PROACTIVE AGEING MANAGEMENT

Module 8

Session 8

Resource document: IAEA draft report on Proactive AM

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International Atomic Energy Agency

Presentation

1. Introduction
2. Common weaknesses of ageing management
3. Proactive ageing management through the application of the systematic AM process
4. Benefits of proactive ageing management

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1. Introduction

Session 8:

- deals with organizational and managerial means for increasing the effectiveness of AMPs in existing and future NPPs

- provides guidance on:
  - **recognizing and avoiding common weaknesses in AM**
  - **strengthening the role of proactive AM through the application of the systematic AM process**

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1. Introduction (Cont'd)
Terminology

- Proactive AM means ensuring req'd functional capability of SSCs through the application of systematic AM process which includes minimizing SSC degradation (as approp.) and timely detection and mitigation of SSC degradation - *"I control ageing"*

- In contrast, reactive AM means repairing/ replacing degraded SSCs; 'run-to-failure' strategy - *"Ageing controls my actions"*

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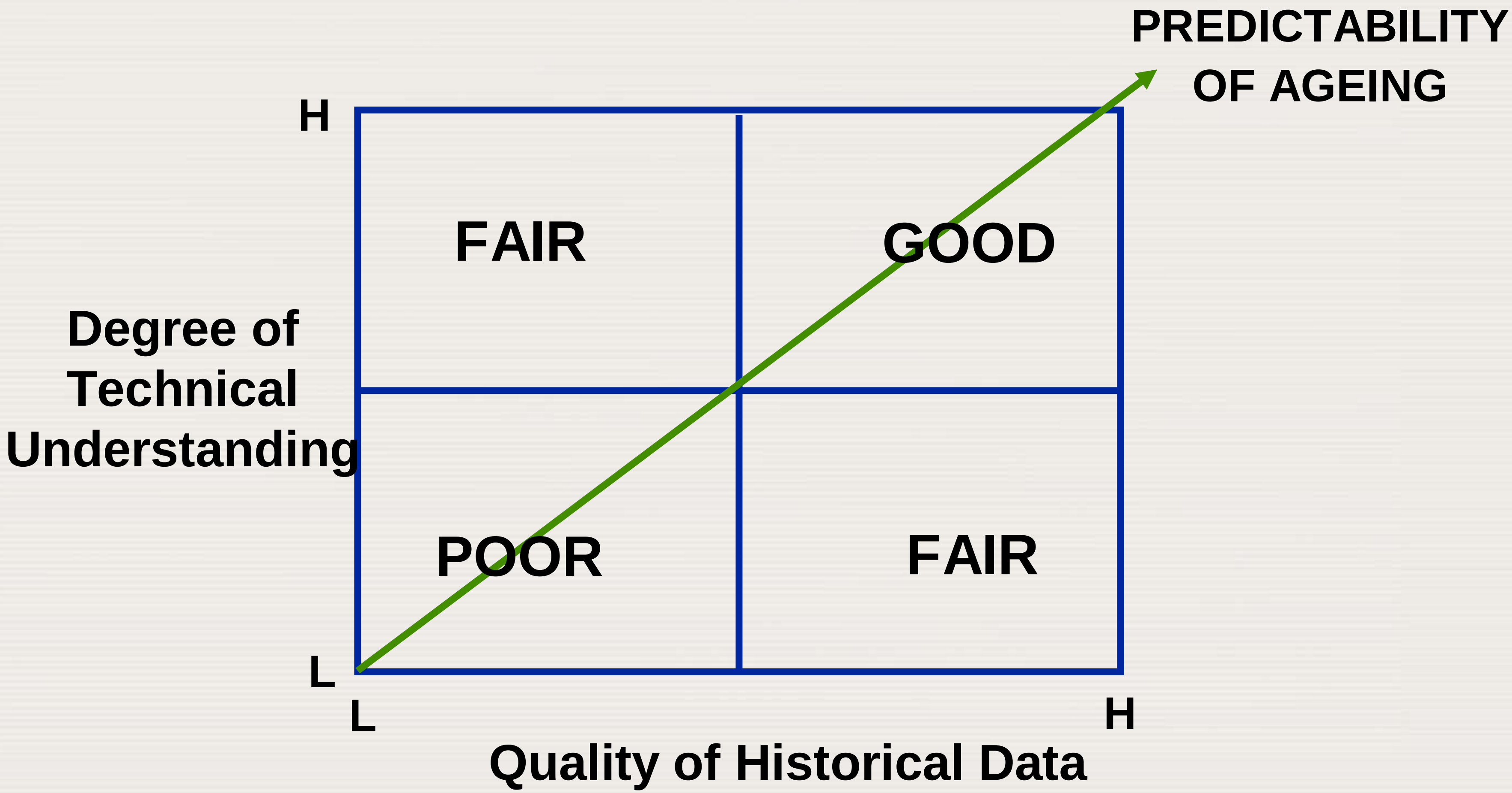
2. Common weaknesses of ageing management

- Insufficient understanding/ predictability of ageing
- Premature ageing
  - **Error-induced ageing**
  - **Inadequate communication/ co-ordination**
  - **Unforeseen ageing**
- Excessive use of reactive AM

Predictability of ageing

- The key to effective ageing management
- Enables operation, inspection and maintenance to be optimized
- Depends on two elements:
  - **modeling** - quantification of technical **understanding**
  - **condition monitoring** to measure the progress of ageing degradation in a component

Predictability of ageing as a function of operating experience and technical understanding of ageing phenomena



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Ageing process - Categories and key factors

1. Change in bulk material properties (temperature, strain, irradiation)
   - ***fair predictability***
2. Crack growth (rate, extent)
   - ***good predictability***
3. Change in material surface/crack initiation (global, local)
   - ***poor predictability***

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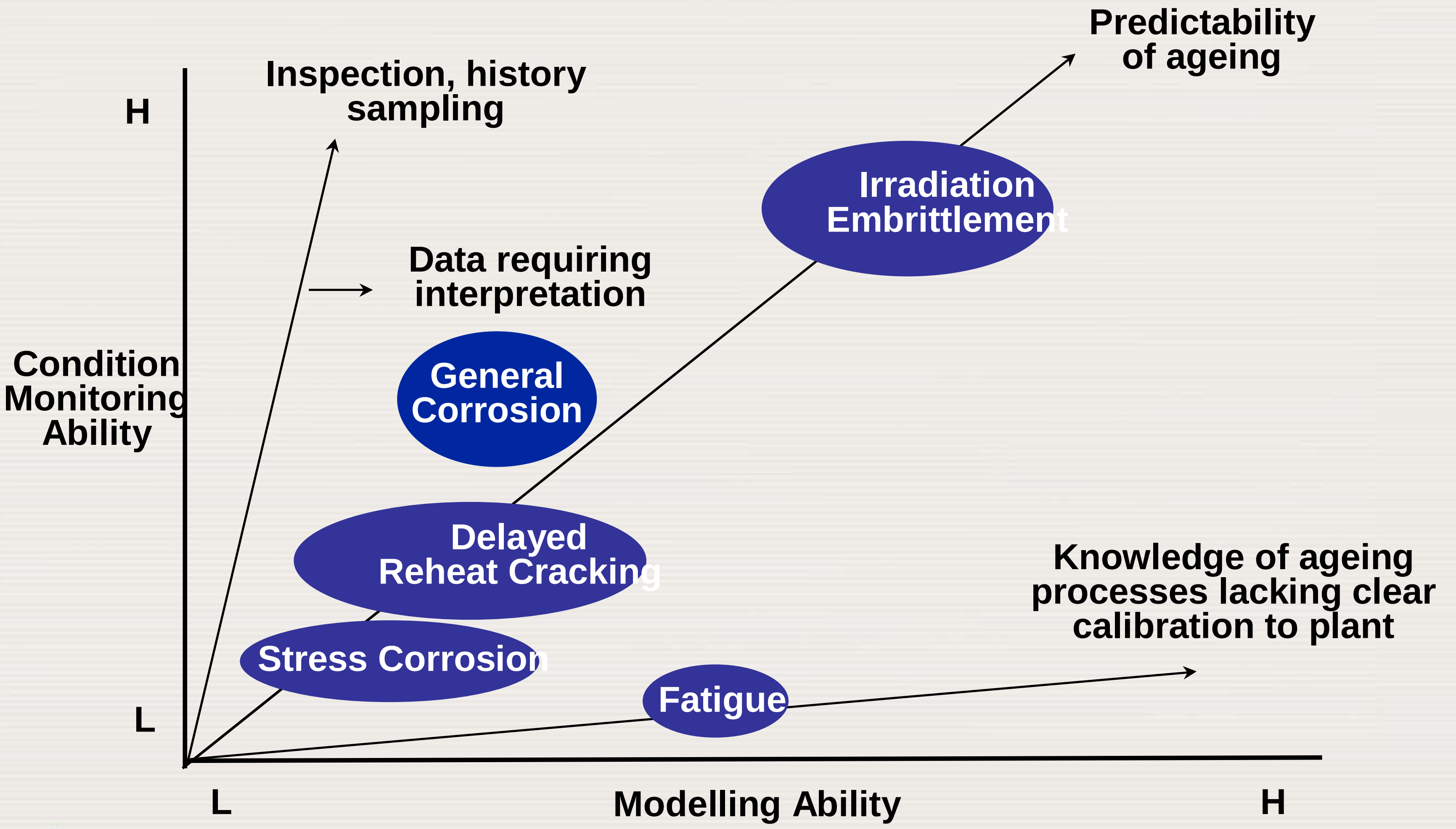
Predictability of typical ageing mechanisms



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Premature ageing

- Means ageing degradation that occurs earlier than expected.
- Caused by pre-service and service conditions that are more severe or different than assumed in design.
- Results from errors or omissions in design, fabrication, installation, commissioning, operation, and maintenance, or lack of coordination between these functions.
- Also caused by unforeseen ageing phenomena.

Examples of error induced ageing

- Thermal embrittlement of elastomers due to high ambient temperature caused by inadvertently closed vents or degraded thermal insulation of steam lines.
- Premature fatigue due to too frequent P/T transients.
- Wearout of components due to excessive testing, or excessive vibration caused by undertightened bolts.
- Stress corrosion cracking due to residual tensile stresses caused by improper installation and improper chemistry.

Improper operation and maintenance is a significant contributor to premature ageing.

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Example of premature ageing caused by inadequate coordination

- Cracking of RHR system piping in elbow due to high cycle fatigue; mixing flows with dT ~ 140 C
- No fatigue design; 10 h operation per year assumed
- Operator used the system for 1500 h; 10 h limit was not communicated by the designer to plant operator

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Examples of ageing unforeseen at the design stage

- IGSCC of austenitic austenitic piping in BWRs and RBMKs
- Delayed hydride cracking in CANDU pressure tubes
- Delayed reheat cracking in AGRs associated with weldments of higher carbon stailess steels
- Erosion-Corrosion in LWR piping

Signs of unforseen ageing phenomena are often detectable at an early stage by existing monitoring techniques -NPP staff should be vigilant

Excessive use of reactive ageing management (AM)

- Many NPPs use reactive AM strategy (i.e. repairing and replacing degraded components) as the primary means of ageing management.
- Risk and cost of can be very high as shown by examples of primary circuit corrosion, including PWR steam generators, BWR internals, RPV heads, and bolts in Magnox reactors.

EPRI found in 1997 that corrosion during the last decade reduced plant capacities on average by 5%.

Typical AM approach to primary circuit corrosion problems

- Inspection
- More inspection
- More sophisticated inspection
- Repair
- Replacement

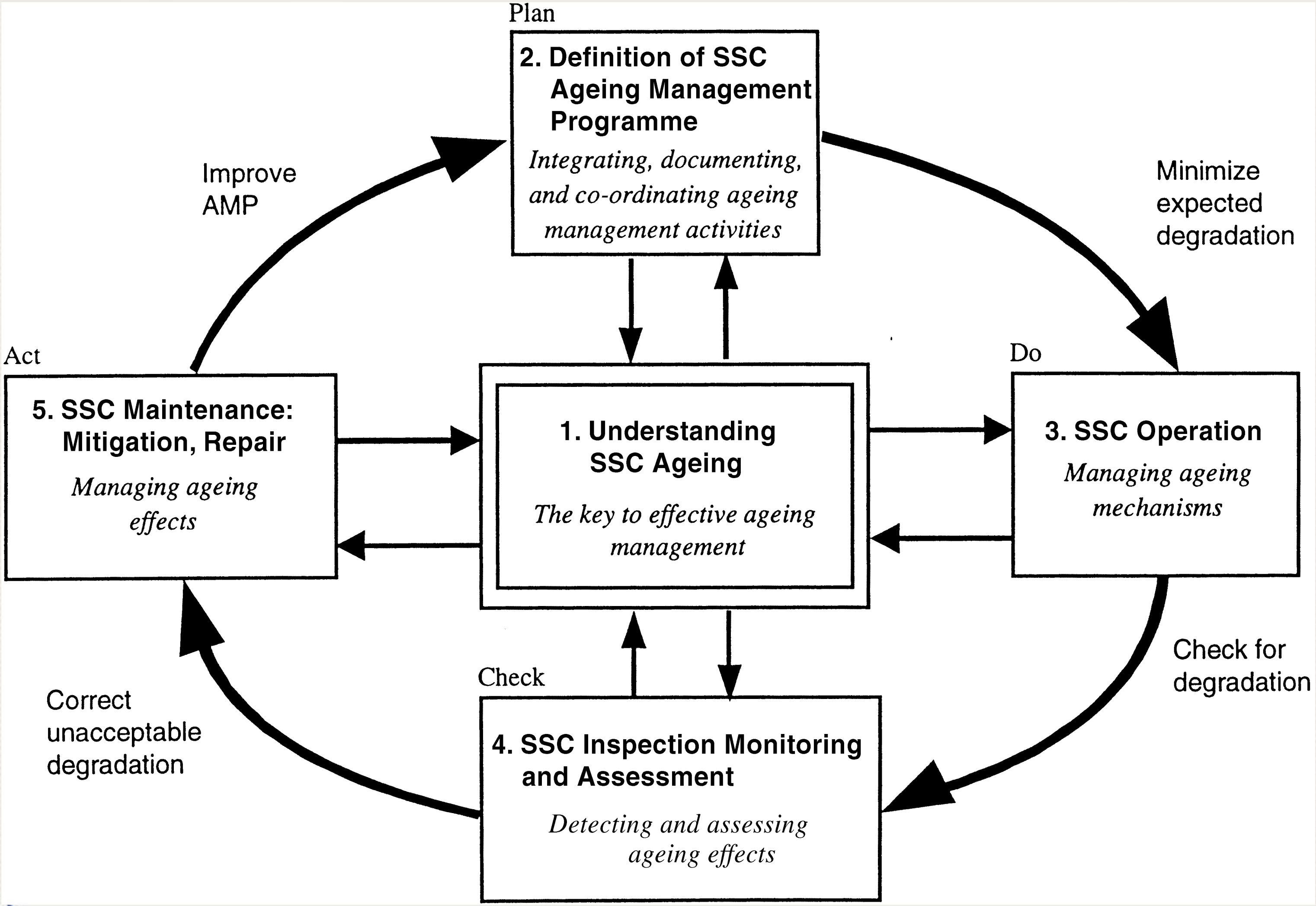
Proactive AM to prevent or slow down the rate of degradation (e.g. water chemistry change for PWRs, H_2 injection for BWRs) has historically been a fall back strategy.

3. Proactive ageing management through the application of the systematic AM process

- Involves focusing AM actions on plant components where the risk and potential benefit is the greatest

- Requires a team approach utilizing systematic AM process/ Deming's 'Plan-Do-Check-Act' cycle

Systematic AM process/ Deming's 'Plan-Do-Check-Act' cycle



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Deming's cycle for AM

- PLAN – seeks to maximize AM effectiveness through coordination of all relevant programmes
- DO – seeks to minimize expected SSC degradation
- CHECK – seeks to effectively inspect/monitor for timely detection, characterization and assessment of SSC degradation to define type and timing of corrective actions
- ACT – seeks to implement timely mitigation/ correction of SSC degradation through maintenance/ design modification – repair/ replacement

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Understanding SSC ageing

- Basis of the systematic AM process which enables optimizing and co-ordinating SSC op. and mtce.
- Depends on:
  - technical understanding of ageing mechanisms
  - quality and quantity of relevant data
- Data needs: material properties from design and fabrication, operating and maintenance histories, inspection results, generic operating experience
  - **Irradiation embrittlement: changes in bulk material properties - good predictability**
  - **Corrosion/ wear/ high cycle fatigue: loss of material from or small cracks in material surfaces/ interfaces - low predictability & significant unavailability**

Co-ordination of SSC ageing managemant programme (AMP)

- Lack of communication and co-ordination is a frequent root cause of premature ageing
- Co-ordination of relevant programmes can improve significantly AMP effectiveness
- Diagram of the systematic AM process facilitates communication among all contributors
- Feedback from all participants, self-assessment and continuous improvement are important features
- Co-ordination generally requires a modest investment but cultural/ organizational implications may be considerable

SSC operation/ use

- Has significant influence on the rate of SSC degradation
- Examples of good operating practices to minimize SSC degradation:
  - **start-up and shut-down within P/T limits to avoid excessive transients**
  - **careful maintenance to avoid contamination of metal components with agresive chemicals**
  - **chemistry monitoring and assessment may allow reducing corrosion rate and increase SG lifetime**
- Prudent to control the operating environment of inaccessible SSCs where detection and repair of degradation is difficult and costly

SSC inspection, monitoring and assessment

- Aimed to detect and characterize SSC degradation before safety margins are threatened
- Essential input for decisions on type and timing of maintenance, operational changes, and design modifications to manage detected ageing effects
- Risk informed methodology can improve inspection effectiveness by targeting on significant SSCs susceptible to ageing degradation

Example: Proactive monitoring, inspection and assessment of steam/ FW piping can help detect wall thinning due FAC (flow assisted corrosion) and predict need for repair/ replacement

SSC maintenance

- Decisions on type and timing of maintenance actions are based on assessment of observed ageing effects, predictability of future degradation, and available maintenance technologies
- For ageing mechanisms with low predictability, such as corrosion, preventive maintenance may be appropriate
  (e.g. SG cleaning before degradation is detected can prevent/ delay tubing corrosion)
- For some ageing problems, modification is the only solution
  (e.g. fatigue caused by thermal stratification in piping can often be mitigated by replacing a horizontal with a sloping section)

4. Benefits of proactive AM

- Experience has demonstrated a high cost of being surprised by ageing. In older NPPs, component replacement has been often the only option.
- Early implementation of proactive ageing management strategy can control and reduce SSC degradation and thus avoid replacement of large components

4. Benefits of proactive AM (cont'd)

- Application of the systematic AM process facilitates the selection of appropriate AM strategies, proactive or reactive, and coordination of relevant programmes to minimize premature ageing.
- It would be prudent to review current AM strategies employed for long lived passive SSCs and major types of active components (e.g. MOVs) to determine potential advantages of the proactive strategy.