WE MAKE IDEAS WORK
Remnant Life Assessment

Seminar American Institute of Chemical Engineers „Excellence in Process Safety“

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INTRODUCTION

Remnant Life Assessment

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Tebodin Consultancy & Engineering

- Established in 1945 in The Hague, the Netherlands
- A network of around 50 offices active in 23 countries
- 4,800 consultants and engineers worldwide
## Remnant Life Assessment

**AGENDA**

- Introduction
- Why RLA
- Goals & Benefits of RLA
- Methodology & Approach
- Degradation Mechanisms
- Lessons learned RLA ME
- New approach
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WHY RLA

Various RLA drivers:
- Plants age exceeds design life
- Capacity and technical integrity
- Costs per ton product
- Safety and environmental compliance
- Changing surroundings
- Relocation
- New technology available
- Input for a long term replacement planning

General goal:

RLA supports investments decisions on existing plants within operational boundaries and sustained technical integrity.
Goals & benefits of RLA

**Goals**

- RLA existing plant
- Long term investment plan
- Incorporate in overall AM plan
- Business Case non-existing plant
- Invest-ment?
- Future?

**Benefits**

- Based on expected degradation and (forecasted) business model
- Quantifiable justification of input for investments
- Structured approach to determine investments
- Better insight in (future) risks
- Check on compliance and obsolescence
- Based on history and forecasted operations
### General Approach

- **Kick off & data collection.** Collection using questionnaire, scope definition. *Output: Basis of Study*

- **Virtual assessment:** Estimate current condition of assets based on theoretical Physics-of-failure models

- **Site Visit:** Visual inspection on site. Collection of additional data (inspection documents, failure history, etc.)

- **Remnant life assessment:** Estimation of remnant life based on latest inspection documents. *Output: Report per discipline and final presentation*

- **Life Cycle Costs Analysis:** *(when in scope)* An estimate of replacement costs and operational costs

### Project phases:

1. **Kick off & data collection**
2. **Virtual assessment**
3. **Site visit**
4. **Remnant Life Assessment**
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METHODOLOGY

- Life Cycle Expectations
- FMMEA
- Physics of Failure Models

Virtual Assessment

- Design Data
  - Monitoring data
  - Material (lab) analysis
  - Maintenance and inspection records
  - Operational data

- Site Visit

Remaining Life Assessment

- Life-cycle Cost Analysis
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METHODOLOGY IN DETAIL

Ref: “A Methodology for Assessing the Remaining Life of Electronic Products
By CALCE University of Maryland USA and the Petroleum Institute, Abu Ddhabi, United Arab Emirates

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DEGRADATION MECHANISMS : STATIC
Degradation mechanisms can be determined based on the materials that are used and the feed per asset:

- CO2/H2S Corrosion
- Acid Sour Water Corrosion
- Microbiologically Influenced Corrosion
- Soil Side Corrosion
- CO2 Corrosion
- Atmospheric Storage Tank Bottom Corrosion
- Sulphide Stress Cracking
- HIC/SOHIC Cracking
Local corrosion:
Can be repaired and determines year of inspection.

General corrosion:
Cannot be repaired and determines year of replacement.

Results:
The results of the RLA for static equipment typically are:

- Estimated replacement years
- Advice on repairs
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DEGRADATION MECHANISMS : CIVIL
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DEGRADATION MECHANISMS: CIVIL

- Overloading
  - Dynamic Loading
  - Static Loading
- Chemical Degradation
  - Alkali-Silica Reaction (ASR)
  - Chloride Ingress
  - Carbonation
  - Sulphate Attack
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DEGRADATION MECHANISMS EXAMPLE : CIVIL
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DEGRADATION MECHANISMS EXAMPLE : CIVIL

• What process liquids and other chemicals are used?
• What is the type of cement?
• Are coatings used?
• How are repairs carried out?
• What is the climate?
• What is the ground water level and what chemicals are in the ground water level?
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VIRTUAL ASSESSMENT EXAMPLE: CIVIL

Concrete Mixes

<table>
<thead>
<tr>
<th>Alt name</th>
<th>User?</th>
<th>w/cm</th>
<th>SCMs</th>
<th>Inhib.</th>
<th>Barrier</th>
<th>Reinf.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>0.42</td>
<td></td>
<td>Ca Nitrite - 5 L/cub. met.</td>
<td>Epoxy Coated</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alternative 1</td>
<td>0.42</td>
<td></td>
<td></td>
<td></td>
<td>Black Steel</td>
<td></td>
</tr>
</tbody>
</table>

*n/a* indicates that, since the user is specifying the diffusion properties of this mix, this value is not specified.

Diffusion Properties and Service Lives

<table>
<thead>
<tr>
<th>Alt name</th>
<th>D28</th>
<th>m</th>
<th>Ct</th>
<th>Init.</th>
<th>Prop.</th>
<th>Service life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base case</td>
<td>8.87E-12 m²/m/sec</td>
<td>0.2</td>
<td>1.76 kg/cub. m.</td>
<td>5.5 yrs</td>
<td>20 yrs</td>
<td>25.5 yrs</td>
</tr>
<tr>
<td>Alternative 1</td>
<td>8.87E-12 m²/m/sec</td>
<td>0.2</td>
<td>1.18 kg/cub. m.</td>
<td>4.6 yrs</td>
<td>6 yrs</td>
<td>10.6 yrs</td>
</tr>
</tbody>
</table>

".*" indicates that the user has directly specified this value; "*+" indicates the service life exceeds the study period.
Carried out by discipline expert.

Results:
- Current status of foundations based on visual inspection.
- Feedback on the use of protective coatings and seals.
- Status of repairs that are carried out and advice on repairing.
- Degradation mechanisms are determined.

→ If needed, samples can be collected and analyzed to support the outcome of the virtual assessment.
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ROTATING
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LESSONS LEARNED

Tebodin executed several Remnant Life Assessment on complete O&G production facilities in the ME. Here are some of the lessons learned:

• Method used works for static, civil and partly electrical
• Method used works for low production variables
• Rotating and utility systems needs a more empiric approach (too many variables)
• A standard approach and understanding of the projects goals to align input from all disciplines
• A lot of discussions on used norms, guide lines and (prove of) degradation models
• Availability of specialist knowledge is essential
• It is a labor and cost intensive method.
• Why don’t we get the same questions from clients in Europe or North America?
Differences Upstream O&G ME with industries Europe and N. America
 • Also aging assets in Europe and N. America, but
 • Asset age is less homogeneous than ME O&G facilities.
 • For other markets than Upstream O&G, there are many production variables
 • External safety and environmental requirements are different.
 • Some markets operate with less margin and/or shorter investment window.

This requires a more tailored approach for RLA!

*In essence:*
Determine per system / component the approach and level of detail of the RLA. The efforts and costs of the study should be relevant to the economical impact of the system/ installation.
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DEVELOP NEW APPROACH

Developed by and with client
Determine project scope

Determine input / output parameters

First check
Compliancy, Sustainability check

Check obsolescence & new technology

Define level of RLA detail per system / component
Criticality

Define level of RLA detail per system / component

Define level of RLA detail per system / component

Detailed scoping RLA
Systems / components

Full RLA on critical components

Empiric RLA. no virtual assessment, expert judgement based + inspections

Simplified RLA
For example NEN2767

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always close
References

• IEC 61508
• API 581 – Risk Based Inspection Technology 2009
• API 650 – Welded Steel Tanks for Oil Storage
• Norsok Standard M-506 – C
• NEN-EN 2767