

Effects of the

Power Upgrade Project GREAT

on the PSA study for the Nuclear Power Plant Ringhals 3

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Ringhals 3 PSA

Ringhals 3 is (after the first part of the power upgrade) a 3000 MWt PWR of Westinghouse design taken into operation in 1981.

PSA has been performed in different campaigns since the 1980:ies.

The current PSA study is plant specific and covers both the risk of core damage, PSA level 1, and the release of source term, PSA level 2, for power operation and the shutdown states.

Almost all relevant internal events have been considered together with important external events, like extreme weather conditions, and area events like fire and internal flooding.

The power upgrade project GRadual Energy Addition unit Three (GREAT)

GREAT was started in 2003 with the aim of increasing the thermal power in two steps, first from 2783 MWt to 3000 MWt and then from 3000 MWt to 3160 MWt.

The project has involved plant changes both on the primary and on the secondary side, for example the reheating system has been renewed and extended. Furthermore a new safety analysis has been performed and the Safety Analysis Report (SAR) has been thoroughly updated.

The first part of the power upgrade was finalized in 2005 and the application for the permit to perform the second part was sent to the SKI in the autumn of 2007 where it is now being reviewed.

Possible effects on the PSA

A power upgrade can affect the PSA in several aspects:

- Increased temperatures and pressures can affect the success criteria
- The probabilities for failure of operator actions can increase
- The new source term can change the release categories
- Introduced plant changes can affect the PSA

Success criteria

The success criteria used in the PSA study are based on the conditions given in the Safety Analysis Report (SAR)

The safety analyses, which form the foundation for the SAR, have conservatively been performed for a higher power level than the one used in the plant at the moment.

In combination with a reduced uncertainty due to more accurate measurements of the feedwater flow and better fuel properties that reduce the probability of fuel bending, these analyses have been judged to be valid also after the power upgrade.

Failure Rates for Operator Actions

A HRA investigation was performed for the first part of GREAT. The focus was on changes in the available grace time for operator actions but the effects of different plant changes were also evaluated.

Five operator actions, for which the failure probabilities were changed, could be identified.

The main conclusions from the investigation were judged to be valid also for the second part of GREAT.

Operator actions judged to be affected by the power upgrade

Manual action ID	Description
___X.DT1.L___NO	No manual start of the auxiliary feedwater system
___X1.T___NO	Manual depressurisation fails. Early in the sequence
___X4___NO	Manual activation of feed and bleed fails. Early in the sequence
___X5___NO	No manual activation of cooling with the residual heat removal system
___X20/21.L_DIA___NO	No isolation of letdown line, no separation of charging pump trains (V-334_1). Early in the sequence

Release Categories and the Large Early Release Frequency

All relevant Release Category analyses were recalculated for the new power level, using the Modular Accident Analysis Program version 4 (MAAP4).

Three release categories were changed. This affected the large early release frequency (LERF), which increased with a little less than 4 %.

The changes in timing for release of source term did not change any release category from a late to an early release.

Plant changes

Some plant changes judged to affect the PSA were

- the introduction of passive autocatalytic hydrogen recombiners
- improvements of the fire protection system
- installation of a diesel secured power supply to the spent fuel water pumps
- replacement of the power operated relief valves

Most of the plant changes were introduced to improve the safety level of the plant and counteract possible negative effects from the power upgrade itself.

Summary

The direct changes in the PSA due to the power upgrade were rather small and several plant changes were introduced to improve the safety level.

Hence, the power upgrade project did not result in any decrease of the safety level of the plant.

Thank you for the attention