

Loviisa Nuclear Power Plant Power Upgrading Project

Problem Statement

The safety analyses were needed to prove that the uprated 1500 MWth power level of Loviisa Nuclear Power Plant does not cause any safety problems.

Improvement Approach

The safety analysis included dynamic simulation studies of a series of accident scenarios. Main tool in the analysis work was APROS Simulation Software.

Benefits

The safety analysis results showed that Loviisa reactors can be safely operated on the higher power. Presently Loviisa NPP is operating on average 50 MWe higher electrical power per unit.

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Figure: Fuel Rod Cladding Temperature During Large Break Loss of Coolant Accident



PROBLEM STATEMENT

A feasibility study for modernizing the two 465 MWe VVER units of Loviisa Nuclear Power Plant (Finland) was carried out starting in spring 1994. During the study no technical, safety or licensing issues were identified which would have prevented raising the reactor thermal output up to 1500 MWth from the level of 1375 MWth. Thus the modernization project including a 9.1 % reactor power upgrading was launched in summer 1995.

It was obvious from the very beginning that reactor power upgrading would bring about a need for extensive revision of the Loviisa Final Safety Analysis Report (FSAR) including the safety analyses. It was also clear that tasks related to the safety assessment by appropriate computer codes and models would be on the critical path on the project schedule. That is why this work was started at the same time as the project organization was put together and the master plan prepared.

The intention was to increase in the plant capacity, by about 50 MWe per unit. This was planned to be achieved by a combination of reactor thermal power upgrading and by improving turbine efficiency.

The uprated reactor power was expected to raise the temperature difference over the reactor by three degrees and the temperature of the sea water trough condenser by one degree.

The analyses were needed to update the Loviisa FSAR to correspond to the uprated 1500 MWth power level and thus to prove that power upgrading does not cause any safety issue.

IMPROVEMENT APPROACH

In 1995 Fortum Oy (former Imatran Voima Oy) decided to implement Loviisa modernization and power uprating project major. The major part of the revised Loviisa FSAR thermal hydraulic analyses were calculated using the APROS simulation software.

The choice of APROS as a main tool was based on several facts. Loviisa reactor features have been included to APROS. APROS has also gone through a wide validation program including calculation of both separate effect tests, integral tests and tests using data from PACTEL facility. APROS has successfully been used in process and automation design for Loviisa NPP.

A completely new simulation model of Loviisa NPP was build for the project. This was to ensure that all the input data was correct and the sources properly documented.

The model included whole primary circuit including safety systems, steam generators, steam lines and safety critical automations systems.

The model was extensively validated against measurement data from the plant commissioning tests etc.

Around 30 different initiating events and scenarios were calculated and their sensitivity to various parameters investigated. Simulations were done using the uprated power level:

- Large break and small break loss of coolant accidents
- Anticipated transients without scram (ATWS)
- Primary to secondary leakages
- Several different pump trips, line breaks, blackouts and valve malfunctions etc.

BENEFITS

Based on the analysis results 1500 MWth is a safe power level to operate Loviisa reactors from the safety analyses point of view. This result was also expected because earlier licensing analyses, concerning 1375 MWth nominal power level, had shown that the margins to the acceptance criteria were in most cases substantial.

The large break loss of coolant accident (LBLOCA) is generally regarded as one of the critical accident scenarios. That is because virtually the whole reactor core will be dry shortly after the break. The results showed as expected that even in this case the hot rod cladding temperature can be maintained in safe region and the whole core is rewetted in about five minutes after the break.

As for the APROS code, it can be said that the code was successfully applied in the analyses.

Several operational transients and postulated accidents were analyzed and not a single major problem was detected which would have made the users to think of changing over to another code.

APROS proved to be such an excellent tool on safety analysis field that Fortum Nuclear Services are currently doing practically all the safety analyses using APROS code. The earlier major tool RELAP5 code has a role in assessing the APROS analysis results.

The power uprating was successfully concluded in 1999. Presently Loviisa NPP is operating at the uprated power level meaning on average 50 MWe higher electrical power per unit. Depending on the price of electricity this translates into additional revenue of 10-15 M€/year and unit.