Requirements for Radiation Protection for New NPPs In Finland

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SÄTEILYTURVAKESKUS
STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY

Content

- Current activities
- Approval Process of a NPP
- Some Radiation Protection aspects

Hankikivi (Fennovoima)

- 1 unit (AES-2006) and Interim Spent Fuel Storage in CL phase

Olkiluoto (TVO)

- 2 operating units - ABB BWR -> 2038
- Unit 3 (EPR) OLG, Commissioning tests, fuel, CA
- Interim Spent Fuel Storage
- Posiva's final repository for spent fuel under construction CLG 2015

Source: TVO

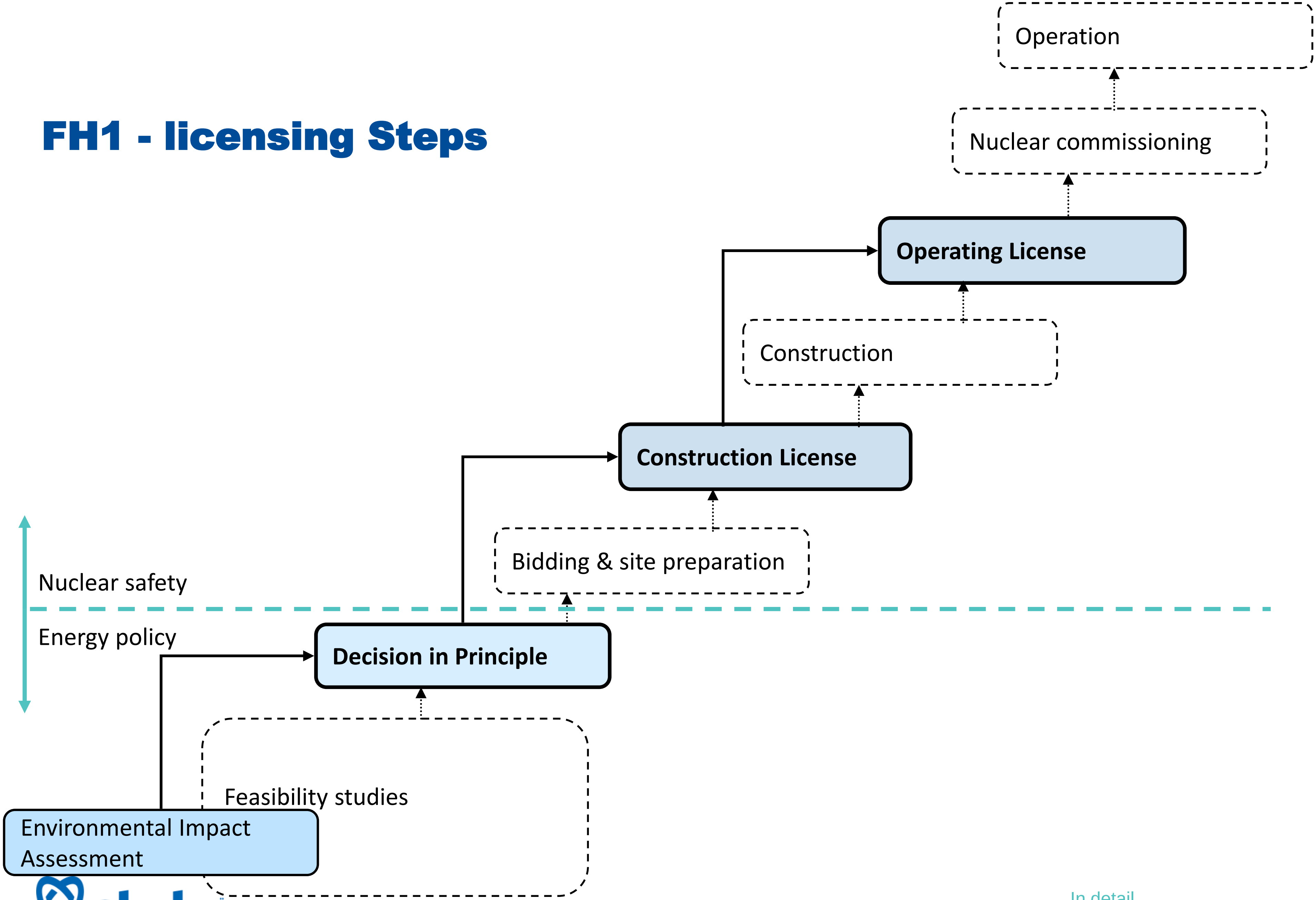
Loviisa (Fortum)

- 2 operating units – VVER
- Interim Spent Fuel Storage

Source: Fortum

TRIGA Mark II research reactor (250 kW)

FH1 - licensing Steps



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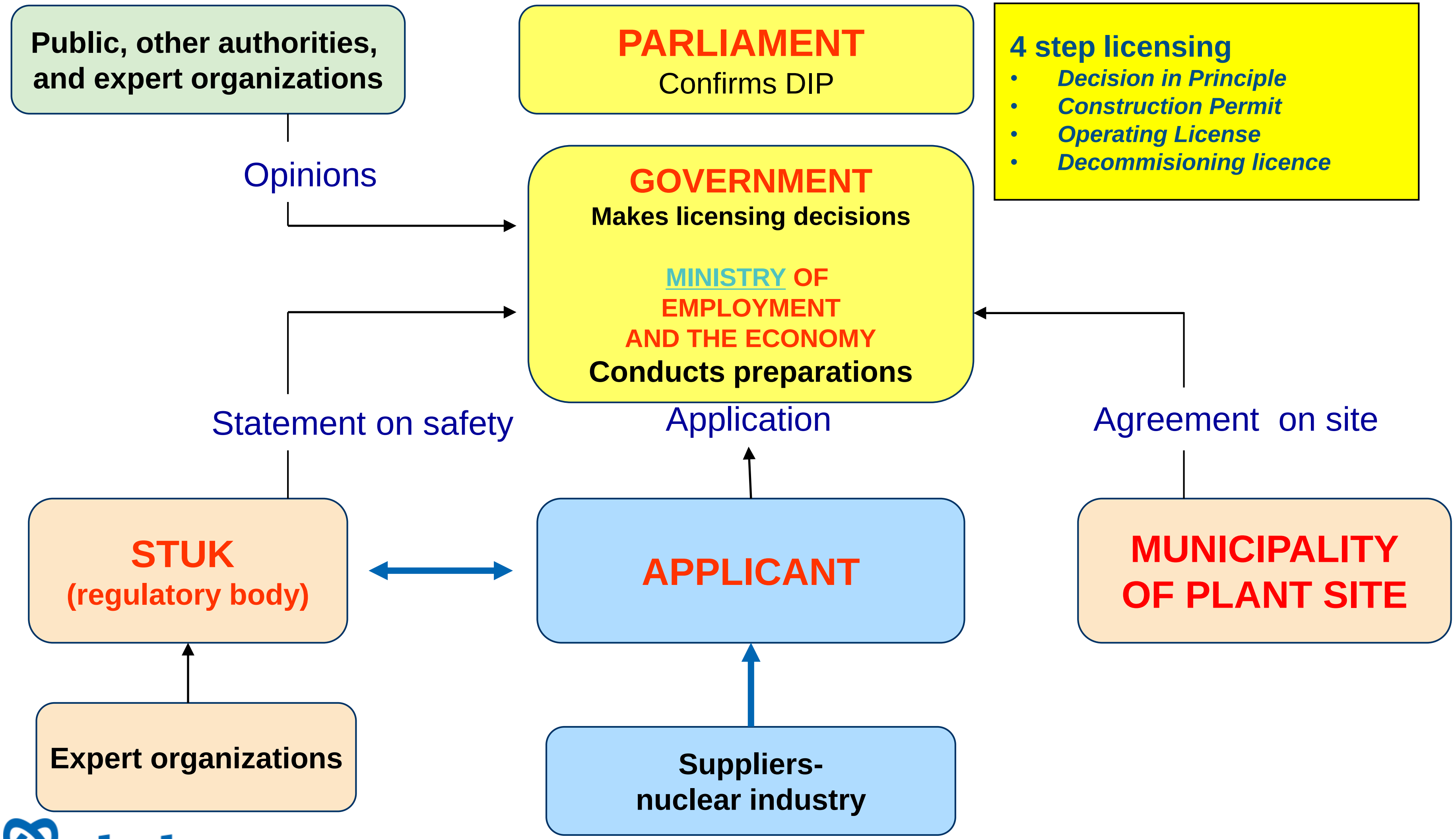
In detail

Licensing of nuclear facilities in Finland



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When applying for a construction licence,

… the applicant shall submit the following to the Radiation and Nuclear Safety Authority (STUK):

1) the preliminary safety analysis report (PSAR), which shall include the general design and safety principles of the nuclear facility, a detailed description of the site and the nuclear facility, a description of the operation of the facility, a description of the behaviour of the facility during accidents, a detailed description of the effects that the operation of the facility has on the environment, and any other information considered necessary by the authorities;

2) a probabilistic risk assessment of the design stage;

3) a proposal for a classification document, which shows the classification of structures, systems and components important to the safety of the nuclear facility on the basis of their significance with respect to safety;

4) a description of quality management during the construction of the nuclear facility, showing the systematic measures applied by the organisations that take part in the design and construction of the nuclear facility in their operations affecting quality;

5) The principle of periodic inspections;

6) preliminary plans for the arrangements for security and emergencies;

7) a plan for arranging the safeguards control that is necessary to prevent the proliferation of nuclear weapons;

8) a description of the arrangements referred to in section 19, paragraph 7 of the Nuclear Energy Act.

(9) a programme for the basic environmental situation of a nuclear installation;

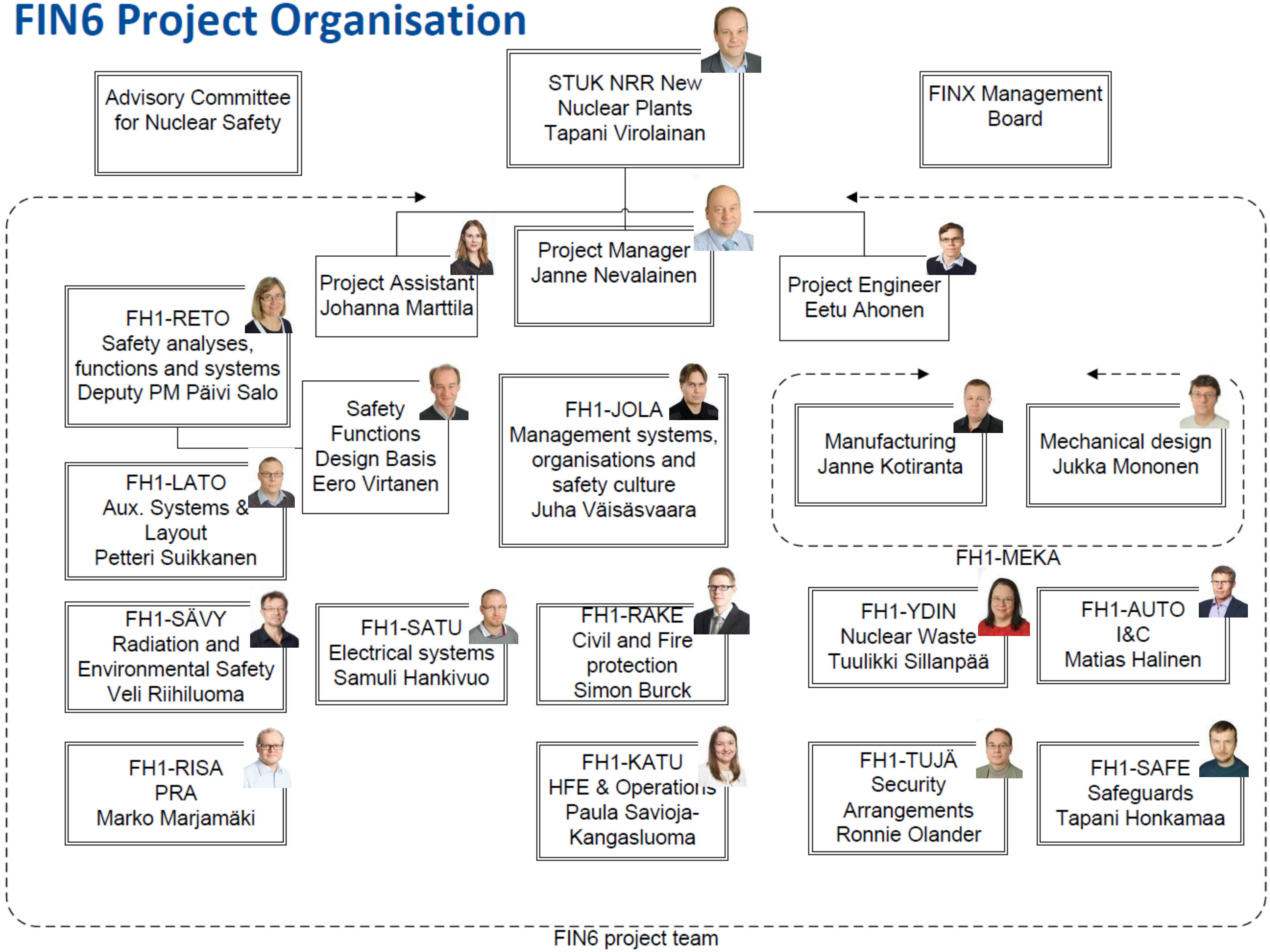
(10) decommissioning plan

An applicant for a license shall also provide STUK with any other reports that the STUK considers necessary.

PSAR

- Important Content (Chapters) for RP in PSAR:
  - Radiation Protection
  - Radiation measurements
  - Transient and accident analysis
  - Waste management
  - Siting / environmental baseline studies
  - Description of systems (accessibility)
  - Technical specifications
  - Organisation
  - Quality
  - …

FIN6 Project Organisation



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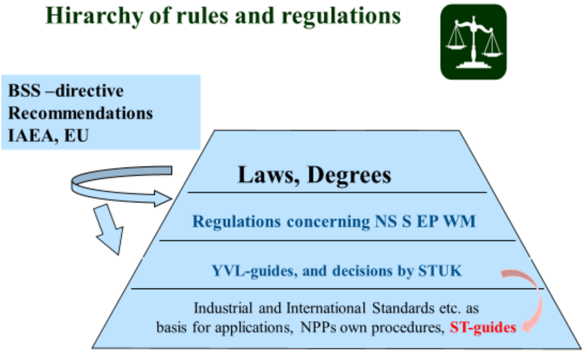
YVL Guides



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 oversight of safety in the use of nuclear energy A.2 Site for a nuclear facility A.3 Management system for a nuclear facility A.4 Organisation and personnel of a nuclear facility A.5 Construction and commissioning of a nuclear facility A.6 Conduct of operations at a nuclear power plant A.7 Probabilistic risk assessment and risk management of a nuclear power plant A.8 Ageing management of a nuclear facility A.9 Regular reporting on the operation of a nuclear facility A.10 Operating experience feedback of a nuclear facility A.11 Security of a nuclear facility A.12 Information security management of a nuclear facility	B.1 Safety design of a nuclear power plant B.2 Classification of systems, structures and components of a nuclear facility B.3 Deterministic safety analyses for a nuclear power plant B.4 Nuclear fuel and reactor B.5 Reactor coolant circuit of a nuclear power plant B.6 Containment of a nuclear power plant B.7 Provisions for internal and external hazards at a nuclear facility B.8 Fire protection at a nuclear facility	C.1 Structural radiation safety at a nuclear facility C.2 Radiation protection and exposure monitoring of nuclear facility workers C.3 Limitation and monitoring of radioactive releases from a nuclear facility C.4 Assessment of radiation doses to the public in the vicinity of a nuclear facility C.5 Emergency arrangements of a nuclear power plant C.6 Radiation monitoring at a nuclear facility C.7 Radiological monitoring of the environment of a nuclear facility	D.1 Regulatory control of nuclear safeguards D.2 Transport of nuclear materials and nuclear waste D.3 Handling and storage of nuclear fuel D.4 Predisposal management of low and intermediate level nuclear waste and decommissioning of a nuclear facility D.5 Disposal of nuclear waste D.6 Production of uranium and thorium in mining and milling activities D.7 Barriers and rock engineering of nuclear waste disposal facility	E.1 Authorised inspection body and the licensee's in-house inspection organisation E.2 Procurement and operation of nuclear fuel E.3 Pressure vessels and piping of a nuclear facility E.4 Strength analyses of nuclear power plant pressure equipment E.5 In-service inspection of nuclear facility pressure equipment with non-destructive testing methods E.6 Buildings and structures of a nuclear facility E.7 Electrical and I&C equipment of a nuclear facility E.8 Valves of a nuclear facility E.9 Pumps of a nuclear facility E.10 Emergency power supplies of a nuclear facility E.11 Hoisting and transfer equipment of a nuclear facility E.12 Testing organisations for mechanical components and structures of a nuclear facility
Collected definitions of YVL-guides: same data is shown both as the collection and within the guides.				

stuk

Application

- The safety requirements in YVL Guides are binding on the licensee, while preserving the licensee's right to propose an alternative procedure or solution to that provided for in the requirements. If the licensee can convincingly demonstrate that the proposed procedure or solution will implement safety level in accordance with the Nuclear Energy Act and STUK Regulations, STUK may approve this procedure or solution.

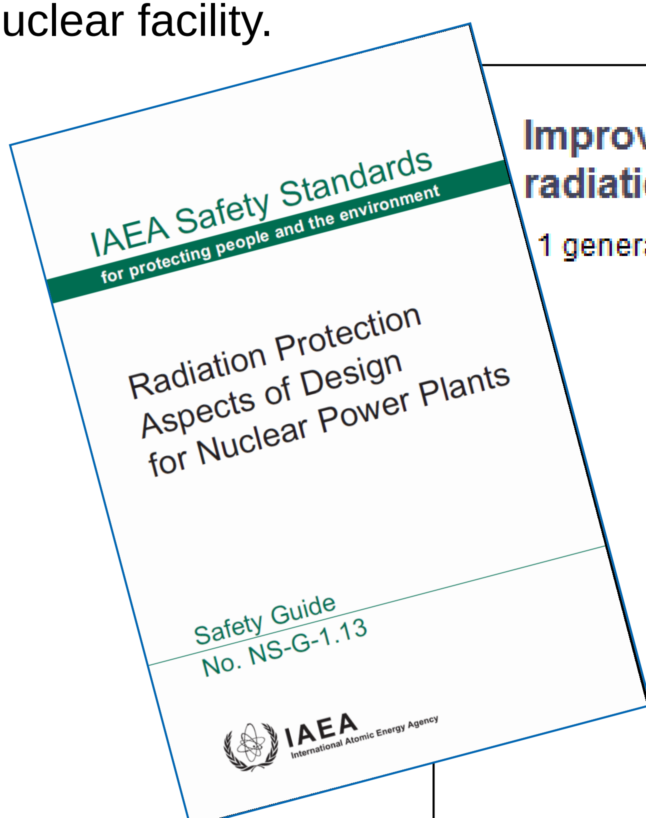
- New YVL Guides are applied to new nuclear facilities as such.

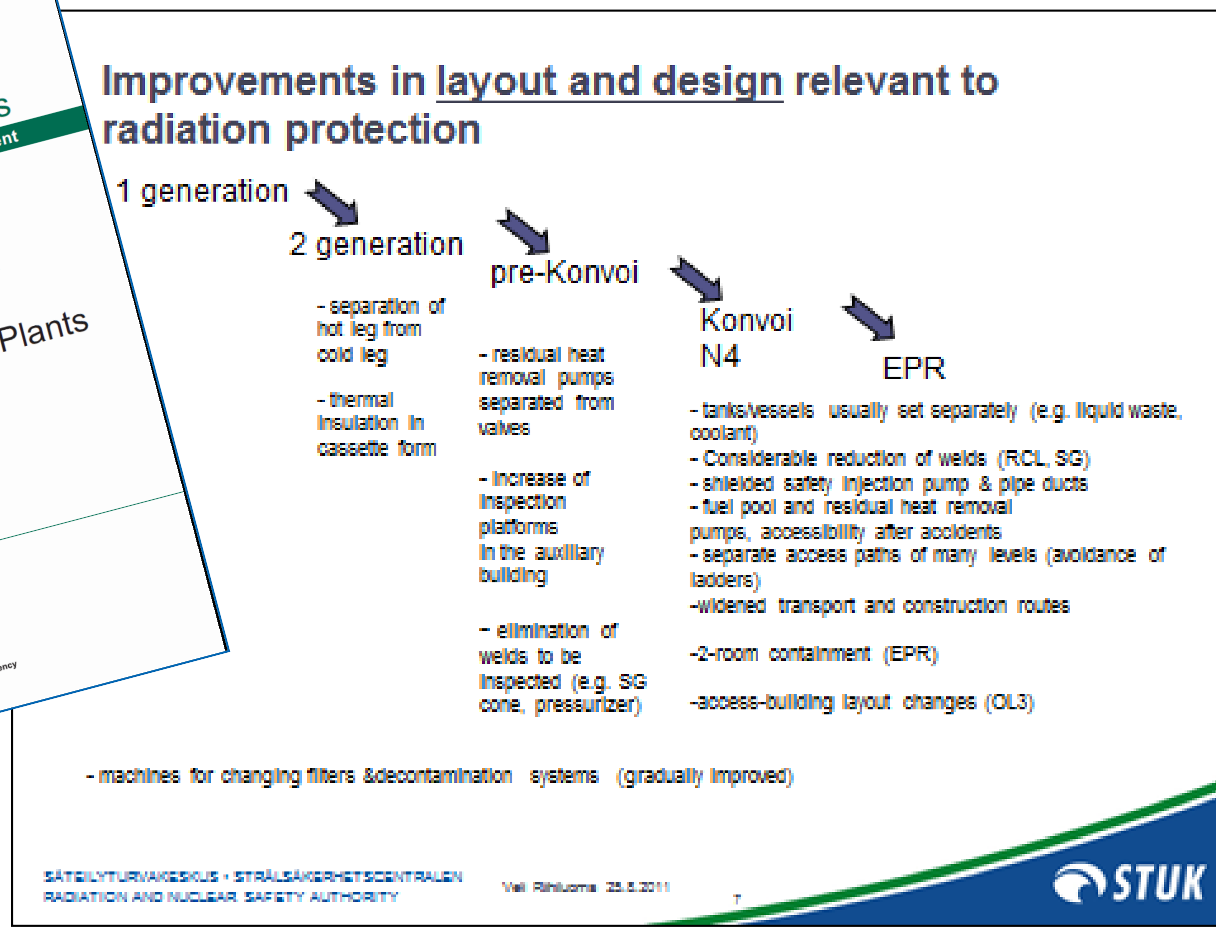
Organisational aspects

- Sufficient expertise in radiation protection, radiation measuring and radiation physics shall be available in all phases of nuclear facility design.

Experience

- **Operating experience feedback** from similar types of nuclear facilities shall be utilised when considering radiation safety aspects in the design of a nuclear facility.





Design features

- A nuclear facility's PSAR and FSAR or the associated topical report shall give a summary of the most important radiation protection-related design features by which the optimization principle in radiation protection is implemented at a nuclear facility.

- A topical report of radiation shielding calculations and the calculation methods shall be submitted to STUK for approval with both PSAR and FSAR

Design shall take into account the operation of a nuclear facility including commissioning, normal operation, anticipated operational occurrences, potential accidents and plant decommissioning. …

Accidents and design

- A topical report describing radiation safety during accidents shall be submitted to STUK for approval with both PSAR FSAR.

- The spreading of airborne radioactive substances… scattering of radiation
- In the design, particular attention shall be paid to rooms where permanent stay is necessary or which may have to be visited during an accident or afterwards:
    - the main control room,
    - emergency control room,
    - local control centres,
    - sampling
    - rooms, laboratory facilities,
    - the emergency response centre and the related access routes.

- Layout design shall be implemented in a way to facilitate the operational actions, maintenance and repairs necessary at the nuclear facility during and after postulated and severe accidents. Functions required during emergency preparedness arrangements are to be taken into account as well

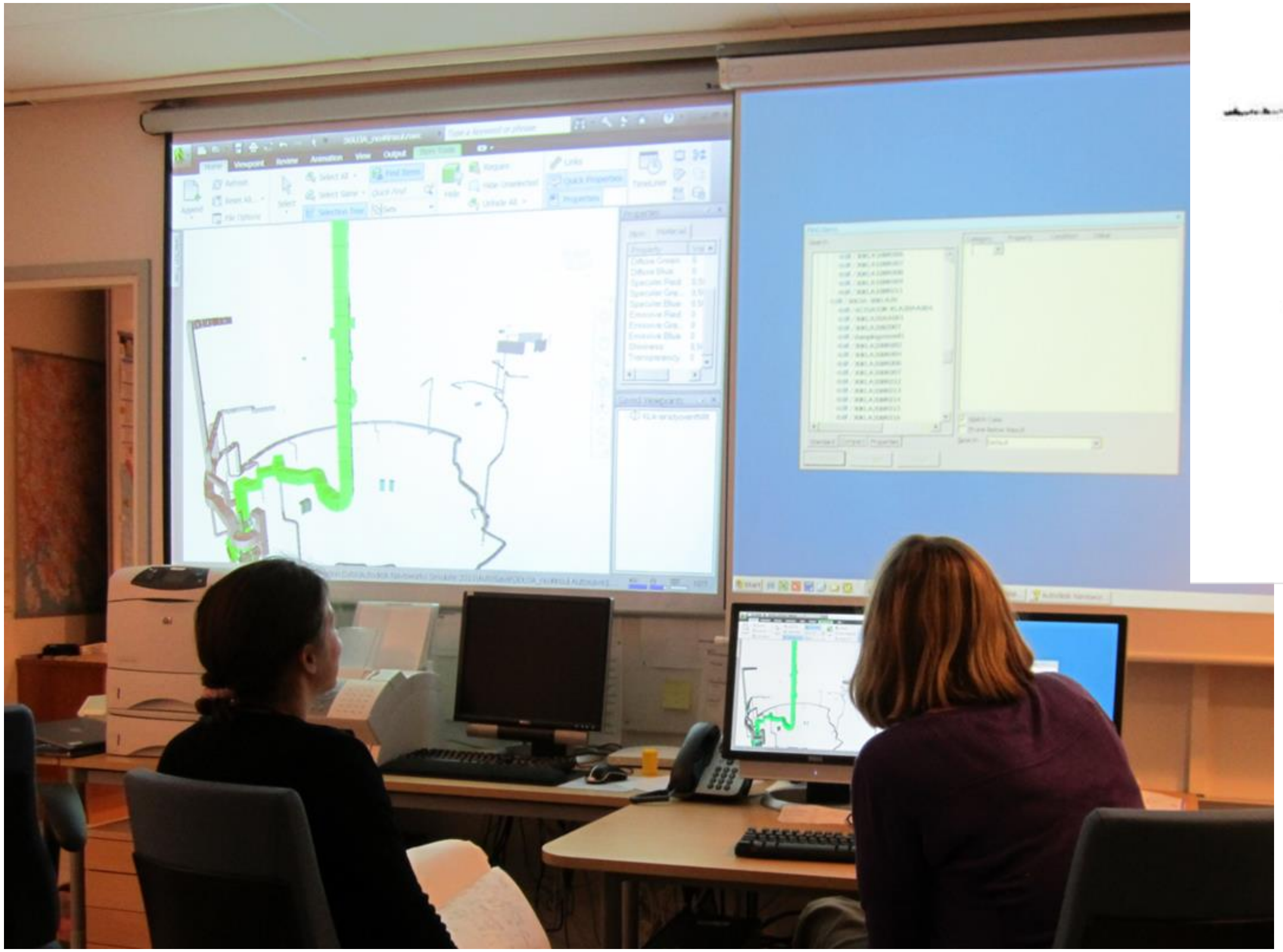
- Design shall indicate those places where the dose rate remains low during an accident. Design shall assume the occurrence of an accident simultaneously at several nuclear facilities on the site.

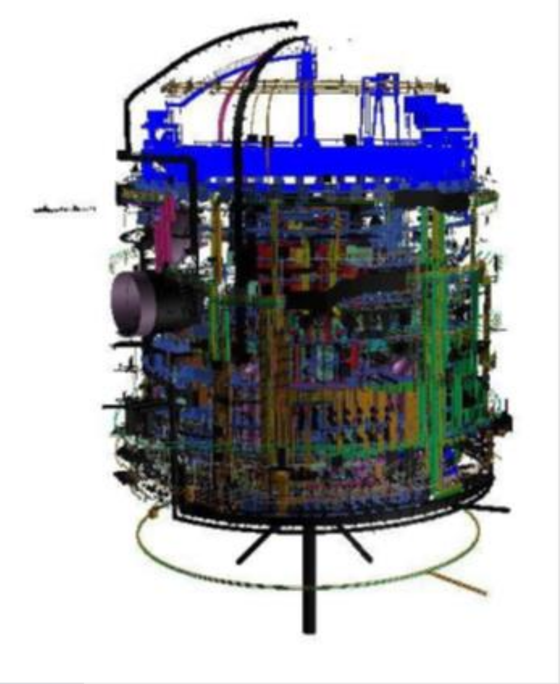
“CHECKLIST” → Accessibility, habitability

System 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
Are accident situations necessary to take in account	X			Separate machine can be used to open bolts
• …..				

Documentation





Components and their locations in closed rooms shall be documented so that no time needs to be spent in search of them during maintenance work done later

Materials

Attention shall be paid to the components, systems, welded seam materials, and sealings of the primary circuit of a nuclear power plant that come into contact with the coolant.

Special attention shall be paid to the reactor core structures. The use of materials having a low nickel, cobalt, silver and antimony content helps prevent the formation of the activation products cobolt-58 (Co-58), cobolt-60 (Co-60), silver-110m (Ag-110m) ja antimony-124 (Sb-124) in particular.

Criteria and justification for the choice of materials and their effect on the facility radiation levels shall be given in both PSAR and FSAR. Detailed information about the material choices shall be given in the construction plans for the components and structures.

Radiological Protection
NEA/CRPPH/R(2014)2
July 2014
www.oecd-nea.org

Radiation Protection Aspects of Primary Water Chemistry and Source-term Management Report

April 2014

OECD

NEA

Table 2: Origin of the main activation products present in the primary cooling system from structures or corrosion mechanism

Radionuclide	Half Life	Activation Reaction	Major Source
^{51}Cr	27.702 days	^{50}Cr (n,) ^{51}Cr	Stainless steel and nickel based alloy
^{54}Mn	312.1 days	^{54}Fe (n,p) ^{54}Mn	Stainless steel and nickel based alloy
^{55}Fe	2.73 years	^{54}Fe (n,) ^{55}Fe	Stainless steel and nickel based alloy
^{56}Mn	2.578 hours	^{55}Mn (n,) ^{56}Mn	Stainless steel and nickel based alloy
^{58}Co	70.88 days	^{58}Ni (n,p) ^{58}Co	Nickel alloys
^{59}Fe	44.51 days	^{58}Fe (n,) ^{59}Fe	Stainless steel and nickel based alloy
^{59}Ni	7.46E4 years	^{58}Ni (n,) ^{59}Ni	Stainless steel and nickel based alloy
^{60}Co	5.271 years	^{59}Co (n,) ^{60}Co	Stellite™ and cobalt bearing components
^{64}Cu	12.701 hours	^{63}Cu (n,) ^{64}Cu	17-4 PH Steel
^{65}Zn	243.8 days	^{64}Zn (n,) ^{65}Zn	Natural zinc injection
^{95}Nb	34.97 days	^{95}Zr decay	Fuel cladding (Zircaloy, Zirlo™, etc.)
^{95}Zr	64.02 days	^{94}Zr (n,) ^{95}Zr	Fuel cladding (Zircaloy, Zirlo™, etc.)
^{99}Tc	2.13E5 years	^{98}Mo (n,) ^{99}Mo ^{99}Tc	Stainless steel, tramp impurities, and fission
^{110m}Ag	249.8 days	^{109}Ag (n,) ^{110m}Ag	Silver-Indium-Cadium Control rod wear, Helicoflex™ seals
^{122}Sb	2.72 days	^{121}Sb (n,) ^{122}Sb	Secondary start-up source
^{124}Sb	60.20 days	^{123}Sb (n,) ^{124}Sb	Secondary start-up source, RCP bearings, impurities
^{125}Sb	2.75 years	^{125}Sn decay ^{124}Sb (n,) ^{125}Sb	Fuel cladding impurities and neutron capture by ^{124}Sb
^{181}Hf	42.4 days	^{180}Hf (n,) ^{181}Hf	Fuel cladding impurities
^{187}W	23.9 hours	^{186}W (n,) ^{187}W	Stainless steel, carbides, and welding artefacts

3.1.3.1 Corrosion Product Transport and Activation

A series of events must occur before a given radionuclide can reach and incorporate into ex-core oxides. Hussey identified five steps in the process [1]; each of these steps is a complicated process that should be evaluated in more detail.

1) Corrosion product release from out-of-core surfaces.
2) Transport to the core and deposition on fuel cladding surfaces.
3) Activation of the corrosion product metal.
4) Release of the activated corrosion product from the fuel cladding surface and transport from the core.
5) Deposition or uptake of the corrosion product on out-of-core surfaces.

Chemistry/Decontamination

- The chemistry, radiochemistry laboratories and decontamination activity shall be described in PSAR…
- PSAR or its topical report shall describe the water chemistry planned for the primary and secondary circuit with its goals and design bases.
- The facility shall have procedures in place for routine decontamination of individual components and component parts.
- The chemical decontamination method applied to the large-scale purification of the interior surfaces of the primary circuit shall be effective without causing excessive corrosion to the materials.
- Rooms, workers…

Work dose assessments

- With both the PSAR and FSAR, a topical report containing an assessment of the doses received by workers from plant operation shall be submitted for approval to STUK.

- The assessment shall take account of individual tasks causing doses of which a collective dose of more than 0.01 manSv is anticipated to accumulate annually.

- The dose assessments shall also be classified by action (radiation protection, operation, maintenance, repair, periodic inspection, fuel handling and waste treatment) or worker group.

- The report shall show dose rates in the working area, working time, number of workers and frequency of action. The safety analysis report shall include a summary of dose assessments and factors likely to affect doses.

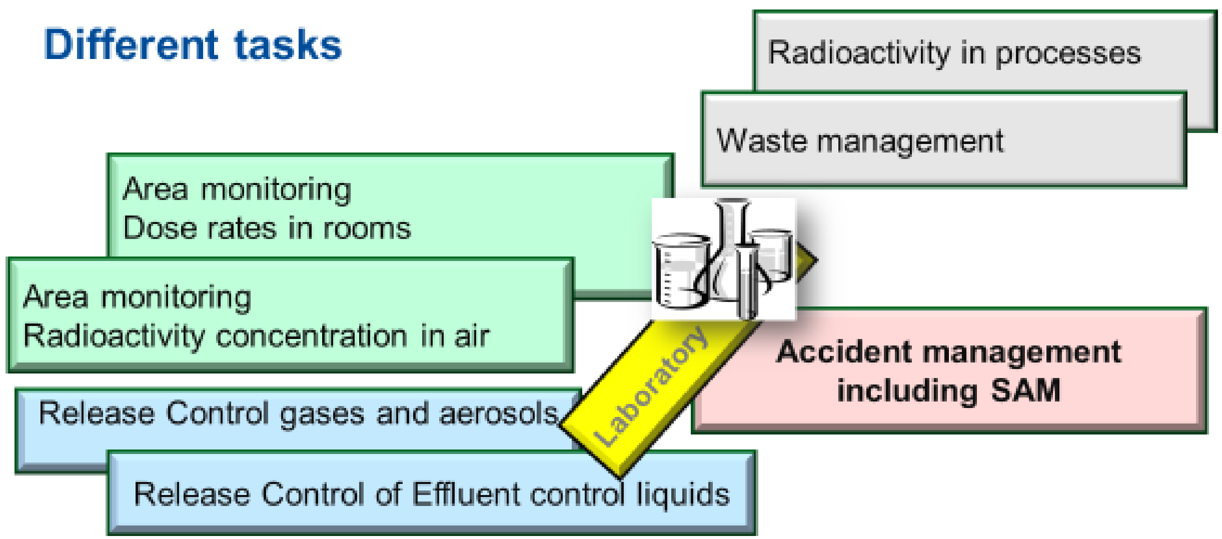
Collective dose assessments

- In designing and constructing a nuclear power plant, calculations must be performed to ensure that the collective annual dose during planned and anticipated regular work tasks does not exceed the value of 0.5 manSv per net electric power of 1 GW during normal operation averaged over the plant's design service life.

- Collective dose calculation shall be justified with operating experiences from similar types of operating nuclear power plant units.

Radiation measurements (RMS)

- Design shall facilitate essential information to protect workers, give information of the processes at Npp and environment



- Personal (individual) radiation measurements
  - Dosimeters, contamination measurement of individuals
- Radioactivity in Environment
- Portable devices

Summary

Essential aspects in radiation protection of a new NPP are:

- Identification of radiation sources, lay-out, shielding
- Primary system material specification
- Chemistry
- On-site habitability during operation and accidents
- Releases & BAT
- Accident analyses and radiological consequences
- Design of the RMS

Reduction fo doses

- It is essential to describe details in PSAR by which the ALARA and BAT targets will be reached
- Even if the dose limits and constraints were not exceeded, it is not justifiable to not implement a design option that would essentially reduce occupational or public dose.
- Utilization of experience: ISOE can be seen as one of the important sources to provide important experience to reach targets

- Thank you