Regulatory Approach to Radiation Protection in new NPPs in Finland

NSFS 2011

August 22nd -25th, 2011

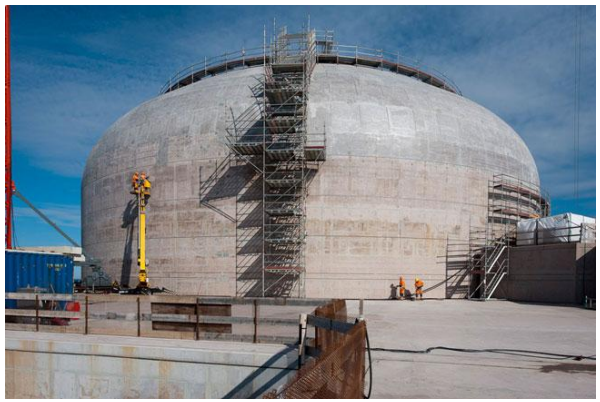
Veli Riihiluoma

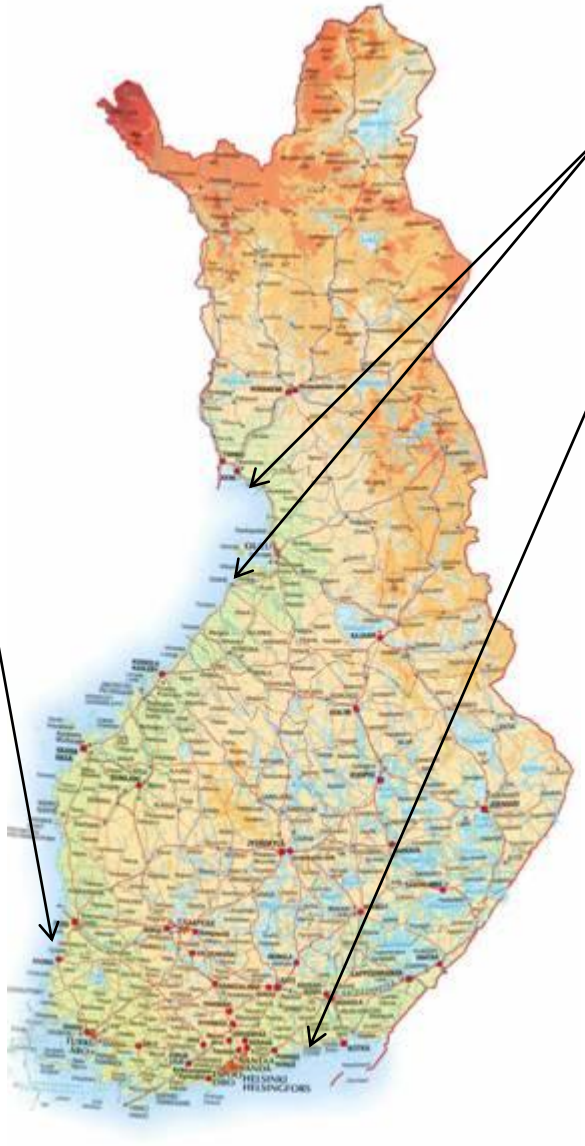
Radiation and Nuclear Safety Authority (STUK)

Nuclear power units in Finland

Olkiluoto NPP (TVO)

- 2 operating units - ABB BWRs
- OL3 (EPR) under construction
- Application for OL4





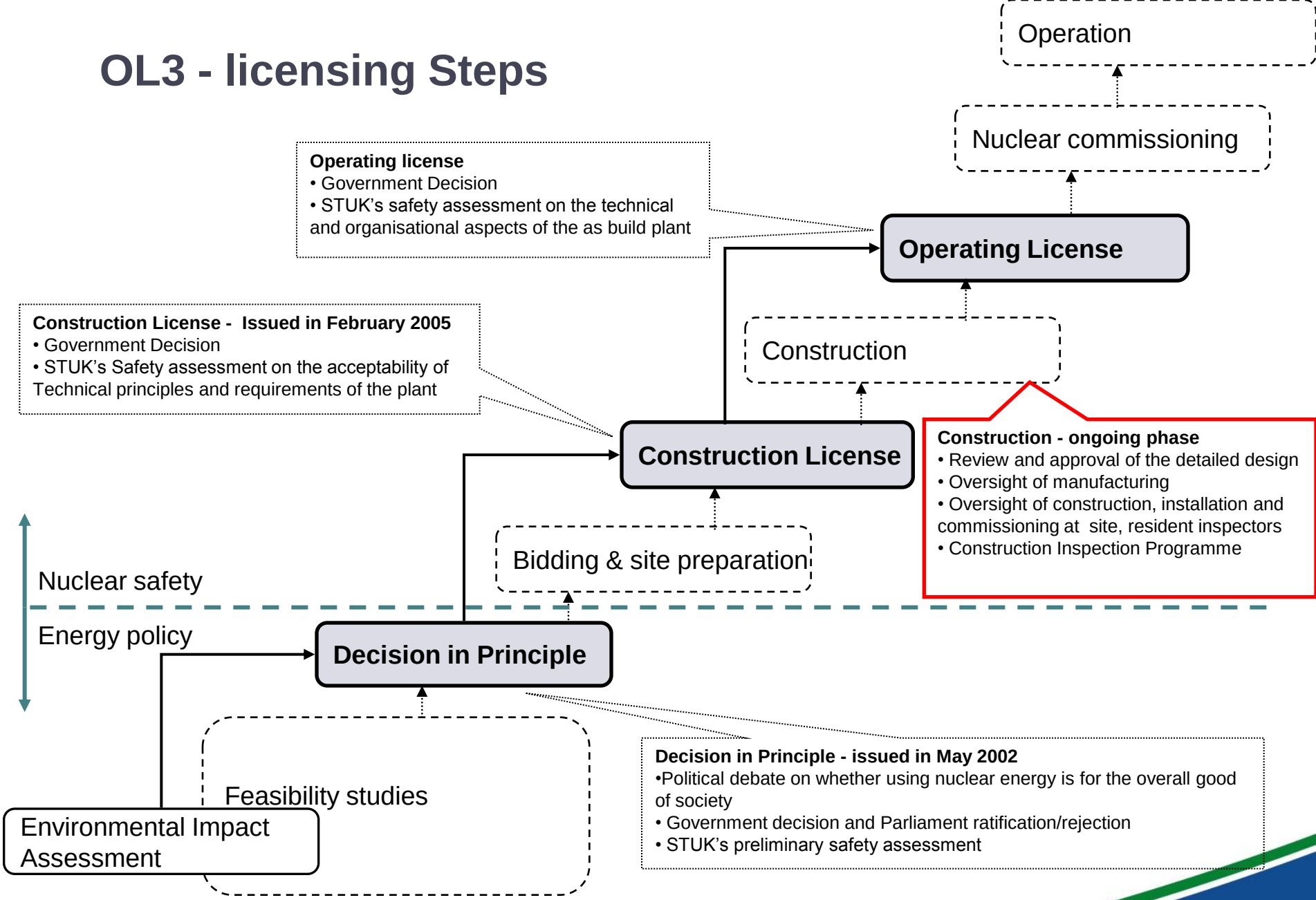
FENNOVOIMA

New utility, no operating reactors, Application for FV1 (2 alternative sites)

Loviisa NPP (Fortum)

- 2 operating units - VVERs
- Application for LO3 (rejected)

OL3 - licensing Steps



Guides in Radiation Protection

YVL 7.1	**Limitation of public exposure in the environment of and limitation of radioactive releases from a NPP (in Finnish)**	**22 Mar 2006**
YVL 7.2	**Assessment of radiation doses to the population in the environment of a NPP**	**23 Jan 1997**
YVL 7.3	**Calculation of the dispersion of radioactive releases from a NPP**	**23 Jan 1997**
YVL 7.4	**NPP emergency preparedness**	**9 Jan 2002**
YVL 7.5	**Meteorological measurements of a NPP**	**28 May 2003**
YVL 7.6	**Monitoring of discharges of radioactive substances from a NPP (in Finnish)**	**22 Mar 2006**
YVL 7.7	**Radiation monitoring in the environment of a NPP (in Finnish)**	**22 Mar 2006**
YVL 7.8	**Environmental radiation safety reports of a NPP (in Finnish)**	**22 Mar 2006**
YVL 7.9	**Radiation protection of workers at nuclear facilities**	**21 Jan 2002**
YVL 7.10	**Monitoring of occupational exposure at nuclear facilities**	**29 Jan 2002**
YVL 7.11	**Radiation monitoring systems and equipment of a NPP**	**13 Jul 2004**
YVL 7.18	***Radiation safety aspects in the design of a NPP***	***26 Sep 2003***

- **Lay -out**

Component Layout and Accessibility - from guide to practice

- The **frequency of work** is taken into consideration in lay out
- Components and their elements are **arranged such that they can be**:
  – **tested, maintained, inspected replaced and repaired** in a manner that will reduce dose.
- The compartments, components are arranged according to their anticipated dose rates.
- Sampling points etc. **installed in a low local dose rate.**
- **Well-designed Shielding - shielding of non-radioactive supply systems from** radioactive components.
- quickly removable and reusable thermal insulation.
- **maintenance-free components** in areas with relatively high dose rates.
- Robotics - possible to use.
- Valves and pumps are designed to **eliminate the occurrence of leaks**. Possibility of leaks taken in account in room design.
- The exposed surfaces of components are **designed to be decontaminable**.
- **...**

Etc.

Improvements in layout and design relevant to radiation protection

1 generation → 2 generation → pre-Konvoi → Konvoi N4 → EPR

2 generation

- separation of hot leg from cold leg
- thermal insulation in cassette form

pre-Konvoi

- residual heat removal pumps separated from valves
- increase of inspection platforms in the auxiliary building
- elimination of welds to be inspected (e.g. SG cone, pressurizer)

Konvoi N4

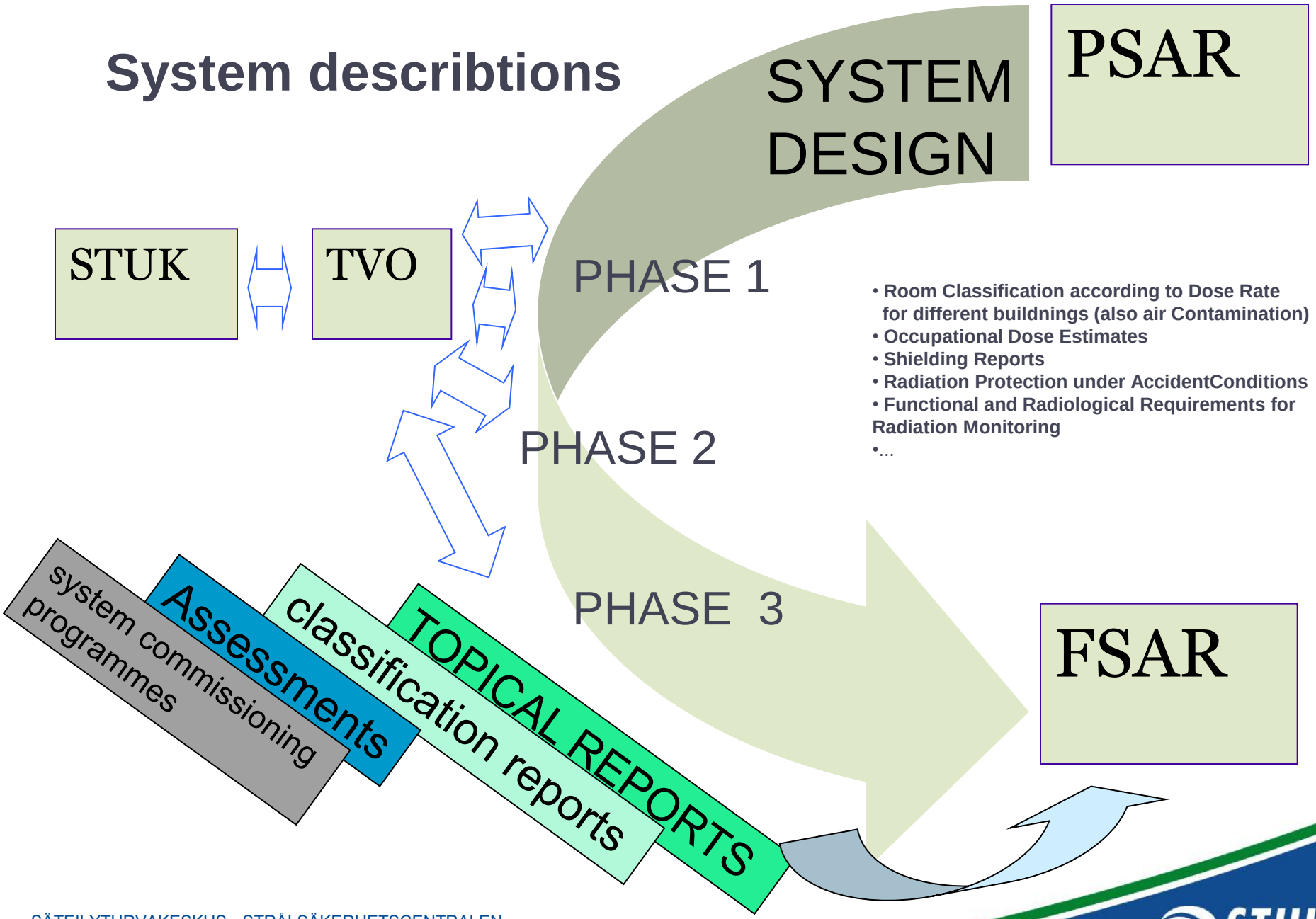
- tanks/vessels usually set separately (e.g. liquid waste, coolant)
- Considerable reduction of welds (RCL, SG)
- shielded safety injection pump & pipe ducts
- fuel pool and residual heat removal pumps, accessibility after accidents
- separate access paths of many levels (avoidance of ladders)
- widened transport and construction routes

EPR

- 2-room containment (EPR)
- access-building layout changes (OL3)

- machines for changing filters &decontamination systems (gradually improved)

System describtions



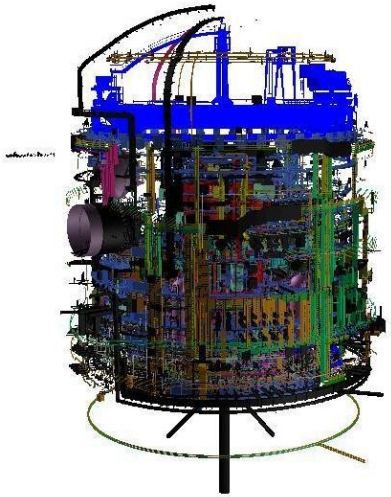
OL3 CHECKLIST for documentation of fulfillment of radiation protection layout principles

- Component X

	Yes	No	NR	comment
Is separation aspects necessary to take account?	x			
Is there enough workplace for inspections?	x			
Is there necessary workplace for maintenance	x			
Is there necessity to take account spread of contamination			x	
Shielding aspects taken in account	x			For sampling a permanet shield must be installed
Ways to minimize dose	x			Separate machine can be used to open bolts

- .....

Autodesk Navisworks Review v.2010 SP1



location of components, piping systems, ducts, cable routings, cubicles, switchgears, instrumentation, civil structures

- Physical separation aspects
- Internal hazards analysis
- Radiation protection requirements

- **materials**

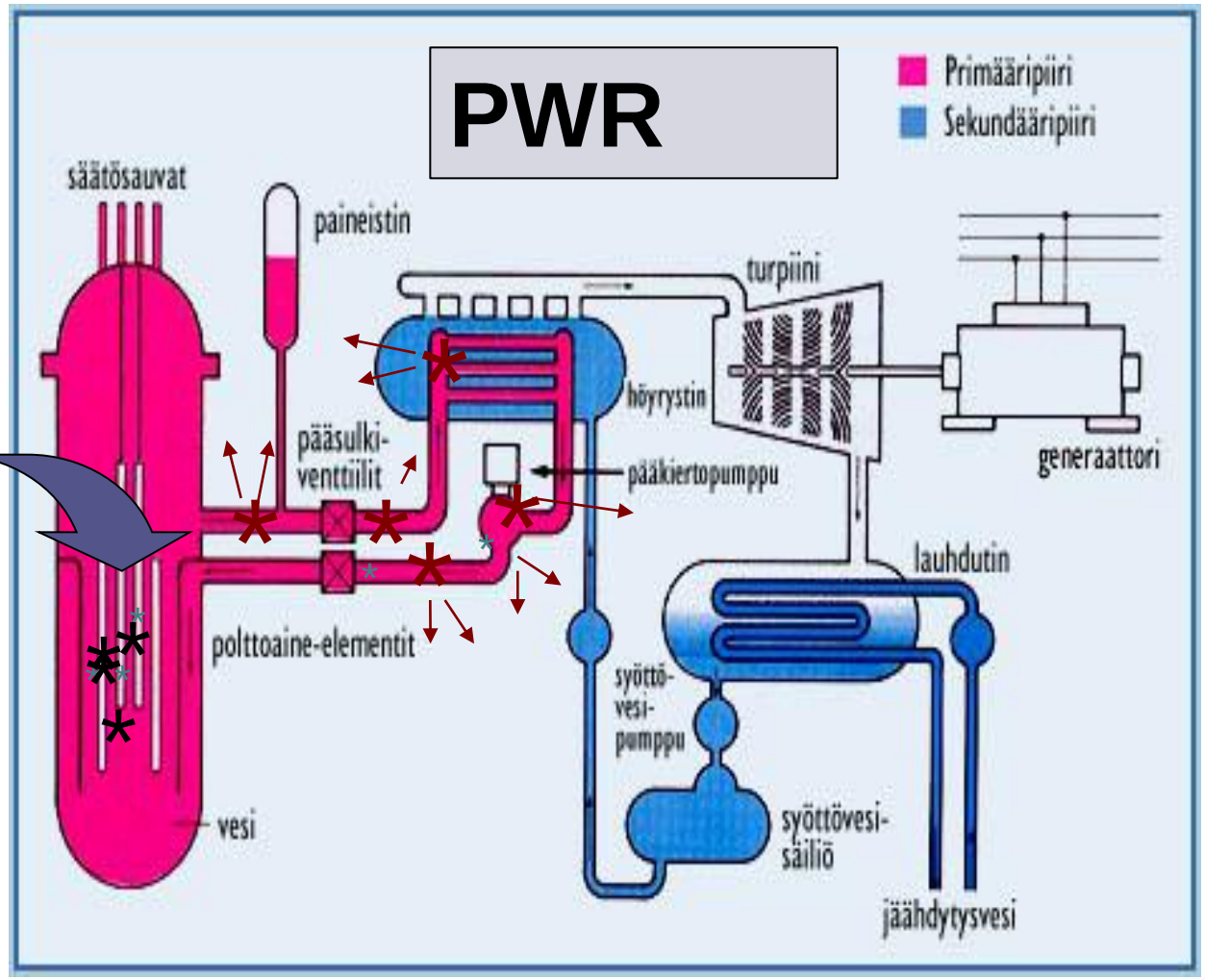
Ni-58 + n -> Co-58 + p

Cr-50 + n -> Cr-51 + γ

Fe-54 + n -> Mn-54 + p

Fe-58 + n -> Fe-59 + γ

Co-59 + n -> Co-60 + γ



Zn-64 + n -> Zn-65 + γ

Ag-109 + n -> Ag-110m + γ

Material selection, SG tubes

- SG tubing material in OL3 was selected **Alloy 690TT** (**nickel base, 58% Ni**)
  - better corrosion resistance (general C & Stress C Cracking) compared to Alloy 600
  - despite a lower Nickel content of Alloy 800 (30-35 % Ni), corrosion release rate is almost double compared to Alloy 690TT
  - Ni release into primary coolant during power operation similar in Alloy 690 and Alloy 800

The cobalt content of construction materials in contact with primary coolant for EPR OL3 was specified as below:

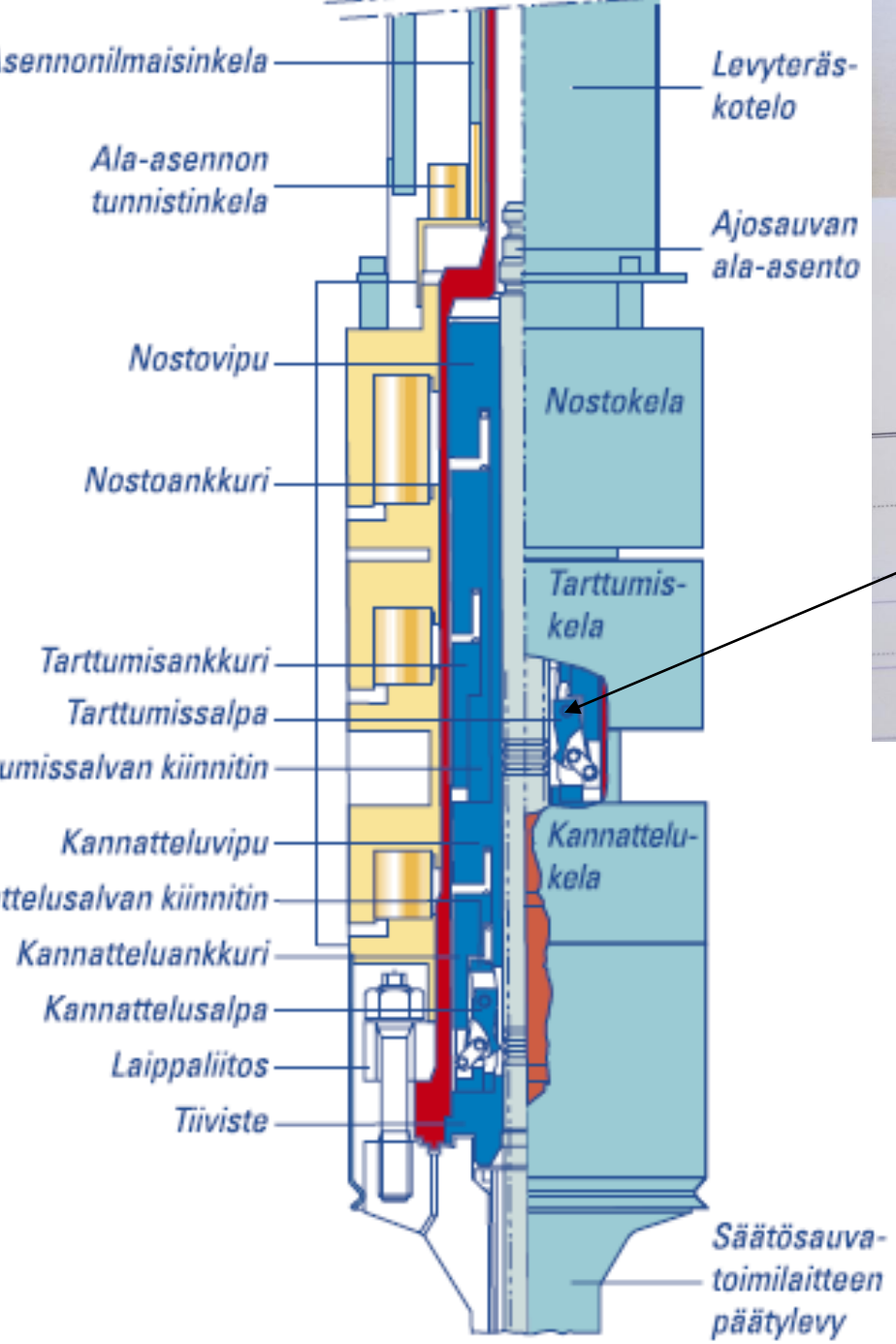
- Stainless Steels or Ni-Cr-Fe alloys (other than tube bundle) Co ≤ 0.06 %
- Tube bundle (averaged over all castings) Co ≤ 0.015 %

the above values are the lowest ever specified values for Cobalt residual content in SG construction materials.

Material selection, Co, hard-facing

Stellite minimisation vs increase of potential technical risk

	EPR (OL3)	Konvoi	P'4 (1300 MW)
CRDM	2.3 m^2	1.6 m^2	1.8 m^2
MCP	1.42 m^2	0	2.5 m^2
RPV + internals	0.45 m^2	0.03 m^2	0.56 m^2
auxiliary systems and valves	0	1.0 m^2	2.3 m^2
Total amount	**4.2 m^2**	**2.6 m^2**	**7.2 m^2**


asennonilmaisinkela
Ala-asennon tunnistinkela
Nostovipu
Nostoankkuri
Tarttumisankkuri
Tarttumissalpa
umissalvan kiinnitin
Kannatteluvipu
ttelusalvan kiinnitin
Kannatteluankkuri
Kannattelusalpa
Laippaliitos
Tiiviste
Levyteräs-kotelo
Ajosauvan ala-asento
Nostokela
Tarttumis-kela
Kannattelu-kela
Säätösauva-toimilaitteen päätylevy

STUK

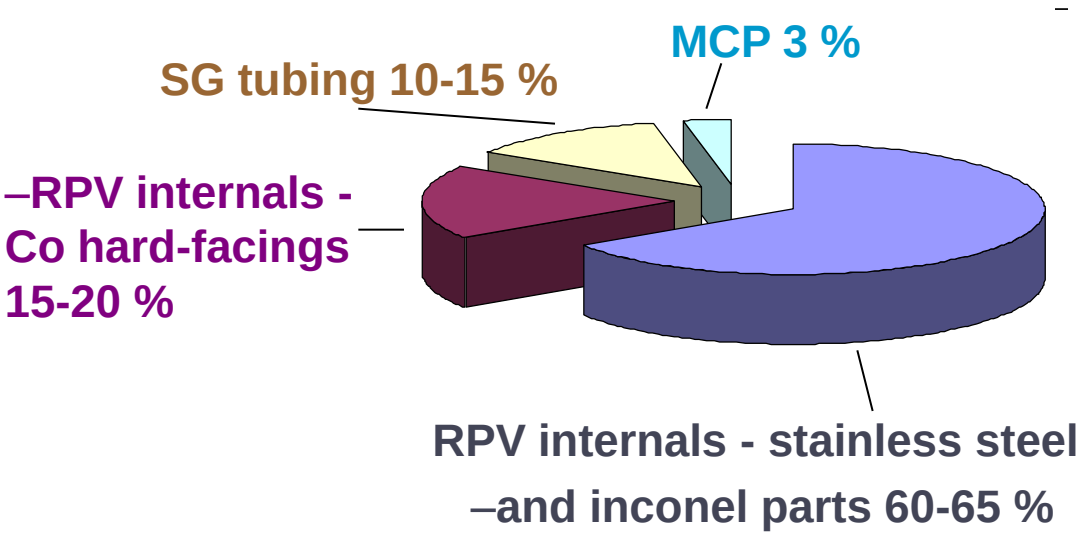
PCC -> ALARA

The primary coolant chemistry has to base on an optimized conditioning and on the limitation of impurities in order:

- To minimize coolant corrosion product (CP) concentration
- To optimize CP migration and re-deposition in order to:
  - Minimize the **deposits on** fuel cladding
  - Limit the accumulation of activated CP on **the out-of-core surfaces of the RCS** and thus minimize the radiation field build-up
- To limit the **corrosion rate of fuel cladding material** (thermal effect and chemistry effects)
- To **avoid oxygen formation** by radiolysis (by hydrogen addition)
- To prevent localized corrosion (SCC/pitting) by limiting impurities (chlorides, fluorides, sulphates)

Material - > dose contribution

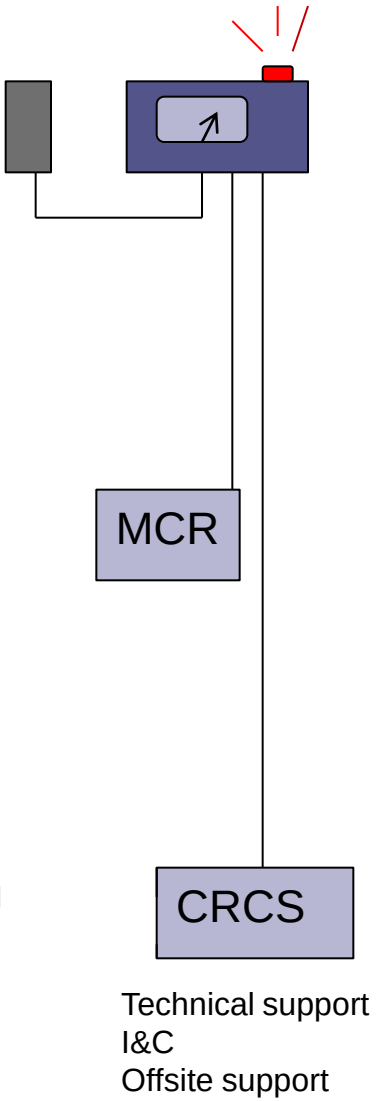
- Main contributors in **Co-60 source term:**



- Main contributors in **Co-58** source term:
  - SG tubing 80 %
  - Fuel assemblies (inconel parts) 7 %

Operational RP

- Instructions (integration of practices)
- Measurements
- Dosimetry
- Training
- New personnel
- Operational material/equipment in RP
- ALARA-planning - taken in consideration in all use of NPP



Collective dose estimation

- **RB, shutdown** **245 mmanSv**

reactor work	22 %
SG, PZR	23 %
logistics (cleaning, supplies, scaffolding, insulation, reactor pool decontamination)	23 %
I&C, ventilation and filtration systems	6 %
pumps and valves	15 %
management, operations team, health physics	10 %
NDE, hydraulic tests	1 %

- **RB, power operation** **30 mmanSv**

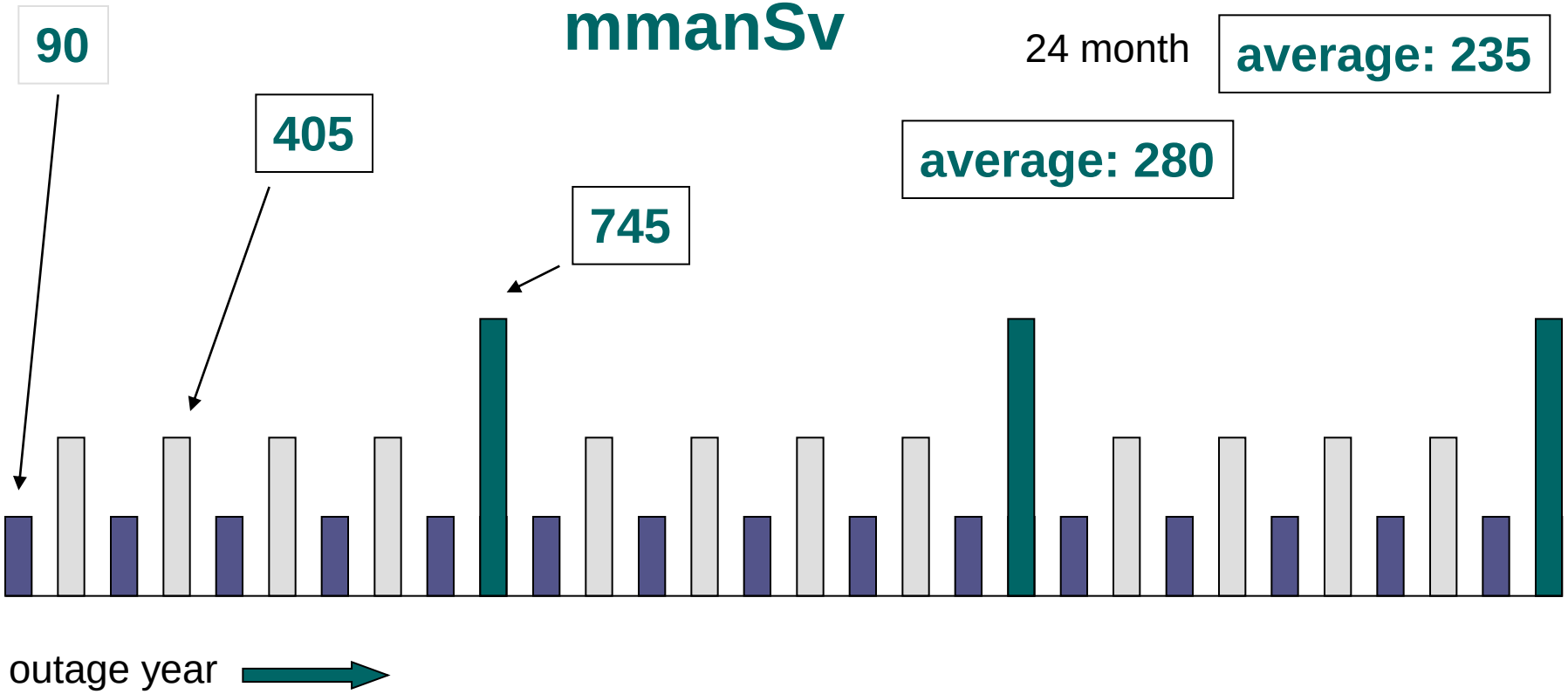
  e.g. tests on polar crane, maintenance of HVAC systems, maintenace of the internal fitration system

- **other buildings** **150 mmanSv**

  e.g. CVCS, SIS, coolant storage system, fuel pool activities; based on Konvoi experience

-> total (12 months cycle) **425 mmanSv**

Duration of outages 12-months outage sequence



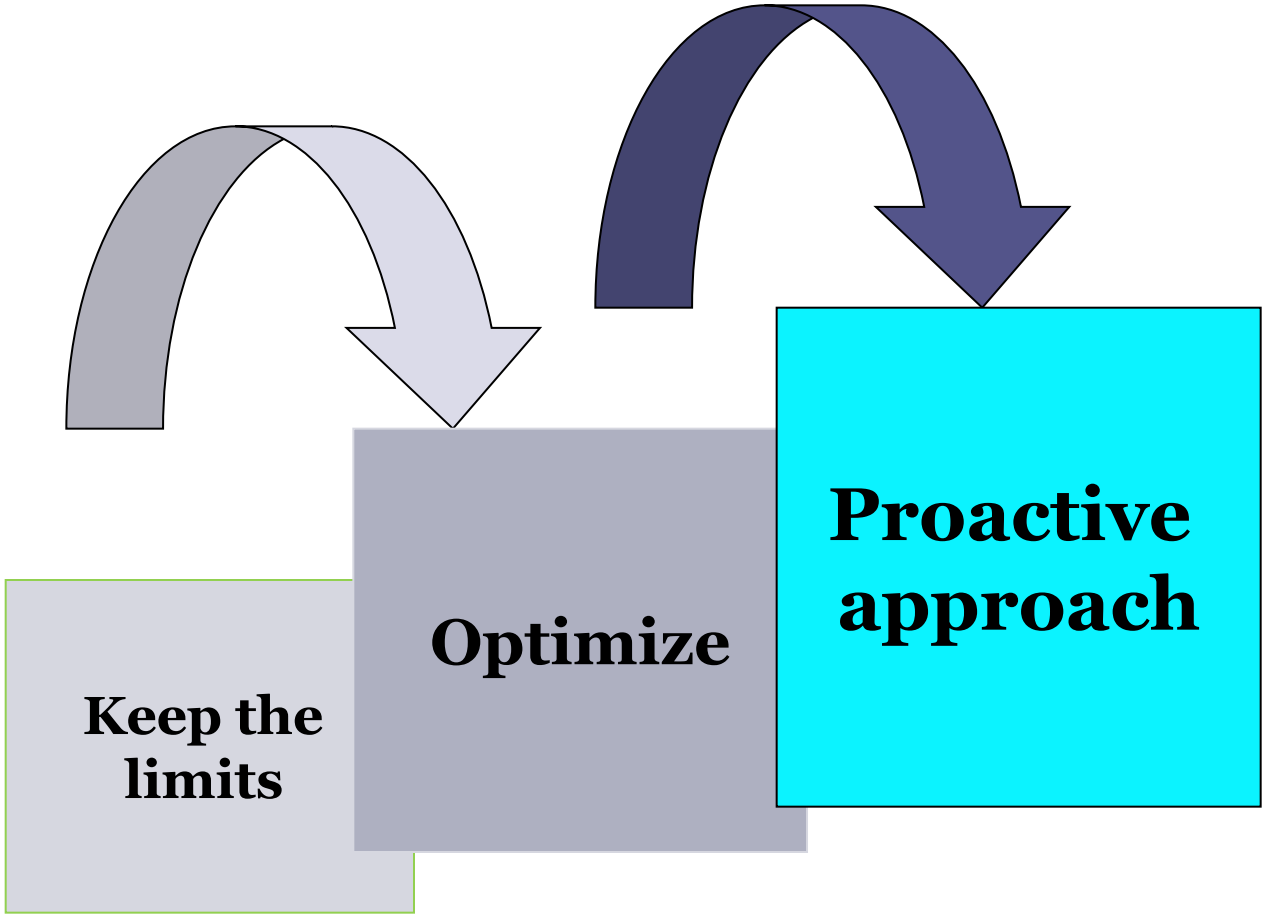
Radiation safety issues reviewed in the OL3 construction license phase

- sources, lay-out, shielding
- primary system material specification
- primary coolant chemistry
- fuel integrity
- collective dose estimation
- on-site habitability during accidents
- releases during normal operation and the use of BAT principle
- accident analyses and radiological consequences
- conceptual design of radiation monitoring system
- waste management issues
- maintenance planning

List of the future YVL guides

A Safety management of a nuclear facility	B Plant and system design	C Radiation safety of a nuclear facility and environment	D Nuclear materials and waste	E Structures and equipment of a nuclear facility
A.1 Regulatory control of the safe use of nuclear energy	B.1 Design of the safety systems of a nuclear facility	***C.1 Structural radiation safety and radiation monitoring of a nuclear facility***	D.1 Regulatory control of nuclear non-proliferation	E.1 Inspection, testing and certifying organisations
A.2 Siting of a nuclear facility	B.2 Classification of systems, structures and equipment of a nuclear facility	**C.2 Radiation protection and dose control of the personnel of a nuclear facility**	D.2 Transport of nuclear materials and waste	E.2´Manufacture and use of nuclear fuel
A.3 Management systems of a nuclear facility	B.3 Safety assessment a NPP	**C.3 Control and measuring of radioactive releases to the environmental of a nuclear facility**	D.3 Handling and storage of nuclear fuel	E.3 Pressure vessels and pipings of a nuclear facility
A.4 Organisation and personnel of a nuclear facility	B.4 Nuclear fuel and reactor	**C.4 Radiological control of the environment of a nuclear facility**	D.4 Handling of low- and intermediate-level waste and decommissioning of a nuclear facility	E.4 Verification of strength of pressure equipment of a nuclear facility
A.5 Construction of a NPP	B.5 Reactor coolant circuit of a NPP	**C.5 Emergency preparedness arrangements of a NPP**	D.5 Final disposal of nuclear waste	E.5 In-service inspections of pressure equipment of a nuclear facility
A.6 Operation and accident management of a NPP	B.6 Containment of a NPP		D.6 Production of uranium and torium	E.6 Buildings and structures of a nuclear facility
A.7 Risk management of a NPP	B.7 Preparing for the internal and external threats to a nuclear facility			E.7 Electrical and I&C equipment of a nuclear facility
A.8 Ageing management of a nuclear facility	B.8 Fire protection of a nuclear facility			E.8 Valve units of a nuclear facility
A.9 Reporting on the operation of a nuclear facility				E.9 Pump units of a nuclear facility
A.10 Operating experience feedback of a nuclear facility				E.10 Emergency power supply of a nuclear facility
A.11 Security arrangements of a nuclear facility				E.11 Hoisting and transfer equipment of a nuclear facility

Collected definitions of YVL-guides: a part of the regulations, but a separate document.


Keep the limits
Optimize
Proactive approach

Thank you

og

Takk fyrir frábæra skipulagningu og samveru hér á Islandi