IN-LINE INSPECTION OF PIPES USING CORROSION RESISTANT ALLOYS (CRA)

M.Sc. Johannes Keuter
PPSA Seminar · Aberdeen · 19-Nov-2014
1. Challenge
2. Technical Solution
3. Summary
Definition of CRA pipelines?
(at least for this paper)

These pipeline types are considered: Pipelines with internal metal layer

Focus of this presentation

Focus of ILI technology

Lined CRA pipes
Cladded CRA pipes
Carbon steel pipes

http://ecx.images-amazon.com/images/I/81YeyQREFaL._SL1500_.jpg
**Definition of CRA pipelines?**

(at least for this paper)

These pipeline types are not considered:

- Duplex
- HDPE Layer
- Hyper-Duplex
- Martensitic steel
- High chromium 13CrMSS
- PU Layer

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Top of Line Corrosion (TLC)

Localized, small-scale corrosion
Dissolution of aggressive gases in droplets support corrosion

TLC can reveal high growth rates, up to several mm/year
Top of Line Corrosion (TLC)

→ CRA pipes used for this high risk area
CHALLENGE

Market Demand
- Thousands of kilometers of pipe with CRA are being designed and manufactured, at least partially

Typical CRA materials
- 316L
- Inconel 625
- Inconel 825

Typical types of CRA
- Mechanical bonded (lining)
- Metallurgical bonded (cladding)

Standard Carbon Steel

Corrosion Resistant Alloy (CRA)
Stainless Steel Layer: ca. 3 mm
Mechanically or Metallurgically bonded
Austenitic: Non-magnetic
Expected defects in CRA pipe

- External defects in carbon steel (CS), e.g. corrosion
- Internal defects between carbon steel and stainless steel
- Erosion in CRA due to e.g. sand
- Pitting in the CRA e.g. caused by seawater ingress or galvanic corrosion
- Geometric deformations in CRA (e.g. wrinkles, dents)
CONTENT

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TECHNICAL SOLUTION – METAL LOSS

FEM simulations of magnetic field

Without CRA

With CRA

Pipe Wall
Brushes
Magnets

Yoke

Pipe Wall CS
Pipe Wall CRA
Brushes
Magnets

Yoke
TECHNICAL SOLUTION – METAL LOSS
TECHNICAL SOLUTION – METAL LOSS

Pull-Test setup at RTRC:
08” spool (clad)
10mm WT CS
3.9mm WT CRA (Alloy 825)

Types of features:

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Carbon Steel
Internal Feature in CRA
Internal Feature in CRA & CS

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TECHNICAL SOLUTION – METAL LOSS

6.5mm external defect in steel

- Axial MFL channel (lines): clear signal, sizable as 65% in steel
- Internal detection sensor on MFL tool (colors): no signal
TECHNICAL SOLUTION – METAL LOSS

13mm external defect through steel into cladding

- Axial MFL channel (lines): clear signal, sizable as 100% in steel
- Internal detection sensor on MFL tool (colors): no signal
3mm Internal defect in cladding

- Axial MFL channel (lines): no signal
- Internal detection sensor on MFL tool (colors): clear detection
Internal defect through cladding and 7mm into the steel

- Axial MFL channel (lines): clear signal; sizable as 70% in steel
- Internal detection sensor on MFL tool (colors): clear detection
Pull-Test setup at RTRC:
08” spool (clad)
10mm WT CS
3.9mm WT CRA (Alloy 825)

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6.5mm external defect in steel

- Internal detection sensor on IEC tool (colors): no signal
TECHNICAL SOLUTION – METAL LOSS

13mm external defect through steel into cladding

- Internal detection sensor on IEC tool (colors): no signal
3mm Internal defect in cladding

• Internal detection sensor on IEC tool (colors): clear detection
Internal defect through cladding and 7mm into the steel

- Internal detection sensor on IEC tool (colors): clear detection

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TECHNICAL SOLUTION – METAL LOSS

Pump-Test setup at RTRC:
08” spool (clad)
10mm WT CS
3.9mm WT CRA (Alloy 825)

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TECHNICAL SOLUTION – METAL LOSS

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TECHNICAL SOLUTION – METAL LOSS

Laboratory test at RTRC:
• 16" spool (clad)
• 12.5mm WT CS
• 3.0mm WT CRA (316L)
Laboratory test at RTRC:

- 06” spool (lined)
- 15.9mm WT CS
- 5.0mm WT CRA (Alloy 825)
TECHNICAL SOLUTION - CRACKS
Laboratory test at RTRC:
- 16” spool (clad)
- 12.5mm WT CS
- 3.0mm WT CRA (316L)

Types of features:

<table>
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<tr>
<td>2</td>
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One internal & one external
TECHNICAL SOLUTION - CRACKS

Crack 2: internal
length 25mm, width 0.3mm, depth 1mm

Crack 1: external
length 25mm, width 0.3mm, depth 1mm
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SUMMARY

**MFL/IEC**

- A combined MFL/IEC tool can be used to inspect the CRA and the CS in lined and cladded pipes
- Can be used in gas
  - Cannot detect ‘external’ features in the CRA

**UT**

- UT can be used to inspect the CRA and CS in cladded pipes, but **not** in lined pipes
  - An UT **tool** can be used to inspect the CRA in lined pipes, but **not** the CS
  - UT need a liquid coupling (expensive batching)

→ Pre-inspection analysis to be performed to determine reachable measurement specifications