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All Around You

Pipeline & Specialty Services

Development of a pig based inspection tool utilising MAPS stress measurement technology

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Introduction

- Weatherford P&SS have developed a technique to determine absolute biaxial stress in pipelines using a magnetic measurement technique
  - Measurement technology licensed from ESR Technology (formerly AEA's engineering safety and risk group)

MAPS Basics

- What is MAPS?
  - Technique for direct measurement of stresses in ferromagnetic material
  - Alternating magnetic field induced in material
  - Amplitude and phase of induced field measured
  - Gives measurements of magnetic parameters
  - Determination of principal axis stress values from these parameters

MAPS - In-line Inspection

What is it?

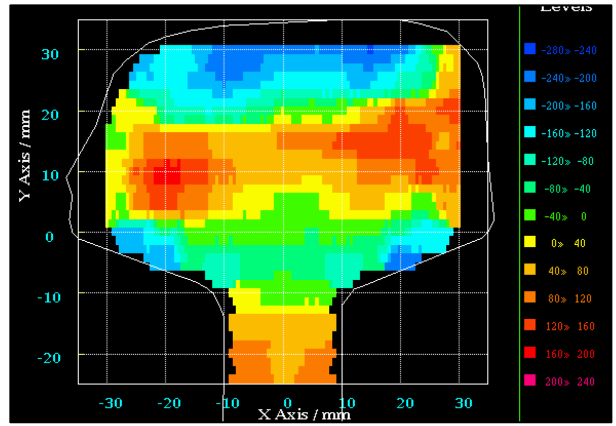
- A new type of intelligent pig that measures true stress in the pipeline
- Measurement technique originally developed by the UK Atomic Energy industry for North Sea offshore, also used in automotive and aerospace industries

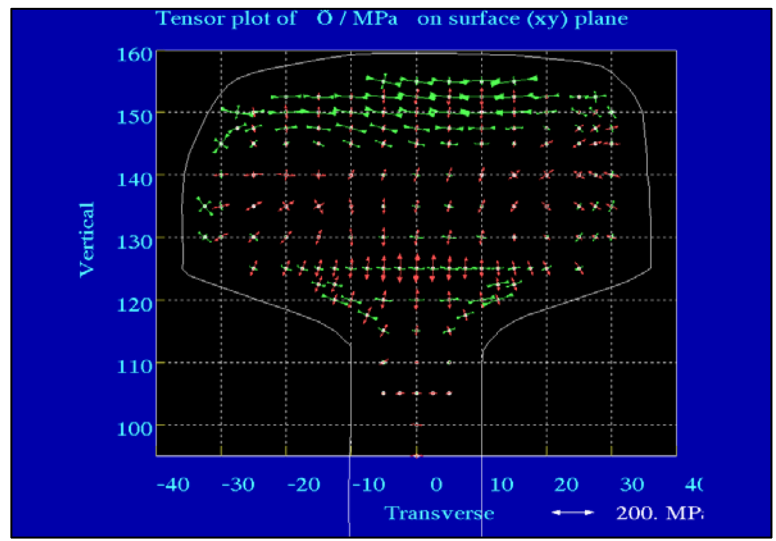
Why are we interested?

- Pipeline operators are keen to know how highly stressed their pipelines are
- There are no easy ways of doing this currently available

MAPS

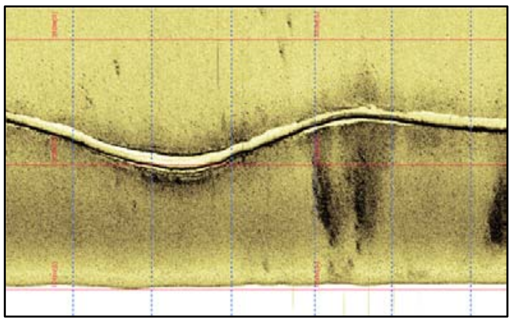
- Other applications - detecting Flaws in railway tracks

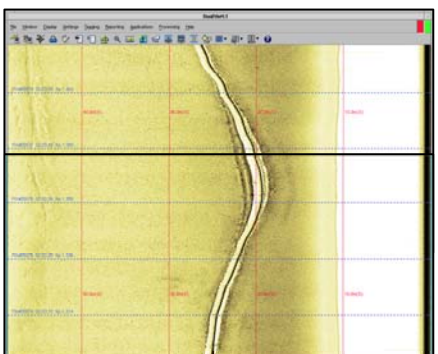




MAPS

- Why measure stress in a pipeline?
  - Pipeline movement can cause major increases in bending stresses
    - Washouts, frost heave, spans, lateral buckles

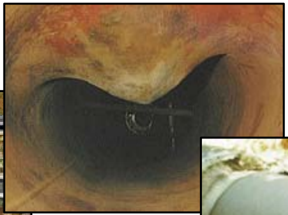


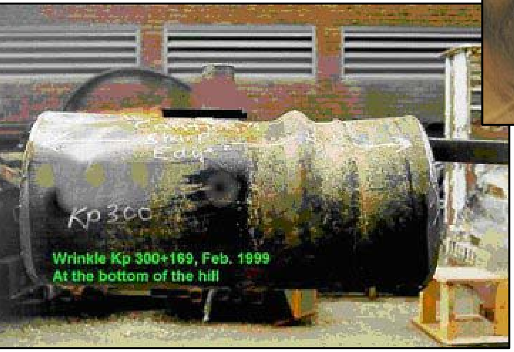


MAPS

- Why measure stress in a pipeline?
  - Metal loss (corrosion) results in higher stresses in the pipe wall
    - Cracks, pitting, general metal loss

  - Mechanical damage (dents etc) increases stress locally





MAPS in Static Applications

- Non-contacting probes
- Measurement of average biaxial stress value over area of probe
- Frequency dependent depth of penetration
  - 0.15 to 7mm

Validation of Static Measurement

- Accuracy of 10-20 N/mm achievable, down to less than ±1 N/mm under optimum conditions
- Previously Tested for Static Applications
  - Against strain-gauge techniques
  - Against X-ray diffraction

MAPS - Dynamic Measurement

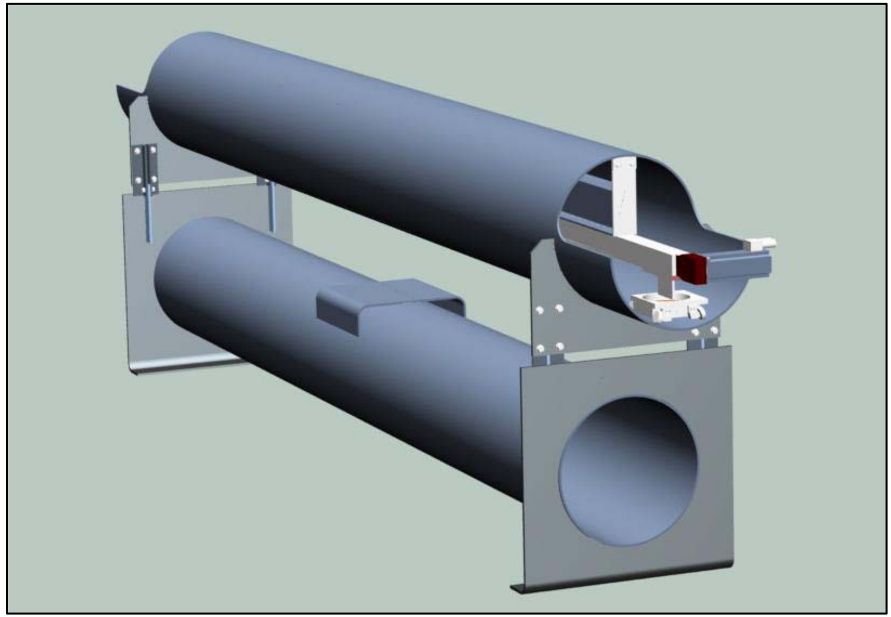
- In-line inspection requires:
  - Ability to correct for magneto-dynamic effects at normal pigging speeds
  - Ability to take readings rapidly enough to provide meaningful axial resolution
  - Three simultaneous measurements to resolve stress components

Aims of Dynamic Test Work

- Test program aimed at demonstrating dynamic capture of MAPS data.
  - Measurement of stress distribution along pipe
  - Detection of applied load
  - Demonstration of repeatability of measurement
  - Characterisation of dynamic effects

MAPS

- Previous work
  - 6 metre length of 24” pipe
  - Stress the pipe with a hydraulic jack
  - MAPS sensor on trolley
  - Move trolley at speeds up to 4 m/s
  - Compare results with strain gauge measurements



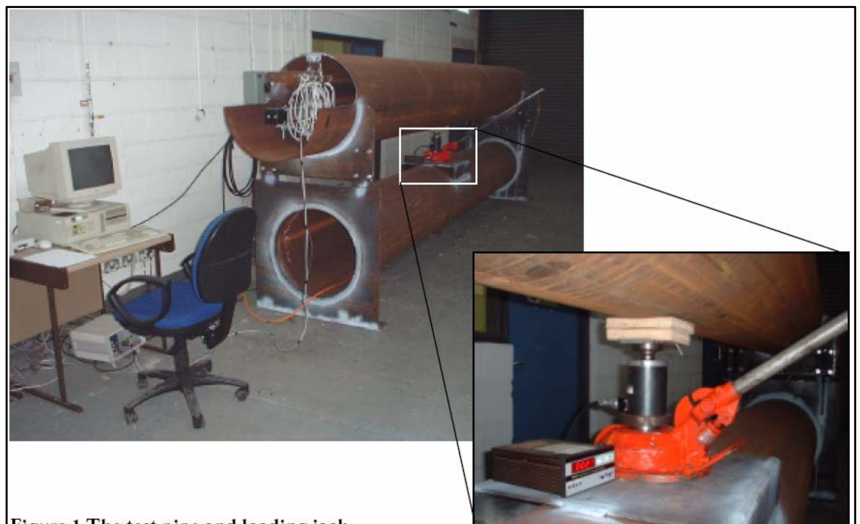
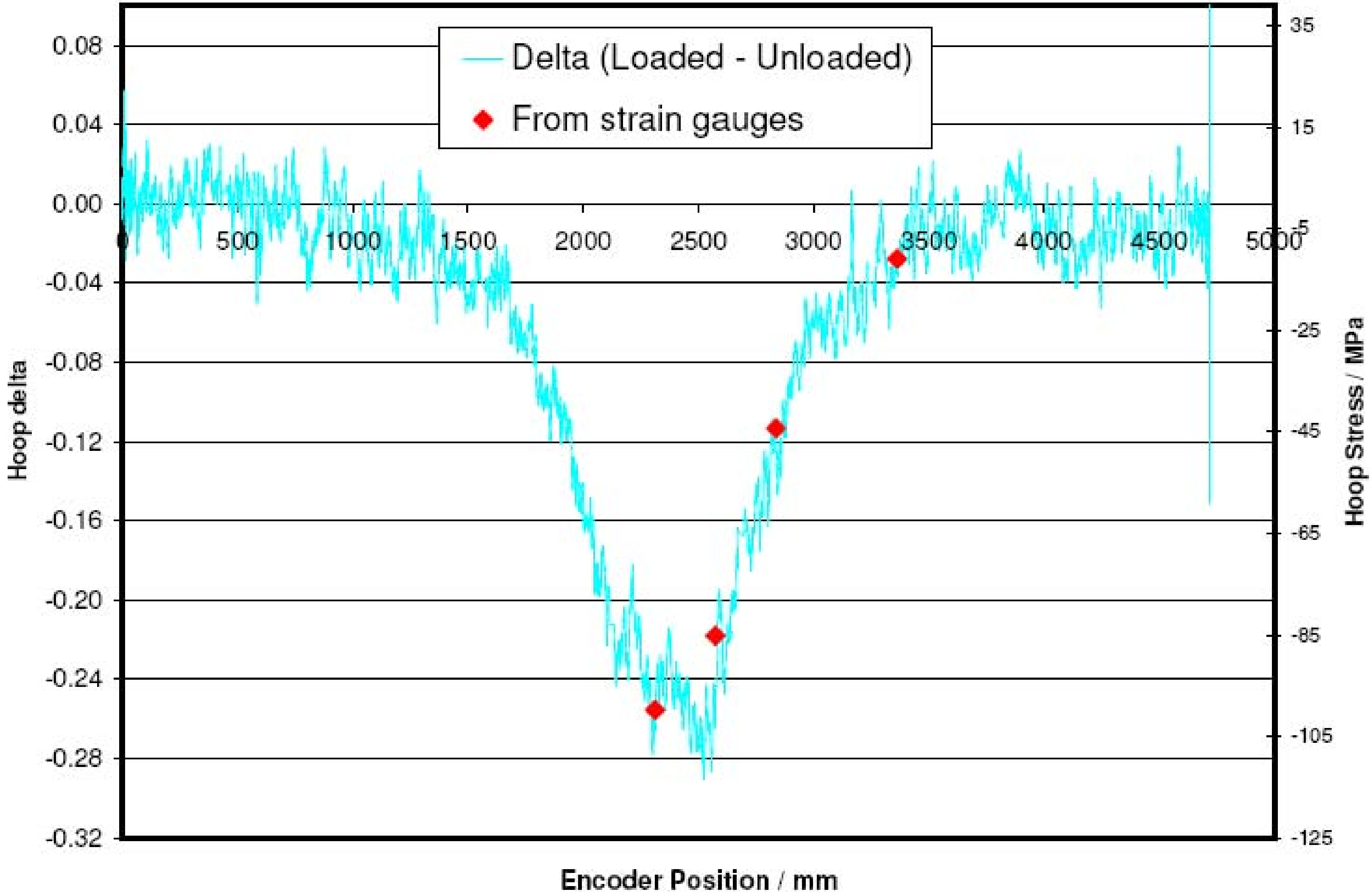


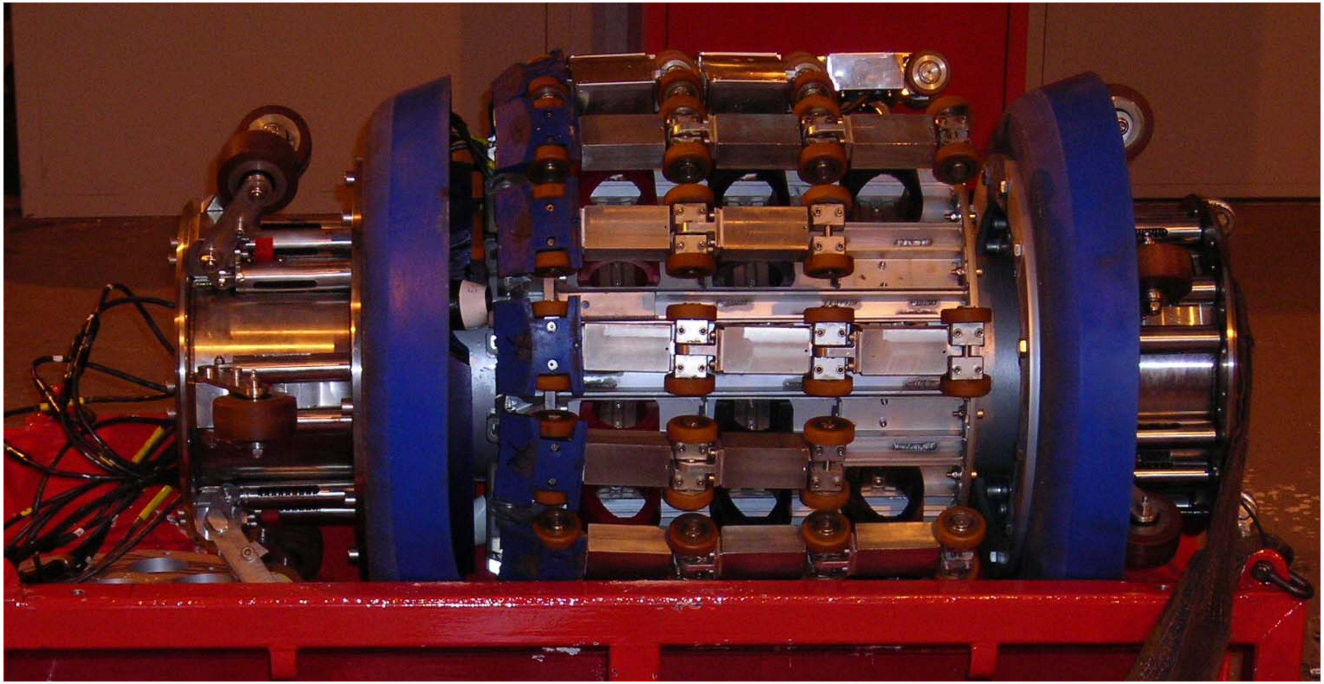
Figure 1 The test pipe and loading jack

Direct Measurement of Stress



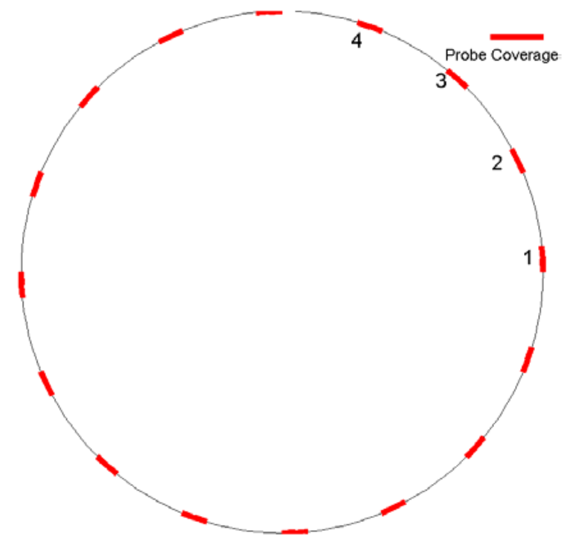
Prototype Tool Build

- Prototype specification
  - 24” diameter
  - Partially populated with sensors, 2-3mm standoff
  - Full specification for environment and range



Prototype Requirements for Field Testing

- 24” prototype pig
- 25% coverage of pipe wall from 16 sets of probes.
- Probe standoff – minimal, 1-2mm.
- Suitable to be part of, or used as a commercial tool.



Tool Design Requirements

- Environmental Capability
  - Compatible with upstream oil and gas pipeline products, with normal levels of CO_2 and H_2S
  - Operating Temperature -10ºC to 50ºC
  - Operating Pressure 200 bar max
  - Operating Range 72 hours

Bending Stress Testing

- Pigging Loop
  - 24” X60 pipe
  - 34m test section
  - 0.4m/s to 1.1m/s
- Two main aims:
  - Demonstrate piggability
  - Demonstrate stress measurement

Test-loop layout

Applying Stress

- Bending Stress applied by lifting pipe
- Measured by
  - Height of lift
  - External strain-gauging
- Max stress of approximately 40% of yield applied

Hoop-stress Testing

- Rig modified for pull-through
- Wire-line unit used to pull pig through pressurised line
- Allows imposition of realistic hoop-stresses (up to 30% yield)

Hoop-stress test set-up

Outcomes

- Setup allowed successful testing of the pig
- Mechanical design assessed
  - Robustness
  - Performance
- Measurement System assessed
  - Accuracy
  - Repeatability

Future Programme

- Detailed assessment of test results
  - Calibration
  - Comparison with external measurements
- Preparation of tool for field trials
  - Mechanical refinements
  - Sensor population