Pipeline Deposit Assessment and Cleaning Techniques

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Agenda

- Why do we clean Pipelines
- Typical Pipeline Deposits
- Deposit Assessment
- Pipeline Cleaning
- Inline Inspection
- Decommissioning
- Waste management / disposal
But why clean pipelines?

- Commissioning
- Maintenance / production / efficiency of the system
- To enable inspection
- Change of service
- To decommission
What we know about any pipeline

Not much
- Third party damage
- Pigging history
- Volume of deposits
- External features
- Cause of corrosion
- Internal features
- Location of deposits
- Liquid holdup

A lot
- Operational history
- Transported products
- Installed components
- Corrosion
- Location
- Pressure drop
- Ownership
- Design documentation
- Material
- As built

Note: Halliburton does not have ILI technology but do have a proven track record in cleaning and assuring successful pipeline inspections.
Project Planning / Engineering

Start

- Sample available? Yes → Chemical analysis → Chemical analysis report
- Deposits present? Yes → Line piggable? Yes
  → Intrusive survey? Yes
  → Run assessment → Deposit location report
- Non intrusive Survey? Yes
- Samples recovered? Yes
  → Production analysis
- Cleaning operations
- Reports

No → Do not know
- No → No
- No → No
- No → No
- No → No
- No → No
- No → No
- No → No
- No → No
Chemical analysis of a deposit in a pipeline

- Laboratory chemical analysis of the produced fluids
- Samples removed during regular pigging operations

- Issues
  - Is the sample representative?
  - What if there are a number of different types of deposit?
  - If a sample is obtained - where in the pipe did it originate?
Agenda

- Why do we clean Pipelines
- Typical Pipeline Deposits
- Deposit Assessment
- Pipeline Cleaning
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- Waste management / disposal
Typical pipeline deposits

- Paraffin wax
- Asphaltenes
- Salts & scales
- Sand and well fines
- Hydrates
- Water
- Erosion & corrosion products
  - “Black powder”
  - FeS’s, FeO’s, Fe$_2$CO$_3$
- Emulsions
## Pipeline deposits and probable cause

<p>| | |</p>
<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
</table>
| **Paraffin wax** | ▪ Fluid temperature change  
▪ Fluid pressure change                                                                 |
| **Inorganic Scale** | ▪ Fluid temperature change  
▪ Fluid pressure change  
▪ Co-mingled incompatible aqueous fluids                                             |
| **Iron Oxide, Iron Sulphide or Iron Carbonate** | ▪ Direct chemical reaction of transported fluid components with pipe alloy  
▪ Ineffective removal of mill-scale from new pipe during pre-commissioning  
▪ Improper dewatering, drying and / or lay-up of pipe during pre-commissioning or remedial works |
| **Sand / well fines** | ▪ Produced from the well with the hydrocarbons                                              |
| **Emulsions**    | ▪ Energised mixing of different liquid and / or solid phases                                |
| **Hydrate**      | ▪ Combination of hydrocarbon gas, water, low temperature and high pressure                 |
Impact of deposits

- Production
- Efficiencies
- Reliability
- Product quality
- Profitability

- OPEX costs
- Pumping costs
- Maintenance cost
- Risk
Agenda

- Why do we clean Pipelines
- Typical Pipeline Deposits
- Deposit Assessment (3 Methods)
- Pipeline Cleaning
- Inline Inspection
- Decommissioning
- Waste management / disposal
Deposit measurement – Time of Flight

- Constant flow conditions
- Known flow area / volume
- Calculated transit time
Deposit measurement – Time of Flight example

- Achieve constant flow
- Launch a gel tracer
- Maintain constant flow
- Data log flow and pressure
- Record time to transit the pipeline

Pipe diameter: 12 inches
Pipe length: 10,000 m
Pipe wall thickness: 0.38 inches
Pipe ID: 11.25 inches
Flow area: 0.06 m²
Flow rate: 12,000 bbl/day = 1.325 m³/min
Fluid velocity: 20.7 m/min

Time of flight: 484.20 minutes = 29052 seconds

Estimated Deposit Volume: 14.84 m³
Average Pipeline ID: 282.42 mm
Average Deposit Thickness: 1.66 mm

Note #1: Based on an even distribution along the pipe.

HALLIBURTON TIME OF FLIGHT TECHNIQUE
As Built Input
Field Data Input

At constant flow, the fluid velocity will change based on the available flow area.
Time of flight technique

Issues:

- With ‘time of flight’ the deposit profile will be unknown

- Do we have this …

- Or this …………

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Deposit location – PressurePulse technology

- Achieve constant flow
- Induce pressure pulse
- The pulse travels at the speed of sound
- The line packing signal reflects the flow conditions at the front of the pulse
PressurePulse – Line packing profile

PT Location Upstream

PT Location Downstream

24 inch pipeline to shore

24 inch pipeline from offshore

Clean Pipeline
Deposits in Pipeline

Pressure Bar

Time (0.1 Seconds)
Deposit location – PressurePulse technology
Debris assessment tools – Intrusive systems

- Data log of pipeline pressure, temperature plus the line geometry

Data logger mounted in a pig
## Deposit location method comparison

<table>
<thead>
<tr>
<th>Feature</th>
<th>Method 1</th>
<th>Method 2</th>
<th>Method 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Can be done on line</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes / ?</td>
</tr>
<tr>
<td>Can locate deposits</td>
<td>No / ?</td>
<td>≈Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Can quantify deposits</td>
<td>Yes</td>
<td>≈ Yes</td>
<td>≈ Yes</td>
</tr>
<tr>
<td>Requires a pig</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Data analysis required</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Accuracy</td>
<td>Good#1</td>
<td>Good#2</td>
<td>Good</td>
</tr>
<tr>
<td>Risk of blockage</td>
<td>Low</td>
<td>Low</td>
<td>Low / ?#3</td>
</tr>
<tr>
<td>Cost</td>
<td>$$</td>
<td>$$</td>
<td>$$$$</td>
</tr>
</tbody>
</table>

**Note #1**: The system will quantify the deposit but will not locate the deposit

**Note #2**: Good accuracy under ideal conditions

**Note #3**: If a foam pig is used the blockage risk may be minimal
Three example cleaning projects

Project 1 GoM
- Line pressure drop high
- Throughput declining
- Complete blockage highly likely

Project 2 W Africa
- Unable to pig the line
- Unable to inspect the line
- High concerns over corrosion

Project 3 N Sea
- Line to be decommissioned
- Hydrocarbon decontamination scope
- Oil in water acceptance criteria of 20 ppmv

After SureStream Flow Assurance Services a production increase of 3,020 bbl/day

After SureStream Flow Assurance Services successful ILI and a production increase of 3,000 bbl/day

SureStream Flow Assurance Services chemical & mechanical cleaning efficiently resulting in <20 ppm.

In almost all projects after completion of services a production increase has been experienced
Case Study – West Africa

16 inch oil pipeline
20.5 km
Unknown quantity of deposits in the pipeline
Cleaning required to enable pipeline inspection
Case Study – West Africa

Deposit profile prior to cleaning

Survey indicated approximately 350 cubic meters of material in the pipeline
Case Study – West Africa

Deposit profile after the first stage of the cleaning operation
Deposit profile after the third stage of the cleaning operation
Case Study – West Africa

- All three profiles
- Approximately **577,500 kg** of sand and material removed from the pipeline
## Track Record

<table>
<thead>
<tr>
<th>Location</th>
<th>Survey Fluid</th>
<th>Length</th>
<th>Diameter</th>
<th>Deposit Type / Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thailand</td>
<td>Oil (liquid at the operating pressure)</td>
<td>10.9km</td>
<td>16 inch</td>
<td>Locate a pig mandrel stuck in the line for several years</td>
</tr>
<tr>
<td>Gabon</td>
<td>Treated sea water</td>
<td>3.57km</td>
<td>16 inch</td>
<td>Deposit assessment</td>
</tr>
<tr>
<td>UK</td>
<td>Potable water (mainly liquid but with gas pocket)</td>
<td>0.48km</td>
<td>4 inch</td>
<td>Locate a sand blockage in a flexible riser</td>
</tr>
</tbody>
</table>
| UK         | 1) Oil export  
             2) Treated sea water | 107km  | 16 inch  | 1) Detect the position of the blockage (pig stuck)  
             2) Assess the wax deposit in the line post remediation                                  |
| UK         | Condensate (liquid at the operating pressure) | 57.9km | 8 inch   | Wax deposit assessment                                                                    |
| Norway     | Oil                           | 100km+ | 8 inch   | Wax deposit assessment                                                                    |
| UK         | Oil                           | 30km   | 8 and 10 inch | Wax deposit assessment                                                                 |
| Gabon      | Oil                           | 20km   | 16 inch  | Sandy deposit (sand, oil and water emulsion). Monitored cleaning operation.               |
| North Sea  | Water                         | 3.5km  | 17 inch  | Water flooded for inspection, displaced gas/oil/water. Scale.                              |
| Australia  | Water                         | 63km   | 14 inch  | Stagnant. Lost pig                                                                        |
| Netherlands| Gas                           | 20km   | 12 inch  | Lost object, deposit demo                                                                 |

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- Waste management / disposal
Pipeline cleaning / deposit removal

Prior to removal

- Deposit may be evenly distributed or at a specific orientation
- Probably adhered to pipe wall
- Probably cause reduced flow area

After removal from the pipe wall deposits are

- transported out of the pipeline
- not accumulated at the 6 o’clock position
Key considerations for pipeline cleaning operations

If the cleaning is to be completed with routine pigs:

- How much material is transported with each pig?
- How much material is in the pipeline?
- How much material will have to be removed?
- Where will the removed material be disposed of?
- How much will disposal cost?

Pipeline deposit calculations

- Paraffin wax
- Sand
- Corrosion
Transportation of deposits / debris

Many factors affect particle behaviour

- **Fluid properties**
- **Particle properties**
- **Flow regime**

![Diagram with flow processes and factors affecting particle behaviour]
Cleaning with pigs

Key considerations when using pigs:-

- Deposit hardness
- Deposit adhesion
- Deposit volume
- Deposit abrasion
- Deposit Restriction
- Fluid flow rate
- Flow type
  - Laminar
  - Turbulent
- Fluid properties
- Fluid carrying capacity
Transportation of deposits / debris
Transportation of deposits / debris

- Fluid design based on deposit and pipeline properties
  - Custom formulation per project
  - Compatibility with production
  - Vast database of fluid characteristics
  - Particle / fluid interaction research
  - Experienced laboratory technicians and chemists
  - Extensive track record
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Waste management / disposal

Waste from pipeline cleaning operations has to be disposed of.

Waste disposal can be the most costly part of a cleaning program.

The three P’s for minimising waste disposal costs:
- Plan, Plan & Plan
Project planning for waste disposal

Start

1. Operational cleaning?
   - Yes
   - No
     - Change of service?
       - Yes
       - No
         - ILI?
           - Yes
           - No
             - Decommission?
               - Yes
               - No
                 - End
               - No
             - End
   - No
     - Hydrocarbon only?
       - Yes
       - No
         - Process compatible?
           - Yes
           - No
             - End
           - No
             - End
       - No
         - End
   - Yes
     - Hazardous materials?
       - Yes
       - No
         - Process system online?
           - Yes
           - No
             - Effluent process requirement
           - No
             - End
       - No
         - Effluent to process
         - End
   - End
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