Overview of Subsea Corrosion Integrity

DNV GL Pipeline Services
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WHY?
Integrity Incidents

The North Sea*

* Fittings are not included

All Incidents reported in the North Sea and the Gulf of Mexico with and without leakage

Sources: DNV GL Internal database and PARLOC 2001 HSE
Corrosion Related Failures

- **Ageing barriers**
  - Coating breakdown
  - Galvanic anode depletion
  - CP system not functional

- **Changing threats**
  - HP/HT, Sour fluids
  - Microbiologically Influenced Corrosion
  - Under deposit corrosion
  - Cracking mechanisms
  - Erosion/Corrosion

- **No barriers**
  - Change from design

Sources: DNV GL Internal database and PARLOC 2001 HSE
Contributing Factors to Corrosion Leaks

- Designs use limited data and/or assumptions for threat identification and barrier selection

- Often threats not identified in design are later determined to be contributors

- Leak responsiveness often use inhibition strategies absent of a comprehensive threat review
Corrosion Threat Management

- Circuitization
  - ...materials will define relevant threats
  - ...CO₂, H₂S, O₂, MIC, CUI, etc.
- Threat identification
  - ...Inhibitor, biocide, coating, CP, CRA, etc.
- Barrier identification
  - ...design performance
- Barrier monitoring
  - ...rate of degradation
- Corrosion monitoring
  - ...Integrity assurance
- Inspection
  - ...time to failure
- Probability of Failure
Corrosion Threat & Probability Assessment

- Circuitization
- Threat identification
- Barrier identification
- Barrier monitoring
- Corrosion monitoring
- Inspection
- Probability of Failure

- ...materials will define relevant threats
- ...CO₂, H₂S, O₂, MIC, CUI, etc.
- ...Inhibitor, biocide, coating, CP, CRA, etc.
- ...design performance
- ...rate of degradation
- ...Integrity assurance
- ...time to failure
Segmentation

- The combination of materials used in a system and the wide range of environments encountered often cause more than one type of attack.

- Segmentation is essential in threat identification and barrier selection
  - susceptibility of threats may differ from one segment to another because of materials
  - rarely do systems have constant threat potential over their entire length.
  - analyzing inapplicable integrity threats in some parts.
Asset Complexity Affects the Type of Threats

The system description is used to identify threats with the potential to affect the subsea system integrity.

Flexible Flowlines

Rigid Flowlines

Intrafield Pipelines

Subsea Well Template with Protection Structure

Subsea Manifold, Process Modules & Metering

Export

FlexiFlowlines

Intrafield Flowlines

Intermediat Towhead

Tie-in

PLEM

Offshore Loading systems

Riser-to-Flowline Interfac

Flowline Jumper

Bend

Umbilical

Dynamic Flexibles

Umbilical

Riser (Pipe/Lines)

Riser J-tubes (Platform)

Midwater Buoy

Intermediar Towhead

SSIV,HIPPS or P/L Isolation Valves

Well, Wellhead and Structural Stability (Wells)

Green: Subsea

Red: Pipelines

Blue: Structures

Yellow: Wells

External Intervention Systems

Workover, W/L & CT Systems (Wells)
Life Cycle

- Threats change throughout life of the asset
  - HP/HT
  - Water cut
  - Souring
  - Microbiologically Influenced Corrosion
  - Erosion
  - Under deposit corrosion
  - Cracking mechanisms
  - Flow regime
Degradation Threats Change Throughout Life Cycle

- O₂
- Chloride (pitting) Corrosion
- Acid
- SCC
- Hydrogen cracking
- Erosion
- Atmospheric
- CUI
- Embrittlement
- Fatigue
- Stray Current (AC/DC)
- H₂S
- Crevice
- CO₂
- MIC
- Fretting
- Preferential weld corrosion
- SWC
- Galvanic
- Elemental sulfur corrosion
- HIC
## Similarities and Differences

<table>
<thead>
<tr>
<th>Stage of Life Cycle</th>
<th>Operating Parameters</th>
<th>Threats</th>
<th>Barriers</th>
<th>Experts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Well</td>
<td>Design, build, commission, operations, life extension, HT, HP, flow, materials</td>
<td>Flow assisted corrosion, erosion, H₂S, cracking, CO₂</td>
<td>Materials, cladding, chemical, coatings</td>
<td>Materials, corrosion, sour services, chemical, testing</td>
</tr>
<tr>
<td>Pipeline</td>
<td>Design, build, commission, operations, life extension, Lower temperatures, pressures, slower velocities</td>
<td>Galvanic, CUI, assisted corrosion, H₂S, CO₂, O₂</td>
<td>Inhibition, CP, coatings, liners,</td>
<td>Corrosion, Inhibitor, Biocide,</td>
</tr>
</tbody>
</table>
Threat Identification

- Multi-disciplinary team (i.e., materials, corrosion, inspection, flow assurance, chemical treatment, operations, maintenance, process, risk, etc.) to identify threat susceptibility
  - With its many forms, causes, and associated prevention methods, corrosion obviously is very complex and requires extensive expertise and significant resources to manage.
Barrier Identification

- Multi-disciplinary team (i.e., materials, corrosion, inspection, flow assurance, chemical treatment, operations, maintenance, process, etc.) to identify barriers
- Each threat may require one or more barriers to effectively mitigate the degradation.
- Secondary barrier may be required for effective mitigation.
  - internal protection means – cladding, internal lining, internal coating, internal HDPE liner, chemical treatment, cleaning pigs
  - external protection means – coating/concrete, cathodic protection; i.e., galvanic anodes, impressed current
Summary

DNV GL collaboration with asset owner

Changing threats & barriers throughout Life of Asset

Corrosion Management throughout Life of Asset
Pipeline Services

For more information go to www.dnvgl.com

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