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

PIGGING PRODUCTS & SERVICES ASSOCIATION

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CONTENT

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1. Challenge
2. Technical Solution
3. Summary

CHALLENGE

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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

CHALLENGE

Definition of CRA pipelines?

(at least for this paper)

These pipeline types are not considered:

http://i00.i.aliimg.com/photo/v0/163396220/stainless_steel_347h_screwed_90_deg_elbow.jpg_220x220.jpg

Duplex

HDPE Layer

http://pihapublic.powercreations.com.au/images/piha-25--thiwu.jpg

Hyper-Duplex

Martensitic steel

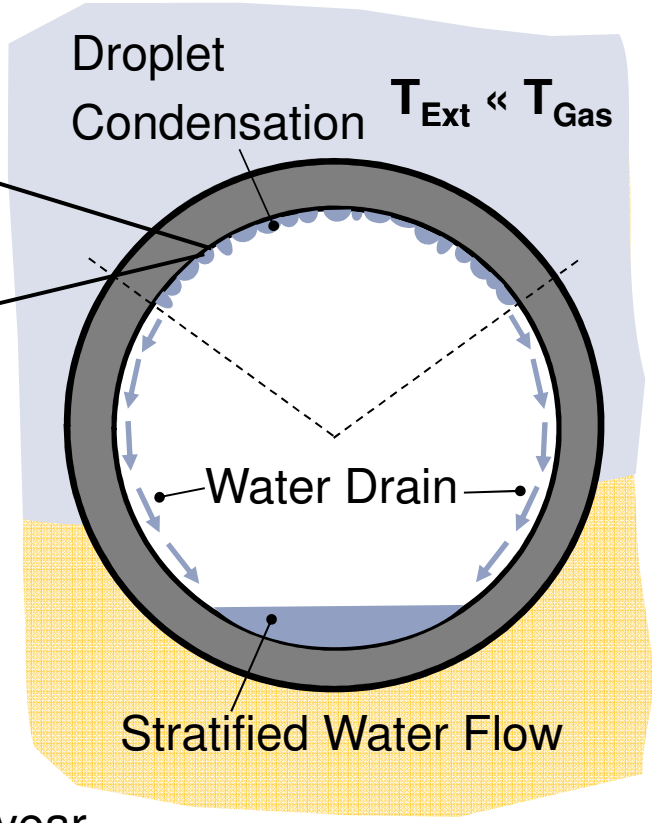
High chromium 13CrMSS

Super-Duplex

PU Layer

CHALLENGE

Top of Line Corrosion (TLC)



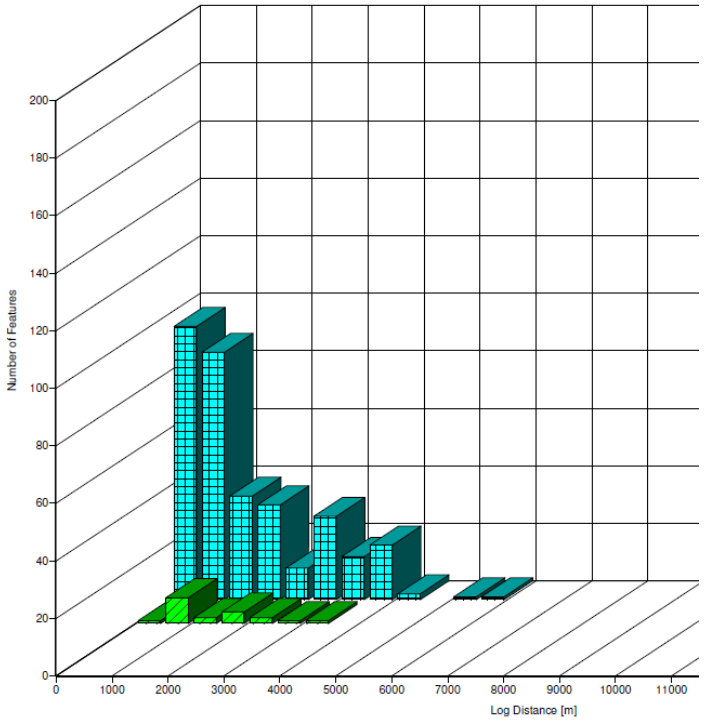
Localized, small-scale corrosion

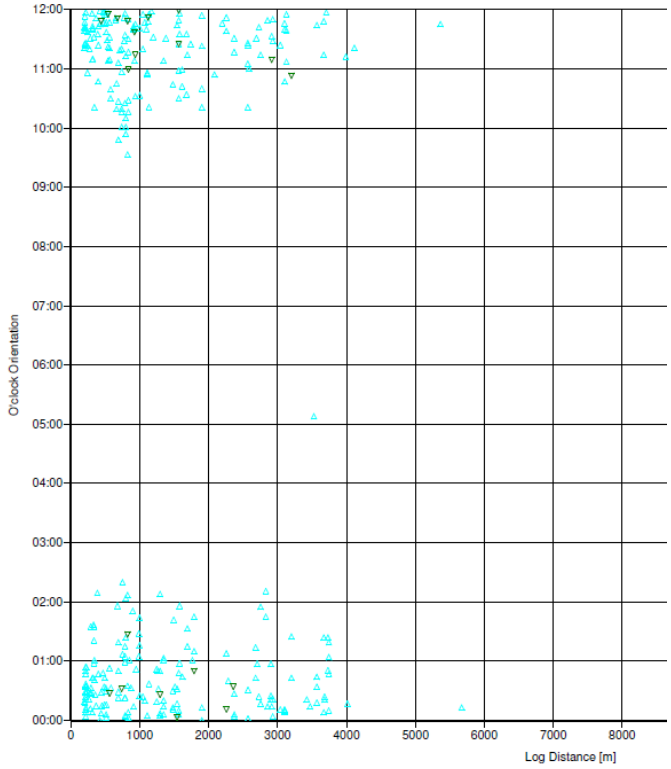
Dissolution of aggressive gases in droplets support corrosion

TLC can reveal high growth rates, up to several mm/year

CHALLENGE

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)

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

CHALLENGE

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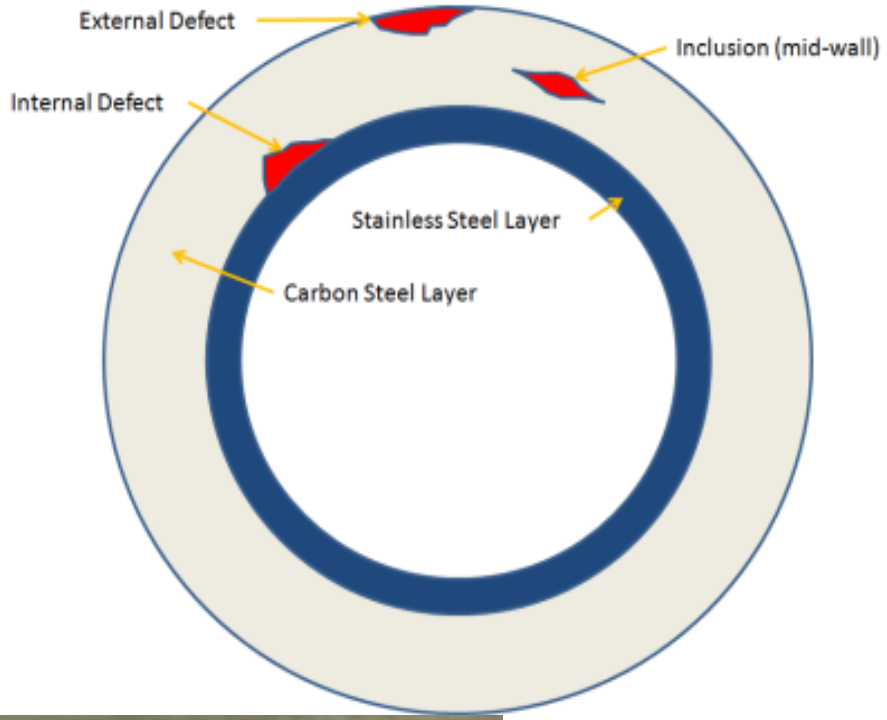
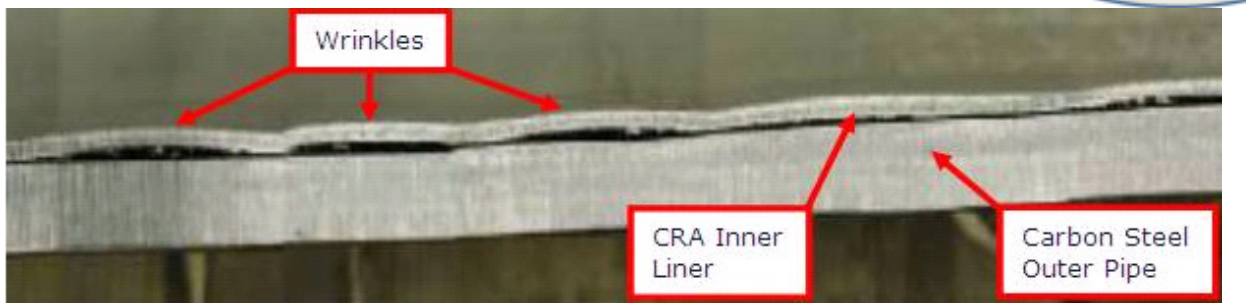
Expected defects in CRA pipe

- 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)





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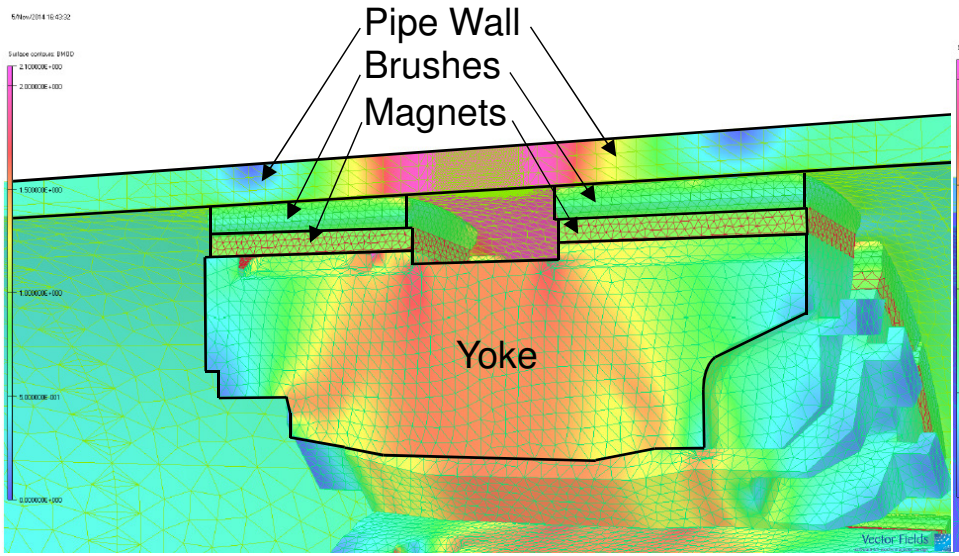
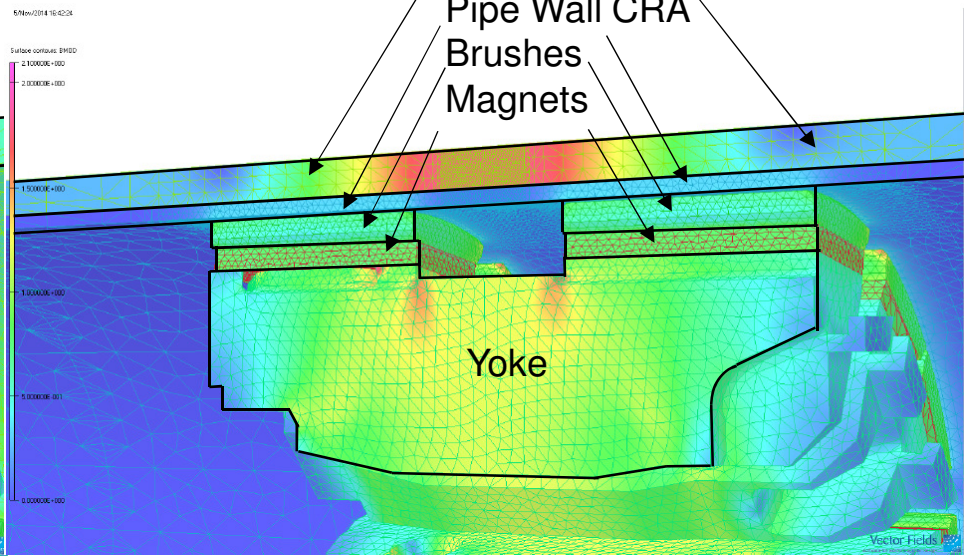
TECHNICAL SOLUTION – METAL LOSS

FEM simulations of magnetic field

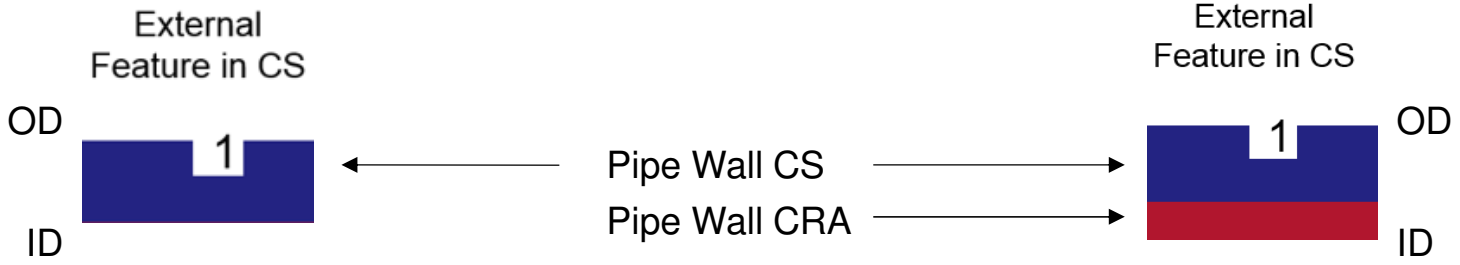
Without CRA

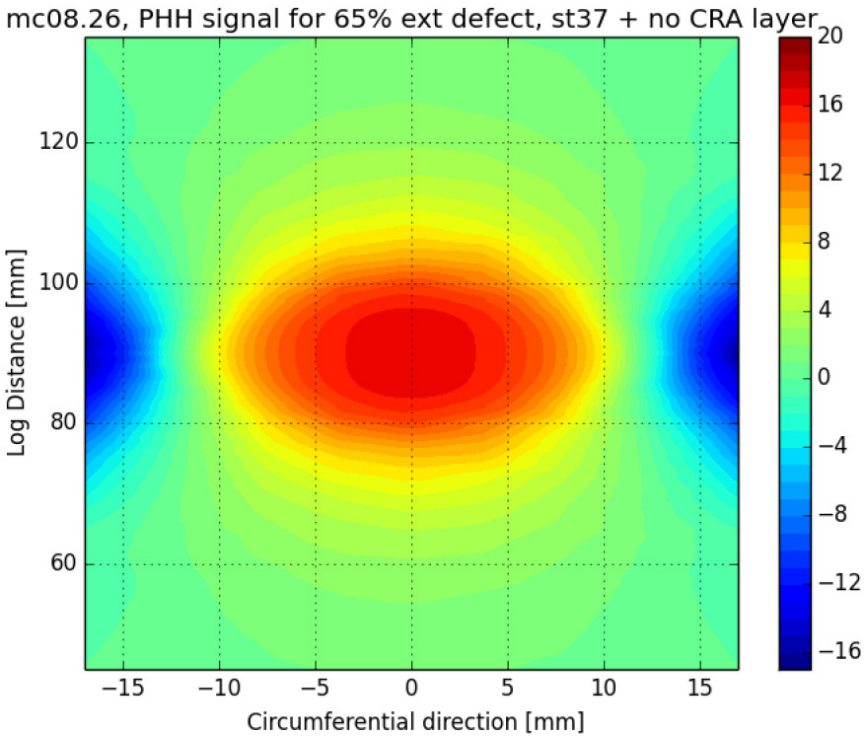


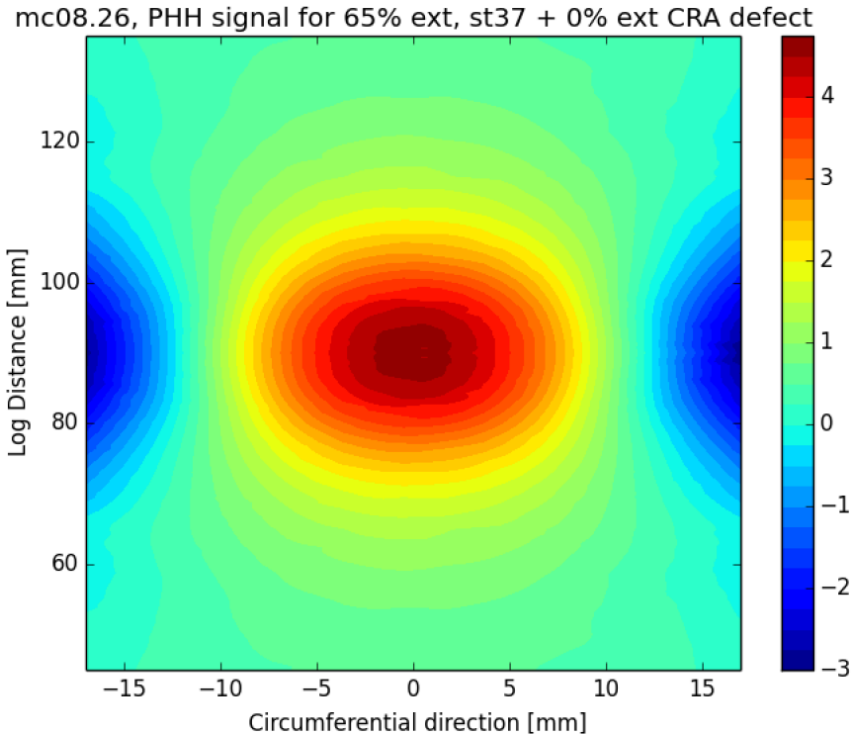
With CRA



TECHNICAL SOLUTION – METAL LOSS







TECHNICAL SOLUTION – METAL LOSS

Pull-Test setup at RTRC:

08” spool (clad)

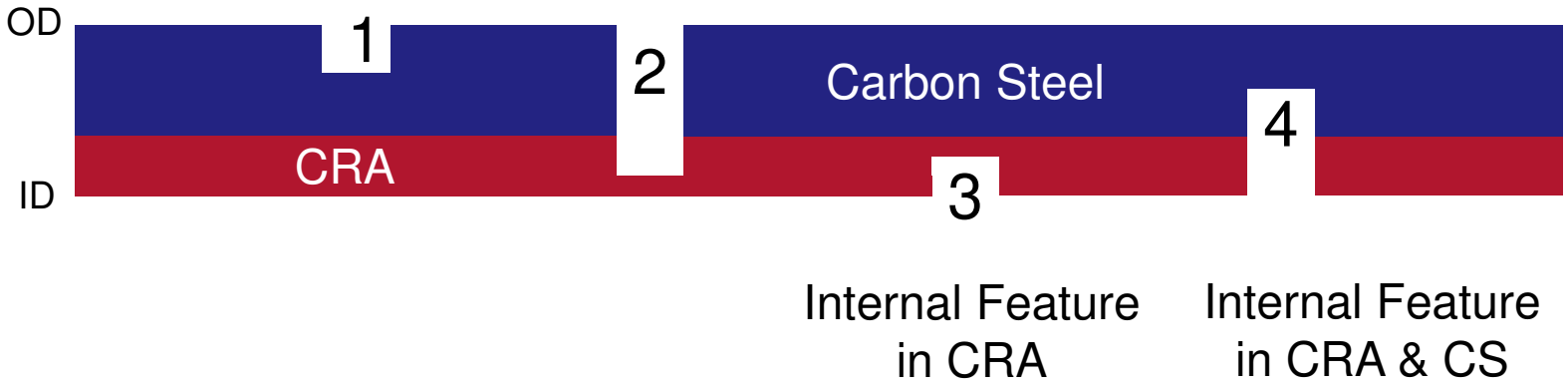
10mm WT CS

3.9mm WT CRA (Alloy 825)

Types of features:

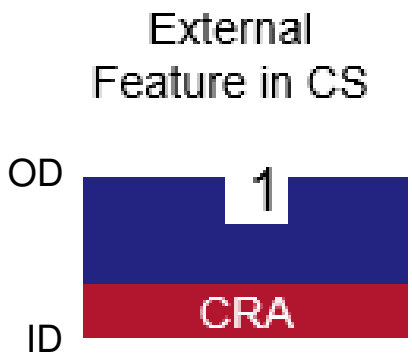
External Feature in CS

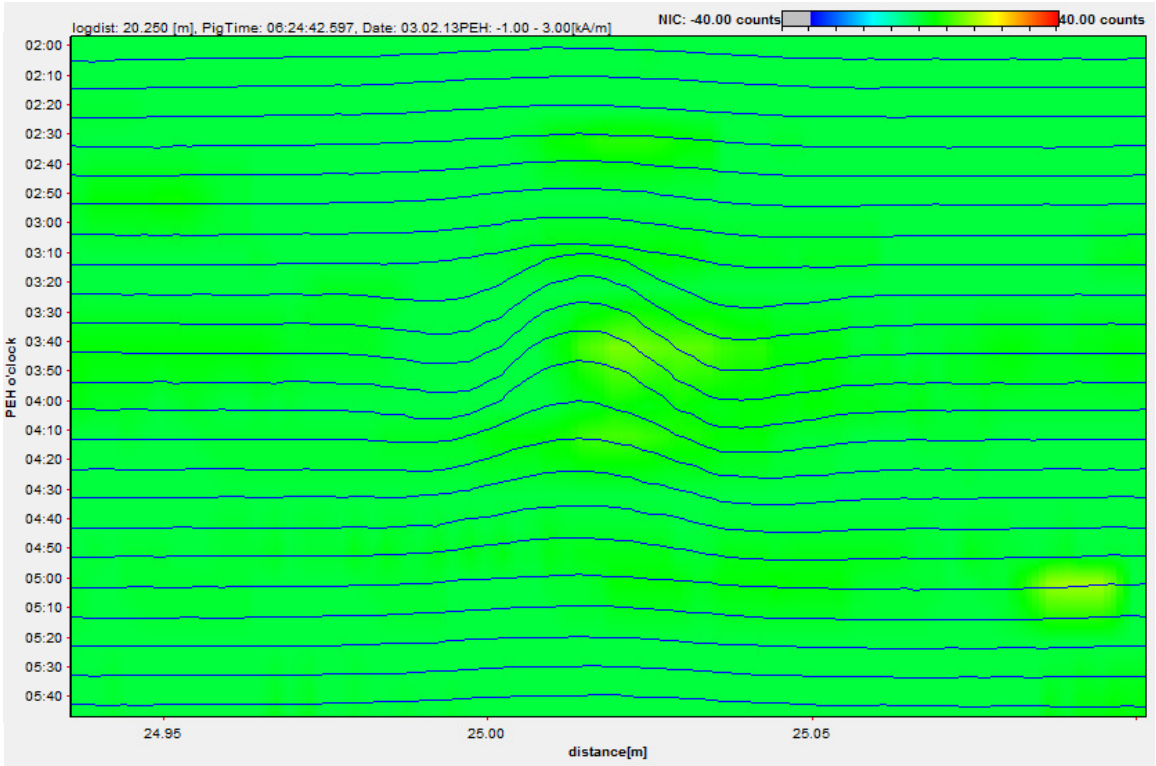
External Feature in CS & CRA



TECHNICAL SOLUTION – METAL LOSS

6.5mm external defect in steel

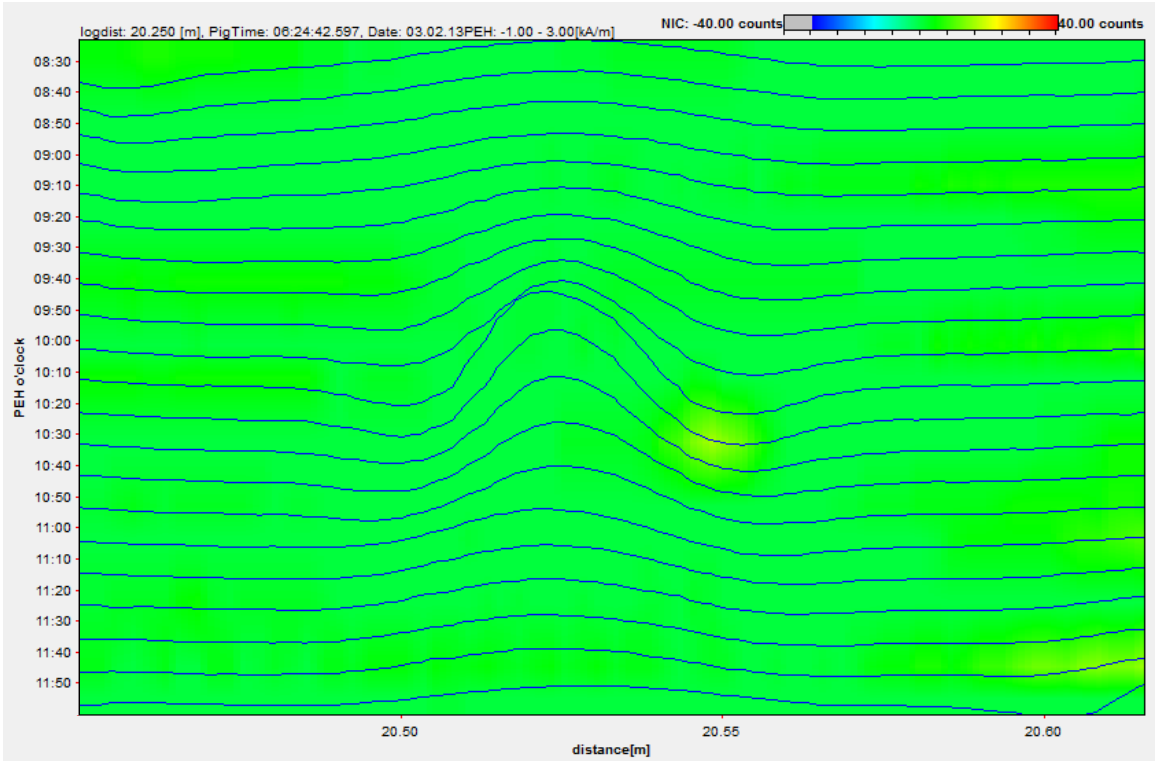




- Axial MFL channel (lines): clear signal, sizable as 65% in steel
- Internal detection sensor on MFL tool (colors): no signal

TECHNICAL SOLUTION – METAL LOSS

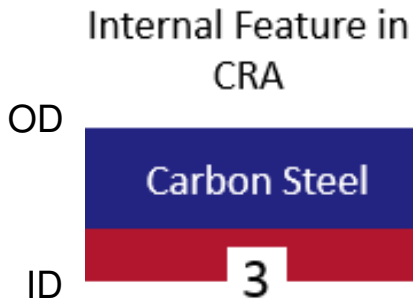
13mm external defect through steel into cladding

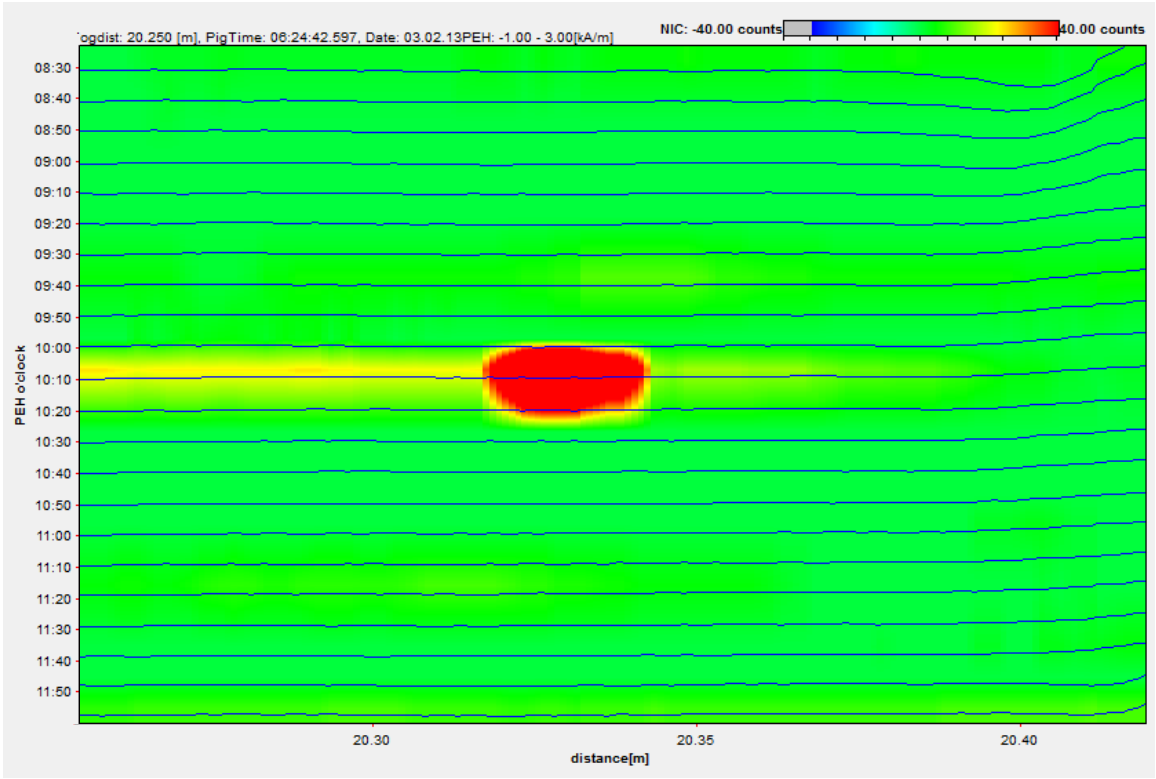


- Axial MFL channel (lines): clear signal, sizable as 100% in steel
- Internal detection sensor on MFL tool (colors): no signal

TECHNICAL SOLUTION – METAL LOSS

3mm Internal defect in cladding





- Axial MFL channel (lines): no signal
- Internal detection sensor on MFL tool (colors): clear detection

TECHNICAL SOLUTION – METAL LOSS

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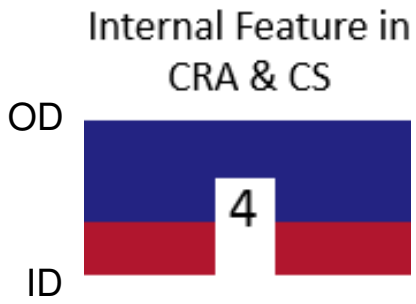
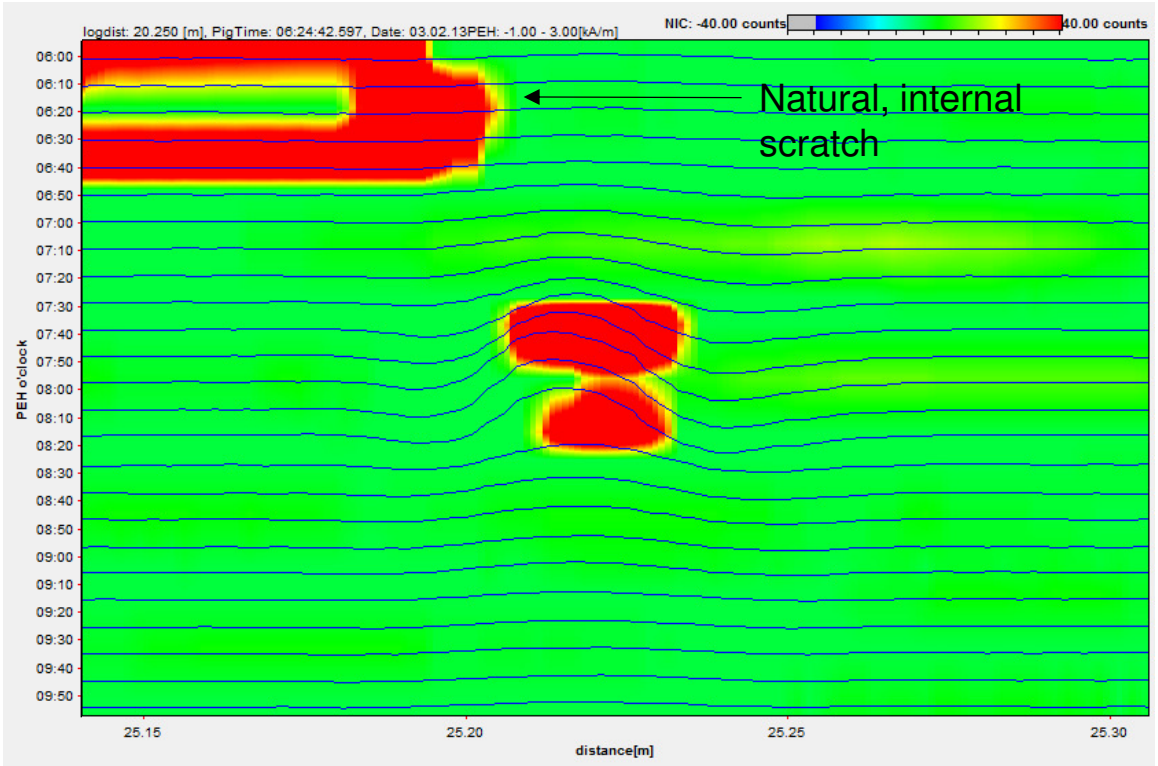
Internal defect through cladding and 7mm into the steel





- Axial MFL channel (lines): clear signal; sizable as 70% in steel
- Internal detection sensor on MFL tool (colors): clear detection

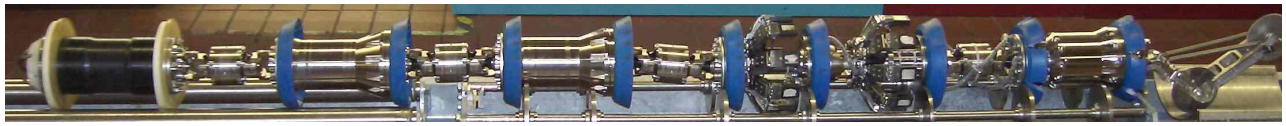
TECHNICAL SOLUTION – METAL LOSS

Pull-Test setup at RTRC:

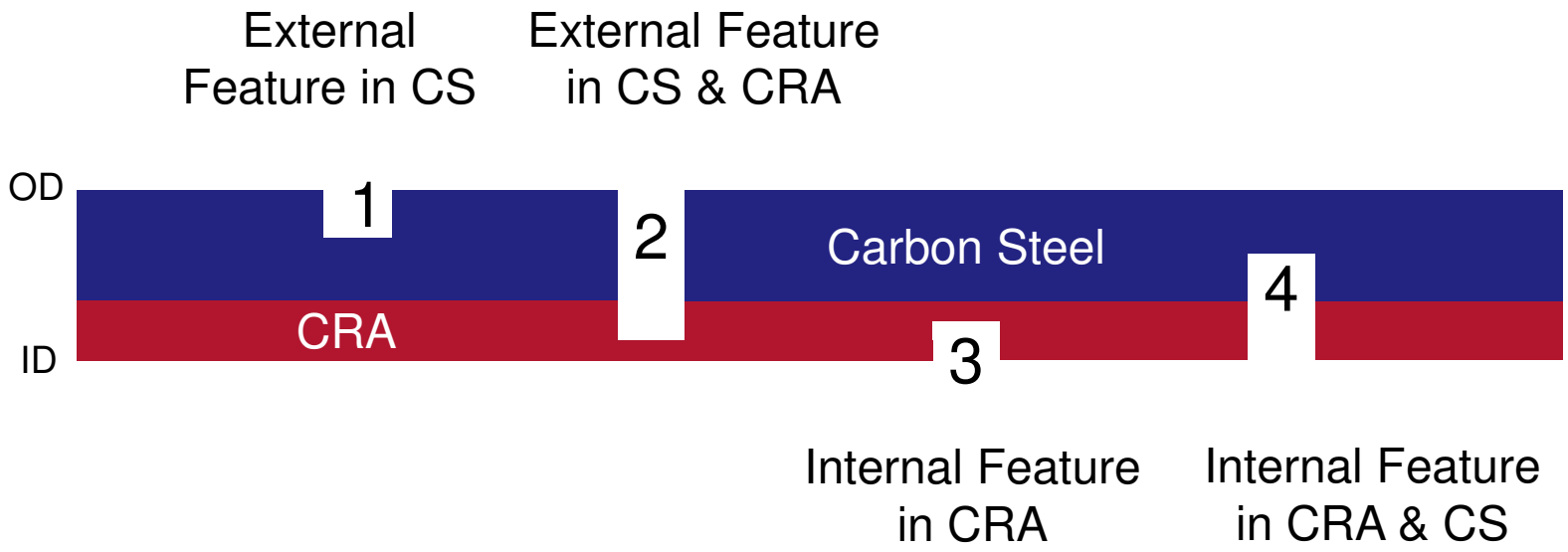
08” spool (clad)

10mm WT CS

3.9mm WT CRA (Alloy 825)



Types of features:



TECHNICAL SOLUTION – METAL LOSS

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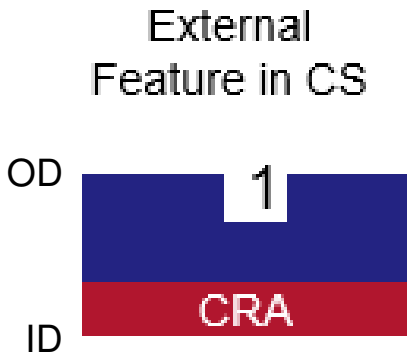
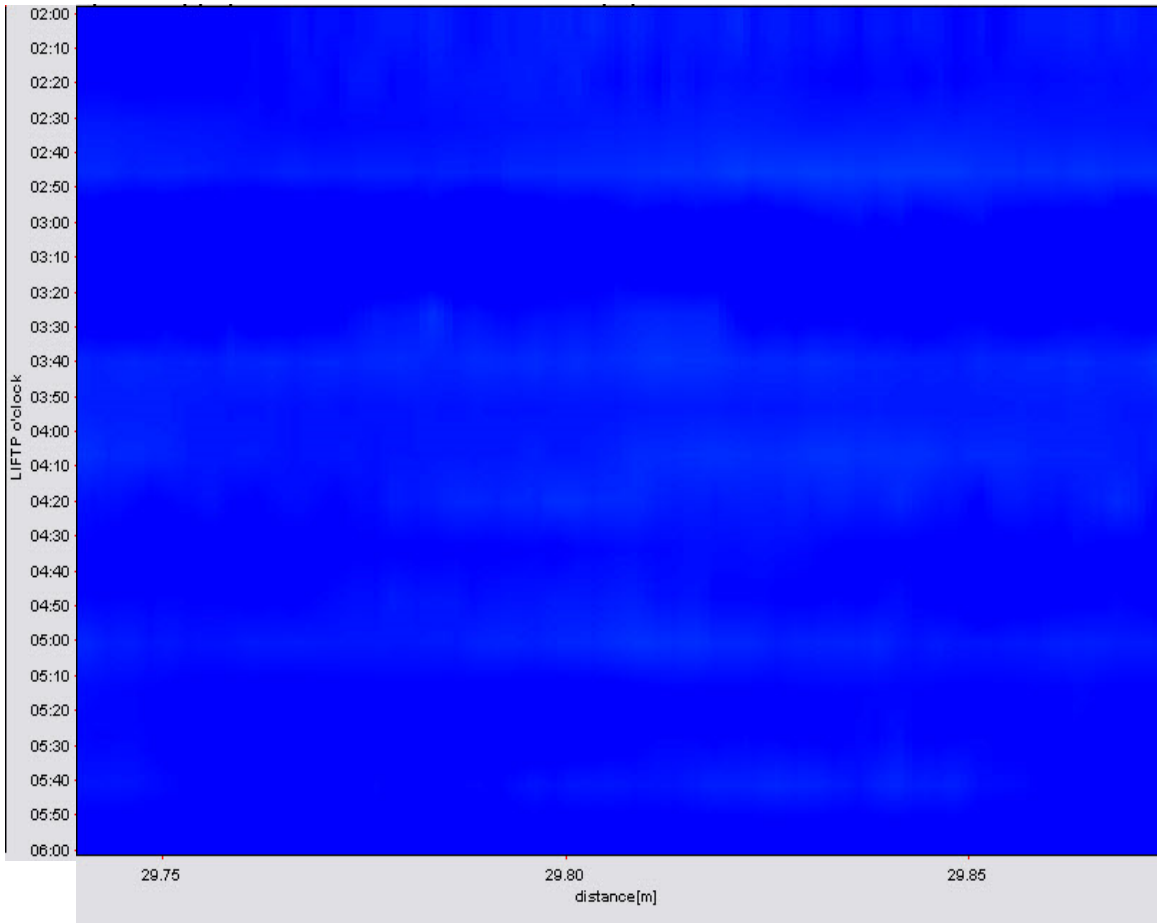
6.5mm external defect in steel



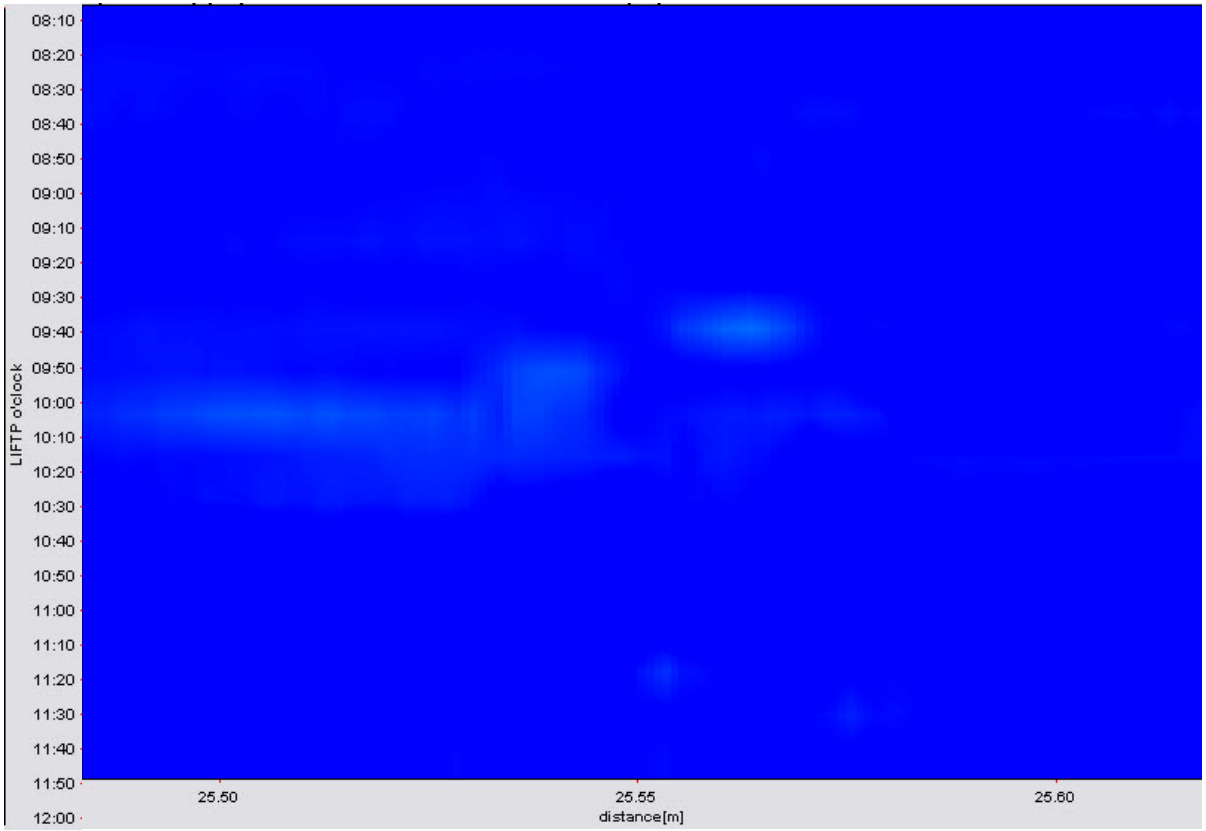
- Internal detection sensor on IEC tool (colors): no signal



TECHNICAL SOLUTION – METAL LOSS

13mm external defect through steel into cladding

- Internal detection sensor on IEC tool (colors): no signal



TECHNICAL SOLUTION – METAL LOSS

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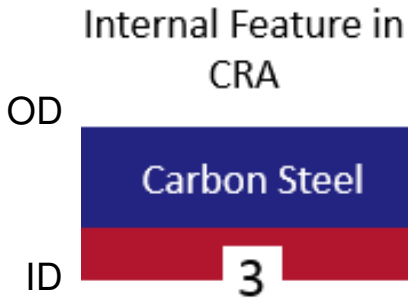
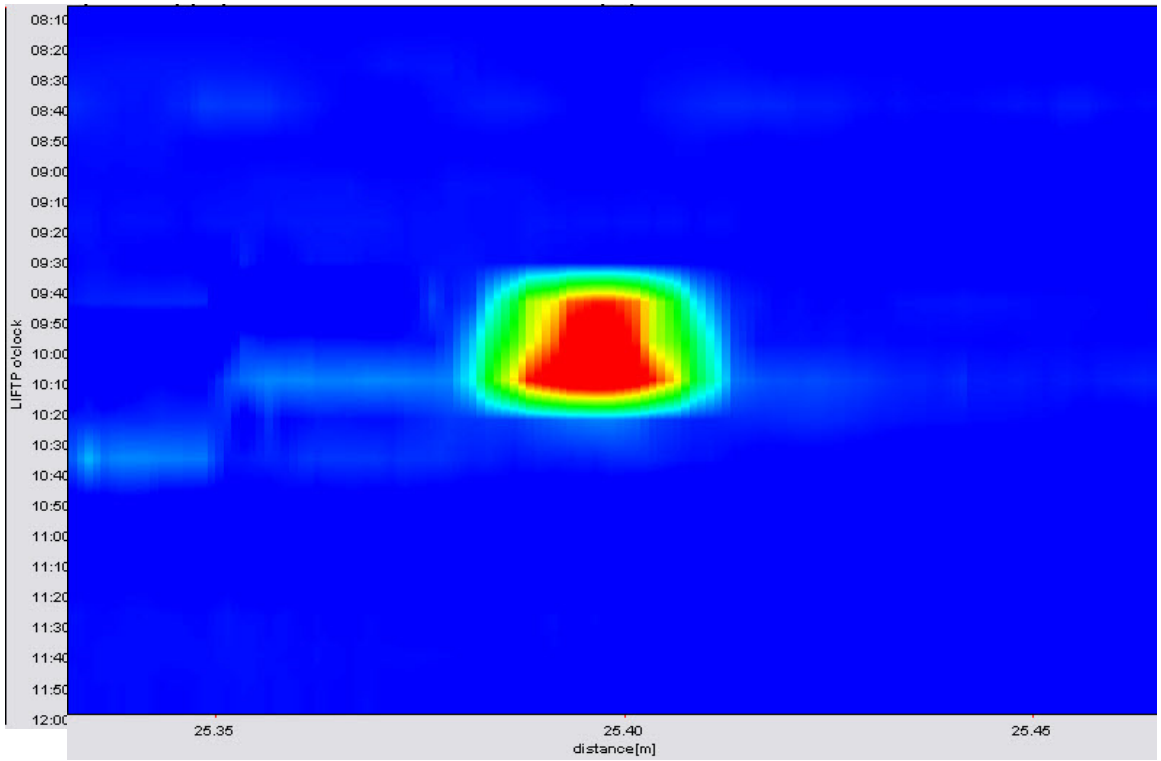
3mm Internal defect in cladding

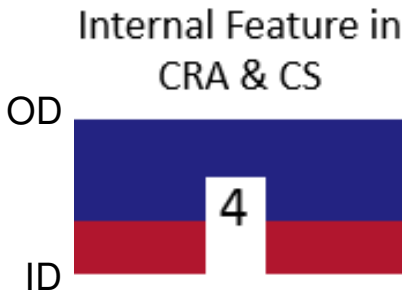


- Internal detection sensor on IEC tool (colors): clear detection

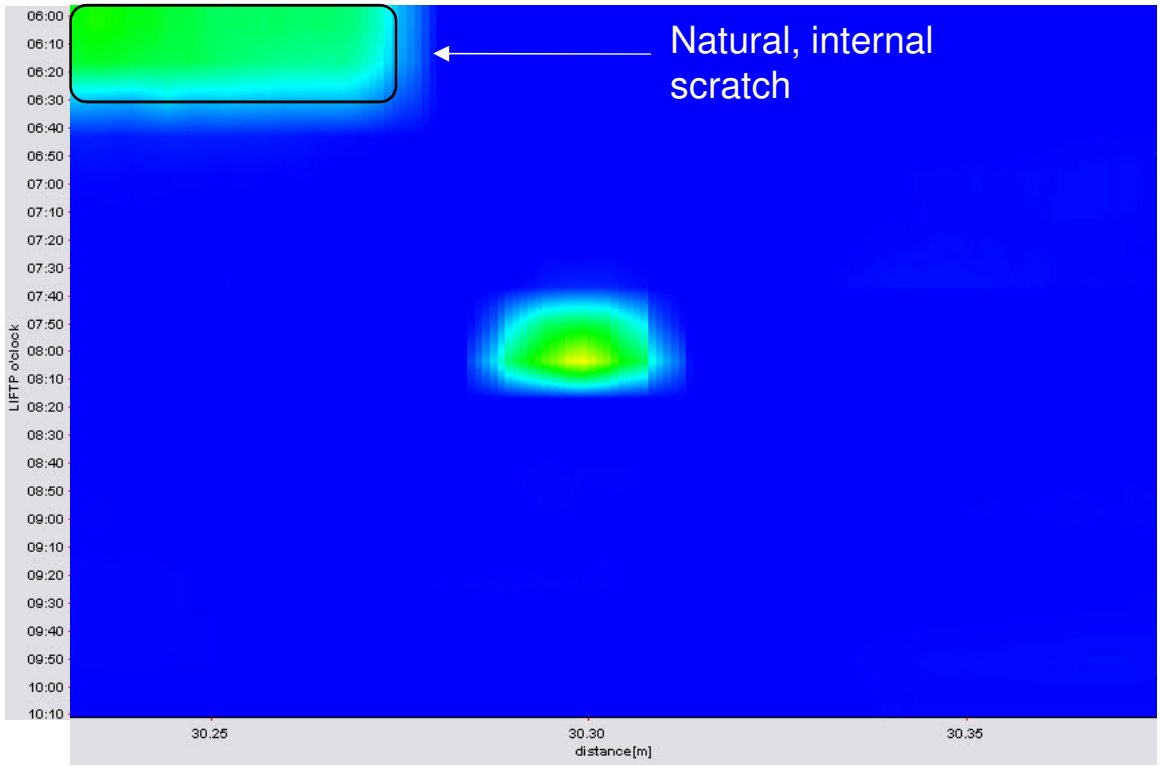


TECHNICAL SOLUTION – METAL LOSS

Internal defect through cladding and 7mm into the steel



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



TECHNICAL SOLUTION – METAL LOSS

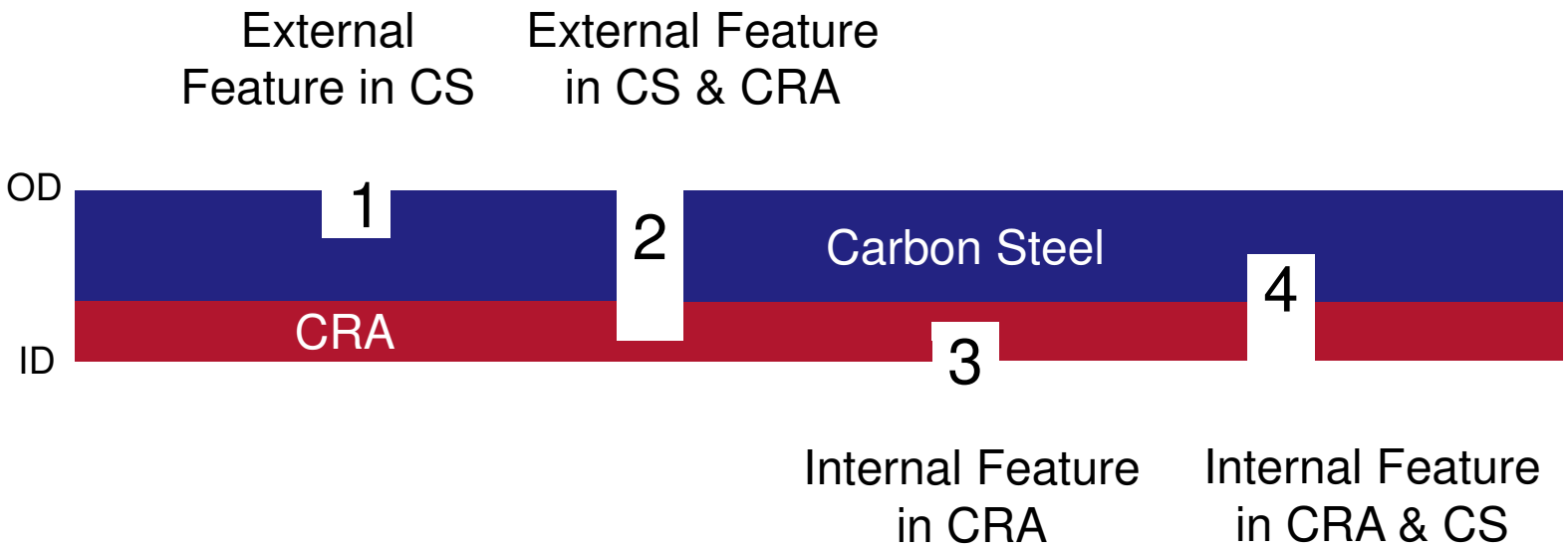
Pump-Test setup at RTRC:

08” spool (clad)

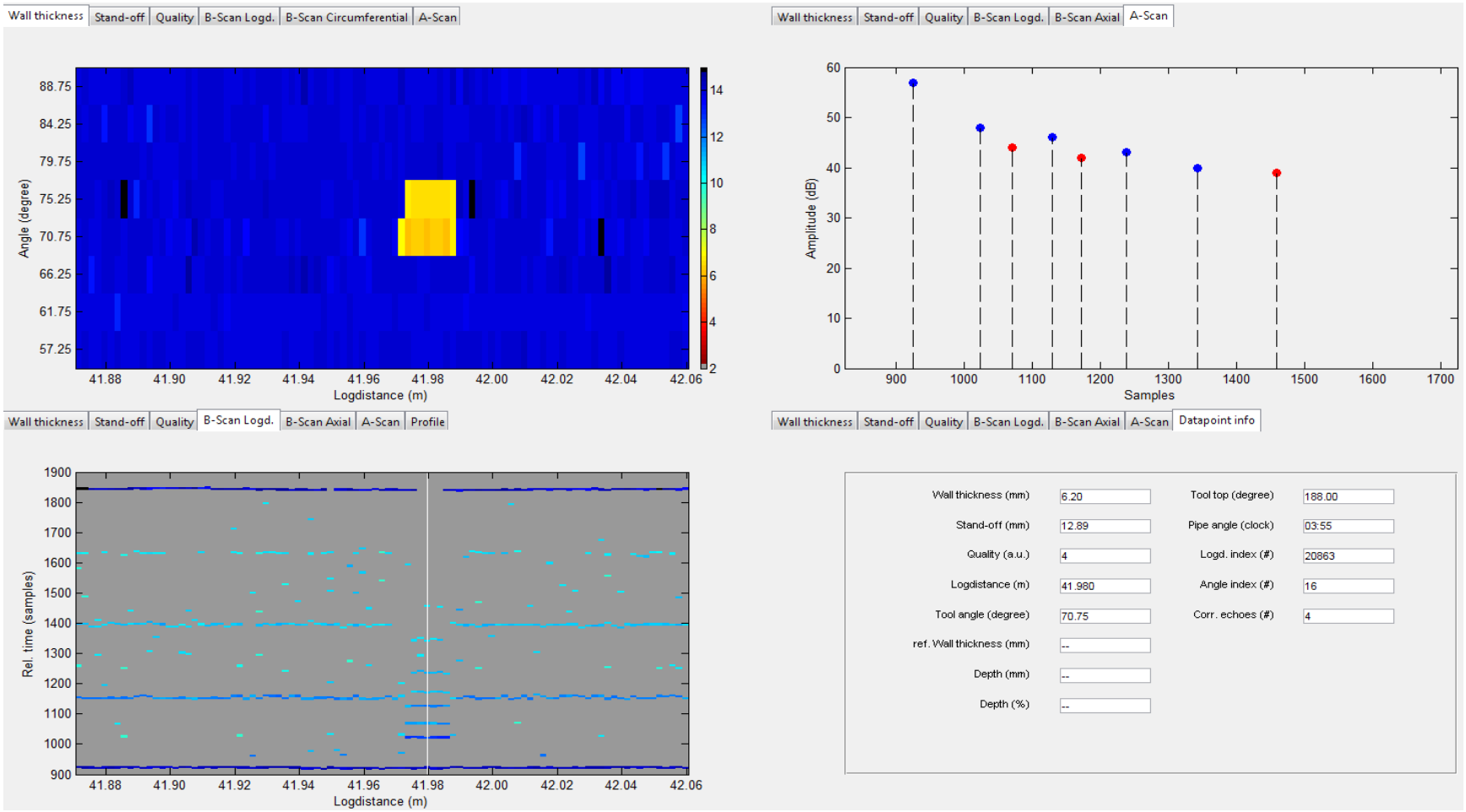
10mm WT CS

3.9mm WT CRA (Alloy 825)

Types of features:



TECHNICAL SOLUTION – METAL LOSS



TECHNICAL SOLUTION – METAL LOSS

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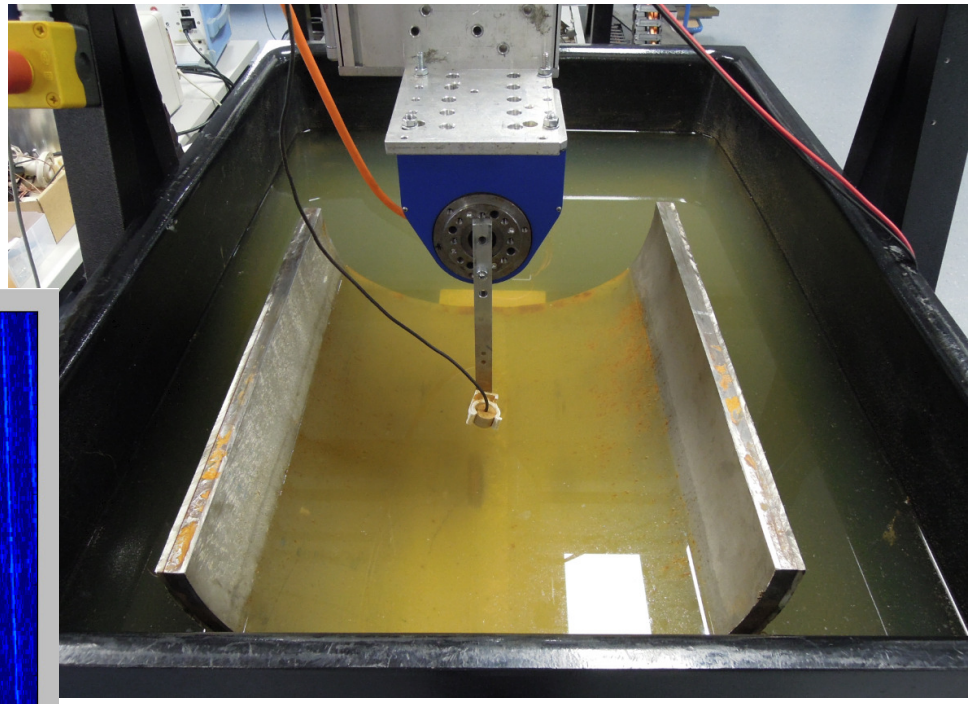
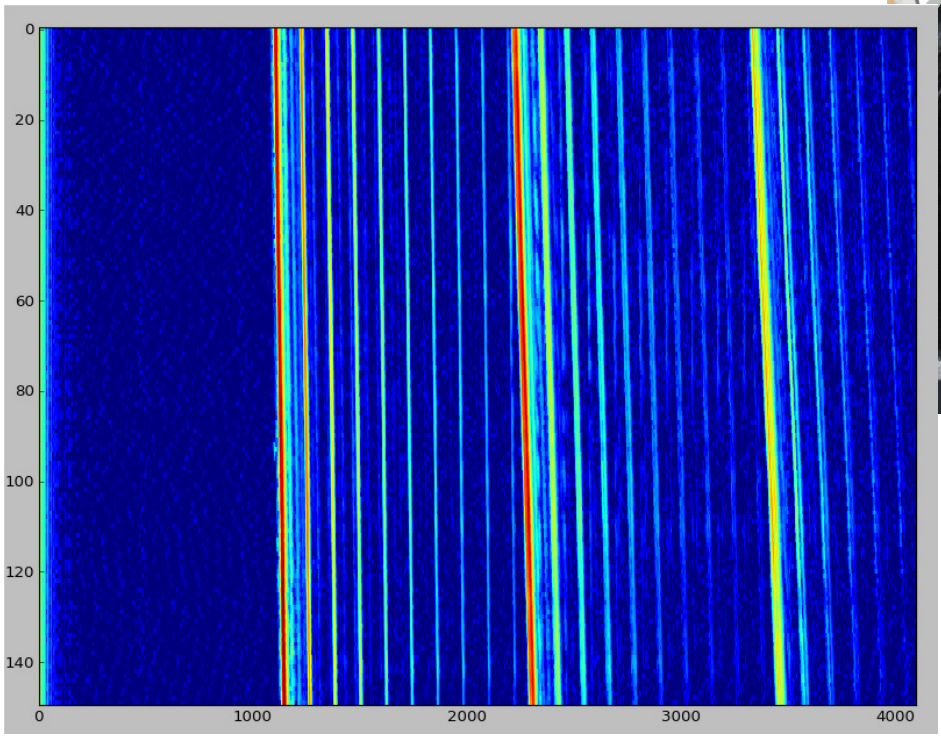
Laboratory test at RTRC:

- 16” spool (clad)
- 12.5mm WT CS
- 3.0mm WT CRA (316L)





TECHNICAL SOLUTION – METAL LOSS

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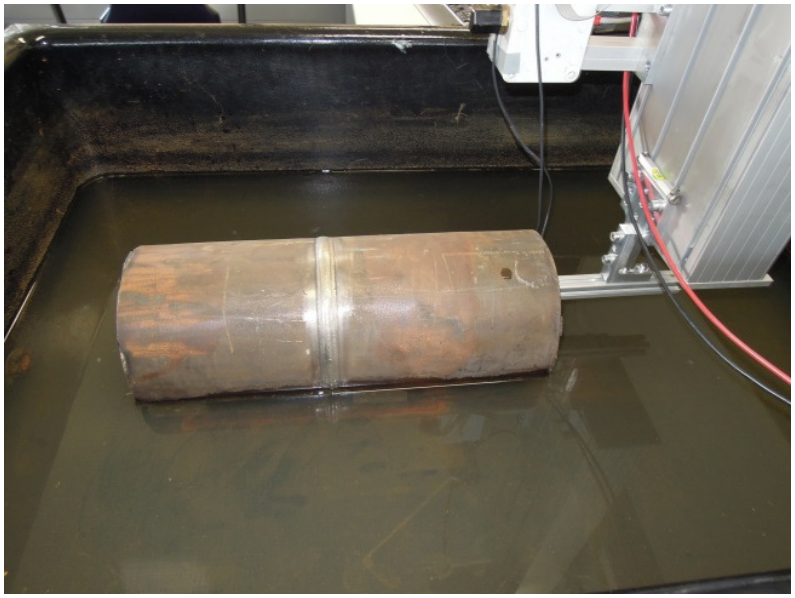
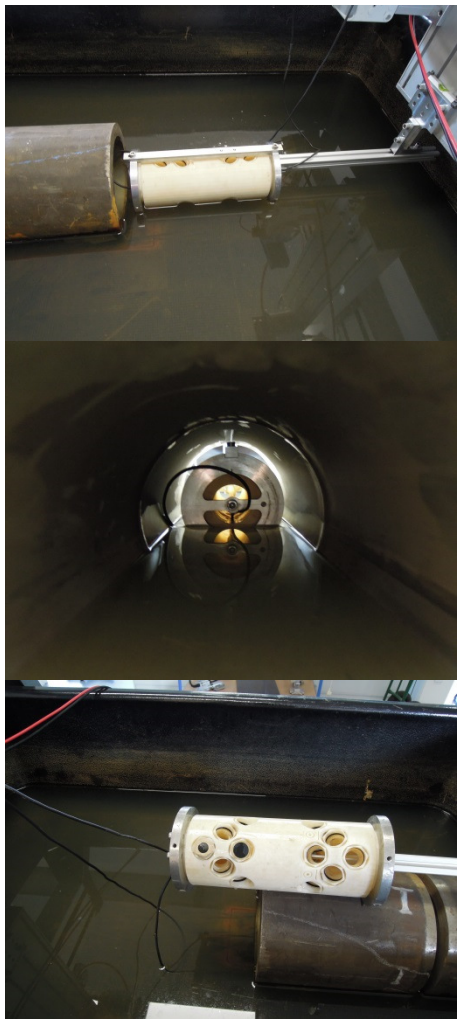
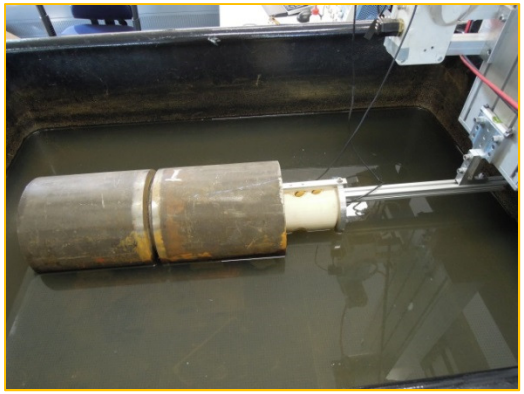
Laboratory test at RTRC:

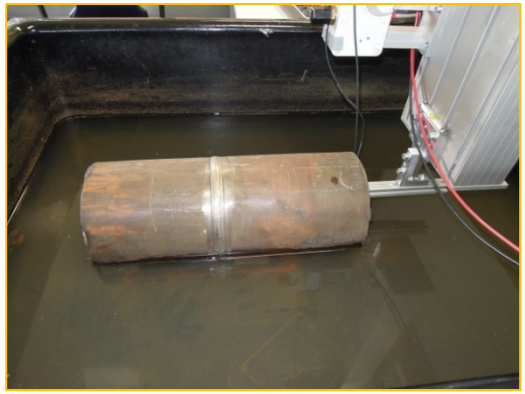
- 06” spool (lined)
- 15.9mm WT CS
- 5.0mm WT CRA (Alloy 825)

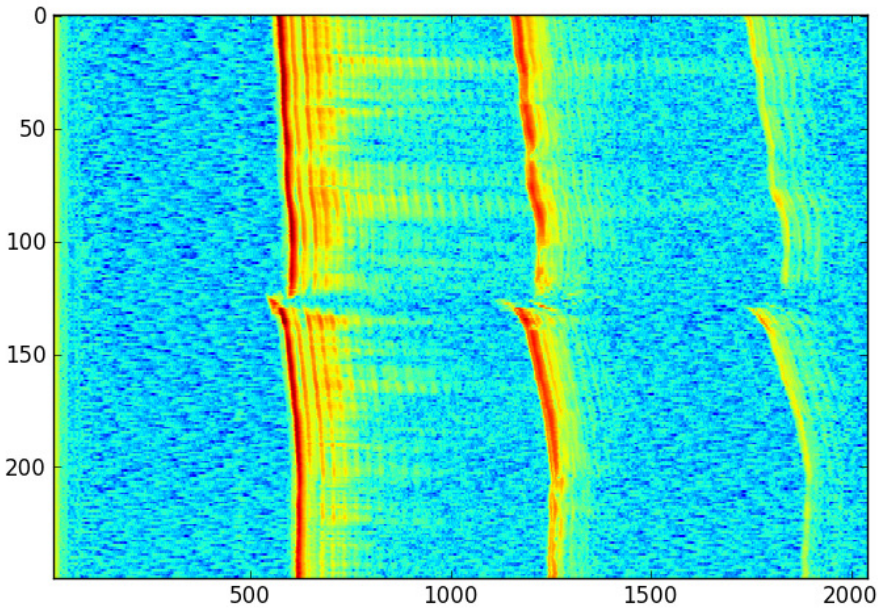


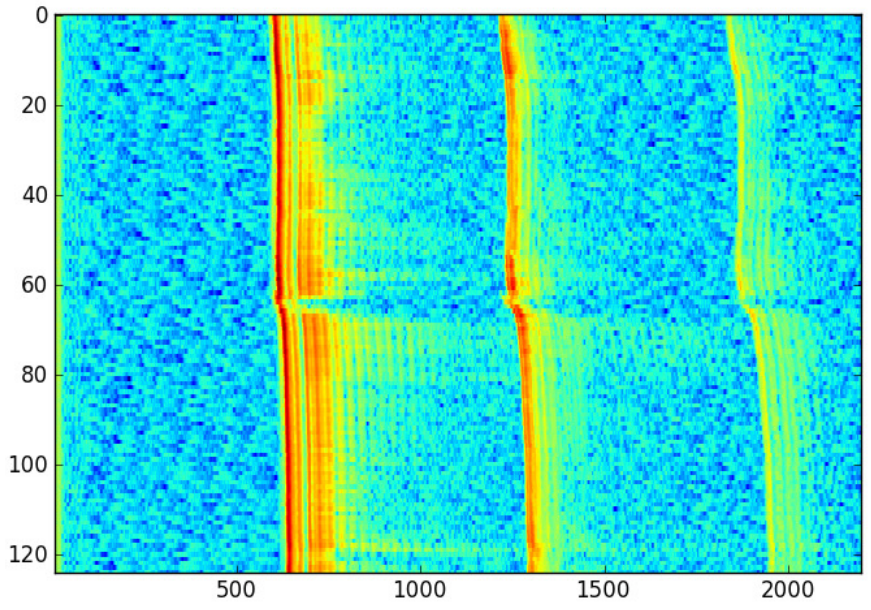


TECHNICAL SOLUTION – METAL LOSS









TECHNICAL SOLUTION - CRACKS

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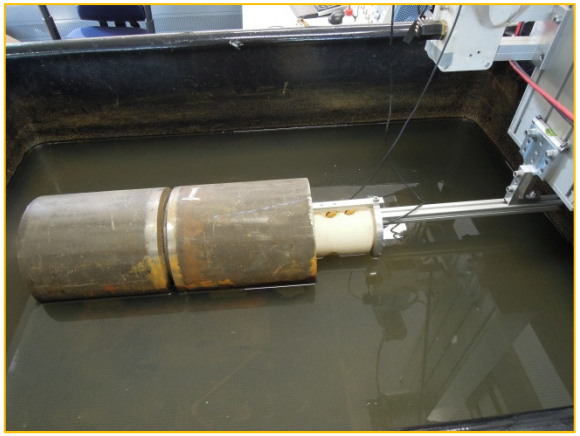

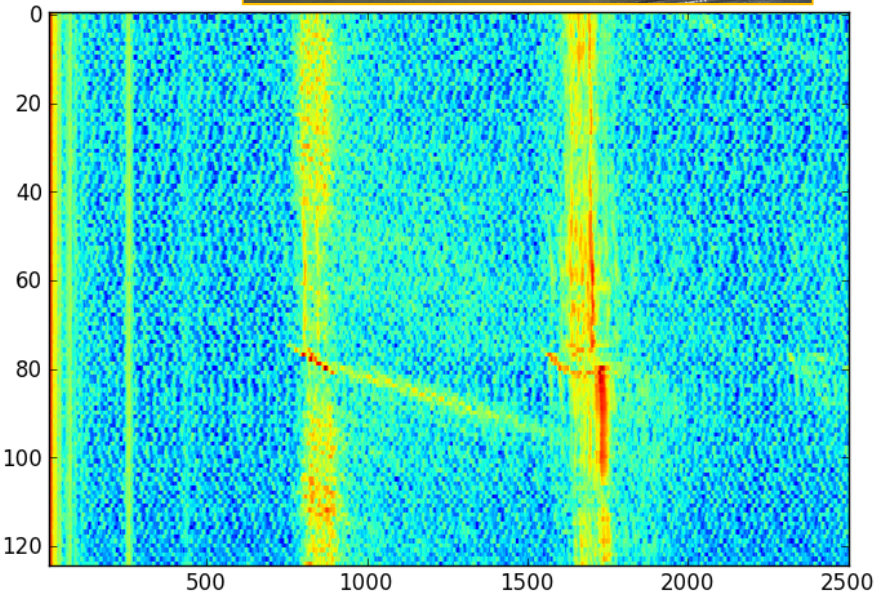

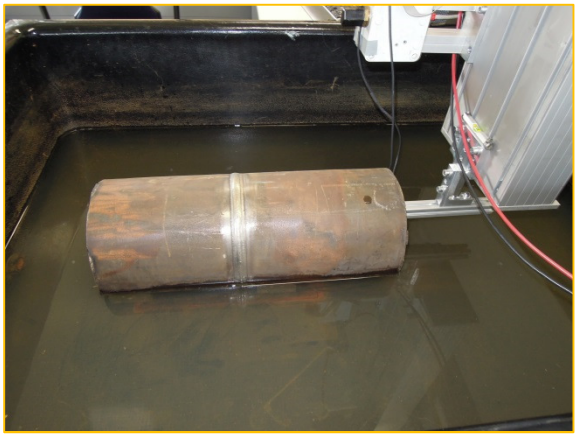

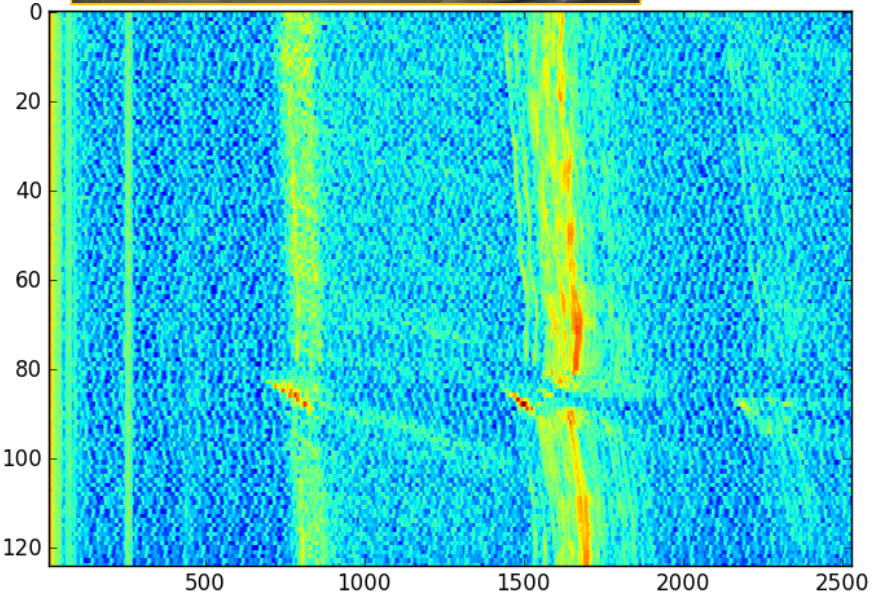

TECHNICAL SOLUTION - CRACKS

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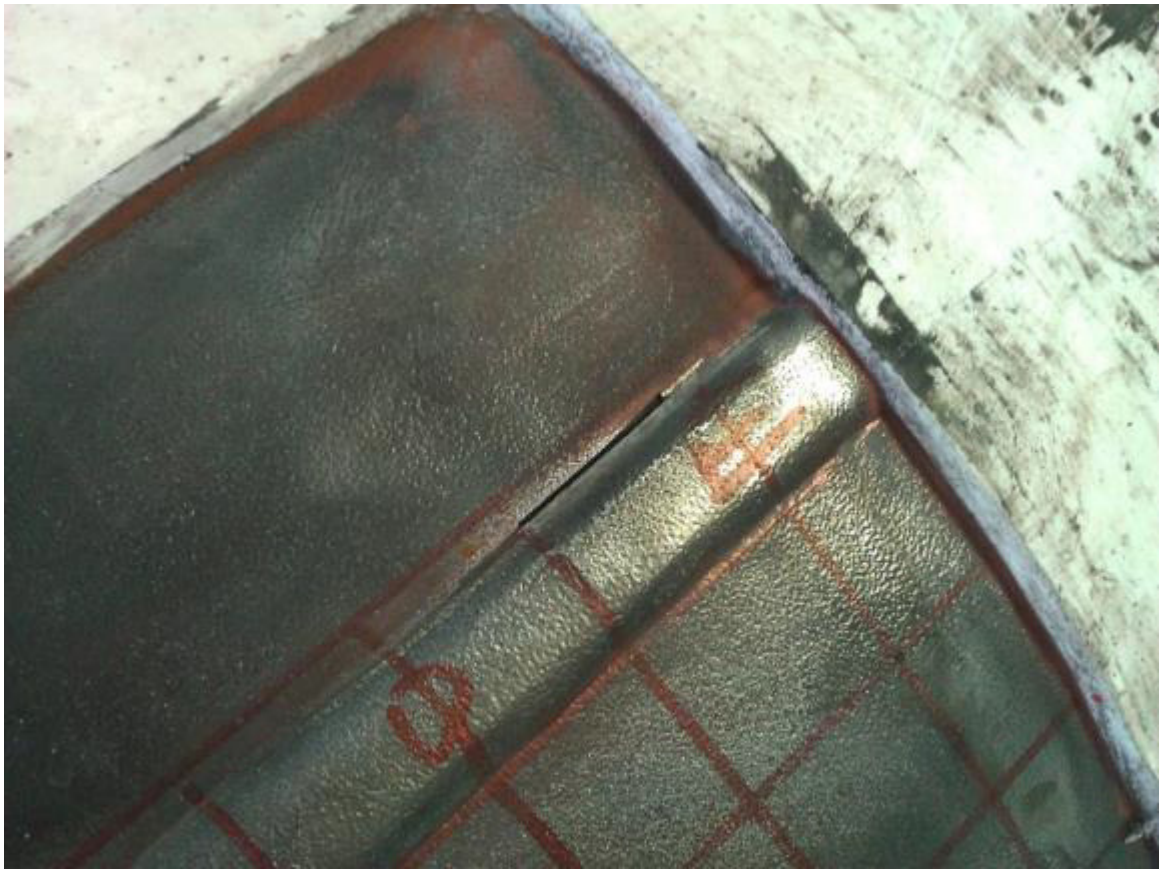
Laboratory test at RTRC:

- 16” spool (clad)
- 12.5mm WT CS
- 3.0mm WT CRA (316L)

Types of features:

No.	Length	Width	Depth
1	25.0	0.3	2.0
2	25.0	0.3	2.0

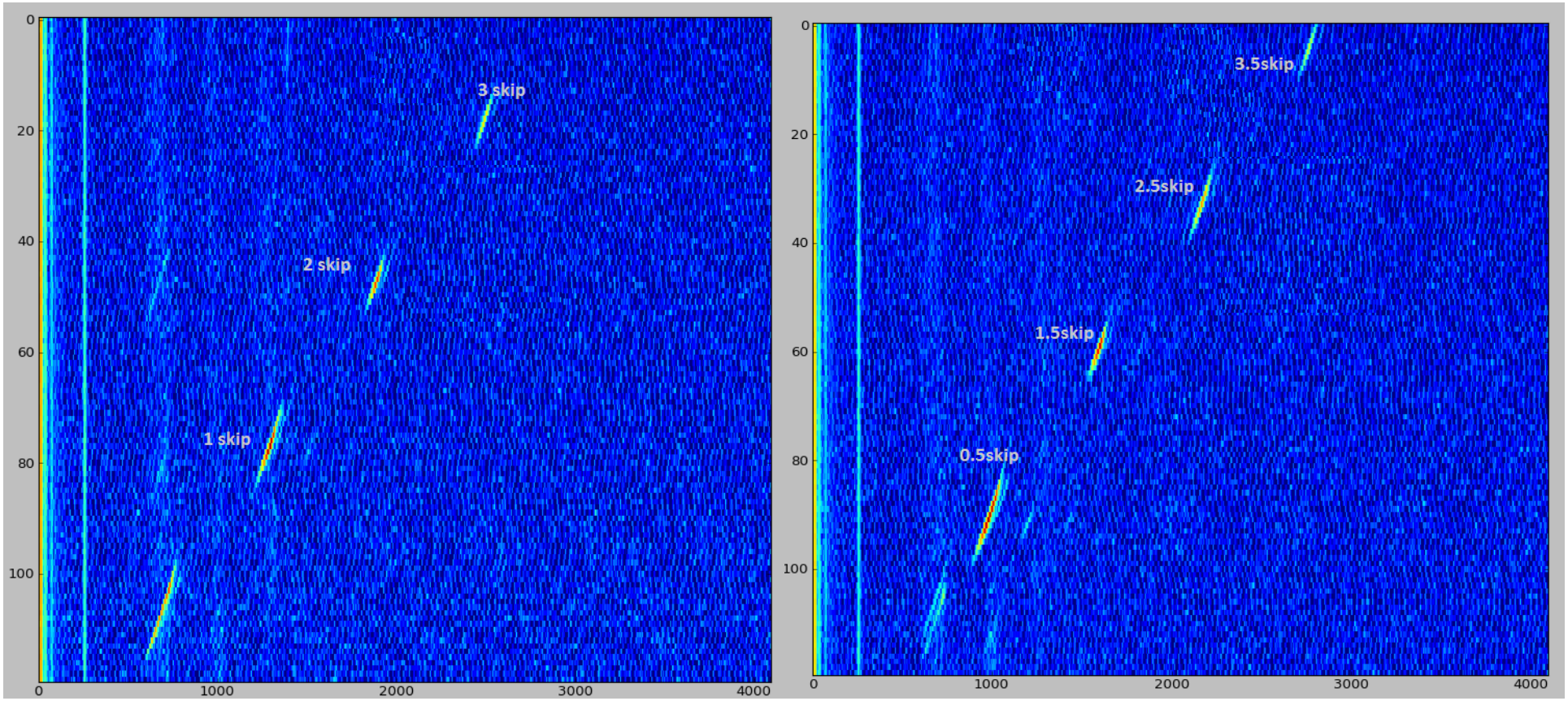
One internal & one external



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

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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


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