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Damage Mechanism Reviews

SOME SHARED LEARNINGS AND PRACTICES REGARDING THE PROCESS ITSELF

Presenter

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Degradation mechanism reviews are now relatively common exercises in operating facilities necessary for sufficiently technically well-grounded and dynamic inspection programs needed in today's operating environments. The newly issued API RP 970 (Corrosion Control Documents)helps with the process but it certainly has omissions in many areas in which responsible operators need to address. Standardized criteria for consistent determinations of environmental cracking mechanisms vulnerabilities is but one example. Rigor of data review and analyses is other. This presentation will discuss experiences and possible pitfalls of in the execution of degradation mechanism reviews and discuss possible controls and practices to optimize the effectiveness of these efforts.

What is a Process Unit Damage Mechanism Review

"A study of a process unit's process, design, materials, and history (operating, inspection and maintenance) to determine potential damage mechanisms, corrosion types, and Corrosion Rates/Potentials to be used for risk assessment and Inspection programming."

Key Participants in Damage Mechanism Reviews

- Inspection/Process Supervision
- Corrosion Expert
- Operations
- Process Engineering
- On-site/Internal Corrosion/Metallurgical Engineering
- Inspectors/Inspection Planners
- Others can be very helpful too: Process SME's, Maintenance, Chemical Vendor Reps

Damage Mechanism Reviews Process

Critical Plant Info to Review

- Applicable operations manuals and procedures
- Current PHA reports
- Simplified PFDs
- P&IDs
- Equipment design and materials of construction
- All applicable MOC's completed since the last Damage Mechanism Reviews
- All available information on damage mechanism related incidents from the Owner's Incident management Database and Industry sources (e.g. American Fuels and Petrochemical Manufacturers (AFPM) incident portal)
- Inspection histories
- Any available corrosion control documents (including material flow diagrams)
- Leak repair locations and histories
- Exchanger bundle replacement histories
- Any special accelerated corrosion inspection programs
- Refinery dead leg lists and dead leg inspection program history
- CML Corrosion Rate data and analysis and other corrosion rate information (corrosion coupon analysis, corrosion probe data, etc.)
- Previous applicable Damage Mechanism Reviews

Corrosion Report Deliverables

A final Damage Mechanism Review Report is typically written by the Corrosion Expert which may include the following:

- Unit Premise Document and Process Summary
- Critical asset level process data spreadsheet: Representative fluid/phase, operating temperature, operating pressure, toxics and toxic percentages
- Applicable degradation mechanism descriptions
- All MOCs considered
- All Injection Points and Mixing Points
- Highlight dissimilar metal weld locations and vulnerable deadleg piping systems/circuits

And there is more in the Damage Mechanism Reviews Report

- Expected corrosion rates for each asset (external if requested as well).
- Applicable environmental cracking and other damage mechanisms applicable to each asset along with "Potential/Probability" assignments and possible locations of damage.
- IOW tables that support determinations of the Corrosion Study
- Other Technical Recommendations (material upgrades, etc.)

QUALITY CONTROL AND QUALITY ASSURANCE

- Accuracy and completeness of Damage Mechanism Reviews are critical to the effectiveness of fixed equipment inspection programs.
- Active involvement by refinery inspection, process and/or operations personnel supporting the Corrosion Expert will help ensure the Damage Mechanism Reviews are technically correct and adequately support plant fixed equipment mechanical integrity program requirements.
- The Inspection Supervisor should review and approve all completed Damage Mechanism Reviews Reports for completeness and compliance with company standards and expectations. All other Corrosion Review Team Members for each Damage Mechanism Reviews should also review the resultant completed corrosion review study report for completeness and accuracy based on their knowledge and expertise and approve the completed report as well. Consider requiring approvals be documented by signature.

QUALITY CONTROL AND QUALITY ASSURANCE

To that end Inspection Supervision should:

- Verify acceptability of Corrosion Expert, verifying knowledge of process and degradation mechanisms and how determinations will be utilized.
- Establish standards from degradation mechanism assignment to assure repeatability and compliance to RAGEGAP (or other).
- Verify the completeness and accuracy of all PSM related information used in the study (e.g., Process Flow Diagrams (PFD's), P&ID's, Material Flow Balance sheets, and Material Flow Diagrams (MFD's).
- Verify the accuracy and completeness of Inspection data in the inspection program and in other records used in the corrosion study (original fabrication records, inspection reports, thickness data, repair records, etc.).

Consider using a QC Checklist

Item	Task Category	Required Elements	Task Responsible Person	Corrosion Engineer Assessment of Compliance	Owner Inspection Supervisor Assessment of Compliance	Objective Evidence	Owner Inspection Supervisor Acceptance	Other Comments
1	Process Management	The Owner Inspection Supervisor determines the scope of the Corrosion Study	Inspection Supervisor	NA				
2		The Corrosion Expert has sufficient training and understanding of RBMI and how his review will be used in the programming?	Corrosion Engineer		NA			
3		If the Corrosion Engineer is third party does the contracting organization provide editorial support and is the work product peer reviewed by the contracting organization?	Third Party Org Mgmt		NA			
4		The Owner Inspection Supervisor shall verify the acceptability of the Corrosion Expert	Inspection Supervisor	NA				
5	Data Required for the Corrosion Study	The Corrosion Expert assembles a list of required information. The information request shall include (unless approved by the Owner Inspection Supervisor):	Corrosion Engineer		NA			
		a. Process description and applicable operations manuals and procedures	Corrosion Engineer		NA			
		b. Applicable maintenance procedures	Corrosion Engineer					
		c. Current PHA reports	Corrosion Engineer		NA			
		d. Simplified PFD's	Corrosion Engineer		NA			
		e. P&ID's	Corrosion Engineer		NA			
		f. RBMI Operations-related Consequence Data (Representative Fluid, Operating Temperature, Operating Pressure, toxics and toxics contents)	Corrosion Engineer					
		g. Equipment design and materials of construction	Corrosion Engineer		NA			
		h. All applicable MOC's completed since the last corrosion study to fully evaluate their impact on damage mechanism hazards	Corrosion Engineer		NA			
		i. Inspection history including original inspection reports for degrading equipment as a minimum	Corrosion Engineer		NA			
		j. NDE Data and available data analysis	Corrosion Engineer		NA			
		j. List of all material spec breaks	Corrosion Engineer					
		k. Any available corrosion control documents (including material flow diagrams)	Corrosion Engineer		NA			
		l. List of all equipment in each current service-related cracking mechanism (wet H2S, amine, etc.) and metallurgical degradation (i.e. creep, graphitization, etc.) program.	Corrosion Engineer					
		m. Leak repair locations and histories	Corrosion Engineer		NA			
		n. Exchanger bundle replacement histories	Corrosion Engineer		NA			
		o. Any special accelerated corrosion inspection programs	Corrosion Engineer		NA			
		p. Refinery dead leg lists and dead leg inspection program history	Corrosion Engineer		NA			
		q. CML corrosion rate data and analysis and other corrosion rate information (corrosion coupon analysis, Permanence data, etc.)	Corrosion Engineer		NA			
		r. Previous corrosion studies	Corrosion Engineer		NA			
		s. List of overdue inspections (and deferral justifications if available)	Corrosion Engineer		NA			
6		The Corrosion Expert reviews the process being studied and assembles a critical process data spreadsheet. The critical process data sheet is submitted to Operations or other designated process expertise determined by Operations within the refinery to populate required process data field and returned to the Corrosion Engineer.	Corrosion Engineer		NA			
7		Owner Inspection Supervisor will submit to the Corrosion Engineer for review all readily available information on damage mechanism incidents from Owner's Incident management Database and the American Fuels and Petrochemical Manufacturers (AFPM) incident portal.	Inspection Supervisor	NA				

Pitfalls – What you can get with Less Managed Reviews

Personnel Competencies

- Corrosion Engineer may have little familiarity with current company inspection and corrosion control standards and programming procedures and software.
- CE Company may have no peer review and other quality management systems otherwise to provide Damage Mechanism Reviews services.
- Owner Process data gatherers may require more experienced support to get the right data in the right amount.

Critical Corrosion Review Process Omissions

- No review of critical internal documents like MOC's, PHA's or past corrosion studies.
- No review and obvious consideration industry incidents from AFPM or Company incident logs.
- Little direct plant data reviewed.
- Process Reviews only at PFD level.
- Inadequate owner team support in data gathering or team meetings.
- Inadequate capturing of Damage Mechanism Reviews meeting discussions.

Pitfalls – What you can get with Less Managed Reviews

Expected Corrosion Rate Assignments

- CE does not review and consider Plant NDE data and analysis ("It's all crap!", they'll say)
- Inconsistencies in CE determined corrosion rates (i.e. often low 1/2/3 mpy determinations for assets with little/no historic corrosion are based on CE discretion).
- CE's often chose arbitrary corrosion rates to "drive inspection", with little understanding of impact on risk analysis and inspection planning.

Degradation Mechanism Assignments

- CE does not consider all potential degradations mechanisms in API-571 or other industry standards and guidelines (i.e. MTI etc. .
- CE criteria for when to assign or not can be inconsistent, arbitrary and not necessarily RAGEGAP.
- CE may make determinations with little of no actual process data, relying on "experience" or known past practices.
- CE provides unprecise guidance on where to assigned degradation mechanisms would be expected within an asset.
- CE consideration of past inspection data may not adequately consider quality/effectiveness.

Pitfalls – What you can get with Less Managed Reviews

Final Reports

- Inadequate documentation in several critical areas (i.e. Unit Premise, Alternative Operating Regimes considered, Team Meeting discussions, basis for degradation assignments (and the lack of assignment in cases)).
- Report format not aligned with (what do you do with "very low vulnerability callouts for instance) or otherwise conducive for ready extraction of necessary data for inspection analysis and planning purposes.
- Technical Recommendations not clearly presented and in a separate section
- Final Reports not comprehensively reviewed and accepted by the Owner.

Special topics: some comments

Corrosion Expert Plant Gathering and Analysis

- Expert requests must be clear and should be documented.
- All operating regimes should be considered.
- Direct process measurement rather than "judgment/estimates" and modeling should be pursued for determining (or at least validating) the more critical process parameters used in the study where possible.
- Expert direct review of Inspection data and reports is often necessary.

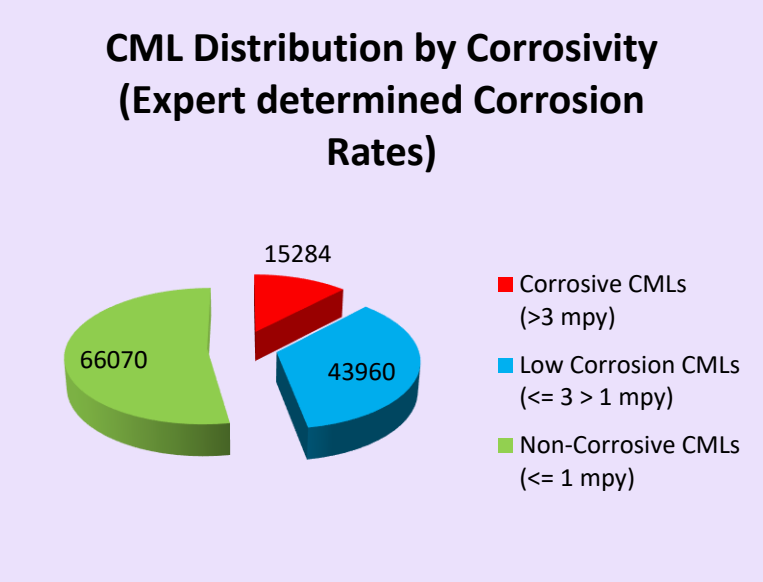
Expected Corrosion Rate Determinations

- Consider available actual NDE data and analysis of that data.
- Consider obtaining actual field test data ASAP to validate corrosion rate assignments where field test data does not exist.
- Normalize/Rationalize "Industry Standard" corrosion rate assignments against points one and two above – There is no absolute "industry standard".
- Consider impact on inspection risk assessment and planning when making determinations.
- Follow owner guidance if available.

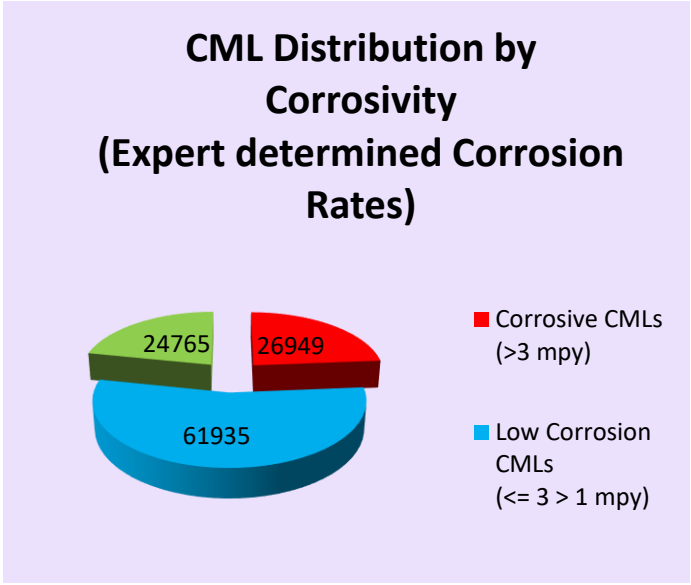
Different Cooks (Experts) can give, Unchecked, Different Answers

Plant 1 and Plant 2 have virtually equivalent operations and history.

Plant 1



Plant 2



These differences can result in very different determined risk profiles and inspection plans

Degradation Mechanism Assignments

- Consider using measured versus modeled critical data wherever possible.
- Consider standardizing degradation mechanism assignment thresholds (H2S > 50 ppm in aqueous phase for instance).
- Consider likely effectiveness of historic inspections when factoring them into degradation mechanism assignment determinations.

Example of a DM Assignment Guideline

Table 7 Caustic Stress Corrosion Cracking

Potential	Criteria
High	➢ Environmental cracking detected during last inspection ➢ Non-PWHT, Caustic > 5%, located in area "B" or "C" of the Susceptibility of Caustic Cracking in Carbon Steel" chart (1) ➢ Non-PWHT, located in area 'A' of the Susceptibility of Caustic Cracking in Carbon Steel" chart (1), and heat traced (Caustic > 5 %)
Medium	➢ No indications found during last environmental damage inspection, and • Non-PWHT, located in area 'A' of the Susceptibility of Caustic Cracking in Carbon Steel" chart (1), Caustic < 5 %, and heat traced, or • Non-PWHT, located in area 'A' of the Susceptibility of Caustic Cracking in Carbon Steel" chart (1), Caustic > 5 %, no heat traced, but steam out
Low	➢ No indications found during last environmental damage inspection, and ➢ Non-PWHT, located in area 'A' of the Susceptibility of Caustic Cracking in Carbon Steel" chart (1), Caustic < 5 wt%, not heat traced, but steamed out ➢ PWHT > 1150°F or not welded (i.e., tubesheets), caustic > 5 wt% and operating above area 'B' of the Susceptibility of Caustic Cracking in Carbon Steel" chart (1) ➢ PWHT>1150°F or not welded (i.e. tubesheets), caustic at any concentration and subject to caustic boil off conditions (≥ 212°F, increasing with caustic concentration and pressure)
Not Susceptible	➢ History of no cracking, and • PWHT, or • Non-PWHT, located in Area 'A' of the "Susceptibility of Caustic Cracking in Carbon Steel" (1), not heat traced, and not steamed out, or ➢ Non-PWHT, located in Area 'A' of the "Susceptibility of Caustic Cracking in Carbon Steel" (1), not heat traced, and steamed out, but thoroughly flushing with water before steam out ➢ Non-PWHT, located above area 'A' of the Susceptibility of Caustic Cracking in Carbon Steel chart (1) and Caustic < 5 %, no heat tracing and no steam out with no concentrating mechanism

NOTE:

- For the purpose of Table 7, caustic service is defined as any service containing > 5% caustic OR a concentrating mechanism that could result in high caustic concentrations (i.e., vapor space of vessels with two phase flow).
- Effective PWHT temperature ≥ 1150°F. No credit for PWHT at or below 1150°F in Table 7.

Mixing Points

- Consider P&ID level reviews to identify all possible locations
- Consider standardizing guidance for assigning thermal mixing points (Delta T exceedance, design considerations)
- Consider standardizing guidance for assigning corrosion mixing points (H2 mixing points, dry process with corrosives into wet process, High delta P mixing (erosion/film degradation), etc.)

Dissimilar Metal Welds

- Establish clear guidance for determining degradation potential at DMW locations depending on metallurgies involved and service conditions
  - Thermal Cracking
  - Environmental Cracking
  - Galvanic Corrosion

The plant needs to be able to compile a complete and accurate list of all DMW locations for consideration.

Questions?