Managing Integrity of Feed Condensate Pipeline: Online Internal Corrosion Monitoring via Electric Field Mapping (EFM)/Field Signature Method (FSM) Technique

by

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PRESENTATION OUTLINE

OBJECTIVE
COMPANY INTRODUCTORY
PIPELINE SYSTEM FACILITIES
INTERNAL CORROSION CONTROL & MONITORING PROGRAMS
ELECTRIC FIELD MAPPING (EFM)
FIELD SIGNATURE METHOD (FSM)
INTERNAL CORROSION MONITORING RESULTS AND DISCUSSION
SUMMARY
To share PETRONAS Gas Berhad’s experiences in managing integrity of condensate pipeline particularly for internal corrosion threat

Our Pipeline System

- PGB operates and maintains 82 pipeline sections
- 1,658 km Gas Mainline
- 357 km Liquid Pipeline
- 378 km Lateral Lines
- 116 km GPP Interconnect
- 45 km Miri Gas Distribution System
Total 2,554 km
- Pipeline size ranges from 2” to 48”
- 2 compressor stations
- 119 metering stations and city gates
- 33 customers i.e. TNB, IPPs, GMSB & Petrochemical plants
- Transmits on the average: 2,000 MMSCFD of sales gas, 132,000 GJ/day of ethane, 3,700 MT/day of Propane & 2,400 MT/day of Butane
The 10” pipeline transports condensate from offshore to gas processing plant to produce sales gas, liquid propane & butane

- Commissioned in year 1998
- OD: 10.75 inches
- Length: 15.1 Km
- Grade: API 5L X 65
- Type: Seamless
- Nominal wt: 11.0 mm & 8.70 mm
- MAOP: 153 bar
- Max inlet P: 80 bar
- Min inlet P: 73 bar
- Operating inlet T: 30 deg C
- Scraper launcher and receiver
- External corrosion protection: 3-layer PE coating and Cathodic Protection
- Internal corrosion protection: CI Program comprises internal cleaning, CI filming and continuous CI injection

The condensate is corrosive as it contains free water & CO₂

<table>
<thead>
<tr>
<th>Type of Hydrocarbon</th>
<th>Composition in Condensate (mol %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>N₂</td>
<td>0.01</td>
</tr>
<tr>
<td>CO₂</td>
<td>10.45</td>
</tr>
<tr>
<td>C₁</td>
<td>6.27</td>
</tr>
<tr>
<td>C₂</td>
<td>5.5</td>
</tr>
<tr>
<td>C₃</td>
<td>7.88</td>
</tr>
<tr>
<td>iC₄</td>
<td>3.78</td>
</tr>
<tr>
<td>nC₄</td>
<td>4.17</td>
</tr>
<tr>
<td>iC₅</td>
<td>4.31</td>
</tr>
<tr>
<td>nC₅</td>
<td>1.51</td>
</tr>
<tr>
<td>C₆⁺</td>
<td>56.12</td>
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<tr>
<td>Total</td>
<td>100%</td>
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</table>

<table>
<thead>
<tr>
<th>Contaminant</th>
<th>NPS10 Feed Condensate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chloride</td>
<td>1.27 mg/L</td>
</tr>
<tr>
<td>Total Sulfur</td>
<td>49.06 mg/L</td>
</tr>
<tr>
<td>Total Mercury</td>
<td>Min : 0.02 ppm Max : 0.08 ppm (from sludge at receiver)</td>
</tr>
<tr>
<td>pH (average)</td>
<td>4 to 7</td>
</tr>
</tbody>
</table>

Water in Feed Condensate 62.3 ppm
The integrity of the pipeline is managed via best practices of API 1160 standard.

Identify potential impact to HCAs → Data gathering, review & integration

Perform risk assessment → Perform inspection and/or mitigation

Revise inspection & mitigation plan → Evaluate overall program

Update, integrate & review data → Manage change

Re-assess pipeline risk

Major risk is of internal corrosion and comprehensive internal corrosion control program is implemented to mitigate the risk.

Internal Pipeline Cleaning and CI Batching

Continuous CI Injection System

- A total of 30 liter volume of CI with 35% concentration is being injected into the pipeline daily
- To path CI film imperfection due to flow regime
A comprehensive internal corrosion monitoring program is also implemented as well.

The working concept of EFM/FSMTM:

- FSM
- ER Probe
- Corrosion Coupon
- EFM
- Product Sampling & Analysis

<table>
<thead>
<tr>
<th>Pipeline Diameter</th>
<th>NPS 10</th>
<th>Results, ppm</th>
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</thead>
<tbody>
<tr>
<td>Manganes</td>
<td>1720</td>
<td>138000</td>
</tr>
<tr>
<td>Iron</td>
<td>85000</td>
<td>9500</td>
</tr>
<tr>
<td>Calcium</td>
<td>120</td>
<td>164</td>
</tr>
<tr>
<td>Sulfur</td>
<td>23.00</td>
<td>-</td>
</tr>
<tr>
<td>Nitrite</td>
<td>&lt; 0.5</td>
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</tr>
<tr>
<td>Sulfate</td>
<td>69800</td>
<td>-</td>
</tr>
<tr>
<td>Chloride</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mercury</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>PH</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>SOR</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>APE</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>
On-line Monitoring System of EFM/FSMTM

EFM/FSMTM measures actual wall loss, corrosion growth rates and generates 3-D images.
EFM/FSM trending results is used a guideline to modify the corrosion control programs accordingly.

Can we rely on a single monitoring system?

- **EFM CR:** 0.068 ~ 0.253 mm/year
- **FSM CR:** 0.020 ~ 0.250 mm/year
- **Corrosion Coupon CR:** 0.001 ~ 0.011 mm/year
- **ER Probe CR:** 0.005 ~ 0.4000 mm/year
- **In-Line Inspection CR:** ???? mm/year
- **Dig Up C Scan CR:** 0.000 ~ 0.230 mm/year
To summarize and conclude our presentation...

- EFM/FSM™ is much more efficient in determining the internal corrosion growth due to the fact that it measures directly on the pipe body as suppose to coupon and probe that measures on reduction of the weight of the coupon/probe which is not part of the pipeline.

- The on-line monitoring capabilities of EFM/FSM enables data to be retrieved on daily basis hence data integrity is safe guarded since no human intervention.

- Based on a conclusive results of EFM/FSM™ the internal corrosion control programs can be altered or changed accordingly

- In-line inspection can further confirmed the effectiveness of the corrosion control on top of the localised monitoring systems

THANK YOU