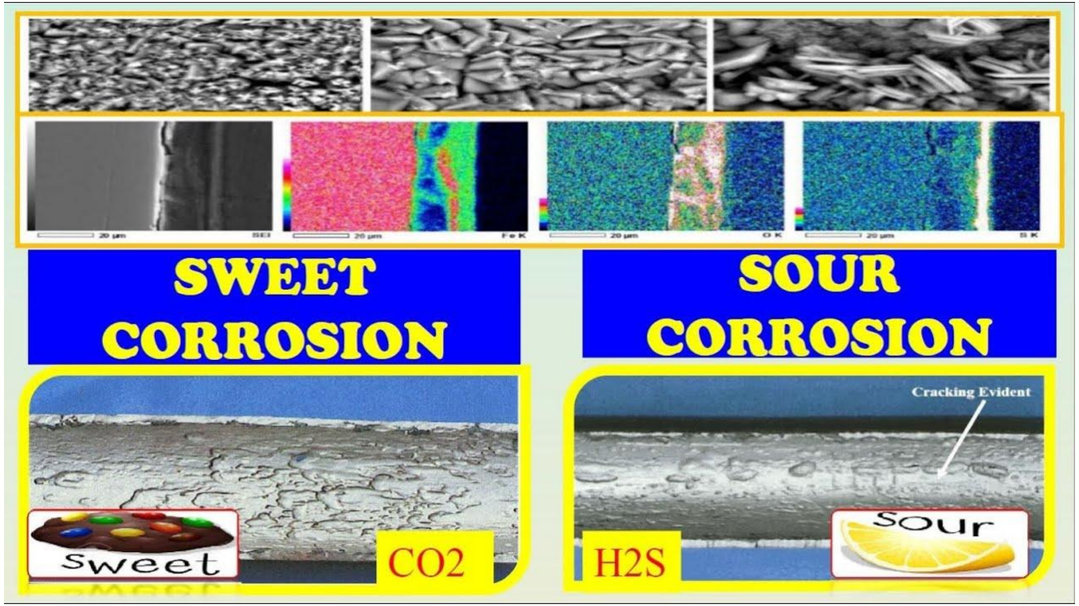


Anomaly dimension class	Definition	Reference point/size for the POD in terms of l x w
General:	{[w ≥ 3A] and [l ≥ 3A]}	4A x 4A
Pitting:	{(([1A ≤ w < 6A] and [1A ≤ l < 6A] and [0.5 < l/w < 2]) and not ([w ≥ 3A] and [l ≥ 3A])}	2A x 2A
Axial grooving:	{[1A ≤ w < 3A] and [l/w ≥ 2]}	4A x 2A
Circumferential grooving:	{[l/w ≤ 0.5] and [1A ≤ l < 3A]}	2A x 4A
Pinhole:	{[0 mm < w < 1A] and [0 mm < l < 1A]}	Minimum dimensions to be further defined by Contractor, see table A3-2
Axial slotting*:	{[0 mm < w < 1A] and [l ≥ 1A]}	2A x ½A
Circumferential slotting*:	{[w ≥ 1A] and [0 mm < l < 1A]}	½A x 2A

Corrosion in pipelines

Internal corrosion mechanisms

- Key issue = what's in the pipe
- Sweet corrosion
  - Most common internal corrosion mechanism
  - CO2 dissolved in water
  - Siderite films are formed
  - Below 60°C – General corrosion
  - Above 60°C –Pitting corrosion
- Sour corrosion
  - Less common than sweet corrosion
  - H2S dissolved in water
  - Can result in pitting and cracking



Corrosion in pipelines

Internal corrosion mechanisms

- MIC
  - Caused by bacteria on pipe wall
  - These consume sulphates and produce H_2S
  - Can be introduced via untreated seawater
  - Can form a grove along the 6 o'clock position

Corrosion in pipelines

External corrosion mechanisms

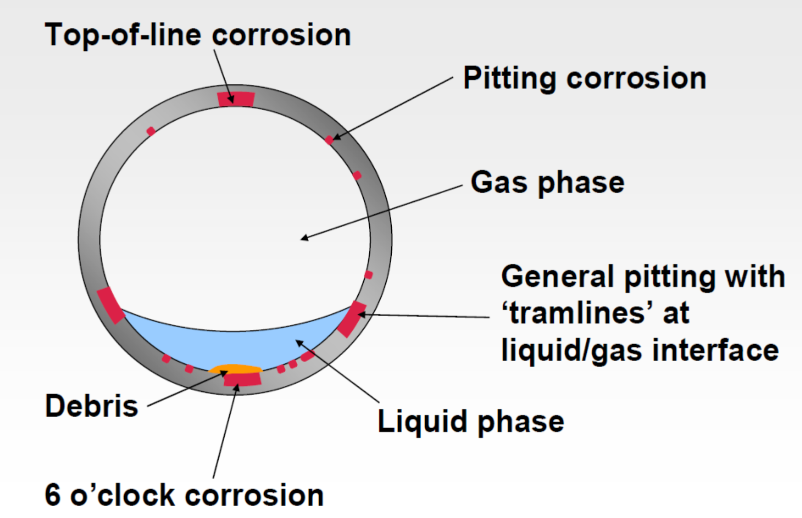
- Oxygen corrosion
  - Subsea pipelines – exposed to seawater and dissolved O_2
  - Onshore pipelines – exposed to moisture and O_2
  - Corrosion occurs if barriers are broken

Corrosion in pipelines

Internal corrosion locations

Some areas are particularly vulnerable to corrosion:

- Top of pipe
  - Issue in high temperature wet gas and multiphase lines
- Bottom of pipe
  - Due to water settling out
  - MIC can result in a groove at 6 o'clock position
- Bends
  - Combined erosion & corrosion



Corrosion in pipelines

External corrosion locations

Some areas are particularly vulnerable to corrosion:

- Riser splash zone
  - Steel is exposed to seawater and atmospheric corrosion
  - Repeated wetting and drying
  - Ineffective cathodic protection

Case Study

Corrosion Defect Assessment of Thistle Alpha Export Line

Background:

- Thistle to Dunlin 16" crude oil pipeline
- Started exporting in 1978
- Length: 12.2 km
- ILI and FFP completed in 2001 & 2009

Case Study

Corrosion Defect Assessment of Thistle Alpha Export Line

Objectives:

- Operator requested LR review ILI results
- Determine if the pipeline was fit for purpose
- Determine the pipeline remnant life

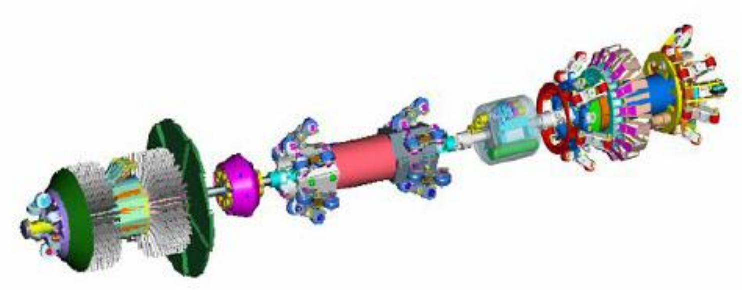
Case Study

The inspection – findings

Data:

-460 external corrosion features

-63399 internal corrosion features



Case Study

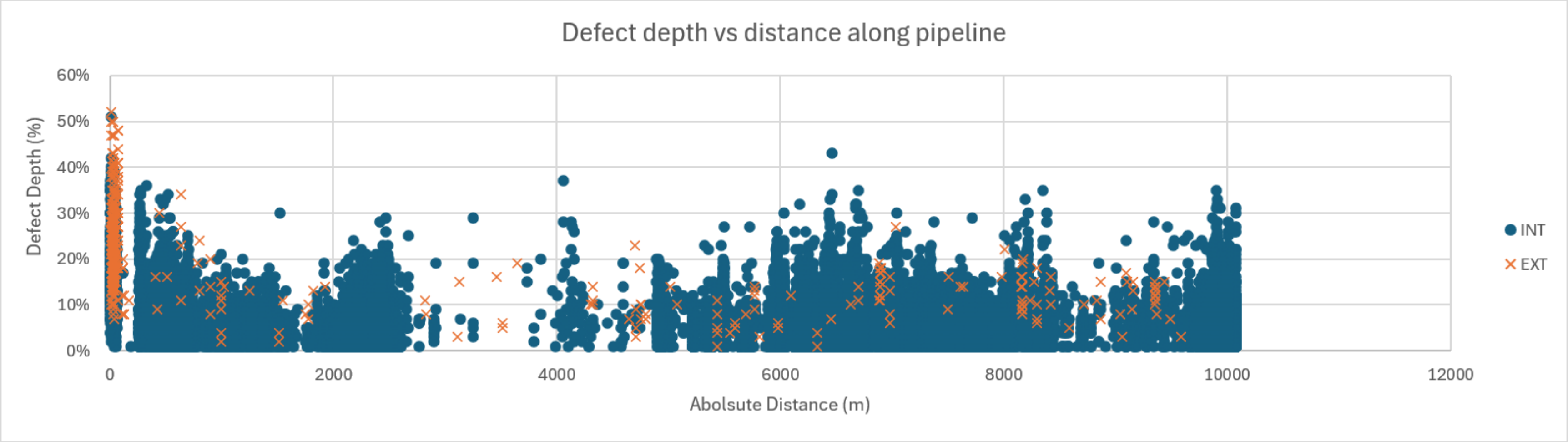
The inspection – inspection issues

Issues:

- Significant wax deposition
- The ILI tool was out with the optimal velocity range between KP 8.4 and KP 12.5
- Power loss occurred at KP10.2

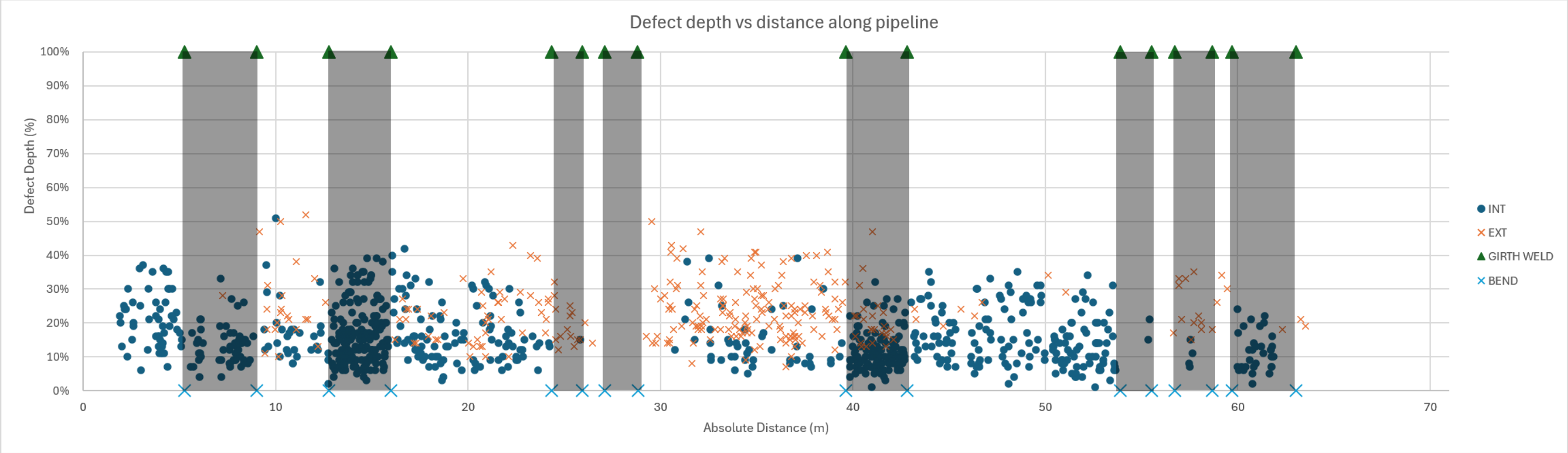
Case Study

The inspection – data deep dive



Case Study

The inspection – data deep dive



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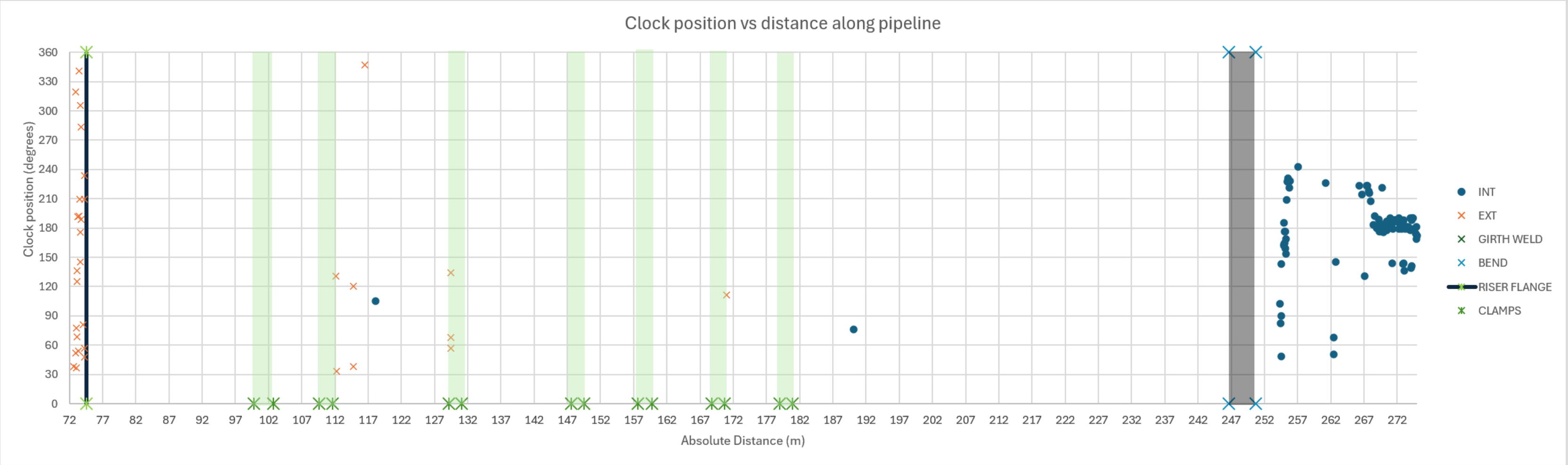
Case Study

The inspection – data deep dive



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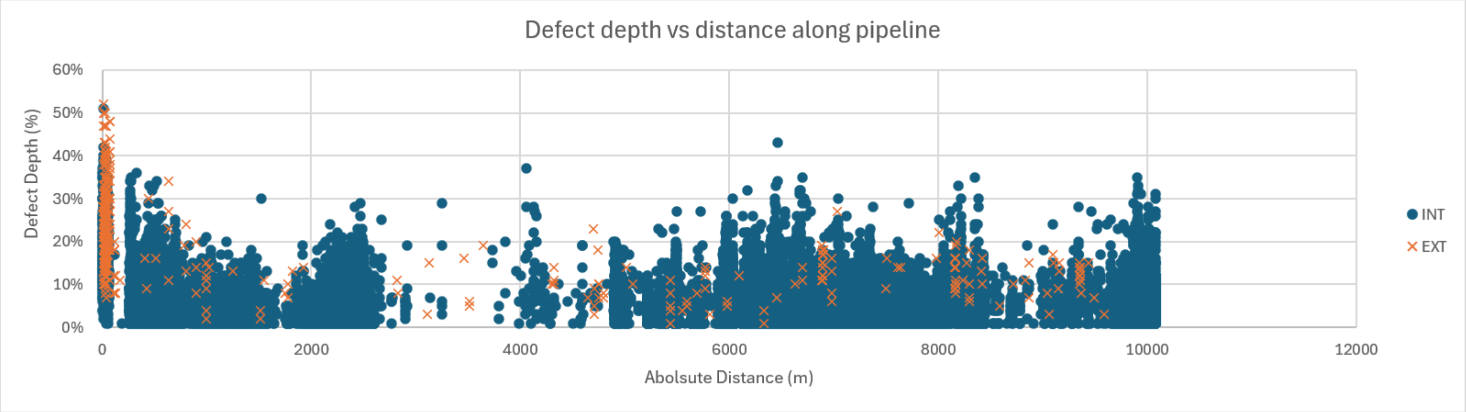
Case Study

The inspection – data deep dive

Points of interest:

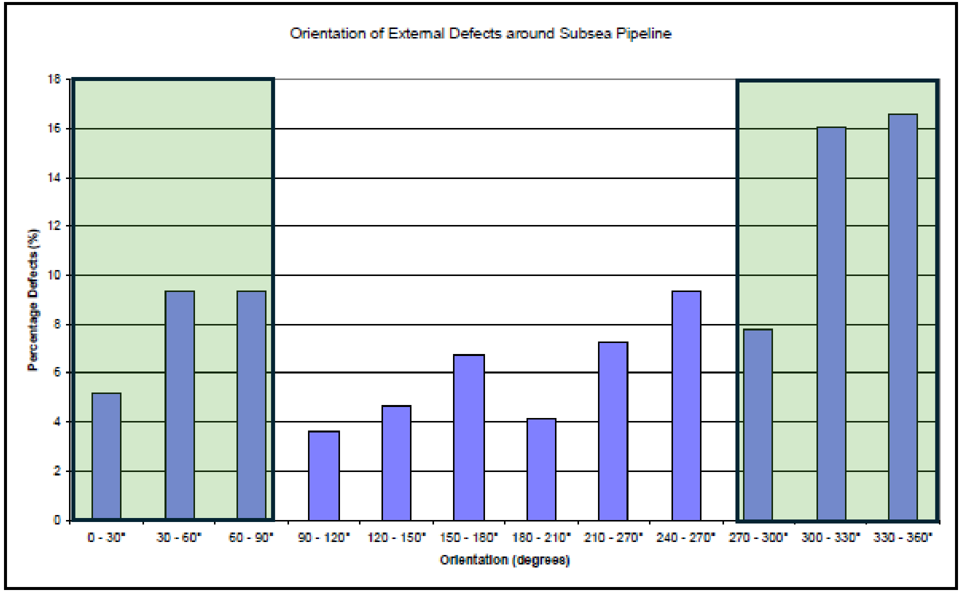
- Majority of external defects located within riser/topsides
- External defects located within subsea pipeline. Note the pipeline has a:
  - 9.5 mm thick corrosion coating
  - 36.6 mm CWC



Case Study
The inspection – data deep dive

Reasons for external corrosion in subsea pipeline:

- Likely pipeline is not fully buried
- Likely CWC and corrosion coating damage
    - Majority of features located within top half of pipe



Case Study

The inspection – data deep dive - conclusions

From the data review alone, LR was able to inform of operator:

- Possible presence of MIC
  - Untreated seawater in the line
  - Possible biocide injection required
- External coating damage
  - Topsides/ Riser
  - Subsea pipeline

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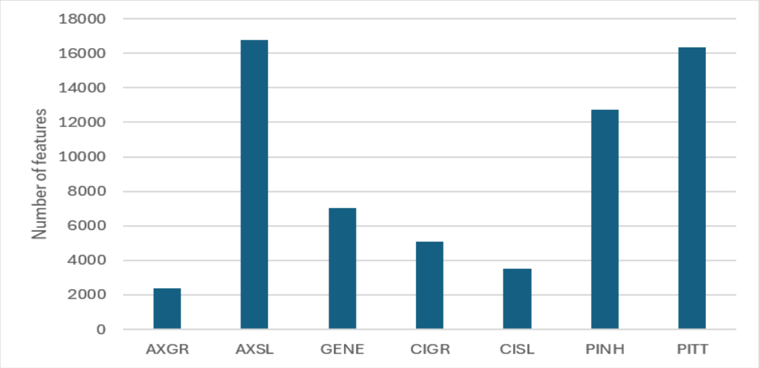
Case Study

Methodology

- Data also noted both axial and circumferential features



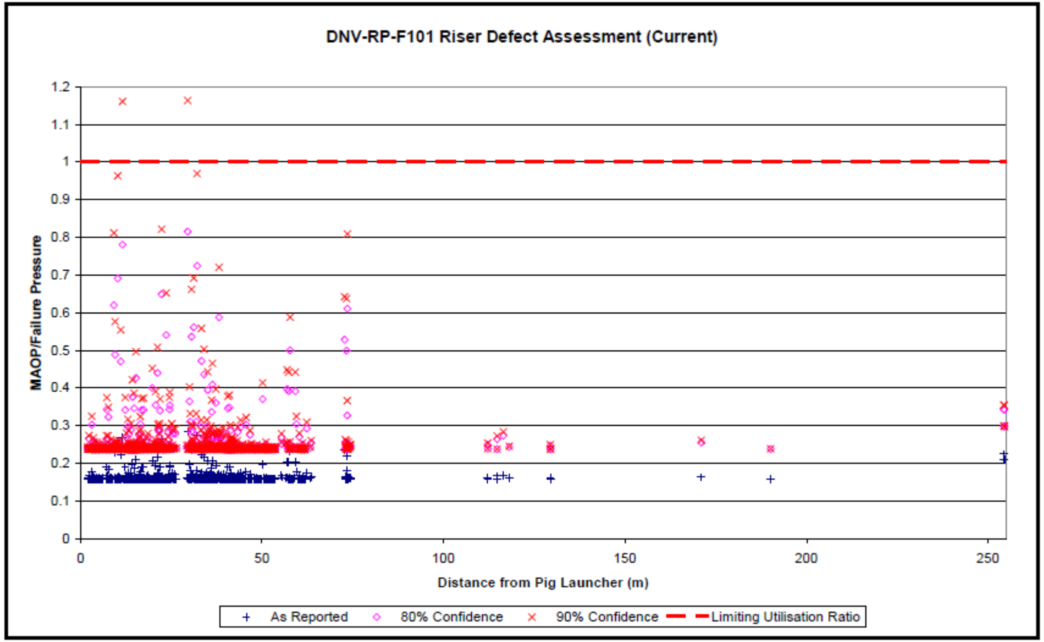
- The defects were assessed using 2 different methods:
  - DNV-RP-F101 method
  - Kastner method

DNV	Kastner
Axial defects	Circumferential defects
Bursting	Plastic collapse
Pipeline pressure / Failure pressure	Axial tensile stress / Axial failure stress

By using both methodologies, a complete picture of pipeline condition could be determined

Case Study

Results: DNV-RP-F101 topside and riser assessment (current)



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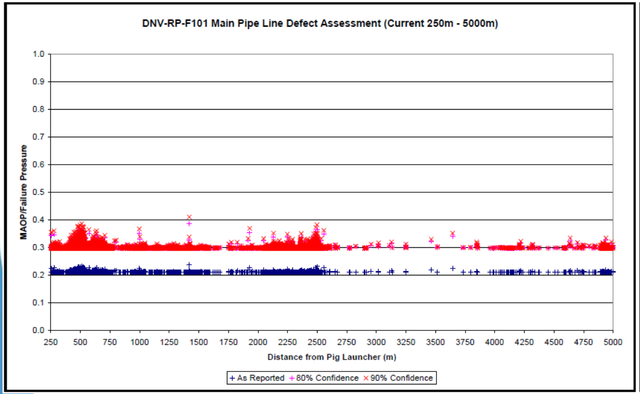
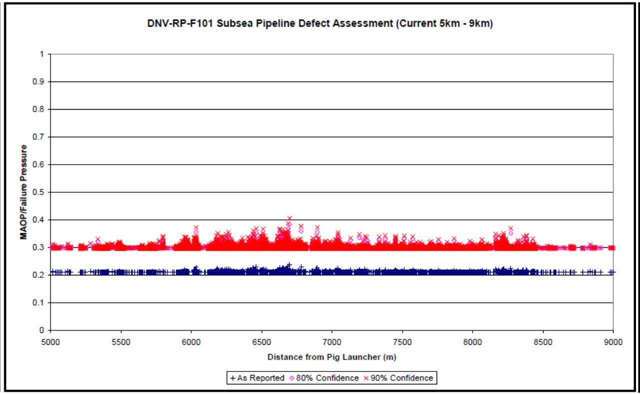
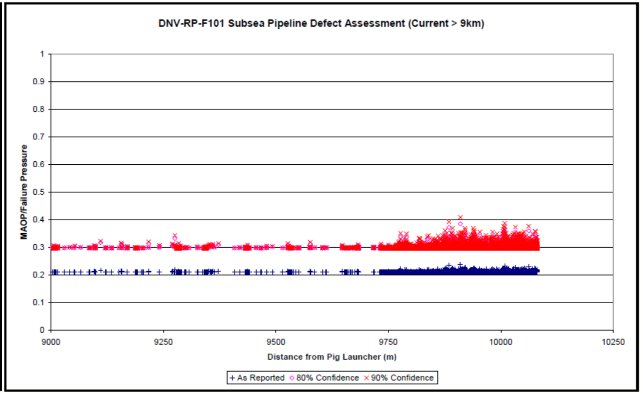
Case Study

Results: DNV-RP-F101 subsea pipeline assessment (current)

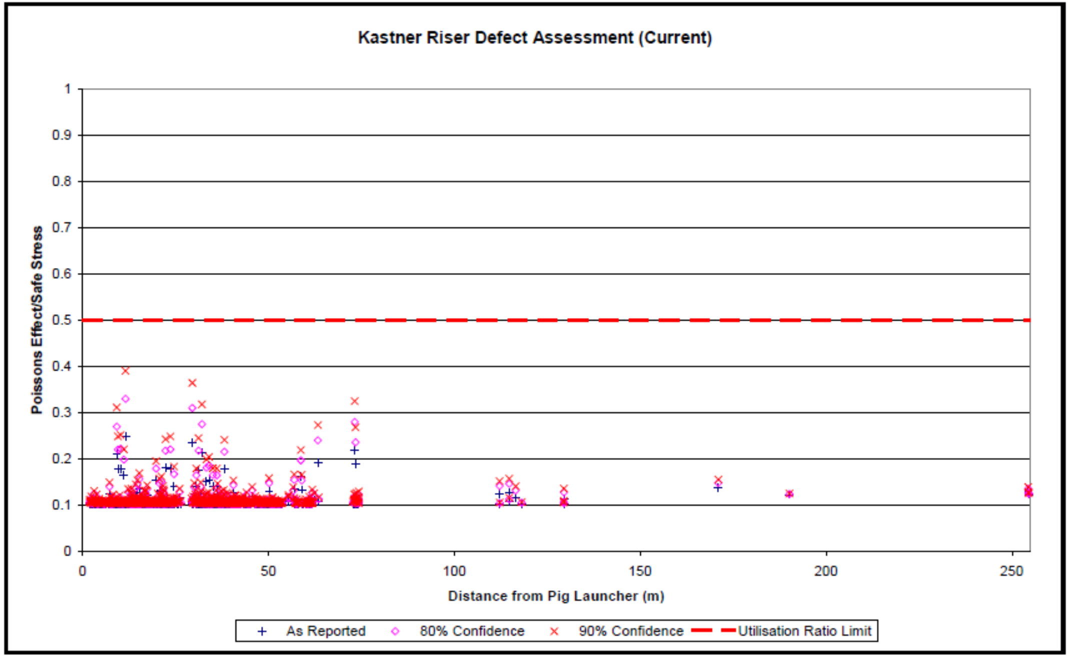






Case Study

Results: Kastner topside and riser assessment (current)



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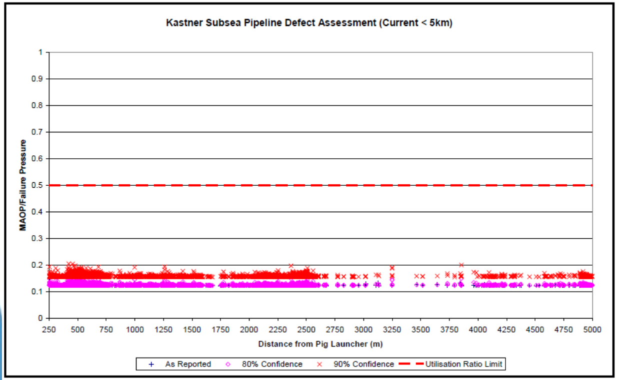
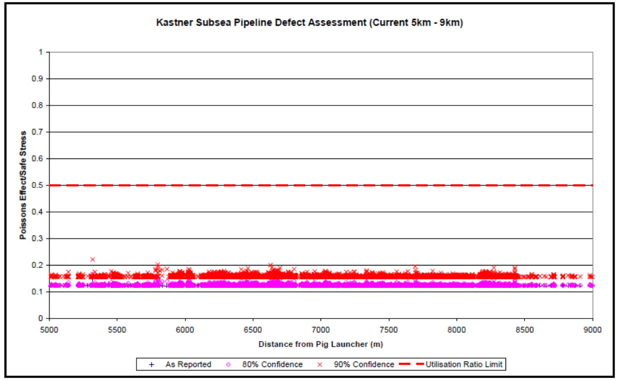
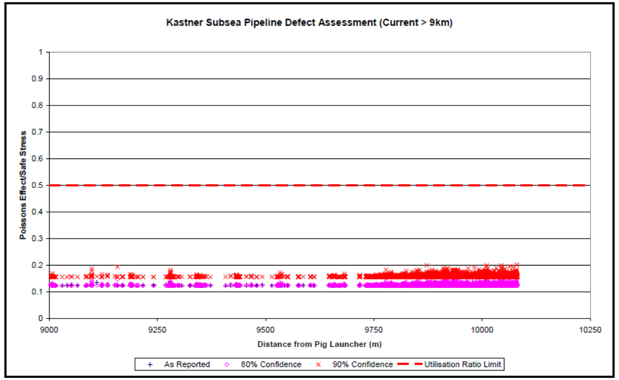
Case Study

Results: Kastner subsea pipeline assessment (current)







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Case Study
Corrosion rates

- Once LR had reviewed current condition, the remnant life was determined.
- Features are “grown” until code violation
- Corrosion rate: 0.65 mm/year
- Based on max observed rate between 2001 and 2009

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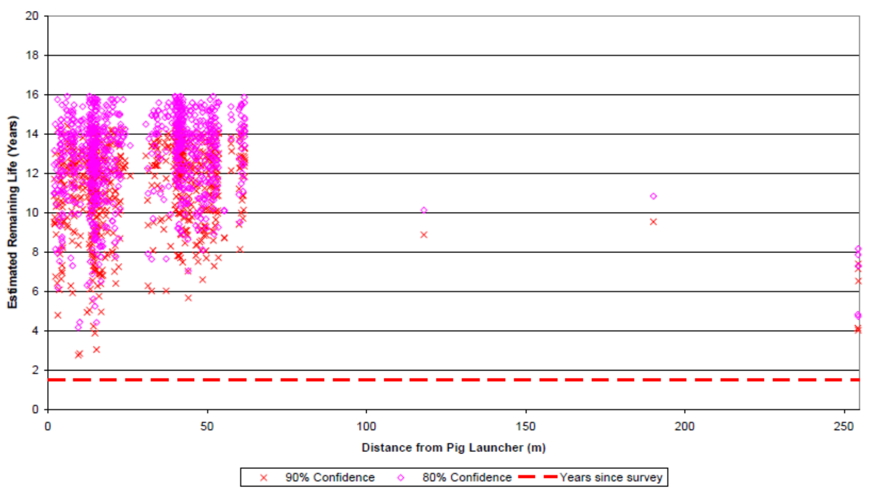
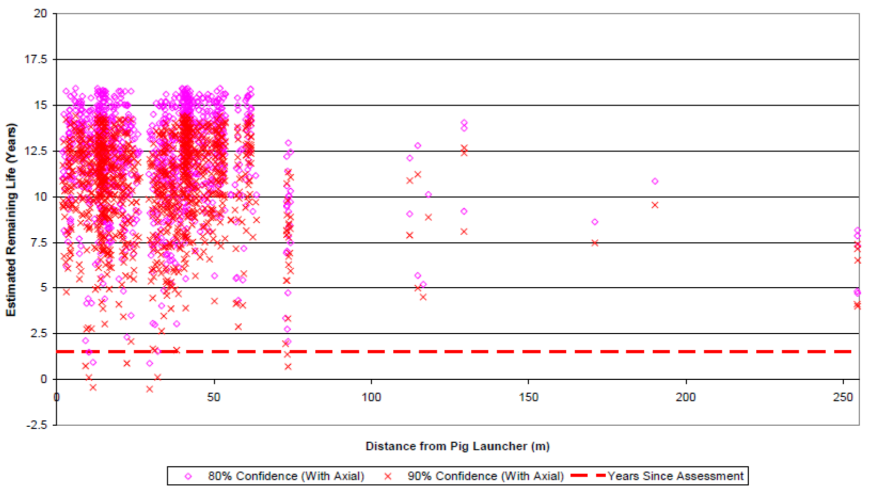
Case Study

Results: DNV-RP-F101 topside and riser assessment (future)





Case Study

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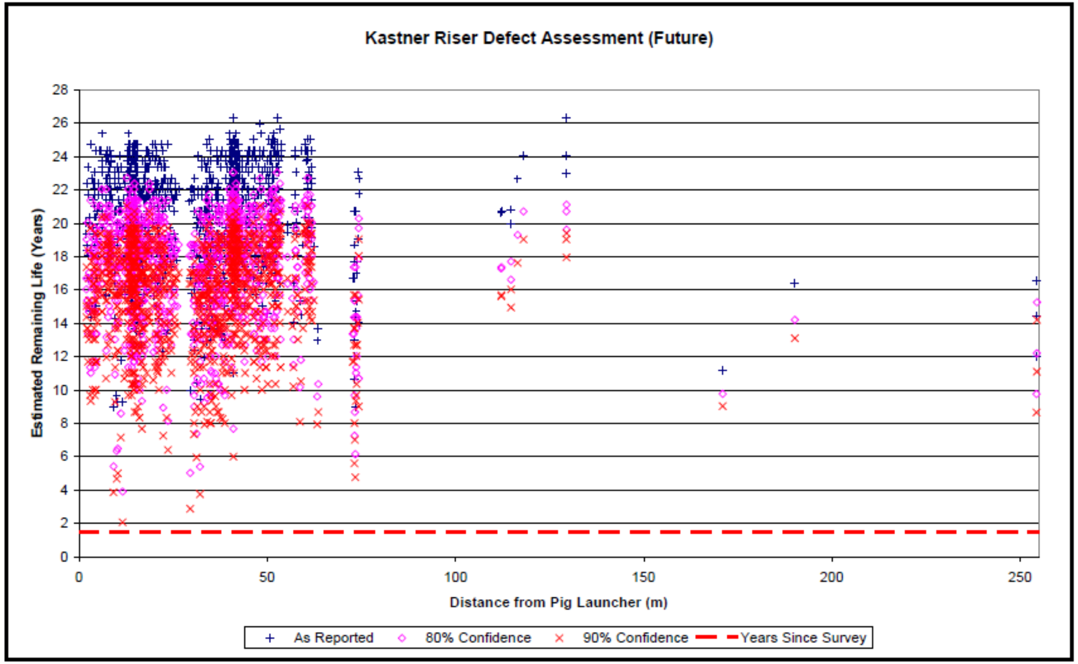

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Case Study

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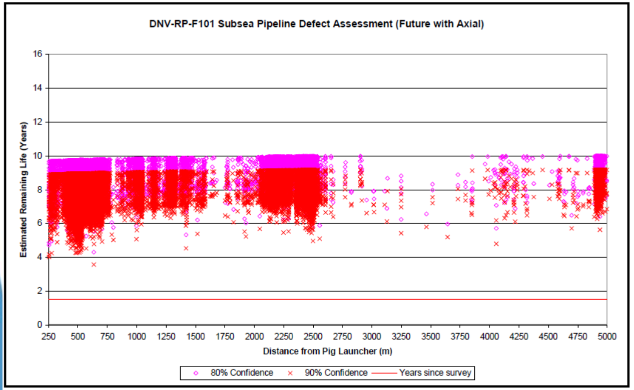

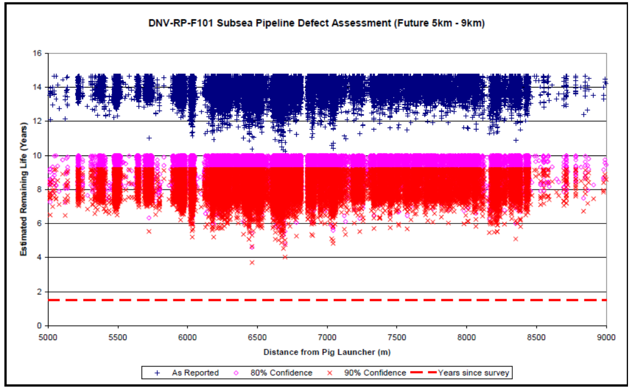

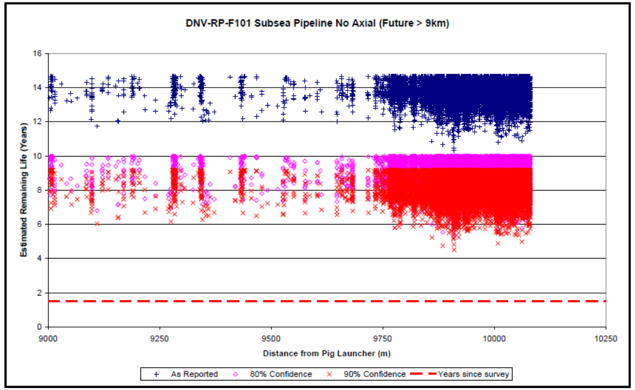

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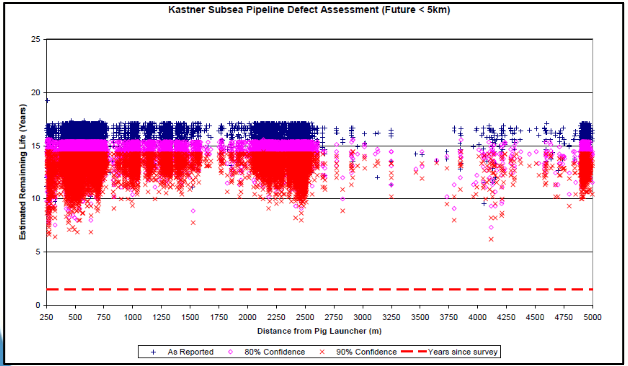

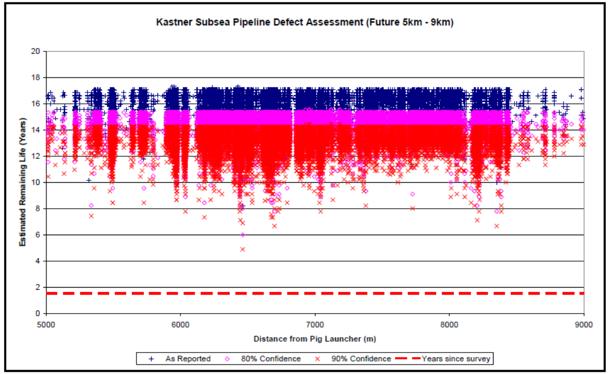

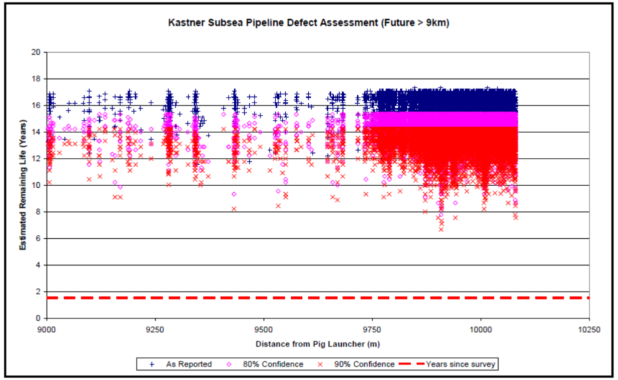

Case Study

Key conclusions from assessment

- Governing external feature was located topsides
  - Defect dimensions at the time of measurement were beyond the allowable code limits
  - LR recommended an immediate repair of all external features
  - This was completed in 2010

- Governing internal feature was located topsides
  - Remnant life of 1. 3 years
  - LR recommended that the 10 worst case topside features be inspected further

- LR recommend that ILI is reperformed as soon as possible
  - Missing 1.9 km
  - Possible inaccuracies

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Thank you for your attention

Contact details:

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