ICorr Aberdeen Branch Welcomes

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Corrosion Awareness Day 2017

Aberdeen Branch

Key Sponsor

Integrity Management: Engineering Services
- Data Management
- Development, management, and maintenance of customer and company software systems
- Analytics and Modelling
  - Failure mechanism predictions, equipment-specific algorithms, mathematical and statistical engineering
- Risk, Reliability, and Maintenance
  - Risk assessments, critical analysis, reliability studies, CMMS optimization, maintenance programs, spare parts analysis

Engineering Solutions
- Solutions for corrosion, structural, pipeline, and process plant requirements including asset life assessments

Subsea Engineering Solutions
- Fitness-for-service engineering and inspection, due diligence studies, inspection campaign management, pipeline engineering

Note: Year End 2015

Headquarters
- Regional Headquarters
- Operational Bases
- M.Sc. Metallurgical Engineering - University of Tehran;
- M.Sc. Corrosion Control Engineering - University of Manchester;
- International Welding Engineer - IIW (International Welding Institute);
- Charter Engineer - IOM3 (Institute materials, minerals, and mining);

- More than 15 years experience in oil and gas industry;
- 4 years in EPC contractor;
- 11 years in third party certification body - Bureau Veritas;
- 3 years in service provider - Oceaneering;
- Work experience in Iran, Abu Dhabi, Malaysia, and the UK;
- Providing service to major operators like:
- NIOC, ADNOC, Total, Saudi Aramco, Petronas, Talisman, and BP.
Corrosion Awareness Day 2017
Aberdeen Branch

Corrosion Management Overview / Risk Based Inspection

- Background to Corrosion Management
- Corrosion Management Processes
- Corrosion Management Tools
- Corrosion Risk Assessment
- Corrosion Management Systems
- Conclusions
To manage has been defined as “to succeed in one’s aims”  
(often with inadequate materials etc.)

The need for corrosion management
- Catastrophic events due to poor corrosion management / human error
- Legislative requirements (Audits, Policies, etc.)

**Corrosion management tools**
- Quality Management System (QMS)
- Risk Based Inspection
- Management of Change
- Total Quality Management (TQM)
- Written Scheme of Examinations
**Basic Concepts**

**Corrosion control strategy** is defined here as the management of available resources, including finance, materials, equipment and manpower, to provide the policies, procedures and organizational systems that are required to **mitigate** the effects of corrosion

- long-term objectives (Cost, Leaks, etc.)
- standard corrosion control procedures
- Corrosion control tactics (inspection/Monitoring)
- Performance standards/KPI

Based on “Quality Management Process”
Basic Concepts

Risk Management Processes
• Strategic decisions
• Tactical decisions
• Operational decisions

1. Significant undesired or unexpected outcomes can be identified, and
2. Opportunities for improvement can be considered.
Identification of Corrosion Risks

Corrosion damage and failure modes
- Uniform corrosion
- Galvanic corrosion
- Localized attack – pitting and crevice corrosion
- Flow induced corrosion – erosion corrosion
- Environmentally assisted cracking
- Corrosion fatigue

Basic corrosion risk assessment steps

Corrosive environment  Engineering factors
Hazards and risks
A hazard has the potential to cause harm or damage; often defined as a physical condition or release of hazardous material as a result of component failure that can cause human injury or death, loss or damage, or environmental degradation.
Risk is the combination of the severity of the effect (the consequences) and the likelihood of it happening (damage mode and probable frequency).

Information needed for corrosion assessment
• asset register (structures/vessels/pipework/storage tanks, etc.),
• historical data (inspection/monitoring/maintenance),
• theoretical analysis (new systems based on published data/models),
• opinions and concerns of stakeholders
• field data where available.
Corrosion Risk Assessment Processes

**Risk assessment:**
1. What would be the worst case scenarios?
2. How likely are they to occur?
3. What would be the damage?
4. How many people could be injured or killed?
5. How will these events affect the business?
Corrosion Risk Assessment Processes

Probability of Failure assessment
1. Failure mode – what could go wrong?
2. Failure effect – how will it affect the project/plant integrity/operations?
3. Failure criticality – how likely is it?
Corrosion Risk Assessment Processes

Matrix analysis

Criticality = Likelihood of failure \times \text{Effect of failure}

Level 1 – Qualitative risk analysis, a simple ranking of equipment
Level 2 – Semi-quantitative risk analysis, a more accurate prioritization that retains vital inputs of a Level 3 analysis but simplifying assumptions
Level 3 – Quantitative risk analysis, an in-depth study including assessment of reliability, financial and limited environmental issues

<table>
<thead>
<tr>
<th>Criticality ranking, 1–5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect of failure</td>
</tr>
<tr>
<td>Likelihood category</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

| Likelihood category      | 1   | 2      | 3    |
|                         | Low | Medium | High |
|                         | Low | Medium | High |

Consequence category

Medium high risk
High risk
Low risk
Medium risk
High risk

A B C D E
Corrosion Risk Assessment Outcome:
1. A minimal inspection plan.
2. The current level of inspection.
3. An optimized level of inspection.

- Inspection frequency can be adjusted
- the methods and tools used for the test and inspection (T&I) schedule can be changed.
- The scope, quality, and extent of the inspection and data collection / interpretation can also be modified.
Corrosion Risk Assessment Processes

Unacceptable high risks
requiring a redesign in more corrosion resistant materials or alternative processing routes to be employed.

Medium–high risks
Could be assessed to see if increased inspection frequencies would allow continuing operation but obviously with a limited life (a predictive maintenance strategy) or if improved corrosion control measures would be effective at decreasing the likelihood of failure and moving the item into a medium risk level and also extending the life.
Corrosion Mitigation Requirements

Corrosion risk mitigation:

1. Materials selection
2. Chemical treatments
3. Use of coatings
4. Cathodic and anodic protection
5. Process and environmental control
6. Design
7. Inspection and monitoring
Corrosion Mitigation Requirements

**Corrosion risk mitigation by Inspection:**

1. condition of equipment
2. requirements for repair
3. rates of localized corrosion or cracking

**Corrosion risk mitigation by monitoring**

Changes in fluid corrosivity due to

i. damaging excursions in composition

ii. chemical treatments.

### Location of Inspection/monitoring

<table>
<thead>
<tr>
<th></th>
<th>Inspection</th>
<th>Monitoring</th>
<th>Data handling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>UT, RAD, MPI, DPI, AE, …</td>
<td>coupons, ER probes, electrochemical measurements, LPR, …</td>
<td>supervisory control and data acquisition (SCADA) systems</td>
</tr>
<tr>
<td>Advanced/Specialised</td>
<td>Computerised Rad, intelligent pigging, …</td>
<td>field signature method (FSM), sand probes, …</td>
<td></td>
</tr>
<tr>
<td>Permanently installed/on-line</td>
<td>UT mat, piezoelectric sensors</td>
<td></td>
<td></td>
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</tbody>
</table>
The effectiveness of inspection programs in finding and monitoring identified damage mechanisms. Ranking typical inspection methods for various forms of damage modes.

Example for General thinning:

<table>
<thead>
<tr>
<th>Effectiveness</th>
<th>Inspection method/coverage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highly effective (90%)</td>
<td>complete internal visual examination plus ultrasonic thickness testing (UT).</td>
</tr>
<tr>
<td>Usually effective (80%)</td>
<td>partial internal visual examination plus UT</td>
</tr>
<tr>
<td>Fairly effective (50%)</td>
<td>external spot UT</td>
</tr>
<tr>
<td>Poorly effective (40%)</td>
<td>hammer testing/telltale holes</td>
</tr>
<tr>
<td>Ineffective (33%)</td>
<td>external visual examination</td>
</tr>
</tbody>
</table>

Increase in the number of effective inspections  

Increase in the confidence in the outcome
Corrosion Management Systems

Setting Performance Measures

UK pressure system regulations require asset owners to record / inform the regulatory authorities of any delay to a scheduled inspection.

1. Corporate level
   - written policy statements
2. Strategic level
   - CRA studies / Competencies / Legislations / Objectives / …
3. Tactical level
   - Annual audits / team allocation / guidelines, codes, standards / …
4. Operational/corrosion team level
   - On time reporting failures / collect monitoring data / …
5. Corrosion team leader
   - Review conformance of records / Specific procedures / …
Corrosion Management Systems

**Data Management Systems**

The choice will depend on the size of the project/operation.

1. An asset register
2. A documentation system
3. Data collection input and interfaces
4. Data analysis capability
5. Planning/work control
6. Reporting
7. Functionality enhancement
Corrosion Management Systems

“Swiss cheese” degradation hazard management model

- Assumptions/design basis unclear
- Inventory increased
- Local stresses/chemistry/temperatures
- Geometry
- Compatibility
- Poor specification
- Inadequate application
- No QA/QC
- Inadequate inspection
- Inadequate field data
- Poor scheduling
- Operate outside of envelop
- No trending
- No correlations
- Inadequate input of data
- Failure to recognize start-up/shutdown hazards
- Previous incidents and upsets not reported
- Lack of/poor performance indicators
- Procedures not followed
- Steps not signed off
- No verification on procedures in use
- Poor decision making
- Confusion over who is in charge
- Inadequate skills
- Lack of underpinning knowledge

Event or incident
Does not meet operational/design specs. Loss of containment

Post event
- Repair/replace/derate
- Shutdown
- Fire protection
- Escape routes
- Rescue/recovery

Plant design
Layout details

Options
Materials
Chemical treating
Coatings CP

Inspection
Monitoring
Maintenance
Operational control
Cleaning/pigging

Learning from the past
Risk assessments
Mitigation and secondary risks

Systems and procedures
Work control
Reviews/audits
Management of change

Effective leadership/supervision
Training/competency
Communicate cooperation

Corrosion
Fouling
Fracture
Wear

Hazard

Hooman Takhtechian, Oceaneering / Corrosion Management Overview
Further studies

- The Offshore Installations (Safety Case) Regulations, SI 1992/2885
- The Pipelines Safety Regulations, SI 1996/825
- The Control of Major Accident Hazard Regulations, SI 1999/743
- Pressure Systems Safety Regulations, SI 2000/128
- API Recommended Practice RP580, Risk Based Inspection; American Petroleum Institute, 2000.
THANK YOU FOR YOUR ATTENTION ANY QUESTIONS?