Pressure Wave Analysis
Streamlines Pipeline Pigging

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Pipeline Operators Objectives and Challenges

- Achieving balance for peak returns
  - Maximise asset performance
  - Minimise maintenance cost
  - Minimise risk

- Debris can build-up overtime
  - Bore restriction impact business performance
  - Risk of full blockage if not managed properly

- Significant effort and resource by Operators into determining pipeline conditions and maintaining their assets
State of the Art Technologies Available for Deposit Assessment

- Accurate upfront diagnostics information required for:
  - Better planning
  - Reduce remediation time, cost and risk

<table>
<thead>
<tr>
<th>Technologies</th>
<th>Advantages</th>
<th>Disadvantages</th>
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</thead>
<tbody>
<tr>
<td>Pressure and flow monitoring</td>
<td>Minimal operational requirement</td>
<td>Only basic knowledge gained</td>
</tr>
<tr>
<td>Theoretical modelling</td>
<td>No operational requirement</td>
<td>Theoretical and relies on assumptions</td>
</tr>
<tr>
<td>Debris mapping pigs</td>
<td>Accurate</td>
<td>Access constrained Intrusive</td>
</tr>
<tr>
<td>Camera inspection</td>
<td>Visual and easily interpreted</td>
<td>Localised measurement Intrusive</td>
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<tr>
<td>External scanning</td>
<td>Accurate Non-intrusive</td>
<td>Localised measurement Time consuming for long system Access constrained</td>
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Halliburton solution: Pressure Wave

DEPOSIT PROFILING
A pressure wave (the pulse) is created at one end of the pipe.

This wave travels in the pipe at the speed of sound while returning a reflected signature wave corresponding to features in the pipe:
- Barriers to flow partial or complete
- Changes in medium (phase, density)
- Leaks

Blockages position, deposit profile, and leaks are then estimated by analysis of the signal response
Data Collection

- Single person operation
- Minimal equipment
- Simple setup
- Non-intrusive
- Fast execution

- Engineer / model
- Induce pulse
- Record reflections
- Repeatable survey
- Transmit data
- Perform analysis
- Report findings
Analysis and Results

- Determine fluid properties and pulse velocity profiles
- Apply pressure and temperature gradients
- Normalise datasets
- Simulate clean pipeline
- Apply proprietary algorithms
- Extrapolate deposit profile
- Issue detailed results
Application During Planning

- Significant effort necessary to plan cleaning
- Planning performed for worst-case scenario:
  - Theoretical understanding of pipeline condition
  - Risk / fear of blockage
  - Unnecessary resources
  - Large number of pig types and quantity
- Clear information about the pipeline condition allows:
  - Assessing piggability
  - Better planning pigging program
  - Determining chemical treatment requirements
  - Identifying debris handling needs
Case study 1

- 10” x 23.5 km condensate export pipeline
- Production started in 1997, no pigging maintenance since first oil
- ILI required by Authority to prepare end-of-life

How would you prepare the pipeline for running an ILI?

- Pressure Wave Analysis
- Minimum effort required to clean the line
- Successful ILI and conclusive data
Application During Operations

- Conservative approach often considered
  - Reduce flowrate to adjust pig speed
  - Operation team fully focused on pigging

- Monitoring methods are flawed:
  - Rely on Subject Matter Expert
  - Pig condition assessment is subjective
  - Received volume of debris can be washed away by the pipeline flow or during pig trap flushing before opening

- Pressure Wave analysis allows:
  - Non-subjective decision criteria
  - Measurement of remaining debris in actual pipeline
  - Clear and fast decisions on effectiveness of the pigging program
Survey Allows Optimisation of Pigging Campaign

Pigging programs can be optimised

- Understanding of starting pipeline conditions may remove the need for undersized / non-aggressive pigs.
- No requirement for debris assessment caliper tool
- Potential significant reduction in the number of cleaning pigs necessary

Additionally:

- Ensures cleaning has progressed to the level necessary to help prevent a failed ILI run.

<table>
<thead>
<tr>
<th>Pig Type</th>
<th>Pig Description</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>Gel pig</td>
</tr>
<tr>
<td>2</td>
<td>80% ID Medium Density Foam Pig</td>
</tr>
<tr>
<td>3</td>
<td>80% ID High Density Foam Pig</td>
</tr>
<tr>
<td>4</td>
<td>100% ID Medium Density Foam Pig</td>
</tr>
<tr>
<td>5</td>
<td>Foam Caliper Tool</td>
</tr>
<tr>
<td>6</td>
<td>95% ID Bi-Directional Cleaning Pig</td>
</tr>
<tr>
<td>7</td>
<td>100% ID Bi-Directional Cleaning Pig</td>
</tr>
<tr>
<td>8</td>
<td>100% ID Bi-Directional Cleaning Pig c/w Wire Brush</td>
</tr>
<tr>
<td>9</td>
<td>100% ID Bi-Directional Gauge Pig</td>
</tr>
<tr>
<td>10</td>
<td>Inline Inspection Tool</td>
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</table>
Case Study 2

- 20” x 25 km multiphase export pipeline
- Stuck pig 40 days after 1st oil!
- Progressive pigging campaign post stuck pig recovery, short time window available

➤ How would you optimise the pigging campaign without compromising safety?

- Initial Pressure Wave Analysis during the planning stage
- 51 pigs and 18 types procured for the project
- Various deposit assessments during pigging campaign
- Line returned to full production with “only” 14 pig runs of 10 different types
Conclusions

Pressure wave analysis provides the following benefits:

- Surveys pipeline debris quickly and safely with a repeatable and verified high level of accuracy
- Allows detailed knowledge of pipeline conditions for planning purposes
- Helps reduce the risk of stuck pigs
- Tracks and optimises the campaign as it progresses and confirms efficiency of the cleaning methodology
- Saves time, resources, and helps lower costs throughout cleaning programs

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