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Current Affairs in the Finnish Nuclear Sector

1 Finnish Nuclear Industry in Brief

At the moment, Finland has four operating reactors:

- Olkiluoto 1: BWR 75, 840MWe, 1979
- Olkiluoto 1: BWR 75, 840MWe, 1982
- Loviisa 1: VVER-440, 488 MWe, 1977
- Loviisa 2: VVER-440, 488 MWe, 1981

There are two power utilities, TVO (Olkiluoto) and Fortum (Loviisa). The regulatory authority is STUK (Radiation and Nuclear Safety Authority). VTT (Technical research centre of Finland) is making research in several different areas including nuclear industry. Posiva is an organisation responsible for the final disposal of spent nuclear fuel. It is owned by TVO and Fortum.

Figure 1. Finnish nuclear power plants. [3]

2 Olkiluoto 3 Construction

A new power plant, Olkiluoto 3, EPR ~1600 MWe is currently being built. According to the plant supplier, commercial operation of OL3 can start at the turn of the year 2010-2011.

At the moment (May 2007) some 1550 direct subcontractors are now involved in the OL3 project, from 28 different countries. The manufacture of components continues according to plans. The first recasting operations of reactor coolant pipelines have been completed and the pipes are now being tested. The manufacture of fuel pools is under way in France. The speed tests of the low-pressure turbines' rotors as well as the balancing of the rotors are under way. The components for the turbine condenser will arrive from Indonesia at the beginning of the summer, and the condenser will be installed in place during the summer. Installation of reinforcement for the next pouring stages has started inside and outside the steel liner of the reactor containment. The next two "storeys" of the liner are to be welded together, after which the steel ring with a total height of 12 m is erected in place in the reactor building at the beginning of the summer. The pouring of the external wall in the fuel building continues and installation of reinforcement for internal structures has started. The concreting of external walls in the safeguard buildings has also begun. The top slab of the turbine foundation has been poured. The amount of concrete needed for the 5m thick slab was almost 3700 cubic metres. The ground slab of the turbine building has also been cast, and

the switchgear building has reached eaves height. Total manpower on the construction site is now ca. 1360, and Finnish workers account for 45% of the manpower. All essential operations are carried out in two shifts, and major pouring operations continue as uninterrupted shift work. [1]

3 Plans for FIN6

On 28th March 2007, Teollisuuden Voima Oy (TVO) and Fortum Power and Heat Oy started the evaluation of the environmental impacts (Environmental Impact Assessment, EIA) of the new nuclear power plant unit (herein FIN6). The EIA of the Olkiluoto 4 option will be implemented by TVO, and the EIA of the Loviisa 3 option by Fortum. The EIA process comprises two stages. The first is the preparation of the EIA programmes by the power companies and the second the drafting of the EIA reports. In both phases, the Ministry of Trade and Industry will act as the contact authority. [2]

4 TVO 1 & 2 Recent Activities within I&C

OL1 and OL2 plants have operated well without any remarkable technical disturbances. Average capacity factor 2006 was 95,4% and the total production 14,3 TWh. Lots of effort has been concentrated to management of ageing.

In 2006, the turbine island modernization was finalized including: HP-turbine modifications, new 2-stage reheater, new steam dryer (moisture 0,3% -> 0,01%), new turbine automation system including control room equipment, new 6,6 kV switchgears and net power increase about 20 MW per unit. Also water handling and desalination system automation was modernized.

In 2007, the main activities will be the finalization of the gas turbine plant (100 MW unit for grid support and emergency power) and the start of some minor I&C renewals. Plant radiation monitoring system renewal, environment radiation monitoring system, and weather station renewals will be started. Also seawater cleaning screens automation will be renewed.

Some not fixed future plans for the I&C activities are:

- Half-long service outage in ~2010-2011
  - Low-pressure turbine modernisation
  - Low pressure turbine renewal
  - Turbine vibration monitoring renewal
  - Automation for condensation water handling
  - Generator renewal
  - Reactor main steam line isolation valves
- Long service outage ~2015-2016
  - Renewal of reactor automation
  - Core shroud and other internals
  - High pressure turbine optimization
  - Cables

5 Recent Activities Related to I&C Systems in the Loviisa NPP

In the Loviisa 1 and 2 automation renewal (LARA-project), the I&C systems of the plant will be renewed gradually; there will be four stages per plant unit. The first system commissioning will take place this year (2007) and the last in the year 2014.

Automation renewal supports the operation of the plant. The goals of the plant operation are maintaining safety on its current good level, maintaining availability on its current good level, and long operation time (50 years).

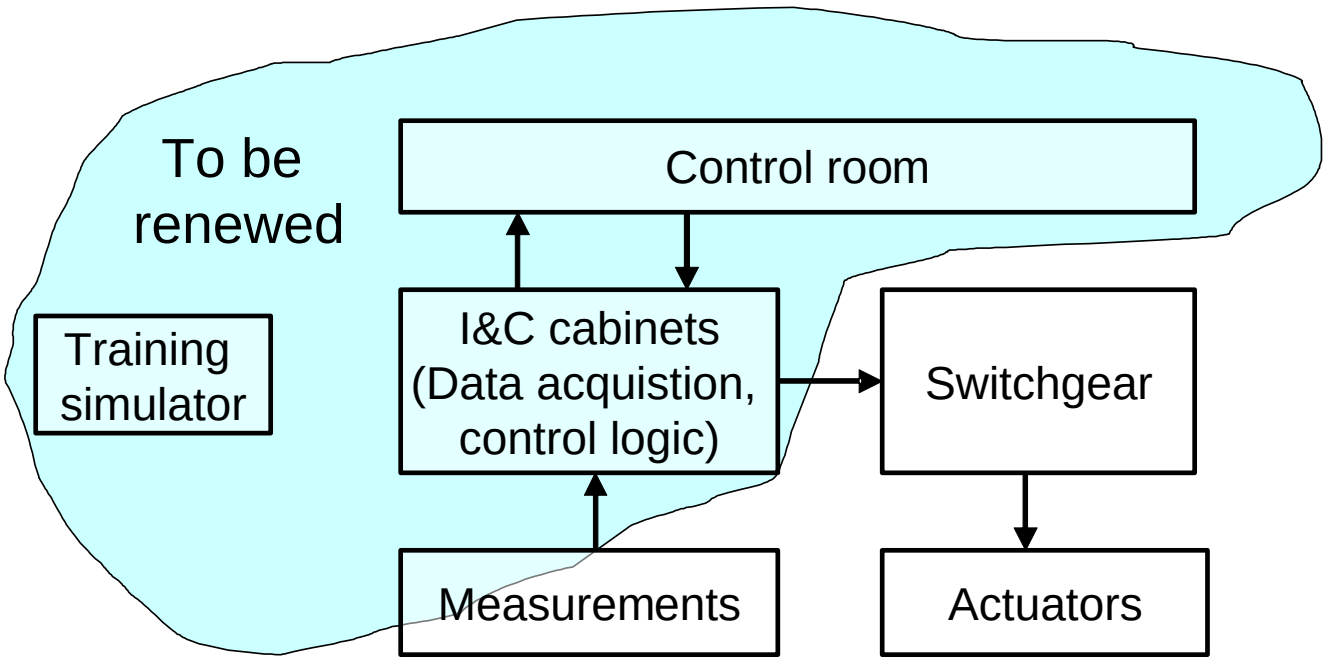

Figure 2. Scope of the renewal project.

The main principles of the renewal are as follows:

- The I&C functions will remain as they are, as a rule.
- Tolerance of CCFs will be built in the I&C concept.
- New I&C cabinets will be placed in the new buildings that fulfill all new requirements.
- Simulators will be used extensively for various purposes:
  - process and control design
  - transient and accident analyses
  - development and validation of the MMI
  - testing of I&C
  - operator training.

There are four renewal stages:

1. Part of reactor I&C and nuclear water treatment I&C
2. Reactor protection system
   - Scram
   - ESFAS
   - I&C of the emergency diesel generators
3. I&C of the primary circuit and the relating auxiliary systems.
4. I&C of the secondary circuit and the relating auxiliary systems.

Fortum has made a contract of the first three stages with the consortium of AREVA NP (former Framatome ANP) and Siemens AG. AREVA's platforms are used for the safety I&C:

- TELEPERM XS

- QDS (Qualified Display System)
- Hardwired equipment (for the Manual Backup of the Reactor Protection System).

Siemens' platforms are used for the operational I&C (and for the Automatic Backup of the Reactor Protection System):

- SPPA T2000 (former TELEPERM XP)
- OM690 (operating stations).

6 STUK's Activities

The Finnish radiation and nuclear safety authority STUK is responsible for regulating the use of radiation and nuclear energy. STUK also carries out research on radiation and its effects and monitor radiation safety of the Finnish environment.

STUK's activities within nuclear energy are naturally dependaple on the activities going on in constructing and modernisation projects in the plants.

7 SAFIR - The Finnish Research Programme on Nuclear Power Plant Safety 2003 – 2006

Major part of the Finnish public research on nuclear power plant safety during the years 2003-2006 was carried out in the SAFIR programme. The key research areas of SAFIR were:

1. Reactor fuel and core
2. Reactor circuit and structural safety
3. Containment and process safety functions, that was divided in 2005 into 3a) thermal hydraulics and 3b) severe accidents
4. Automation, control room and IT
5. Organisations and safety management
6. Risk-informed safety management.

Figure 3. The main participants of the SAFIR 2003 – 2006 research programme.

The research programme included annually from 20 up to 24 research projects, whose volume varied from a few person months to several person years. The total volume of the programme during the four year period 2003-2006 was 19.7 million euros and 148 person years. The research in the programme was carried out primarily by Technical Research Centre of Finland (VTT). Other research units responsible for the projects include Lappeenranta University of Technology, Fortum Nuclear Services Oy, Helsinki University of Technology and RAMSE Consulting Oy. In addition, there have been a few minor subcontractors in some projects.

SAFIR Final Report and Executive Summary are available in the SARIR webpages http://www.vtt.fi/safir.

8 SAFIR2010 - The Finnish Research Programme on Nuclear Power Plant Safety 2007-2010

SAFIR2010 research programme on nuclear power plant safety for the years 2007-2010 is strongly based on the chapter 7a, “Ensuring expertise”, of the Finnish Nuclear Energy Act. The programme is the newest link in the chain of public research programmes on nuclear safety that have proved to excel in order to maintain and develop know-how in Finland. The steering group of SAFIR2010 consists of representatives from Radiation and Nuclear Safety Authority (STUK), Ministry of Trade and Industry (MTI), Technical Research Centre of Finland (VTT), Teollisuuden Voima Oy (TVO), Fortum Power and Heat Oy, Fortum Nuclear Services Oy (Fortum), Finnish Funding Agency for Technology and Innovation (Tekes), Helsinki University of Technology (HUT) and Lappeenranta University of Technology (LUT). SAFIR2010 research programme is divided in eight research areas, which are:

1. Organisation and human factors
2. Automation and control room
3. Fuel and reactor physics
4. Thermal hydraulics
5. Severe accidents
6. Structural safety of reactor circuit
7. Construction safety
8. Probabilistic safety analysis (PSA)

In 2007 there are altogether 30 research projects. The total volume of the programme in 2007 is planned to be approximately 46 person years and 6.3 M€

9 Automation and Control Room Related Projects in SARIF2010

Model-Based Safety Evaluation of Automation Systems (MODSAFE)

The assurance of automation systems and devices for use in critical applications requires the safety assessment of their software. In this project, methods based on formal model checking are developed and applied in the safety analysis of NPP safety automation. The general objectives of the project are:

- Development of methods for model based safety evaluation of NPP automation
- Application of the methods in selected case studies
- Evaluation of the suitability of formal model checking methods for NPP automation analysis
- Operationalisation of model based safety evaluation to a part of safety case of safety automation systems

- Development of recommendations for the practical application of the methods

The model checking methodologies applicable for analysis of safety critical programmable systems have been developed and applied in other industries. However, these methods have not been applied in the safety evaluation of NPP automation systems in Finland, but the need for more or less formal and automated analyses has been identified in the practical analyses made to support licensing of programmable systems. For example, the manual inspection of programmable safety functions is difficult, and often insufficient.

The results of the project are applicable in the safety analysis of NPP safety automation functions and automation devices in many ways: the inspection of automation functions (e.g. functional block diagrams) is easier when automated tools are available, the complex safety issues related with time dependent features of the systems (delays, sequential functions, memory) can be systematically analysed. In general, applications of more or less formal methods provide useful information and insight about the automation systems.

The project has two main partners, VTT Technical Research Centre of Finland and Helsinki University of Technology.

Certification Facilities for Software (CERFAS)

According to the Finnish YVL Guide 5.5, all equipment in Safety Class 2 and essential accident instrumentation in Safety Class 3 shall possess a type acceptance certificate. In response to this need, CERFAS project develops facilities for software certification services, primarily for demands on NPP control fields in Finland.

The aim of the project is to develop facilities for a high level software certification service. Conditions for high level services are the application of diverse expertise and effective dedicated evaluation tools. This leads to networking in the area of software certification services.

The objective of CERFAS is to develop facilities for flexible, supported, commercially exploitable, high quality software certification service able to certify safety critical and safety related software. The other main features to support the service are the following: advanced methods for evaluation of software process and artefacts, that is, documents, code, test plans, etc. competence development to provide facilities for software certification service.

Operator practices and human-system interfaces in computer-based control stations (O'PRACTISE)

The project aims at developing practices of Human Factors Engineering (HFE) for the design, operation and evaluation of human-system interfaces at nuclear power plant (NPP) control rooms. In the project, it will be gathered knowledge of changing operator practices and new human-system interface (HSI) solutions in order to promote safe use of digital technologies and develop new methods and practices for the management of design process and evaluation of the safety of HSIs. The aim is also to develop expertise in user-centred design of complex industrial systems in Finland, further promote international collaboration with research and expert organizations, and institutions and strengthen the delivery of expertise in the field of user-centred design.

As a result of the project, a realistic concept of operation for digitalized control rooms (CRs) can be developed, and new ideas and concepts for presentation of process information can be presented. The project will collaborate with, and is partly funded by the Halden Reactor Project (HRP). The project will also collaborate with Electricité de France (EdF).

10 Recommendations to the IAEA-TWG-NPPCI

The following list of topics gives some ideas to the IAEA-TWG-NPPCI to be considered while planning the future activities.

- Possibilities of Open souce in the area of safety-critical software.
- Design and licencing patterns as a means to front-load readiness to develop and evaluate safety-critical software.
- Automated tools for the analysis of software modules.
- Managing the large difference in lifetime between nuclear power plants and I&C systems.
- Managing complexity while introducing diversity in I&C systems.
- Concept of operations and operator practices in digitalised control rooms.
- Functional & task analysis for operator functions.
- Information tools for improving collaboration between operations and maintenance.
- Role of large screen displays in supporting situation awareness.
- New methods to analyse and control mental effort in stress situations.
- Human Factors Engineering practices in design of automation and control stations.

11 References

[1] Olkiluoto 3 - Current news in May 2007 (http://www.tvo.fi)

[2] Ministry of Trade and Industry 2007, Nuclear energy (http://www.ktm.fi),

[3] Ministry of Trade and Industry 2007, Nuclear Energy in Finland (http://www.ktm.fi/files/15316/NuclearEnergyinFinland.pdf)