Safety improvements at Olkiluoto

SAFIR seminar 2019-03-22
After Chernobyl, the Finnish Radiation and Nuclear Safety Authority (STUK) required improvements at OL1/OL2:

- Filtered containment venting
- Wet-containment ex-vessel core cooling
- Severe Accident Management EOPs
- SAM instrumentation

Power uprate in 1998 required additional measures:

- Seismic improvements
- Diversity measures
- On-site gas turbine plant
SAM: History

- Severe accidents were not included in the original design.
- The provisions for severe accident management were installed in Olkiluoto 1 and 2 BWRs during the SAM project, which was finished in 1989.
- The SAM approach is hardware oriented.
- Plant modifications in order to prevent/withstand severe accident loads and minimize environmental consequences.
- System specific procedures existed for system malfunctions before SAM implementation.
- Ten symptom based EOPs (currently eleven) existed for design basis and beyond design basis events to prevent core damage.
- EOP for severe accident management developed in the SAM project. The number of required operator actions minimized.
IMPORTANT Pre-fukushima systems

Containment overpressure protection: for LOCA w/o PS
Filtered containment venting: for SAM and DECs
Lower drywell flooding
Containment penetration shielding
Containment fire water filling
Automatic depressurisation

- RPV level very low for 15 min
- Neutron power over 8 % and RPV level very low

Possibility to flush containment sumps with nitrogen
Possibility to maintain DPVs open with firewater
SPDS at Technical Support Centre, secondary TSC and at STUK headquarters
Background, OL3

OL3 design basis incorporated early-2000’s state of the art:

- Extreme external hazards (tornadoes, earthquakes, flooding)
- Complete diverse backup (N+1) for all safety functions
- Loss of ultimate heat sink
- Total loss of AC + EDGs
- Core catcher + complete severe accident management
- Safety systems: (N+2) × (N+1)
# Power sources:

<table>
<thead>
<tr>
<th>OL1/OL2</th>
<th>OL3</th>
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<td>Power from OL3 or OL1/OL2 via &quot;cold&quot; 400 kV (Olkiluoto grid station)</td>
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- EPR specialty
Immediately after Fukushima, a domestic stress test

- Idea of STUK, immediately taken up by the responsible minister
- Fast, one-month study confirming the adequacy of design basis
- Helped retain and restore public confidence
- Together with EU stress test, resulted in a set of improvement task
- No clear statutory background: Utilities playing along

STUK update of YVL Guides and Nuclear safety decrees in 2013

- Provided a statutory background for already decided measures
- Introduced a number of new issues
- Individual application decisions for OL1/OL2 and OL3: exceptions granted when it would be impossible to fulfil the new requirements.
Fire Water

• Necessary as emergency feed water during a prolonged Station Blackout
• A thorough walk-through of fire-water lines. Pipe supports enhanced to withstand seismic events.
• The output valves from the Korvensuo reservoir enhanced for seismic resistance to enable gravity-driven water supply to fire engines. Only one of the three lines between the reservoir and the unit can withstand seismic events, however.
• One of the firewater pump houses was seismically qualified, the other has been improved.
• Firewater addition to spent fuel pools: new lines to supply firewater: regular firewater —> firewater dry-risers -> SFPC system.
• The addition of a water level measurement to SFPs: a robust system that can be operated with a common multimeter
• Two new, improved fire engine.
• Two new motor-driven, container-installed firewater pumps
Movable fire water pumps
Pump container
Mobile generators

Six small generators for loading SAM systems batteries and powering emergency operations centers on long term

Three different locations,

Seismically qualified, flooding proof
Floods, Seismic events and weather phenomena

A vertical survey of the whole plant site -> changes of level to make sure that rainwater is removed to the sea. Complete, with the exception of certain temporary OL3 site buildings.

Interim spent fuel storage (KPA storage): penetrations between service water pump house and pipe culverts have been made leak-tight to prevent water ingress into KPA basement floors.

TVO and Satakunta rescue authority have agreed upon anti-oil-spill measures: Rescue authority dedicates equipment and prioritizes Olkiluoto. TVO has anti-oil-spill equipment stored at key locations and instructions for the situation.

Seismic improvement of certain I&C cabinets
Anti-oil-spill measures
EFW-line renewal

EFW- backflow line modification to prevent the sea water system loss from causing the near-immediate loss of system EFW (emergency/auxiliary feedwater)

- Return of water back to demin water pools
- Work ready at OL1.
- Some negative operating experience: pump vibrations increased.
- Problems solved in revision 2018
- OL2 will be modified in 2019
- The modification improves core damage frequency ca. 50 %
Design basis: Total, complete loss of AC systems
- starts automatically at
  - 2/4 EDG busbars being at low voltage for 60 s or
  - Low level for 7 min
- Manual RPV level control
- Usable for 8 hours during SBO
- Allows the decrease of prim. pressure to 5 bar
328: Low pressure firewater injection

Started manually after SBO and primary pressure decrease
- Manual RPV level control
- Usable after 3 hours during SBO
- Allows the injection up to 8 bar
OL3: Fukushima-improvement

Preparation for a total loss of AC systems: portable reserve switchgear equipment for SBO busbars
• To be used if all AC systems are permanently lost in case of a power surge.

Otherwise, the plant was already compliant with all Fukushima-related recommendations.
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Results

After the completion of works (mostly in spring 2018), OL1 and OL2 will be able to withstand a simultaneous loss of all AC and the loss of seawater without core damage, with essentially infinite grace time for repairs to enter cold shutdown.

At OL3, the requirement to get SBOs back on-line is 2 h, but this can be fulfilled.
Thank you!