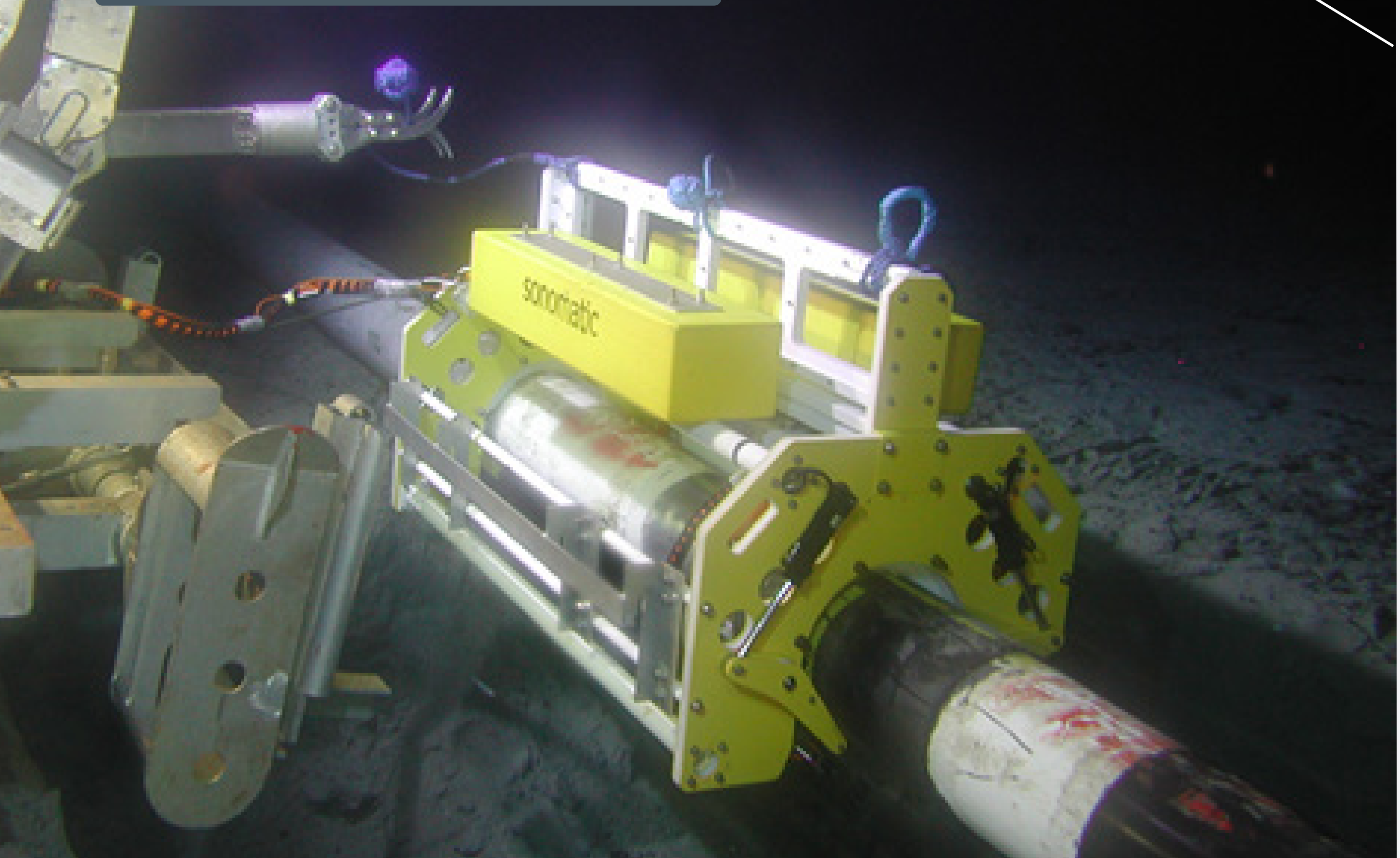
SPECIALIST PACKAGE

DIRECT ASSESSMENT FOR CHALLENGING PIPELINES

SONOMATIC

THE PURPOSE

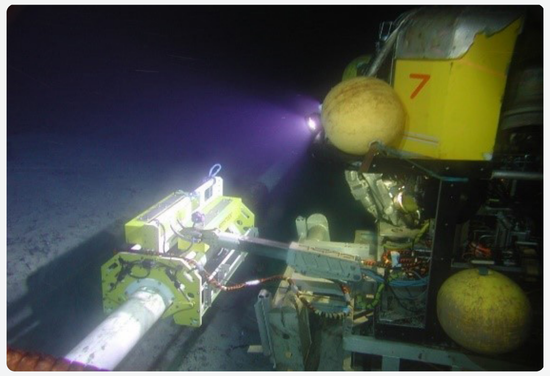
This document is composed to assist our clients and the supply chain with a high-level understanding of the benefits and services associated with Direct Assessment as the primary inspection tools, acknowledged globally as an approved pipeline integrity inspection protocal.

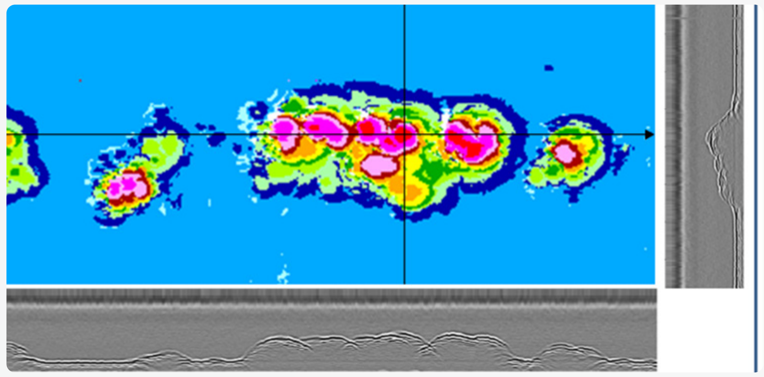


SO-MKT-SP-002 (Rev0)

DIRECT ASSESSMENT (DA)

Pipeline inspection is essential to provide vital information for integrity assessment, to allow data driven engineering decisions to be made and prevent costly failures. Some pipelines deviate from conventionally "piggable pipelines", so inspection for corrosion could be complex and/or not feasible. Sonomatic presents a summary of DA, a pipeline inspection method permitted for pipeline integrity management. The DA concentrates on internal, external and stress corrosion cracking direct assessment.





WHY DIRECT ASSESSMENT?

Direct Assessment is needed as an integrity assessment method for pipeline segments:

- Where ILI or hydrostatic pressure testing cannot be used
- To avoid impractical, costly retrofitting of a pipeline
- To avoid interrupting gas supply to a community fed by a single pipeline
- To provide an alternative where sources of water for hydrostatic pressure testing are scarce and where water disposal may create problems
- DA may provide a more effective, equivalent alternative to ILI and hydrostatic pressure testing for evaluating a pipeline's integrity

FACTORS IMPEDING PIGGABILITY

- Telescopic connections
- Small diameter pipelines
- Multiple diameter pipelines
- Tight bend radius
- Partially opening valves
- No alternate supply if pig is "hung up"
- Low pressure and low flow conditions

WHY DIRECT ASSESSMENT?

Direct Assessment is a structured multi-step evaluation method to examine and identify the potential problem areas relating to internal corrosion, external corrosion and stress corrosion cracking problem using:

- Internal Corrosion Direct Assessment (ICDA)
  - o NACE SP0206 – Dry Gas Internal Corrosion Direct Assessment Methodology
  - o NACE SP0110 – Wet Gas Internal Corrosion Direct Assessment Methodology
  - o NACE SP0208 – Liquid Petroleum Internal Corrosion Direct Assessment Methodology
  - o NACE SP0116 – Multiphase Flow Internal Corrosion Direct Assessment Methodology
- External Corrosion Direct Assessment (ECDA)
  - o NACE SP0502 – External Corrosion Direct Assessment Methodology
- Stress Corrosion Cracking Direct Assessment (SCCDA)
  - o NACE SP0204 – Stress Corrosion Cracking Direct Assessment Methodology

THE DA PROCESS

1. In the pre-assessment, extensive data is collected, integrated and analyzed based on the integration and analysis of high data consequence areas are identified and regions are identified for ICDA/ ECDA/SCCDA.

2. Indirect inspection process is to locate and define the severity of coating faults and areas where corrosion may have occurred or may be occurring. Two or more indirect inspection tools are to be used over the entire length of each ECDA region of the pipeline to provide improved detection reliability under the wide variety of condition that may be encountered along the pipeline.

3. In the direct examination, field examinations are done via excavation (for onshore pipeline) and inspected (for offshore pipelines) to confirm corrosion at the identified sites.

4. Post assessment includes remaining life calculation, defining of re-assessment interval and overall effectiveness of the DA process. The post assessment will provide evidence and justification for various mitigation requirements in order to increase the re-assessment interval and remaining life.

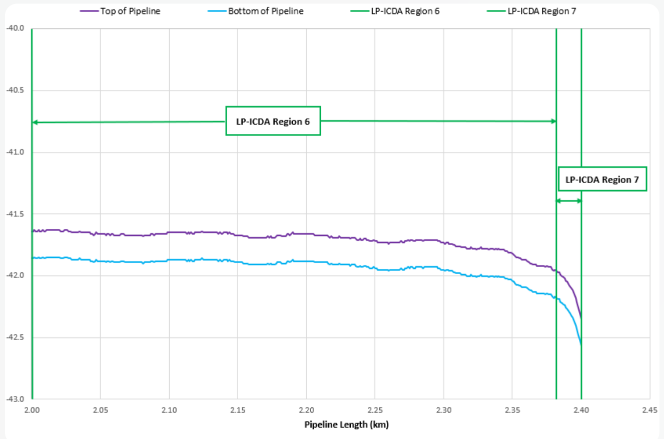
CASE STUDY

The case study is on an offshore condensate pipeline which had exceeded its design life. The pipeline was considered unpiggable due to it being connected through a PLEM that was not designed to allow the passage of a Inline Inspection (ILI) or routine cleaning pigs.

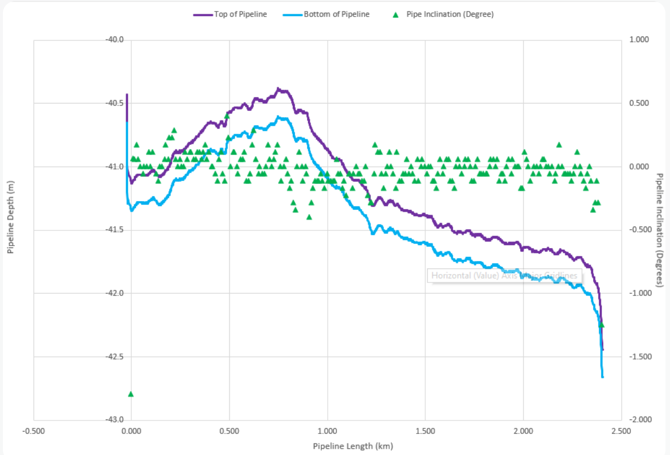
The pipeline was selected for Direct Assessment (DA) to assess its integrity using the NACE Internal Corrosion Direct Assessment (ICDA NACE SP0208) and NACE External Corrosion Direct Assessment (ECDA NACE SP0502) methodology:

Pre-Assessment

- Data Review was carried out of the:
  - Internal Inspection History (e.g., corrosion monitoring and corrosion inhibitor)
  - External Inspection History (e.g., Riser Inspection, ROV Inspection for CP and anodes, free spans, pipeline damage, burial, pipeline support, debris etc.)
- Pipeline ICDA regions were identified through:
  - Defining segments of the line for easier management of date and
  - Utilisation of ROV survey data to create a profile.

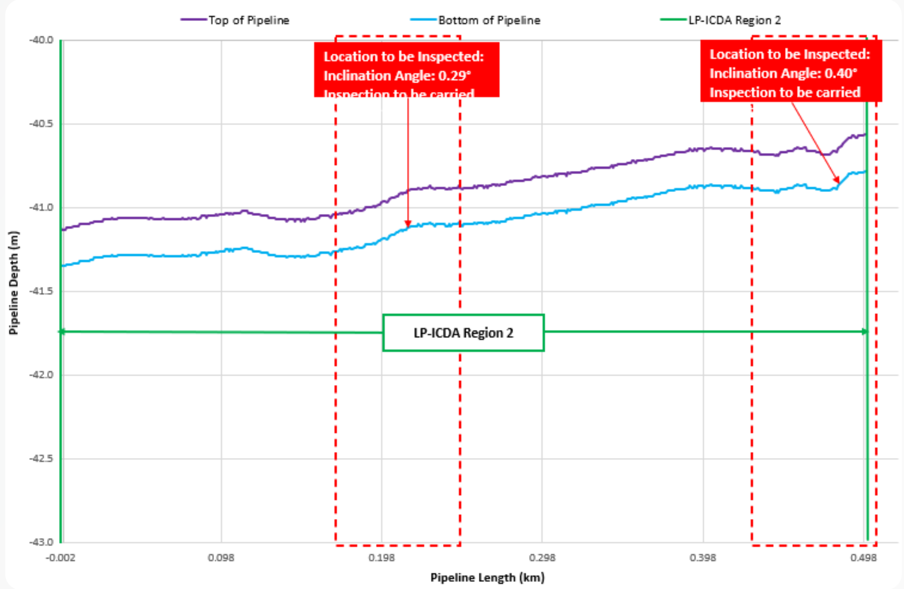


- Internal Corrosion Hazard Assessment was carried out to identify:
  - What the corrosion issues are relative to the pipeline e.g., CO_2 Corrosion, H_2S Corrosion, MIC, Erosion Corrosion, O_2 Corrosion, Galvanic Corrosion, Under-Deposit Corrosion etc.
  - Other influencing factors e.g., emulsion breaking, water chemistry, effect of turbulence and flow disturbances etc.
  - A calculated Internal corrosion rates
- A Pipeline Inclination Profile was generated to allow the angle to be calculated at every elevation change along the length of the pipeline.



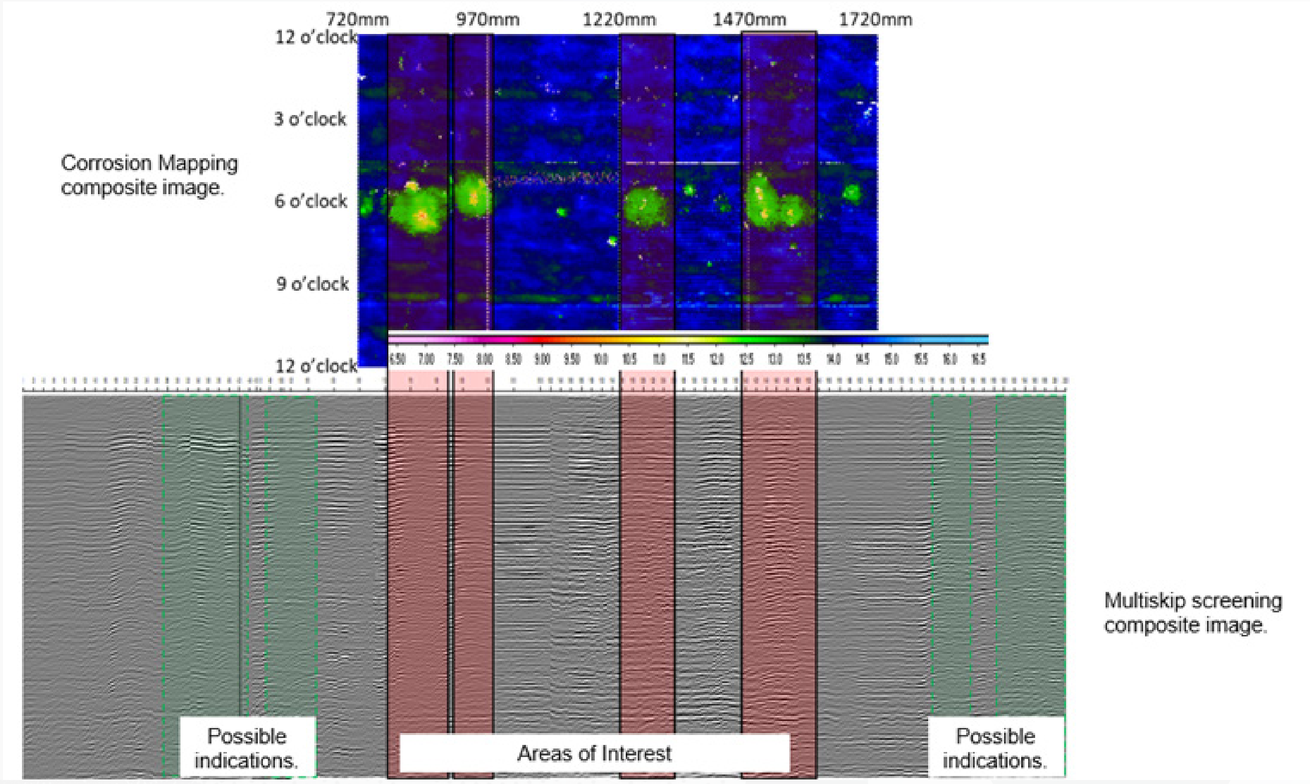
- Flow Modelling Analysis was be carried out to quantify:
  - Water accumulation which was calculated based on the critical Froude numbers
  - Solid accumulation which was calculated based on minimal bed velocity

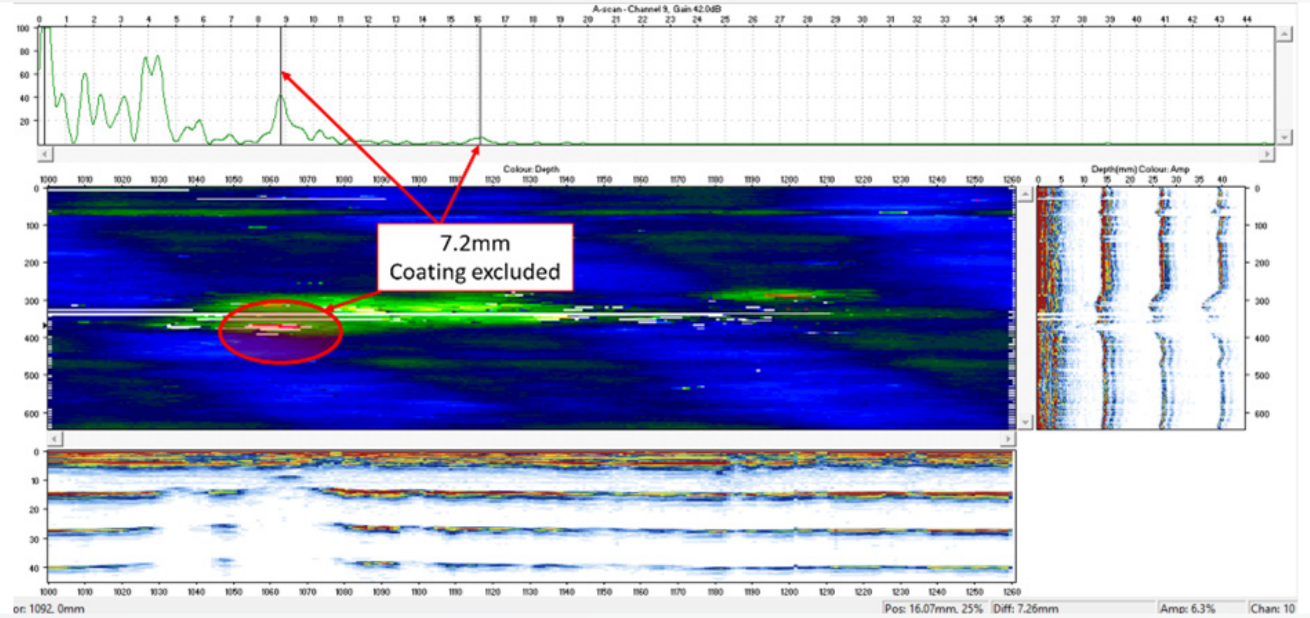
- Critical ICDA inspection locations were identified through the flow modelling analysis results which showed the locations where accumulation of the water and solids within the pipeline were expected.



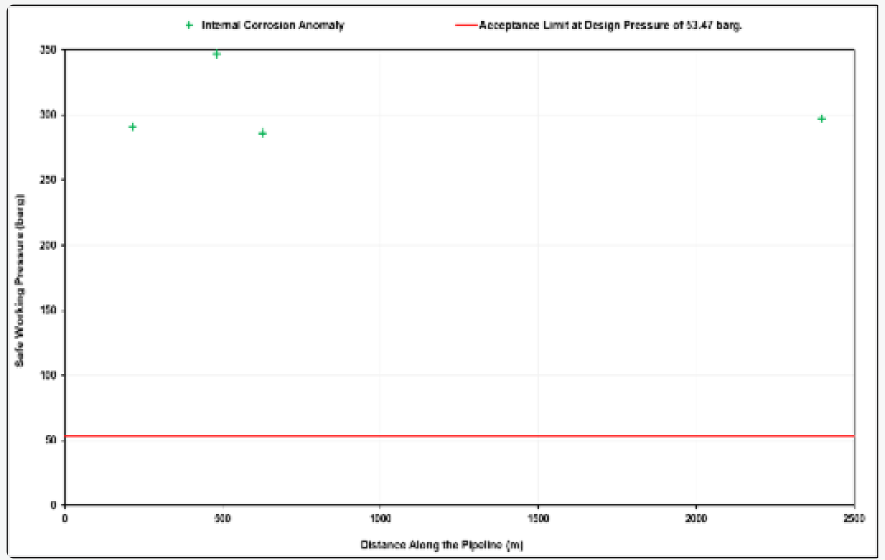
Direct Examination at the identified locations were carried out by Sonomatic's Field Services Group:

- MultiSkip inspection screening technique was used on the MAG-ST deployment tool and identified several areas of interest.
- Corrosion mapping was required to quantify the depth, length and width of the corrosion morphology to allow the post assessment to be carried out. Zero-degree corrosion mapping was carried out using Sonomatics ROViT deployment tool.





- **Post Assessment** the following activities were carried out:
  - o Assessment of LP-ICDA effectiveness.
  - o Determine and validate corrosion rate.
  - o Remnant Life assessment using ASME B31G method and DNV-RP-F101 method.
  - o Safe Working Pressure calculations using Modified ASME B31G, DNV-RP-F101 and Kastner.



  - o Determination of Re-Assessment Intervals based on API 1160 and NACE SP0208.
  - o Recommendations were as follows:
    - To monitor the growth of specific defects at the defined inspection interval.
    - To conduct fluid sampling analysis to identify minimum CO_2 content, H_2S content and bacterial count in the product stream.
    - CO_2 corrosion control through the implementation of corrosion inhibitor.

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