Integrity Management of Brownfield Projects: Challenges and Rewards

Presenters

Monzar Najami
Principal Inspection Engineer

Hooman Takhtechian
Principal Corrosion Engineer
Agenda

- Introductions
- About Oceaneering
- Integrity Build: Definition and Objectives
- Brownfield RBA Overview
- Challenges of RBA Programmes
- Operational Elements and Influencing Factors
- Industry Best Practice - Process, Plant, People, Performance
- Conclusion and Discussion
About Oceaneering

Oceaneering provides services to deep water, space, Oil & Gas, and Motion entertainment environments to execute with new, leading-edge connections to solve tomorrow’s challenges, today.

Founded in 1964 as an ROV/ Diving specialist

Oceaneering Acquisition of OIS in 2004 ( Asset Integrity )

Branches in 5 continents

Has more than 8000 employees
Worldwide Locations

- Aberdeen, Scotland
- Stavanger, Norway
- Baku, Azerbaijan
- Dubai, United Arab Emirates
- Kuala Lumpur, Malaysia
- Luanda, Angola
- Rio de Janeiro, Brazil
- Perth, Australia
- Hanover, Maryland
- Houston, Texas
- Morgan City, Louisiana

Headquarters
Regional Headquarters
Operational Bases
Inspection, Maintenance, and Repair (IMR)

Asset Integrity

Grayloc® Connectors

Decommissioning

Diving Services

Umbilicals

Subsea Connections

Installation Workover Control Systems (IWOCS)

Installation Services

BOP Intervention

Umbilicals

Subsea Control Valves

Flow Assurance

Video, Communications, and Applications

Dredging

BOP Intervention

Installation Tooling

Pipeline Repair

Flow Assurance

ROV Services

Subsea Control

Intervention Tooling

Valves

Installation Services
Integrity Management of Brownfield Projects: Challenges and Rewards

Asset Integrity

Data Management
Development, management, and maintenance of customer and company software systems

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, and pipeline engineering
The Aim of this Presentation is to:

- Share Best Practice for Operators/EPC/Vendors for a more efficient Integrity New Build (INB) programmes (Brownfield)

- Respond and adapt to Cost, efficiency, and Quality demands

- Lessons learnt/Best Practice in INB can benefit the existing operating facilities (e.g. Generic RBA / FM programmes)

- The Use of Technology (Recent Software RBA, CAD, IDB -Inspection Data Base) improves Governance & Standardization
Equipment Life Cycle Flowchart

Scope Definition

Design

Procurement including offsite manufacture

Site Fabrication, Construction & Testing

Handover / Acceptance

Commissioning

Operation

In-Service Inspection

Maintenance, Repairs & Replacements

Alterations, Re-rating & Life Extension

Decommissioning

Dismantling, Demolition & Disposal

Historical Data where available e.g.:
- corrosion rates
- suitable materials
- inspection requirements

Asset Records

Procedures

Auditing

Competent Resources

Training

Design & Offsite Manufacture

Site Construction

Operation

Retirement

ETP 32-10

ETP 32-20

ETP 32-30 & ETP 32-40

Asset Integrity
Integrity Build

Integrity Build: Why is it required?

- Compliance & Standardization (Legislative Governance, such as safety Case, & Regional Requirements)
- Ensure that integrity is designed into the project.
- To ensure safe and reliable operation of the facilities, by producing Inspection and Integrity plans, uploaded into the Maintenance Management System (MMS)

Integrity Build: Deliverables?

- Front End Integrity Management Strategies include RBA, PSV, Vibration, Baseline, FHA (Flexible Hose Assembly), Inspection Dwgs, Structural, etc.
- (Desk Top related) Integrity Build RBA process, Inspection Plans, CUI register, PSV assessment etc.
- (Site related activities): Programmes Baseline Inspection, Vibration, PSV, Dead Legs, etc. implementation during the Facilities Construction stage prior to commissioning
- Operation Related Strategies: FIMS, CMS, FM Strategy
Integrity Build

Risk Based Assessment
Vibration
PSV
Baseline Inspection
Fabric Maintenance
Dead Leg

Use of Technology
Continuous Improvement
Stakeholder Engagement
Life Cycle Approach

IMS Strategies

Case for Safety
IMS & Philosophy, Implementation strategy
Local Processes & Integrity Systems
Engineering Design Review & Revamp Project
Front End IMS Strategies

Governance & Compliance
Operator/Partners/Region

CMMS Upload
Inspection Job Plans (WSE)
Inspection Programme
Vibration Programme
PSV Testing Programme
Corrosion Management

Project Deliverables
Project Close out and Handover
Project Lessons Learnt

PHASE (A) PREPARE
PHASE (B) DEVELOP
PHASE (C & D) APPROVE DELIVER
A Typical RBA process (Greenfield vs. Brownfield)

**Greenfield**
- High Level Criticality Review
- Project Engineering Assessments
- RBA Review

**Selection of Pipework and Equipment for Baseline Inspection**

**Define/Scope/Plan**
- Pipework Baseline Inspections
  - Workpacks preparation, CM1 definition, R & R, site prep requirements, planning, agree on documentation and reporting

**In-situ Implementation of Inspection Programme**

**Implementation of Inspection Programme**
- Location: Vendor Facilities
- Inspection Reporting
- Anomaly Processing
- As build Correction
- Data management

**Brownfield**
- High Level Criticality Review
- RBA Review
- Anomaly Register
- Project Engineering Assessments

**Selection of Pipework and Equipment for Baseline Inspection**

**Define/Scope/Plan**
- Vessels Baseline Inspections
  - Workpacks preparation, CM1 Definition for NDT activities, R & R, vendor coordination, planning, agree on documentation and reporting

**Gap Analysis**

**In-situ Implementation of Brownfield Inspection Programme**

**Implementation of Brownfield Inspection Programme**
- Brownfield Project Inspection Programme
- Brownfield Inspection History
- Inspection Reporting
- Anomaly Processing
- As build Correction
- Data management
Brownfield RBA Process Highlights

Critical path data maturity & Quality for Brownfield revamp project

Historical Data

Revamp Project Inspection reports

Existing WSE

Fitness for Design Assessment:

Existing MMS (SAP/Maximo etc)

Brownfield data input
Crucial for PoF evaluation

Format /content
/availability/QA /

Inspection Results interpretation/Actions

Format and Contents

Helpful and insightful

Comprehensive /Redundant

Relevant Insights
High level Criticality review as per
- Location (Offshore/Onshore)
- Unit/System criticality (Safety, Environmental, Business)
- Process/Utility
- Fluid corrosivity (Wet, Dry, Sour, ...)
- Material Selection (CS, CRA, Clad, Non-metal, ...)
- Threat complexity and barrier effectiveness
- Inspection requirements / complexity
- History of failure / Significant anomalies in the same or similar facilities

High
• Feed gas / Unstabilized HC condensate
• Offshore unmanned platform
• Separation and Processing facilities
• Carbon steel material for wet system
• No barrier: Uncoated CRA
• Failure history in the same / similar facilities. Requirement for baseline
• Intrusive inspection / Advance NII techniques required

Medium
• Dehydrated HC, Export product
• Utility system (Boilers,
• Closed drain
• Critical vendor package
• Inland
• Barrier effectiveness to be reviewed: Storage tank CP / Chemical injection
• Failure history in the industry
• No complex NDT / Known CMLs

Low
• Low critical utility (Air, Nitrogen, lube oil, fire water ...)
• Low critical Vendor package (chemical injection, waste water treatment, ...)
• Non metals
• Passive barrier by design
• No major failure in the industry
• Only visual inspection
Challenges in conducting a Brownfield RBA

Challenges in the **consequence assessment**

- Methodology (Quantitative/Qualitative)
- Stakeholders engagement
- Different scenarios
- Various modes of failure
- Availability of backup data
- On time assessment

### Stakeholders
- Process safety engineer
- Environmental engineer
- Mechanical engineer
- Operation and Maintenance

### Failure modes
- Pin hole leak
- Medium size
- Large size
- Full rupture

### Backup data
- New / old studies
- HAZOP,
- FRA,
- ENVIID

### Methodology
- Brainstorming sessions
- Software
- Manual calculation
- Use of other QRA done

### Time
- Adequate time before RBA assessment
# Challenges in conducting a Brownfield RBA

## Challenges in the data collection

- Data availability
- Data validation
- Anomaly reports
- Tagging
- Monitoring records

<table>
<thead>
<tr>
<th>Data Availability</th>
<th>Data validation</th>
<th>Anomalies</th>
<th>Tagging</th>
<th>Monitoring</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material certificates</td>
<td>Traceability</td>
<td>List of anomalies</td>
<td>Corrosion circuit mapping</td>
<td>Process data</td>
</tr>
<tr>
<td>Welding procedures</td>
<td>Gap analysis</td>
<td>NCRs / TQs</td>
<td>Insp. Isometrics</td>
<td>Corrosion rate</td>
</tr>
<tr>
<td>Equipment drawings</td>
<td>MOC (management of change)</td>
<td>Repair records</td>
<td>CML tagging</td>
<td>Chemicals</td>
</tr>
<tr>
<td>Datasheets</td>
<td></td>
<td>Root cause Failure Analysis</td>
<td></td>
<td>Deposits/Corrosion product analysis</td>
</tr>
<tr>
<td>Baseline data</td>
<td></td>
<td>FFS (fitness for service)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inspection reports</td>
<td></td>
<td>...</td>
<td></td>
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<td>...</td>
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</tr>
</tbody>
</table>
Challenges in the **Threat Assessment**

How much credit can we take from the existing data?

<table>
<thead>
<tr>
<th>Monitoring records</th>
<th>Corrosion rates from Inspection</th>
<th>Materials</th>
<th>Anomalies</th>
<th>Risk assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Availability</td>
<td>• Baseline data available?</td>
<td>• Change in material spec and standard</td>
<td>• Manufacturing defects</td>
<td>• Participation of operation rep. in the RBA review sessions</td>
</tr>
<tr>
<td>• Reliability</td>
<td>• Thickness measurement technique</td>
<td>• Coating type</td>
<td>• Root cause analysis available?</td>
<td>• Late life scenarios</td>
</tr>
<tr>
<td>• Validity due to change in the process</td>
<td>• Spot/Scan?</td>
<td>• Manufacturing process</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Sampling locations relevant?</td>
<td>• Measurement points</td>
<td>• Cladding/weld-overlay</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• ...</td>
<td></td>
<td>• ...</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Solution:** Hybrid corrosion rate assessment

Theoretical estimated rate vs. Calculated rate based on actual data
### Challenges in conducting a Brownfield RBA

**Typical list of damage mechanisms considered in the pressure system RBA**

<table>
<thead>
<tr>
<th>Damage Type</th>
<th>Internal Threats</th>
<th>External Threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wastage</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Amine corrosion</td>
<td>Atmospheric corrosion</td>
</tr>
<tr>
<td></td>
<td>Chloride pitting corrosion</td>
<td>Chloride pitting corrosion</td>
</tr>
<tr>
<td></td>
<td>CO₂ corrosion</td>
<td>Corrosion under insulation / fireproofing (CUI / CUF)</td>
</tr>
<tr>
<td></td>
<td>Corrosion by chemicals (including well workover fluids)</td>
<td>Crevice corrosion (including flange faces)</td>
</tr>
<tr>
<td></td>
<td>Crevice corrosion (including flange faces)</td>
<td>Galvanic corrosion</td>
</tr>
<tr>
<td></td>
<td>Erosion, erosion-corrosion and solids-free flow-induced damage</td>
<td>Marine corrosion (including external MIC and Splash Zone)</td>
</tr>
<tr>
<td></td>
<td>Galvanic corrosion</td>
<td>Mechanical damage (abrasion, wear, galling and fretting)</td>
</tr>
<tr>
<td></td>
<td>H₂S (pitting) corrosion</td>
<td>Soil corrosion (including external MIC)</td>
</tr>
<tr>
<td></td>
<td>High temperature degradation</td>
<td>Stray current corrosion</td>
</tr>
<tr>
<td></td>
<td>Mechanical damage (abrasion, wear, galling and fretting)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Microbiologically Influenced Corrosion (MIC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oxygen corrosion</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Preferential weld corrosion (PWC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stray current corrosion</td>
<td></td>
</tr>
<tr>
<td>Cracking</td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>Amine stress corrosion cracking</td>
<td>Carbonate stress corrosion cracking</td>
</tr>
<tr>
<td></td>
<td>Chloride stress corrosion cracking (SCC)</td>
<td>Chloride stress corrosion cracking (SCC)</td>
</tr>
<tr>
<td></td>
<td>Fatigue (Corrosion)</td>
<td>Fatigue (Corrosion and Mechanical)</td>
</tr>
<tr>
<td></td>
<td>Hydrogen embrittlement</td>
<td>Hydrogen embrittlement</td>
</tr>
<tr>
<td></td>
<td>Hydrogen induced cracking (HIC) and Stress-oriented HIC (SOHIC)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liquid metal embrittlement (Hg)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sulphide stress cracking (SSC)</td>
<td></td>
</tr>
</tbody>
</table>
Challenges in conducting a Brownfield RBA

Challenges in the Brownfield **Deadleg Management**

- Deadleg identification
- Deadleg risk assessment
- Operational / Physical deadlegs
- Mitigation

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**Deadleg identification**
- Isometrics available?
- Line walk carried out?
- Deadleg tagging (old and new tags)
- ...

**Threat assessment**
- Failure histories captured?
- Sampling from deposits / stagnant fluids

**Operational / Physical deadlegs**
- Change in the process captured?
- Isolated, mothballed, decommissioned items
- ...

**Mitigation in place**
- Draining
- Flushing
- Chemical treatment
- Preservation philosophy
### Challenges in the Brownfield CUI Management

- Coating Spec. under insulation
- Insulation type
- Removal of unnecessary insulation
- High critical location
- Failure histories

<table>
<thead>
<tr>
<th>Coating</th>
<th>Risk assessment</th>
<th>High critical locations</th>
<th>Mitigation in place</th>
</tr>
</thead>
</table>
| • Coating spec for the temperature  
  • Old/New spec.  
  • ... | • Failure histories captured?  
  • Insulation type  
  • Actual operating temperature  
  • ... | • Cyclic temperature  
  • Branches  
  • damaged cladding?  
  • Line walk done?  
  • ... | • Removal of unnecessary insulation  
  • Available screening and NII techniques? |

Challenges in conducting a Brownfield RBA
Challenge of developing and implementing an asset integrity program during Brownfield development projects

Schedule and milestones often take primacy over integrity management processes,

Risk for delay in emerging vital integrity related interventions,

Task conflict- Planning Challenges,

Cost variance throughout the project,

QA issues during implementation – clear and common acceptance criteria for existing anomalies.
Operational Elements and Influencing Factors

OPS ELEMENTS

PROCESS

PLANT

PEOPLE

PERFORMANCE

GOVERNANCE

PLANT STATUS

ORGANIZATION

MEASUREMENT

STANDARISATION

DOCUMENTATION

ENGAGEMENT

COMPETENCY

BEST PRACTICE

BEST PRACTICE

BEST PRACTICE

BEST PRACTICE

BEST PRACTICE

Lessons Learned
recognize mistakes
observe what works
document them
share them
Clear Governance and Compliance strategies (overseas element)  
Timely Brownfield RBA scheduling:  
Post revamp project (Not too early and not too late)  
Generic Inspection Plans for Low Criticality levels  
Standard Inspection isometric – same process  
Semi quantitative RBA approach to equipment of same category  
Baseline Inspections: Define early & align with Project Plans  
Define and Engage with stakeholders early vendors /project etc  
More scrutiny re Revamp project documentation and decision making processes  
Ensure commensurate costing for Brownfield RBA  
FIMS & CMS Strategies to be developed and aligned with the RBA process  
Document Control: Extend the change processes outside of the organization to include Vendors (Share documents)
**PLANT STATUS**
- Preservation of existing equipment
- Plant specific: U/G Piping - CP - CUI - MIC - FM
- Acceptance Criteria during revamp project and repairs
- Permanently mothballed equipment/pipework
- FM Opportunities - Blasting on Live Lines

**DOCUMENTATION**
- Historical data
- Punch List items – and handover process
- As build P & ID and construction drawings
- In-situ verification of existing equipment (3D laser mapping)

**BEST PRACTICE**
- Boundary Definition (Pipelines/Utilities etc)
- Define process systems (what is included)
- Pressure Systems - limits (e.g. Tubing, vendor skids, auxiliaries etc)
- Interface documents - Elect/Inst/Pipeline/Vendors processes
- Vendor skids documentation and inclusion in baseline
- FM strategy applicable to Brown field

**GOVERNANCE**

**STANDARISATION**

**BEST PRACTICE**

**ORGANIZATION**

**ENGAGEMENT**

**BEST PRACTICE**

**MEASUREMENT**

**COMPETENCY**

**BEST PRACTICE**

**PERFORMANCE**

**DOCUMENTATION**

**BEST PRACTICES**

**PROCESS**

**PLANT**

**PEOPLE**
Best Practice - People

- Management Structure “Organogram”
- Roles & Responsibilities
- Outline interface processes
- Project Primacy pitfalls

- Plant operators – Engage workforce with local experience
- EPC/OPS/IMS/Operator – Communication protocols
- Use of Technology (Docs sharing, comms, etc)
- Understand Company Culture and Human Element
- More Engagement with RBA workshops

- Stakeholder identification, engagement plan
- Establish effective communication - “Integrity Sale pitch”
- Human Factors Vs Process: Ownership, Inclusion, Work load, error traps, latent conditions,
- Competency, Training and Awareness
- Safety during Brownfield Revamp - “e.g. beware of live lines”
- Integrity TA for revamp: Operation Team
Best Practice - Performance

PROCESSE

GOVERNANCE

STANDARISATION

BEST PRACTICE

PLANT

PLANT STATUS

DOCUMENTATION

BEST PRACTICE

PEOPLE

ORGANIZATION

ENGAGEMENT

BEST PRACTICE

PERFORMANCE

MEASUREMENT

COMPETENCY

BEST PRACTICE

- Project KPI and periodic monitoring
- Peer Review
- Self Verification Process
- Integrity Reviews and as-built corrections

- Competency Reviews (QA system)
- Technical Reporting Validity
- Use of technology/software/data management protocols
- Lack of experience of integrity inspection process (construction vs. Integrity)

- Forensic Inspections: Minimize/Manage
- Improve Inspection QA/Reporting/Recommendation (error traps)
- Identify and manage Critical Path risks at early stages of the project

Lessons Learned
Recognize mistakes
Observe what works
Document them
Share them
Conclusion and Discussion

• RBA Brownfield Facilities; It is an Acid Test for the Facilities
• Major opportunities (FM Blasting on Live Lines/Temp Repairs/RO)
• Generic RBA’s for low risk items( Cuts cost and adds value)
• Project primacy : Risk Review By Operator
• Get in early – Design phase- before manufacturing start
• Implementation Baseline inspection to be part of Engineering Projects
• Team work and local Ops experience inclusion
• The Need of a rigorous selection process for Integrity Contractor
• Revamp Project: Reporting and recommendation (QA issues)
Thank You for Your Attention!

For more information please visit:
www.oceaneering.com/asset-integrity

Or contact:
Monzar Najami (mnajami@oceaneering.com)
Hooman Takhtechian (htakhtechian@oceaneering.com)