A Corrosion Under Insulation Prevention Strategy For Petrochemical Industry Piping

Brian J. Fitzgerald
Stefan Winnik
Exxon Mobil Chemical Company

Corrosion Under Insulation- Have You a Problem?
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Discussion Outline

- CUI Background and Examples
- CUI Leak Data & Maintenance Costs
- CUI Prevention Measures
- CUI Prevention Costs
- CUI Prevention Strategy
Corrosion Under Insulation: Background

• Highly unpredictable and difficult to detect

• One of the top causes of equipment leaks & near misses

• Maintenance costs are significant

• Affects carbon steel and SS equipment in the operating range of -4 C to 150 C

• Wet insulation is the root cause

• CUI rate depends on temperature and internal/external contaminate sources
Corrosion Under Insulation Example

• This is a 3-inch, sch 40 propane line that is 20 years old.

• The line was found to have very thin areas as a result of the CUI.

• The line was replaced with stainless steel

• The cost to replace was only slightly more than the cost to refurbish in place.
Corrosion Under Insulation Example

• This is a 30 inch, sch ST, light hydrocarbon line that was in service 4 1/2 years.

• The line had severe CUI and thin sections in the bottom center area of the pipe.

• The line operated at 150 psig at 180 F (82 C)

• Cost to refurbish was $435K.
Corrosion Under Insulation Example

- This 6 inch, sch 40, hydrocarbon vapor line was in service for 12 years
- The line had severe CUI and wall thinning at each insulation section joint.
- Cost to refurbish line was $460K
CUI Leak Data Analysis

- 84% of all CUI leaks are in piping
- 81% of piping CUI is on pipe < 4 inches NPS and

- Pipe wall thickness is key to failure frequency
  - The 16-20 year population is mainly < 4” NPS / low WT pipe
  - The over 25 year population is mainly > 6” NPS / heavy WT pipe
• Fixed Equipment is the largest maintenance cost item.

• Fixed Equipment issues are longer-term so it is difficult to justify improvements unless the focus includes life cycle costs.

• 35 cents of every maintenance dollar is spent on fixed equipment
• Piping accounts for 55% of Fixed Equipment maintenance costs or about 20 cents of every maintenance dollar.

• CUI accounts for 40-60% of piping maintenance costs or about 10 cents of every maintenance dollar.
CUI Prevention Measures

CUI Prevention Tool Suite:

• TSA coating of carbon steel
• Organic coating of carbon steel
• Replace personnel protection insulation with wire cages
• Stainless steel for small diameter pipe
• Al-foil wrap to prevent external SCC of stainless steel under insulation
• Low-dust abrasive blasting for surface preparation

Driver - Inspection-free; Maintenance-free Concept:

• Do it once while keeping initial cost reasonable with focus on life cycle cost
• Want 25-30 years service life; this is a challenge for organic coatings
• Life cycle savings by reduction of future maintenance and inspection costs.
  • Inspection with high CL for detecting CUI is approximately same cost as
    CUI prevention deployment
## CUI Prevention Costs: Tool “Suite” Cost Comparison

<table>
<thead>
<tr>
<th>CUI Prevention Strategy</th>
<th>Initial TEC(^1)</th>
<th>DCF RR(^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Thermal Spray Aluminum</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ New Construction</td>
<td>95% to 105%</td>
<td>30% to 40%</td>
</tr>
<tr>
<td>▪ In-situ maintenance</td>
<td>105% to 120%</td>
<td>20% to 30%</td>
</tr>
<tr>
<td>2. Use of Personnel Protection Cages(^2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ New Construction</td>
<td>95% to 100%</td>
<td></td>
</tr>
<tr>
<td>▪ In-situ maintenance</td>
<td>85% to 90%</td>
<td></td>
</tr>
<tr>
<td>3. Al-foil on Stainless Steel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ New Construction</td>
<td>97% to 99%</td>
<td></td>
</tr>
<tr>
<td>▪ In-situ maintenance</td>
<td>93% to 95%</td>
<td></td>
</tr>
<tr>
<td>4. Small Diameter Stainless Steel Pipe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ New construction</td>
<td>115% to 125%</td>
<td>15% to 25%</td>
</tr>
<tr>
<td>5. Non-Painted (Bare) CS Pipe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ New Construction</td>
<td>60% to 80%</td>
<td></td>
</tr>
<tr>
<td>6. NDE @ hgh confidence level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>▪ In-situ maintenance</td>
<td>95% to 100%</td>
<td></td>
</tr>
</tbody>
</table>

Note 1: Organic paint = 100%
Note 2: vs. insulation costs
## Life Cycle Comparison: 1500 ft of NPS 8 Pipe

<table>
<thead>
<tr>
<th></th>
<th>Replace Existing CS Pipe w/ TSA</th>
<th>Replace Existing CS Pipe w/ Painted CS Pipe; paint every 10 Yr</th>
<th>TSA Existing CS Pipe In-situ; strip coat, re-insulate</th>
<th>Paint Existing CS Pipe In-situ; strip, paint, re-insulate; re-paint every 10 Yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Cost (Yr 0)</td>
<td>643,030</td>
<td>628,950</td>
<td>308,566</td>
<td>255,400</td>
</tr>
<tr>
<td>Yr 10 Cost</td>
<td>------</td>
<td>378,000</td>
<td>--------</td>
<td>378,000</td>
</tr>
<tr>
<td>Yr 20 Cost</td>
<td>------</td>
<td>560,000</td>
<td>--------</td>
<td>560,000</td>
</tr>
<tr>
<td>Life Cycle Cost</td>
<td>643,030</td>
<td>1,566,950</td>
<td>308,566</td>
<td>1,193,400</td>
</tr>
<tr>
<td>NPV @ 10%</td>
<td>643,030</td>
<td>858,105</td>
<td>308,566</td>
<td>484,554</td>
</tr>
<tr>
<td>DCF Rate of Return</td>
<td><strong>39%</strong></td>
<td><strong>24%</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Cost per Ft²</td>
<td>189.00</td>
<td>185.00</td>
<td>91.00</td>
<td>75.00</td>
</tr>
<tr>
<td>Annualized Cost/ sq ft/yr (20 Yr)</td>
<td><strong>9.44</strong></td>
<td><strong>23.01</strong></td>
<td><strong>4.53</strong></td>
<td><strong>17.52</strong></td>
</tr>
</tbody>
</table>

### Notes:
1. Cost basis is 2002 U.S. Gulf Cost data; inflation assumed at 4%
2. TSA to Paint costs used for this analysis. 7:1 ratio for Replacement cases & 12:1 ratio for In-situ cases
3. At NPS 3 and below 304 stainless steel pipe may be cost competitive
4. Personnel Protection Cages should be used to eliminate thermal insulation when ever possible
5. Re-paint costs may be painting or NDE costs
**CUI Prevention Strategy:**

### Conventional CUI Management

- Application of protective systems along with NDE/inspect is usually used to fight CUI.
- Conventional paint systems have a life 5-13 years. Re-paint to prevent CUI; on-going NDE/inspection to mitigate CUI.
- De facto “run-to-failure” in place if maintenance is not done. NDE improves CUI damage estimate but does not reduce CUI.
- Cost to field strip insulation, surface prep, paint and insulate (including scaffolding) is 13 times more than original painting cost.

### CUI Prevention Strategy

- Based on “suite” of tools in use within industry.
- Tools capable of CUI prevention; break the inspect & maintain cycle.
- CUI prevention means “do it once” and move toward “inspection-free & maintenance-free” operating mode.
- Deployment based on economic reality and life cycle savings. Significant risk reduction may also be obtained by elimination of de facto “run-to-failure”.
CUI Prevention Strategy
Summary

• Piping systems are prone to CUI and they contribute significantly to piping maintenance costs.

• Significant maintenance savings are possible with a CUI Prevention Strategy focused on an “inspection-free; maintenance-free” philosophy.

• The full range of CUI Prevention “tools”, including organic coatings, needs to be evaluated on a TEC and life cycle basis to reach the optimum choice.