INTERNAL AXIAL CORROSION IN OFFSHORE PIPELINES: INSPECTION & ASSESSMENT

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PPSA Seminar 2014

19th November 2014, Aberdeen, UK

AGENDA

Topics

1. **Introduction: Long Axial Corrosion**
2. **Impacts of Long Axial Corrosion on ILI and FFP**
3. **DNV Method: Assessment of Long Axial Corrosion Defects**
4. **Summary & Conclusions**

LONG AXIAL CORROSION

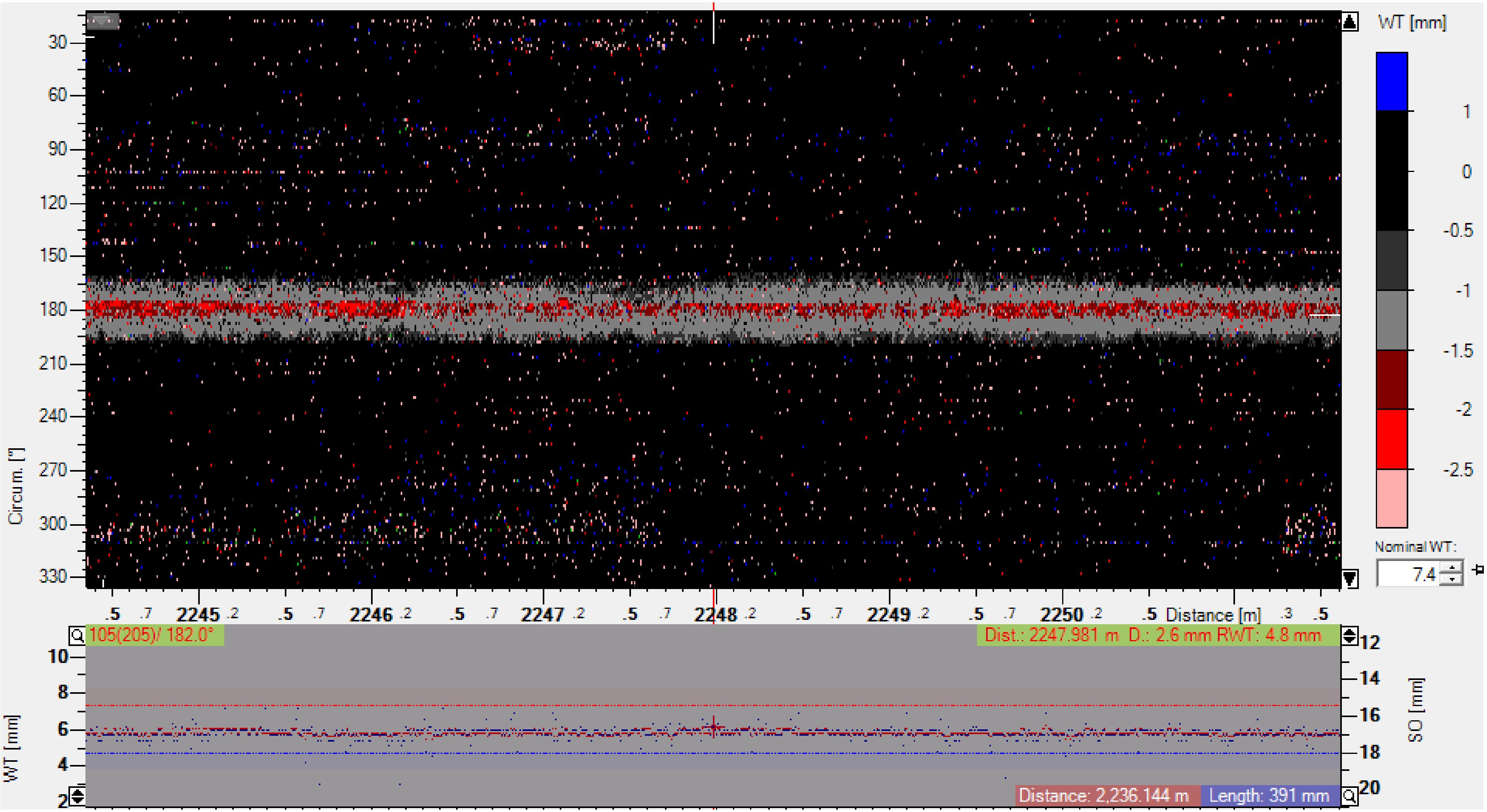
Characteristic Observations

typical type of corrosion in crude oil and water injection pipelines:

- internal corrosion along six o’clock position
- coherent corrosion areas of up to several kilometers length
- often high corrosion growth rates (> 1 mm/year)
- synonyms: channeling, channeling corrosion, six o’clock corrosion, bottom-line corrosion
- different shape of corrosion anomalies:
  - smooth and uniform WT reduction (e.g. corrosion/erosion)
  - rough surface, irregular and complex shaped geometry (e.g. MIC)

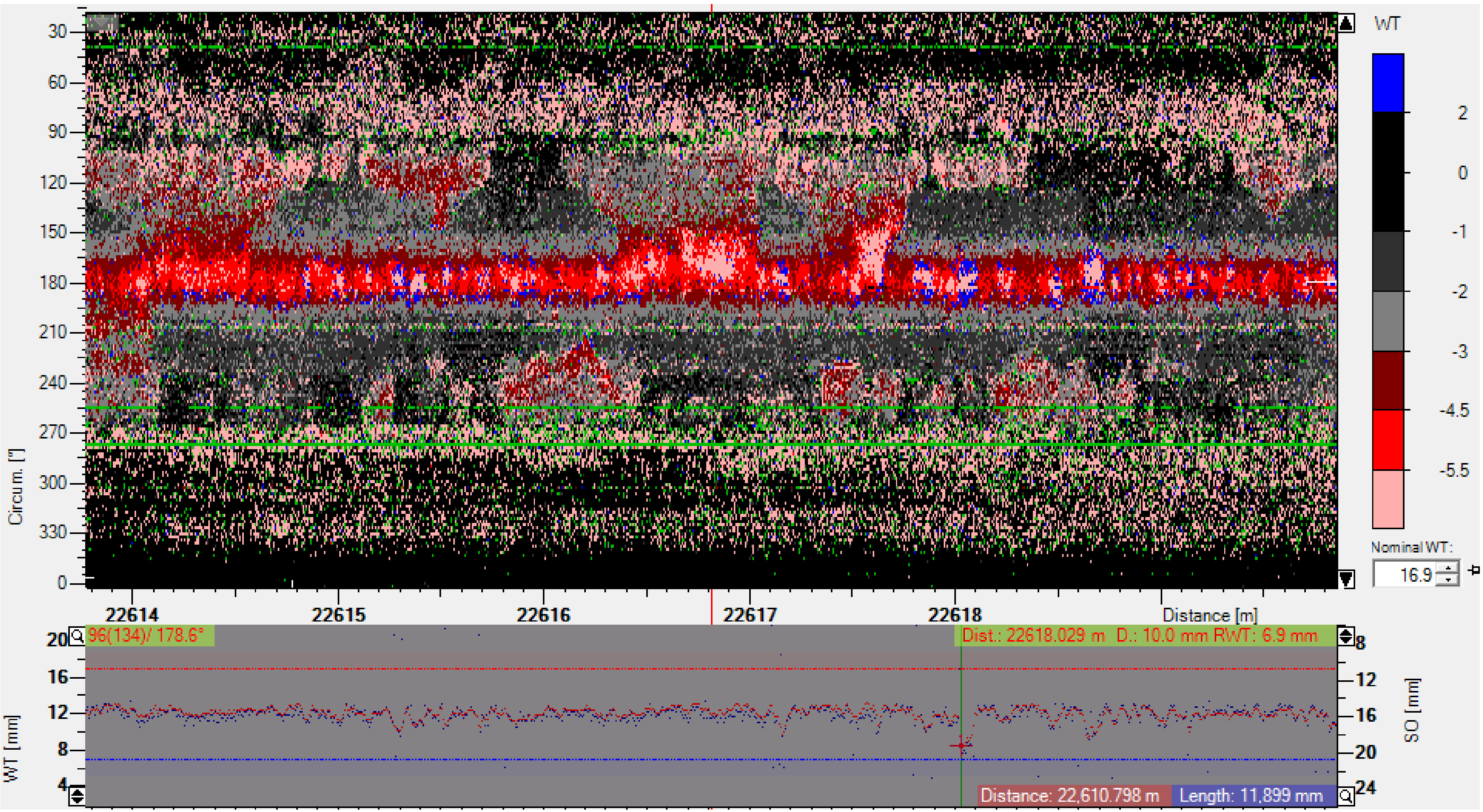
LONG AXIAL CORROSION: EXAMPLE 1

Smooth and Regular Shape, Groove-like



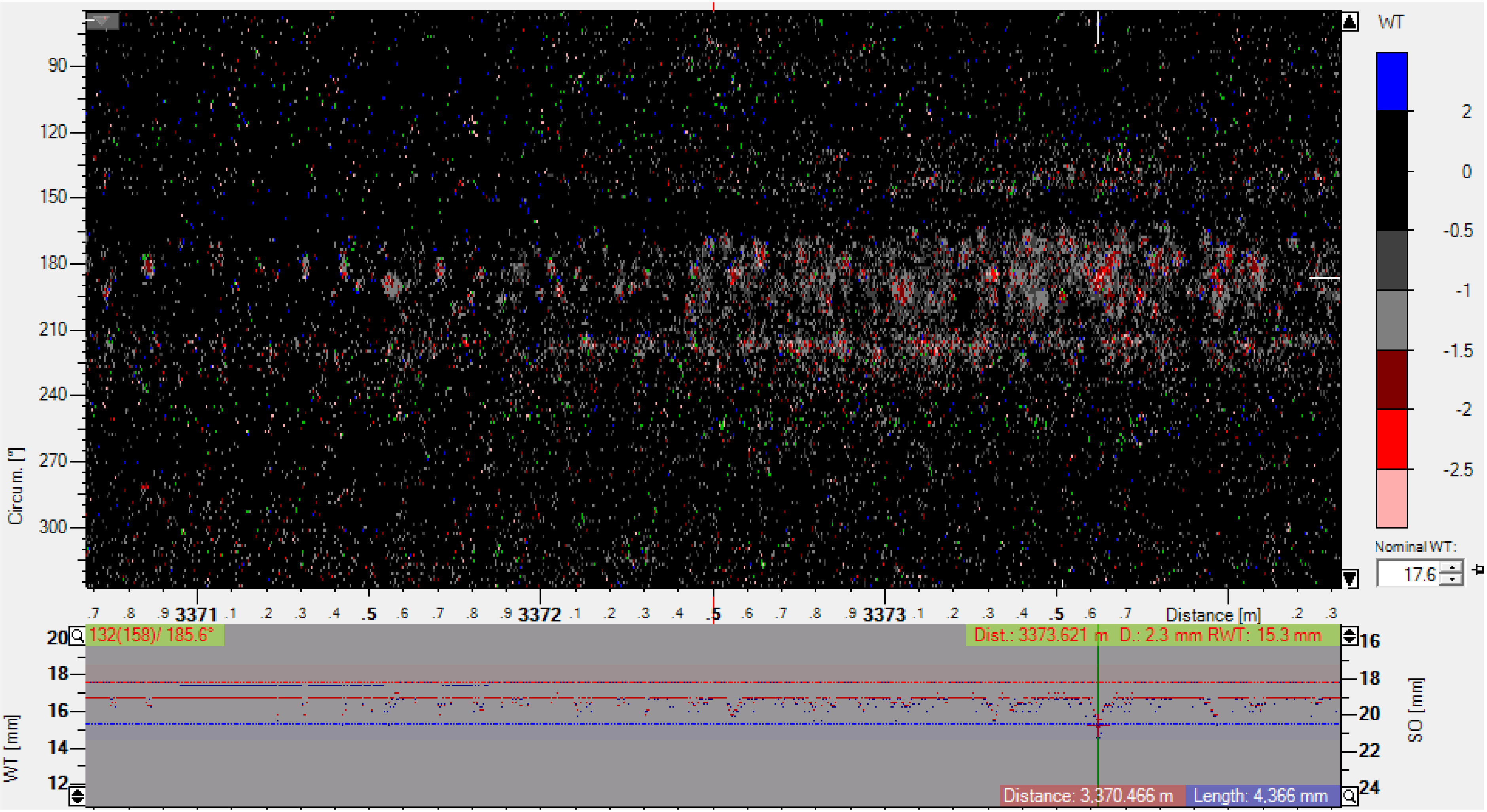
LONG AXIAL CORROSION: EXAMPLE 2

Rough Surface, Irregular and Complex Shape



LONG AXIAL CORROSION: EXAMPLE 3

Chain of Corrosion Pits (Early Stage of Channeling)

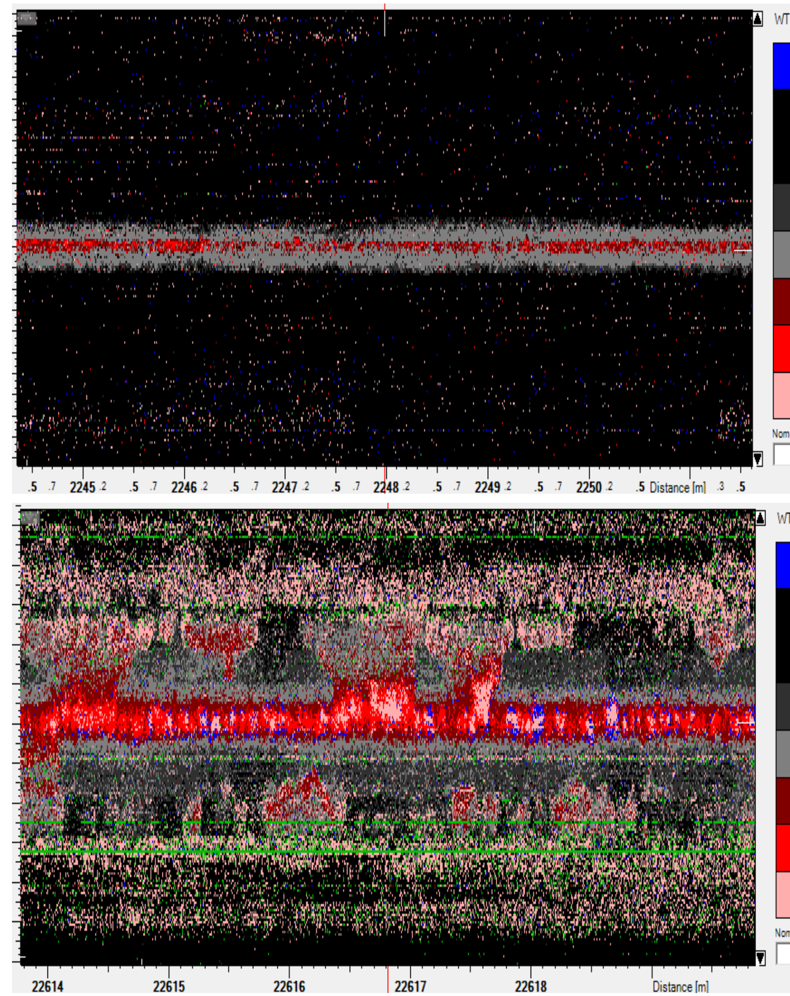


IMPACTS OF LONG AXIAL CORROSION…

… on ILI and Assessment

characteristics of channeling corrosion
➔ impacts on ILI and assessment:

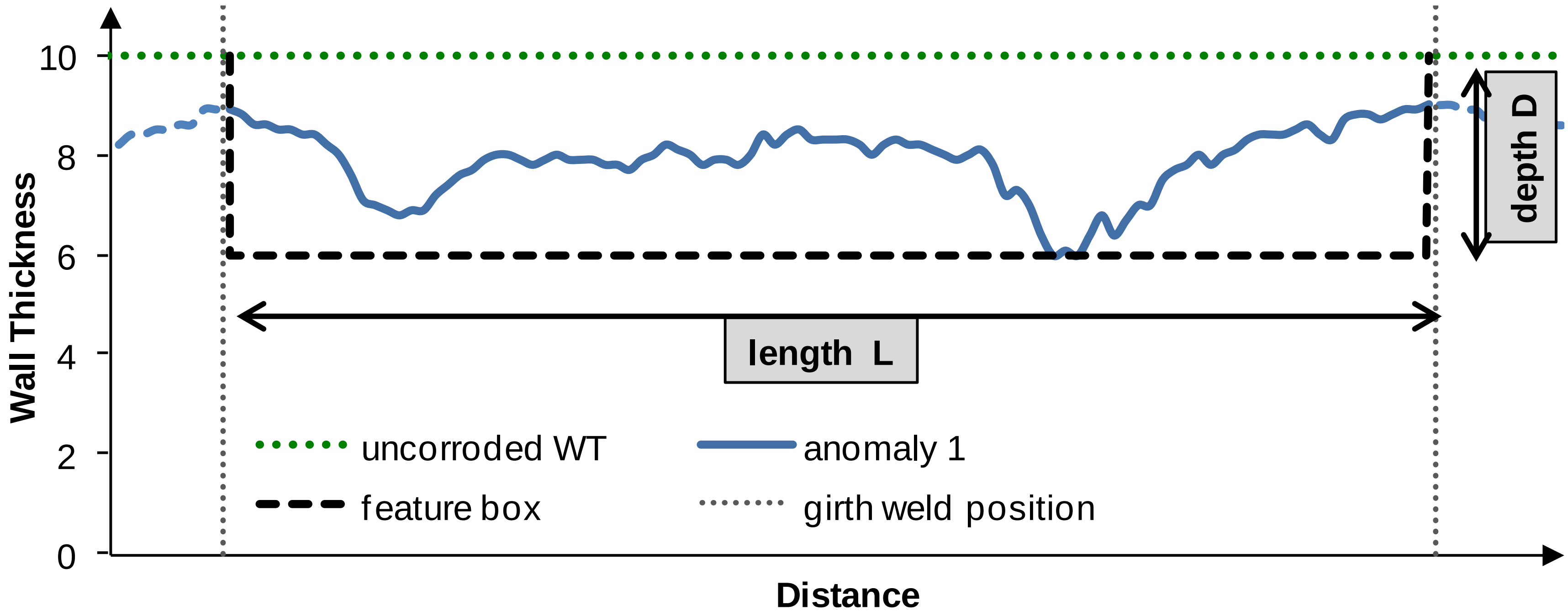
- **ILI technology**
  → UT
- **cleaning**
  → modification of standard procedures
- **re-processing/filtering of ILI data**
  → eliminate outliers
- **reporting & assessment**
  → next slides



IMPACTS OF LONG AXIAL CORROSION

Reporting of Detected Anomalies

- coherent corrosion over several km: usually reported as one anomaly per pipe joint (length = joint length, depth = peak depth)



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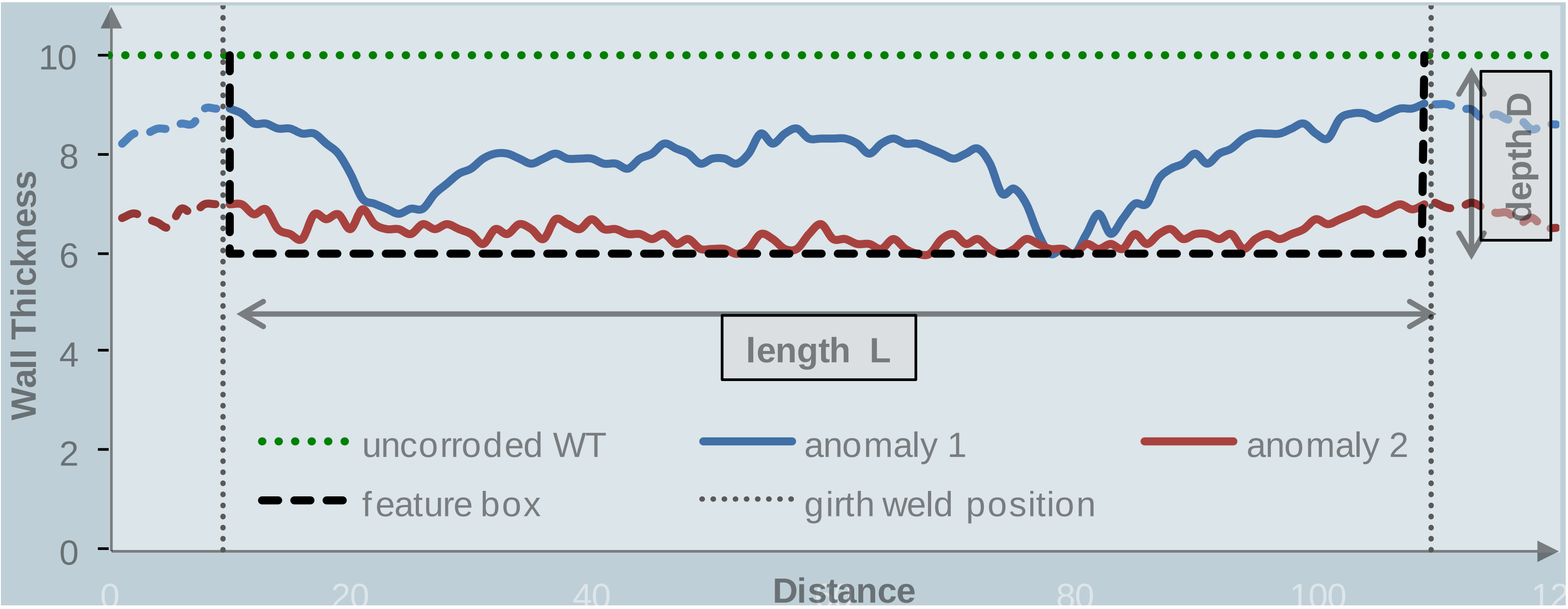
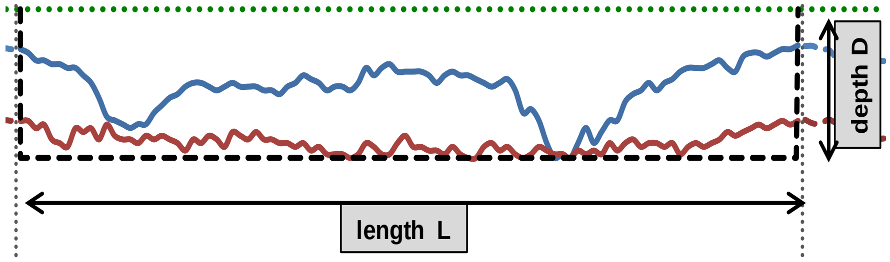


➔ peak depth & length: no meaningful description of complex anomalies

IMPACTS OF LONG AXIAL CORROSION

Assessment of Detected Anomalies

- different codes/standards for calculation of safe operating pressure P_{safe} of metal loss anomalies
- **list-based methods:**
  - e.g. B31.G, DNV-RP-F101 single
  - input: maximum depth, total length
  - same P_{safe} for anomalies 1 & 2



- **data-based methods:**
  - e.g. RSTRENG (Effective Area), DNV-RP-F101 complex
  - anomalies described by actual remaining wall thickness profile (river-bottom profile, RBP)
  - well suited for assessing complex shaped anomalies
- **all conventional methods**: impact of continuous metal loss (→ many bad joints) on system PoF not accounted for

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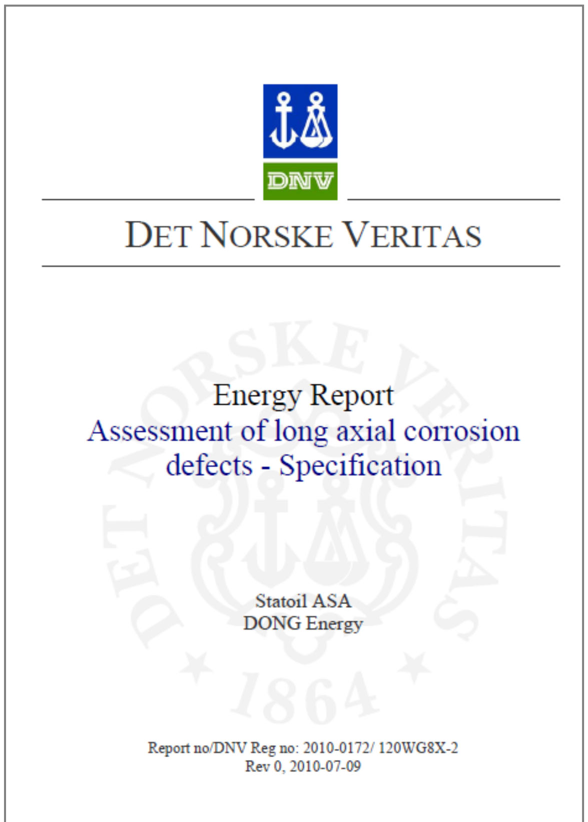
Topics

1. **Introduction: Long Axial Corrosion**
2. **Impacts of Long Axial Corrosion on ILI and FFP**
   - Inspection Technology
   - Cleaning
   - Data Processing
   - Reporting
   - Assessment
3. **DNV Method: Assessment of Long Axial Corrosion Defects**
   - Main Ideas
   - Application Examples
4. **Summary & Conclusions**

ASSESSMENT OF LONG AXIAL CORROSION

DNV Method: Overview

- JIP (DNV, Statoil, DONG Energy) → ***"Assessment of long axial corrosion defects – Specification"***



DNV

DET NORSKE VERITAS

Energy Report
Assessment of long axial corrosion defects - Specification

Statoil ASA
DONG Energy

Report no/DNV Reg no: 2010-0172/ 120WG8X-2
Rev 0, 2010-07-09

- results will be incorporated in revised DNV-RP-F101
- NDT Global involved in testing & reviewing of algorithms
- DNV method gives guidance on
  - extraction of RBPs from UT ILI data
  - calculation of pipeline pressure capacity
  - determination of corrosion growth rates
  - extrapolation of pressure capacity

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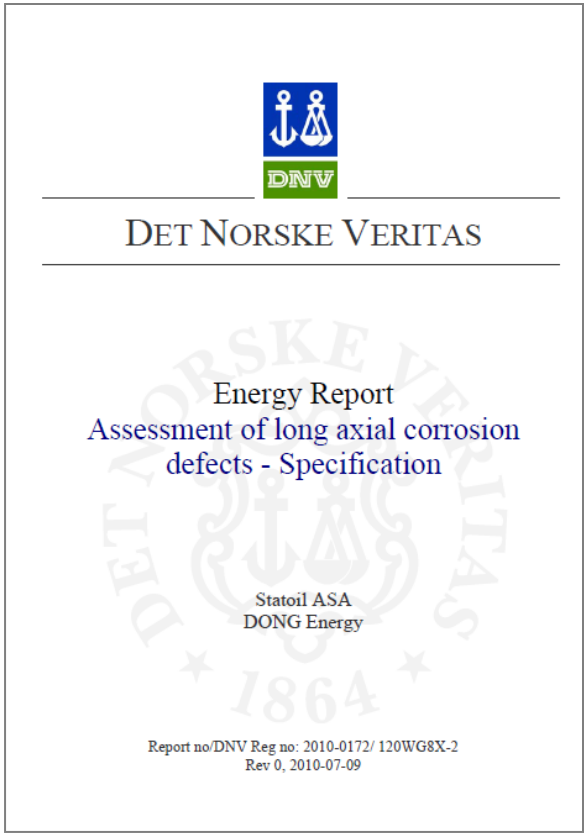

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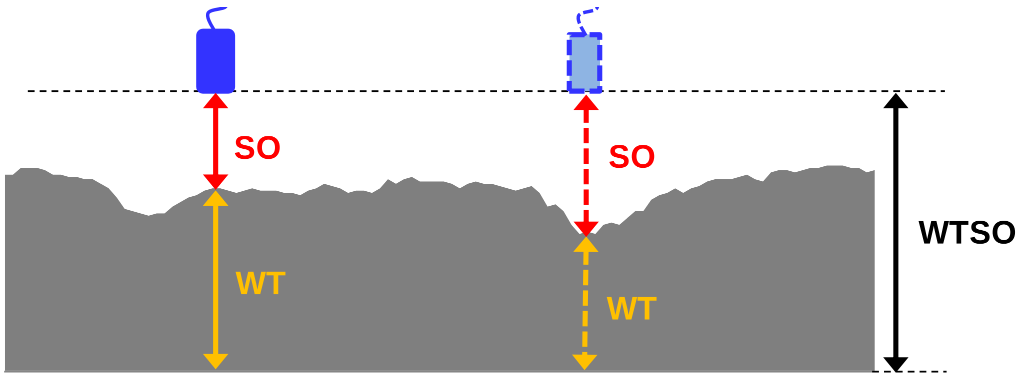
ASSESSMENT OF LONG AXIAL CORROSION

Filtering of WT Data & Extraction of RBPs

- rugged corrosion anomalies and rough internal pipe surface

→ echo loss (missing data) and/or outliers in UT WT data

- important: identification & replacement of erroneous WT values before calculation of RBPs



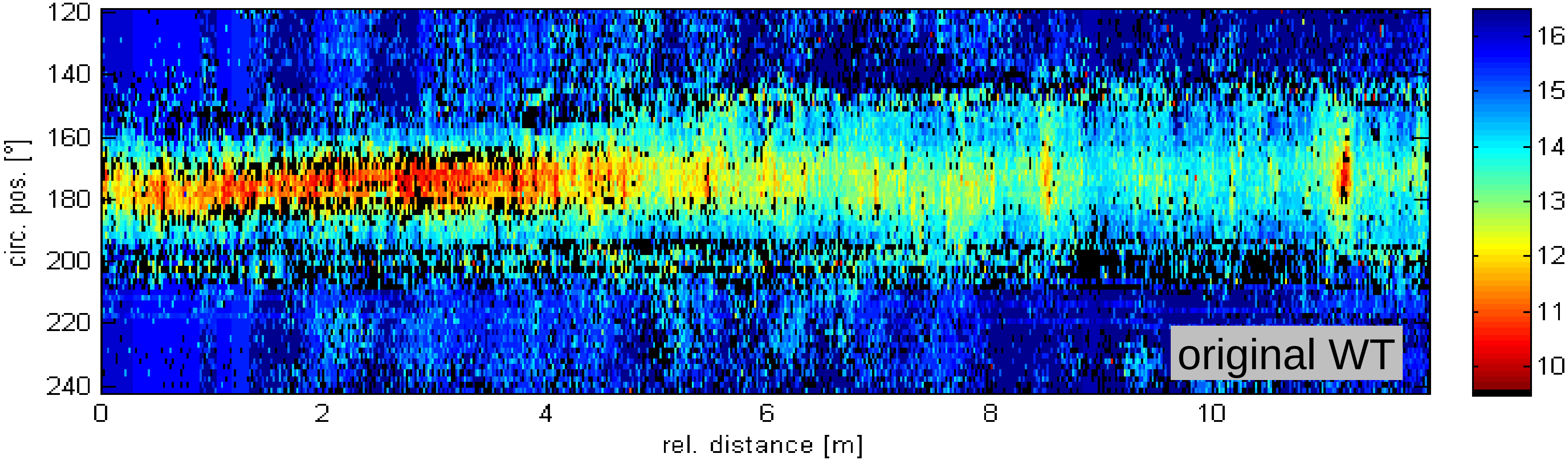
→ use of stand-off (SO) data:

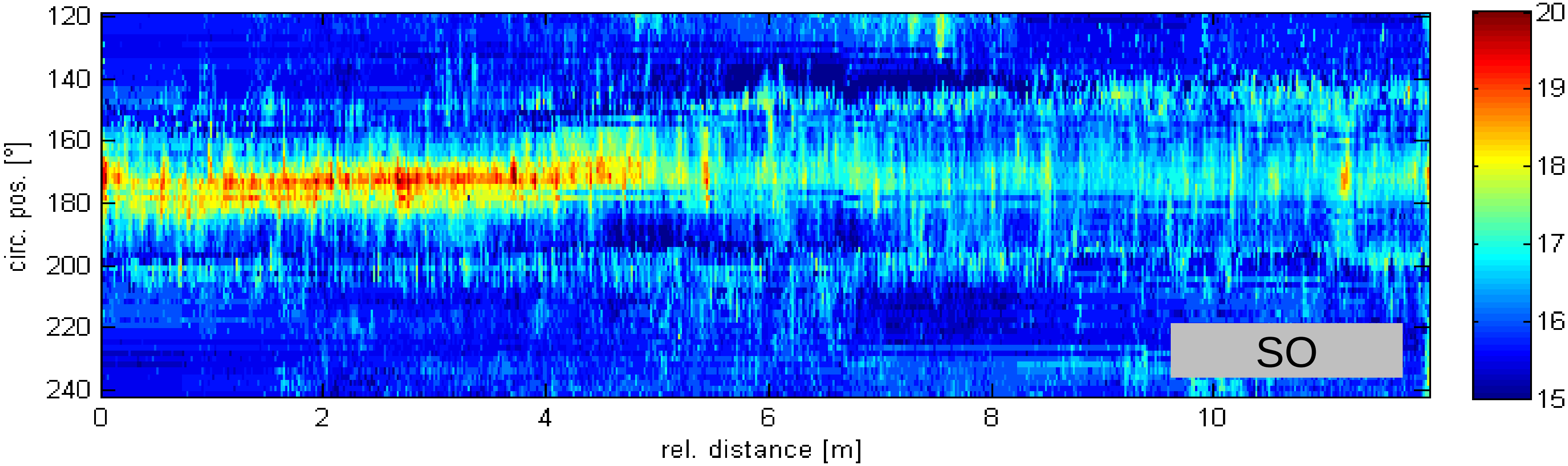
- strong signal (1^{st} echo)
- usually no echo loss/outliers

- WTSO = WT + SO
  - = distance sensor – outer pipe wall, ideally constant
  - WT missing or outlier → WTSO outside tolerance band
    → WT replaced by $RWT_{SO} = WTSO_{median} - SO$

ASSESSMENT OF LONG AXIAL CORROSION

Filtering of WT Data & Extraction of RBPs: Example





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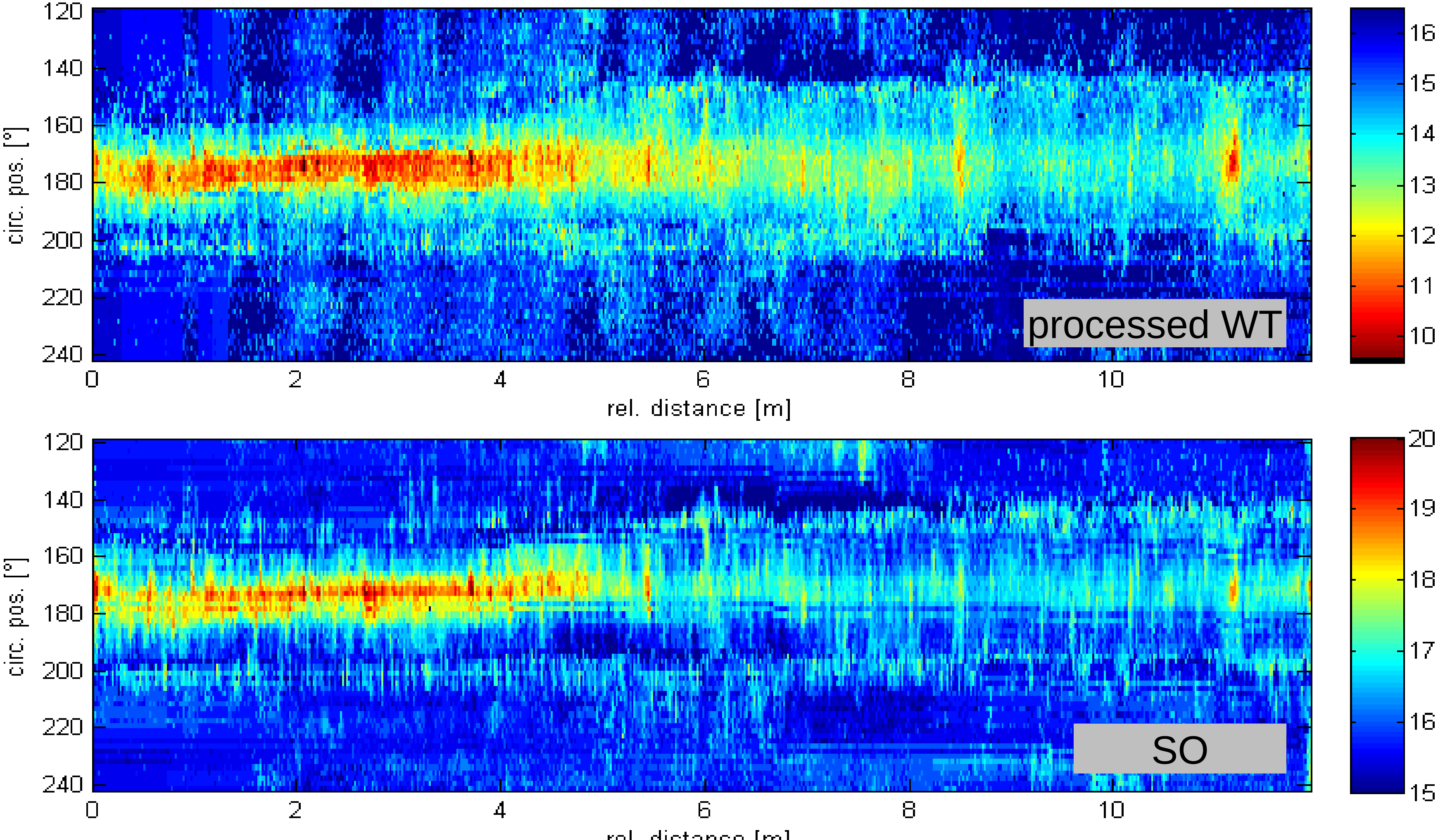

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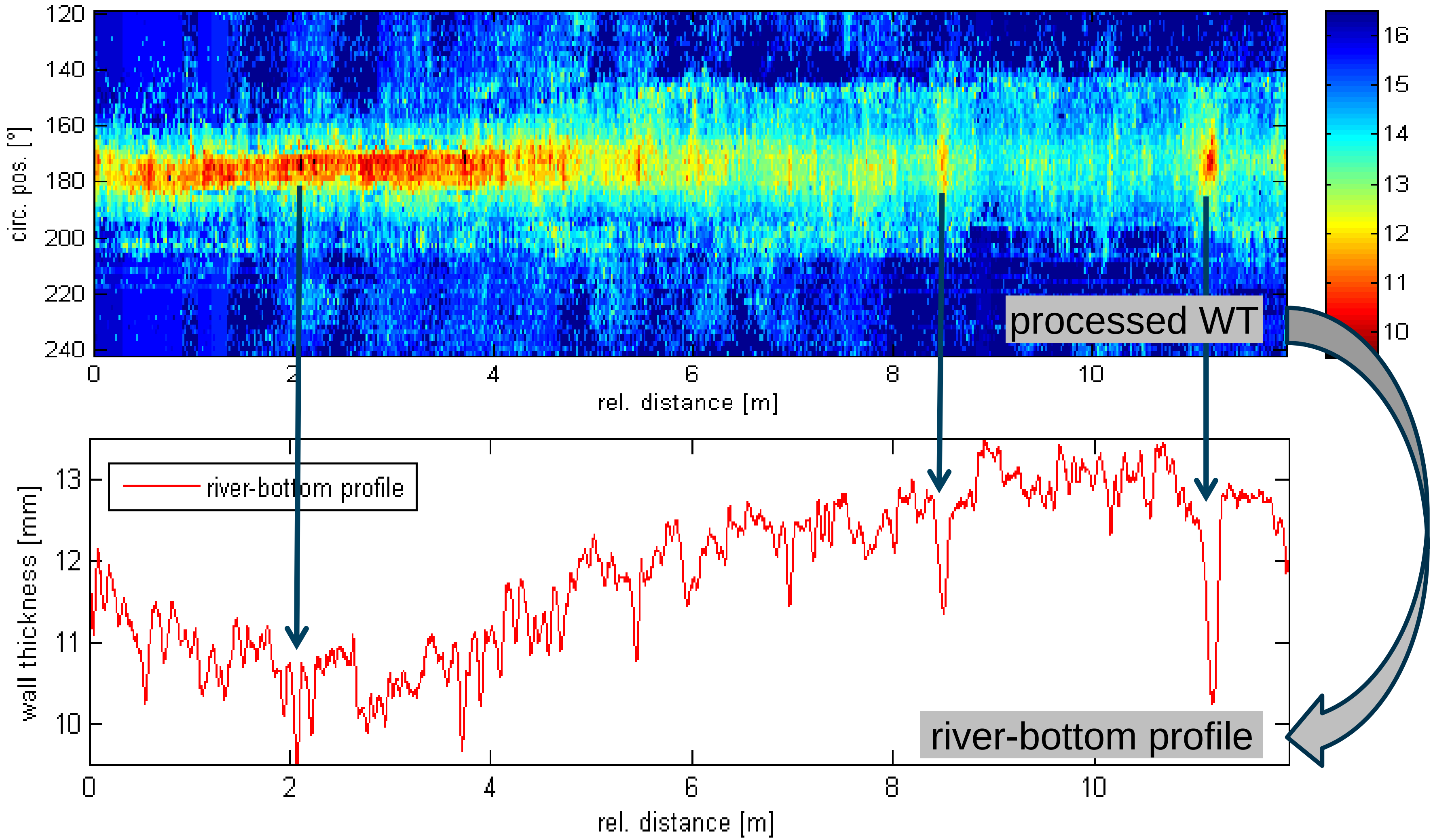
Filtering of WT Data & Extraction of RBPs: Example



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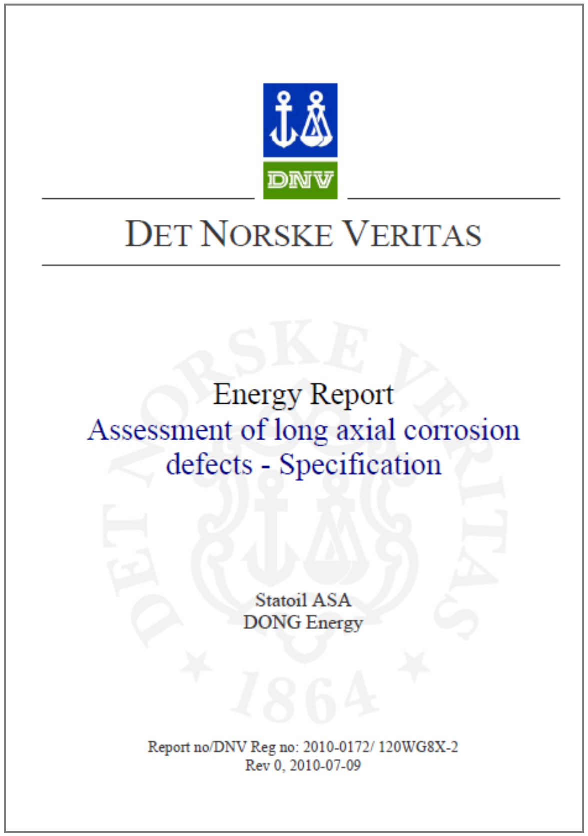

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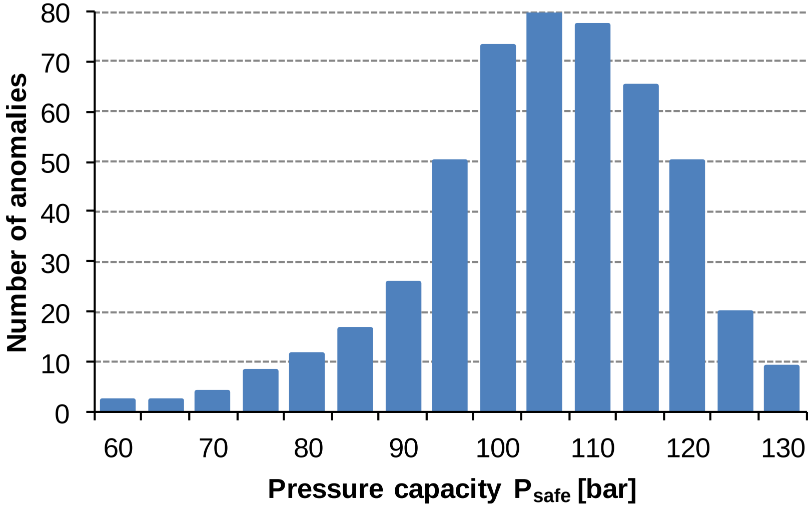
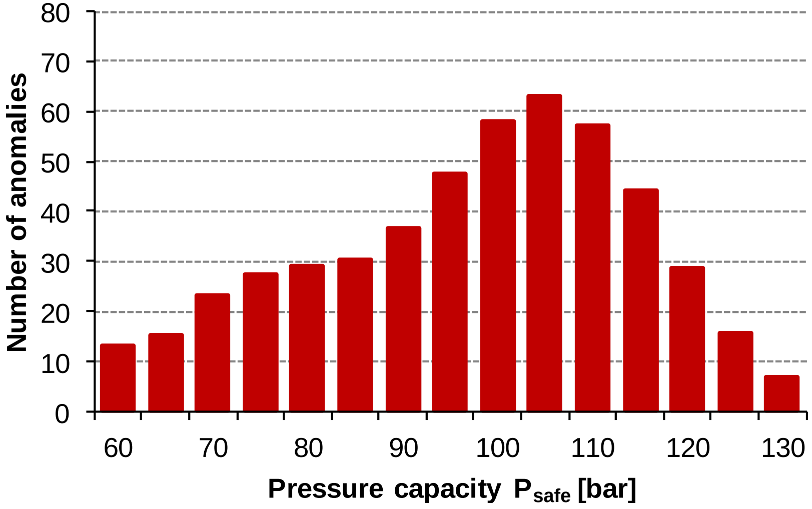
ASSESSMENT OF LONG AXIAL CORROSION

Calculation of Pipeline Pressure Capacity

Requirements:

- complex corrosion anomalies
  → assessment based on RBPs
- standard methods:
  P_{safe} (pipeline) = P_{safe}(worst joint)
- *however:* minimum P_{safe} not sufficient to describe condition of pipeline
- *example*: P_{safe} histograms with same minimum P_{safe} but different number of "bad" joints
- many bad joints (e.g. channeling)
  → "system effect" → higher PoF





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ASSESSMENT OF LONG AXIAL CORROSION

Calculation of Pipeline Pressure Capacity

Requirements:

- assessment based on RBPs ✓
- account for potential increase in PoF ✓

DNV Method:

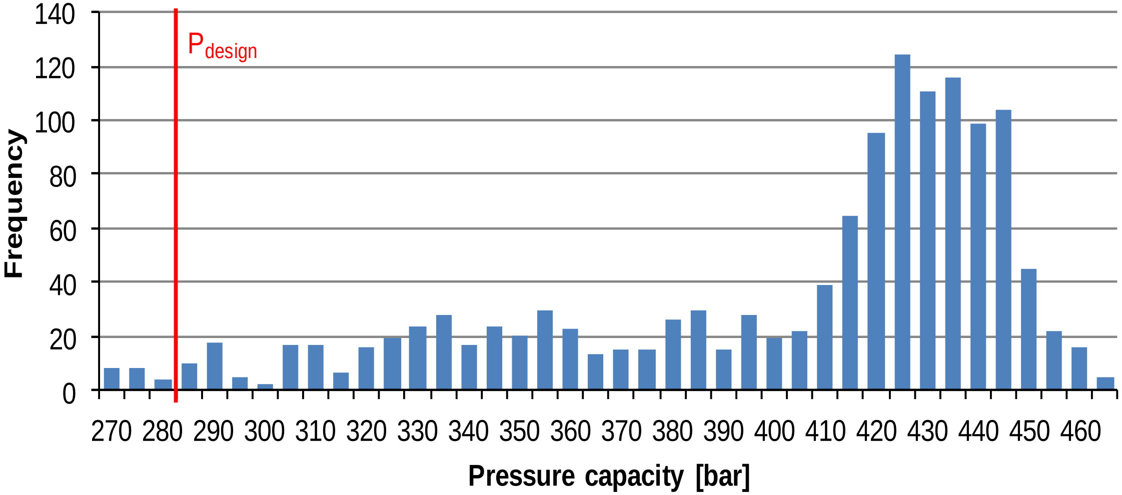
- basis: DNV-RP-F101 Complex Shaped Defects Method (Part A)
- affected area divided into subsections
- P_{safe} calculated for all subsections
- P_{safe}(section i) → PoF(section i) for considered assessment pressure
- total PoF(pipeline) calculated from PoF of all sections i
- PoF(pipeline) vs. max. allowable PoF (safety class)
  → P_{safe}(pipeline)

ASSESSMENT OF LONG AXIAL CORROSION

Calculation of Pipeline Pressure Capacity

Example:

- water injection pipeline affected by channeling corrosion
- assessment based on 190 pipe joints with remaining WT < threshold
- RBPs extracted according to DNV method
- P_{safe} calculated for sections of 1.7m length (DNV-RP-F101 complex)
- P_{safe}(pipeline) = 260 bar
- P_{safe}(worst joint) = 268 bar
- P_{safe}(pipeline) is 8 bar (3%) below P_{safe}(worst joint)
  → system effect
- more joints with low P_{safe}
  → higher system effect



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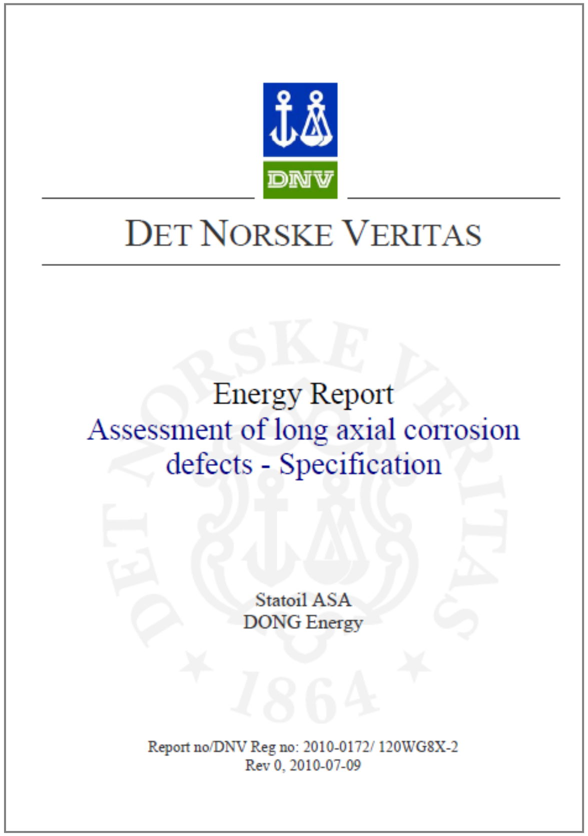
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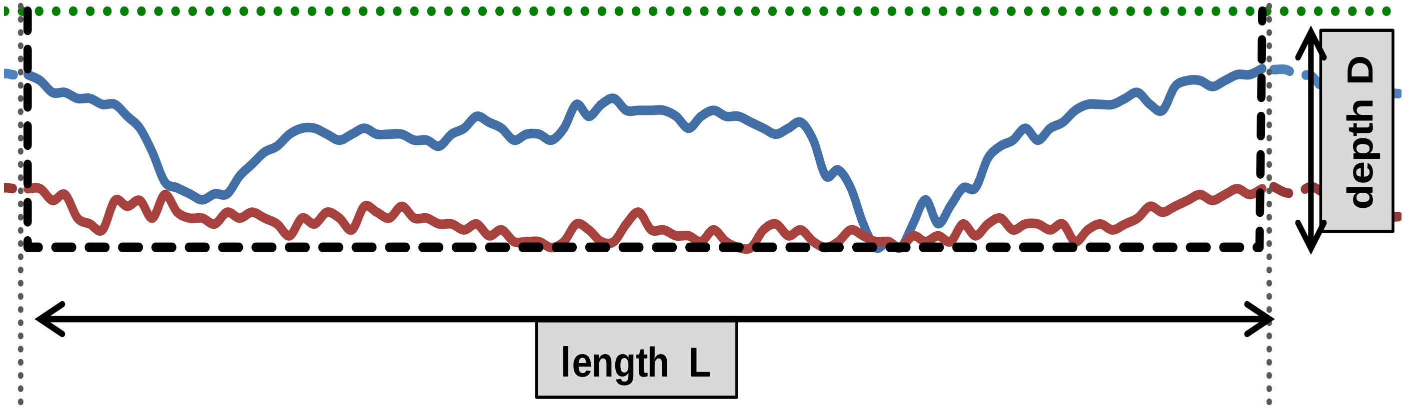
ASSESSMENT OF LONG AXIAL CORROSION

Corrosion Growth Analysis (CGA)

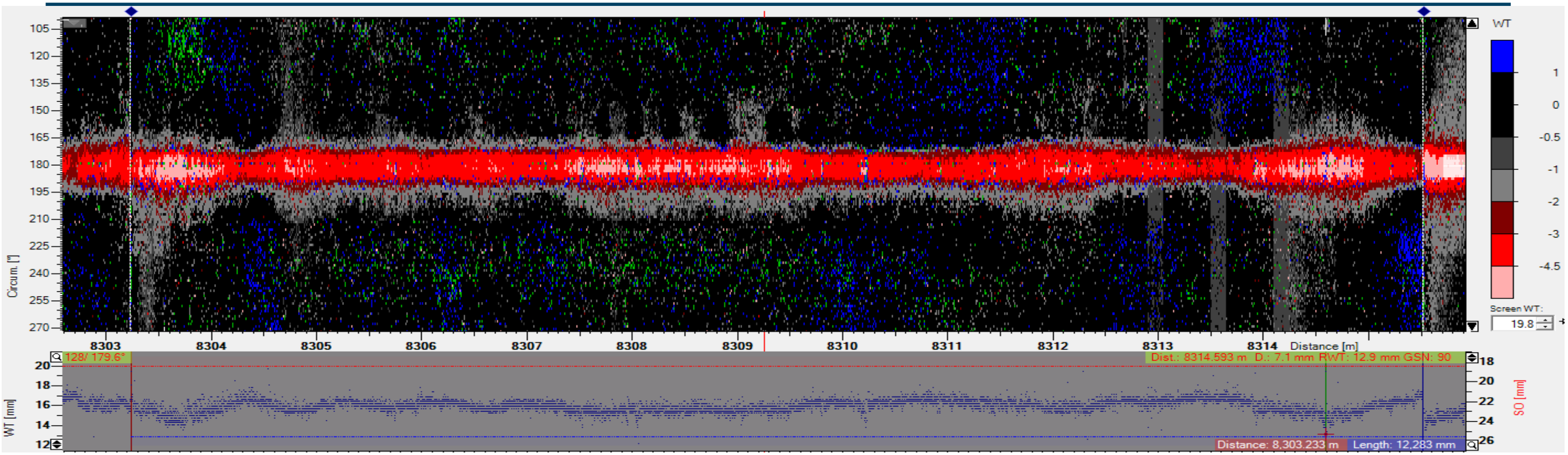
- basis: results of consecutive UT ILIs
- **list-based CGA** (→change in peak depth): not sufficient for long complex corrosion features

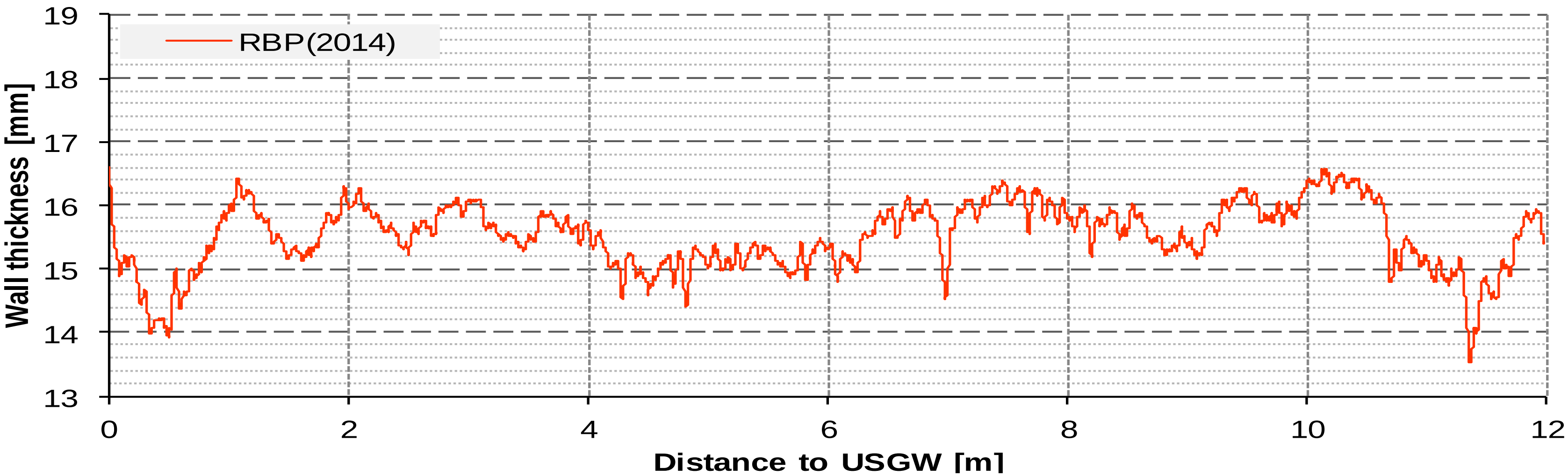


- Level 4 of DNV Method: calculation of corrosion growth rates from comparison of RBPs, i.e. **data-based CGA**

ASSESSMENT OF LONG AXIAL CORROSION

Corrosion Growth Analysis: One Pipe Joint





ASSESSMENT OF LONG AXIAL CORROSION

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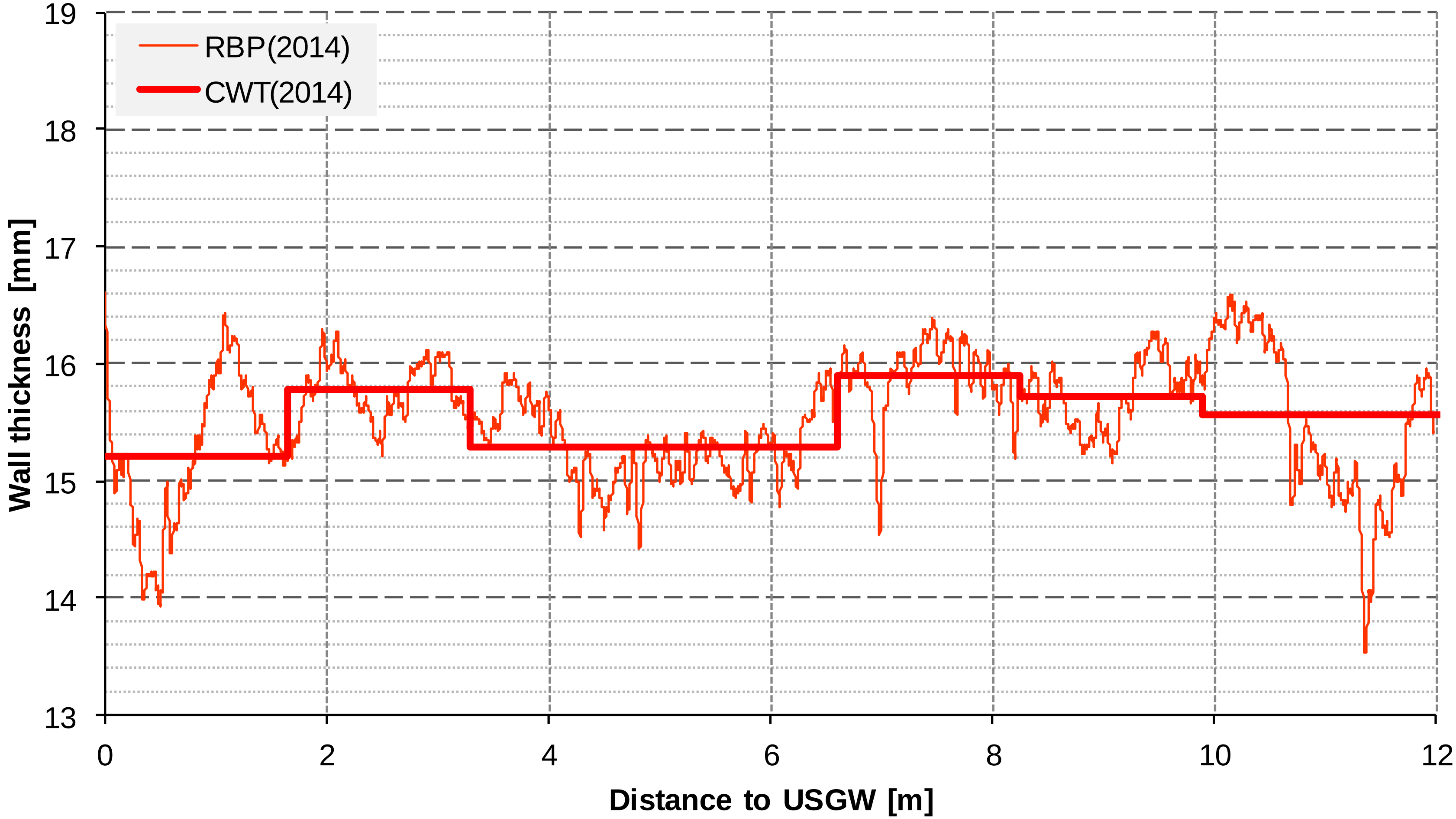

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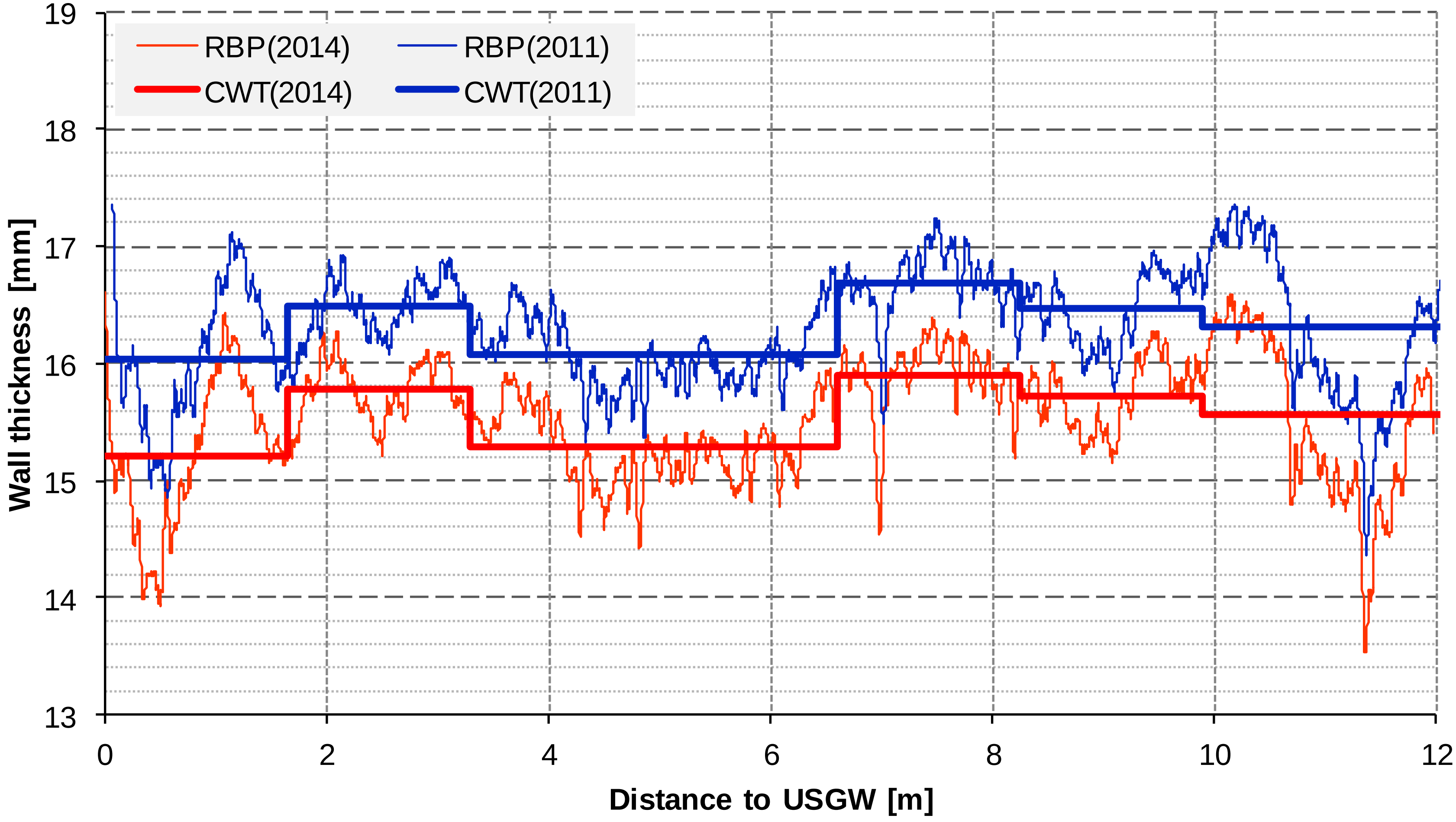

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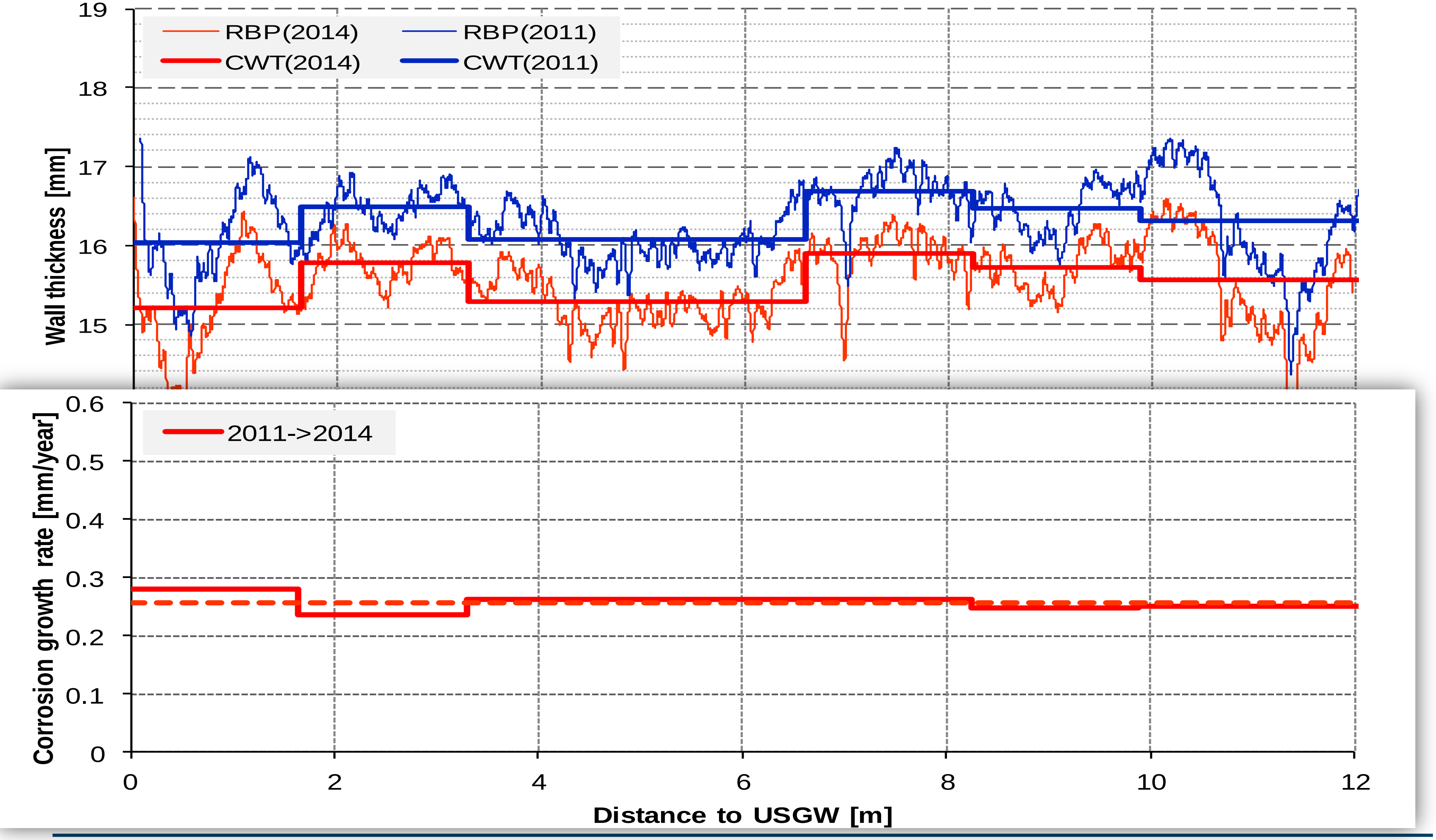

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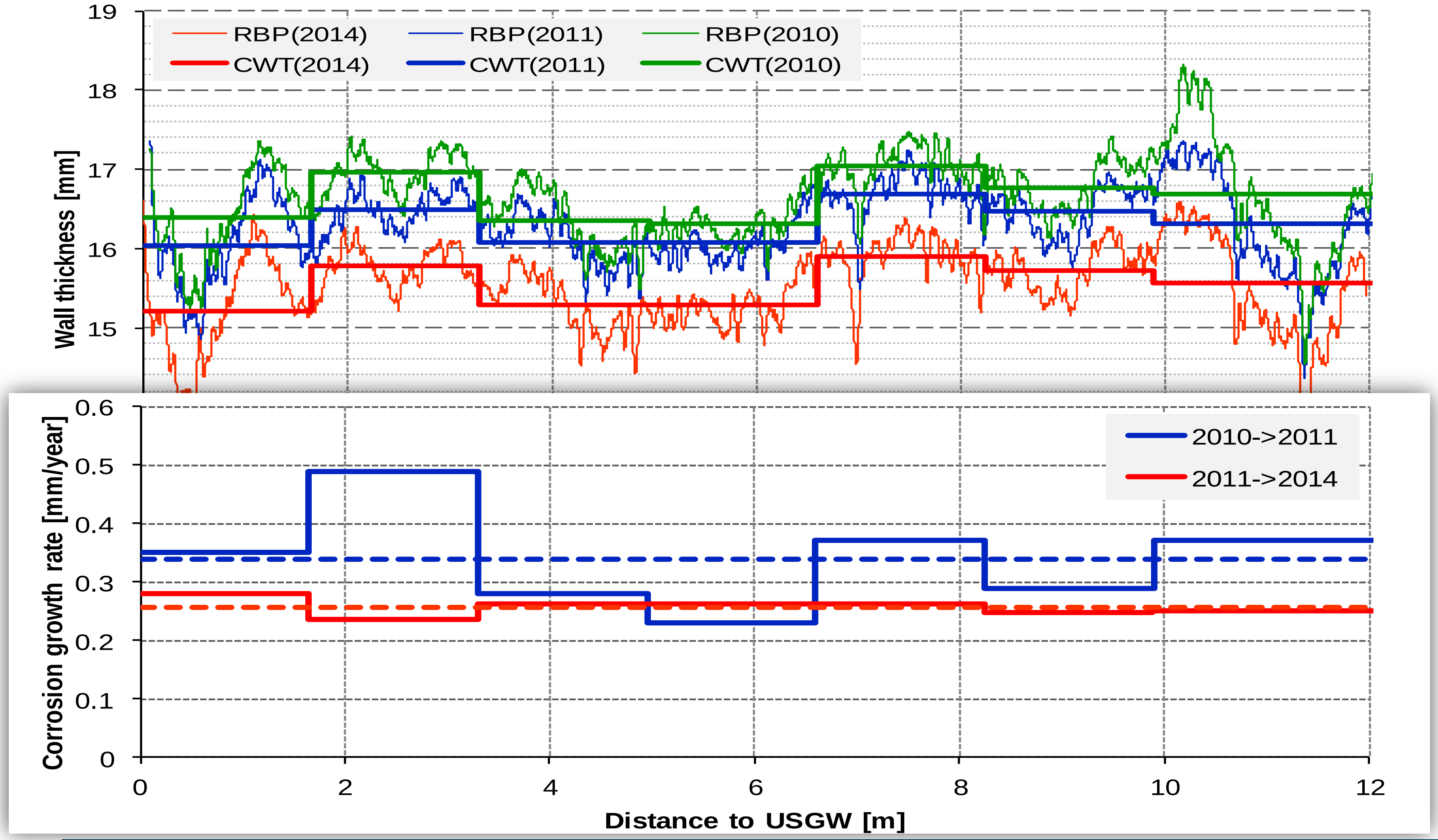
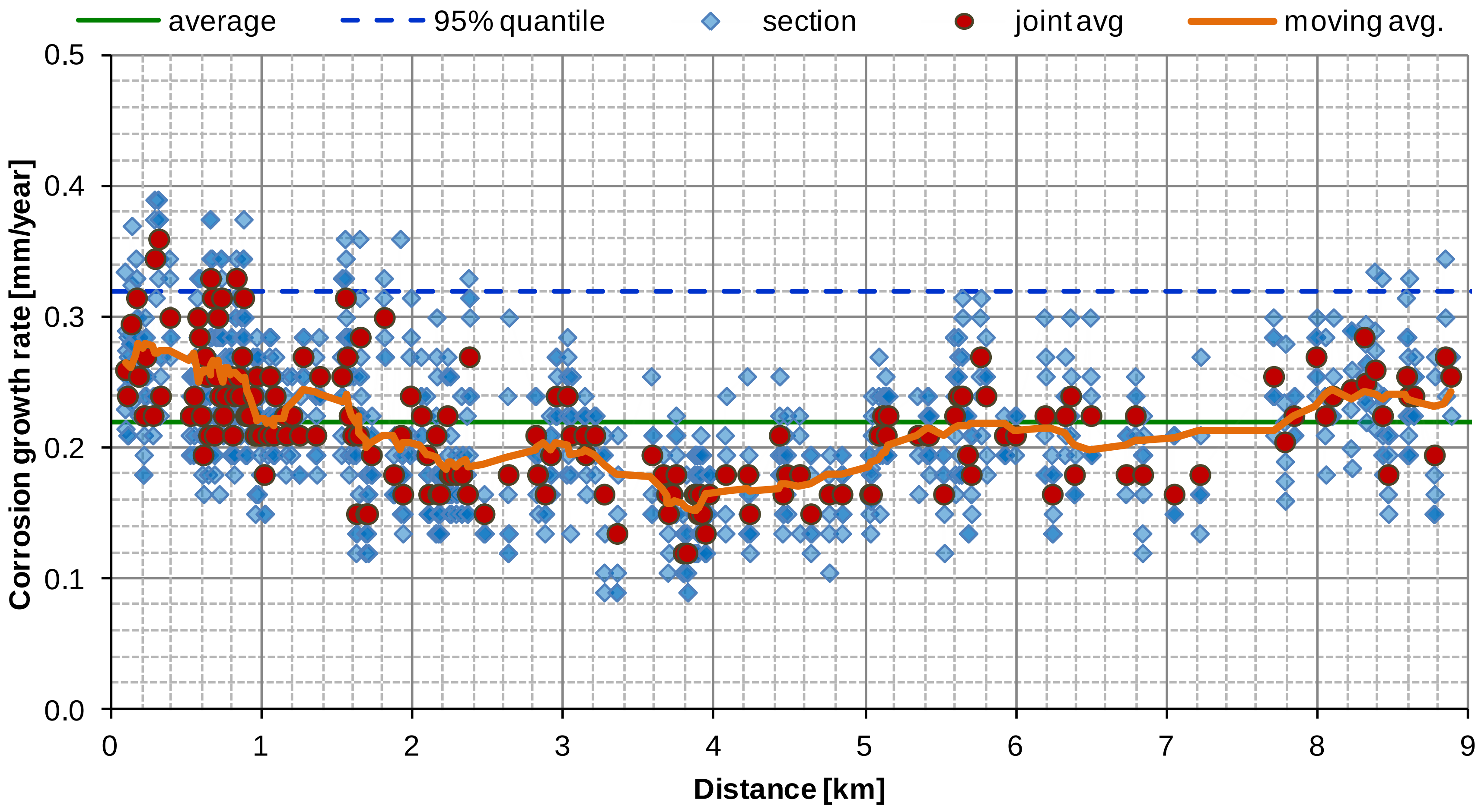


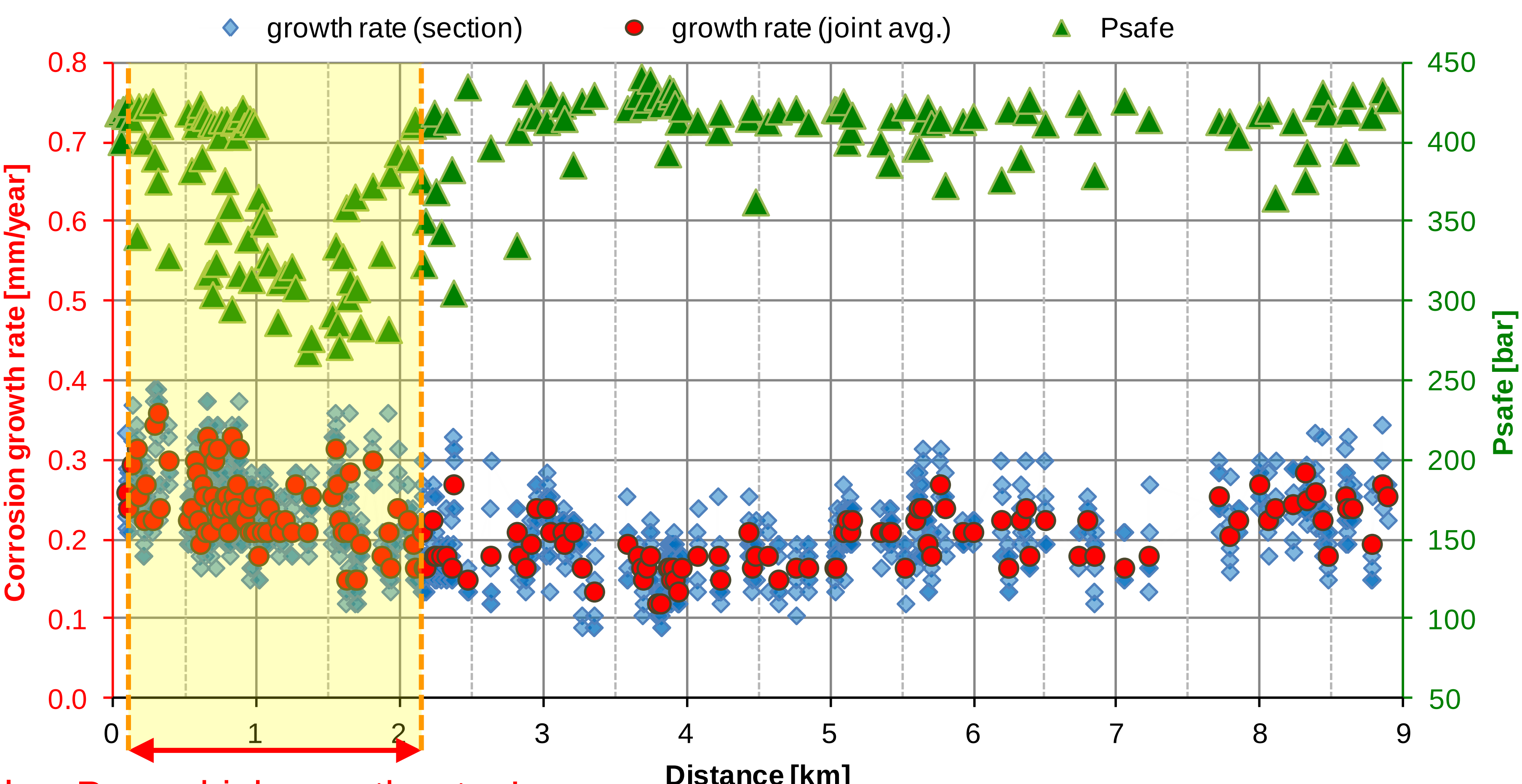
ASSESSMENT OF LONG AXIAL CORROSION

Corrosion Growth Analysis: Results for 190 Pipe Joints



ASSESSMENT OF LONG AXIAL CORROSION

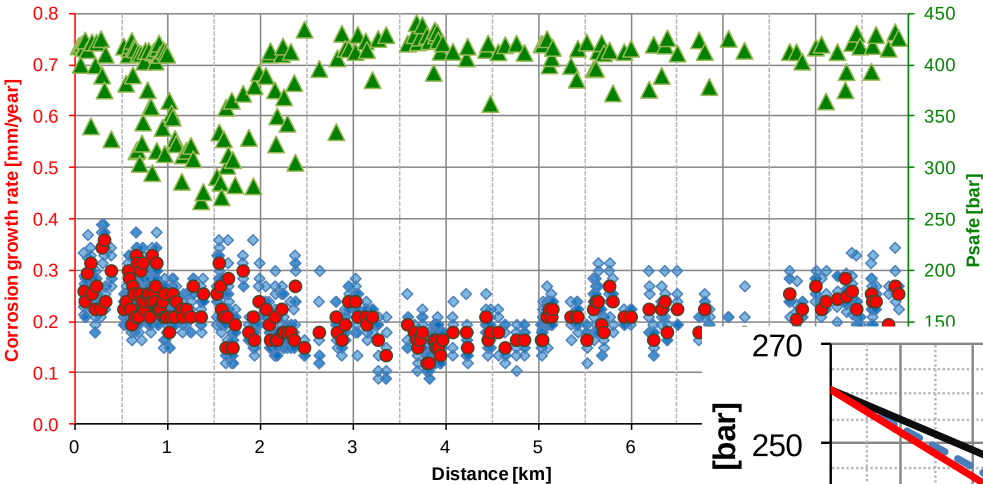
Extrapolation of Pressure Capacity: P_{safe} vs. Growth Rate

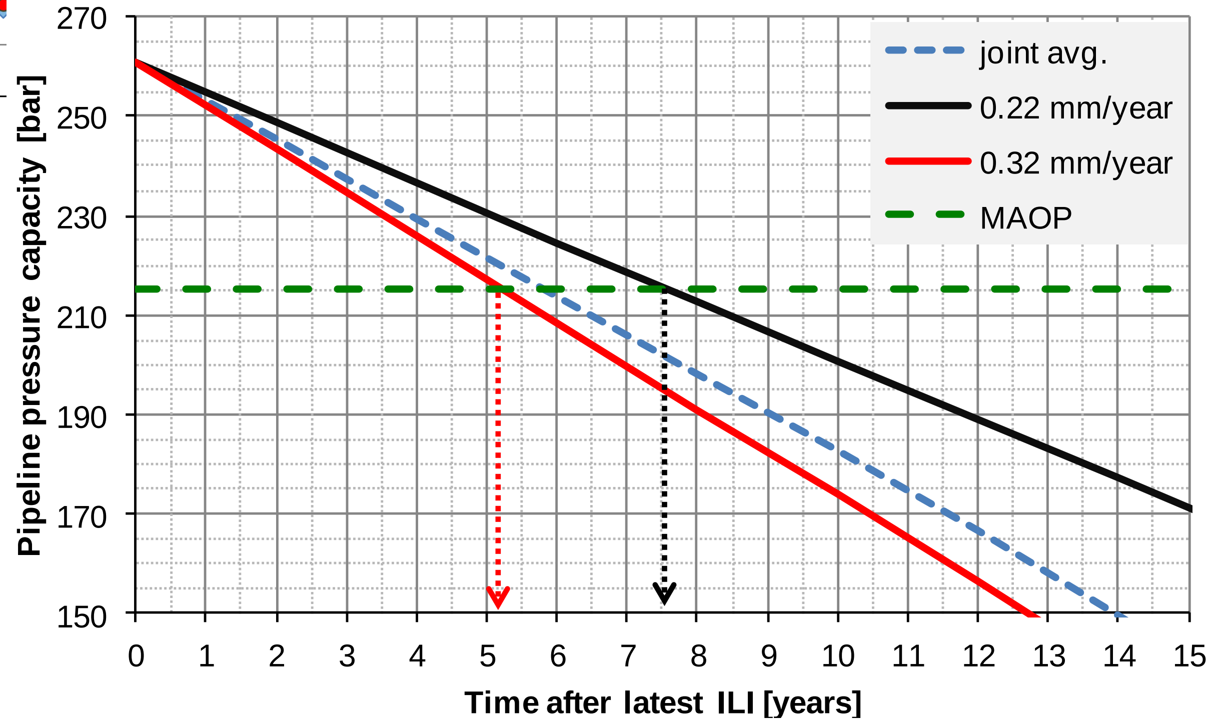


low P_{safe} + high growth rates!

ASSESSMENT OF LONG AXIAL CORROSION

Extrapolation of Pressure Capacity: Results





P_{safe}(pipeline) reaches MAOP
5.2 – 7.5 years after latest ILI

SUMMARY & CONCLUSIONS

- long axial corrosion → impacts on ILI & assessment
- can be reliably detected & sized using UT ILI
- feature list information not sufficient to characterize complex anomalies
  → data-based assessment methods (pressure & corrosion growth) required
- methodology specifically designed for assessment of long axial corrosion was developed by DNV:
  - filtering of WT using SO, especially helpful in case of non-optimum data quality
  - accounts for higher PoF resulting when many pipe spools are affected by severe corrosion
  - NDT experience: DNV method proved good applicability

THANK YOU!

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