

Analysis of main PSA tasks with regards to Ageing PSA and its applications.

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“Enlargement and Integration Workshop”

November, 2007

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Introduction

• PSA

- the methodology has matured over the past decade
- is seen as an effective and essential tool
 - to complement the traditionally performed deterministic analysis.
- is increasingly used as an integral part of the risk informed decision making process

• PSA Applications

- various applications of PSA are in use today
 - in design, operation, accident management, etc.

Use of PSA for Particular Applications

- Extent to which PSA tools **can** contribute to **risk informed decisions at each particular case**
 - depends on **specific characteristics of the PSA model**
 - e.g. its quality, completeness and level of details
 - and **type of the activities**
- **Example**
 - a basic criterion determining the **range of use** of PSA for **ageing management** is the **level** to which **ageing effects** are incorporated in **PSA tools** at all

Use of PSA for Particular Applications

- **But**
 - even PSA models **without** systematically **incorporated ageing effects** may be adequate and useful for **certain limited** ageing related **applications**
 - as making priorities in ageing management, etc.

Use of PSA/APSA for Ageing Related Activities

- Periodical Safety Review /PSR/
- Ageing Management Programme
- Plant Life Extension, etc.

Use of PSA/APSA for Ageing Related Activities

- Periodical Safety Review /PSR/
 - **A safety assessment process consists in identifying**
 - safety issues, determining their safety significance and making decisions on the need for corrective measures.
 - **PSA performance includes**
 - identification and ranking of important design and operational features,
 - of dominant accident sequences, systems, components, human interactions and dependencies important for safety
 - A comparison of the results against safety goals or quantitative health objectives may be involved.

Use of PSA/APSA for Ageing Related Activities

- Periodical Safety Review /PSR/
 - The application may involve modelling of ageing effects in PSA
 - Typically there are two types of SSCs:
 - SSCs, which are periodically renewed or replaced (can be modelled 'as new'),
 - and SSCs which are subject to an ageing process
 - **Incorporating ageing effects would be more a more important with increased age of plant**

Use of PSA/APSA for Ageing Related Activities

- Ageing management
 - use of risk informed methods should be considered
 - to prioritise the ageing management review of the selected components
 - on the basis of their safety significance.
 - **PSA could be used in optimisation**
 - of plant specific ageing program scope for safety related equipment
 - includes identification of safety significant components and may involve modelling of ageing effects in PSA and identification of the risk significant SSCs potentially degrading due to ageing phenomena.

Use of PSA/APSA for Ageing Related Activities

- Lifetime extension
 - often referred as a sub-case of the PSR with the consideration of ageing effects beyond the design lifetime
 - which involves modelling of ageing effects in PSA
 - a full scope PSA is needed to address the application in complete and consistent manner
 - The key issue is the possible impact of ageing phenomena and component lifetime considerations beyond the design lifetime on the overall risk metrics
- example
 - The evaluation of increase in risk due to ageing of plant equipment past the design lifetime
 - Typical equipment of major interest are reactor vessel, steam generators, piping, etc.

Why PSA and Ageing issues?

- It is evident that PSA is feasible framework to determine the effect on risk due to components ageing and PSA can be useful in the ageing management process

and

- Lack of treatment of ageing issues with respect to advanced NPP ageing represents one of the aspects which could have significant impact on credibility of PSA tools
 - In advanced or extended life time

Why PSA and Ageing issues?

- **Incorporation ageing effects** into PSA models would **enhance** their **capability to practically support** safety related decision making in sense of treatment ageing effects on risk assessment results.
- Explicit consideration of ageing issues - important feature of Risk Assessment evaluation
 - allows to prioritize the contributors according to their risk importance
 - ageing activities can be focused on important issues

PSA and ageing issues

- Standard PSA tools do not address ageing effects
 - **differences between standard PSA and “ageing PSA”**
 - currently **constant failure rates** - used in reliability models
 - most of /passive/ components were **screened out** in standard PSA - it should be reviewed for **advanced** or **extended** plant age
 - some components failures could be missing in MCSs, because they have not been modeled - were neglected for low probability /vessels, pipes, cables.../
 - **ageing may introduce additional correlations** of failure rates /even/ among dissimilar components
 - **different failure probabilities** of events other than hardware failures
 - HE, component unavailability due to testing and maintenance, etc. could be **different for older plants** from those for new ones

PSA and Ageing issues

- **Incorporating ageing effects into PSA**
 - various approaches and scopes
 - relevant issues :
 - Scope of addressing ageing effects
 - Level of details
 - Data available
 - Type of applications
 - etc.

PSA and ageing issues

- Main issues of incorporating ageing effects
 - **Data**
 - Operating experience, /accelerated ageing tests/, PSA results, data for modeling of ageing mechanisms
 - **Reliability models**
 - Ageing failure rate models, physical models
 - **PSA models modifications**
 - Structure issues
 - Parameter issues

PSA Tasks with regards to APSA structure issues

- Initiating events analysis,
 - adding of new IE
 - previously excluded due to low likelihood,
 - review of existed IE assumptions
- Accident sequence analysis,
 - event tree modifications
 - review of timing issues, success criteria,
 - new intersystem dependencies, new consequential events, etc.

PSA Tasks with regards to APSA structure issues

- Accident sequence analysis
 - system fault tree modifications
 - incorporating of new BEs
 - **selected passive components**
 - new failure and CCF mechanisms
 - review of BE boundaries
 - appropriate /new/ level of details for specific degradation mechanisms with relation to particular applications
 - logic structure modifications – e.g. due to changes in success criteria
 - new maintenance and testing practices

PSA Tasks with regards to APSA structure issues

- Accident sequence analysis
 - Human reliability analyses
 - review of conditions for human interventions
 - ageing may have impact on time windows
 - review of operator event boundary
 - availability of information due to ageing, etc.
 - possible new HE
 - due to new IE and changes in ET/FT
- LERF calculation
 - Level 1/2 interface review

PSA Tasks with regards to APSA parameter issues

- Data analyses
 - **IE frequencies**
 - time dependent models should be implemented
 - **Active components**
 - dependent reliability models, testing and maintenance issues, etc.
 - **Passive components**
 - physical reliability models

PSA Tasks with regards to APSA parameter issues

- Data analyses
 - **HE Probabilities**
 - some new parameters
 - organisational impacts, maintenance and testing practices, etc.
 - **Dependent failures**
 - due to common ageing mechanisms
 - **Repair and mission times, maintenance duration, testing intervals**
 - could be affected by ageing

PSA Tasks with regards to APSA passive components - example

- **Incorporating passive components into PSA models**
 - **Selection of components for detail consideration**
 - **Screening process**
 - System importance measures
 - consequence evaluation
 - expert judgment, operating experience,
 - ageing mechanisms

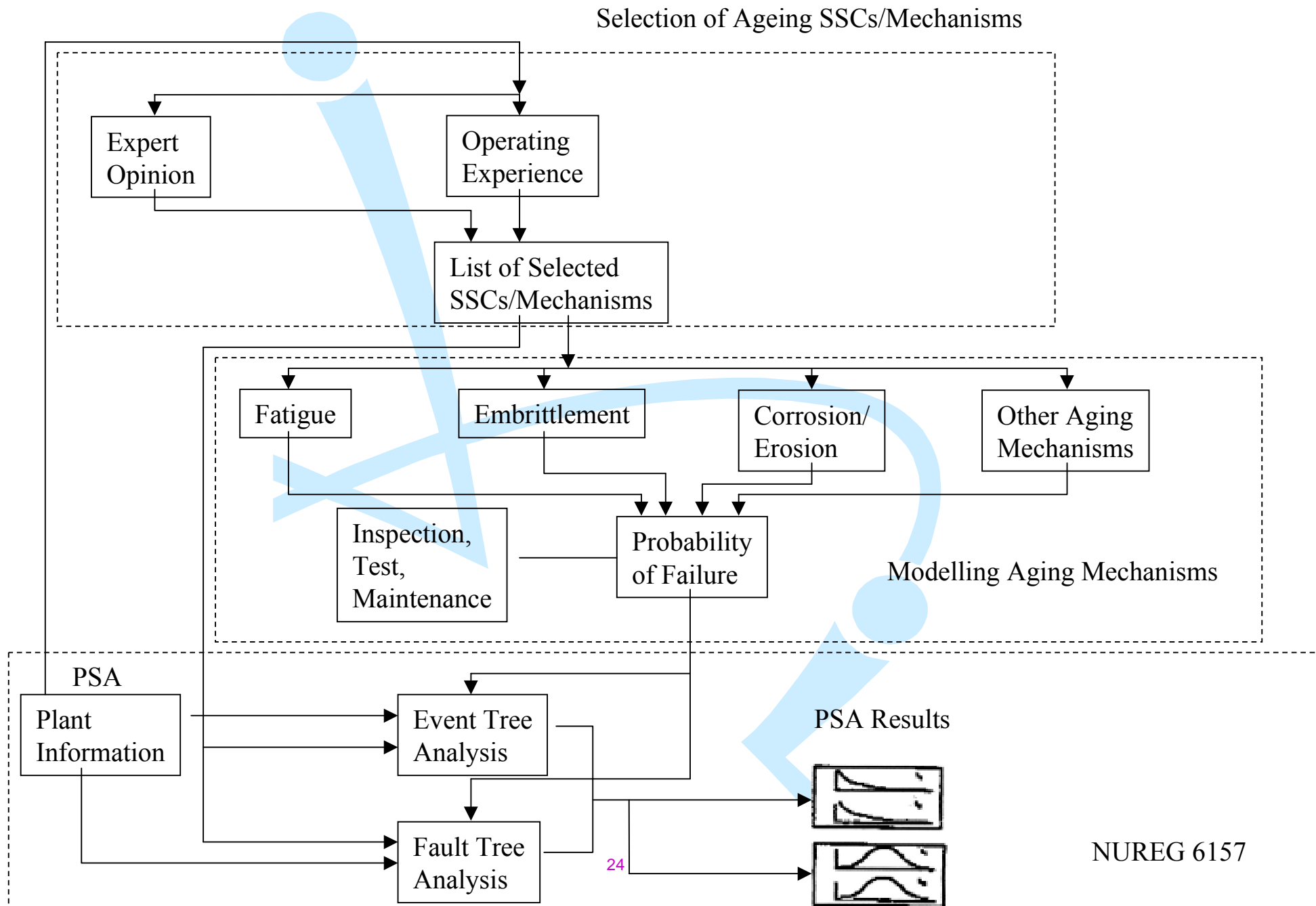
PSA Tasks with regards to APSA passive components - example

- **Determination of component failure probabilities as a function of component age**
 - **Data needed for modelling of ageing mechanisms**
 - Data related to material properties and operating conditions
 - Data needed to model specific ageing mechanisms
 - Fatigue, Irradiation embrittlement, Stress corrosion cracking and Erosion/Corrosion, etc.
 - **Evaluation based on detailed mechanistic failure models /example/**
 - Degradation and cracking of pipework welds
 - Weld failure as a function of component age
 - Failure probability determined by
 - comparison of stresses on component with the material strength at selected component age

PSA Tasks with regards to APSA

passive components - example

- Modification of existing PSA model
 - by including the events corresponding to failure of the selected passive components
 - passive component failures will be added into system FT models
- Models will be quantified by using the corresponding component failure probabilities for particular age



APSA Applications

- Effective risk and ageing management support
 - More credible outputs, range of use...age dependent outputs
 - Use of models for degradation mechanisms
 - would allow the effective use of information, which failure rate based models cannot accommodate
- Prediction for extended /long term operation
 - **Extrapolation of observed trends to distant future**
 - Treatment of maintenance and replacement policy
 - Accelerated ageing tests

Conclusions

- It is important
 - to **assure** continuation of plant **safe operation** even in advanced or extended plant life
- It is essential
 - to **assess** the effects of age-related **degradation** of plant structures, systems and components /SSCs/
- Better understanding
 - of **behavior** of age-degraded structures and components is clearly needed to **ensure** that the **degradation** can be **adequately managed** for the continued safe operation

Conclusions

- and **APSA**
 - is an excellent tool, which could help us in the process
 - and will support particular **ageing related** activities and applications

