Report of the stress test peer review follow-up fact finding site visit to Ringhals, Sweden, 13-14 September 2012

1 INTRODUCTION

In accordance with the action plan set out by ENSREG following the peer review of the stress tests, the fact finding team of four international experts and a representative of the regulatory body (SSM) visited the Ringhals nuclear power plant (NPP) in Sweden. The objective being to exchange information with respect to measures to improve safety and to identify any lessons learned from implementation of these measures. Ringhals has 4 units, an ASEA-Atom BWR (R1: 2600MWth, in operation since 1973) and 3 Westinghouse three-loop PWRs (R2: 2660MWth, 1974; R3:3151MWth, 1980, R4: 2783MWth, 1982). The current plant licensee is Ringhals AB (RAB).

In addition to the ongoing modernisation programme required by the regulation SSMFS 2008:17 (2005), RAB, in response to the Fukushima and the stress tests performed an assessment of the plant capabilities, and developed an action plan for safety enhancement of Ringhals NPP. This action plan is divided into three phases (see the table):

Immediate	Completed	1	Improved power supply system for the on-site ECC
		2	Walk-down: EOP clarifications; improved training on mobile equipment; improved adaptors for feeding SG using fire water system; new portable lights and torches; improved supervisors licensing; and renewed SAMGs training
		3	Spent fuel pool cooling: clarification of maintenance procedures; and improved EOP
		4	Analyses: external events, station blackout, spent fuel pool cooling and hydrogen control; electric accumulators capacity; and extended SBO analyses
Short term	To be completed by end of 2013	1	Improved emergency preparedness organization: improve food supplies; improve training; and prepare plans in order to overcome site isolation at severe site conditions
		2	Technical improvements: adaptors allowing fire trucks to feed filtered vent equipment; and flooding protection improvements
		3	Operator instructions: modernize site supervisor plan concerning severe weather; improved plans for replenishing supplies; improve instructions for re-starting a unit from complete AC and DC blackout; and improve action plan for OBE
Long term	Pre-feasibility studies to be presented by end of 2013	1	Addition of mobile equipment and strengthen emergency organization
		2	R1-4 Re-qualify buildings and equipment to cope with H4 external events. Analyses and possibly some plant modifications
		3	R1-4 Re-qualify containment and PMR – buildings to meet H5 external events. Analyses and possibly some plant modifications
		4	R3-4 Increased station DC coping time
		5	R1-4 Improve DC charging capability
		6	R2-4 Install low leakage RCP seals
		7	R2-4 Install CRDM rigging
		8	R1-4 Install additional means for SFP charging

The visit consisted of presentations delivered by RAB on the current status of the action plan, followed by discussion, and by a site tour. The whole site was addressed by the follow-up visit, but it was more focused on PWR units, since BWR type plant in Sweden (Forsmark) was visited during the stress test peer review. During the site tour, cooling water intake and outlet structures, various compartments of the filtered containment venting (FCV) building, diesel generator (DG) building, fire brigade facilities and the on site emergency control centre (ECC) were visited.

2 ASSESSMENT RELATIVE TO EARTHQUAKES, FLOODING AND OTHER EXTREME WEATHER CONDITIONS

The Swedish peer review report identified several findings related to compliance of NPPs to updated design basis and beyond design external hazards. Some of the findings were related

to clarification of safety assessment methods and acceptance criteria. It is expected that the planned actions to be completed by 2013 will improve compliance with an updated design requirements for external hazards, but completeness of the programme regarding the issues identified during the peer review still should be assessed by SSM.

Specification of immediate and short term actions aimed at enhancing seismic resistance was made by RAB using the seismic margin assessment (SMA) methodology. This type of methodology can be useful for the identification of modifications needed to comply with some design basis earthquake. However, selection of appropriate methods for determination of seismic hazard in more general scope including consideration of seismically induced fires or floods should be still addressed within the long term actions.

Existing seismic instrumentation is shared between two and two units (1 and 2; 3 and 4) and communication between two control rooms may be an issue. The seismic instrumentation for unit 3 is installed underground on the bedrock between the containment building and the foundation of the FCV building, i.e. not in the open field. Due to potential influence of the monitoring by the buildings the acceptability of this arrangement should be carefully examined in regard of the Swedish geological context.

The definition of high sea level for assessment of the margin against flooding remains an issue to be further considered since the site platform is at about 3 m level in comparison with the high sea level 2.65 m, which could be a concern regarding adequacy of the margin. Specification of the protection against flooding over 3 m will be considered in the long term actions for beyond design basis improvements. In connection with this issue the team visited the ECC located under a non-seismically resistant building with all its entrance doors located close to the building at 3.20 m level. The vulnerability of the ECC should be reassessed.

SSM expects that the relevant WENRA Group will provide guidance on assessment of external hazards, which can be used also for development of national requirements.

3 ASSESSMENT RELATIVE TO LOSS OF ELECTRICAL POWER AND LOSS OF ULTIMATE HEAT SINK

Although certain mobile equipment was provided to RAB in 80-ties, additional needs for mobile power resources with fixed connection points, as well as increased robustness of existing power sources, was identified as a major potential measure for improvement in case of loss of AC power. Similarly, enhancement of the supply of water for cooling the reactors, containments, the emergency DGs, and the spent fuel pools (SFPs) was to be considered. Potential leakages through the reactor coolant pump (RCP) seals in case of prolonged station black-out was also identified as an issue.

The action plan considers a number of improvements in this area. The plan includes procurement of additional power sources and pumps, new piping, connection points and extra instrumentation for local control. The plan also includes new mobile DGs for battery charging and other purposes, power sources for control actions, such as compressed air for valve operation, and increasing battery capacities. The RCP seals will be changed or modified to make them leak resistant, without relying on cooling water.

In the plant assessment it was realized that during fuel loading the existing gravity fed injection of water into the reactor may not be sufficient and further analysis to address this issue is ongoing.

All Swedish NPPs are dependent on sea water as the ultimate heat sink and a re-evaluation of emergency procedures and implementation of possible changes regarding alternative cooling capabilities is ongoing.

4 ASSESSMENT RELATIVE TO SEVERE ACCIDENT MANAGEMENT

During the site visit it was reconfirmed that the adequate hardware measures (hydrogen recombiners, filtered containment venting (FCV), containment spray/flooding from mobile sources, resistant main control room and both on-site and off-site emergency centres) as well as symptom based emergency operating procedures (EOPs) and severe accident management guidelines (SAMGs) were introduced in Ringhals already in the 80s. Areas for further safety improvements identified in the Swedish peer review report include consideration of: multiple unit accidents; long term performance of FCV; management of large volumes of contaminated water; treatment of hydrogen outside the containment, including SFPs; enhanced monitoring of parameters in SFPs; enhancement of SAMGs for all plant states; training and drills for extended scope of SAMGs; further enhancement of on-site emergency centres and of off-site emergency centre.

Based on presentations and discussions held during the site visit it can be stated that the post Fukushima action plan adequately covers areas for improvements identified in the peer review report, with the following more specific comments:

- Existing provisions for mitigation of severe accidents generally seem to provide efficient mitigation of severe accidents and will be further significantly strengthened for very unlikely external hazards with frequency of occurrence $\leq 10^{-7}$/year
- In the current Ringhals strategy the FCV is only considered as ultimate containment overpressure protection and not as means for containment heat removal, and in the opinion of the plant its long term performance does not represent an issue
- The plant is advised to reflect more explicitly in the action plan the areas for improvements listed above, and demonstration of feasibility of SAMGs under harsh radiological situations and severely damaged infrastructure, the increased robustness of emergency facilities against external hazards and integration of SAMGs into on-site emergency plan and physical protection plan.

5 CONCLUSIONS

The follow-up Ringhals plant visit observed that significant progress has been made for the implementation of post-Fukushima safety improvements.

In addition to existing safety provisions and ongoing modernization programme, there is a comprehensive post-Fukushima action plan for further enhancement of the robustness of the plant. The action plan adequately reflects areas for improvements identified in the Swedish peer review report. Nevertheless the plant is advised to update the action plan taking into account full set of ENSREG recommendations. The plant and SSM should establish the processes to ensure that the plan is implemented in accordance with the established schedule, and in particular that the important safety modifications will be implemented in the near future.

Plans for long-term actions include strengthening of permanently installed severe accident mitigation equipment for very unlikely external hazards with frequency of occurrence $\leq 10^{-7}$/year, and providing mobile equipment with adequate capacity separately for each of the PWR Ringhals unit plus one spare equipment for the whole site is above the usually adopted approach and are considered by the team as good practices possibly applicable for other plants.