REGULATORY REQUIREMENTS FOR RADIATION SAFETY IN THE DESIGN OF A NEW FINNISH NPP

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Introduction

There are two operating nuclear power plants in Finland, two BWR units at Olkiluoto site and two PWR units at Loviisa site. These reactors were commissioned between 1977 and 1981. The total electricity capacity in Finland is about 15 GW. In 2003, nuclear power plants generated one fourth of Finland's electricity. Despite of the diversity of the electricity generation methods, Finland is highly dependent on imported energy. Electricity consumption is estimated to increase and the demand for extra capacity has been estimated at about 2500-3000 MW by 2010 [1]. It should also be taken into account that a considerable proportion of the production capacity constructed in the 1970's must be replaced with production capacity of new power plants in the near future. In practice, the climate politics commitments made by Finland exclude coal power. Therefore, the capacity can be increased significantly only by natural gas, nuclear power and biofuels [1].

Licensing a New Nuclear Power Plant in Finland

The licensing process of a new nuclear power plant in Finland is shown in Figure 1. The project of the fifth Finnish nuclear power reactor was formally started in May 1998 with Environmental Impact Assessment (EIA) process. The EIA process was completed in January 2000. Results of the EIA were used to support the application for a Decision in Principle, which the electricity generating company TVO submitted to the Ministry of Trade and Industry in November 2000. The Finnish Government made in January 2002 a Decision in Principle, which concluded that constructing of a new nuclear power plant unit in Finland is in line with the overall good of the society. The Finnish Parliament ratified the decision in May 2002. Based on this decision, TVO was authorised to continue preparations for the construction of a new nuclear power plant unit.

In October 2003, TVO decided the plant site to be Olkiluoto and in December 2003 TVO made a contract with a consortium of Framatome ANP and Siemens to build a French-German reactor concept EPR (European Pressurised Water Reactor). TVO submitted the application for Construction License to the Ministry of Trade and Industry in the beginning of 2004. The Construction License evaluation process takes approximately one year, and the construction works on-site could start at the earliest at the beginning of 2005. Based on TVO's schedule, estimated construction time is about four years. The Operating License evaluation process takes approximately one year, and thus, the new unit could be in operation in 2009 if no unexpected delays occur.

At the same time the application for Construction License was sent to the Ministry of Trade and Industry, TVO submitted so called licensing documentation to STUK. According to the Finnish Nuclear Energy Decree Section 35, these documents include:

- Preliminary Safety Analysis Report (PSAR)
- Proposal for a Classification Document
- Description of Quality Assurance during the Construction
- Plans for Physical Protection and Emergency Preparedness
- Plan for Safeguards
- Description of the Applicant's Arrangements for the Regulatory Review by STUK
- Other reports that STUK considers necessary.

Based on the review of these documents, STUK prepares its statement on safety and safety assessment, which will be submitted to the Ministry of Trade and Industry. STUK's positive statement on safety is a prerequisite for the Government to grant the Construction License.

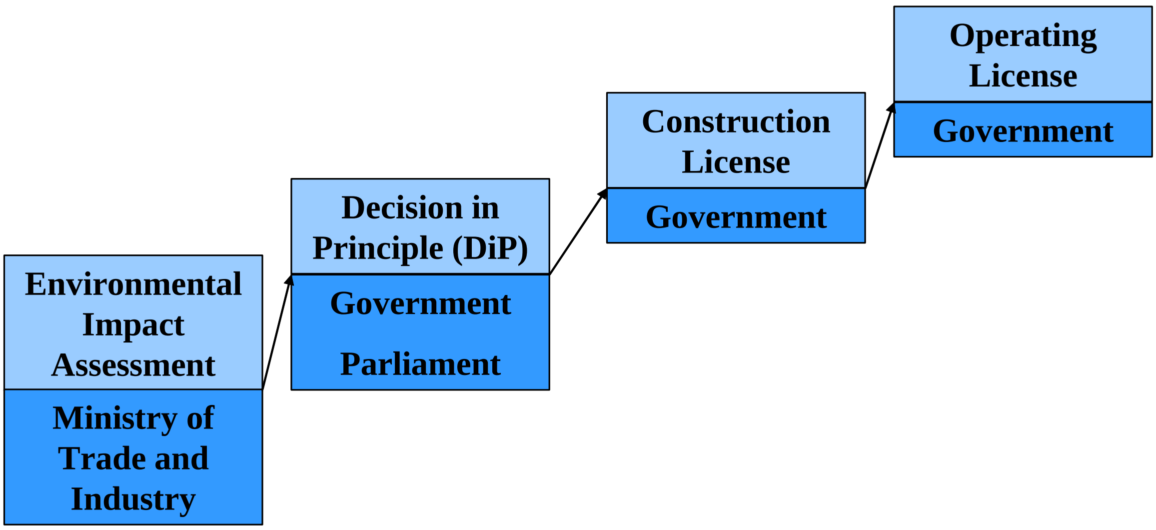

Figure 1: The licensing process of a new nuclear power plant in Finland.

FIN5 Project at STUK

After the Decision in Principle, the Radiation and Nuclear Safety Authority (STUK) established a project group to co-ordinate the license application regulatory review process of the fifth Finnish NPP unit at STUK. The role of the project group is to plan and co-ordinate the review work. The line organisation at STUK performs the actual review work to which the project group also participates. One specific task of the project group is to evaluate utility's quality management. After planning the review process, the duty of the project group is to see that the work performed at STUK proceeds as planned.

The FIN5 regulatory project at STUK is divided into 10 subprojects, which are introduced in Figure 2. One of the subprojects deals with radiation and environmental safety as well as emergency preparedness issues. It includes for example review of siting issues, radiation safety of the plant and related analyses, radiation instrumentation and emergency preparedness arrangements.

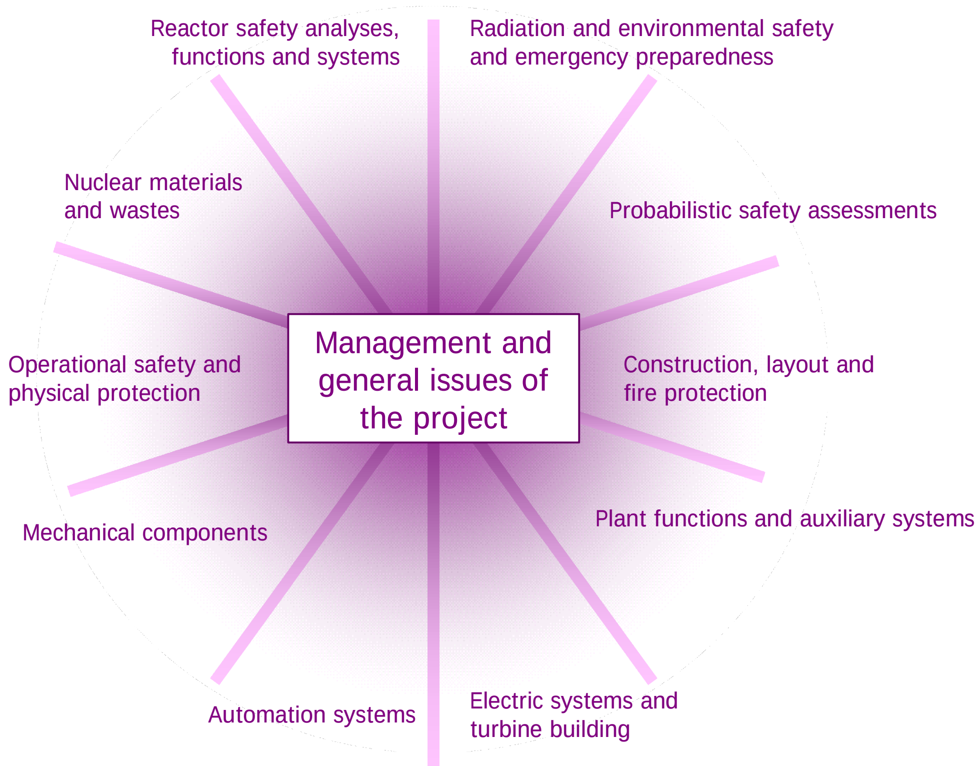

Figure 2: Different sectors of the project group, which co-ordinate the license application process of the fifth Finnish NPP unit at STUK.

Work Planning and a Tool for Requirement Management

From June 2002 to the end of 2003, the FIN5 project at STUK lived a so called preparation phase. The main task was the future work planning. A project manual was prepared, which includes for example a description of the project organisation, responsibilities and project management, main phases of the project and resource estimates. The planning was also performed on the subproject level. Every subproject manager made an inspection and review plan, which includes for example milestones for review process, resource allocations and prioritisation of items to review.

Another major task during the preparation was a development of a tool for Requirement Management. In Finland, the safety requirements of the nuclear power plants are introduced in the Nuclear Energy Act (990/1987) and Decree (161/1988), in five separate Decisions of Council of State (General Regulations for the Safety of NPPs, Physical Protection of NPPs, Emergency Response Arrangements at NPPs, the Safety of a Disposal Facility for Reactor Waste and the Safety of Disposal of Spent Nuclear Fuel). By virtue of the Nuclear Energy Act (990/87) and the Decision of the Council of State (395/91) on General Regulations for the Safety of Nuclear Power Plants, STUK issues detailed regulations concerning the safety of nuclear power plants. These regulations are called YVL Guides. In the preparatory work for Requirement Management system, the YVL Guide requirements that the licensee (applicant) and the new reactor have to fulfil were identified. Also the requirements for STUK’s oversight were defined.

The first version of the Requirement Management tool was implemented with simple Excel files. The second step will be a more sophisticated database application, where the search of the data is easier. The requirement management system can be used for example as a standard review plan for a Preliminary Safety Analysis Report because all requirements are linked to the different Chapters of the SAR.

Radiation Safety Related YVL Guides

After the Decision in Principle, STUK made a plan according to which the existing YVL Guides were evaluated and updated. The guide YVL 7.18, concerning the radiation safety aspects in the design of NPPs, was up-dated during 2003. The main content of the new guide is shown in Figure 3. In this updated guide, accident situations including severe accidents and aspects of decommissioning of the plant are taken into account in more detail. Other relevant radiation safety guides during the construction license review phase are:

- YVL 1.10 Safety criteria for siting a NPP
- YVL 7.1 Limitation of public exposure in the environment of and limitation of radioactive releases from NPPs
- YVL 7.2 Assessment of radiation doses to the population in the environment of a NPP
- YVL 7.3 Calculation of the dispersion of radioactive releases from a NPP
- YVL 7.5 Meteorological measurements at NPPs
- YVL 7.6 Monitoring of discharges of radioactive substances from NPPs
- YVL 7.11 Radiation monitoring systems and equipment in NPPs.

Relevant safety guides during the operating license review phase are:

- YVL 7.4 NPP emergency preparedness
- YVL 7.7 Radiation monitoring in the environment of NPPs
- YVL 7.8 Environmental radiation safety reporting of NPPs
- YVL 7.9 Radiation protection of NPP workers
- YVL 7.10 Monitoring of occupational exposure at NPPs. [2]

1 General
2 Design principles
- 2.1 General requirements
- 2.2 Radiation sources and shields
- 2.3 Materials and their corrosion resistance
- 2.4 Plant layout
- 2.4.1 Rooms and access routes
- 2.4.2 Entering and leaving the controlled area
- 2.5 Decontamination of rooms and equipment
- 2.6 Decommissioning
- 2.7 Accidental situations

3 Radiation safety in systems design
- 3.1 Individual systems and components
- 3.2 Pipelines
- 3.3 Drainage and leak collection systems
- 3.4 Treatment of resins and concentrates
- 3.5 Limitation of the effluent release

4 Regulatory control

Figure 3: The main contents of the YVL guide 7.18 on the radiation safety aspects in the design of NPPs.

Collective Dose Target

In the updated regulatory guide YVL 7.18, a new design criterion for an annual personnel collective dose of 0.5 manSv per 1 GW of net electric power averaged over the plant life is set forth. Almost similar criterion is also written in the European Utility Requirements (EUR) document, where the target for annual collective effective dose averaged over the plant life is set as 0.5 manSv per reactor unit.

The existing reactors in Finland were commissioned between 1977 and 1981. Average personnel collective radiation doses per reactor for operating OECD country NPPs [3] and for existing Finnish NPPs for the years 1991-2001 are shown in Figure 4. The collective dose at the Olkiluoto NPP has been clearly under the international average value of the BWR reactors. On the other hand, the comparison of the collective dose at the Loviisa NPP to the average value of the PWR reactors does not give such an excellent result. Average collective doses per reactor of the German Konvoi generation NPPs (Emsland 1, Isar 2 and Neckarwestheim 2) and French N4 generation NPPs (Chooz B1 and B2, statistics only from the year 2001) [3] and the Finnish regulatory collective dose design criterion calculated for the EPR net electric power (0.8 manSv/year) and the collective dose target in the EUR document (0.5 manSv/year) are also shown in Figure 4. The statistics of the Konvoi NPPs would indicate that the collective dose in the EPR could be low.

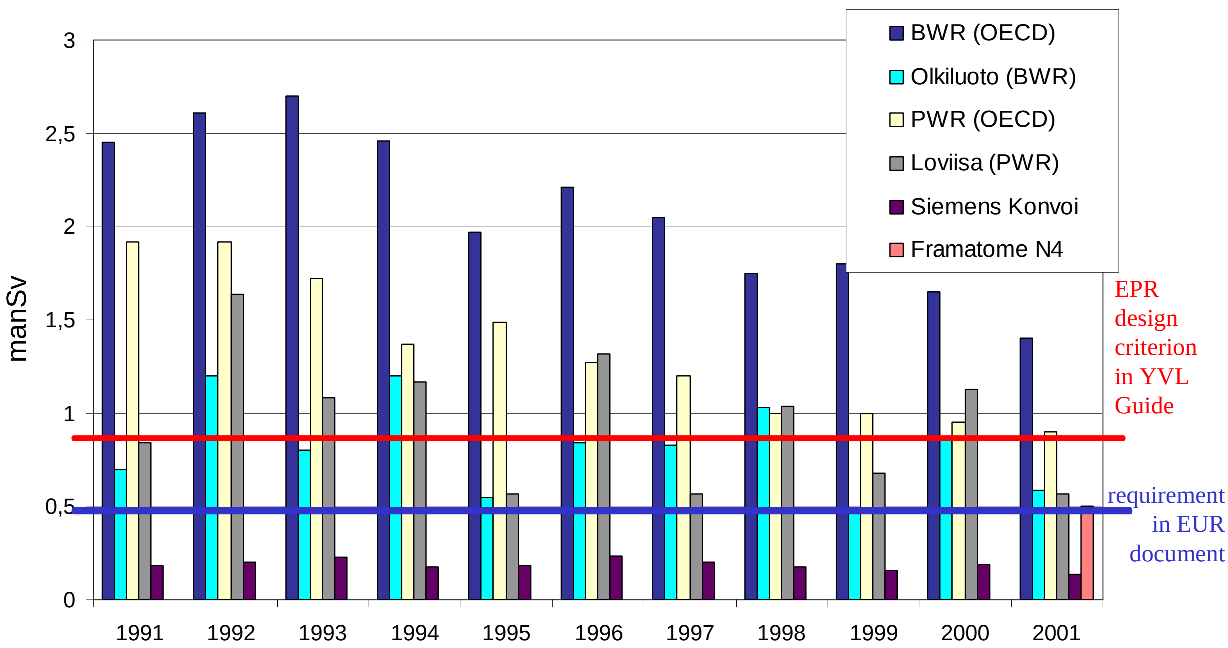

Figure 4: Average personnel collective radiation doses per reactor for operating OECD country NPPs, German Konvoi generation NPPs, French N4 generation NPPs and for existing Finnish NPPs.

On-site Habitability during Accident Situation

In a nuclear power plant, on-site habitability during accident situations has to be taken into account. “On-site habitability” determines conditions whether or not the occupancy of a certain area inside or outside the site buildings is possible on a continuous or transient basis. The regulatory guide YVL 7.18 requires analyses of the magnitude and location of the possible radiation sources and evaluation of doses in different accident management and emergency preparedness measures. In the design process, these doses shall not exceed the normal dose limits of a radiation worker. In a case of a real emergency situation, the normal dose limits can be exceeded while performing measures needed to save lives or restrict the radiation hazard and bring the radiation source under control.

Assessment of the on-site habitability during severe accidents at the existing Finnish nuclear power plants has been primarily done during 1980's and 1990's. A reassessment was done in 2002-2003 [4]. The method for assessing habitability included the following steps: defining the accident scenario and the sources of radiation, identification of the possible severe accident management actions and vital areas of the plant and finally calculating the dose rate levels in these vital areas. Habitability was evaluated based on the calculated dose rate levels, the occupancy times and the dose limits. Radiation hazard was classified into three parts, i.e., possible direct radiation from the containment, air contamination and systems carrying radioactive air or water. The results showed that direct radiation from the containment is generally adequately shielded but penetrations and hatches have to be separately analysed and the radiation dose levels near them are usually rather high. Skyshine radiation from the reactor containment is a special feature at the Loviisa NPP and the nearby area outside the buildings might have very limited access for the first hours after the accident. The skyshine effect is not usually relevant hazard in nuclear power plants, because they have adequate concrete shielding also in the roof of the containment. An interesting result was that air contamination also in the building next to the containment might be a hazard even if the containment is intact and leaks only at the nominal rate. Systems outside the containment can also create higher local radiation levels, e.g. near the emergency core cooling systems, containment spray system, sampling systems and containment filtered venting system.

[1] "Nuclear Energy in Finland," Ministry of Trade and Industry, Energy Department, Helsinki, October 2002.

[2] http://www.stuk.fi/english/publications/yvl-guides.html

[3] MADRAS database, version 3.8 (Rev. 9), European Technical Centre (CEPN), 2001/2002.

[4] K. Alm-Lytz, "On-Site Habitability at Finnish Nuclear Power Plants during Severe Accidents," Licentiate's thesis, Helsinki University of Technology, Espoo, 2003.