Nordic Reactor Safety Related Progress

Joint NKS-R and NKS-B Seminar,
Stockholm, 12-13 January 2016

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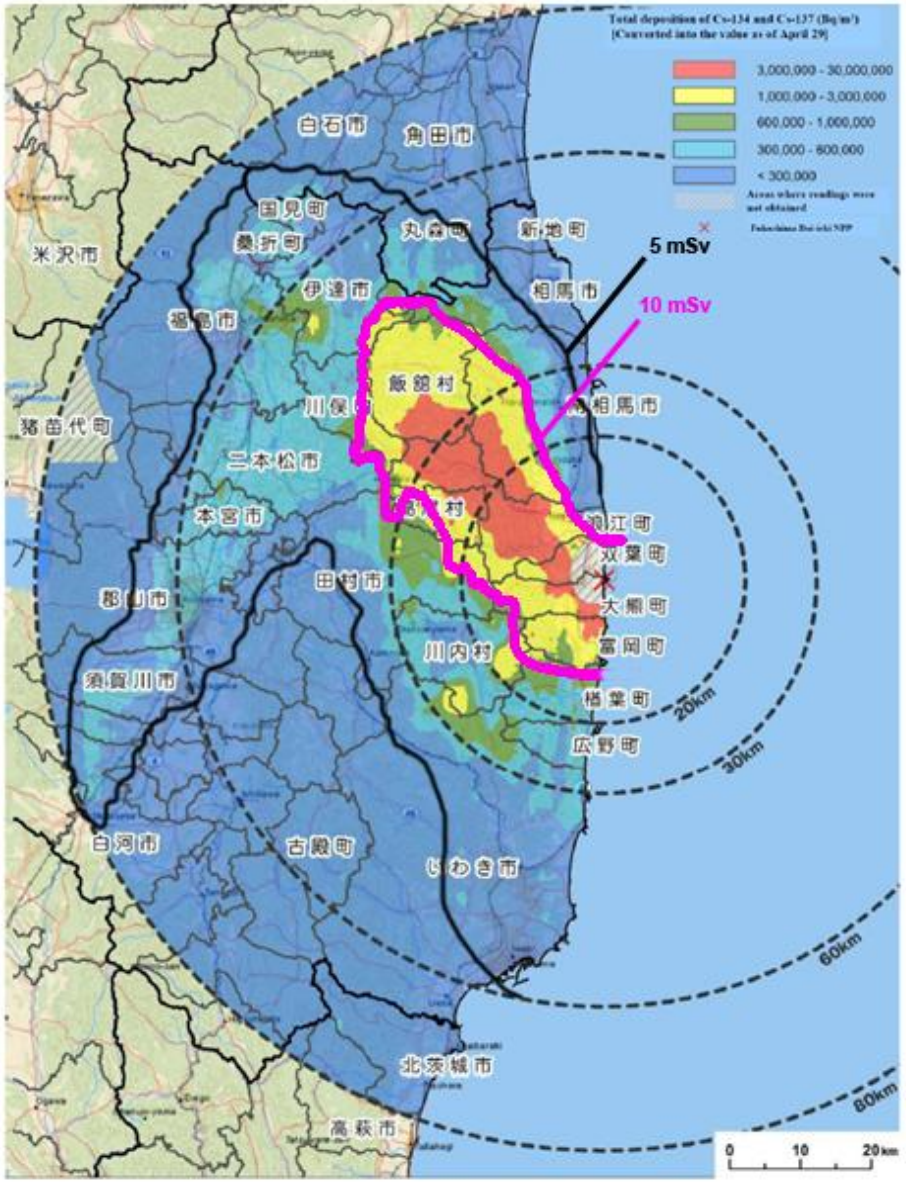
Fukushima Dai-ichi accident 11 March 2011

Photo: TEPCO

Figure: Nuclear Emergency Response Headquarters Government of Japan



Fukushima Dai-ichi accident 11 March 2011

- Concerns about safety of NPPs in Europe

- Stress Tests initiated in June 2011
  - Flooding
  - Earthquake
  - Extreme weather cnnditions
  - Robustness against loss of AC power and loss of ultimate heat sink
  - Severe accident management

- Followed by Peer Reviews and developing National Action Plans to improve nuclear safety in Europe

General situation in Finland
(prior to the Fukushima Dai-ichi accident)

- Comprehensive PSA studies
  - Natural hazards included in the studies

  → No significant deficiencies arose from the Stress Tests
  - Some aspects re-evaluated based on National Safety Review
    - high sea water level (Loviisa), total loss of AC power (Olkiluoto), loss of sea as a heat sink (Loviisa & Olkiluoto), loss of fuel pool cooling (Loviisa & Olkiluoto)

- Severe accident management
  - Required in Finnish regulatory framework since 1980's
  - Implementation in 1980's and 1990's in existing plants
  - Taken into account in the design of new plants (including OL3)

  → Only minor changes due to lessons learnt from the Fukushima Dai-ichi accident
    - Emergency preparedness in case of multi-unit accidents
  - Situation in Sweden rather similar to that in Finland

Major safety enhancements in Finnish plants

- Protection against extremely high sea level in (Loviisa 1&2)
  - At Olkiluoto site the flooding risk is lower
- Reducing the reactor cooling dependency on AC power (Olkiluoto 1&2)
  - Independent diesel driven auxiliary feed water pumping station at Loviisa
- Reducing the heat removal dependency on sea water systems (Loviisa 1&2 and Olkiluoto 1&2)
- Improving fuel pool cooling capabilities (water injection, monitoring) (Loviisa 1&2, Olkiluoto 1&2, Olkiluoto 3)
- Ensuring emergency preparedness in case of multi-unit events

Olkiluoto 1 & 2:
Steam turbine driven auxiliary feed water pump

SEP 13-061 Appendix 1
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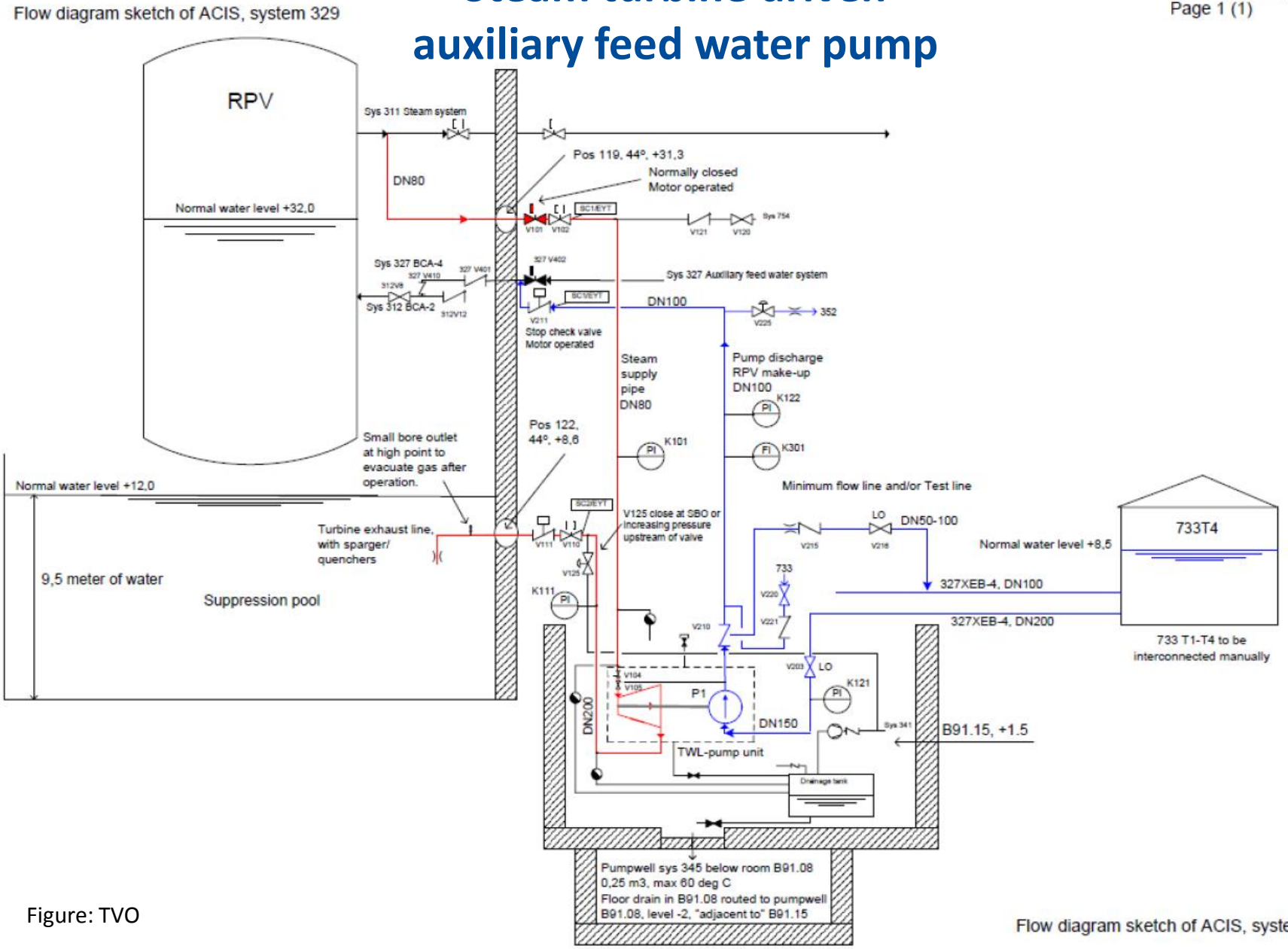
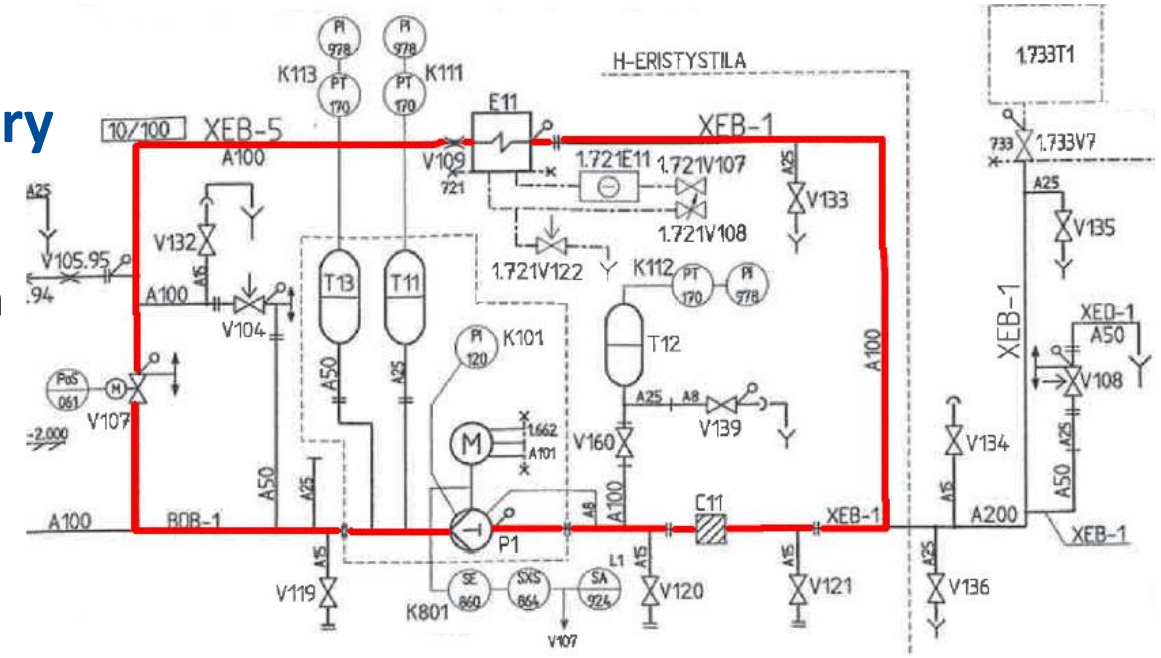


Figure: TVO

Olkiluoto 1 & 2:
Changes in 327 (auxiliary feed water system)

Original arrangement when pumps are started but water is not injected into the reactor

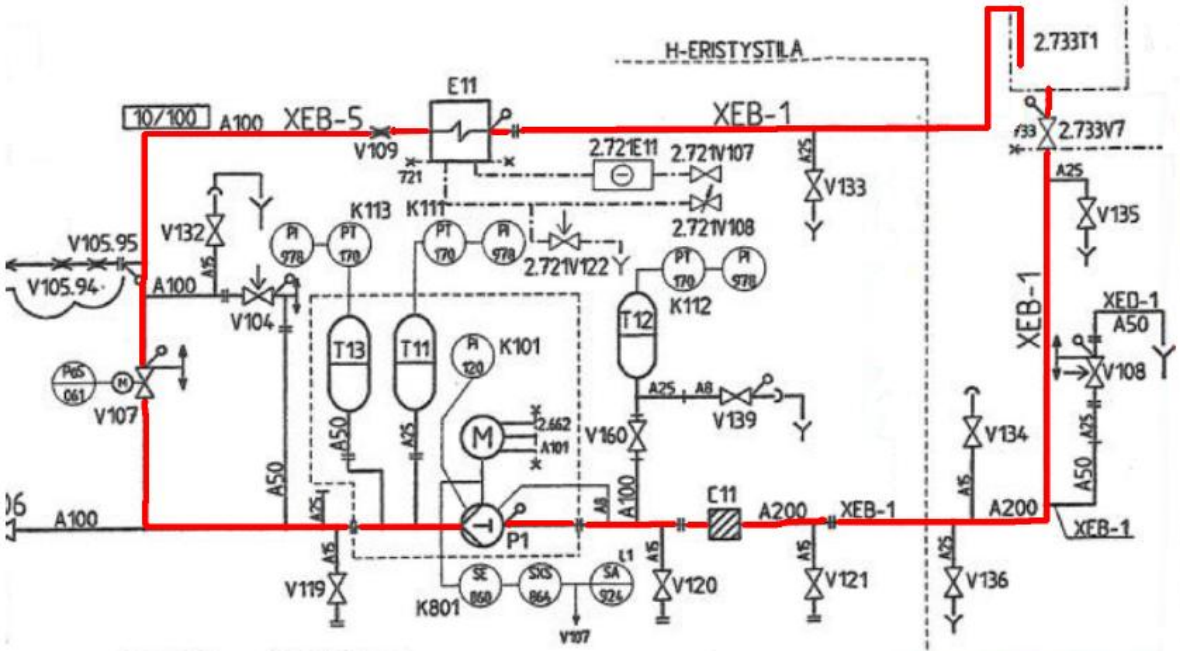
- Recirculation through a closed loop
- Requires seawater cooling



Figures: TVO

New arrangement

- Recirculation through demineralized water tank
- High heat capacity of the tank
- No cooling needed for a long time



Olkiluoto 1 & 2:
Fire water injection into fuel pools

Connection outside
the reactor building

Photos: TVO

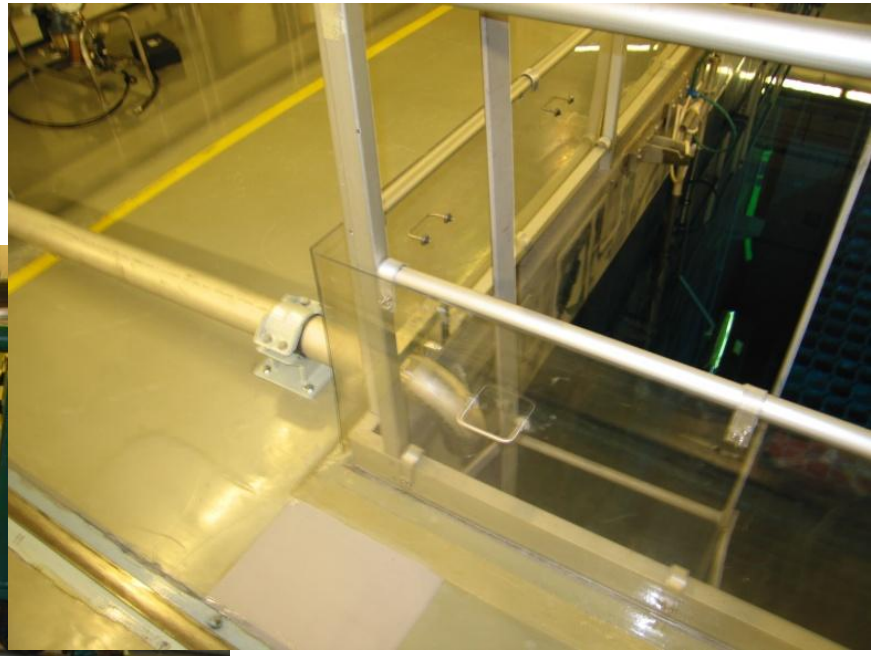
Olkiluoto 1 & 2:
Fire water injection into fuel pools

Connections inside
the reactor building

Photos: TVO

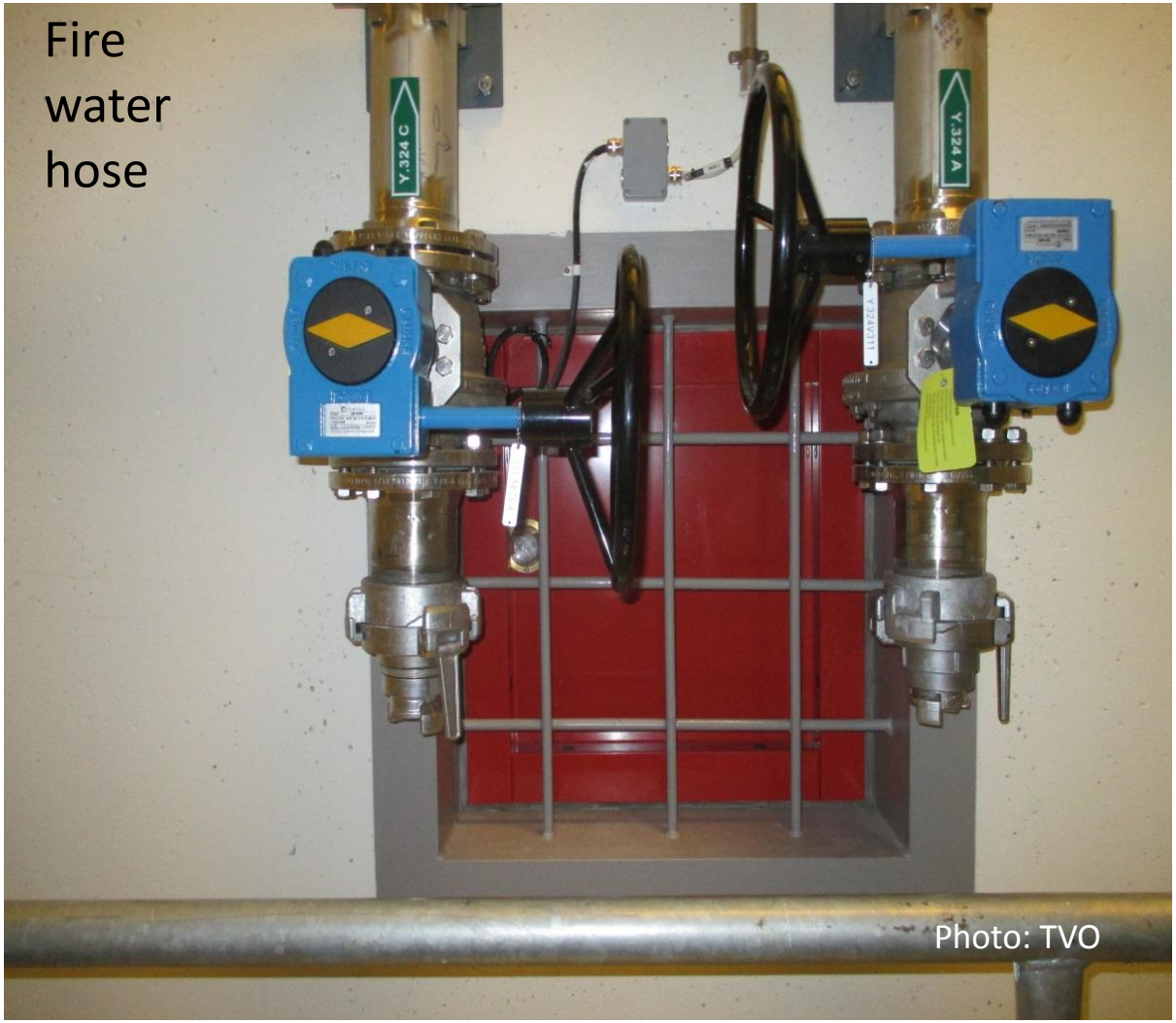
Olkiluoto 1 & 2:
Fire water injection into fuel pools

Entry into the pool



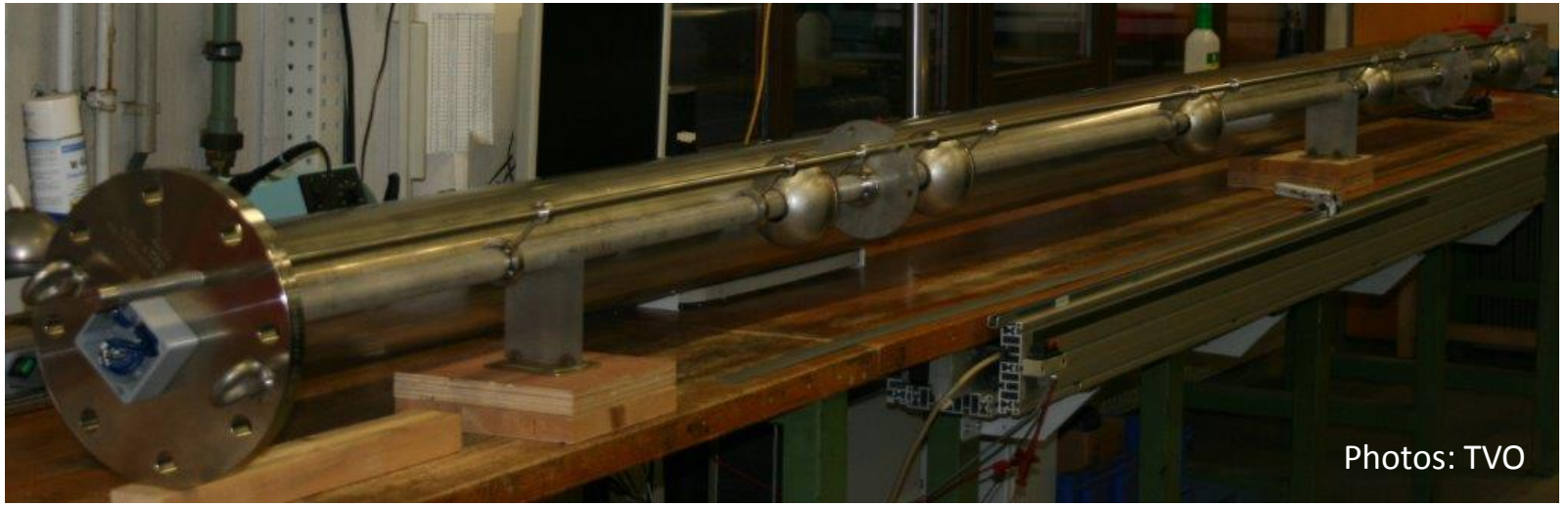
Photos: TVO

Olkiluoto - Spent fuel storage:
Fire water injection into fuel pools



Olkiluoto 1 & 2:
Fuel pool instrumentation

Water level measurement device



Photos: TVO

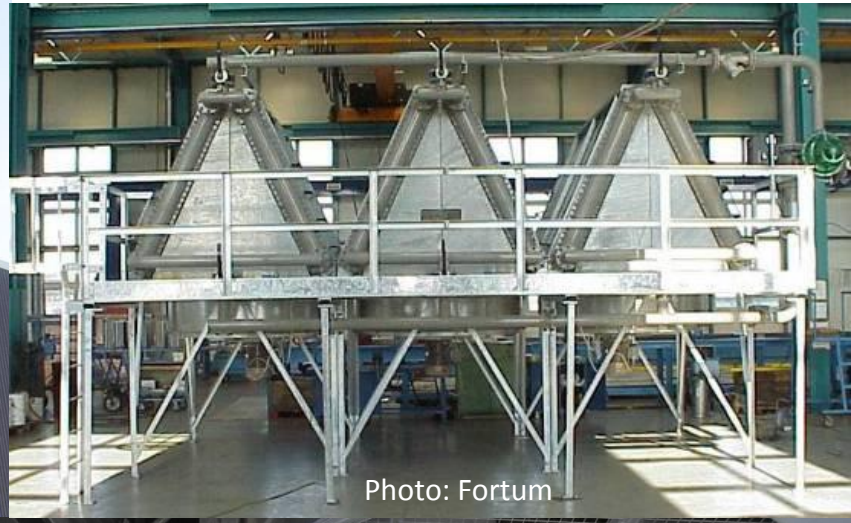
Loviisa 1 & 2
Diversification of heat removal

Photos: Fortum

Loviisa 1 & 2 – Diversification of heat removal

Photo: STUK

Loviisa 1 & 2: Diversification of heat removal



Loviisa 1 & 2: Flooding protection

(diesel driven auxiliary emergency feed water pumping station)

Photo: STUK

Loviisa 1 & 2
Flooding protection
(diesel driven auxiliary emergency feed water pumping station)

Photos: STUK

Approaches in Sweden and in Finland

SSM Independent Core Cooling (SSM2014-122-6)	STUK YVL Guides (published in Nov 2013)
Rather strict independence from other safety systems	Existing equipment can be credited Mobile equipment not preferred
	Loss of power distribution system (not combined with other extreme events)
Can be considered as a separate level of Defence-in-Depth	DEC-situations as part of level 3 of DiD
Safety margins based on considerable uncertainties	Realistic assumptions can be used in DEC situations
Very robust approach	Case by case approach
No single failure criterion	
Need to guarantee that additional provisions are effective in expected conditions during situations they are credited	
Site autonomy of 72 h	

WENRA RHWG work after Fukushima accident

More insights on WENRA Safety Objectives for new NPPs

O1. Normal operation, abnormal events and prevention of accidents
O2. Accidents without core melt
O3. Accidents with core melt
O4. Independence between all levels of DiD
O5. Safety and security interfaces
O6. Radiation protection and waste management
O7. Leadership and management for safety

WENRA RHWG work after Fukushima accident

Selected key safety issues for new NPPs

Position 1: DiD approach for new nuclear power plants

Position 2: Independence of the levels of DiD

Position 3: Multiple failure events

Position 4: Provisions to mitigate core melt and radiological consequences

Position 5: Practical elimination

Position 6: External Hazards

Position 7: Intentional crash of a commercial airplane

WENRA RHWG report “Safety of new NPP designs” in March 2013

(www.wenra.org/archives/wenra-statement-report-new-NPP)

WENRA RHWG work after Fukushima accident

Safety Reference Levels for Existing NPPs

Taking into account Fukushima lessons learnt
in WENRA Reference Levels

- Major changes in
  - Issue E “Design Basis Envelope”
  - Issue F “Design Extension” (includes severe accidents)
  - Issue LM “EOPs and SAMGs”
  - Issue R “On-site Emergency Preparedness”
  - Issue T “Natural Hazards” (new issue)
- Some changes in issues A, B, C, D, G, N, O, P, S
  - Safety culture under C7 (RLs C7.1, C7.2, C7.3)
- Published in September 2014 (www.wenra.org/archives/wenra_srl)

Changes in Finnish regulatory framework

Updated Government Decrees in 2013

- Safety of NPPs (717/2013)
- Emergency Preparedness of NPPs (716/2013)
- these were replaced by STUK Regulations in the beginning of 2016
  (In Finnish: http://www.finlex.fi/fi/viranomaiset/normi/555001/; In Swedish: http://www.finlex.fi/sv/viranomaiset/normi/555001/)

Update of all of the YVL Guides (renewal project)

- Published in November 2013

The above work was ongoing already pre-Fukushima

- The accident delayed the work
- Lessons learnt were taken into account

DiD concept was not found to have such weaknesses that a thorough revision should take place

- Extreme natural hazards have been addressed in more detail as DECs

WENRA RHWG work after Fukushima accident

Implementation of revised Safety Reference Levels for Existing NPPs

STUK and SSM are actively participating in RHWG work

Self assessments of implementation status (October 2015)

- No significant gaps in YVL guides
- In Sweden somewhat wider revision of regulation is needed

Peer review of self assessments in 2016

- In three RHWG meetings (Jan, May, Sep)
- The results from these will finally set the implementation status

Implementation of the new RLs should take place in 2017 at latest

- National implementation plans required

Thank you