



DIGITAL SYSTEMS - RELIABILITY ANALYSES

OL1/OL2 PLANT MODIFICATIONS -EXAMPLES

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Olkiluoto NPP – Modernization 1980-1993

660 MWe -> 710 MWe

Replacement of 1,5 km CS piping to SS because of erosion corrosion

Coating of MSR and cross under pipes

1984: Reactor power 2000 -> 2160 MWt

New safety analyses, upgrading of safety systems

Replacement of LP preheaters and flash boxes to SS

New steam dryers to MSR cross under pipes (MOP/SCRUPS)

Replacement of reactor core grid

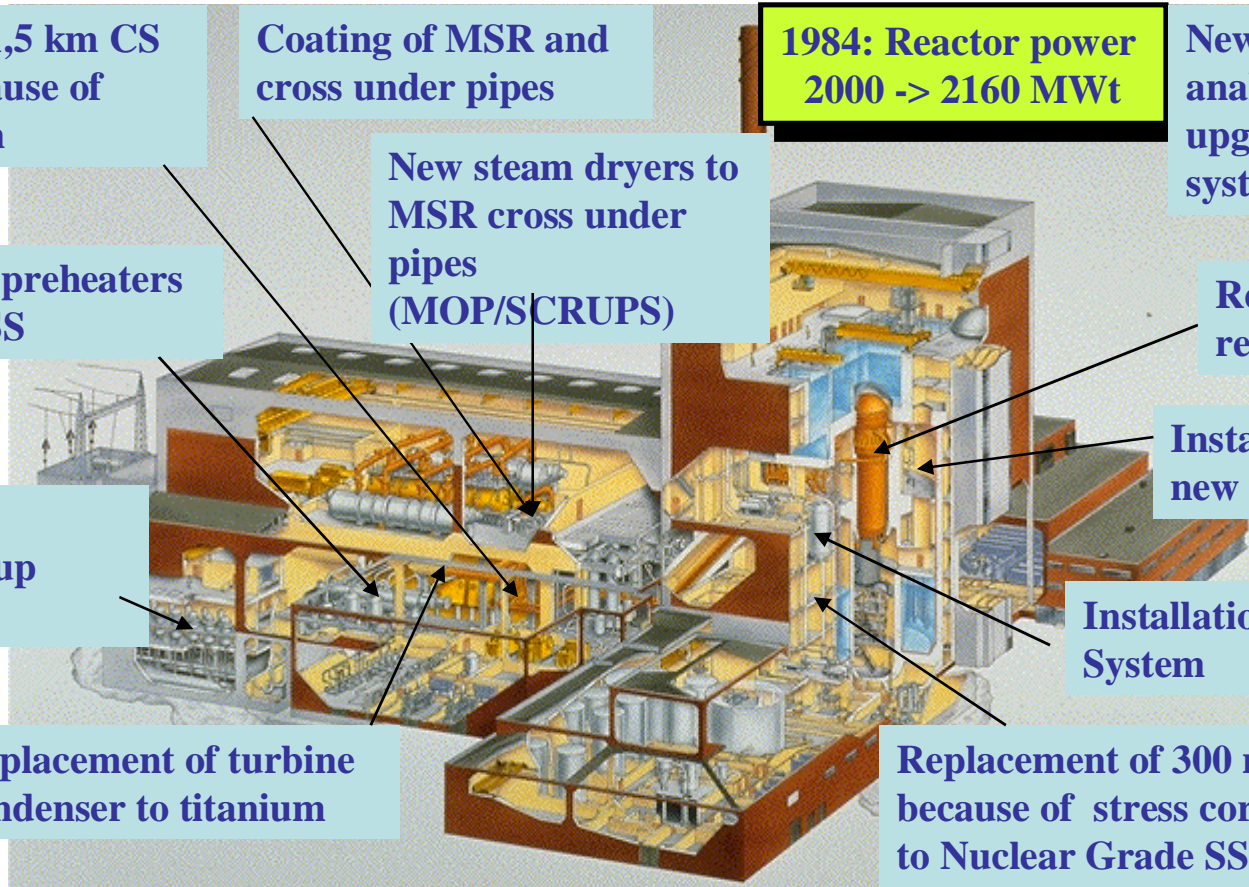
Modification of condensate clean up system

Installation of one new safety/relief valve

Replacement of turbine condenser to titanium

Installation of SAM System

Replacement of 300 m piping because of stress corrosion risk to Nuclear Grade SS



Olkiluoto NPP – Modernization Project 1994-1998

710 MWe -> 840 MWe

New LP-turbines (ca +35 MW)

Modification of HP-turbine

Modifications of reheaters

New turbine control/safety system

**Reactor power
2160 -> 2500 MWt**

New safety analyses,
upgrading of safety

New generator

New HP-control/
stop valves

New loading machine automation

New steam separators/
scroud head

New generator
circuit breaker

New type of fuel (10x10)

New main transformer

2 new safety/relief valves

Strengthening of
the outer grid

Upgrading of
boron system

New moisture separators
(SCRUPS) to cross under
pipes and process modifications

**New electrical
systems of reactor
internal pump**

Modifications of
preheaters

**New neutron flux
measuring system**

Modifications of condensate
and feed water pumps

Improvements of waste and waste
water treatment systems

Olkiluoto NPP – After Modernization Project Outages 1999 - 2004

840 MWe

Steam moisture:
ca 0,3 %

TI Main steam lines
Exchange of pipe supports

Erosion corrosion
program
continues

Feed water pumps
OL2: 4 -> 3 pumps operation in 2002
OL1: 4 pumps operation (cost-benefit)

New feed water spargers
OL2: 2003 OL1: 2004

New CR Control and Indication System
New fire alarm system
Exchange of DC/AC Converters
New Plant Information System
New Camera System
Modification of Cont. lower Air Lock
Modif. of screening plant (sea water)
Exchange of piping continues

Olkiluoto NPP – Turbine Island Modernization

Olkiluoto 2: 2005 Olkiluoto 1: 2006

New 2-stage reheaters with new type of moisture separators

New HP turbine with additional extraction

840 MWe -> 860 MWe

Reactor:
New Steam Dryer

Steam moisture:
0,3 % -> 0,01 %

Exchange of the drywell-wetwell sealing

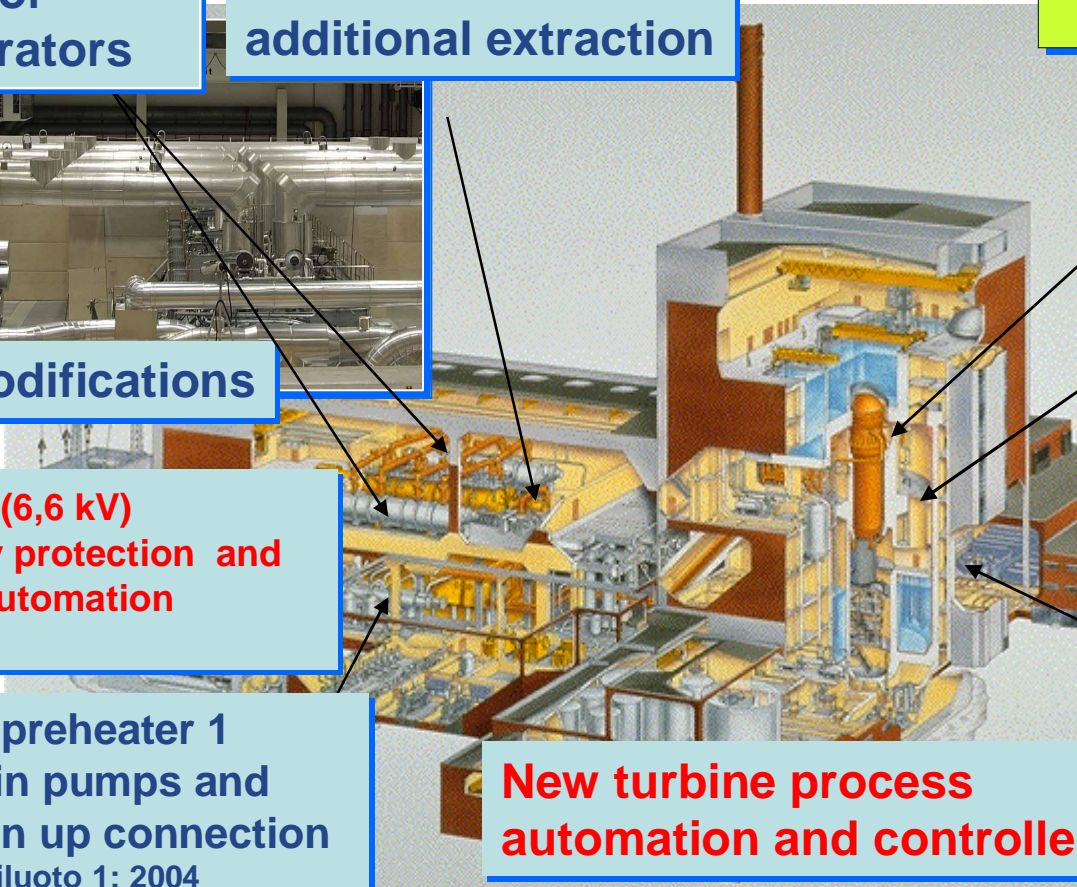
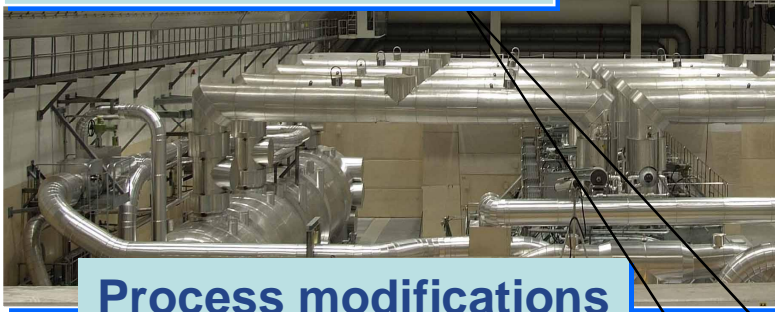
Process modifications

Exchange of MV (6,6 kV) switchgears, Relay protection and Fast changeover automation (400->110 kV)

Exchange of LP preheater 1
Modif. of LP drain pumps and condensate clean up connection
Olkiluoto 2: 2003, Olkiluoto 1: 2004

New turbine process automation and controllers

Modifications on the simulator in 2004



OL1/OL2 - Reliability analyses – examples cont.

- Neutron flux measuring system (PRM/SIRM)
 - Reliability analysis incl. FMEA provided by supplier for PRM/SIRM (no trip SS10/SS7)
 - PRM - no trip SS10 (H6 APRM)
 - both digital (AC 410) and hardwired as backup
 - Supplier's reliability data is used for hardware and software CCF
 - PSA-modelling; both hardware and software is considered based on suppliers analysis

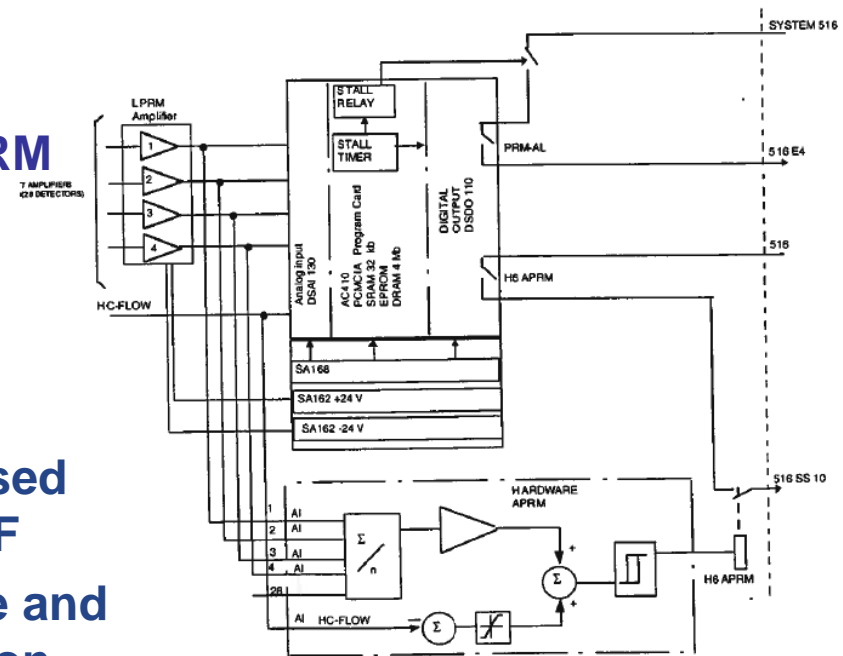


Figure 2.1 Principal Description of one PRM Subdivision

OL1/OL2 - Reliability analyses – examples cont.

- **Electrical systems of reactor internal pumps**
 - Digital (Logidyn D, control logic) and hardware backup for SC2 commands (MRH 3000)
 - Separate detailed reliability analysis including FMEA provided by supplier
 - Data – MHR300 calculated (parts count), Logidyn (expert judgment)
 - PSA modelling - Single failure probability and CCF (CCF model for high-redundant systems) is considered in PSA-model
 - based on suppliers reliability analysis
 - different success criteria for successful rundown of MCPs
- **Exchange of MV (6,6 kV) switchgears, Relay protection and Fast changeover automation (683)**
 - PLC (Simatic S7)
 - both PLC hardware components and software (CCF) is considered in modelling - for software engineering judgment (SIL) / for hardware generic data is used

OL1/OL2 - Reliability analyses – examples cont.

- **Feedwater and condensate system control**
 - TXP platform is used
 - **Separate detailed reliability analysis including FMEA provided by supplier**
 - **PSA-modelling:**
 - **is based on supplier’s reliability analysis**
 - **Both a hardware failure and a software failure considered in modelling(CCF)**
 - **Supplier’s data is used, for software failure engineering judgement is used**

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OL1/OL2 - Reliability analyses – examples cont.

Table 5-1 Equipment – Functional Failure Matrix

No.	Module or component		FF#	Functional failures of					Comments
	Signature	Module or component name		Input Data Acquisition	Intra-SUB Event Communication	Inter-SUB / External Event Communication	Signal Processing	Actuation Signal Performance	
				1	2	3	4	5	
1	CC155U	Central AP rack					X		
2	SV	Power Supply Unit					X		
3	CPU948R	AP Central Processing Unit					X		
4	IM324R	Interface Module			X				
5	IM304	Interface Module			X				
6	CP1430	Communication Processor				X			
7	S5 DEDA	Watchdog Module							No effect to analyzed functions
8	EU902	Rack			X		X		
9	FUM210	Sensor Conditioning Module for Binary Signals	X						

Summary – modification works at OL1/OL2

- **Reliability analysis required from Supplier**
 - dependability requirements are set in connection of contract (reliability targets, methods etc.)
- **Typically FMEA is required to justify FT-modelling**
 - treatment of software failures? (YVL 5.5)
- **Based on Suppliers analyses necessary parts are transferred to OL1/OL2 PSA model**

Thank You

