On-stream Inspection Programs - Improving Mechanical Integrity

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Presentation Overview:

• What is Mechanical Integrity?
• What are On-stream Inspections?
• Why implement On-stream Inspection Program and how do they improve mechanical integrity?
Mechanical Integrity is

- Mechanical Integrity: Condition of process equipment that makes it suitable for continued operation at known process conditions for a specified period of time.
- Mechanical Integrity Program: Activities that serve to establish, maintain, and confirm this condition of continued suitability for service.
  - PMI or positive material identification programs
  - MOC or Management of Change programs
  - RBI or Risk Based Inspection programs
  - Inspection Programs
Inspection Programs are

• Inspection Program: Activities to evaluate an asset’s condition

• Typical Types of Inspections
  – Internal Inspection
  – External Inspection
Types of Inspections

• **Internal Inspection**: An inspection performed from the inside of a pressure vessel using visual and/or NDE techniques

• **External Inspection**: A visual inspection performed from the outside of a pressure vessel to find conditions that could impact the vessel’s ability to maintain pressure integrity or conditions

**Inspection Codes**


• API 570 Piping Inspection Code In-service Inspection, Rating, Repair, and Alteration of Piping Systems-3rd ed., November 2009

• API 653 Tank Inspection, Repair, Alteration, and Reconstruction 4th ed. April 2009
Impact of Internal Inspection

• Safety
  – Confined Space programs
  – Lockout/Tagout programs

• Cost
  – Refinery Downtime
  – Blinding, Cleaning, Entering
  – Inspection

• Mechanical Integrity
  – Increase Corrosion Rate
  – Induce Cracking
Increased corrosion during the Sd/Su and de-inventorying of the reactor in a sulfuric acid alkylation units

- The unit operates round 10°C (50°F) and 95% to 100% sulfuric acid resulting in less than 5mpy corrosion
- During Sd/Su and de-inventorying
  - Increased temperature due to the heat of reaction
  - Decreased concentration due to de-inventorying
- Resulting in over 200mpy corrosion for the time period or more than 6 mils lost
Potential increase of metal temperature during cleaning of a caustic scrubber in the Isomerization unit

- Cleaning method included Steaming-out vessel.
- During Steam-out vessel temperature reached 95°C (200°F)
- While caustic cracking was not an issue during operation, the vessel is now susceptible due to cleaning
On-stream Inspections are

- **On-stream Inspection**: An inspection performed from the outside of a pressure vessel while it is on-stream using non-destructive examination (NDE) procedures to establish the suitability of the pressure boundary for continued operation.

- **Risk Based Inspection Recommended Practices**
Why Implement On-stream Inspection?

• Reduce the safety risk from vessel entry
• Reduce maintenance and operating cost:
  – Minimize requirements for internal inspection (cleaning & blinding).
  – Extended intervals between internal inspections.
• Improve mechanical integrity:
  – Conduct On-stream inspection instead of internal inspection
  – Allows for more frequent onstream inspection if needed.
How to implement On-stream Inspection programs.

1. Understand the potential Damage Mechanism.

2. Understand the Risk associated with the vessel.

3. Determine the Risk Mitigation strategy
   a. Understand the objective of the inspection
   b. Understand available NDE Technology specifically the probability of detection.
Through Risk Based Inspection Program

API 581 Risk vs. Time Graph

- Risk
- Risk Target
- Risk Threshold
- Installation Date
- RBI Date
- Target Date

Total Risk Without Inspection
Inspection Effectiveness is

API 581 Inspection Effectiveness Categories

<table>
<thead>
<tr>
<th>Qualitative Inspection Effectiveness Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>A Highly Effective</td>
<td>The inspection methods will correctly identify the true damage state in nearly every case (or 80–100% confidence).</td>
</tr>
<tr>
<td>B Usually Effective</td>
<td>The inspection methods will correctly identify the true damage state most of the time (or 60–80% confidence).</td>
</tr>
<tr>
<td>C Fairly Effective</td>
<td>The inspection methods will correctly identify the true damage state about half of the time (or 40–60% confidence).</td>
</tr>
<tr>
<td>D Poorly Effective</td>
<td>The inspection methods will provide little information to correctly identify the true damage state (or 20–40% confidence).</td>
</tr>
<tr>
<td>E Ineffective</td>
<td>The inspection method will provide no or almost no information that will correctly identify the true damage state and are considered ineffective for detecting the specific damage mechanism (less than 20% confidence).</td>
</tr>
</tbody>
</table>
## Example Inspection Effectiveness Table

### API 581 Localized thinning Inspection Effectiveness Table

<table>
<thead>
<tr>
<th>Inspection Effectiveness Category</th>
<th>Intrusive Inspection Example</th>
<th>Non-intrusive Inspection Example</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A</strong> Highly Effective</td>
<td>100% visual examination (with removal of internal packing, trays, etc.) and thickness measurements</td>
<td>50 to 100% coverage using automated ultrasonic scanning, or profile radiography in areas specified by a corrosion engineer or other knowledgeable specialist.</td>
</tr>
<tr>
<td><strong>B</strong> Usually Effective</td>
<td>100% visual examination (with partial removal of the internals) including manways, nozzles, etc. and thickness measurements.</td>
<td>20% coverage using automated ultrasonic scanning, or 50% manual ultrasonic scanning, or 50% profile radiography in areas specified by a corrosion engineer or other knowledgeable specialist.</td>
</tr>
<tr>
<td><strong>C</strong> Fairly Effective</td>
<td>Nominally 50% visual examination and spot ultrasonic thickness measurements</td>
<td>Nominally 20% coverage using automated or manual ultrasonic scanning, or profile radiography, and spot thickness measurements at areas specified by a corrosion engineer or other knowledgeable specialist.</td>
</tr>
<tr>
<td><strong>D</strong> Poorly Effective</td>
<td>Nominally 20% visual examination and spot ultrasonic thickness measurements</td>
<td>Spot ultrasonic thickness measurements or profile radiography without areas being specified by a corrosion engineer or other knowledgeable specialist.</td>
</tr>
<tr>
<td><strong>E</strong> Ineffective</td>
<td>No inspection</td>
<td>Spot ultrasonic thickness measurements without areas being specified by a corrosion engineer or other knowledgeable specialist.</td>
</tr>
</tbody>
</table>
How do On-stream Inspections improve Mechanical Integrity?

• Increased Safety
• Eliminated impacts to Mechanical integrity
  – Increased corrosion during the Sd/Su and de-inventorying of the reactor in a sulfuric acid alkylation units
  – Removal of protective layers during cleaning
  – Potential increase of metal temperature during the cleaning of a caustic scrubber in the Isomerization unit
Presentation Recap:

- What is Mechanical Integrity?
  - Condition of an asset
- What are On-stream Inspections?
  - Inspection performed outside of an asset using non-destructive examination (NDE) to understand the condition to an expected confidence.
  - On-stream inspections are implemented along Risk Based Inspection programs
- Why implement On-stream Inspection Program?
  - Reduce cost
  - Improve Mechanical Integrity
QUESTIONS?

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