Managing the significant threat of corrosion under insulation
DNV GL CUI Manager
Frode Wiggen
# Agenda

<table>
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<th>01</th>
<th>Background</th>
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<tr>
<td>02</td>
<td>Joint Industry Project</td>
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<td>03</td>
<td>CUI risk management methodology</td>
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<td>Implementation</td>
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<td>05</td>
<td>Q&amp;A</td>
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</tbody>
</table>
A hidden killer

- Corrosion Under Insulation is difficult to detect.

- Lack of cost effective non-intrusive inspection methods.

- The oil and gas industry has never operated under a standard methodology.

- There is no decision-making tool for managing the threat of CUI.
New industry standard driven by industry collaboration
New industry standard driven by industry collaboration
Risk - based management of corrosion under insulation
DNVGL-RP-G109 – methodology description
CUI process as described in DNVGL-RP-G109

**Continuous Improvement**
- Use achieved results to update CUI strategy
- Standardisation and Procedure development
- Experience transfer

**Risk Assessment**
- Identify challenge
- Assess risk
- Establish or update plan for risk management of CUI

**Risk Update**
- Ensure and document that the risk mitigation effect are sufficient

**Risk Mitigation**
- Execute the risk mitigating activity
CUI barriers

- Water on metal surface – Water wetting barrier
- Degraded coating – Coating barrier
- Carbon steel with high corrosion rate – Material barrier
- Insufficient design, thin walls – Design barrier

Hazards → Losses
Barrier assessment

\[ \text{PoF}_{\text{CUI}} = f(\text{PoF}_{\text{material}}, \text{PoF}_{\text{coating}}, \text{PoF}_{\text{water wetting}}, \text{PoF}_{\text{design}}) \]
Barrier assessment, material

PoF as Function of Temp.

- Very High
- High
- Medium
- Low

Temperature °C

Design Barrier
Coating Barrier
Water Wetting Barrier
## Barrier assessment, coating

<table>
<thead>
<tr>
<th>Description</th>
<th>NORSOK M-501 system ref.</th>
<th>NACE SP0198 2010 syst. ref.</th>
<th>Temp. area</th>
<th>Age of the coating</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primer (&lt;50 µm)</td>
<td>NA</td>
<td>NA</td>
<td>&lt;60ºC</td>
<td>0-5 VH</td>
<td>6-10 VH</td>
</tr>
<tr>
<td>Hot Dip Galvanizing (HDG)</td>
<td>NA</td>
<td>NA</td>
<td>&lt;200ºC</td>
<td>L M H</td>
<td>VH VH VH</td>
</tr>
<tr>
<td>Zinc Silicate with top sealer as first layer (epoxy)</td>
<td>NA</td>
<td>NA</td>
<td>&lt;105ºC</td>
<td>L M H</td>
<td>VH VH VH</td>
</tr>
<tr>
<td>2 layer with zinc rich primer as first layer (vinyl)</td>
<td>System 1</td>
<td>NA</td>
<td>&lt;80ºC</td>
<td>M H</td>
<td>VH VH VH</td>
</tr>
<tr>
<td>3 layer with zinc rich primer as first layer (epoxy)</td>
<td>System 1</td>
<td>NA</td>
<td>&lt;80ºC</td>
<td>VL L M H</td>
<td>VH VH VH</td>
</tr>
<tr>
<td>Two component epoxy or polyester based coating</td>
<td>System 7A</td>
<td>NA</td>
<td>&lt;80ºC</td>
<td>VL VL L M H</td>
<td>VH VH VH</td>
</tr>
<tr>
<td>3 layer on epoxy primer (zinc free)</td>
<td>System 6 (A/B) (SS)</td>
<td>NA</td>
<td>&lt;80ºC</td>
<td>L M H</td>
<td>VH VH VH</td>
</tr>
<tr>
<td>2 layer epoxy coating (&gt;350 µm)</td>
<td>System 7 (B/C) SS-1/CS-1</td>
<td>45 to 60ºC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 layer epoxy Phenolic / Novolac</td>
<td>System 6C (SS) System 9 (C3) SS-2/3 / CS-3/4</td>
<td>45 to 120ºC/130ºC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fusion Bond Epoxy (FBE)</td>
<td>NA</td>
<td>CS-2</td>
<td>45 to 60ºC</td>
<td>L M H</td>
<td>VH VH VH</td>
</tr>
<tr>
<td>Thermal Spray Aluminum (TSA) with top sealer</td>
<td>System 2A SS-6/CS-5</td>
<td>45 to 595ºC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Air dried silicone or Modified silicone</td>
<td>NA</td>
<td>SS-4</td>
<td>45 to 540ºC</td>
<td>M H</td>
<td>VH VH VH</td>
</tr>
<tr>
<td>Inorganic copolymer or coatings with an inert multipolymeric matrix</td>
<td>NA</td>
<td>SS-5 / CS-6</td>
<td>&gt;100ºC to 600ºC</td>
<td>L M H</td>
<td>VH VH VH</td>
</tr>
</tbody>
</table>
# Barrier assessment, water wetting

- Climate
- Location
- Cladding
- Insulation type
- Drainage

## Design Barrier

<table>
<thead>
<tr>
<th>Water exposure</th>
<th>Very High</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Very Low</th>
<th>Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Very High</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
<td>Medium</td>
<td>High</td>
</tr>
<tr>
<td>Medium</td>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Very Low</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Very Low</td>
<td>Very Low</td>
<td>Low</td>
<td>Low</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>Medium</td>
<td>High</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Probability of breach due to workmanship**

- Workmanship
- Inspection & Maintenance
- Age
### Nominal pipe size (mm/inch)

| OD mm (mm) | 15 | 20 | 25 | 32 | 40 | 50 | 65 | 80 | 100 | 125 | 150 | 200 | 250 | 300 | 350 | 400 | 450 | 500 | 550 | 600 | 650 | 700 | 750 | 800 | 850 | 900 | 950 | 1000 |
|------------|----|----|----|----|----|----|----|----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| 1/2        | 7.0 | 9.0 | 11.5 | 14.0 | 17.5 | 21.0 | 25.5 | 30.0 | 35.0 | 40.0 | 45.0 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 |
| 3/4        | 10.2 | 13.0 | 16.5 | 20.0 | 24.0 | 28.0 | 32.0 | 36.0 | 40.0 | 45.0 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 |
| 1          | 14.0 | 18.0 | 22.0 | 26.0 | 30.0 | 35.0 | 40.0 | 45.0 | 50.0 | 55.0 | 60.0 | 65.0 | 70.0 | 75.0 | 80.0 | 85.0 | 90.0 | 95.0 | 100.0 |
| 1 1/2      | 19.0 | 25.0 | 30.5 | 36.0 | 42.0 | 48.5 | 55.0 | 61.0 | 67.0 | 73.0 | 79.0 | 85.0 | 91.0 | 97.0 | 103.0 | 109.0 | 115.0 | 121.0 | 127.0 | 133.0 | 139.0 |
| 2          | 26.0 | 34.0 | 40.5 | 47.0 | 53.5 | 60.0 | 67.0 | 74.0 | 81.0 | 88.0 | 95.0 | 102.0 | 109.0 | 115.0 | 121.0 | 127.0 | 133.0 | 139.0 | 145.0 | 151.0 |
| 2 1/2      | 31.8 | 40.8 | 47.0 | 53.0 | 59.0 | 65.0 | 71.0 | 77.0 | 83.0 | 89.0 | 95.0 | 101.0 | 107.0 | 113.0 | 119.0 | 125.0 | 131.0 | 137.0 | 143.0 | 149.0 |
| 3          | 39.0 | 50.0 | 56.5 | 63.0 | 69.5 | 76.0 | 82.5 | 89.0 | 95.0 | 101.0 | 107.0 | 113.0 | 119.0 | 125.0 | 131.0 | 137.0 | 143.0 | 149.0 | 155.0 |
| 4          | 53.0 | 66.5 | 74.0 | 81.5 | 89.0 | 96.5 | 104.0 | 111.0 | 118.0 | 125.0 | 132.0 | 139.0 | 146.0 | 153.0 | 160.0 | 167.0 | 174.0 | 181.0 |

Ref ASME B36 10
From PoF to risk assessment

Material Barrier

Design Barrier

Coating Barrier

Water Wetting Barrier

Probability of Failure

Consequence of Failure

QRA/TRA or CoF from existing RBI
Risk mitigation

- Modifications, maintenance, repair

- Analysis, new data, new technology and knowhow, inspection and monitoring
## Risk reducing effect of mitigation, examples

<table>
<thead>
<tr>
<th>Mitigation</th>
<th>Material</th>
<th>Coating</th>
<th>Water wetting</th>
<th>Design</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>GVI</td>
<td></td>
<td></td>
<td>Limited effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVI external cladding</td>
<td></td>
<td></td>
<td>Short term effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CVI under insulation</td>
<td></td>
<td>Good effect</td>
<td>Good effect</td>
<td>Good effect</td>
<td></td>
</tr>
<tr>
<td>Refurbishment of coating</td>
<td></td>
<td>Very good effect</td>
<td>Good effect</td>
<td>Very good effect</td>
<td>Assumed controlled conditions and QA</td>
</tr>
<tr>
<td>Coating local repair</td>
<td></td>
<td>Short term effect</td>
<td></td>
<td></td>
<td>Often reduced quality</td>
</tr>
<tr>
<td>Repair of insulation damage</td>
<td></td>
<td></td>
<td>Good local effect</td>
<td></td>
<td>Assumed that dry condition is confirmed and assured</td>
</tr>
<tr>
<td>NDT-RT</td>
<td></td>
<td></td>
<td>Short term effect</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permanent removal of insulation</td>
<td></td>
<td>Very good effect</td>
<td>Very good effect</td>
<td>Very good effect</td>
<td></td>
</tr>
</tbody>
</table>
Update of risk based on mitigation

Examples of mitigation:
- Permanent removal of insulation
- CVI after removal of insulation, reinstall insulation afterwards
- RT-NDT of 50% hot spots
- General visual inspection
- Coating repair, spot
- Coating repair, full refurbishment
Implementation – Digital tool
A systematic approach

RECOMMENDED PRACTICE

DNVGL-RP-G109 Edition December 2019

Risk based management of corrosion under insulation
A systematic approach – with many features

VERACITY
by DNV GL
CUI Manager functionalities

- Implements the **methodology** and CUI experiences data from the **Recommended Practice**
CUI Manager functionalities

- Implements the **methodology** and CUI experiences data from the **Recommended Practice**

- Facilitates structured continuous assessment and documentation of present and **future** CUI risk
CUI Manager functionalities

- Implements the **methodology** and CUI experiences data from the **Recommended Practice**
- Facilitates structured continuous assessment and documentation of present and **future** CUI risk
- Facilitates prioritisation of **most cost and risk efficient** mitigation
CUI Manager functionalities

- Implements the **methodology** and CUI experiences data from the **Recommended Practice**
- Facilitates structured continuous assessment and documentation of present and **future** CUI risk
- Facilitates prioritisation of **most cost and risk efficient** mitigation
- **Integrate** with existing ERP systems and enables machine learning
CUI Manager functionalities

- Implements the **methodology** and CUI experiences data from the **Recommended Practice**
- Facilitates structured continuous assessment and documentation of present and **future** CUI risk
- Facilitates prioritisation of **most cost and risk efficient** mitigation
- **Integrate** with existing ERP systems and enables machine learning
- **Build a global data base for shared experience transfer** and improvements
Experience transfer

CUI is a common challenge across geographies and industries

Information sharing and learning across companies and industries are poor

The CUI Manager will build a global shared database to enable learning across industries

DNV GL will issue annual CUI learning reports to CUI manager users
Increase safety and reduce cost

Allows easy implementation of industry experience and methodology

Facilitates assessment and documentation of present and future CUI risk

Enables comparison of mitigation cost with risk mitigation effect

Developes CUI knowledge and gives insights for improved CUI management
Q&A
Thank You!
For more information visit dnvgl.com/CUI or please contact us.

Frode Wiggen
Frode.Wiggen@dnvgl.com
+47 91157161

www.dnvgl.com/CUI