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Role of PRA and Applications in Licensing of Olkiluoto 3 NPP in Finland

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Introduction

Konvoi & N4 are reference NPPs to EPR

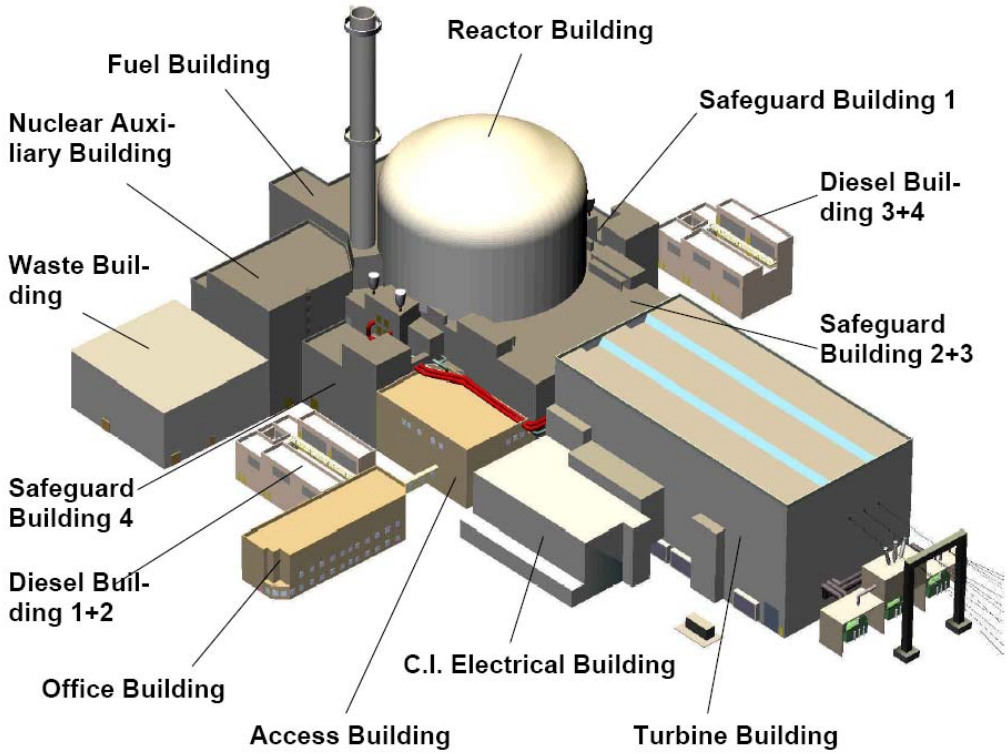
EPR complies with international, Finnish and EUR requirements

Severe accidents are taken into account in design

Diversity is applied in systems design and safety functions

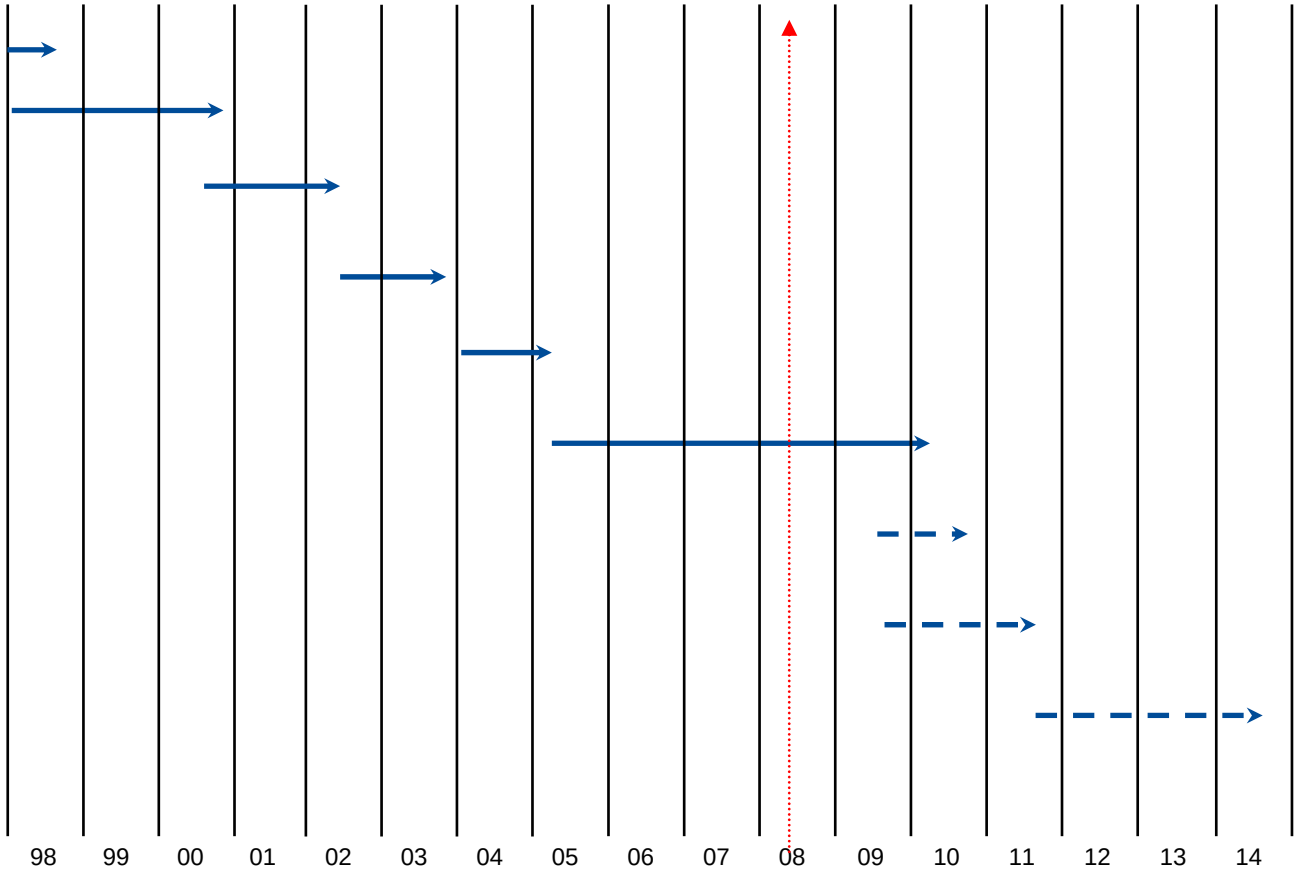
EPR is protected against a collision of a large passenger jet

PRA is used to support the design starting from the early conceptual design



OL3 Schedule

- EIA
- Feasibility studies
- **Decision in principle**
- Preparatory phase
- **Construction Permit**
- Construction
- **Operating License**
- Commissioning
- Commercial Operation



Risk Informed Licensing Requirement

Decision in Principle on the construction of a NPP unit

Application for a Construction License, CDF < 1E-5 /a, LRF < 5E-7 /a

- **Submission of Level 1 and 2 design phase PRA to STUK**
- **Evaluation of the acceptability of Design Phase PRA (and applications)**
  - **(Upgrade of PRA and/or the plant design)**
  - **Design Phase PRA is to demonstrate that a plant design basis is adequate and design requirements are sufficient**

Construction Phase

- **Supplementation of Design Phase PRA (Applications such as RI-ISI, RI-IST, RI-TS, RI-PM, Training, EO- Procedures, Safety classification of SSC)**

Application for an Operating License, CDF < 1E-5 /a, LRF < 5E-7 /a

- **Submission of Level 1 and 2 Construction Phase PRA to STUK**
- **Evaluation of the acceptability**
  - **(Upgrade of PRA and/or the plant design)**

Operation Phase

- **Utilization of PRA during operation and updates (Plant modifications, RI-ISI, RI-IST, RI-TS, RI-PM, Training, Procedures, Incident and Event Analysis)**

Review Findings - Construction License Phase

Deficiencies in Scope of PRA

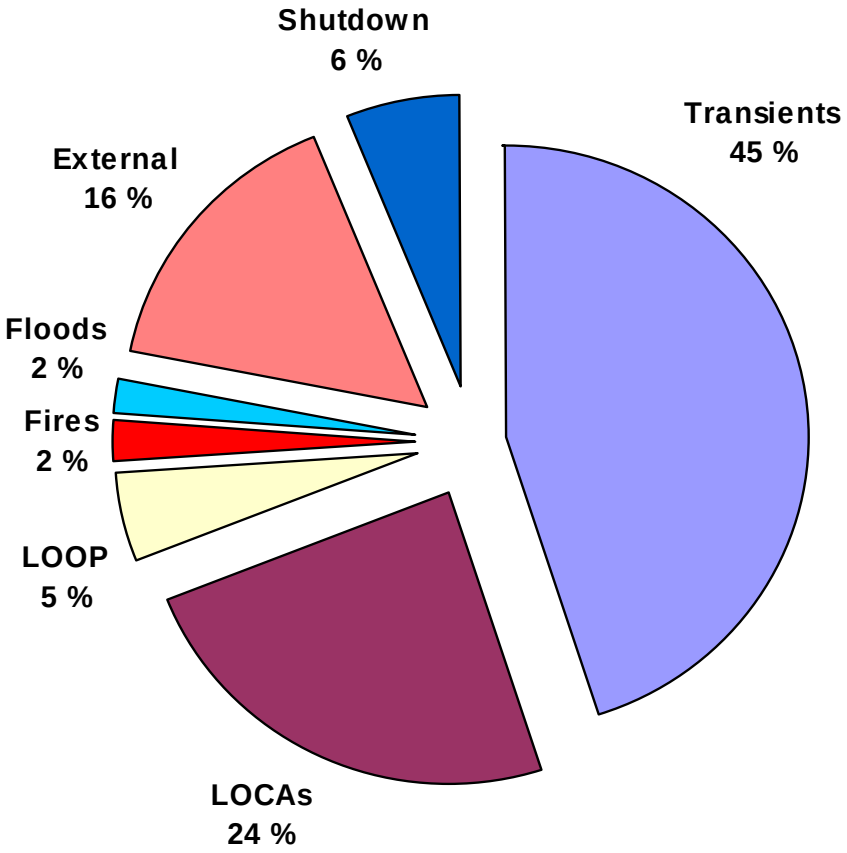
- **Fires and Floods not modelled in low power and shutdown**
  - principles outlined in the PSAR, building layout drawings, and topical reports provide an adequate demonstration to meet requirements
- **Drop of reactor pressure vessel head analyzed – other drops assessed in qualitative way**
  - to be analysed ”in construction phase”
- **Potential missiles (e.g. RCP fly wheel) not identified systematically**
- **External hazards**
  - only frazil ice, organic material in seawater e.g. algae, and the combined phenomenon of storm and snowfall quantified
  - seismic events not modelled in design phase
- **Planned shutdown not modelled**

Review Findings - Construction License Phase

Deficiencies in Design Phase PRA model

- **Primary circuit depressurisation concept not updated**
- **CCFs (especially I&C systems and HRA)**
- **Auxiliary and support system dependencies (in detailed design phase)**
  - heating ventilation and air conditioning
  - pressurised air and nitrogen systems
- **Some of the MAAP4 calculations of physical phenomena were not representative for dose calculations**
- **Containment function in low power and shutdown (no Level 2)**
- **Probability of sump clogging?**
- **I&C signals**
  - e.g. level measurements (SGs, pressuriser)
  - hardwired back-up system signals not credited- conservative
- **Gas turbine not modelled**

OL3 NPP Design Phase PRA Risk Profile, CDF ≈ 1.8E-06 /a



Transients 45%

- **Loss of feed water**
- **Component cooling system failures**

Loss of Coolant Accidents 24%

- **Small LOCA most important**

Loss of off-site power supply 5%

Internal Fires 2%

Internal Floods 2%

External events 16%

- **Frazil ice**
- **Organic material in sea water**
- **Wind&Snow**

Low power and shutdown 6% (internal)

Olkiluoto 3 - Examples of Design Changes

Construction License Phase

- **Process systems**
  - **Physical protection against floods of ESWS pumping stations**
    - doors between redundancies moved over the flood level
    - watertight entrance door was implemented
  - **Containment isolation valves diversified**
  - **Sea water intake coarse bar screens protected with electrical heating against frazil ice blocking**
  - **Air intakes of the emergency DGs and the cooling systems improved (snow blocking and external fire)**
  - **Alternative air intake for SBO diesels redesigned (diverse diesel generators for two safety trains)**
  - **Capacity of filtered venting system increased in order to provide more diversity to decay heat removal in case of accident situations**

Olkiluoto 3 - Examples of Design Changes

Construction License Phase

- **Electrical systems**
  - **Gas turbine is to improve reliability of the AC power supply**
  - **Manual back up for start up and control power supply for SBOs**

- **I&C systems**
  - **Hard wired reactor scram and indications for measurements in the Remote Shutdown Station**

Olkiluoto 3 - Examples of Design Changes

Construction License Phase

- **Fire protection**
  - **Changes to MCP design and MCP room to limit oil leakage, oil spreading and consequences of possible fire**
  - **Vertical and horizontal walls were introduced in the annulus (divisions)**
  - **Cable routes of different redundancies to MCR were separated from each other by fire resistant tunnels and ducts**
  - **Low cable spreading space below MCR was provided with a gas suppression system (manual from the MCR)**
  - **Turbine hall was provided with a sprinkler system**

Olkiluoto 3 - Potential Design Changes...

Operating License Phase

- **Further evidence on fire safety of FRNC-cables is needed; OL 3 concept includes no fixed extinguishing systems in cable rooms**
  - **Standard cable fire tests do not yield necessary information on possible fire spreading**
    - **Preliminary fire simulation (CFD) by Two Model Monte Carlo (TMMC) at VTT (2004) revealed that fire spreading is possible under certain conditions**
    - **However, the boundary conditions which enable fire spreading were unsure**
  - **Further evidence of fire safety is still required,**
    - **FRNC cable rooms with no fixed extinguishing systems looks acceptable based on Information from deterministic fire analysis**
    - **However, further simulation (CDF) and probabilistic fire analysis (fire PRA) are to demonstrate whether the above conclusion is valid**

Olkiluoto 3 - Potential Design Changes...

Operating License Phase

- **Detailed study of the FRNC-cable properties by VTT is to be done**
  - **small scale tests of FRNC-cable specimens (two meter long)**
    - **results give improved parameters to the simulation**
  - **fire simulation (CFD) of critical fire compartments by Two Model Monte Carlo (TMMC) in order to**
    - **clarify need for improved passive fire protection measures**
    - **clarify need for additional fixed fire extinguishing systems**
    - **assess effectiveness of operative fire fighting measures**

Risk Informed Applications for an Operating License

RI-PSI/RI-ISI

- **Requirements (Reg. guides YVL 2.8 and YVL 3.8):**
  - **Insights of PRA must be used in the drawing up and development of the inspection programs of piping, (RI-PSI/RI-ISI)**
  - **While drawing up the risk informed inspection program, the systems of classes 1,2,3 and non nuclear must be regarded**
  - **Limitation of radiation doses (ALARA principle) shall be taken into account by focusing inspections and optimising inspection periods**
- OL3 is the first new NPP to fully implement risk informed approach for PSI and ISI

Risk Informed Applications for an Operating License

RI-PSI/RI-ISI

- Acceptable RI-ISI methods are described in a standard, “ASME Code, Section XI Nonmandatory Appendix R”
- Acceptable application guidelines are given in a European Union report, ENIQ Report nr 23, “European Framework Document for Risk-informed In-service Inspection”
  - **results of risk-informed inservice inspection program must be evaluated by an expert panel**
  - **In addition to power operation, low power and shut down states and the transfers between them shall be considered in the RI-ISI approach**
- Methods are successful for existing NPPs, but some problems in implementation for new reactor designs
  - **lack of detailed standards and guides, e.g. no ASME Code for new NPPs still available**

Risk Informed Applications for an Operating License

Conclusions on OL3 RI-PSI/RI-ISI

- STUK identified some problems in the first review of the method of RI-PSI/ RI-ISI
  - **inspection scope (not all safety related systems included)**
  - **assessment of degradations mechanisms (water hammering etc.)**
  - **isolation of breaks**
  - **spatial analysis: secondary (indirect) effects of pipe breaks (e.g. humidity, temperature, water jets)**
  - **the role and use of expert panel**
- After discussions between licensee, vendor and STUK, these issues were adequately addressed in the method
  - **revised method description was accepted with a few remarks**

Risk Informed Applications for an Operating License

RI-TechSpecs

- **Requirements of using PRA (Reg. guide YVL 2.8):**
  - **to optimize the test intervals and test strategies of components and systems**
  - **to evaluate the allowed outage times (AOT) of safety systems**
  - **to identify such situations in which the transition to other operating mode may cause higher risk than that of continuing power operation and fixing the failures**
- **Risk informed method for Tech Specs of OL3 has been submitted to STUK**
  - **main concern was the analysis of transition to other operating modes and the analysis of shutdown risk vs. continued operation**
  - **revised method description has been accepted**

Summary and Conclusions

- **OL3 PRA has been used (as required by YVL 2.8)**
  - to Suppport the Design of SSCs -> many modifications
  - to Evaluate the Safety Classifications of SSCs
  - to RI-TS and RI-PSI
- **OL3 PRA will be used (as required by YVL 2.8)**
  - to RI-ISI
  - to RI-IST
  - to Optimise On-line Preventive Maintenance
  - to Plan Training of NPP staff
  - to Drawing up of Disturbance and EO Procedures

Summary and Conclusions

Strengths of risk informed process

- **OL3 design phase PRA proved to be very useful in identifying design vulnerabilities that led to design and procedural changes**
  - **e.g. in process systems, electrical systems, I&C systems and in fire protection systems**
- **During construction, PRA updates has provided valuable insights into the detailed design of SSCs and eventually lead to further design changes**

Improvements needed

- **PRA insights were not adequately utilised in the design process**
  - **unintentional dependencies and shortcomings in design process were found in safety systems in STUK's review**
- **Use of PRA in the technical change management process was not timely, interactive and systematic enough**

OL3 Construction Site 29.4.2008

Source: TVO/Hannu Huovila