Plant safety review in Finland after the Fukushima accident
Review Perspective

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Two parallel activities

- National safety review of the operating plants, the plant under contruction, new plants, sites
  - Started a week after the accident
  - Ends by the end of 2011 as a separate activity
- EU ”Stress tests”
  - Started at the beginning of June
  - Continues until 2012

- Results of the national review will be utilised in the STUK Stress Test report

1. National Safety Review: Schedule

Date	Action
March 17	Ministry of Employment and Economy sent a request to STUK concerning safety of NPPs and their preparedness for impacts of extreme natural phenomena and availability of electricity
March 22	STUK sent a request for assessment on the subject to Licensees
April 15	STUK received replies from Licensees
May 16	STUK sent the ministry a report on how the Finnish nuclear power plants are prepared for exceptional natural phenomena http://www.stuk.fi/stuk/tiedotteet/en_GB/news_680
August 4	Based on the answers received in April, STUK sent to Fortum (utility operating two VVERs at Loviisa) a more detailed request for actions
October 24	Based on the answers received in April, STUK sent to TVO (utility operating two BWRs and constructing an EPR) a more detailed request for actions
December 15	Deadline for answers from the Licensees

Legal basis

- Finnish Nuclear Energy Act (990/1987)
  - **Section 7 a – *Guiding principles***

    The safety of nuclear energy use shall be maintained at as high a level as practically possible. For the further development of safety, measures shall be implemented that can be considered justified considering operating experience and safety research and advances in science and technology.
- Government Decree on the Safety of Nuclear Power Plants (733/2008)
  - **Section 24, Operational experience feedback and safety research**

    Nuclear power plant operational experience feedback shall be collected and safety research results monitored, and both assessed for the purpose of enhancing safety. Safety-significant operational events shall be investigated for the purpose of identifying the root causes as well as defining and implementing the corrective measures. Improvements in technical safety, resulting from safety research, shall be taken into account to the extent justified on the basis of the principles laid down in section 7 a of the Nuclear Energy Act.

National safety review, request to utilities

- Detailed requests for plant safety assessments have been sent to licensees:
  - Fortum (the Loviisa plant)
  - TVO (the Olkiluoto plant)
- The investigations are conducted according to the requirements given in the STUK Guides (so called YVL-Guides)
- The utilities were asked to avaluate plant behaviour in accidents concerning multiple units
- All important external events should be evaluated (not only earthquake & flooding)

Methods

- No new analyses were required at this stage, because
  - Both plants have been recently reviewed
    - Loviisa, renewal of the operating license 2007
    - Olkiluoto 1&2, periodic safety review 2008
  - FSAR analyses were updated at that time
  - Both plants have a completed Level 1 / Level 2 PRA studies. The PRA models are regularly updated

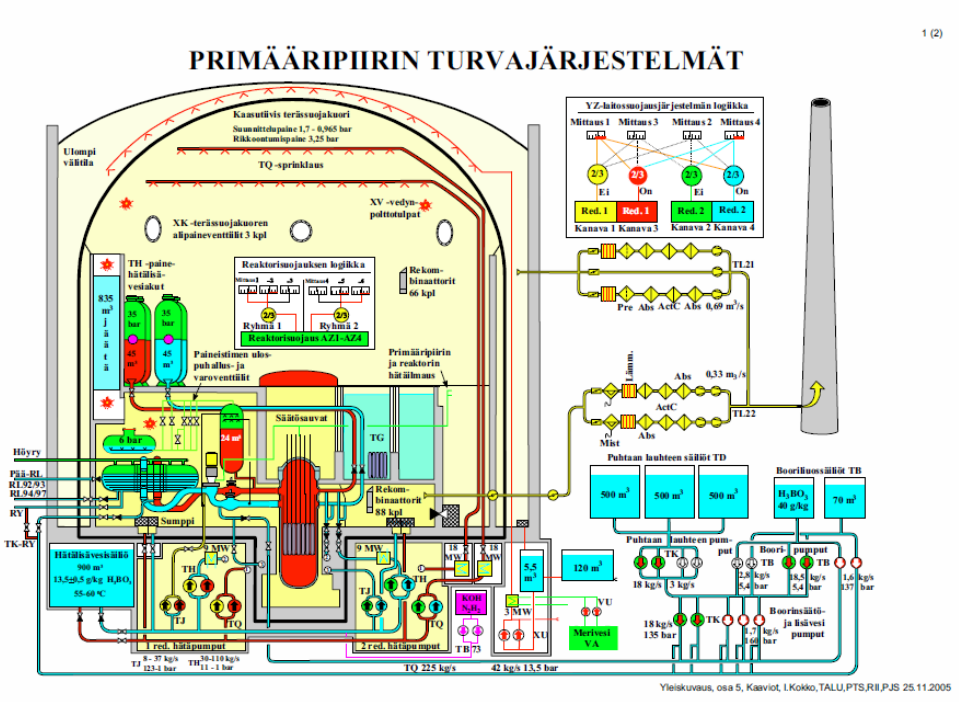
- New analyses (deterministic and PRA) will be required to support the eventual plant modifications

Emergency planning

- Emergency measures are regularly tested by exercises
  - Every year a smaller scale (utility-STUK) exercise for both plants
  - Every third year a large scale execise (utility, STUK, ministry, local communities, local police, local fire brigade, etc.). Typically an accident resulting a release is used

The Loviisa plant

- Two 500 MW VVER units. Operation started 1977, 1980
- Operation licence: Lo1 2027, Lo2 2030
- Ice condenser containments
- Four redundant (in some respects two redundant) safety systems
- Low power, large water inventory -> plenty of time in most accidents
- Plant modifications in 90’s to cope with severe accidents



National Safety Review: Request to Fortum (Loviisa 1 and 2) in August

- Actions
  - A plan to secure decay heat removal to ultimate heat sink in extreme external events
  - A plan and schedule to secure plant safety in case of abnormal sea level
  - A plan and schedule to secure alternative means of decay heat removal from fuel storage pools located in the reactor building
  - A plan and schedule to secure alternative means of reactor cooling in case of loss of existing systems
  - A plan and schedule to increase fuel reserve for emergency power at the site
  - A plan and schedule to secure DC power for long time needs
- Investigations
  - Investigation of earthquake resistance of fire fighting systems and fuel storage pools for earthquakes that go beyond the existing design basis
  - Investigation of need to secure containment heat removal without sea (the present method) as the ultimate heat sink
  - Investigation to secure decay heat removal from fuel storage pools (outside containment)
  - Investigation of extreme weather conditions to plant safety
  - Investigation of availability (and operability) of safety systems and their components in accidents of long duration
  - Investigation of needs and possibilities to use mobile power supply and mobile pumps in accidents
  - Investigation of possibilities to secure availability of demineralized water at the site in an accident of long duration
  - A review of the applicability of procedures and availability of personnel in case of accident in multiple units

Possible enhancements in Loviisa 1&2

- No such hazards or deficiencies that would require immediate actions have been found.
- Preliminary plans for safety enhancements:
  - Possible improvements on flooding protection will be evaluated (requirement for action plan and schedule).
  - In case of loss of sea water as the ultimate heat sink the possibility of transferring heat into the atmosphere has been studied (requirement for analyzing). One possibility for this might be small-scale cooling towers sized for decay heat removal from both of the reactors and all fuel pools.
  - Improvements to ensure decay heat removal from the fuel pools inside the containment and from the spent fuel storages in case of loss of current systems will be considered (requirement for action plan and schedule).
  - Enhancing the reliability for charging of batteries of the diesel motor driven additional emergency feed water pumps is considered to ensure better operability of the system (requirement for analyzing).

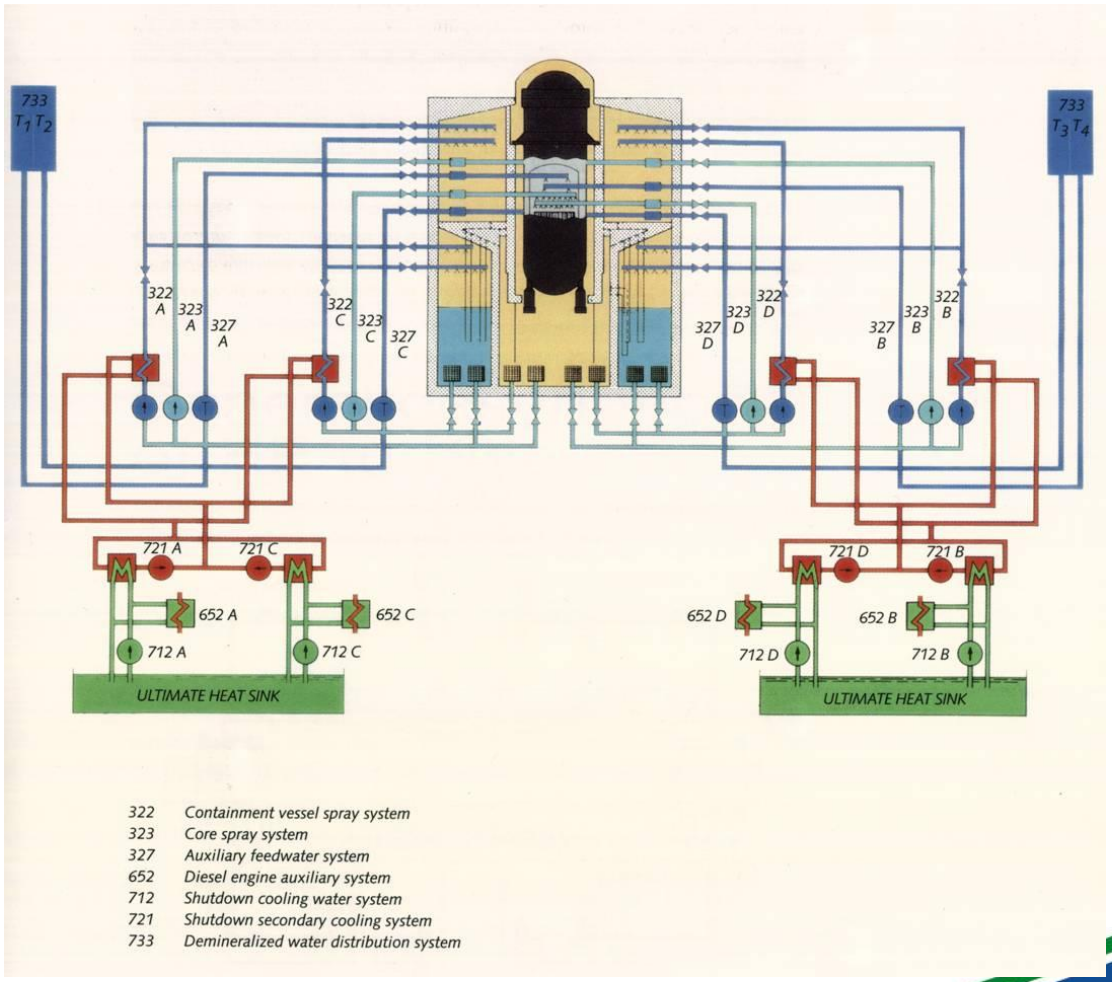
Possible enhancements in Loviisa 1&2 (cont'd):

- Preliminary plans for safety enhancements
  - Possibilities to
    - implement connections for mobile systems to supply feed water into the steam generators (requirement for analyzing),
    - extend the operation time of diesel generators at site by increasing the fuel storage capacity (requirement for action plan and schedule),
    - extend the operation time of DC batteries (requirement for action plan and schedule), and
    - mount mobile equipment rapidly during accident situations (requirement for analyzing)

    will be examined.
  - Some procedural changes to enhance water supply capabilities for decay heat removal during shutdown states will be considered (requirement for analyzing).
  - The required action plans and analyses are to be submitted by 15 Dec 2011.

The Olkiluoto 1 and 2 units

- Two 840 MW BWRs. Operation started 1979, 1982
- Operation licence to 2018
- Four redundant safety systems
- Good physical separation
- Plant modifications in 90's to cope with severe accidents

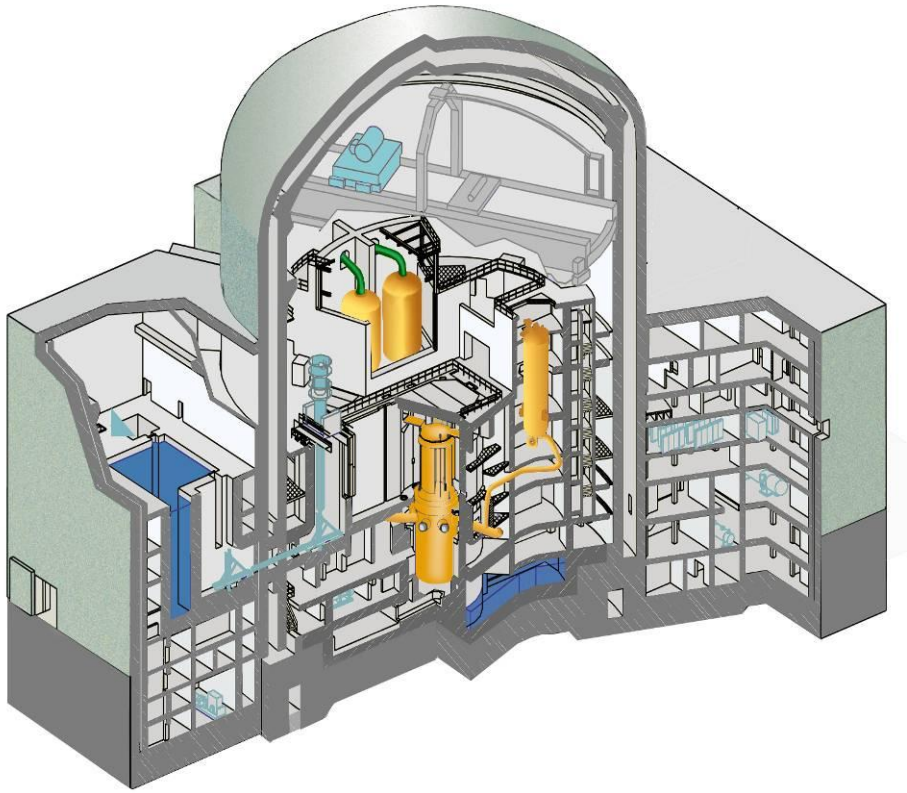


National Safety Review: Request to TVO concerning the operating plants Olkiluoto 1 and 2)

- Actions
  - A plan to secure decay heat removal to ultimate heat sink in extreme external events
  - A plan and schedule to secure decay heat removal from reactor core and containment in case of total loss of AC power
  - A plan and schedule to secure operation of the auxiliary feedwater system for accidents involving loss of seawater as ultimate heat sink
  - A plan and schedule to secure decay heat removal from fuel storage pools located in the reactor building in case of loss of existing systems
- Investigations
  - Investigation of earthquake resistance of fire fighting systems and fuel storage pools for earthquakes that go beyond the existing design basis

National Safety Review: Request to TVO concerning Olkiluoto 3 under construction

- Actions
  - A plan and schedule to secure decay heat removal from reactor core in case of loss of existing systems
- Investigations
  - Investigation to secure decay heat removal from fuel storage pools in the fuel building
  - Investigation to secure decay heat removal to ultimate heat sink in extreme external events



National Safety Review: Request to TVO concerning fuel interim storage

- Investigations
  - Investigation of alternative methods to supply coolant to fuel storage pools (including potential need for new instrumentation)
  - Assessment (update) of the effects of extreme sea water level to systems for storage pool cooling and their electricity supply

National Safety Review: Request to TVO concerning the Olkiluoto site

- Actions
  - A plan and schedule to secure DC power for long time needs

- Investigations
  - Investigation, and if needed a plan to secure fuel reserve for emergency power at the site
  - Investigation of extreme weather conditions to plant safety
  - Investigation of availability (and operability) of safety system and their components in accidents of long duration
  - Investigation of needs and possibilities to use mobile power supply and mobile pumps in accidents
  - Investigation of possibilities to secure availability of demineralized water at the site in an accident of long duration
  - A review of the applicability of procedures and availability of personnel in case of accident in multiple units

Possible enhancements in Olkiluoto 1&2

- No such hazards or deficiencies that would require immediate actions have been found.
- Preliminary plans for safety enhancements:
  - Further improvements in seismic robustness (at present the plant fulfills the design basis of 0.1 g PGA), e.g. adding support for some batteries and strengthening some fire fighting equipment (requirement for analyzing). Planned 2013-2014.
  - Reanalysis of harsh weather conditions and the design basis of the plant including study of effects of cold or warm weather exceeding current design basis. E.g. the new automation equipment may demand enhanced or more reliable HVAC systems (requirement for analyzing).
  - Safety significant instrumentation and control systems as well as valve operations have a battery back-up power source, and there is mobile equipment at the plant site, which can be used for re-charging the batteries. However, enhancements to manage a long-lasting accident at several units will be considered (requirement for analyzing).

Possible enhancements in Olkiluoto 1&2 (cont'd):

- Preliminary plans for safety enhancements
  - Suitability of plant modifications are investigated in order to allow direct injection of fire fighting water into the reactor pressure vessel using the diesel motor driven pumps of the fire fighting water system. A booster pump powered by a mobile diesel generator may also be needed. This modification would improve the possibilities for coping with station blackout and loss-of-main-heat-sink scenarios (requirement for action plan and schedule). Planned 2013-2014.
  - Possibilities to decrease the level of dependability on seawater will be studied. E.g. modifications of auxiliary feed water system have been considered (requirement for action plan and schedule). Planned 2013-2014.
  - The spent fuel pools at the units and in the spent fuel storages will be equipped with water level measurements and permanent systems for make-up water delivery, which can be manually operated from a safe location. (Accident management is based on evaporation of the pool water.) (requirement for action plan and schedule for RB, analysis for KPA) Planned 2012-2014.
  - The required action plans and analyses are to be submitted by 15 Dec 2011.

Possible enhancements in Olkiluoto 3 (under constr.)

- No such design deficiencies have been identified regarding provisions against natural hazards and disturbances in power supply that would lead to significant changes in the plant design.
- Nevertheless, the following items are under investigation:
  - ensuring the reactor heat removal in case of exceptional external events (requirement for action plan and schedule);
  - water supply to the spent fuel pools by independent equipment (requirement for analyzing);
  - heat transfer to the ultimate heat sink also in case of exceptional external events (requirement for analyzing).
  - The required action plans and analyses are to be submitted by 15 Dec 2011.

Summary

- Preliminary mapping of the situation concerning extension of external hazards, total loss of AC and UHS was made rapidly following the March 11 earthquake.
- Based on this analysis, more specific requirements were sent to TVO and Fortum to produce action plans or to analyze further a number of specific issues.
- The responses by the utilities (due 15 Dec 2011) will be utilized in formulating the national stress test report.
- Many of the practical improvements can be implemented during the 2013-2014 outages.