Prediction of Amine Corrosion in Refinery and Gas Processing Rich Amine Circuits

Predict-Amine 2.0

Failure Prevention
Risk Mitigation
Optimized Material Selection

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Outline

• Introduction to Amine Corrosion

• Overview of Rich Amine Joint Industry Program

• Predict-Amine 2.0: Functionality Description

• Predict-Amine 2.0: Interface / Application

• Questions and Discussion
Impact of Amine Corrosion

• Amine units provide gas treating capabilities that remove acid gases (CO$_2$ and H$_2$S) from feed gas
• Most piping in amine units built from carbon steel - some higher alloy utilization in re-boilers and heat exchangers
• There are limited data and guidelines in industry to quantify amine corrosion with respect to velocity (wall shear stress) and acid gas loadings
• Different amines are used in the industry with varied operating conditions and limits

• Loss of production in Amine Units can cost upwards of $400,000 per day
Corrosion Problem Areas in Typical Amine Units

LEAN AMINE

TREATED GAS

RICH AMINE

CONTACTOR

ABSORBER

FILTER

STRIPPERS

LEAN TO RICH AMINE HEAT EXCH.

Lean To Rich Amine Heat Exch.

Amine Make-up

SOUR GAS FEED

ACCUM

ACID GASES

SOUR GAS FEED
Amine Corrosion – Overview

• H₂S and CO₂ from feed gases are absorbed into the amine solvent by chemical reaction
• Amines with dissolved CO₂ and H₂S from the contactor are called Rich Amines
• Corrosion in Rich Amine circuits is caused due to dissolved acid gases and presence of impurities
• Acid gases are removed from amines in regenerators at high temperature or low pressure
• Amine from regenerator contains low dissolved acid gases and is called Lean Amine
• Predict-Amine 2.0 focuses on Rich Amine Corrosion
Amine JIP Inception

• Absence of quantified data made corrosion prediction / prevention of failure difficult

• Need for a sound engineering basis to quantify corrosion in amine systems

• In 2003 Honeywell along with major refiners and gas processors formed a Joint Industry Program designed to generate data for amine corrosion
  - Program sponsored by twelve leading operating companies

• Purpose: To create a definitive, engineering basis for dealing with amine corrosion for MEA, DEA and DGA®

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Corrosion Prediction using Predict-Amine 2.0

• Key Variables for assessing Amine Corrosion
  - Acid Gas Loading
  - Velocity (Wall Shear Stress)
  - Temperature
  - Impurities and HSAS
  - CO₂ / H₂S Ratio

• Types of Amines
  - MEA
  - DEA
  - DGA
  - Phase II of Amine JIP focuses on MDEA

• Materials evaluated
  - CS
  - 304L
  - 316L
  - Alloy 2205
  - Alloy 825
Predict-Amine 2.0

• Incorporates
  - Large database of quantitative corrosion data developed by Amine JIP from simulated lab tests
  - Flow modeling calculations for wall shear stress
  - Algorithms/rule sets to address effect of the key variables that affect corrosion

• Predicts amine corrosion rate for five (5) commonly used materials in MEA, DEA and DGA services
• Provides tools for sensitivity and multipoint analysis
• Provides access to 3D Piping tools for modeling
• Provides secure access to all JIP data, presentations, trends and correction factors
Predict-Amine 2.0: How does it work?

1. Calculate shear stress at pipe wall for process flow conditions

2. Convert the field shear stress into an equivalent lab flow loop velocity

3. Using lab velocity and acid gas loading, predict corrosion rates for all materials using respective iso-corrosion diagrams developed from JIP DATA

4. Correct corrosion rates for the effect of temperature, impurities and CO₂ loading based on trends developed from JIP DATA
Iso-Corrosion plots in Predict-Amine 2.0

- Ability to predict corrosion rates for all relevant data ranges
- Facilitates easy quantification of amine corrosion

ISOCORROSION DIAGRAM FOR COMBINED AVG CS-CS HAZ
(72 Hour Laboratory Test, 18 wt% MEA, 130 F)
Amine Corrosion: Effect of Temperature

Effect of Temperature on corrosion rate of CS-CS HAZ (72 hours laboratory test, 0.5 mol/mol, 30% DEA, 20 ft/sec comparison)

Temperature (F)

Corrosion rate (mpy)

CONFIDENTIAL DATA

Honeywell International, Inc
Amine Corrosion: Effect of Impurities

Effect of Impurity concentrations on corrosion rate of 304L
(72 hours laboratory test, 0.8 mol/mol, 18% MEA, 130 F, 20 ft/sec comparison)

![Graph showing the effect of impurity concentrations on corrosion rate of 304L](image_url)

- **Static**
- **Flow Through**

**Corrosion rate (mpy)**

**Impurities (%)**
Predict-Amine Interface : Inputs

- Easy to use Interface
- Simplified Inputs
- Extensive Functionality
- Units Flexibility
- Access to JIP Data
- Help system
- 3-D Piping Analysis
- XP/Vista/7 compatible
Predict-Amine Interface : Results

- Corrosion rates
- Flow regime
- Wall shear stress
- Flow parameters
- Customizable Charts and Grids
Additional Key Functionalities

- **Automated Multi-point Analysis**
  - Using MS Excel run multiple cases with one click

- **Automated Sensitivity Analysis**
  - Evaluate parametric sensitivity to examine trends and check for inflection points

- Secure access to all program data, including reports, meeting presentations, corrosion rates and iso-corrosion curves

- **Automatic Unit Conversions (SI / American)**

- **Network and Corporate licensing** for ease of deployment
Multi-point Analysis using Excel
Sensitivity Analysis in Predict-Amine 2.0
3-D Piping Model for Amine Piping Circuits
Secure, Electronic JIP Data Access
Predict-Amine 2.0 Licensing Options

• **New users** (non-sponsors of JIP) pay a competitive price for valuable data and functionality hitherto available only to JIP sponsors

• **Program Sponsors** get a substantial (40%) discount on all prices

• Comprehensive consulting support and customization services offered to all users

• Various options available for licensing:
  - Single user workstation licenses
  - Single / Multi user network based licenses
  - Corporate (worldwide) Licenses
  - Annual or Multi-year licenses available
Predict-Amine 2.0 Brings Value

- As a tool for corrosion quantification
- To support inspection planning, and allocation of resources towards situations that have potential for high corrosion
- To determine the right alloy (a more expensive material is not always better)
- To mitigate and minimize risk of failure (as a component in any RBI program)

- Applicable in various scenarios
  - Material selection for new equipments
  - Utilize existing inspection resources wisely
  - Locating critical locations in existing amine units
  - Determining inspection intervals
  - Evaluating materials or amine quality
  - Optimizing Asset Integrity and Reliability programs
Conclusions

• Predict-Amine 2.0 may be used by all refinery and gas processing operators for assessing rich amine corrosion

• Supports better inspection and maintenance planning, and allocation of monitoring/equipment resources

• Mitigate and minimize risk of failure (as a component in any RBI program)

• Lean Amine and MDEA data may be obtained by joining current JIP programs

• Supports enhanced safety and reliability through better decision making and failure prevention
Thank you

- Questions?
- Discussion