Updates to DNVGL-RP-G103: Recommended Practice for Non-Intrusive Inspection

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Talk Outline

• Inspection for Integrity
• Non-Intrusive Inspection
• Background to the Recommended Practice
• The NII process
• Updated to the Recommended Practice
• Examples of cost savings
OBJECTIVE OF INTEGRITY MANAGEMENT IS TO PROVIDE ASSURANCE OF THE INTEGRITY OF ASSETS.

FOR PRESSURE EQUIPMENT THE PRIMARY OBJECTIVE IS IDENTIFYING AND IMPLEMENTING ACTIONS TO AVOID FAILURE BY LEAKS OR RUPTURE.

INTEGRITY MANAGEMENT IS A THROUGH LIFE ACTIVITY.

A COST-EFFECTIVE APPROACH TO INTEGRITY MANAGEMENT IS ESSENTIAL. THIS MEANS ALIGNING ACTIONS TO RISK LEVELS. HENCE GREATER USE OF RBI.

EFFECTIVE DECISION MAKING IS BASED ON UNDERSTANDING THE RISKS, RELIES ON SOUND KNOWLEDGE OF EQUIPMENT CONDITION AND HOW THAT MAY EVOLVE OVER TIME.
Inputs to Integrity Management Decisions

- **Design and Fabrication**
- **Process chemistry**
  - Process monitoring
- **Degradation risk assessment**
- **Corrosion control**
  - Corrosion monitoring
- **Flow assurance**
  - Sand and flow monitoring
- **Inspection**
- **Hazard identification**
- **Consequence assessment**
- **Risk based inspection planning**
- **Fabric maintenance**
- **Compliance and regulation**
The Role of Inspection

• Provide information on the condition of equipment, e.g.
  • Confirm absence of degradation.
  • Identify and characterise degradation types.
  • Determine size and locations of degradation.
  • Estimates of degradation rates.

• The information provided, and analysis thereof, allows decisions to be made, e.g.
  • Define the requirements for the next inspection (timing, type etc).
  • Determine if the vessel is Fit for Service and what the safe operating life is.
  • Define any operating restrictions, e.g. de-rating.
  • Identify if there is a need for repairs.
  • Identify if changes to the corrosion control strategy is needed.
  • Update the RBI parameters.

• These decisions depend on appropriate inspection.
The Role of Inspection Planning

• Effective inspection depends on the planning process.
• The starting point is a clear understanding of the objectives:
  • Ensure a high probability that any degradation of concern is identified.
    • Degradation of concern: that with the potential to threaten integrity in the interval to the next inspection.
  • Provide information on the state of equipment and corrosion conditions that will be useful in planning future integrity management activity.
Objectives of Inspection: Detect Degradation of Concern (safety net role)
Objectives of Inspection: Gather Information for Planning

- Historical inspection results from individual equipment items and plant wide can help identify degradation trends.
- Valuable beyond saying current condition acceptable – input to planning, i.e. when to inspect, where to inspect, how to inspect.
Consequences of Ineffective Inspection

• Inefficiency:
  • Unnecessarily short inspection intervals leading to additional inspection cost.
  • Excessive expenditure on corrosion control.
  • High costs of ongoing fitness for purpose assessment.
  • Unnecessary re-rating leading to lost throughput.
  • Unnecessary or premature replacement involving large capital cost.

• In-service failure with large cost of clean up, lost production, repair and/or expedited replacement.
Consequences of Missed Degradation

- Consequences can be serious for personnel and the environment
- Knowledge that degradation is present can allow action to be taken before a critical condition is attained
Internal Visual Inspection (IVI)

**Positives ✓**
- Industry accepted practice
- Can inspect for a variety of degradation mechanisms without prior knowledge
- Can clean out deposits at the same time
- Can check on internal furniture

**Negatives ✗**
- Requires shutdown
- Requires vessel cleaning
- Requires man-entry
- Additional NDT required for some mechanisms
- Not always quantitative
- Poor reporting can cause issues for repeatability
Non-Intrusive Inspection (NII)

**Positives ✔**
- Does not need shutdown
- External cleaning only
- Avoids man-entry
- Quantitative
- Reproducible
- Can detect additional issues IVI cannot

**Negatives ✗**
- Industry slow to accept
- NDT methods are often morphology specific
- No information on internal furniture
- Poor application of NII can result in poor integrity decisions

NII requires more upfront planning to ensure aim of inspection is met
• NII being applied on limited basis to high value cases
• Inspection design concepts from Nuclear Industry being introduced

2000-2006
• HOIS development of NII Guidelines (driven by Operator members and UK HSE)
• Mitsu-Babcock Group Sponsored Project (GSP 235) outputs shared and included HOIS Development
• Pilot projects (ConocoPhillips and Marathon) followed by wider application. Limited number of operators

2007
• HOIS Guidelines published as DNV-RP-G103
• Wider industry uptake

2007-2010
• Extensive application with early adopter North Sea operators
• 2nd revision of G103 includes option for deferment and has evaluation requirements specified

2010-2017
• NII beginning to be used by most major operators
• Application of G103 in Norway, Australia and Middle East. Wider onshore application (gas plants and refineries)
• Development and Issue of HOIS RP on Statistical Analysis of Inspection Data
• Operators building internal NII systems and processes. Setting targets around use of NII.

2018-2019
• G103 revised in HOIS to simplify application, clarify requirements
• OGTC support for greater industry uptake of NII
• Design for through life NII being considered in new projects
Timeline
Publication

• HOIS document
• Currently published through DNVGL to reach as wide of audience as possible
• DNVGL changing access (behind pay wall)
• HOIS members currently voting on whether to:
  • Publish through DNVGL – paid for document
  • Publish as HOIS document from [www.hoispublications.com](http://www.hoispublications.com) – free
  • Discuss options further at next HOIS meeting in November and vote again.
NII Process

NII assessment and definition of requirements
Work scope meeting requirements
Inspection
Evaluation
Justification
Identify Suitable Candidates

Consider:

• Size
• Access to vessel
• Outstanding work orders/ anomalies
• Access for process/ cleaning etc.
• Material
  • HDPE tanks unsuitable
• Design
  • Plate type heat exchangers, electrical gas heaters, spiral type heat exchangers, fin fan/ air coolers unsuitable
Updated: NII Assessment

1. Select vessel for consideration
   - If the vessel is not intrinsically suitable for NII, go to NII is not appropriate.
   - If the vessel has previous in-service inspection been carried out?
     - If yes, proceed to: Is operating history still relevant?
     - If no, go to NII is not appropriate.
   - If yes, proceed to: Is entry scheduled for other reasons?
     - If yes, perform NII.
     - If no, go to: Apply flow chart for high level decision.
   - If no, go to: Can NII be considered?
     - If yes, go to: Prepare NII inspection plan.
     - If no, go to NII is not appropriate.

Removed: Designed for NII

New: FISI
High Level Decision
NII Assessment

• Carbon steel vessel
  • Managed in RBI process with basic CRA in place.
  • Three previous IVI’s, most recent in inspection at RBI interval by IVI.
  • Some internal (wide spread) pitting but low level, not expected to impact on remaining life.

• Confidence in ability to predict type and locations of degradation – Medium

• Previous inspection effectiveness – Medium

• Severity and rate of degradation – Medium

• NII is possible in principle.
## Updated: NII Strategy

<table>
<thead>
<tr>
<th>Type</th>
<th>Definition</th>
<th>Aim</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Degradation mechanism NOT expected to occur, or The current condition and likely corrosion rate is such that 1 mm of wall loss would not be seen within two inspection intervals and upset conditions are unlikely.</td>
<td>To confirm no onset of degradation.</td>
</tr>
<tr>
<td>B</td>
<td>Degradation mechanism (wall loss only) expected, with low/medium progression (will not affect integrity within two inspection intervals). Location of degradation can be predicted.</td>
<td>To confirm predictions.</td>
</tr>
<tr>
<td>C</td>
<td>Degradation expected with medium/high progression (may affect integrity within two inspection intervals). Locations cannot be predicted</td>
<td>To confirm absence of flaws of defined limiting sizes.</td>
</tr>
</tbody>
</table>
NII Strategy

1. Degradation likely/measurable within two inspection intervals?
   - Yes
     - Degradation predictable?
       - Yes
         - Degradation low/medium?
           - Yes
             - Type B
           - No
             - Type C
       - No
         - Type C
   - No
     - Type A
New: Inspection Requirements

• Quantified definition of requirements according to strategy type:
  • Coverage
  • POD
  • Accuracy

\[ C_R = F_{COV} \times F_{CONS} \times F_{ZONE} \times C_1 \]

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>( C_1 )</td>
<td>Base coverage:  ( 5% ) for CRA  ( 7.5% ) for carbon steel</td>
</tr>
<tr>
<td>( F_{COV} )</td>
<td>Coverage modifier based on:  Confidence to predict degradation  Density of features</td>
</tr>
<tr>
<td>( F_{CONS} )</td>
<td>Consequence of failure</td>
</tr>
<tr>
<td>( F_{ZONE} )</td>
<td>Zone surface area</td>
</tr>
</tbody>
</table>
New: Homogeneity and Spatial Distribution
## Updated: Technique Selection

<table>
<thead>
<tr>
<th>Vessel feature</th>
<th>Suggested techniques</th>
<th>Applicable strategy</th>
<th>Note #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cylindrical and spherical shell (carbon steel)</td>
<td>0° corrosion mapping (PA and single probes)</td>
<td>A, B, C</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>TOFD fast screening</td>
<td>A, B, C</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>M-skip (screening)</td>
<td>C</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>EMAT (screening)</td>
<td>C</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>SLOFEC/MEC (screening)</td>
<td>C</td>
<td>2</td>
</tr>
<tr>
<td>Shell cladding on corrosion resistant alloy clad vessels</td>
<td>UT angled beam shear waves (PA and single probes)</td>
<td>A</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>UT PA angled beam compression (DMA probe?)</td>
<td>A</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>TOFD fast screening</td>
<td>A</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>0° corrosion mapping (PA &amp; single probes)</td>
<td>A</td>
<td>4</td>
</tr>
<tr>
<td>Base metal/cladding interface on corrosion resistant alloy clad vessels</td>
<td>0° corrosion mapping (PA &amp; single probes)</td>
<td>A</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>TOFD fast screening</td>
<td>A</td>
<td>6</td>
</tr>
</tbody>
</table>

### Notes
1. The methods shown address general and localised wall loss and provide quantitative sizing capability.
2. The methods shown are generally used for screening to identify the worst degradation. Sizing capability is typically more limited and a quantitative sizing methods is often necessary for follow up where degradation is found.
3. Suitable for detection of localised pitting and cracking in non-weld clad material
4. With appropriate set up suitable for detection and sizing of localised pitting in non-weld clad material
5. Detection and sizing of delamination of clad material or early stage corrosion growth in the base metal
6. Detection and sizing of delamination of clad material or early stage corrosion or crack growth in the base metal
Inspection Techniques

- Corrosion Mapping
- Time of Flight Diffraction (TOFD)
- CHIME
- Multiskip
- Angled Shear Wave
- Pulsed Echo
- Phased Array
Inspection Deployment

Automated Scanners

Manual Scanners

Flange Face Scanner

Rope Access

Domed End Scanner

Nozzle Scanner
Updated: Evaluation

- Did the coverage and locations meet the requirements?
- Did the techniques meet the requirements?
- Was the probability of detection achieved?
Main Changes in 2019

• The results of HOIS member consultation
• Changes to existing material:
  • More quantified approach to:
    • Type A and type B inspections and selection of strategy type
    • Definitions of conformance levels
    • Categorisation of degradation
  • Inspection requirements, change in approach, more quantified requirements
  • Simplified approach to technique selection
  • Evaluation of inspection
  • Inclusion of information from HOIS Statistical Analysis RP
New sections/appendices

- Review of candidate inspection techniques
- Clad vessels
- Design for inspectability
- Repeat NII
- NII as the first in-service inspection (FISI)
- HOIS work on NII and IVI trials
- Evaluation of inspection performance achieved
Guidance Notes

• OGTC review of industry use of NII identified the need for guidance to assist users with application of G103

• OGTC motivated and funded a project in HOIS to develop Guidance Notes

• HOIS project included a survey of users to highlight areas for additional guidance and clarification

• Guidance notes developed by Sonomatic under HOIS sub-contract

• First issue available in February 2019 and presented at Working Group meeting at OGTC

• Revised following feedback from the WG meeting and from UK HSE
Guidance Notes Content

1. Introduction
2. Principles of the NII Process
3. Roadmap for Implementation
4. Information Requirements
5. Assessment for NII
6. Strategy Selection
7. Definition of Inspection Requirements
8. Work Scope Development
9. Inspection Activity
10. Evaluation
11. Inspection Interval Following NII
12. Update to RBI
13. Integration with Integrity Management Processes
14. References
Appendices
Examples, FAQ, NII for non-technical
Examples of Successful NII

• TEG Contactor
  • Critical path for shutdown
  • IVI duration ~900 hours
  • NII reduced shutdown by 9 days

• Gas plant saved £4m by rolling out NII to 40+ vessels
• IVI replaced by NII on onshore H₂S vessel saved £750K
• $7m production added by NII on onshore Gas Plant vessels for operator in Australia
H₂S Absorber

- Type A/ B
- 5 week outage for IVI: £250K (not including cleaning)
- Process was against doing an IVI as last time the trays were put back in incorrectly
- NII carried out for £144K (including scaffolding costs)
Key Success Factors for NII

• Detailed review of vessel history, process and risks.
• Appropriate coverage, inspection locations and techniques must be chosen.

• Inspection team must have:
  • In-depth understanding of equipment.
  • Ability to deal with vessel specific difficulties.
  • Ability to judge data quality as it is being collected.
  • Ability to identify anomalies and define suitable follow up work.
  • Good communication with site personnel.
  • In-depth understanding of the objectives of the NII.
  • Good communication with the integrity team.

• Failure to recognise the significance of the above can lead to valueless data being collected and a high cost of follow up.