Tebodin

WE MAKE IDEAS WORK
Remnant Life Assessment

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

Louwman Museum , The Hague | April 23rd 2015

Remnant Life Assessment

INTRODUCTION

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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 world wide

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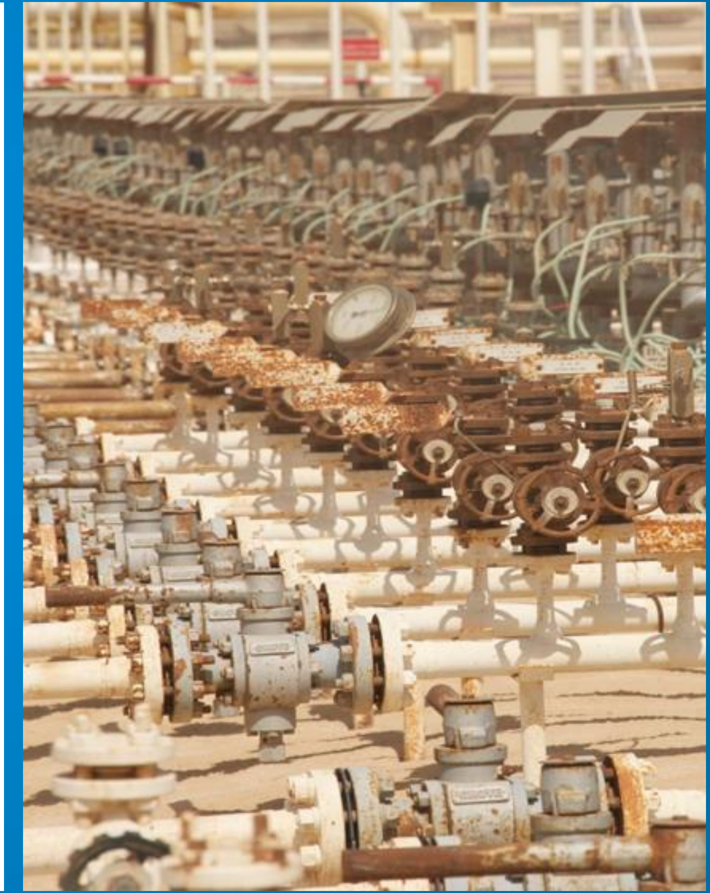
AGENDA

- 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:

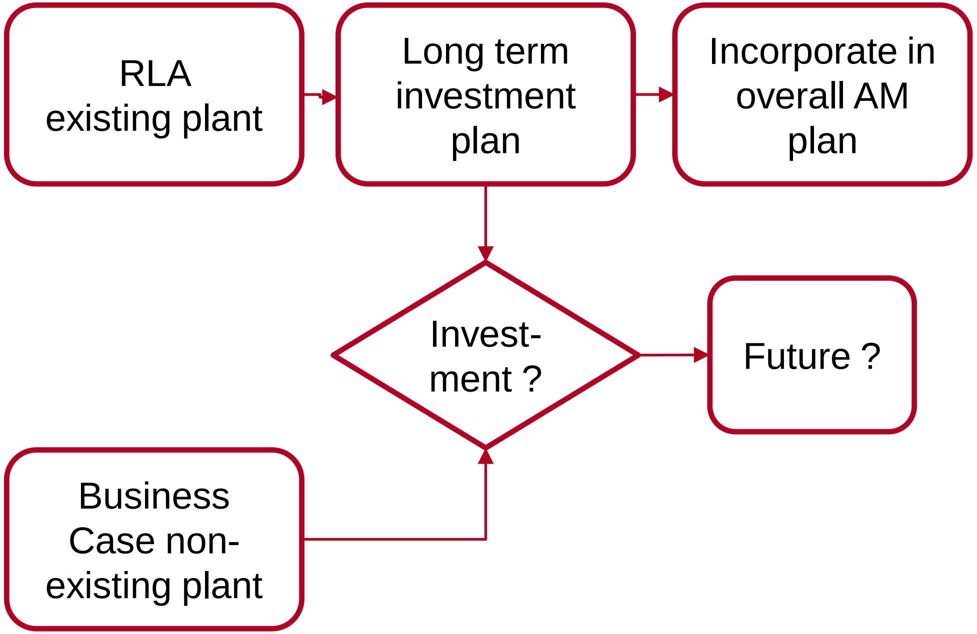
- Plants age exceeds design life
- Capacity and technical integrity
- Costs per ton product
- Safety and environmental compliance
- Changing surroundings
- Relocation
- New technology available
- Input for a long term replacement planning

General goal:

RLA supports investments decisions on existing plants within operational boundaries and sustained technical integrity.

Goals & benefits of RLA

Goals



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

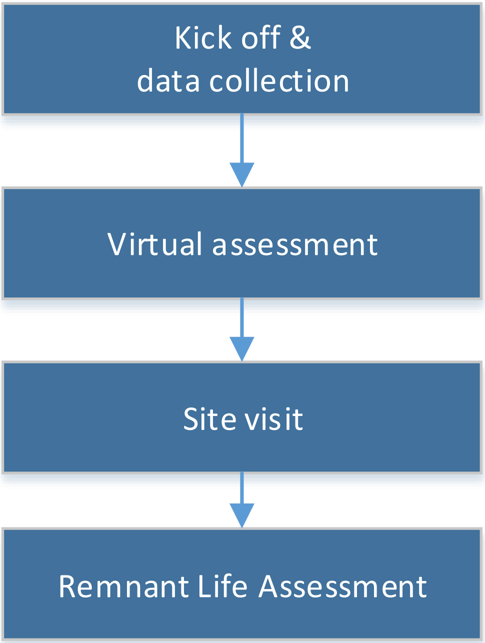
- Virtual assessment: Estimate current condition of assets based on theoretical Physics-of-failure models

- 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:



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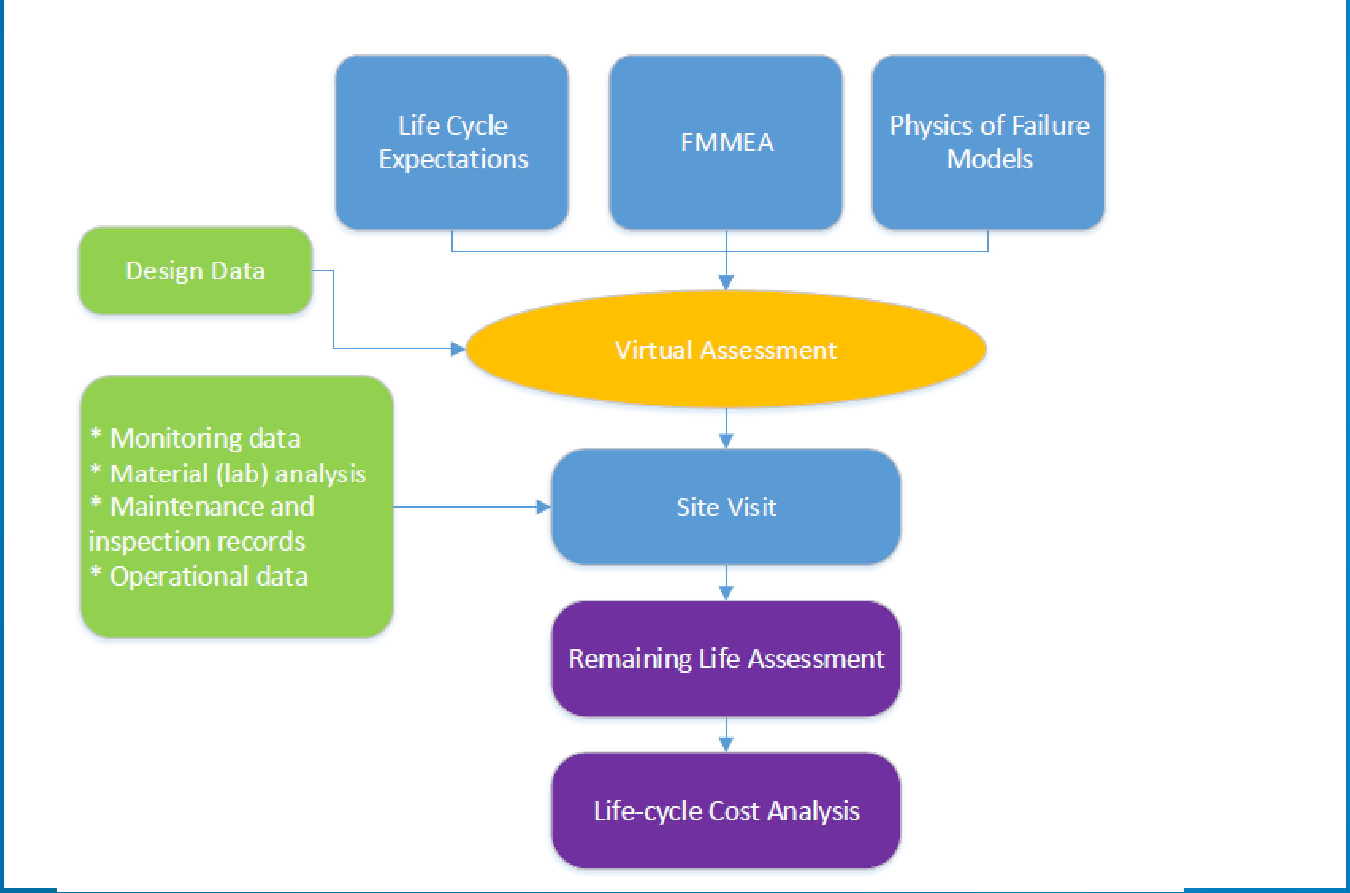
METHODOLOGY



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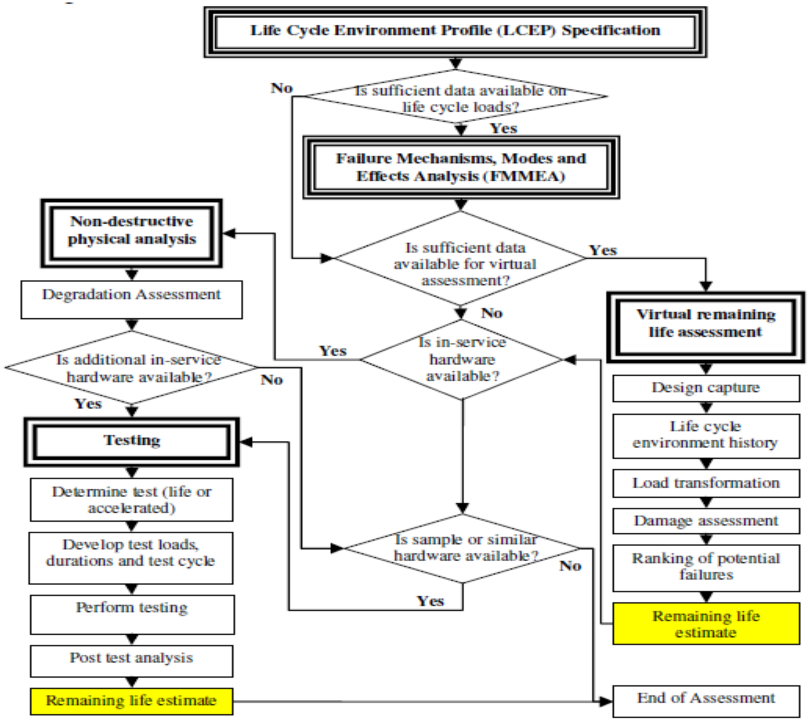
METHODOLOGY IN DETAIL



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

Product	Analysis Approach
Civil Structures	
Reinforced concrete bridge [10]	A non-destructive chemical diffusivity evaluation in reinforced concrete structures was conducted, and the result was used to analytically estimate remaining life.
Reinforced concrete structures [11]	An accelerated corrosion test was conducted on a reinforced concrete structure. The result was compared to empirical data to estimate remaining life.
Reinforced concrete structures [14]	A damage modeling technique was used to assess the degradation of a reinforced concrete structure. This data was analyzed to provide an initial estimate of the remaining life. A mathematical technique was employed to refine the estimate.
Reinforced concrete structures [15], [16]	Analytical calculations based on available data were used to estimate the remaining life of a bridge.
Mechanical Products	
Turbine rotors [17], [18], [19]	An ultrasonic detection technique was employed to examine the cracks in turbine rotors. Based on the ultrasonic test data, stress and fracture analysis of the cracks were conducted to estimate the time to failure.
Refinery heater tubes [20], Steam turbine components [21]	Creep properties of the product were obtained from nondestructive testing, and were utilized to calculate an acceleration rate of degradation. This estimate was compared to an empirical database to predict remaining life.
Furnace heater tubes [22]	Ultrasonic wall thickness examination of furnace heater tubes was conducted and the result was used to analytically estimate the remaining life.
Turbine rotor [23], Fossil fuel power plant components [24], Industrial furnace tubes [25], Petrochemical plant components [26], Power plant components [27]	Samples were extracted from the product and subjected to a variety of tests including creep, impact and hardness tests. The results were compared to virgin material properties to estimate the extent of degradation and thereby predict remaining life.
Boiler heater tubes [28]	Non-destructive and destructive testing was conducted on boiler re-heater tubes to assess damage and estimate remaining life. A virtual assessment was also conducted to estimate remaining life, and compared to the results of non-destructive testing.
Pressure vessel nozzle [29], Furnace tubes [30], High pressure rotor [13], [31], Super heater tubes [32]	A sample of the product was tested by subjecting it to cyclic stresses. Using characteristic curves of the virgin material and comparing the cracks that developed the remaining life was estimated.
Pressure vessels [33], Gas turbine [34]	A general approach for remaining life assessment of the product was developed, with emphasis on quantifying the system parameters and modeling the damage as a function of those parameters.
Service turbine generator of a ship [35], Power plant components [36]	A finite element modeling and assessment method of estimating the remaining life was used.
Pressure vessels[12], [37]	Non-destructive examination of the product was conducted and used to develop a finite element model for evaluation. The model predictions were compared to a predetermined failure criterion to estimate the remaining life.
Components of a liquefied natural gas (LNG) plant [38], Super-heater outlet header [39]	The damage to the components of the product was modeled using finite element analysis, from which remaining life was estimated.
Pressure vessels [33], Gas turbine [34]	A general approach for remaining life assessment of the product was developed, with emphasis on quantifying the system parameters and modeling the damage as a function of those parameters.

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DEGRADATION MECHANISMS : STATIC

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Degradation mechanisms can me determined based on the materials that are used and the feed per asset:

- CO_2/H_2S Corrosion
- Acid Sour Water Corrosion
- Microbiologically Indluenced Corrosion
- Soil Side Corrosion
- CO_2 Corrosion
- Atmospheric Storage Tank Bottom Corrosion
- Sulphide Stress Cracking
- HIC/SOHIC Cracking

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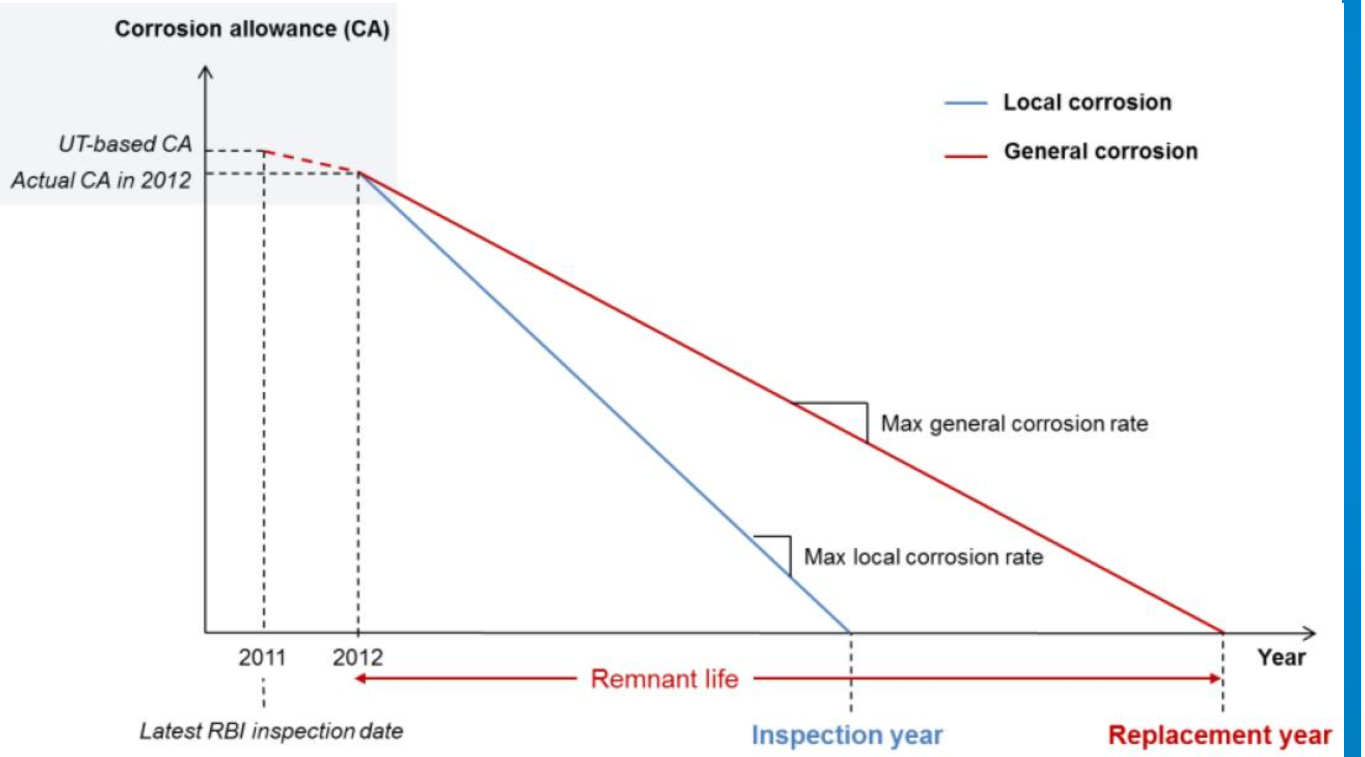
DEGRADATION MECHANISMS : STATIC



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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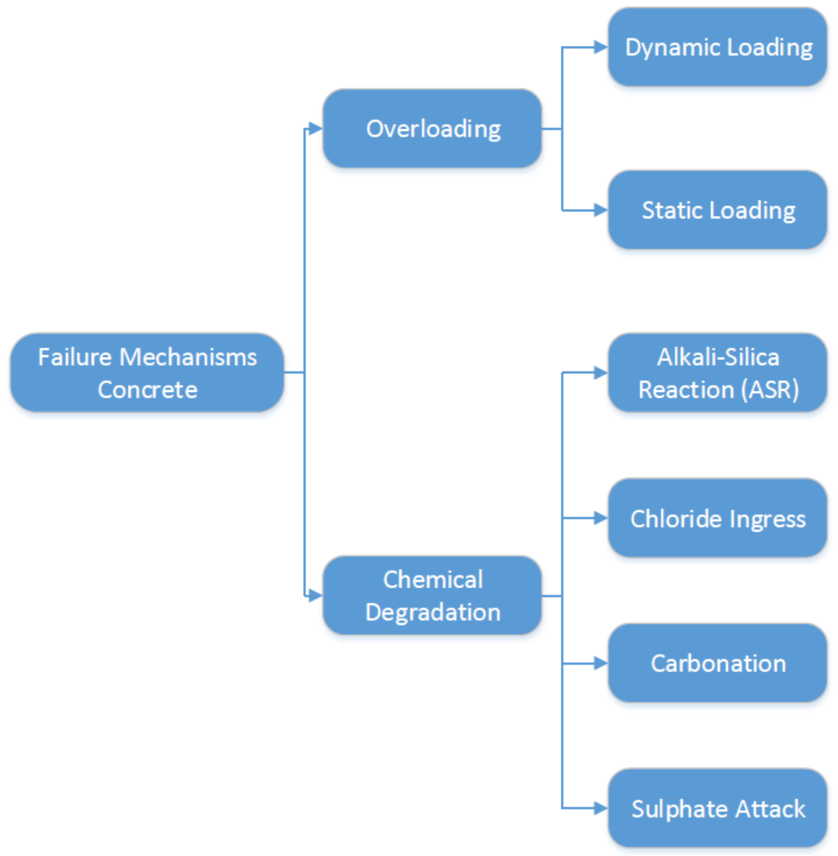

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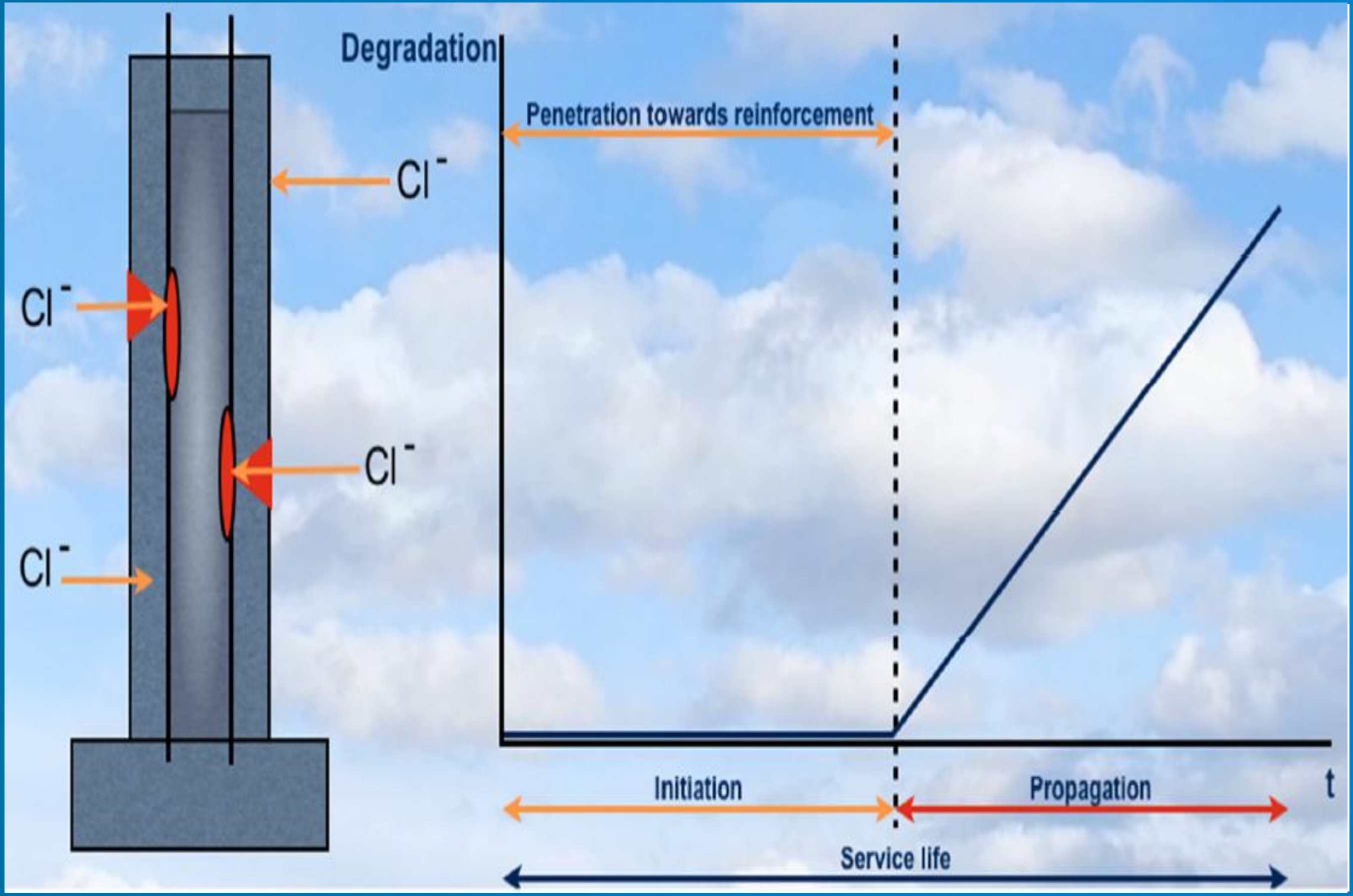
DEGRADATION MECHANISMS EXAMPLE : CIVIL



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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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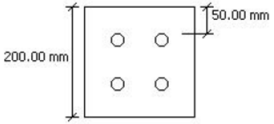
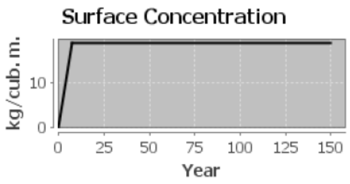
VIRTUAL ASSESSMENT EXAMPLE: CIVIL



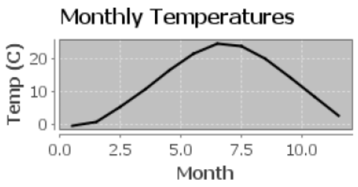
square column/beams (2-D)

Outer dim: 200mm; clear cover: 50mm



Max surface: 18.8

Years to buildup: 7.4



Loc: New York: NEW YORK

Type: Parking garages

Concrete Mixes

Alt name	User?	w/cm	SCMs	Inhib.	Barrier	Reinf.
Base case		0.42		Ca Nitrite - 5 L/cub. met.		Epoxy Coated
Alternative 1		0.42				Black Steel

"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

Alt name	D28	m	Ct	Init.	Prop.	Service life
Base case	8.87E-12 m*m/sec	0.2	1.76 kg/cub. m.	5.5 yrs	20 yrs	**25.5 yrs**
Alternative 1	8.87E-12 m*m/sec	0.2	1.18 kg/cub. m.	4.6 yrs	6 yrs	**10.6 yrs**

"->" indicates that the user has directly specified this value; "+" indicates the service life exceeds the study period.

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SITE VISIT CIVIL

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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ROTATING

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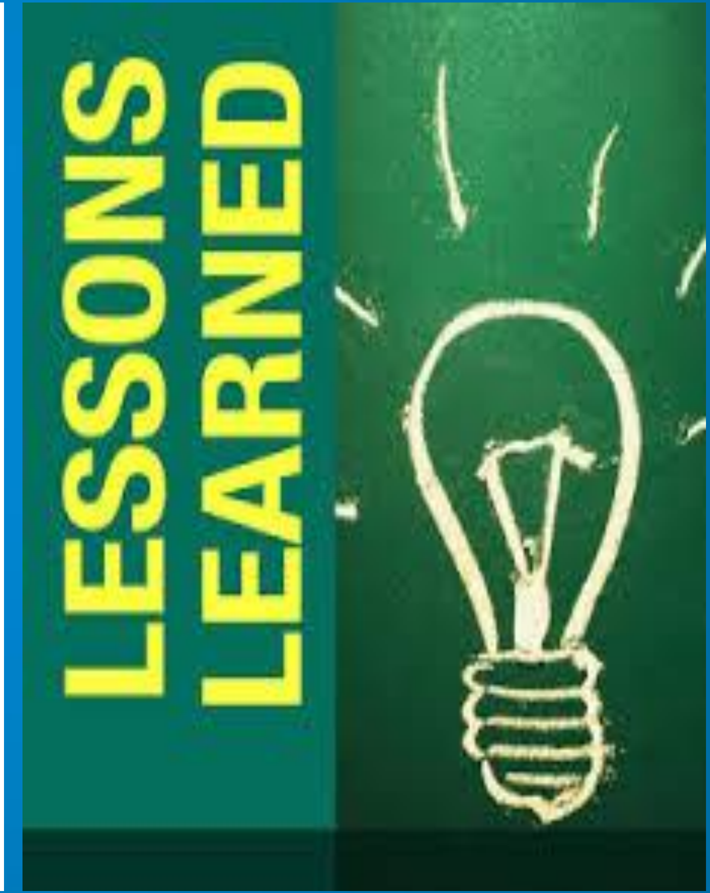
LESSONS LEARNED

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?



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DEVELOP NEW APPROACH

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, their 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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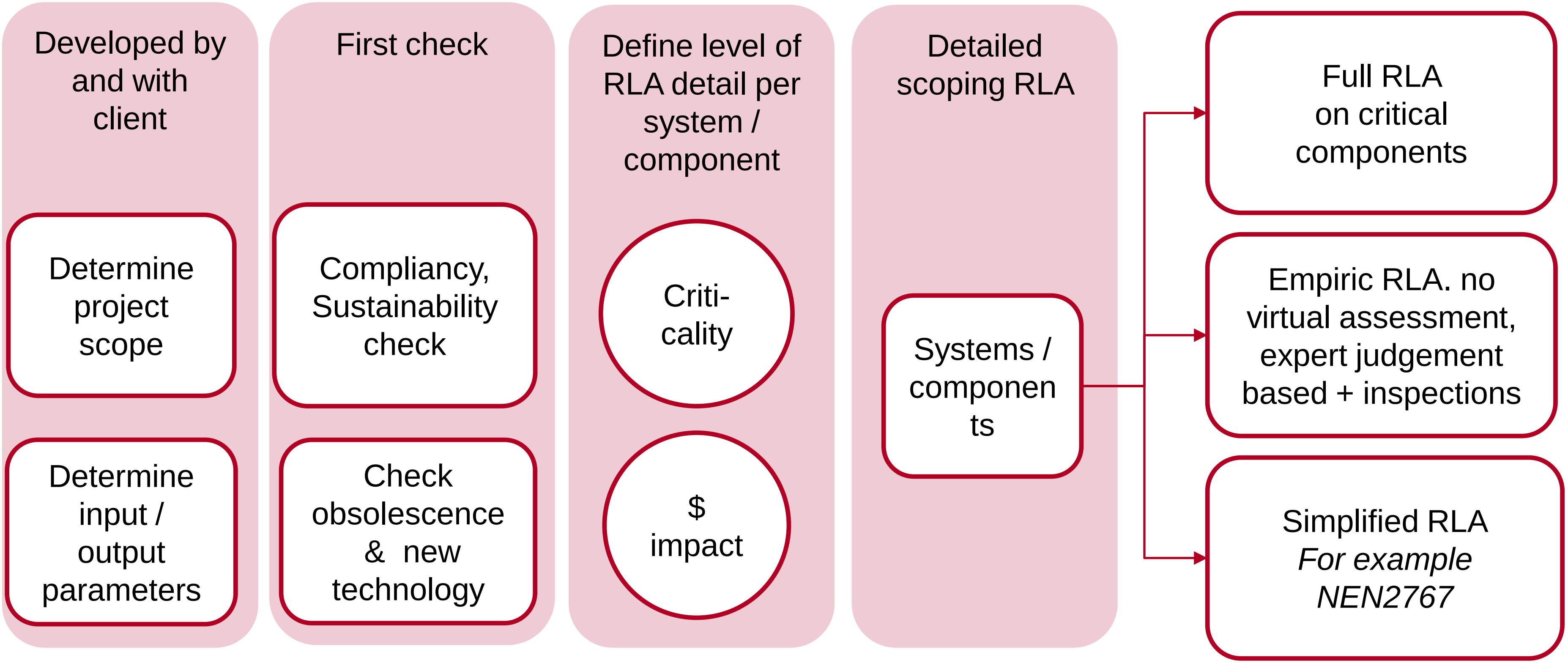
DEVELOP NEW APPROACH



always close

References

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