PPSA Pigging Seminar 2007

A new pipeline cleaning technology:

**Hydraulically Activated Power Pigging (HAPP™)**

by

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for

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Introduction

Deposition of wax, hydrates or other substances are a consequence of the …

- chemical composition of the crude oil (i.e. wax content, …)
- hydrodynamic conditions in the pipeline (i.e. flow velocity, turbulences,…)
- thermodynamic conditions in the pipeline (i.e. pressure, temperature,…)
- pipeline wall physics (i.e. material, roughness, …)

Consequences of deposition of wax, hydrates or other substances are …

- reduced inner diameters & increased wall roughness
- restricted flow
- higher pump capacities for compensation
- rising operation costs & pipeline blockage

Prevention and cure strategies:

1. Adjustment of chemical, physical and thermodynamic crude oil properties.
2. Pipeline pigging…
Today's cleaning methods

Today's typical cleaning pigs

Utility Pigs

Cleaning Pigs
- Brush Pigs
- Scraper Pigs
- Dependent Hydraulic Jet Pigs

Sealing Pigs
- Mandrel Pigs
- Foam Pigs
- Solid cast Pigs
- Spherical Pigs

Plug Pigs
Characteristics of cleaning pigs

Cleaning force / effectiveness

Mechanical force (scraping) between pipe inner wall and the pig’s cleaning edge

- easy to establish  
- a faster pig velocity results in a higher impact on deposits  
- not controllable  
- a faster pig velocity results in a superficial deposit removal  
- up to many pig runs might be necessary  
- cleaning edge smears wax back onto wall

High pressure water jets fed through hoses

- very strong cleaning force  
- high effectiveness  
- limited in reach
Characteristics of cleaning pigs

Deposit removal

**Removed deposits** are usually pushed out of the line with the pig moving forward

⇒ plug formation in front of the pig
⇒ high risk of pig getting stuck
⇒ several pig runs with different pig diameters might be required

**Deposit removal with bypass flow through the cleaning pig**

⇒ removed deposits are permanently flushed down-stream
⇒ less risk of plug formation thus pipeline blockage

**Today’s general rules** to avoid pipeline blockage by accumulated deposits in front of pigs

1. select pig type(s)
2. thoroughly determine pig size (diameter)
3. determine number of cleaning runs needed

⇒ **Set-up of a pigging job requires extended time, effort and experience is very expensive!**
Characteristics of cleaning pigs

Pipeline operations

Regular pigging programs: • Pigging is done after build up of a defined wax layer or in periodical intervals
⇒ Line can be kept in operation

Line heavily effected: • A thoroughly established pigging program is required
• Several pigging runs
⇒ Operations are interrupted or reduced

Line is blocked: ⇒ No operations at all anymore!

⇒ Interruption of pipeline operations is most undesired by pipeline operators as it causes enormous secondary economic losses.
## Comparison of cleaning pig features

<table>
<thead>
<tr>
<th>Pig</th>
<th>Feature</th>
<th>Active cleaning force</th>
<th>N° of cleaning runs required</th>
<th>Risk of getting stuck</th>
<th>Adjustable travel speed</th>
<th>Reach</th>
<th>Cleaning effectiveness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandrel pigs</td>
<td></td>
<td>no</td>
<td>many</td>
<td>high</td>
<td>no</td>
<td>unlimited</td>
<td>low</td>
</tr>
<tr>
<td>Foam pigs</td>
<td></td>
<td>no</td>
<td>many</td>
<td>high</td>
<td>no</td>
<td>unlimited</td>
<td>low</td>
</tr>
<tr>
<td>Solid cast pigs</td>
<td></td>
<td>no</td>
<td>many</td>
<td>high</td>
<td>no</td>
<td>unlimited</td>
<td>low</td>
</tr>
<tr>
<td>Spherical pigs or spheres</td>
<td></td>
<td>no</td>
<td>many</td>
<td>high</td>
<td>no</td>
<td>unlimited</td>
<td>low</td>
</tr>
<tr>
<td>Brush pigs</td>
<td></td>
<td>no</td>
<td>less many</td>
<td>less high</td>
<td>no</td>
<td>unlimited</td>
<td>low/medium</td>
</tr>
<tr>
<td>Scraper pigs</td>
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<td>less many</td>
<td>less high</td>
<td>no</td>
<td>unlimited</td>
<td>medium/high</td>
</tr>
<tr>
<td>Dependent Hydraulic Jet Pigs</td>
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<td>yes</td>
<td>only one</td>
<td>none</td>
<td>yes</td>
<td>limited</td>
<td>very high</td>
</tr>
</tbody>
</table>
HAPP™ – how it cleans

Hydraulically Activated Power Pig
Main Components

- Cleaning head
- Seal
- Brake system
Energy balance

Pressure over pipe length

P [bar]

Max. operating pressure

P_{operating} = P_{available for transport}

Pipe length

Pumping station
Two ways to drive a HAPPTM

1. Pumping pressure can be increased:
   • Required cleaning energy is taken from the additional pumping energy.
   • Operating pressure and flow is entirely maintained

2. Pumping pressure can not be increased:
   • Required cleaning energy is taken as part from the transportation energy.
   • Operating pressure and flow are lowered for the energy share used for cleaning.

Cleaning energy = $\Delta p \times \text{flowrate}$
### Technical features

**Pipeline inner diameters:** ..... > 6”

**Cleaning method:** ............... high pressure fluid jets

**Cleaning efficiency:** ............. one single pigging run ⇒ 100% clean

- deposit removal even out of pits
- freeing of captured water

**Cleaning pressure needed:** ...depending on deposit properties (usually 10 - 30bar)

**Travel direction:** ................. reversible (flow reverse)

**Brake force:** ....................... adjustable, remains the same over the cleaning run

- lowers to zero if an obstacle blocks the pig

**Travel speed:** ...................... adjustable down to 60 times slower than the fluid speed

**Removal of debris:** ............... continuously by bypass flow

**Pipeline operations:** .............. can be maintained while pigging

**Pipeline geometry:** ............... negotiation of T-fittings, steps, deformed pipe ID, welding lines, elbows, etc.
HAPP™ – units

Cleaning head

Cleaning head connected to 288 psi (19.8 bar), 48 gpm (182 l/min) water supply.
Cleaning head

Flow pattern of a cleaning head at 140 psi (9.7 bar) and 160 gpm (606 l/min).
HAPP™ – units

Seal unit with cleaning head

Seal body with rigid and wear resistant seal cups installed.
Test set-up to determine the brake systems’ travel speed/brake force characteristics. A hydraulic ram was used to pull the brake systems through a pipe section.
HAPP™ – units

HAPP™ prototype unit

HAPP™ prototype design based on the cleaning head and brake system tests.
Seal unit

Seal incorporating seal body with polyurethane seal cups.
Brake unit

Housing of the brake unit
Launch of a HAPP™ unit

HAPP™ – units

HAPP™ ready for launching
Reception of a HAPP™ unit

HAPP™ after a cleaning run of the 7.3 miles, 6.25 inches Braheney Line [operated by Equilon Pipeline Company, Denver City, TX pipeline contained 4 elbows à 22.5°, radius: 1.5 D]
References

The 6 inch HAPP™ has been tested as following:

**Cleaning efficiency** has been tested & verified in paraffin contaminated spool pieces of the test loop facilities of SHELL E&P Technology Company, Houston, USA.

**Mechanical reliability** has been tested & verified in the test loop of Aqua Drill International, Dickinson, Texas, USA.

**A complete & successful cleaning job** has been carried out at the 7,3 miles onshore crude oil line in Denver City, Texas, USA.
[Braheney Line, ID: 6,25”, operated by Equilon Pipeline Company]
Advantages...

... with respect to other pigging technologies on the market

Operations:
• Pipeline operation can continue while pigging.
• No limits in operation reach.

Effectiveness:
• The adjustable and controlled travel speed allows an extraordinary pigging effectiveness: With only one single cleaning run the pipeline is 100% clean!
• Various cleaning heads are available for removal of all kind of deposits.
• Active pigging: The local pressure difference across a HAPPTM can be transformed in any kind of cleaning energy (brush, high pressure fluid jets, rotating, etc.).
• The HAPPTM construction allows negotiation of T-fittings, steps, deformed pipe ID, welding lines, elbows, etc.

Debris removal:
• Hydraulically activated cleaning prevents plug formation by constantly carrying away debris downstream.

Safety:
• No conventional pig blocking due to debris plug in front of it.
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Thank you for your attention!

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for
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