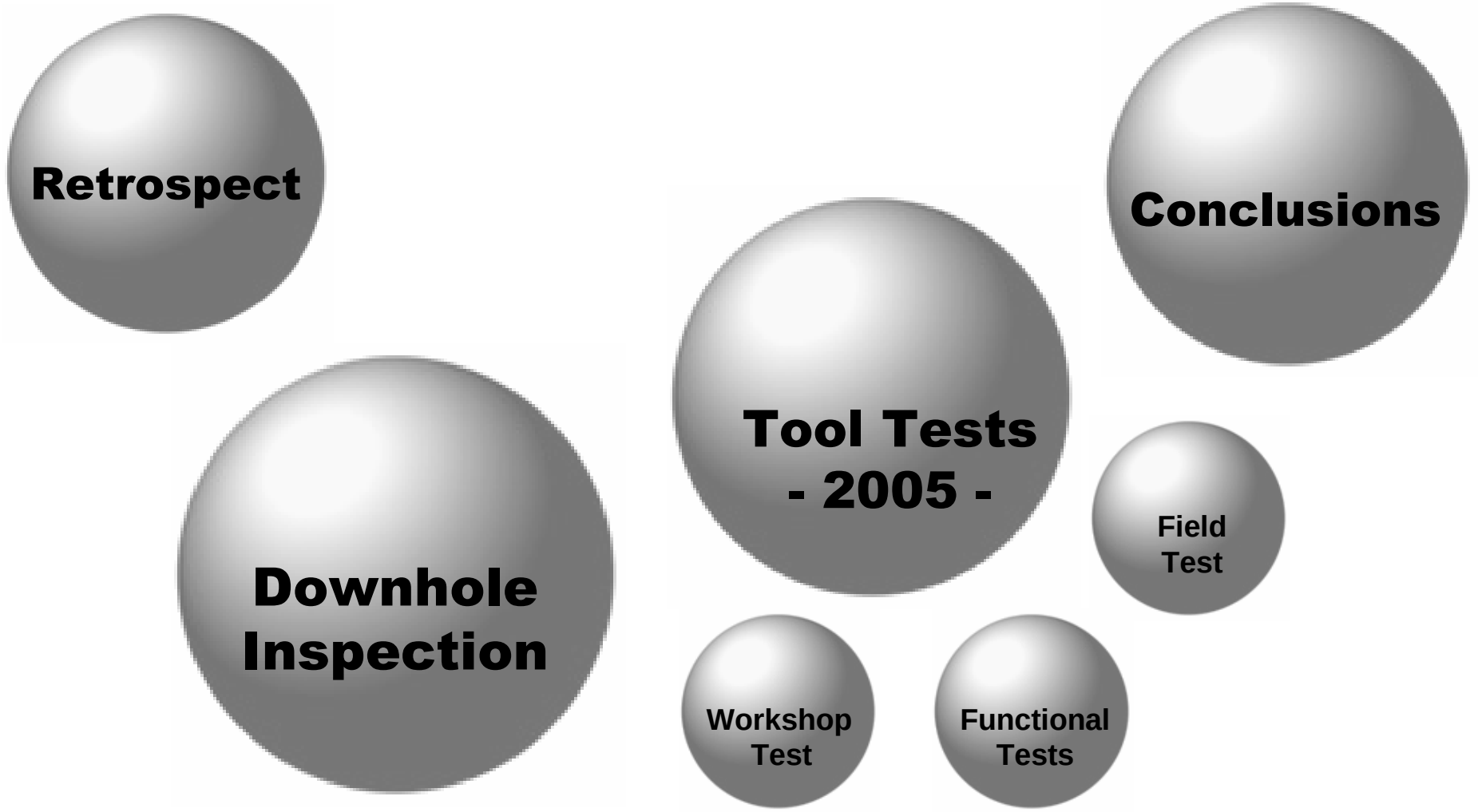
TECHNOLOGY OF INTELLIGENT PIGGING SYSTEMS

NOVEL BOREHOLE- AND TEST PROCEDURES FOR UNDERGROUND GAS STORAGE ASSETS BY USING AN INTELLIGENT PIG FOR DOWNHOLE INSPECTIONS

OUTLINE


Retrospect
Conclusions
Tool Tests
- 2005 -
Downhole
Inspection
Field
Test
Workshop
Test
Functional
Tests

INVOLVED COMPANIES

VNG - Verbundnetz Gas AG
- client

UGS - Untergrundspeicher- und Geotechnologie-Systeme GmbH
- technical processing, project coordination

GE Oil & Gas Pipeline Solutions, PII - Pipetronix
- tool modification, tool-cable-connection

AGR - PipeTech AS
- tool modification, tool-cable-connection

SLB - Schlumberger
- tool-cable-connection

RETROSPECT

- casing integrity affected by flaws (base material/welds)
- cracks (base material/welding areas) vitally important for evaluation of Casings
- existence of evaluation routine by the use of FEM based on survey logging data
- conventional downhole logging offers no information about cracks and weld conditions

RETROSPECT

- aim of VNG – Verbundnetz Gas AG:
  - advancement of methodology
  - use of new tools ➡ more data, higher resolution, higher accuracy
- UGS accomplished a comprehensive research regarding
  - appropriate inspection methods and tools
  - possibility to adapt standard pigging systems (pipeline industry) for downhole inspections
- main requirements for an underground application achieved by an umbilical operated system offered by PII in partnership with AGR

DOWNHOLE INSPECTIONS
- Relevant Flaws -

- possible flaws:
  - corrosion-dependent areal defects
  - cracks within the base material and welds
  - fabrication defects
  - defects due to mechanical loads/operational demands

- main focus (project):
  - detection of metal loss/corrosion
  - crack detection

DOWNHOLE INSPECTIONS
- Technical Requirements For Inspection Tools -

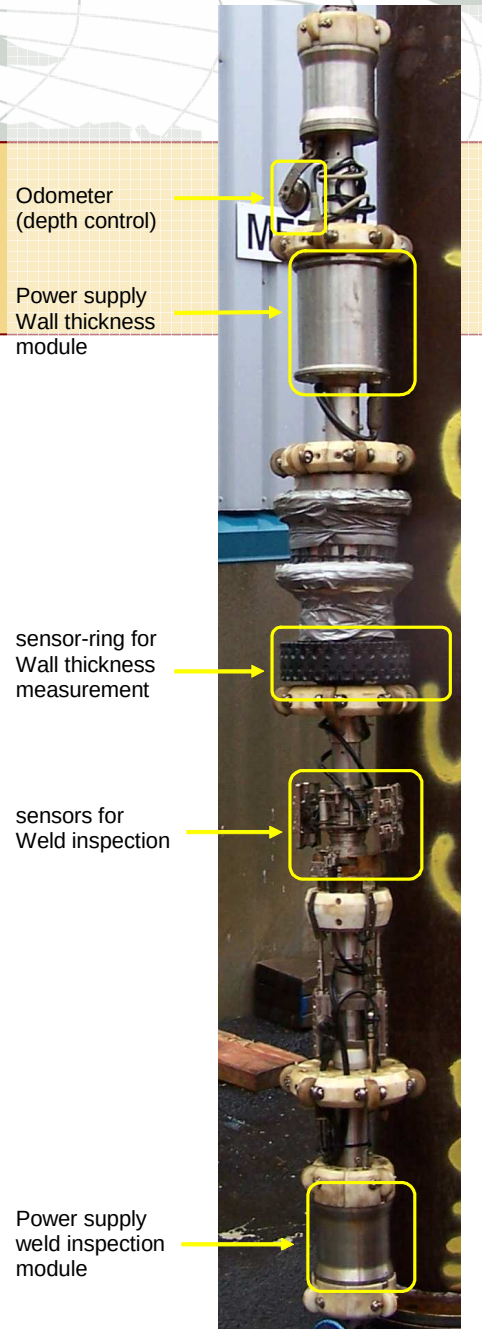
- tool application in an 11 3/4” last cemented Casing
- application over an gas filled storage cavern (back up: 3 packer systems)
- inspected Casing filled with saturated brine
- tool requirements for downhole application:
  - stiff tool configuration
  - standard tool-cable-connection, standard cable head
  - online data-communication
  - max. inspection depth of 600 m

DOWNHOLE INSPECTIONS
- Technical Requirements For Inspection Tools -

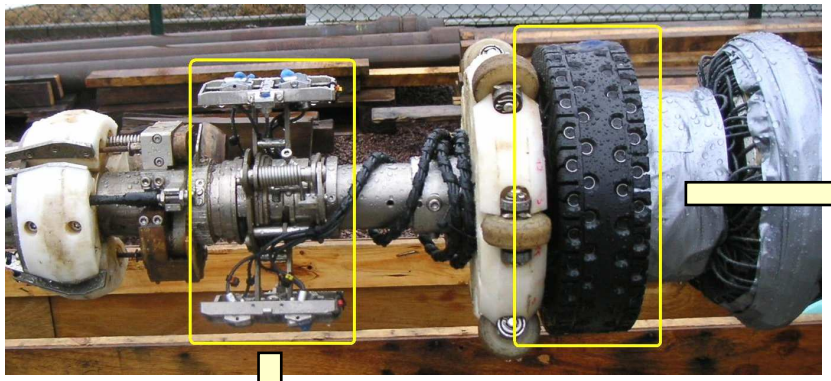
- Tool tests:
  - bi-directional moving (vertical Casing)
  - investigation of present Casing condition
    - Wall thickness, Casing geometry, possible ovalities
  - Investigation of existing defects (base material, welds)
    - detection, sizing of defects
    - designation of defect types
  - documentation, interpretation, evaluation of all measured defects
  - indication of restrictions regarding the inspection method and tool

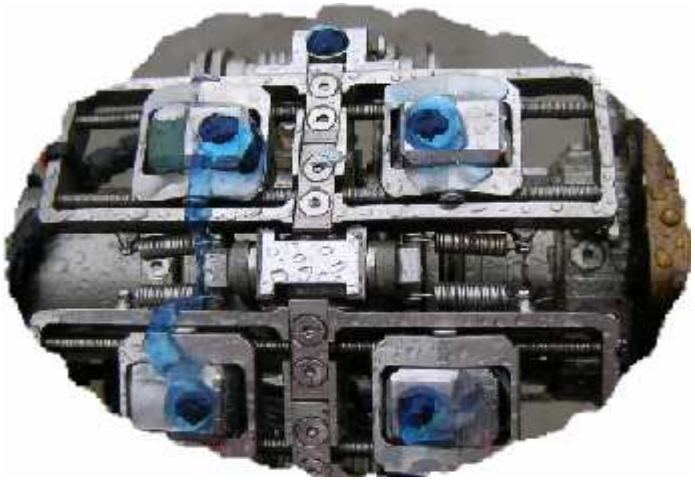
DOWNHOLE INSPECTIONS
- Inspection Tool -

- ICP – Intelligent Casing Pig
- conventional ultrasonic inspection combined with **T**ime **o**f **f**light **d**iffraction
- tool modification from formerly flexible to rigid
- tool consists of 2 modules:
  - module for Wall thickness and corrosion measurement
  - module for circumferential crack detection



DOWNHOLE INSPECTIONS
- Inspection Tool -





DOWNHOLE INSPECTIONS
- Tool-Cable-Connection -

- 1st Test ➡ use of existing cable and tool-cable-connection

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- technical specification, material conditions not suitable for real downhole application; no standard cable head

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- tool adaptation to a standard Wireline-Service incl. functional tests

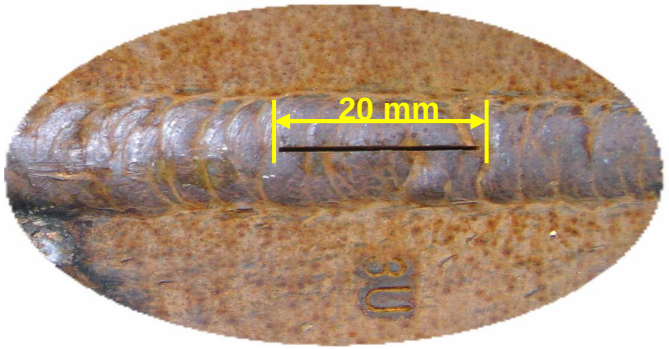
TOOL TESTS 2005
- Workshop Test -

Preparation:

- test casing incl. 3 welds
- artificial defects (base material/welds)

Results:

- bi-directional moving within the vertical test casing
- pass of Wall thickness variations, offsets, eccentricity
- online presentation possible



TOOL TESTS 2005
- Workshop Test -

Wall thickness measurement:

- weld identification
- detection, localization, sizing of defects
- differentiation into several defect types
- documentation, interpretation, evaluation of measured defects
- comparison between actual and measured defects

Crack detection/weld inspection:

- inspection of all 3 welds
- detection, localization, sizing of defects
- partly differentiation into defect types
- number of placed defects ≠ number of measured defects

TOOL TESTS 2005
- Functional Tests -

- first downhole application ➡ meet safety regulations

Tests performed:

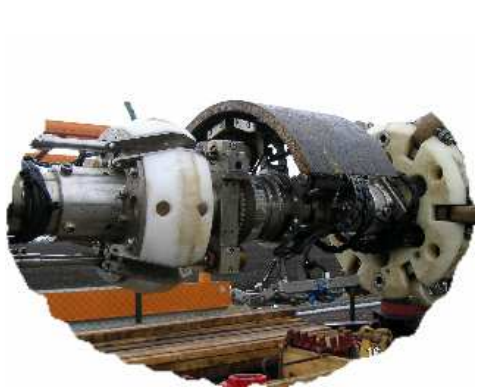
1. 1st adaptation test – verification of the mechanical/electrical tool-cable-connection
2. Pressure test – proof pressure resistance of the whole inspection system at a max. test pressure of 85 bar
3. Final functional test – verification of the complete tool functionality after performing the pressure test

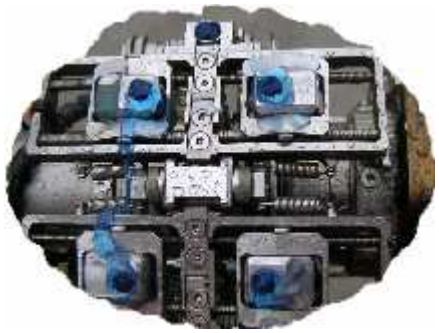
TOOL TESTS 2005
- Field Test -

- test objectives equal to initial mentioned tool requirements for inspections
- final tool check at the test-site

⬇ TOOL ACCEPTANCE ⬇

- tool and software optimizations





TOOL TESTS 2005
- Field Test ● Test Assembly -

⬅ ICP – inspection tool

Wireline-Service ⬇

lubricator system incl.
⬇ cable preventer ⬇

TOOL TESTS 2005
- Field Test -

Results:

- bi-directional moving trough a vertical casing
  ➡ few restrictions in movement
- pass of Wall thickness variations, offsets, eccentricity
- max. inspection depth: 540 m
- tool-cable-connection mechanically / electronically functional
- selective data transfer ➡ simplified online presentation
- tool restrictions due to pressure increase

TOOL TESTS 2005
- Field Test -

Wall thickness measurement:

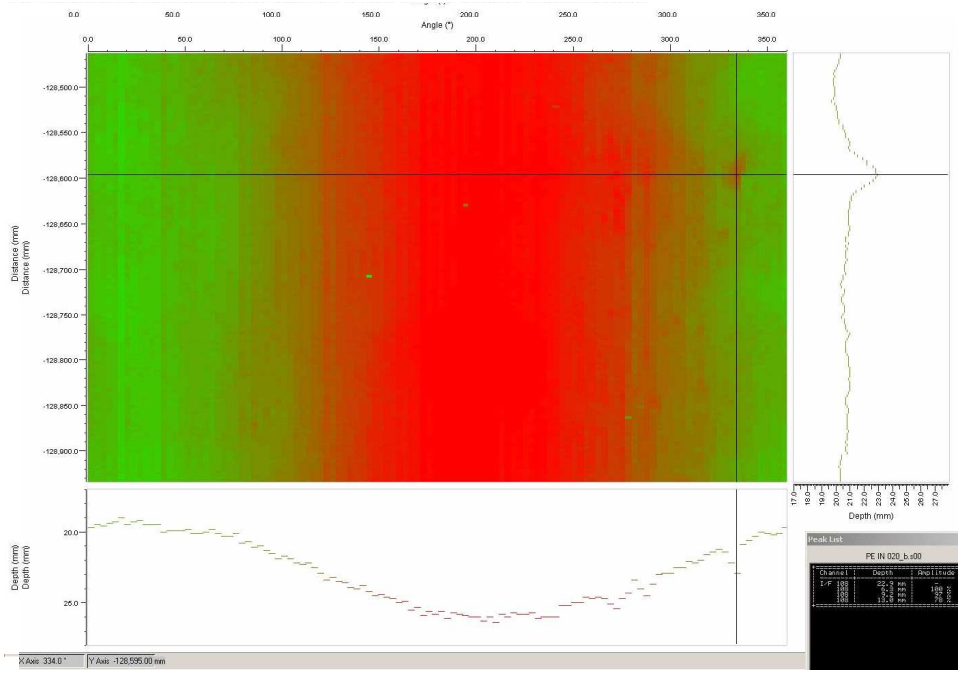
- weld identification
- detection, localization, sizing of selective/areal defects
- documentation, interpretation, evaluation of defects

Crack detection:

- partly inspection of welds
- tool restrictions due to pressure increase

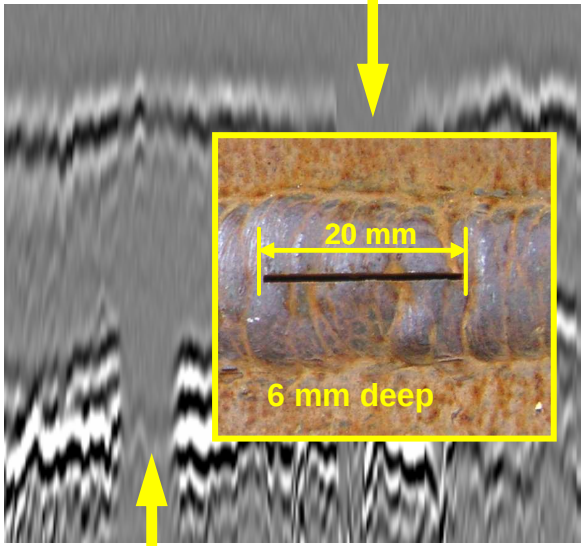
TOOL TESTS 2005
- Examples for Wall Thickness Measurement -

- weld detection
  (Wall thickness view)
- weld detection
  (standoff view)
- dent detection
  (standoff view)
- external wall thinning
  (Wall thickness view)
- internal wall thinning
  (standoff view)



TOOL TESTS 2005
- Examples For Crack Detection -

crack opened to the interior surface

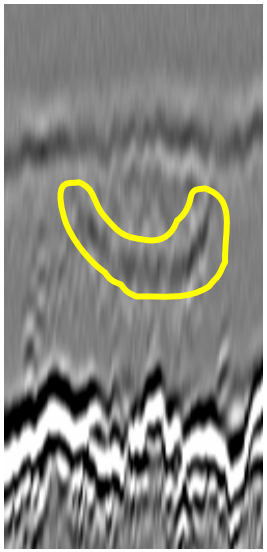


crack opened to the exterior surface

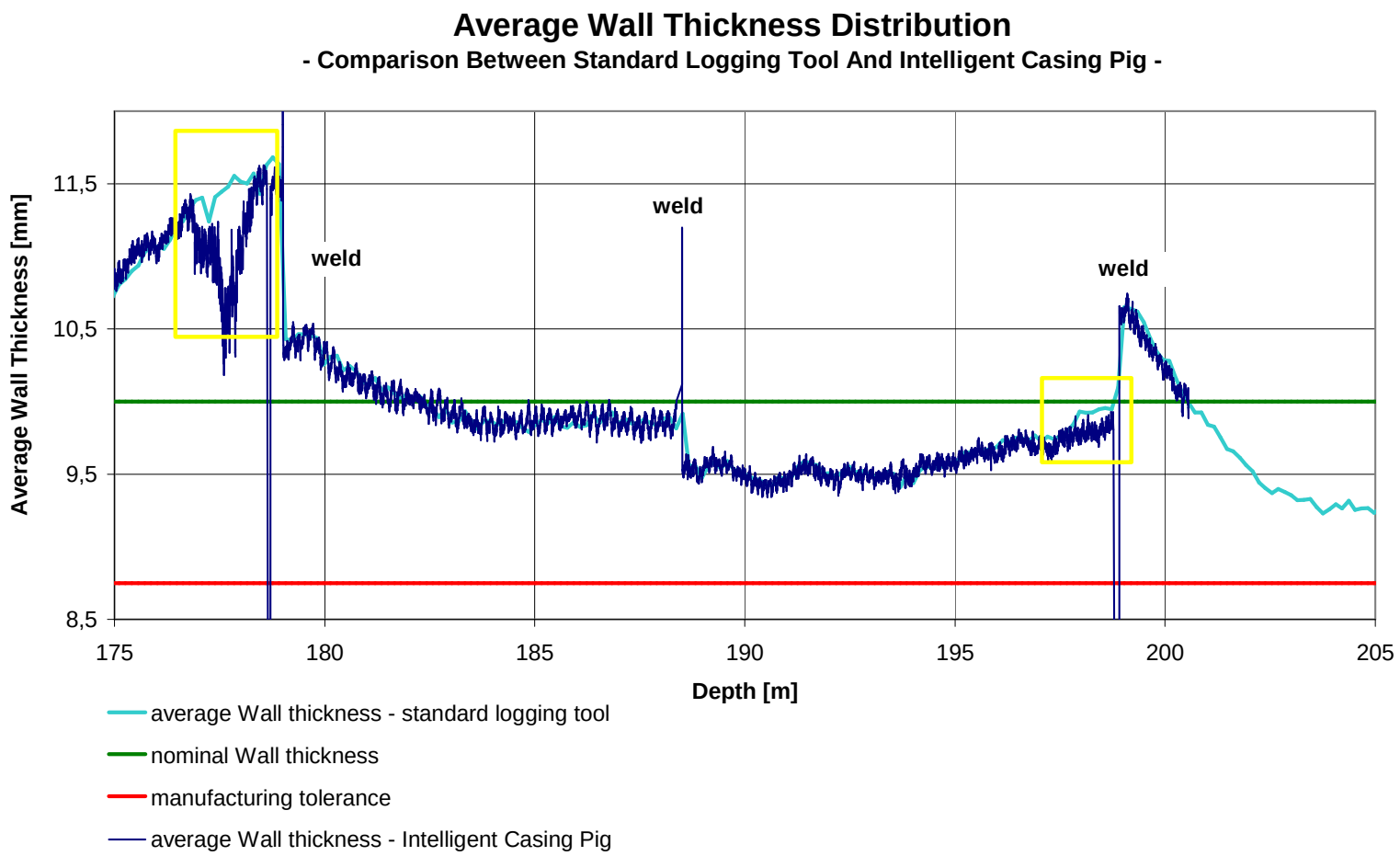
lateral wave

backwall echo

internal defect (embedded)



TOOL TESTS 2005
- Field Test -



CONCLUSIONS

- tool-connection to standard Wireline-Service build/tested
  ➡ defined rated break point within standard cable-head
- bi-directional movement proved (Workshop/Field Test)
  ➡ optimization by increasing tool weight
- tool and software optimization necessary
- reference measurements
- comparison between different inspection tools
- compensation of measured defect against actual defects necessary

CONCLUSIONS

- adaptation of standard pigging systems for Downhole inspections basically possible
- appearance of tool restrictions (Workshop/Field Test)
  ➡ basis for tool/software optimization

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inspection of a production string

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removal production string/material tests

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REALISTIC EVALUATION OF ICP

CONCLUSIONS
- Project Progression -

- modification/optimization of tool and software
- smaller tool dimensions (applications in greater depths)
- continuous circumferential crack detection
- development of tool module for axial crack detection
- further field tests (production strings)

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UPDATE OF EXISTING EVALUATION STANDARDS

THANK YOU !