International Atomic Energy Agency

IAEA Activities on PSA and Reliability Data

EC Enlargement and Integration Workshop on Use of PSA for Evaluation of Aging Impacts on the NPP Safety, 15-16 November 2007, Budapest, Hungary

J.Yllera

J.Yllera@iaea.org

Outline

- **IAEA Activities on PSA and Applications**
  - **Regular Programme**
  - **Technical Cooperation**
  - **Extra budgetary Programmes**

- **Specific IAEA on Reliability and IEs Data.**
  - **Guidance**
  - **Interchange of Experiences and Databases**
  - **(Remarks on Considerations of Ageing in reliability data)**

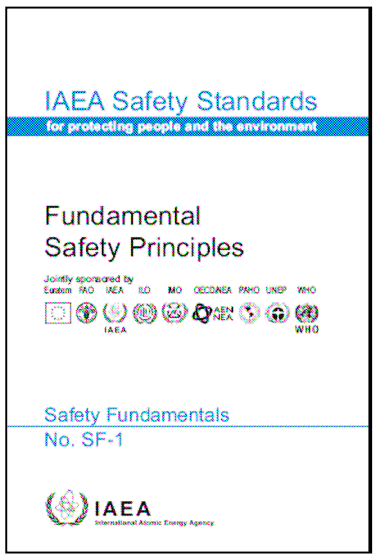
RBP: Development of Safety Standards on PSA

Hierarchical structure

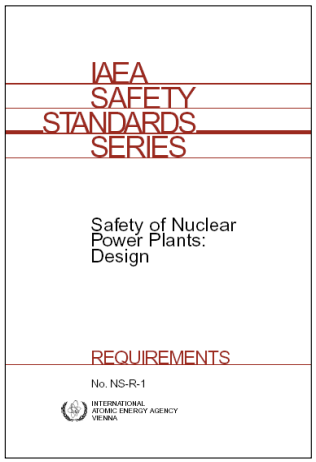
RISK MUST BE ASSESSED

Comprehensive & detailed PSA is required

New Safety Guides provide recommendations on PSA performance and application



2006



2000

SAFETY REQUIREMENTS:
Safety Assessment and Verification of Nuclear Facilities and Activities
(DS348)

2007

Development & Application of Level 1 PSA for NPPs
(DS394)

Development & Application of Level 2 PSA for NPPs
(DS393)

2008

Fundamentals **Requirements** **Safety Guides**

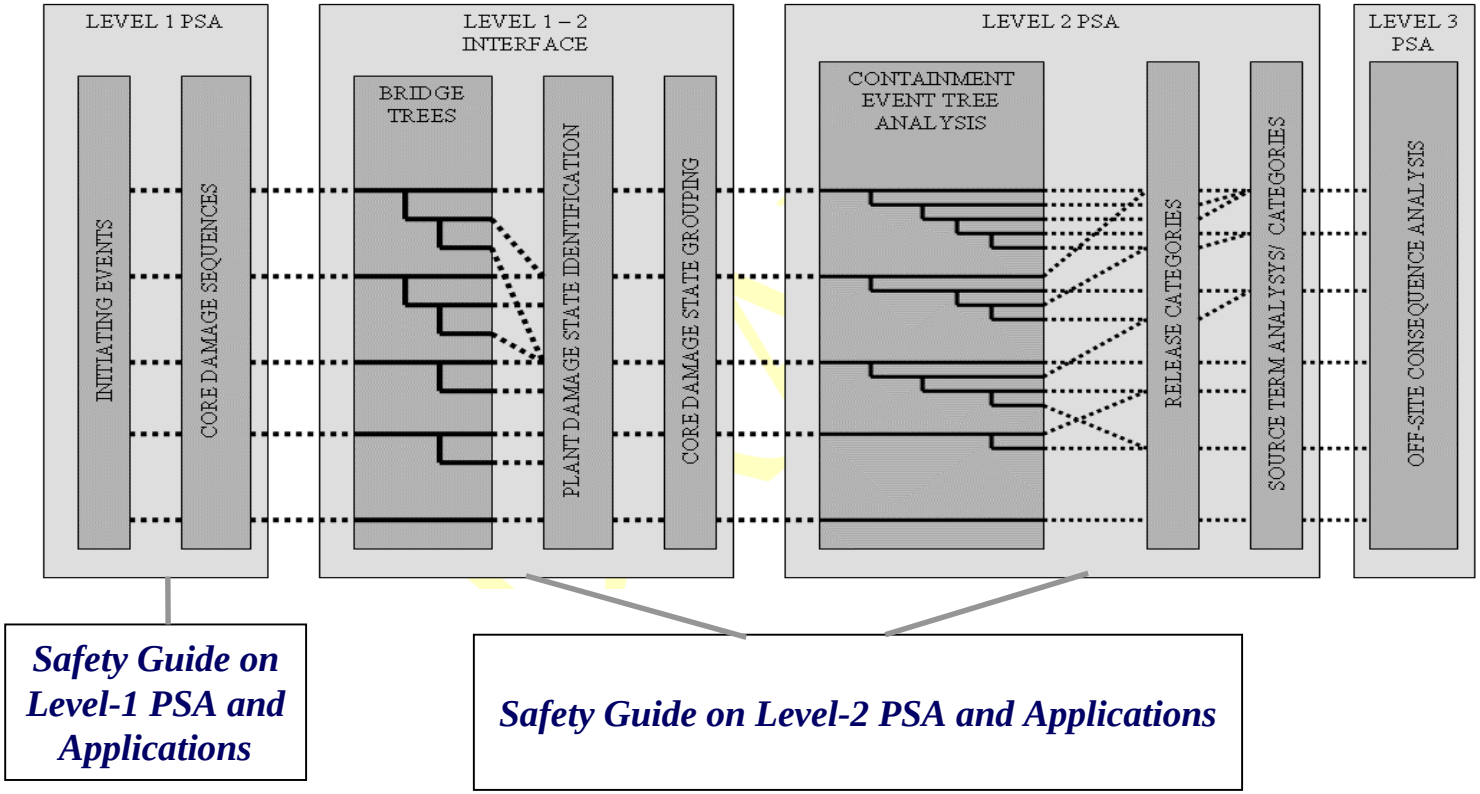
Scope and Status of the Safety Guides on PSA

- Level 1 PSA (Draft SG 394):
  - Reactor core
  - Internal events and hazards
  - All modes of Operation
- Level 2 PSA (Draft SG 393):
  - Reactor core
  - Internal Events (extension to other modes of operation)
  - Full power operation (Extension to other modes of operation)

➔ ***Both Safety Guides on PSA were approved by NUSSC to be sent for official comments by Member States (MSs); available on IAEA SS Web page***

➔ ***Technical Meeting to consider official comments provided by MSs will be held at the IAEA on December 3-7, 2007***

INTERFACE BETWEEN SAFETY GUIDES ON PSA



- ***Both Safety Guides on PSA were approved by NUSSC to be sent for official comments by Member States (MSs); available on IAEA SS Web page***
- ***Technical Meeting to consider official comments provided by MSs will be held at the IAEA on December 3-7, 2007***

Safety Guide on Risk Informed Decision Making

- OBJECTIVE:

  The Safety Guide on RIDM provides principles and suggests approach to integrate the results of deterministic and probabilistic safety analyses to make sound, optimum, and safe decisions

- STATUS:

  A preliminary draft is developed and will be considered at the Technical Meeting (end of November)

- *Not specific for Nuclear Power Plants, but thematic.*

Development of Other Documents

- TECDOCs considered building blocks supporting IAEA Safety Standards
- Draft Report on Level 2 PSA (more details on level 2 PSA, update of safety series on level 2 PSA)
- Draft Report on the Use of Plant Specific Data
- Draft TECDOC on Reliability Centred Maintenance (jointly with NE)

PSA Reviews

- **IPSART Mission in Armenia (Oct. 2007)**
- **Pre- IPSART Mission in Chashma 1 NPP, Pakistan (Nov. 2007)**
- **New Design Reviews:**
  - **Chapter 19 of PSAR (PSA & SA) for Chashma 2 NPP**
  - **Review of 4 new designs for the UK against SSs.**
  - **Review of other designs already requested.**

Review Services being reconsidered. Looking for Integration, consistence and modularity.

TC Projects

- **RER0987 on Harmonization of PSA and PSA Applications:**
  - **Harmonization of LPSD PSA. Other topics planned**
  - **Development of databases for PSA**
  - **WSs on selected topics on PSA applications**

- **Individual activities under other Projects:**
  - **Training course on PSA and Safety Assessment for Decision Making (RE)**
  - **PSA Applications (RA)**
  - **Training Course on PSA (Indonesia)**

Evaluation and Planning of TC and EBP activities for 2008 (on going)

PSA Databases

- **Power Reactor Information System (PRIS):**
  - **Being expended to include:**
    - **Information on Initiating events**
    - **Information on equipment failures (under discussion)**

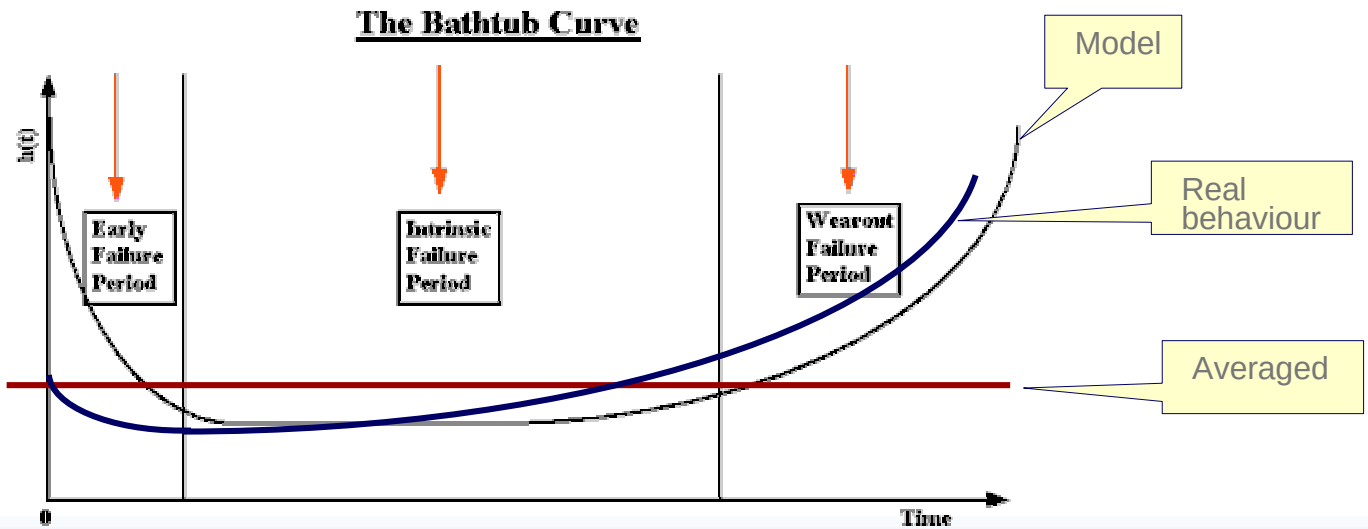
- **IE and Reliability data for VVERs (under RER0987):**
  - **Database on Initiating Events:**
    - **VVER 440 (mostly developed)**
    - **VVER 1000 (being populated)**
  - **Framework for the acquisition of Reliability Data (under development)**

Plant Ageing and Life Extension Issues. Usability of PSA. Challenges and limitations

- Ageing management and life extension are issues of important interest for many plants and countries.
- Which role does PSA play or could play in this context ?

Consideration of Ageing in PSA

- **Does PSA accounts for ageing? Yes and no. Calculated failure rates are "averaged" constant values over the time from generic or plant specific analysis. Many passive and ageing components and structures (eg. pipes, cables, vessels,etc.) are not even modelled.**
- **The so called "Ageing PSA", i.e. with consideration of time dependence of component failure rates, is in an exploratory phase. Why?**
  - Models for component behaviour are **just models** used to describe the reality. Thus for instance, real components are not Boolean, i.e. perfectly working or totally failed. The observed data is adjusted to the postulated model.
  - The bath tube curve (No ageing for a long time period, component replacement before ageing starts) is just a model, simple however it contains in accuracies. Some ageing mechanisms develop very early. Some factors may accelerate it
  - This model (constant failure rates = exponential distribution of component lifetimes) is used because it simplifies the estimate of failure rates and the calculation of plant risk, which may be easily unattainable for complex systems with time dependent parameters



Practical Issues when considering Ageing Effects on PSA (1)

- Some ageing component or structures are not modelled in the PSA.
  - Many relevant ageing mechanisms may affect passive components which are not (or only indirectly) modelled in the PSA. Examples of them are: Pipes, reactor vessels and internals, as well as other elements or equipment of the reactor coolant circuit, cables, containment parts, etc. Others, such as cranes, refuelling machines, etc. are in no way considered in PSAs.
- PSA uses commonly a Bayesian approach. Prior distributions are generic and don't account for ageing.
  - Scarcity of plant specific data, even under the assumption of constant failure rates requires the use of generic data. Hence, the acquisition of time dependent failure rates differentiating ageing effects from random failures is much more difficult. Ageing models would be "poluted" with generic data.
- It requires recording not only of number of failures within an observation period , but how old is the equipment when it fails? PSA uses data censoring methods (normally failures during a given time interval with possibility for component replacement). Observation periods should be large enough.

Practical Issues when considering Ageing Effects on PSA (2)

- It requires not only to distinguish whether a record describes a catastrophic component failure, but whether and to which extent ageing effects took place and have been removed. Some failure modes seem to be more time dependent (e.g. plugging) than others.
- Ageing is a slow phenomena. Incipient or partial failures are reported in maintenance and test records due to ageing or wear out, but pieces are replaced sometimes without any impact on calculated failure rates. In other cases, replacement is impossible or very difficult. Appropriate maintenance, testing and inspection can retard/mitigate ageing. Inappropriate practices produce the opposite effect indeed. Such factors are plant specific.
- Some parts within the component boundary (e.g. a valve motor, relays) can be interchanged from one component to another or with components from the storage (tracking difficulties for data collection)

Practical Issues when considering Ageing Effects on PSA (3)

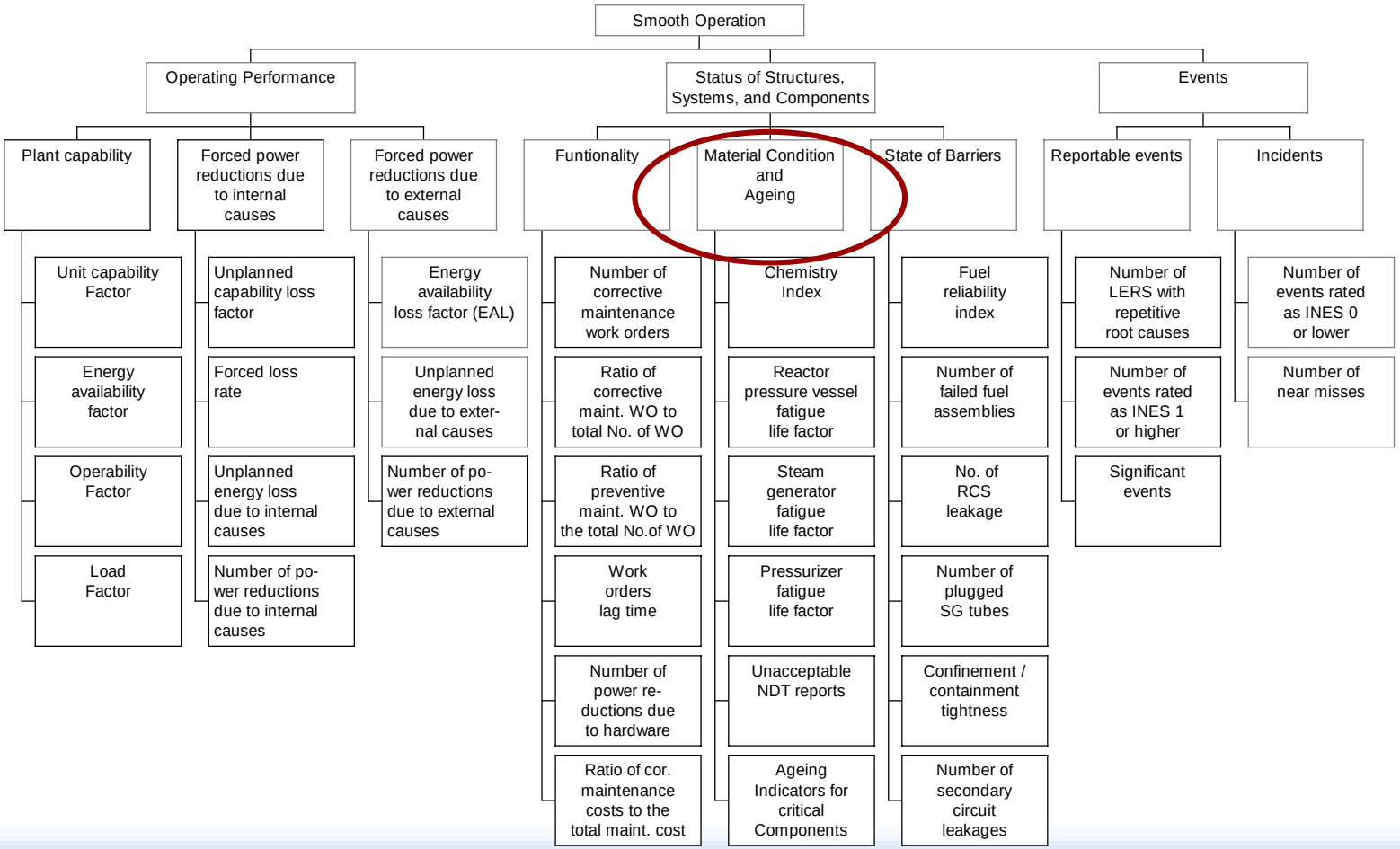
- Models usually consider that components can be considered as new after surveillance and maintenance (saw curve). This would no longer hold.
- Models become time dependent and very difficult to solve for complex systems. Many failure probabilities in the PSA should nor be treated as average.
- Which life time distribution law should be selected to reflect ageing? It would have more parameters than the exponential law (just one). Different sampling methods and fit tests can be used. Scarcity of failure records hinders often the use of fitting tests already for the exponential distribution (exponential). Additional uncertainties in parameter estimation are introduced. Uncertainties should be propagated to the PSA results
- Computer codes need to be adapted for time dependent models (ageing) and calculations.
- Risk assessment with consideration of ageing effects (time dependence) should not be focused on the time of the analysis, but projected to the future. Therefore, it is needed to extrapolate the ageing effects observed to assess trends in the future with the use of the model. PSAs at the end of the plant life, when sufficient ageing effects have been observed to provide better data, are of **no use** for the plant under consideration, but perhaps for others.

Potential use of current PSAs for ageing management issues (proactive approach)

- PSA identifies significant risk contributors (bound to model hypothesis)
- Ageing management efforts can be directed to them, including their passive associated elements (cables, pipes, structures, etc.)
- In a similar way PSA can be of help in assessing the safety relevance of (some) observed ageing effects
- Seismic PSA helps to identify risk significant structures and passive components. However, ageing affects their fragilities and resistance, but what is the magnitude of the effect . Can they (all) be tested? Risk impact from such ageing degradations is not easy to estimate and decision criteria on the issue is missing
- Reliability data collection for PSA, if properly carried out, allows to correlate failures, and intervening circumstances, thus helping to identify potential ageing effects and degradation mechanisms which may not be seen in other ways.

IAEA Work on SPIs

- **A number of SPIs have been proposed in the IAEA system, which help to monitor component degradation and ageing effects in safety relevant components and barriers.**



Life extension

- In several countries plant life extension (after ~ 40 years) is being requested. Practices in granting operating permits and extension periods vary from country to country
- Current rules for license renewal are focused on ageing management of mostly passive components and structures, particularly those that have to last for a long life and are not (or not easily) replaceable, and **they are deterministic**. Active components are supposed to be predominantly monitored through other practices.
- PSA is being used by licensees in some countries in the context of license renewal applications and periodic safety reviews. PSA can play a complementary role by ranking by safety significance relevant active components, which can be affected by ageing despite the existing maintenance and surveillance practices, such as: motors, DGs, batteries, breakers, inverters, battery chargers, I&C components, etc.
- PSA is also indirectly used in license renewal, since ISI and other test and maintenance practices credited are risk informed in many plants

Life extension (2)

- Backfitting requirements are made in many countries at the time of license renewal.
- Some countries require plants to maintain the state of the art in technology or conform with modern standards, which poses important problems to replace obsolete or ageing components. In a few ones, risk informed criteria is used for periodic safety review and license renewal (e.g. NL, UK, where BSLs and SAPs should not be exceeded. However, generally the criteria are deterministic.
- External factors, e.g. reluctant public opinion, economy of alternative energy sources, etc. may deter operators to request a life extension which would entail tremendous modernization efforts. PSA has been used together with other analyses by plant operators to justify adequate safety levels.