International “APSA” Network on Incorporating Ageing Effects into PSA Applications

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http://www.energyrisks.jrc.nl/APSA/
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Network on

“Incorporating Ageing Effects into PSA Applications”

• Operating under AMA project by Sector of Probabilistic risk and availability assessment of energy systems, IE JRC Petten

• www.energyrisks.jrc.nl/APSA
Objectives - Network on

“Incorporating Ageing Effects into PSA Applications”

- Evaluation of available methods and approaches of incorporating ageing effects
- Discussion of potential APSA applications
- Demonstration of feasibility
  - approaches and models via case studies
- Discussion of effort and “effectiveness”
  - implied by different approaches in incorporating ageing effects into PSA
- Identification of further research needs
The benefits of such a network could be:

- a better understanding of **important issues** related to incorporating ageing effects into PSA when we need it and **what** is important...
- **increased** knowledge **on use of several approaches** and methods to include **ageing effects** in PSA models
- some **experience** based on particular case evaluations
- available information reflected **efforts implied** by different methods
- others
Working method

- A network of operators, research, industry and consultants
  - With an active interest in the area
  - With their own/national research program in the area

- Networking via series of workshops and via internet
  - E-mail
  - APSA website
  - meetings
Current APSA Network Partners

- **TSOs / Vendors / Regulators / Research / Academia:**
  - Czech Republic /UJV Rez/,
  - Finland /VTT/,
  - France / IRSN, CEA, EDF, Framatome/
  - Germany /EON, Vattenfall/,
  - Hungary /VEIKI/,
  - Italy /ENEA/
  - Lithuania /LEI/,
  - Japan /JAERI, Maritime Research/,
  - Korea /KAERI/
  - Romania/INR/,
  - Slovakia /Relko/,
  - Sweden /Relcon, Vattenfall/
  - Switzerland /KKG/,
  - UK /BE, Rolls-Royce Naval Marine/
  - USA /Ohio St. University, Los Alamos NL, Sandia NL, Statwood Consulting/
• PSA

- is increasingly being used as integral part of the safety related decision making process
- the methodology has matured over the past decade and PSA is nowadays seen as an effective and essential tool
  - to complement the traditionally performed deterministic analysis.
- various applications of PSA are in use today
Background

- Standard PSA tools do not address ageing effects
  - Some differences between standard PSA and “Ageing PSA”
    - currently **constant failure rates** are used in reliability models
    - failures of certain **components are missing in MCS**, simply because they were neglected due to low probability arguments (vessels, pipes, cables)
    - ageing may introduce **additional dependencies** among failure rates, even across different components
    - different failure probabilities for **non-hardware failures** for older plants (e.g. human errors, component unavailabilities due to test & maintenance)
Applications

The 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.

For example a basic criterion determining the range of appropriate use of PSA for ageing management is the level to which ageing effects are incorporated in PSA tools at all.
APSA Applications

• Ageing PSA Applications

  • Advanced life operation, life extension,
    • Ageing management, identification of weak points, etc.
      • Risk assessment, importance evaluation, maintenance, testing and inspection support/prioritization

  • Ways of incorporating ageing effects into PSA models for particular applications
Ways of incorporating ageing effects into PSA models for particular applications

- Advanced age operation
  - RM systems, Living PSA tools
    - Constant failure rates /updated data collection/
    - Ageing effects for selected passive components
- Risk assessment for Life extension
  - Ageing incorporated also for selected/important active components
- RI Inservice inspection /in advanced age/
  - More detailed incorporating for passive components
Network Main Tasks

- Current tasks
  - Available Methods and Approaches
    - On incorporating ageing effects into PSA models
  - Case Studies
    - Demonstration of approaches and feasibility
  - Dissemination of results, outputs, relevant information, links
    - WEB, questionnaires, meetings
## Network Main Tasks

### Available Methods and Approaches
- Evaluation and documentation, state of the art
- Methodology problems
- Data collection and elaboration issues
  - Which data, how to collect, how to analyze, data sources/
  - Discussion of further research needs
- Currently introductory report on “APSA in risk informed applications” is under development
Network Main Tasks

- **Case Studies**
  - Selection of topics for case studies
    - Data analysis
      - Demonstration of methods
    - Use of ageing models for active and passive components
      - Selected types of AC, selected pipes, etc.
    - Incorporating ageing effects into PSA models, evaluation of impact
    - Use of PSA and APSA for ageing management, etc.
  - Preparation of data sets, models, incorporating of ageing effects
    - PSA models are supposed to be used for some case study applications
Current Network Activities

• Report on “APSA in risk informed applications”
  • Potential use of APSA in RI applications
  • Models and data used for assessing of ageing of systems, structures & components
  • Incorporating ageing effects into PSA models

• Ongoing Case studies
  • Current case study on demonstration of selected methods for data analyses and identification of ageing trends
    • in cooperation with IRSN/France & Statwood/USA

• IRSN/JRC Workshop on "Practical Applications of Age-dependent Reliability Models & Analysis of Operational Data"
  • Paris, 5-6 October 2005, hosted by IRSN
Network Main Tasks

- **Current Case Study**

  - Currently performed exercise is on
  - demonstration and use of parametric/non-parametric methods for data analysis and identification of ageing trends
  - In cooperation with IRSN/France, Statwood Consulting/USA

![Failure rate graph](image)
APSA Network Website

• Dissemination of results and other relevant information
  • APSA Project description /objectives, tasks, etc./
    • News, meetings, publications, questionnaire responses,
    • Case studies, conclusions and results
  • Report on “APSA in risk informed applications”
    • “Living” report
      • Initial version in 2005
  • References, useful links, etc.
Development of the report

- Report on “APSA in risk informed applications”
  - **Introduction**
  - CH 2 Potential use of APSA in risk informed activities
  - CH 3 Models and data used for assessing the ageing of systems, structures and components
  - CH 4 Incorporating Ageing effects into PSA models
  - **Conclusions**, References
  - Appendices “A” : details related to report
  - Appendices “B” : case studies – related to chapters
Development of the report

- Report on “APSA in risk informed applications”
  
  Inputs:
  - Statwood Consulting /USA/, IRSN /France/, CEA /France/,
  - VTT /Finland/, IRN /Romania/, JRC

  Comments and revisions:
  - VTT, IRN, EDF /France/, LEI /Lithuania/,

- Living initial version on APSA Network website
  - End of 2005
Development of the report

• Ageing PSA Applications
  • Identification of potential applications
  • Way of incorporating ageing effects into PSA models for particular applications
  • A part of currently developed report “APSA in RI Applications”
Ongoing Case studies

• demonstration of approaches and feasibility, comparison of results

• IRSN /France/, Statwood Consulting /USA/
  • Case studies on identification of ageing trends
    • Examination of Failure Data from continuously Operating I&C Components
      • Demonstration of approaches described in report “APSA in RI applications”
      • Comparison of parametric and nonparametric tests
New Studies

- New proposals
  - Methodology issues
    - ageing may introduce additional dependencies among failure rates, even across different components
      - additional correlations of failure rates
    - discussion of extrapolation /different reliability models/

- Case studies
  - Impact of maintenance and corrective actions
  - Incorporating ageing effects into PSA models
    - Selected safety system, active components or passive components
      - Impact evaluation on system level
  - Use of PSA in ageing management
Other relevant projects

• Accelerated ageing reliability tests
  • motor operated valves
    • The test program was developed by IRSN in the frame of Ageing Probabilistic Safety Analysis (APSA) study for PWR 900 MW reactor
  • Results of the tests
    • ageing reliability model and knowledge of ageing kinetics
      • could be useful for any further ageing assessments of such type of equipments, as:
        • Ageing PSA,
        • lifetime extension,
        • test and maintenance optimisation,
        • equipment qualification, etc.
  • The test duration is estimated for 18 months including the works for modification of existed facilities
    • The approximate cost of experiences is 1,0 – 1,3 M€.
• Accelerated ageing reliability tests
• Objectives
  • Main goal - to obtain initial data to estimate ageing related reliability parameters for the selected component type
  • Those parameters will be applied as an input data for the Ageing PSA model.
  • As a supplement to the main goal, the results of the test would clarify the following issues:
    • kinetic and behaviour of certain ageing mechanisms susceptible to affect the actuator-valve assembly,
    • clear demonstration of certain conditional indicators could be used for the predictive or preventive maintenance,
    • evolutions in time of safety and maintenance margins with regards to the accidental operation requirements.
Accelerated ageing reliability tests

Selection of component type was done with use of following criteria:

- safety importance (deterministic) and risk significant (PSA),
- large statistical population on the operating units,
- combination of operating and environmental stressors,
- reasonable price of test.

Test programme

- identification of significant aging mechanisms for MOV under the study,
- selection and justification of available simulation approaches when it is technically feasible,
- definition of test conditions for the simulation of each significant aging mechanism.
- proposal of methodology for statistical evaluation of experimental failure data
APSA under FP-7: Context

- 7th EU Research Framework Program: 2007-2013
  - EC Direct actions:
    - JRC non-nuclear
    - **JRC nuclear**
  - EC Indirect actions:
    - Non-nuclear
    - **nuclear (Euratom):**
      - Fusion energy research
      - **Nuclear fission and radiation protection**
  - i.e. in terms of budget & number of activities:
    - nuclear << non-nuclear
    - within nuclear: fusion >> fission
Nuclear fission:

key issues:

- operational reactor safety and management of long-lived waste

cross-cutting topics:

- nuclear fuel cycle, actinide chemistry, risk analysis and safety assessment and societal and governance issues

Activities:

- Reactor systems

Research to underpin the continued safe operation of existing reactor systems, taking into account new challenges such as life-time extension and development of new advanced safety assessment methodologies, and to assess the potential and safety aspects of future reactor systems in the short and medium term, thereby maintaining the high safety standards already achieved within the EU.
Collaborative projects:
- Support to (existing (e.g. APSA-NW)) research projects carried out by consortia with participants from different countries, aiming at developing new knowledge, new technology, products or common resources for research. The size, scope and internal organisation of projects can vary from field to field and from topic to topic. Projects can range from small or medium-scale focused research actions to larger integrating projects which mobilise a significant volume of resources for achieving a defined objective.

Networks of Excellence
- Support to joint research programmes implemented by a number of research organisations integrating their (existing (e.g. national ageing RTD)) activities in a given field, carried out by research teams in the framework of longer term co-operation. The implementation of these joint programmes will require a formal commitment from the organisations integrating part of their resources and their activities.

Coordination and support actions
- Support to activities aimed at coordinating or supporting research (networking, exchanges, studies, conferences, etc). These actions may also be implemented by means other than calls for proposals.

Actions to promote and develop human resources and mobility
- Support for training and career development of researchers
APSA under FP-7: initial interest

• In advance
  • Expression of interest
  • Ideas and proposals
  • Information about existing national projects
    • Collaborative projects versus Networks of Excellence
  • March - April 2006

• Preparation of the Expression of interest
  • Since summer 2006

• Project preparation and applications
Network Main Tasks

- Current tasks
  - Available Methods and Approaches
    - On incorporating ageing effects into PSA models
  - Case Studies
    - Demonstration of approaches and feasibility
  - Dissemination of results, outputs, relevant information, links
    - WEB, questionnaires, meetings
Any New Network Partners interested in the topic are welcomed.
Introduction

The project’s proposed working method is a NETWORK of operators, industry, research, academia and consultants with an active interest in the area (physical networking via a series of workshops and virtual networking via the Internet).

The resulting knowledge should help PSA developers and users to incorporate the effects of equipment ageing into current PSA tools and models, to identify and/or develop most effective corresponding methods, to focus on dominant ageing contributors and components and to promote the use of PSA for ageing management of Nuclear Power Plants (NPPs).