Regulatory Approach to Radiation Protection in new NPPs in Finland

ISOE European Workshop in Prague
20.-22. 6. 2012

Veli Riihiluoma
Radiation and Nuclear Safety Authority (STUK)
Content

• General information
• Regulatory background
• Sources, lay-out...
• System specific review
• Primary system material specification
• Dose estimation
• Future aspects
Some projects in NPP sector in Finland (status 2012)

- **Minor up-date of RMS (Lokit, RA)**
  - Lo2 RPV
  - Lo1 RPV
  - Dos. Serv.
  - Seals YD

- **RMS renewal**
  - Constr. licence
  - Operation licence

- **Preparation**
  - 2/5 alternatives
  - Febr. 2009
  - EIA June 2008

- **Construction**
  - Constr. licence
  - Operation licence

- **Operation licence**
  - OL 3 PWR
  - OL 4

- **Licence renewal/PSR**
  - Dep. for spent fuel

- **Loiisa 1/2 PWRs**
  - Constr. licence

- **Olkiluoto 1/2 BWRs**
  - Constr. licence

- **Operation licence**
  - Veli Riihiluoma 20.6.2012
**Olkiluoto NPP (TVO)**
- 2 operating units – ASEA BWRs
- OL3 (EPR) under construction
- OL4 (TBD)
  - ABWR, Toshiba Westinghouse
  - APWR, Mitsubishi Heavy Industry
  - AP1400, KHNP
  - EPR, Areva
  - ESBWR, GE Hitachi

**FENNOVOIMA**
**Hankikivi 1 (TBD) Pyhäjoki**
- ABWR, Toshiba Westinghouse
- EPR, Areva

**Lovisa NPP (Fortum)**
- 2 operating units - VVERs

Source: TVO

Source: Fortum
## Guides in Radiation Protection

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• Lay –out -> ALARA
Improvements in layout and design relevant to radiation protection

1 generation

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

2 generation

- 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)

pre-Konvoi

- 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

Konvoi N4

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

- machines for changing filters & decontamination systems (gradually improved)
• Detailed design
Process -> ALARA
System descriptions

STUK  
TVO

PHASE 1

PHASE 2

PHASE 3

SYSTEM DESIGN

PSAR

• Room Classification according to Dose Rate for different buildings (also air Contamination)
• Occupational Dose Estimates
• Shielding Reports
• Radiation Protection under Accident Conditions
• Functional and Radiological Requirements for Radiation Monitoring
• ALARA report

TOPICAL REPORTS

Assessments
system commissioning
programmes

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

- Physical separation aspects
- Internal hazards analysis
- Radiation protection requirements
• Materials -> ALARA
- 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 & 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 %

Co-operation between RP and material experts
Material selection, Co, hard-facing

Stellite minimisation vs. increase of potential technical risk

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<th>Konvoi</th>
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<td>CRDM</td>
<td>2.3 m²</td>
<td>1.6 m²</td>
<td>1.8 m²</td>
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<tr>
<td>MCP</td>
<td>1.42 m²</td>
<td>0</td>
<td>2.5 m²</td>
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<tr>
<td>RPV + internals</td>
<td>0.45 m²</td>
<td>0.03 m²</td>
<td>0.56 m²</td>
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<tr>
<td>auxiliary systems and valves</td>
<td>0</td>
<td>1.0 m²</td>
<td>2.3 m²</td>
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<tr>
<td><strong>Total amount</strong></td>
<td><strong>4.2 m²</strong></td>
<td><strong>2.6 m²</strong></td>
<td><strong>7.2 m²</strong></td>
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Material -> dose contribution

• Main contributors in **Co-60** source term:
  - SG tubing 10-15 %
  - RPV internals - Co hard-facings 15-20 %
  - MCP 3 %
  - RPV internals - stainless steel and inconel parts 60-65 %

• Main contributors in **Co-58** source term:
  - SG tubing 80 %
  - Fuel assemblies (inconel parts) 7 %
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) formation
- To optimize CP migration and re-deposition
- 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)

Co-operation between RP and chemistry experts
Operational RP -> ALARA

- Instructions (integration of practices)
- Dosimetry
- Operational material/equipment in RP (Integration of functions with old units)

- Measurements (RMS-system) instructions/tests/maintenance

- Outage planning/work permits (short, well planned outages to minimize dose)

- New personnel (Timing of recruiting/hiring new personnel due to delay)
- Training (timing is a challenge)

ALARA-planning - taken in consideration in all use of NPP
RMS -> ALARA

- RP of persons
  - Area monitoring
  - Personnel monitoring

- Control of activity flow
  - Start of reactor protection measures
  - Process Monitoring

- RP of the environment and population
  - Stack monitoring of radioactive releases
  - Monitoring of liquid releases
  - Monitoring of the environment

- Technical support
  - I&C
  - Offsite support

- Lay-out
  - Materials, RMS

- Guidance / Planning
• In future
Doses for 12-months outage sequence

- Design criterion for an annual personnel collective dose:
  - \(< 0.5 \text{ manSv} / \text{1 GWe} \) averaged over the plant life
  - \(< 0.8 \text{ manSv} / \text{year} \) for OL3 (1600 MWe)

- EUR document requirement for EPR:
  - Target for annual collective effective dose averaged over the plant life is 0.5 manSv / year

- OL3 PSAR: 0.425 manSv/year (12 months cycle)
### List of the future YVL guides

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

Optimize

Keep the limits
Proactive Approach

Keep the limits

Optimize

EXPERIENCE (ISOE)

Guidance / Planning

Lay – out
Materials, RMS

Operational
RP / PCC…
• Thank you
• Děkuji
• EXTRAS
Regulatory Oversight (man-years/NPP)

Source: Kaisa Koskinen
Applying operating licence

Section 36
When applying for an operating licence, the applicant shall provide the Radiation and Nuclear Safety Authority (STUK) with the following:

1) the FSAR
2) a PRA
3) a classification document,
4) a QM programme for the operation of the nuclear facility;
5) the Technical Specifications
6) a summary programme for periodic inspections;
7) plans for the arrangements for security and emergencies;
8) a description on how to arrange the safeguards that are necessary to prevent the proliferation of nuclear weapons;
9) administrative rules for the nuclear facility;
10) a programme for radiation monitoring in the environment of the nuclear facility;
11) a description of how safety requirements are met; and
12) a programme for the management of ageing.
Collective dose estimation

- **RB, shutdown**
  - 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**
  - e.g. tests on polar crane, maintenance of HVAC systems, maintenance of the internal filtration system

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

-> total (12 months cycle): 425 manmSv
Licensing steps in Finland

Feasibility studies

Decision in Principle:
- Political debate on whether using nuclear energy is for the overall good of society
  - Government decision and Parliament ratification/rejection
  - STUK’s preliminary safety assessment
  - Issued in February/May 2002 for Olkiluoto 3
  - Issued in May/July 2010 for Olkiluoto 4 and Fennovoima 1

Construction Licence:
- Government Decision
- STUK’s Safety assessment on the acceptability of Technical principles and requirements of the plant
- Issued in February 2005 for Olkiluoto 3

Construction:
- Review and approval of the detailed design
- Oversight of manufacturing and construction

Operating Licence:
- Government Decision
- STUK’s safety assessment on the technical and organisational aspects of the as build plant

Bidding & site preparation

On 1 July 2010, the Parliament ratified these decisions.

The EIA process involves two stages. First, the power companies prepare the EIA programmes and, second stage, draw up the EIA reports. The contact authority for both stages is TEM.