Strål
säkerhets
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Swedish Radiation Safety Authority

Swedish action plan
for nuclear power plants

Response to ENSREG's request Rev.1

December 2014

Abstract

The action plan was issued for the first time in December 2012 and has been reviewed and revised in December 2014. This report is supplemented with a new section V, "Progress on implementation and update of the Action Plan", following the table of content according to requirements on national updated reports presented in "ENSREG 2nd National Action Plan ToR-Final, HLG_p(2014-28)_141". Furthermore, the tables containing actions under part IV has been updated commenting current action status.

Following the severe accidents which started in the Fukushima Dai-ichi nuclear power plant, the European Council of 24/25 March 2011 requested stress tests to be performed on all European nuclear power plants. The Swedish national action plan is part of these stress tests and has been developed with the intention to manage all plant weaknesses identified by the EU stress tests as well as by other forums such as the second extraordinary meeting under the Convention on Nuclear Safety. For the most part, the Swedish national action plan presents investigations whose aim is to determine and consider which measures are fit for purpose, how they shall be implemented as well as the point in time for this. The Swedish national action plan mainly contains crosscutting and comprehensive measures due to the fact that it is crucial that the significance to safety of the measures' is considered in relation to other measures to improve safety that are in progress or are planned, but that are not covered by The Swedish national action plan. This is essential for ensuring that the level of safety at Swedish nuclear power plants is always as high as is feasible and possible.

The measures listed in the Swedish national action plan are scheduled in three different categories, 2013, 2014 and 2015, corresponding to the year when the measures shall be completed. This categorization is based on an assessment of the urgency of the measures' implementation as well as the complexities of these measures. If the measures are described as investigations the deadline refers to the report of this investigation. The deadline does in these cases not include any technical or administrative measures that the investigations reports are expected to propose. Furthermore are all licensee actions (LA) in the Swedish national action plan valid for all Swedish NPPs.

SSM did in early 2013 conduct a conjunction to the licensee holder in accordance with the schedule in the Swedish national action plan. SSM did in connection with the conjunction introduce parameters and parameter values in order to clarify the level of ambition of measures in the Swedish nation action plan. This in order to establish a framework that guarantee a consistent and quality assured process with the goal to further improve reactor safety as much as reasonable and possible. Depending of reported results and conclusions of the coming evaluations SSM will follow up with new conjunctions in order to secure that necessary technical and administrative measures will be implemented.

SSM has continuously performed reviews of the licensee actions belonging to each category and thereafter decided of further work, including implementation of necessary technical and administrative measures. It is therefore highly likely that the majority of necessary technical and administrative measures will be implemented after 2015 due to a high degree of complexity, though it's important

that all necessary measures will be implemented as soon as reasonable possible. All necessary actions resulting from the investigations, such as technical and administrative measures shall be fully implemented before the end of 2020.

Table of Contents

I General data about the sites and plants

I.1 Background

Following the severe accidents which started in the Fukushima Dai-ichi nuclear power plant, the European Council of 24/25 March 2011 requested stress tests to be performed on all European nuclear power plants. The Council invited the ENSREG, EC, and WENRA to develop the scope and modalities for the stress tests. WENRA drafted the preliminary stress test specifications in April. On 24 May 2011 full consensus of ENSREG and EC was achieved. The stress tests and peer review focus on three topics which were directly derived from the preliminary lessons learned from the Fukushima disaster as highlighted by the IAEA missions following the accident and reports from the Japanese Government. Natural hazards, including earthquake, tsunami and extreme weather, the loss of safety systems and severe accident management were the main topics for review.

SSM submitted the final national stress test report on 31 December 2011 (1). The peer review was completed with a main report that includes final conclusions and recommendations at European level and a report that include specific conclusions and recommendations for Sweden. The report was approved by ENSREG and the EC on 26 April 2012 (2). In a joint ENSREG/EC statement the stress test report was accepted and it was agreed that an ENSREG action plan would be developed to track implementation of the recommendations. As part of the ENSREG action plan each national regulator will generate a country-specific action plan. Therefore SSM on 26 April 2012 (3) required all licensees to present action plans for dealing with the deficiencies identified during the European stress tests. On 15 September each respective licensee submitted their action plans.

ENSREG decided that a consistent compilation of peer review recommendations and suggestions will be prepared, to assist the preparation or review of national action plans by national regulators (4).

I.2 Method

The Swedish national action plan has been developed, in agreement with the Swedish NPPs, with the intention to handle all plant weaknesses identified by the EU stress tests as well as by other forums such as the second extraordinary meeting under the Convention on Nuclear Safety.

The conclusions drawn by SSM on the basis of the ongoing modernization work at Swedish nuclear power reactors were also taken into consideration when preparing the Swedish national action plan. This knowledge and the lessons learned have demonstrated the importance of thorough investigation and quality assurance of the measures implemented. It is also crucial that these measures' significance to safety is considered in relation to other measures to improve safety that are in progress or are planned, but that are not covered by the Swedish national action plan. All of these factors are essential for ensuring that the level of safety at Swedish nuclear power plants is always as high as is feasible and possible.

For the most part, the Swedish national action plan presents investigations whose aim is to determine and consider which measures are fit for purpose, how they shall be implemented as well as the point in time for this. SSM has primarily chosen to define crosscutting and comprehensive measures in the Swedish national action plan. Assessments in terms of detailed measures for individual reactors must and will be conducted as part of the work ensuing after preparation of the Swedish national action plan.

The Swedish national action plan is, for topic 1-3 (Chapter 1-3), in many ways comparable to the list of identified measures in the ENSREG report, *Compilation of recommendations and suggestions – Peer review of stress tests performed on European nuclear power plants* (4), but also includes specific measures identified in the Swedish national stress test report (1) and the Swedish peer review report (2), as well as other measures identified by the licensees outside of the scope of the stress tests or identified by other fora, such as the second extraordinary meeting under the Convention on Nuclear Safety (5). The Swedish national action plan covers all Swedish NPP sites, though for the preparation of the Swedish national action plan, SSM resolved that each licensee must present a site-specific action plan describing all measures planned for each reactor or its organization, taking all the above into consideration. These site-specific action plans (6), (7) and (8) form the basis of the Swedish national action plan, although each individual site or unit-specific measures has not yet been reviewed. However, SSM assumes that the licensees, to the extent that is reasonable and possible, already now begin the work with implementing measures, which to today have been identified as suitable to implement.

A review will be performed as part of a step-wise process during the implementation of the Swedish national action plan. The implementation of the Swedish national action plan will begin with establishment and completion of site-specific action plans, which will include a review by SSM to ensure that all measures identified in the Swedish national action plan have been appropriately considered for each reactor. This step will be followed by the licensees implementing and completing each measure. Prior to the implementation of a measure SSM will perform a review and regulatory supervision in accordance with normal procedures for plant improvements. Most measure consist of two phases, where the initial phase covers further evaluations and analyses to determine whether additional technical and administrative measures are needed. If so, the second phase will include implementation of such measures. If the results from the evaluations and analyses indicate that no further measures are needed, SSM will perform a review to ensure the quality of such decisions.
Regarding the measures presented under topic 4-6 and additional topics and conclusions (Chapter 4-7), measures are in addition to the lessons learned from the nuclear accident at Fukushima Dai-ichi in 2011, measures are also identified based on Swedish and international operating experience, recent safety analyses, research findings, results of development projects and experience gained from emergency preparedness exercises. Many of these lessons learned are the outcomes of the activities of the Swedish emergency organization during and after the Fukushima Dai-ichi accident. This includes experiences gained when the emergency organization at SSM was activated around the clock over a three-week period to monitor the events in Japan, as well as the experience feedback from SSM's visit to Japan that took place after the accident. Prior to the implementation of a measure SSM will perform a review and regulatory supervision in accordance with normal procedures for plant improvements.

The measures listed in the Swedish national action plan are scheduled in three different categories, each category with its own deadline when the measures shall be completed. If the measures are described as investigations the deadline refers to the report of this investigation. The deadline in these cases does not include any technical or administrative measures that the investigation reports are expected to propose. The categories are as follow:

2013	Measures shall be completed by 31 December 2013
2014	Measures shall be completed by 31 December 2014
2015	Measures shall be completed by 31 December 2015

This categorization is based on an assessment of the urgency of the measures' implementation as well as the complexities of these measures. The categories were chosen to create a framework for efficient and quality-assured implementation of each action, but also to form the basis for an appropriate and transparent implementation process that will be sufficient for each stakeholder. Furthermore are all licensee actions (LA) in the Swedish national action plan valid for all Swedish NPPs.

I.3 Brief description of the Swedish nuclear power plants

There are 10 nuclear power reactors in operation in Sweden; seven BWR and three PWRs. All the BWRs were designed by the domestic vendor ASEA-ATOM (later ABB Atom, now Westinghouse Electric Sweden AB) and all the PWRs by Westinghouse (USA). The three oldest BWRs have external main recirculation loops while the other four units have internal recirculation pumps with no large pipes connected to the reactor pressure vessel below core level. The BWR containments are all of the PS-type and various layouts of the vent pipe configuration and pressure suppression pools. All PWRs are 3-loop standard Westinghouse design reactors.

Measures to increase the level of safety at Swedish nuclear power facilities have gradually been taken in accordance with new knowledge and experience. New knowledge and experience have emerged from lessons learned from incidents and accidents, from research, from safety analyses and from new reactor designs. International accidents/ incidents such as the TMI nuclear accident in 1979 as well as domestic incidents such as the 'strainer event' in Barsebäck 2 in 1992 and the electric power system event at Forsmark 1 in 2006, have had a major influence on these measures. For example PSR started in Sweden in the early 1980s as a result of the TMI nuclear accident and the requirements regarding the reviews have developed over the years and are now quite similar to those recommended in the IAEA Safety Standards. Another example are the Swedish regulations on design and construction of nuclear power reactors which were issued in 2005 and have resulted in extensive back-fitting and modernization programs for all Swedish NPPs. Additionally, insights from the European stress tests have identified further areas of improvement that will be implemented in the upcoming years to strengthen the robustness of Swedish nuclear power reactors.

I.4 Description of severe accident mitigation measures

After the TMI accident in the United States in 1979, a major investigation, decided by the Swedish Government, was launched and conducted by a group of experts and resulted in a number of recommendations concerning:

- strengthening of the regulatory body,
- strengthening of the emergency preparedness and response organizations on the regional level,
- an increased focus on MTO-issues, both at the licensees and at the regulatory body,
- enhanced training of plant operators,
- strengthening of the experience feedback, both at the licensees and at the regulatory body,
- improved SAM, and
- implementation of filtered containment venting system.

Based on these recommendations, the Swedish Government decided that all Swedish nuclear power reactors shall be capable of withstanding a core melt accident without any casualties or ground contamination of significance to the population. In the decision it was stated that these requirements can be considered met if a release is limited to a maximum of 0.1 % of the reactor core content of caesium-134 and caesium-137 in a reactor core of 1800 MW thermal power, provided that other nuclides of significance are limited to the same extent as cesium. This resulted in an extensive back-fitting for all Swedish nuclear power reactors including:

- filtered containment venting through an inert MVSS with a decontamination factor of at least 500,
- unfiltered pressure relief in BWRs in the case of large LOCA and degraded pressure suppression function to protect the containment from early over pressurization,
- independent containment spray,
- all mitigating systems designed to withstand an earthquake, and
- a comprehensive set of SAM procedures and guidelines.

It was assumed during back-fitting design that the environmental protection requirements can be met if containment integrity is maintained during accident sequences (core melt scenarios) and that the releases and leakage from the containment can be controlled and limited.

Several potential threats to containment integrity occur during a core melt process. In brief, these can be categorized into the following groups: pressure loads due to gas and steam generation, temperature loads due to the high temperature of the molten core, impulse loads due to hydrogen combustion and the interaction between the molten core and water, concrete removal due to contact between the corium and concrete as well as high temperatures and aggressive materials.

Two postulated events (special events) were chosen as design basis events for the severe accident mitigating systems:

- Loss of all AC power and steam-driven emergency core cooling systems for 24 hours (BWRs and PWRs). This is the main design basis event covering events where the core is damaged and measures to mitigate external release from the containment are required. It consists of a loss of all core cooling including loss of all ordinary and alternate back-up AC power supply systems. The loss of core cooling will cause core uncover and subsequent core melt. Since containment cooling is also lost, a pressure build-up will occur in the containment. At a certain pressure value, the filtered containment venting system will be activated in order to protect the containment against overpressure.
- Large LOCA in combination with degraded pressure suppression function (for only BWRs). This is the design basis event with respect to early containment over pressurization in the BWRs. The large LOCA causes a rapid pressure build-up in the containment but it does not affect the emergency core cooling or the electricity supply. The maximum amount of radioactive material available for release in this case will thus be equivalent to the content of the primary water during normal operation as specified by the technical specifications.

During these events, no manual actions within the first 8 hours shall be assumed. This means that after 8 hours, prepared manual actions can be credited and the independent containment spray is assumed to be available, which will temporarily reduce the containment pressure and also reduce the filtered release (or delay the initiation).

In the scenario with loss of all AC power in both BWRs and PWRs, reactor pressure vessel melt-through is assumed. In order to fulfill the requirements, cooling of the core debris in the containment must be accomplished and no significant environmental impact shall be allowed.

For the postulated event with loss of all AC power in BWRs, the pressure in the containment will not reach the design limit pressure and therefore the actuation of independent containment spray at this time will significantly delay the over pressurization of the containment. At a certain level of pressure, due to compression of non-condensable gases, the filtered containment venting is assumed to be actuated manually, but in the absence of manual actions, the filtered containment venting will be automatically actuated through the bursting of a rupture disc when pressure in the containment exceeds the rupture disc limits.

In the design scenario for PWRs, pressure in the containment will reach the design limit pressure typically after 4-6 hours. Since no manual actions are credited during the first 8 hours, the filtered containment venting will be automatically actuated through the bursting of the rupture discs and will reduce the containment pressure through filtered venting. After 8 hours the independent containment spray is available which will reduce the containment pressure and also reduce the current containment filtered venting release.

All of the currently operating plants in operation have chosen the MVSS concept to fulfill the requirements of filtered venting, and a conceptual illustration of the overall severe accident mitigation concept for the BWRs and PWRs is presented in Figure 1 and Figure 2, respectively. The major component is the scrubber system comprising a large number of small venturi scrubbers submerged in a pool of water. The water contains chemicals for adequate retention of iodine. A venturi scrubber is a gas cleaning device that relies on the passage of the gas through a fine mist of water droplets. The design of the venturis is based upon the suppliers' broad experience in this area, gained when designing venturis for cleaning polluted gases from various industrial plants.

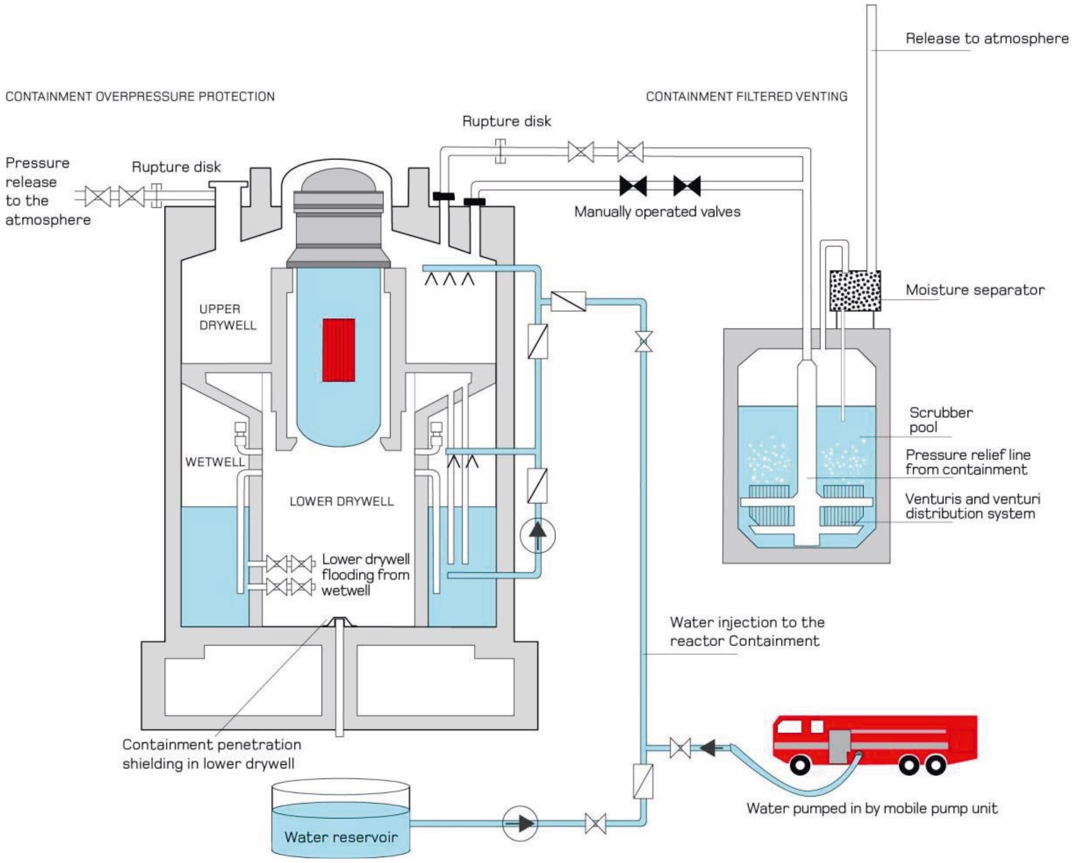

Figure 1 - Schematic view of the severe accident mitigation features installed in Swedish BWRs.

The MVSS can be activated automatically, via a rupture disc, or manually. There are two separate venting lines from the containment for these two modes of operations. The venting line with the rupture disc is always open so that no operator actions are needed to vent this way. The design principle of the system is the same for BWRs and PWRs. The system is made inert to avoid hydrogen combustion.

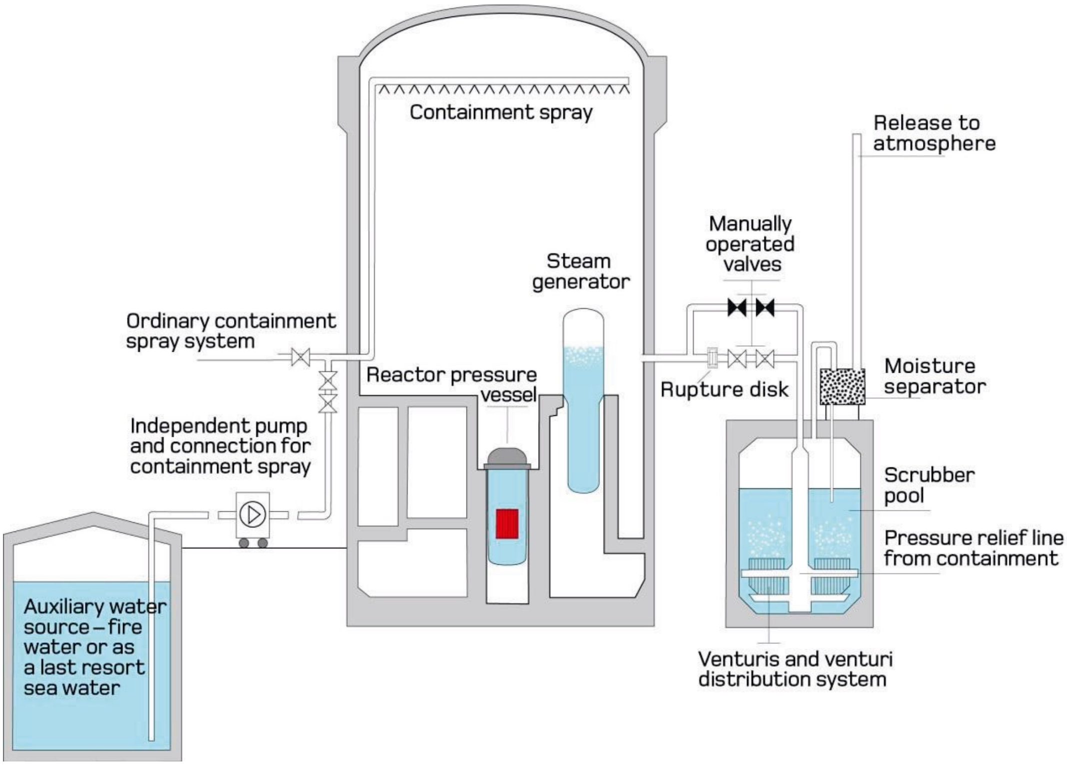

Figure 2 - Schematic view of the severe accident mitigation features installed in Swedish PWRs.

The Swedish strategy for dealing with a core melt in BWRs is to let the core debris fall into a large volume of water in the lower regions of the containment. This is a quite uncommon approach and only a few reactors in the world apply this strategy. Since the strategy is somewhat unique, the international research related to the special phenomena associated with this strategy is fairly limited, even if a wide range of international research has been conducted on phenomena that are also applicable to Swedish plants. An extensive national research programme was set up in the 1980s to highlight all important aspects needing to be addressed and this programme is still progressing. There are uncertainties connected with the Swedish strategy which need to be addressed. Through the Swedish strategy, a major initiating interaction between concrete and core melt will most likely be avoided. However, there are still some open issues identified related to steam explosions which could occur when the core melt interacts with the water and the coolability of the core debris in the containment. The severe accident research is now targeted to confirm that the uncertainties connected to the chosen solution are acceptable. Since the governmental decision in the 1980s, the Swedish utilities and the regulator have collaborated to conduct further research on severe accidents and to monitor international research within the area of severe accidents.

I.5 Description of modernization and safety upgrading of all Swedish nuclear power reactors

Safety improvements of Swedish nuclear power reactors have traditionally been conducted through consecutive plant modifications and specific projects as a result of experience from events and problems identified in the plants. These successive modifications have to a large extent been based on new insights gained through safety analyses and research, but also from newer reactor designs, which have indicated possible safety improvements. This process has to a large extent been driven and confirmed by the PSR.

Examples of events that have resulted in facility modifications include the 'strainer incident' at Barsebäck in 1992. Experience from this event showed that the emergency core cooling systems in the BWRs with external reactor recirculation pumps did not perform as postulated in the safety analysis reports. The event led to re-evaluations of previous analyses as well as modifications of the affected systems in question at all Swedish reactors. The problem has also been recognized internationally as a major generic safety issue.

Due to the background of these events, SSM decided to issue general regulations on the design and construction of nuclear power reactors. These regulations named SSMFS 2008:17 (previously SKIFS 2004:2) and the general advice on their interpretations entered into force on 1 January 2005 with transitional provisions. When they entered into force, the regulations contained transitional provisions providing the basis for the regulator's decision concerning reactor-specific modernization programs, including a timetable for implementation of these programs. Many measures in the transitional plan are implemented but there are still some measures where pre-planning or where construction is in progress. Measures that remain to be implemented are described in Section 7.1.

When the regulations (SSMFS 2008:17, previously SKIFS 2004:2) were developed, they were based on Swedish and international operating experience, recent safety analyses, results from research and development projects and the development of IAEA Safety Standards and industrial standards that were applied in the construction of the facilities. The regulations contain specific requirements for nuclear power reactors on design principles and the implementation of the defense-in-depth concept, robustness against failures as well as other internal and external events.

The regulations contain requirements on the facilities' resistance against natural phenomena and other events, such as for example earthquakes, flooding, extreme winds, extreme temperatures, extreme ice formation and electrical disorders. Requirements are also imposed on the main and emergency control rooms, safety classification, event classification and the design and operation of the reactor.

The requirement of diversification is expressed as reasonable technical and administrative measures shall be taken in order to counteract common cause failures through diversification. The requirement has resulted in a number of redevelopments where some are described here in general terms without specification of nuclear power plant:

- A system for automatic injection of boron acid and improvements of control rod maneuver system to ensure reactivity shutdown in case of faults on the reactor scram system (ATWS) or faults of all control rods (ATWC) on the BWRs.
- Implementation of an external water source for core cooling as a complement to the condensation pool in BWRs that previously only used the condensation pool in the safety analysis.
- Construction and connection of diversified systems for residual heat removal and for cooling of safety equipment, at some plants.
- Different measures are implemented to fulfill diversification of the reactor protection system to be initiated on two different parameters and with a diversified control system to execute safety functions.

Another requirement that has resulted in a lot of analysis and reconstruction is demand of more stringent physical and functional separation of redundant safety functions and between redundant safety functions.

- Some reconstruction is made to separate circuits of redundant residual heat removal systems.
- There have been measures to separate cables and control equipment such as introduction of new fire compartments and transfer of cables to separate safety functions from other functions.

A third requirement that have resulted in a lot of reconstruction is the resistance to external and internal events. The requirement has resulted in reinforcement of buildings to withstand bad weather conditions and to ensure safety functions to continue operation after an earthquake.

The requirements have also resulted in fire protection improvements to prevent initiating fires from spreading to redundant safety functions. Fire extinguishing systems have been improved and introduced in different compartments and shielding and fire dampening cables have been introduced in safety functions.

Requirements to improve accident management measures have resulted in measures to protect the integrity of the containment such as installation of hydrogen re-combiners and measures to make long time cooling of a core meltdown possible.

The regulations have also been extended to include requirements regarding protection from single failure, protection from local dynamic effects from pipe breaks, operational aids in emergency control room and environmental qualification and surveillance of equipment.

For the power plants that were commissioned in the 1970´s extensive measures had to be performed to fulfill several requirements. At some plants the entire reactor protection systems have been replaced. Redundant safety trains are introduced in new buildings, at some plants, with safety functions for residual heat removal and auxiliary power supply.

In parallel with modernization programs, power uprates have been conducted or planned at seven out of the ten Swedish nuclear power reactors in operation during the period 2005-2015.

In addition to the plant modifications listed above, the licensees need to implement measures to comply with the regulator's new regulations on security and physical protection (SSMFS 2008:12). These measures are not described in this report.

I.6 Measures taken at Swedish nuclear power plants as an immediate consequence of the Fukushima accident

Since the accident at Fukushima Dai-ichi, a number of measures to increase the level of safety have been taken at Swedish nuclear power plants. These measures were mainly identified in connection with the stress tests conducted by Swedish nuclear facilities and in connection with investigative work linked to the licensees' international forum, WANO. Approximately 60 measures have been completed so far. The measures implemented at each NPP are relatively straightforward measures that are feasible to take in the short term to increase the likelihood of preventing a serious incident while also reinforcing the work on severe accident management including emergency response organizations. No large-scale renewal work or organizational changes had been carried out at any NPP so far. This situation implies that the safety benefits of these measures are often limited and/or difficult to assess. The following are examples of measures that have been taken at at least one NPP:

- Inspections, testing and verification
- Preparing documentation for impending technical updates
- Purchase of basic mobile equipment
    - Mobile illumination
    - Mobile battery chargers
    - Mobile air compressor
    - Head torches for control rooms
    - Construction fans
- Updates of procedures, routines and training programmes
- Updates of analyses
- Reinforcement of consequence-mitigating systems
- Reinforcement of firefighting services' capability to provide assistance in connection with severe accidents
- Agreements concluded with businesses and associations

The safety improvements carried out relate to implementing recommendations from the licensees' international organization, WANO. In addition to the measures described, all licensees' takes part in and monitors ongoing international work and research in different fora as a consequence of the event at Fukushima Dai-ichi.

PART I

1 Natural hazards

1.1 Introduction

SSMs requirements regarding resistance of the plants against extreme external hazards have been developed over the years.

External events were one of the areas assessed in the framework of the European stress tests. In the Swedish national report for stress tests, external events have been described for different types of accidents, starting from design basis where the plants can be brought to safe shutdown without any significant nuclear fuel damage and up to severe accidents involving core meltdown or damage of fuel in the spent fuel pool.

As a result of the stress test assessments, some areas of improvement for the Swedish NPPs have been identified by the licensees while others have been identified by the regulator when reviewing licensee reports.

SSM is following the work of WENREA and ENSREG for developing a methodology for assessing margins to cliff-edge effects due to external events.

1.2 Actions to be performed by the licensees

In the following Section, measures related to natural hazards to be performed by the Swedish licensees are given.

The implementation of technical and administrative measures shall as far as possible seek for the most robust solution in all situations and therefore decisions shall be based on complete and verified analyses and data. For this reason many of the measures highlight the need of further evaluations and reassessments. The outcome of the evaluations and reassessments shall result in which technical and/or administrative measures that needs to be implemented and when in time they will be fully implemented. The evaluations and reassessments shall be completed according to schedule in Chapter 8.

All licensee actions (LA) might not be applicable to all reactors. However, if an action is judged not to be applicable for one reactor, a sufficiently detailed and clear justification must be presented by the licensee.

T1.LA.1 - Seismic plant analyses
A return frequency of 10-5/year (with a minimum peak ground acceleration of 0.1g) shall be used as a basis for plant reviews/back-fitting. The following actions shall be performed:

- Further studies regarding the structural integrity of the reactor containments, scrubber buildings and fuel storage pools shall be performed.
- The pipes between the reactor containment and the MVSS that allows a controlled pressure relief of the reactor containment shall be evaluated further. The function of the pipe is essential to fulfill the requirements regarding release of radioactive nuclides to the society and to the environment in case of a core meltdown.

T1.LA.2 – Investigation regarding secondary effects of an earthquake
Investigation regarding secondary effects of an earthquake shall be performed. Fire analyses at Swedish NPPs are in general performed according to SAR but effects of fire as a result of an earthquake have not been carried out at any of the Swedish NPPs. A more detailed analysis of earthquake induced flood, where for example leakage from broken water storage tanks and cracks in the cooling water channels are taken into account have to be included in the analyses regarding secondary effects.

T1.LA.3 – Review of seismic monitoring
Seismic monitoring systems are installed at all Swedish sites. The utilities shall review the procedures and training program for seismic monitoring and implement them.

T1.LA.4 – Investigation of extreme weather conditions
An investigation shall be performed of plant characteristics in extreme weather conditions. Especially the investigation shall assess plant robustness against extreme weather combined with events such as ice storms and heavy snow load on structures. A systematic analysis shall also be performed of other possible combination of natural hazards.

Some improvements are identified in the national report (e.g. improving the resistance of some buildings against tornado induced missiles and heavy snow load) but it is expected that further analyses will identify additional measures against extreme weather.

T1.LA.5 – Investigation of the frequency of extreme water levels
An investigation of the frequency of extreme water levels shall be performed. Historical data shows that the frequencies used so far might be underestimated. The frequencies used today are based on extrapolations of measured water levels on the sites during the latest decades.

An analysis of the combined effects of waves and high water including potential dynamic effects shall be performed. Historically extreme sea water levels in Scandinavia have always been connected to very high wind speeds. Thus it is important to extend the analyses with this combined effect.

T1.LA.6 - Flooding margin assessments
An analysis of incrementally increased flood levels beyond the design basis and identification of potential improvements, as required by the initial ENSREG specification for the stress tests shall be performed. This analysis shall include capability to mitigate internal and external flooding events required by station design to be performed. This includes ensuring that the capability to mitigate internal and external flooding events required by station design is verified. If adequate, the analysis shall also include an evaluation on how the water is distributed inside the plants during external flooding.

T1.LA.7 – Evaluation of the protected volume approach
A study shall be performed to identify critical areas and spaces regarding flooding of the sites. This study shall consider the need of further improving the volumetric protection of the buildings containing safety related equipment located in rooms at or below ground level.

T1.LA.8 – Investigation of an improved early warning notification
All sites shall investigate the need of improved early warning systems for deteriorating weather, as well as the provision of appropriate procedures to be followed by operators when warnings are made.

T1.LA.9 – Investigation of external hazard margins
In conjunction with recommendation regarding flooding margin assessments, a formal assessment of margins for all external hazards including, seismic, flooding and severe weather, and identification of potential improvements shall be performed. Weaknesses in the plants shall be identified.

Regarding the seismic margins an evaluation of structures, systems and components against ground motions exceeding DBE shall be performed. Such evaluations shall emphasize on margins.

T1.LA.10- Develop standards to address qualified plant walk-downs
The operators shall develop standards to address qualified plant walk-downs with regard to earthquake, flooding, on-site fire and extreme weather, to provide a more systematic search for non-conformities and correct them (e.g. appropriate storage of equipment, particularly for temporary and mobile equipment and tools used to mitigate beyond design basis external events). Potential debris affecting essential safety systems of the plant shall be recognized and evaluated. The walk-downs shall also include the mapping of potential on-site fire initiators.

1.3 Actions to be performed by the regulators

1.3.1 Topic-specific actions

In the following Section measures, related to natural hazards, to be performed by the regulator (RA) are given.

T1.RA.1 - Research project regarding the influence of paleoseismological data
SSM will start up a research project regarding the influence of paleoseismological data on the existing model regarding frequency and strength of the ground response spectra's constructed in the project SKI 92:3, Seismic safety.

T1.RA.2 - Estimation of extreme weather conditions
SSM shall initiate a study to better estimate extreme weather conditions. The study will be performed as a research project in cooperation with the industry. A research project is ongoing within the Finnish SAFIR-program, EXWE, thus cooperation would be useful.

1.3.2 Generic actions

Furthermore the following generic measures valid for two or more topics are presented and described in Section 0. The following generic measures in Section 0 are valid for topic 1;

- G.RA.1 - Implementation of the results from the analysis of long-term safety
- G.RA.2 - Review of actions belonging to category 2013
- G.RA.3 - Review of actions belonging to category 2014
- G.RA.4 - Review of actions belonging to category 2015

2 Design issues

2.1 Introduction

Design issues, such as prolonged loss of electrical power and ultimate heat sink regardless of cause, were included in the framework of the European stress tests and in the Swedish national report for the stress tests. Thus, design issues have been highlighted for all Swedish NPPs.

In the framework of the European stress tests the Swedish NPPs considered several of different situations and the impact on the NPPs due to loss of electrical power and loss of ultimate heat sink for both the reactor and spent fuel pools were assessed starting from design basis events where the plants can be brought to safe shutdown without any significant nuclear fuel damage, and finalizing with events more severe than the situations considered during the construction of the plants which results in severe accident conditions involving core meltdown or damage to the spent nuclear fuel in the storage pool. It shall be noted that the severe accidents involving core melt and melt-through of the reactor pressure vessel is discussed separately as a specific topic in this action plan and will be discussed further in Chapter I.

Actions presented in this Chapter are mainly based on the conclusions drawn within the framework of the stress tests including the stress test peer review process which was finalized in April 2012, and during the 2nd extraordinary review meeting for the CNS which took place in Vienna 27 to 31 August 2012

2.2 Actions to be performed by the licensees

In the following Section measures, related to design issues, to be performed by the Swedish licensees are given.

The implementation of technical and administrative measures shall as far as possible seek for the most robust solution in all situations and therefore decisions shall be based on complete and verified analyses and data. For this reason many of the measures highlight the need of further evaluations and reassessments. The outcome of the evaluations and reassessments shall result in which technical and/or administrative measures that needs to be implemented and when in time they will be fully implemented. The evaluations and reassessments shall be completed according to schedule in Chapter 8.

All licensee actions (LA) might not be applicable to all reactors. However, if an action is judged not to be applicable for one reactor, a sufficiently detailed and clear justification must be presented by the licensee.

T2.LA.1 – Implementation of the demonstrations of design basis in SAR
Design basis events for loss of ultimate heat sink and loss of electrical power shall be included in SAR.

T2.LA.2 – Define design basis for alternate cooling and alternate residual heat removal
Alternative means of cooling and residual heat removal of the reactor cores and the spent fuel pools as well as alternative means of cooling of the safety systems shall be further evaluated and reassessed. Evaluation and assessment shall define design basis for technical and administrative measures to ensure the capabilities for the reactors to maintain core cooling and spent fuel pool cooling as well as operation

of the safety systems during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site. Work on T2.LA.2, regarding core cooling, may potentially be coordinated with the action T3.LA.2 - Define the design basis for an independent core cooling system.

T2.LA.3 - Primary and alternative AC power supplies and AC power distribution systems
Robustness of the on-site and off-site power supplies and corresponding power distribution systems as well as the alternative power supplies and corresponding power distribution systems shall be further evaluated and reassessed. Evaluation and assessment shall define technical and administrative measures to ensure the capabilities for the reactors to maintain operability of active safety relevant systems during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneously event affecting all reactors at the site. Evaluations and reassessments shall consider both the primary and the alternate power supply and the power distribution systems designs and especially highlight separation, dependence and the need of diversification within and between these systems, as well as the possibilities to reconnect and restart. Additionally, storage of fuel and lubricating oil, the pipes and equipment needed to ensure refueling and the possibilities for external support (including procure contracts with the grid system owner, for direct connections to nearby power production facilities) shall be further evaluated.

T2.LA.4 - Reassess DC power supplies and DC power distribution system
Robustness of the DC power supplies and corresponding power distribution systems shall be further evaluated and reassessed. Evaluation and assessment shall define technical and administrative measures to ensure the operability of the DC power supply and distribution systems during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneously events affecting all reactors at the site. Evaluations and reassessments shall especially consider batteries discharge time and the capabilities to recharge batteries and/or disconnect less important loads.

T2.LA.5 - Reassess the integrity of the primary system
For PWR the integrity of the primary system shall be further evaluated and reassessed for prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility. Evaluation and assessment shall define technical and administrative measures to ensure the capabilities for the reactors to maintain the integrity of the primary system during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site. This especially includes reassessments of the primary pump seal for the PWR units.

T2.LA.6 - Reassess the operability and habitability of the Main and Emergency Control Rooms as well as emergency control center
Operability and habitability of the main and the emergency control rooms as well as emergency control center shall be further evaluated and reassessed to ensure continued operability and adequate habitability conditions during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and

simultaneous event affecting all reactors at the site. Evaluation and assessment shall define technical and administrative measures to ensure the continued operability and adequate habitability conditions in the emergency control center.

T2.LA.7 - Reassess the instrumentation and monitoring
Instrumentation and monitoring systems shall be further evaluated and reassessed to ensure reliable and adequate monitoring and measurements of essential parameters in the plants (including the spent fuel pools) during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site. Evaluation and assessment shall define technical and administrative measures to ensure the operability of the instrumentation and monitoring systems.

T2.LA.8 - Reassess the integrity of the spent fuel pools
Integrity and robustness of the spent fuel pools during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site shall be further evaluated and reassessed. Evaluation and assessment shall define technical and administrative measures to ensure that fuel in the spent fuel pools is adequately protected during all potential situations.

T2.LA.9 – Evaluate the need for mobile equipment
Robustness of existing mobile pumps, power supplies and air compressors with prepared quick connections, procedures, and staff training with drills shall be further evaluated and reassessed (including considering simultaneous event affecting all reactors at the site). Evaluation and assessment shall define the need for additional mobile devices with prepared quick connections, procedures, and staff training with drills in order to ensure the operability of the existing safety equipment, enable direct feeding of the primary or secondary side, allow extended use of instrumentation and operation of controls, allow effective fire-fighting, and ensure continued emergency lighting. The Evaluation and assessment shall define the need for equipment to be stored in locations that are safe and secure during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site.

T2.LA.10 – Reassess and update equipment inspection programs
Regular programs for inspections shall be reassessed and, if needed, updated to ensure that equipment and mobile devices are properly installed and maintained, particularly for temporary and mobile equipment and tools intended to be used during prolonged severe and extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures.

T2.LA.11 - Reassess and update training programs
Relevant staff training programs for deployment of equipment and mobile devices intended to be used during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site, shall be reassessed and, if needed, updated.

T2.LA.12 - Evaluate the need for consumables
The need of consumables (including fresh water, fuel and lubrication oil) during prolonged extreme situation resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site, shall be further evaluated and reassessed. Additionally, the minimum acceptable level of consumables available in storages and storage tanks shall be further evaluated and reassessed. For storages and storage tanks shared between units, the priority of volumes between units shall also be reassessed. Evaluation and assessment shall define technical and administrative measures to ensure that acceptable volumes are available during all potential situations.

T2.LA.13 - Evaluate the need for resources
The necessary resources (including personnel and equipment) to handle prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site, shall be further evaluated. Evaluation and assessment shall define technical and administrative measures to ensure that necessary resources will be available during prolonged extreme situation.

T2.LA.14 - Evaluate the accessibility of important areas
Accessibility of important areas at the site and inside the reactors units (incl. all areas where access is need for successful execution of manual actions) during accident scenarios, especially following natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site, shall be further evaluated and reassessed. Evaluation and assessment shall define technical and administrative measures to ensure adequate accessibility during all potential situations.

T2.LA.15 – Investigate the effects of simultaneous event affecting all reactors at the site
The consequences of simultaneous events affecting all reactors at the site and resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures, shall be further evaluated.

T2.LA.16 – Reassess the use of severe accident mitigation systems
The use of the severe accident mitigation systems as a heat sink before severe damage to fuel has occurred where not considered in the original design of these systems and shall therefore be further evaluated and reassessed. Evaluations shall consider applications and relating strategies for a prolonged use of the severe accident mitigation systems before severe damage to fuel has occurred during prolonged severe and extreme situations.

T2.LA.17 – Reassess the procedures and operational training
Procedures and operational training shall be further evaluated and reassessed to ensure that prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site are appropriately considered.

T2.LA.18 - Evaluate the need for external support
The need and possibility for external support during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site, shall be further evaluated and reassessed. Evaluation and assessment shall define technical and administrative measures to ensure necessary support during prolonged extreme.

T2.LA.19 – Reassess the risk of criticality and/or re-criticality
Evaluate and reassess the risk of criticality and/or re-criticality during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneously events affecting all reactors at the site. Evaluation and assessment shall define technical and administrative measures to minimize the risk of criticality and/or re-criticality during prolonged extreme situations resulting from natural phenomena and other events that could arise outside or inside the facility including common cause failures and simultaneous event affecting all reactors at the site. Evaluations shall especially consider the risk of criticality in PWR during boron dilution.

2.3 Actions to be performed by the regulators

No specific actions to be performed by the regulators (RA) have been identified for topic 2.

Generic actions valid for two or more topics are presented and described in Section 0. The following generic measures in Section 0 are valid for topic 2;

- G.RA.1 - Implementation of the results from the analysis of long-term safety
- G.RA.2 - Review of actions belonging to category 2013
- G.RA.3 - Review of actions belonging to category 2014
- G.RA.4 - Review of actions belonging to category 2015

3 Severe accident management and recovery (On-site)

3.1 Introduction

SAM was a topic that was emphasized in the framework of the stress tests. In the Swedish national report on the stress tests, SAM and emergency preparedness organization were described for different types of accidents, starting from design basis, where the plants can be brought to safe shutdown without any significant nuclear fuel damage, and up to severe accidents involving core meltdown or damage to the spent nuclear fuel in the storage pool.

It needs to be mentioned that the severe accidents involving core melt and melt-through of the reactor pressure vessel are design basis accidents for the consequence mitigating systems in Swedish NPPs where the system for filtered containment venting is the main component. The containment filtered venting systems, including relevant instrumentation, are designed for passive operation during at least 24 hours.

It also needs to be mentioned that the reference levels defined by WENRA which are related to SAM have already been incorporated into Swedish national legal frameworks, and in this way it is ensured that they are implemented. Furthermore, according to the Swedish regulations, PSA shall be a part of the SAR for the Swedish nuclear power plants. All operating NPPs are expected to perform complete plant-specific Level 1 and Level 2 PSAs, including all modes of operation of the plant (power operation, refuel, start-up, hot and cold shutdown) and all initiating events that may have an effect on the nuclear safety. However, in the Swedish national report on the stress tests, some areas such as seismic PSA were identified, see also Chapter 1.

3.2 Actions to be performed by the licensees

In the following Section measures, related to severe accident management, to be performed by the Swedish licensees are given.

The implementation of technical and administrative measures shall as far as possible seek for the most robust solution in all situations and therefore decisions shall be based on complete and verified analyses and data. For this reason many of the measures highlight the need of further evaluations and reassessments. The outcome of the evaluations and reassessments shall result in which technical and/or administrative measures that needs to be implemented and when in time they will be fully implemented. The evaluations and reassessments shall be completed according to schedule in Chapter 8.

All licensee actions (LA) might not be applicable to all reactors. However, if an action is judged not to be applicable for one reactor, a sufficiently detailed and clear justification must be presented by the licensee.

3.2.1 Severe accident management hardware provisions

T3.LA.1 – Consider improvements of the capability to cool the spent fuel pool
For cooling of the spent fuel pool, the following improvements shall be considered: Permanent filling pipes from a protected location to the spent fuel pools in units that do not yet have them. Analyses of the conditions with a boiling fuel pool with respect to high temperatures, radiation, pathways for water and steam, and procedures.

T3.LA.2 – Define the design basis for an independent core cooling system
Fundamental design principles of an independent core cooling system for injection of water to the reactor pressure vessel to handle SBO shall be defined. This shall include a conceptual design of the system as well as definition of major system parameters.

T3.LA.3 – Investigate instrumentation of spent fuel pool
Instrumentation for measurement of necessary parameters in the spent fuel storage (water level, temperature) in the event of severe accident as well the resistance of the equipment from harmful environment conditions shall be investigated. This shall include robust/simple level measurement in the fuel pools that can be read from a radiation protected location.

T3.LA.4 – Investigate the need for measuring radiation levels
The need for more dose rate monitors in the reactor building to support accident management shall be investigated.

3.2.2 Procedures and guidelines

T3.LA.5 – Develop a plan to handle more than one affected unit
A thoroughly plan for managing several, simultaneously affected units shall be developed, including staffing and procedures.

T3.LA.6 – Improve the strategies for managing re-criticality
The strategies for handling re-criticality, both for detection and countermeasures shall be improved.

T3.LA.7 – Develop the strategies for managing loss of containment integrity
Strategies for handling cases with lost containment integrity shall be developed.

T3.LA.8 – Evaluate accident management programmes
The accident management programmes (severe accident management guidelines, emergency operating procedures) for all plant states including spent fuel pools and multi-units events shall be evaluated. This shall also include guidelines for emergency preparedness organization for handling long-term accidents.

3.2.3 Severe accident management training and exercises

T3.LA.9 – Consider an extended scope of training and drills
The training and drills for extended scope of the accident management such as consideration of multiunit accidents under conditions of infrastructure degradation with the need to coordinate all parties at the state level shall be considered.

The enhancement of the SAM system in all aspects: The question on how to enhance existing accident management system to achieve a robust system capable to handle Fukushima-like conditions shall be further investigated.

3.2.4 Improved communications

T3.LA.10 – Investigate the need for a new call-in system
To ensure the call-in of personnel, the need for new call-in methods shall be investigated.

3.2.5 Mitigation of hydrogen risk

T3.LA.11 – Analyze the management of hydrogen
Management of hydrogen in the containment in long-term shall be analyzed. Furthermore, the possibility and consequences of accumulating hydrogen in the reactor building including necessary instrumentation and management shall be investigated.

3.2.6 Large volumes of contaminated water

T3.LA.12 – Investigate the need for means to manage large volumes of contaminated water
The need for means to manage larger quantities of radioactive water in the long-term shall be investigated.

3.2.7 Radiation protection

T3.LA.13 – Reassess personal safety issues
Personal safety issues have to be re-assessed. The difficulties that will be encountered due to rapid changes of radiation and contamination levels during execution of accident management measures shall be considered. Routines for the

emergency preparedness organization shall be further developed regarding the protection of the personnel in severe accident environments. Access to protective equipment, dosimetry and management, as well as working procedures shall to be clarified.

3.2.8 On-site emergency control center

T3.LA.14 – Secure the accessibility of the emergency control center
Accessibility and functionality of the ordinary on-site emergency control center. shall be secured with regard to location, protection, robust communications systems and power supply.

3.2.9 Support to local operators

T3.LA.15 – Set up action plans for support to local operators
Action plans shall be set up where the need for external resources, both human and material, shall be identified along with the information from where and how they can be obtained, as well as the time for their transport to the site.

3.2.10 Long-term issues

T3.LA.16 – Reassess the use of containment filtered venting system in the long-term
The use of the containment filtered venting system during prolonged severe accident conditions (more than 24 hours) shall be further evaluated and reassessed.

T3.LA.17 – Investigate long-term handling of the containment chemistry
Long-term handling of the containment chemistry (for a year or more) shall be investigated.

3.2.11 Emergency support organization

T3.LA.18 – Evaluate the need for common resources available at the site
The need for common resources available at the site for assisting with multi-unit severe accidents shall be evaluated since the currently available resources may not be sufficient if all units at the site are affected (even in the short term).

3.2.12 Other issues

T3.LA.19 – Investigate the performance of the common system for filtered containment venting
The performance of the common system for filtered containment venting at Oskarshamn 1 and 2 shall be investigated.

3.3 Actions to be performed by the regulators

No specific actions to be performed by the regulators (RA) have been identified for topic 3.

Generic actions valid for two or more topics are presented and described in Section 0. The following generic measures in Section 0.1 are valid for topic 3;

- G.RA.1 - Implementation of the results from the analysis of long-term safety
- G.RA.2 - Review of actions belonging to category 2013
- G.RA.3 - Review of actions belonging to category 2014
- G.RA.4 - Review of actions belonging to category 2015

PART II

4 National organizations

4.1 Introduction

Appointed central or regional (county) authorities are responsible for managing nearly all accidents and crisis situations involving nuclear technology with potential off-site consequences. However, if a national crisis with the potential of affecting many citizens with large, cross-sector or cross-regional negative economic, environmental or other detrimental societal effects occurs, it will require decisions and actions by the government.

SSM has the collective responsibility in Sweden for radiation protection and nuclear safety and is placed under the Ministry of the Environment. SSM is a regulatory, supervisory and licensing authority with an expert role in radiation protection, nuclear safety and emergency preparedness and response. Expert advice from SSM is delivered to the authority responsible for deciding on and implementing protective measures. In the case of the Fukushima Dai-ichi nuclear power plant accident, the Ministry for Foreign Affairs was the counterpart, receiving advice from SSM and making decisions regarding protective measures for the Swedish citizens in Japan. If an accident at a nuclear facility occurs in Sweden, the local County Administrative Board in the county where the nuclear installation is located is in charge of protecting people and the environment.

The County Administrative Board in the affected region (county) is responsible for planning and leading the regional emergency preparedness work. It decides on measures to be taken to protect the public, issues warnings and provides information to the public and is responsible for decontamination following radioactive fall-out/releases. The responsibility for directing rescue services also lies within the County Administrative Board in the affected county unless the government decides otherwise.

There are also a number of other authorities and organizations involved such as MSB, SMHI, The National Food Agency and The Swedish Board of Agriculture.

4.2 Actions to be performed by the operators or other national organizations

The County Administrative Boards in the counties with nuclear power plants conduct, at an interval of a few years, a major exercise involving relevant actors at all levels of the government, private companies, the nuclear power utility(ies) and the press as a part of the nuclear emergency preparedness in Sweden. The last exercise was SAMÖ/KKÖ conducted and evaluated in 2011, involving the nuclear power facility at Oskarshamn (OKG). The next country-wide exercise focusing on a nuclear power plant accident will be Havsörn, to be conducted in December 2013 and involving the nuclear power facility at Forsmark (Forsmarks kraftgrupp AB). There will be a number of central authorities involved such as SSM, MSB and SMHI. At the regional level, apart from the County Administrative Boards, for example the police, municipalities within the affected regions and media will be involved.

The purpose is to exercise and further develop the emergency preparedness and response planning concerning a nuclear accident, including collaboration between regulators and local organizations in the affected counties. Strengths and weaknesses should be identified and the actor's collected ability should be evaluated. The actors should be given the possibility to work in a realistic environment.

The duration of Havsörn will be two to three days; the first one to two days will be a simulated event handled in the different actor's emergency centers as well as a field exercise. The last day of the exercise will be in the form of a seminar exercise focusing on the later stages of an accident. An evaluation will be carried out the day after the exercise. The current planning is to select and prepare historical weather with support from SMHI and SSM so that, together with the technical scenario, the weather will give the simulated radiological consequences. To as large extent as possible the technical systems and communication systems that should be used in a real accident will be used.

The goal of the exercise is that national, regional and local organizations as well as other affected organizations will have the possibility to coordinate and cooperate in accordance with the Country Administrative Board's regional emergency preparedness and response plan and the SSM's and other national central authority's emergency preparedness and response plans for nuclear accidents at the Forsmark nuclear power plant, the law on protection against accidents and other applicable legislations.

4.3 Actions to be performed by government or authorities

During the nuclear accident at the Fukushima Dai-ichi NPP, relevant national organizations were activated; SSM had its crisis organization activated around the clock during the period 11-31 March 2011 in the Emergency Response Centre located within the premises of the Authority. Several other authorities and organizations were also affected by the situation in Japan, for example MSB, the National Board of Health and Welfare, Swedish Customs, the Swedish National Food Agency, UD, FOI. Activities within the national organizations throughout this period have been evaluated and the results continue to be assessed.

The activities carried out in Sweden throughout the nuclear accident at the Fukushima Dai-ichi NPP led to a number of lessons learned regarding the performance of the national organizations. One example is the experience from the cooperation between SSM and the FOI during the accident. During the accident, FOI was contracted by SSM to assist the emergency organization and to perform analyses and supplementary radiation monitoring. This interaction has been evaluated further and the need for clarification regarding the role of FOI during a radiological or nuclear emergency is currently being discussed.

The nuclear accident at the Fukushima Dai-ichi NPP highlighted the importance of international cooperation and the capability of a country to coordinate assistance from international authorities and organizations during emergency situations. The Swedish government appointed a Committee of Inquiry to examine the possibilities for Sweden to receive international support during emergency and crisis situations, including nuclear accidents. The experiences from the Fukushima Dai-ichi NPP accident were incorporated in the committee's inquiry. The results of the inquiry were delivered to the Government on 27 April 2012.

The responsibilities for security and safeguards at a national level of authority are shared between SSM, FOI and ISP. On 7 June 2011, the Ministry of the

Environment appointed a former deputy director-general to examine the responsibilities for security and safeguards at a national level of authority and to provide recommendations for potential future organizational changes related to the authorities' roles and responsibilities. The examination of responsibilities for security and safeguards at a national authority level was completed in December 2011. The conclusion has been documented in an official memorandum available at the Ministry of the Environment.

5 Emergency preparedness and response and post-accident management (Off-site)

5.1 Introduction

The Swedish stress tests have resulted in a new focus on different aspects of an emergency response in extreme conditions that shall be addressed during emergency preparedness work. SSM has also reviewed and evaluated its own emergency preparedness and response programme, including its links with other authorities and organizations at the national level (chapter 4). The progress made so far is due to initiatives taken by SSM, including the results of the evaluation of the national SAMÖ/KKÖ exercise that took place between February and April 2011, an evaluation of the accident management at the Fukushima Dai-ichi NPP and the results of a recent IAEA IRRS review.

5.2 Actions to be performed by the licensees

The severe accident procedures are intended to cover a maximum of 24 hours. Major events would mean that the on-site emergency preparedness organization would require outside assistance to rescue personnel and to extinguish fires in the plant (for about a week). A prerequisite for external rescue personnel to operate is that they can get to and from the site. In the event of a severe accident, the licensee's emergency preparedness organization contacts the emergency group at Vattenfall and E.On, respectively. The emergency groups have joint exercises with the companies' emergency preparedness organizations. The groups maintain competence regarding the unit's design and function, radiation protection/radiology and reactor safety. However, it is important to note that the licensee is responsible for all actions undertaken to mitigate the consequences of an event. The evaluation covers evacuation of remaining personnel, inward transportation of personnel, food, fuel, raw water, nitrogen, boric acid, etc. to the site.

In the off-site emergency preparedness organization, the emergency supervisor at the County Administrative Board controls public emergency operations according to the Civil Protection Act (2003:778). Internal communications are required to create a joint status report and forward it to the external emergency preparedness functions. In order to communicate internally and externally, there are a number of systems such as: Meridian PBX with fixed connections and DECT, fixed telephones via external connections, mobile telephones via GSM, operations phone (via 400 kV network), telephones via military lines (FTN) and pagers.

In their work with the stress tests, the licensees have identified the following recommendations for further evaluations and reassessments. All recommendations have not been identified by all licensees and are not relevant to all units.

Clarify the responsibility for off-site decontamination stations for personnel during shift turnovers and how equipment is to be replaced. Plan for a location off-site where staff can be equipped, dosimetry can be performed, safety equipment may be distributed, etc.

Investigate the course of action during a long-term need for personnel and all kinds of needed material, food and protective equipment.

An investigation shall be performed to ascertain advantages and disadvantages when replacing the present substitute Command Center with a suitable office outside the site so that both Command Centers are not situated within the site where they would possibly both become affected by the same bad conditions.

It shall be investigated whether some of the functions included in the staffing of the emergency preparedness organization are sufficient to sustain shifts around the clock.

At present, calling in personnel is dependent on a functioning GSM/Telenet/telecommunications network. An improvement in this area shall be investigated.

Identify alternative evacuation routes. It might be preferable to wait with abandonment. If there are no roads, the rescue leaders must investigate the possibility of cross-country, sea or air transportation. This scenario shall be highlighted and preparations made.

For some sites, connecting auxiliary power to the Command Center is important. In the event that diesel engines and gas turbines are not available, the Command Center is then restricted to using available battery power.

5.3 Actions to be performed by the regulators

Work is in progress in Sweden to address the questions that have arisen and the lessons learned during the management of an accident at a nuclear facility far away from but nevertheless having implications for Sweden. The work is aimed at two aspects that have arisen from handling the accident at Fukushima Dai-ichi. The first aspect is improving the crisis management of Swedish citizens abroad affected by an accident at a nuclear facility in that country. The second aspect is improving the crisis management of an accident of similar severity at a nuclear facility if it occurred in Sweden. The completion of the European stress tests for nuclear power plants and SSM's conclusions that have been documented in the report on the Swedish stress tests is contributing to this work. Assessing the efficiency of the Swedish national emergency preparedness and response system for severe accidents will also contribute.

As a result of the accident in Japan and the subsequent activation of SSM's crisis organization continuously over three weeks, several measures for improving the organization have been identified. These have been compiled along with measures resulting from the evaluation of the SAMÖ/KKÖ exercise, and a number of them have been implemented in a first phase of prioritized improvements. Some examples of measures already taken are: clearer routines for incident documentation, improved routines and checklists for the different functions in the crisis organization, supplementary training for staff and improvements in procedures for operational communication, shift planning, work schedules and information management for the regular SSM organization during the time that the crisis organization is activated.

Another important measure is the updating and formalization of pre-defined criteria on countermeasures and the implementation of measurable operational intervention levels and routines for application of intervention levels. These measures are nearly completed and will be finalized no later than 2013, partly in coordination with the other Nordic countries through ongoing work on the modernization of the Nordic Flag Book specifying protective measures in early and intermediate phases of a nuclear or radiological emergency.

In addition to these measures, a more overarching action has been identified as necessary for improving the possibilities for the SSM crisis organization to fulfill its responsibilities during a nuclear accident or event. SSM's regulations specify that the operator of nuclear facilities shall deliver a source term to SSM early during an event. SSM is also responsible for independently assessing the source term to be used in SSM's analysis of the radiological consequences. However, the plant parameters that would provide the basis for a thorough assessment of the situation and the prediction of the accident progression and radionuclide release are not available online in the Emergency Response Center at SSM. SSM and the nuclear facilities are currently working towards establishing a system for electronic transmission of plant data from the Swedish nuclear power plants to SSM's Emergency Response Center. This work is currently expected to be finished by the end of 2015.

Experiences gained from SSM's supervision of emergency preparedness at nuclear facilities as well as experience gained from the Fukushima Dai-ichi accident have led to a revision of the Swedish regulation SSMFS 2008:15, SSMs Regulations Concerning Emergency preparedness at Certain Nuclear Facilities. Specifically with regards to experiences gained from the Fukushima Dai-ichi accident, clearer and more stringent demands are made regarding radiation protection of personnel and the communications infrastructure at a power plant. The regulation makes specific demands on having a detailed plan for obtaining protective equipment in a drawn out or long-term event, on having a communications system that is not a public system and an increased demand on having an alternative command and control center not located near the power plant and having alternative communications possibilities. The revision of SSMFS 2008:15 is in its final review stage and the revised regulation will be implemented in 2013.

5.3.1 Actions identified in Sweden at a national level

In addition to the specific measures identified for improving the efficiency of SSM's crisis organization and the improvements in SSM's regulation for emergency preparedness at nuclear installations (SSMFS 2008:15), several overarching questions for the Swedish national emergency preparedness and response have been identified. These questions have been clarified, gained impetus and become more clearly defined through a fact-finding mission in Japan undertaken by Swedish regulators in December 2011. The purpose of that mission was to achieve a better understanding of how to more efficiently handle the emergency response and compare the Japanese experiences and Swedish systems. These areas are listed below.

The need for information
The pressure on Japan from other countries and international organizations to provide information on the event and to continuously publish everything from measurement protocols to decisions in English has been considerable. There is a need to evaluate how Sweden could manage this and how this should be organized so that foreign actors, who do not understand the Swedish system, receive a correct picture of the situation.

Endurance
The acute phase of the catastrophe in Japan lasted for several months. The intermediate and long-term stages will continue for a long time. There is a need to evaluate how Sweden, a relatively small country, could handle a drawn out course of events.

Measurement capacity
The need for measurements for mapping fallout, monitoring and control of contaminated persons, foodstuffs and provisions, export control, etc., is great, even with a 'small' discharge. With a large discharge, the experience from Japan shows that the need would be enormous. There is a need to evaluate which measurement capacity Sweden should have and how Sweden shall arrange to receive help from other countries.

International assistance/cooperation
Japan, the world's third largest economy with 128 million citizens, 55 reactors in operation before the accident and conducting extensive research and development within nuclear power technology and radiation protection, has received help from several countries to handle the accident. It is clear that Sweden alone would not be able to handle a large accident at a Swedish nuclear power plant. How to receive international assistance needs to be planed beforehand.

Allocation of responsibilities
An accident in a nuclear reactor leading to a large discharge of radioactive material is a national catastrophe. There is a need to evaluate whether the division of responsibilities is optimal and how the responsibility for handling this type of event shall be allocated between local, regional and national actors in Sweden. This evaluation should also address how the collaboration between local, regional and national actors and the nuclear installation during an accident at a Swedish nuclear power plant should be organized.

Ambition level
An overarching issue that should be investigated is the organizational form of the Swedish emergency preparedness and response system for managing a serious accident at a nuclear power plant in Sweden including the efficiency and optimization of the organization with regards to the available resources. This investigation also needs to address the level of severity of an accident for which Sweden shall withhold and maintain a preparedness and response.

5.3.2 Conclusions of the regulatory body regarding the outcome of the operators' activities

SSM's overall assessment of the emergency response organizations at the nuclear facilities is that all licensees have given a good description of strategies, instructions and equipment. The stress tests have also demonstrated limitations in the emergency preparedness organizations. Investigations need to be conducted to ascertain what is needed so that a facility's emergency preparedness organization is dimensioned to deal with situations in which several facilities are affected simultaneously. SSM's opinion regarding which areas in the operators' emergency preparedness that need further and deeper evaluation as a result of the European stress tests for nuclear power plants is summarized as the following items:

Emergency planning
Emergency planning shall comprise severe emergency situations involving all units at the site.

Accessibility and functionality
Accessibility and functionality of the ordinary on-site emergency control center and the alternative emergency control center shall be secured with regard to location, protection, robust communications systems and power supply.

Personal safety
Personnel safety issues have to be re-assessed. High demands shall be applied due to rapidly changing high radiation and contaminations levels during execution of accident management measures. Routines for the emergency preparedness organization shall be developed further when it comes to protection of personnel in a severe accident environment. Access to protective equipment, dosimetry and management, as well as working procedures, need to be clarified.

Shared resources
The need for shared resources available at the site shall be evaluated since the currently available resources are insufficient if all units at the site are affected (even in the short term).

Need for external resources
Action plans shall be set up where the need for external resources, both human and material, shall be identified along with the information on where and how they can be obtained as well as the time for their transport to the site.

Critical areas for accident management
Areas critical for accident management in the long term shall be identified. These areas can for example include the need for external resources, routines for access to the site and means for managing the larger quantities of radioactive water.

6 International cooperation

6.1 Introduction

Sweden is party to all of the relevant conventions expected for a country operating nuclear power plants, encompassing nuclear safety, emergency preparedness and response, nuclear liability, spent nuclear fuel, radioactive waste and physical protection. Sweden has also formally committed to implement the Code of Conduct on the Safety and Security of Radioactive Sources and the Supplementary Guidance on the Import and Export of Radiation Sources.

6.2 Actions to be performed by the licensees

The industry organization WANO has addressed the Fukushima events in various ways. Soon after the event, a WANO Fukushima commission was formed to draw important conclusions on how to make WANO more efficient. In August 2011, the commission issued a number of new wide-ranging commitments to nuclear safety in the form of recommendations which have since then been approved by the Governing Boards:

Expanding the scope of WANO Peer Reviews, e.g.: Emergency Preparedness; SAM; Multiple Unit Impacts; Design Safety Fundamentals.

The frequency of WANO Peer Reviews shall be expanded: each station is to be reviewed at least every four years.

A worldwide and integrated event response strategy shall be developed: WANO should take an active role in promoting and implementing a worldwide and integrated nuclear industry event response strategy that effectively and efficiently employs the resources of key international nuclear organizations.

All Swedish nuclear power plants have agreed to host WANO peer reviews with a frequency of at least one review every fourth year for each unit, with a follow-up review in between. The scope of these peer reviews has been expanded to include the new areas.

6.3 Actions to be performed by the regulators

The Swedish Parliament has decided on all the necessary legislative changes to prepare for Sweden to accede to the 2004 Protocol to Amend the Paris Convention on Third Party Liability in the Field of Nuclear Energy. It is expected that this step will be harmonized between all EU Member States. Sweden has signed the 2004 Amendments to the Paris and Brussels Protocol, but the ratification will be done simultaneously by all EU Member States. No date has been decided.

International communication and information dissemination in a crisis situation is an area that should be re-evaluated in the light of the experience and feedback from the Fukushima Dai-ichi accident. Assessment and possible improvement of international crisis communication and information dissemination are presently being discussed, for example at the Nordic NEP meeting held in March 2012 and at the IAEA meeting with National Competent Authorities held in April 2012. Other work is performed by HERCA and OECD/NEA. Any changes and amendments of the international instruments in this area are not yet decided or planned.

SSM could evaluate operating and regulatory experience in a more systematic way, including experience in other States, and establish and implement guidance for dissemination of all significant operating experience lessons learned to all relevant authorized parties.

SSM recently issued a survey to certain elements of the international community to assess the licensing challenges associated with regulatory supervision of large plant modifications, management systems, operations and safety culture at nuclear power plants. The result of this survey has been reported to the Government in October 2012.

SSM participates in several international information systems and receives data on events and lessons learned from several sources.

Sweden received invaluable information about the experiences from the Fukushima Dai-ichi accident through contact with Japanese authorities, government bodies and engineers via organizations such as INRA, through presentations at the IAEA General Conference 2011, through bilateral information exchange between Japan and Sweden and other international meetings.

SSM staff from the Section for Emergency Preparedness and Response travelled to Tokyo and Fukushima prefecture in December 2011. The main objectives of the journey were to find out facts about the accident at Fukushima Dai-ichi and its consequences, to learn from the Japanese experiences in handling the accident and to investigate possible future areas for research collaborations. The group met with representatives of national and local governments involved in handling the consequences of the nuclear accident as well as representatives of the Tokyo Electric Power Company (TEPCO), that owns and operates the Fukushima Dai-ichi NPP. The group also met with the Investigation Committee, led by Professor Hatamura, for the accidents at the Fukushima NPP.

A full-scope IRRS mission to Sweden was performed 6-17 February 2012. The purpose of this IRRS mission was to review the effectiveness of the Swedish framework for safety within the competence of SSM. Special attention was also given to the review of the regulatory implications of the Fukushima Dai-ichi accident within the Swedish framework for safety. The mission resulted in a total of 22 recommendations, 17 suggestions and 15 cases of good practice.

During the IRRS mission to Sweden, it was noted that the process for development of SSM's regulations and general advice does not explicitly mention the use of IAEA Standards in this process. This resulted in, as part of one of the IRRS recommendations, a suggestion to better ensure the compliance with relevant IAEA Safety Standards in the process of developing legislation, regulations and general advice. The implementation will be incorporated in the post-IRRS action plan to follow up received recommendations and suggestions.

SSM is aiming for a more strategic process for following up the production and use of IAEA Safety Standards involving more coherent coordination between representatives in the IAEA sub-committees of NUSSC, RASSC, TRANSSC and WASSC and better coordination with the Government Offices. This work has started and will continue throughout the full CSS term of 2012-2016.

An action plan for managing recommendations and suggestions from the IRRS mission to Sweden is being prepared. The recommendations mentioned in this report (Better use of IAEA Safety Standards, guidance for disseminating operating experience and lessons learned) is planned to be implemented by December 2013.

The WENRA Reactor Harmonization Working Group developed safety reference levels (RLs) for existing nuclear power plants. The methodology and results of the harmonization study were published in January 2006 in the report "Harmonization of Reactor Safety in WENRA Countries". Stakeholders were invited by WENRA to provide comments and, as a result, the RLs were updated in March 2007. The RLs were updated once again in January 2008, mainly to take into account the publication of the IAEA document GS-R-3. Sweden has implemented most of the RLs but still has work that remains to be done regarding safety in connection with fires and a few other issues. Due to the experience from the Fukushima accident, WENRA will once again revise the RLs.

PART III

7 National conclusion and generic activities

7.1 Remaining modernization and safety upgrading of all Swedish nuclear power plants

Since the 10 power reactors operating in Sweden represent seven somewhat unique designs owing to their respective age and vendor, and have different prerequisites for complying with general regulations on design and construction, an impact assessment was conducted for each reactor. These assessments identified whether further analyses and/or back-fitting were needed in relation to each Section of the regulations. See Section I.5 for a more detailed description of the modernization and safety upgrading of all Swedish nuclear power plants

At the present time, a significant share of identified measures has been implemented, but some measures remain to be performed, especially for Oskarshamn 2 and Ringhals 2. For instance, almost all modernization activities of Oskarshamn 2 is planned to be completed in 2013. All modernization and safety upgrading of all Swedish nuclear power plants shall be completed before the end of 2015. The following measures are still to be implemented;

Independence of safety functions

- Actions to secure that scram, at all initiating events, can be performed without crediting pressure relief. (O2)
- Modernization of the electrical and control equipment in order to enhance the separation between operational and safety classified equipment. (O2)

Improvement of physical and functional separation

- Shielding of areas in the help system building from the pressure relief paths, by installation of rapid reacting isolation gates in order to increase safety margins against the impact on electric equipment at an external pipe break. Actions to improve physical separation between cables in auxiliary building. (R2)
- Actions to improve separation within the component cooling system. (R2)
- Strengthening the independence of the auxiliary feed water system through increased separation and installation of new water sources. (R2)
- Measures to minimize the risk that steam can spread from leaks or breaks in the blowdown system and that the chemical and volume control system shall affect the cooling system of the containment or the residual heat removal system. (R2)

Diversification of safety functions

- Action to diversify the initiation and execution of safety functions. (F1, F2, F3, O1, O2, O3)
- Installation of an automatic boron injection system in order to diversify the safety function reactivity control. (O1, O2)
- Installation of a diversified residual heat removal system. (O2)

- Installation of new separated and diversified reactor protection systems. (O2)
- Installation of new separated and diversified diesel generators. (O2)
- Analyses of station black out and ATWC-events. (R2, R3, R4)

Accident management measures

- Action to increase the capability to cool the containment after a severe accident if a core meltdown melts through the reactor pressure vessel. (F3)
- Installation of water relief valves in the pressure relief system. (O2, R1)
- Additional analyses of severe accidents. (R1)
- Enhancement of functions that can secure long term cooling after an accident. (R2, R3, R4)
- Actions to secure the venting of non-condensable gases from the reactor tank after an accident. (R1)

Robustness to local dynamic effects from pipe breaks

- Improved protection of containment isolation valves against dynamic effects. (O1, R2, R3, R4)
- Improved protection of components and equipment in containment against dynamic effects.(R3, R4)

Resistance to external and internal events

- Review of the design values for external events. (O2)
- Reinforcement of the roof in the central control room to better withstand earthquakes. (O2, R3, R4)
- Reinforcement of the ceilings of the reactor building and of the water intake building to better withstand wind, snow and tornado. (O2)
- Measures to take care of possible impact on safety functions from turbine missiles. (O2)
- Reinforcement of buildings to resist the slow external events and improvement of operational aids. (R1)
- Installation of a new emergency control room. (O2)

Environmental qualification and surveillance

- Environmental qualification of equipment outside the containment. (O2, R1)
- Analysis of environmental conditions. (R2, R3, R4)

Measures presented above are only reported for information's sake. The measures listed above are already covered by earlier SSM decisions as described in Section I.5 and SSM will for this reason not include any of these measures in the Swedish national action plan. However SSM will, in its review of the remaining modernization and safety upgrading of all Swedish nuclear power plants, review that and how measures listed above are implemented.

In addition to the measures listed above, the licensees need to implement measures to comply with the regulator's new regulations on security and physical protection (SSMFS 2008:12). These measures are not described in this report.

7.2 Experiences from the Fukushima accident that have led to planned actions or actions being considered in Sweden

The Fukushima accident highlighted a number of important questions concerning the Swedish emergency preparedness and response system for NPP accidents. Thus, an investigation of the adequacy and efficiency of the current system is needed. Such an investigation should consider several questions regarding the level of ambition and the distribution of responsibilities concerning how severe accidents should be incorporated in existing emergency preparedness and response plans. The following suggestions should be evaluated regarding their potential for improving the Swedish nuclear energy preparedness and response system and addressed if deemed appropriate. The suggestions are based on the consequences outside the plant in case of a release of radioactive substances, as well as on the experience of handling an accident.

Revise the emergency preparedness and response zones around the NPPs
Sweden currently has emergency preparedness and response zones that are insufficient if an emission occurs similar in extent as was the case in the Fukushima accident. The inner preparedness and response zone currently covers 12-15 km from the NPP.

Developing a national plan and crisis management
A better operational coordination of involved authorities is needed. During an accident, several authorities have different responsibilities and are involved in different decisions. It is thus important that they are coordinated and that the public receives consistent information. Also, coordination and cooperation between national, regional and local authorities, and the facility/company during an accident at a NPP is necessary for a successful response.

Develop endurance and the ability to receive international support
An accident at a Swedish NPP can lead to a drawn-out crisis where the acute phase continues for several weeks or even months. This leads to a large stress on the organizations that should handle the accident and its consequences. Thus, these organizations need to develop a plan to be able to handle a prolonged course of events. Furthermore, Sweden has to improve its capability to receive international assistance. With insufficient planning it is difficult to take advantage of international support.

Improve the ability to inform foreign organizations
The pressure on Sweden to inform other countries and international organizations during an event and to continually publish information translated into English will be substantial in the event of a NPP accident in Sweden. Organizations with responsibilities within nuclear energy preparedness and response need to improve their ability to inform in English so that foreign actors, without deep knowledge of how the Swedish system works, receive a comprehensive and correct picture of the situation.

Improve the capability to communicate uncertainties
To communicate uncertainties is difficult, but important to maintain the confidence of the public. Thus, this ability needs to be improved and to be exercised regularly.

Increased knowledge about radiation and increased ability to evaluate the risks in the community
Insufficient knowledge of radiation and its risks can invoke fear in the population.

It is especially difficult to communicate risks when an accident has occurred and thus education on a regular basis is essential. People living in the proximity of a NPP should be the priority of such a campaign, since they are the ones most likely to be affected by an accident. Risk assessment could be a mandatory part of the school education given in those areas.

Develop the ability to derive and publish dispersion prognoses
The strain on the responsible authorities to regularly publish dispersion prognoses in the event of an accident at a Swedish NPP will be intense. Radioactive releases, can lead to large concerns both in Sweden and its neighboring states. Thus, the ability to rapidly and understandably publish dispersion prognoses needs to be developed.

Improve the measurement capability within the nuclear energy preparedness and response
The necessity to measure fallout, contaminated people and provisions, to perform decontamination and so forth can be extensive after a NPP accident with radioactive emission. The present measurement capability is insufficient if a major radioactive emission should occur. Thus, the measurement capability within the Swedish emergency preparedness and response system needs to be improved, and provisions for receiving assistance in this area need to be made.

Review the planning of decontamination and handling of waste from a radioactive emission
The decontamination after a NPP accident requires extensive resources such as measurement capabilities, planning of actions to be taken, the possibility to handle large amounts of radioactive waste and long term follow-up. Thus, the planning of decontamination should be revised with the knowledge gained from the Fukushima accident in mind.

Review the starting point for decontamination after a radioactive fallout
ICRP's new recommendations state that measures should be considered in all territories where the inhabitants are at risk of obtaining an extra dose in the range of 1-20 mSv during one year as a result of extensive fallout from a NPP accident. Furthermore, ICRP states that the goal is the lower part of this range. Thus, Sweden should consider revising its decontamination planning with regards to ICRP's new recommendations.

Review the limits for radioactive substances in provisions
At present, Sweden only has limits for Cs-137 in its provisions. If a NPP accident occurs in the EU, EU will introduce limits for trade with provisions between EU member states. The EU limit for Cs-137 is not the same as the Swedish limit. Furthermore, Japan has lowered its limits for provisions to a limit far below both the EU and the Swedish limit. Sweden thus should evaluate how it should handle its limits for radioactive substances in provisions.

PART IV

8 Summary of implementation of activities

8.1 Introduction

Actions described in Chapter 1 to 6 of the Swedish national action plan is aggregated in the table below with heading numbering of topic number (TX) or generic (G), provided responsible licensee holder (LA), regulator (RA) or national organizations (NA) and a numerical order and heading of action. The actions are scheduled in three different categories each category with its own deadline when the actions shall be completed. If the actions are described as investigation the deadline refers to the report of this investigation. The deadline does in these cases not include any technical and administrative actions that the investigation reports are expected to propose. The categories are as follow;

2013 Actions shall be completed by 31 December 2013
2014 Actions shall be completed by 31 December 2014
2015 Actions shall be completed by 31 December 2015

This categorization is based on an assessment of the urgency of the actions' implementation as well as the complexities of these actions. The categories were chosen to create a framework for efficient and quality-assured implementation of each action, but also to form the basis for an appropriate and transparent implementation process that will be sufficient for each stakeholder. Furthermore are all licensee actions (LA) in the Swedish national action plan valid for all Swedish NPPs.

SSM will in early 2013 conduct a conjunction to the licensee holder in accordance with the schedule in the Swedish national action plan. SSM will in connection with the conjunction introduce parameters and parameter values in order to clarify the level of ambition of measures in the Swedish nation action plan. This in order to establish a framework that guarantee a consistent and quality assured process with the goal to further improve reactor safety as much as reasonable and possible. Depending of reported results and conclusions of the coming evaluations SSM will follow up with new conjunctions in order to secure that necessary technical and administrative measures will be implemented.

It is very likely that a many of the necessary technical and administrative measures will be implemented and completed after 2015, due to the fact that the measures in the Swedish national action plan for the most part are investigations, though it's important that all necessary measures will be implemented as soon as reasonable possible. All final actions such as technical and administrative measures that investigations define as necessary to implement shall be fully completed by 2020. However it's highly likely that SSM in most cases will decide that necessary measure shall be implemented earlier than 2020 in order to secure that the implementation take place as soon as reasonable possible without jeopardizing reactor safety.

Strålsäkerhetsmyndigheten
Swedish Radiation Safety Authority

8.2 Summary of actions to be performed by the licensees

In the following section, the actions which are already handled or going to be performed by the licensees are summarized, see Table below.

Table 1: Licensees actions. December 2014 update.

Action ID **Licensee Action (NA)**	**Action**	**Category** Completed	**Comments**
TOPIC 1 – NATURAL HAZARDS			
T1.LA.1	Seismic plant analyses	2013	*Further studies regarding the structural integrity of the reactor containments, scrubber buildings and fuel storage pools have been performed. The analyses showed that those structures can withstand an earthquake significantly stronger than the Swedish 1E-5-earthquake.*
T1.LA.2	Secondary effects of an earthquake	2014	*A more detailed analysis of earthquake induced flood, have been included in the analyses regarding secondary effects. Also seismic induced fires have been analyzed. Minor weaknesses have been addressed.*
T1.LA.3	Seismic monitoring	2014	*Seismic monitoring systems are installed at all Swedish sites. The licensees have reviewed the procedures and training program for seismic*

			monitoring and implemented them.
T1.LA.4	Extreme weather condition	2015	*Ongoing work*
T1.LA.5	Extreme water level estimation	2015	*Ongoing work*
T1.LA.6	Flooding margin assessments	2014	*Analyses of incrementally increased flood levels beyond the design basis and identification of potential improvements have been performed. These analyses included capability to mitigate internal and external flooding events. Weaknesses have been addressed and physical measures will be taken at some plants.*
T1.LA.7	Protected volume approach	2014	*Based on performed stress tests, measures will be performed at some plants.*
T1.LA.8	Early warning notification	2013	*The licensees have introduced instructions that the control room staff shall check the weather forecast once per shift with the Swedish Metrological Institute (SMHI). Discussions are ongoing with SMHI to create a routine where SMHI provides the licensees information directly on weather situations that may pose a threat to a plant.*
T1.LA.9	External hazard margins	2015	*Ongoing work*
T1.LA.10	Qualified walk-downs	2014	*Extensive efforts have been undertaken to manage resistance to earthquakes and other external events. As part of this, a walk-down methodology defined and documented, and several walk-downs performed. The licensees has chosen the*

			deterministic method represented by SMA (Seismic Margin Assessment), the produced routine based on guidelines in the EPRI NP-6041 SL.
TOPIC 2 – DESIGN ISSUES			
T2.LA.1	Demonstrations of design basis	2013	*Included in the Safety Analysis Reports for all Swedish NPPs.*
T2.LA.2	Alternate cooling and alternate residual heat removal	2015	*Ongoing work*
T2.LA.3	Primary and alternative AC power supplies and AC power distribution systems	2014	*Reassessments have been performed for all NPPs. All licensees have drafted plans for the strengthening of the electrical power supply.*
T2.LA.4	DC power supplies and DC power distribution system	2014	*The licensees have analyzed the actual available battery capacity available with existing loads. The analyzes shows that there are considerable margins of the batteries at some of the plants. For the remaining plants measures are envisaged to expand of the battery capacity in existing battery systems or application of load shedding or a combination thereof.*
T2.LA.5	Integrity of the primary system	2013	*For PWR the integrity of the primary system has been further evaluated and reassessed for prolonged extreme situations resulting from natural phenomena and other events. This included reassessment of the primary pumps seals which will*

			be replaced.
T2.LA.6	Main and Emergency Control Rooms as well as emergency control centre	2013	*Operability and habitability of the main and the emergency control rooms as well as emergency control center have be further evaluated. Some weak points have been identified and will be addressed. For example the inner roofs in control rooms have been strengthened to withstand strong earthquakes.*
T2.LA.7	Instrumentation and monitoring	2015	*According to plan.*
T2.LA.8	Integrity of the spent fuel pools	2013	*Integrity and robustness of the spent fuel pools during prolonged extreme situations have been further evaluated and reassessed The assessments have defined technical and administrative measures to be addressed. For example measures have been identified and addressed regarding strengthening of the water supply to the fuel pools.*
T2.LA.9	Mobile equipment	2015	*According to plan.*
T2.LA.10	Equipment inspection	2013	*Plans have been developed to ensure that the procedures for inspection and maintenance are incorporated in ordinary activities, both for equipment that existed before Fukushima and equipment acquired as a result of the stress tests.*
T2.LA.11	Training programs	2015	*According to plan.*

T2.LA.12	Consumables	2014	*The licensees have evaluated and assessed the technical and administrative measures needed to ensure adequate accessibility during all potential situations.* *The conclusions drawn is that the review carried out by all facilities for fuel supplies and consumables as well as development of Technology Guiding decisions and analyzes and reports implemented the requirements of the Technical Steering decisions are deemed to fulfill the requirement.*
T2.LA.13	Resources	2015	*According to plan.*
T2.LA.14	Accessibility of important areas	2015	*According to plan.*
T2.LA.15	Simultaneously event affecting all reactors at the site	2015	*According to plan.*
T2.LA.16	Severe accident mitigation systems	2015	*According to plan.*
T2.LA.17	Procedures and training	2015	*According to plan.*
T2.LA.18	External support	2015	*According to plan.*
T2.LA.19	Criticality and/or re-criticality	2014	*For Ringhals PWRs re-criticality must be considered in the long time scenario. Measures have been identified and addressed.* *The overall probability for re-criticality the that*

			endangers the containment integrity is judged to be very small for the BWRs.
TOPIC 3 – SEVERE ACCIDENT MANAGEMENT AND RECOVERY (ON-SITE)			
T3.LA.1	Capability to cool the spent fuel pool	2014	*The concept for the preliminary studies and analyzes is based on the feed-and-bleed cooling concept of the fuel pools. Overall requirements for alternative function for cooling the fuel in the fuel pools have been developed by the licensees in a common project.*
T3.LA.2	Independent core cooling system	2014	*The licensees have in a common project developed a"Position Paper" that defines requirements that shall be adopted.*
T3.LA.3	Instrumentation of spent fuel pool	2014	*The necessary instrumentation to monitor temperature and water level in the fuel pools will be introduced in connection with the introduction of an alternative function for cooling the fuel in the fuel storage pools, see Action T3.LA.1.*
T3.LA.4	Measuring radiation levels	2014	*Recommendations on more dose rate monitors in the reactor building to support accident management have been addressed at all utilities.*
T3.LA.5	Capability to handle more than one affected unit	2014	*As a direct measure after the Stress tests the licensees have developed training scenarios and emergency exercises in which more than one*

			reactor is involved.
T3.LA.6	Managing re-criticality	2014	*The licensees have conducted a review of existing emergency operating procedures with bearing on re-criticality. This has resulted in an updating of the instructions in the Emergency Operating Procedures.*
T3.LA.7	Managing loss of containment integrity	2014	*The licensees have investigated possible strategies on loss of containment function and approaches to assess the containment damage extent. The outcome of the investigations will be incorporated in the Emergency Operating Instructions.*
T3.LA.8	Accident management programmes	2014	*A review of the instructions has been carried out for all utilities. Some changes have been implemented based on the findings. As the emergency preparedness organization develops, further mobile equipment are introduced and analyzes carried out, the emergency procedures will be developed.*
T3.LA.9	Training and drills	2014	*As a direct measure after the Stress tests the licensees have developed training scenarios and emergency exercises in which more than one plant is involved.*
T3.LA.10	Call-in system	2014	*The licensees have in some cases decided to introduce enhanced call-in-systems.*
T3.LA.11	Support for handling hydrogen in a lengthy sequence	2014	*Investigation into the handling of hydrogen (oxyhydrogen) after a severe accident is handled in*

			a joint licensees project within the Nordic Owners group (NOG). So far, the project has focused on hydrogen formation and accumulation in the reactor containment. A number of potential shortcomings in the handling of hydrogen gas after a severe accident have been identified.
T3.LA.12	Managing large volumes of contaminated water	2015	*Ongoing work*
T3.LA.13	Personal safety issues	2014	*This issue is handled within the framework of action in response to the requirements of the new emergency regulations, SSMFS 2014: 2.*
T3.LA.14	Emergency control center	2014	*This issue is handled within the framework of action in response to the requirements of the new emergency regulations, SSMFS 2014: 2.*
T3.LA.15	Support to local operators	2014	*This issue is handled within the framework of action in response to the requirements of the new emergency regulations, SSMFS 2014: 2.*
T3.LA.16	Containment filtered venting system in the long-term	2014	*Investigations and assessments of the ability to manage a severe accident have been performed by the licensees with different suggested solutions of the case.*
T3.LA.17	Handling of the containment chemistry	2014	*Investigations and assessments of the ability to manage a severe accident have been performed by the licensees. The conclusion of the study is that none of the studied phenomena are expected to*

			provide substantial degradation of the containment and increase the emissions. Uncertainties remain for some plants regarding the risks of corrosion and degradation of polymeric materials, and that current research in these areas should be followed.
T3.LA.18	Available common resources	2014	*The licensees have evaluated the existing shared resources on the site with different suggested solutions.*
T3.LA.19	Common system for filtered containment venting	2014	*To ensure that the MVSS function as intended with simultaneous failure of Oskarshamn 1 and 2 an Emergency Operating Procedures governing the coordination has been developed..*
TOPIC 5 – EMERGENCY PREPAREDNESS AND RESPONSE AND POST-ACCIDENT MANAGEMENT (OFF-SITE)			
T5.LA.1	Clarify the responsibility for decontamination stations outside the site for personnel during shift turnovers and how equipment is to be replaced	2014	*This has been handled within in the update of the emergency plan.*
T5.LA.2	Investigate the course of action during a long-term need for personnel	2014	*This has been handled within in the update of the emergency plan.*
T5.LA.3	An investigation is suggested to ascertain advantages and disadvantages in replacing the present substitute Command Centre with a suitable office outside the site	2014	*This has been handled within in the update of the emergency plan*
T5.LA.4	It shall be investigated whether some of the functions included in the emergency preparedness	2014	*An investigation has been conducted and the number of persons to maintain permanent*

	organization staffing are sufficient, to sustain shifts around the clock		*staffing around the clock in case of emergency has been established for the roles in emergency response organization. The results have been incorporated the emergency plan.*
T5.LA.5	Presently calling in personnel depends on a functioning GSM/Telenet. An improvement in this area shall be investigated	2014	*This has been handled within in the update of the emergency plan.*
T5.LA.6	Identify alternative evacuation routes. Alternative collection sites shall be decided upon and incorporated in the licensee's emergency plans. These sites shall be communicated with the emergency planning at the county administration board.	2014	*This issue is handled within the framework of action in response to the requirements of the new emergency preparedness regulations, SSMFS 2014:2.*
T5.LA.7	The Command Centre shall be connected to its own auxiliary power supply that is independent of the regular power supply at the plant site.	2013	*Auxiliary power is now in place for all the Command Centers*

TOPIC 6 – INTERNATIONAL COOPERATION			
T6.LA.1	Expanding the scope of WANO Peer Reviews	2015	*According to plan.*
T6.LA.2	Expanding the frequency of WANO Peer Reviews	2015	*According to plan.*
T6.LA.3	Developing a world-wide integrated event response strategy	2015	*According to plan.*

Table 1: Summary of actions to be performed by the licensees, December 2014 update.

8.3 Summary of actions to be performed by the regulators

8.3.1 Generic actions to be performed by the regulators

Generic measures related to two or more topics that are to be performed by SSM are given in the following Section.

G.RA.1 - Implementation of the results from the analysis of long-term safety
SSM presented 31 October 2012, an analysis of long-term safety in the Swedish nuclear power industry to the Swedish Government. The analysis encompasses an overall evaluation of how the nuclear power reactors fulfill the requirements imposed on safety upgrades, an assessment of which additional requirements on safety improvements that are necessary for extended periods of operation (exceeding 40 years) as well as conditions that may be decisive for operating a reactor over extended operating period. SSM has also conducted an analysis of the Swedish supervisory model in the field of reactor safety. In the upcoming years, SSM will implement the results from the analysis (which includes an extensive review and development of existing requirements).

G.RA.2 - Review of actions belonging to category 2013
SSM will perform reviews of the licensee actions belonging to category 2013 and thereafter decide of further work, including implementation of necessary technical and administrative measures.

G.RA.3 - Review of actions belonging to category 2014
SSM will perform reviews of the licensee actions belonging to category 2014 and thereafter decide of further work, including implementation of necessary technical and administrative measures.

G.RA.4 - Review of actions belonging to category 2015
SSM will perform reviews of the licensee actions belonging to category 2015 and thereafter decide of further work, including implementation of necessary technical and administrative measures.

Strålsäkerhetsmyndigheten

Swedish Radiation Safety Authority

8.3.2 Summary table of actions to be performed by the regulators

In the following section, the actions which are already handled or going to be performed by the regulatory body, see Table below.

Table: Summary of actions which are already handled or going to be performed by the regulators, December 2014 update.

Action ID Regulator Action (RA)	***Action***	**Category** Completed	**Comments**
TOPIC 1 – NATURAL HAZARDS			
T1.RA.1	*Research project regarding the influence of paleoseismological data*	2013	*A literature search has been initiated.*
T1.RA.2	*Estimation of extreme weather conditions*	2013	*This work has been performed by the Swedish Meterological and Hydrological Institute.*
TOPIC 5 – EMERGENCY PREPAREDNESS AND RESPONSE AND POST-ACCIDENT MANAGEMENT (OFF-SITE)			
T5.RA.1	*Up-dating and formalization of pre-defined criteria on* *countermeasures and the implementation of measurable operational intervention levels and routines for application of intervention levels*	2013	*In the last quarter of 2013 the Nordic Flagbook, "Protective Measures in Early and Intermediate Phases of a Nuclear or Radiological Emergency, Nordic Guidelines and Recommendations", was completed and approved by the Director Generals of the Nordic Radiation Safety Authorities. The acceptance and subsequent implementation of the*

			guidelines and recommendations in the Flagbook is ongoing through a project during 2015, conducted with the regional authorities and other relevant actors in handling a NPP accident. An investigation on the emergency zone sizes has been completed in June 2014 and the results of that investigation are planned to also be considered in the implementation of intervention levels.
T5.RA.2	*SSM and the nuclear facilities are currently working towards establishing a system for electronic transmission of plant data from the Swedish nuclear power plants to SSM's Emergency Response Centre.*	2015	*This project is ongoing. Progress was made in 2014 but the final goals of the project have not been accomplished yet.*
T5.RA.3	*Implementation of the revised Swedish regulation SSMFS 2008:15, SSM's Regulations concerning Emergency Preparedness at Certain Nuclear Facilities.*	2013	*The revised Swedish regulation on Emergency Preparedness at Nuclear Facilities, SSMFS 2014:2, was completed during 2014. This regulation enters into force on January 1, 2015.*
T5.RA.4	*The Nordic Flag Book*	2013	*In the last quarter of 2013 the Nordic Flagbook, "Protective Measures in Early and Intermediate Phases of a Nuclear or Radiological Emergency, Nordic Guidelines and Recommendations", was completed and approved by the Director Generals of the Nordic Radiation Safety Authorities. The Flagbook has been translated into Swedish during 2014. See answer to T5.RA.1 for further information.*

TOPIC 6 – INTERNATIONAL COOPERATION			
T6.RA.1	*Accede to the 2004 Protocol to amend the Paris and Brussels Conventions on Third Party Liability in the field of nuclear energy*	Ongoing	*Status unchanged*
T6.RA.2	*Assessment and improvement of international crisis communication and information dissemination.*	Ongoing	*The Swedish emergency preparedness guidelines have been updated. Sweden participates in WENRA and HERCA.*
T6.RA.3	*IRRS recommendation to SSM to establish and implement guidance for dissemination of all significant operating experience and lessons learned to all relevant authorized parties*	2013	*This is an ongoing process.*
T6.RA.4	*Actively participate in information exchange after the Fukushima accident – International organizations*	Ongoing	*Sweden participates in meetings and information exchange*
T6.RA.5	*IRRS-recommendation: Better ensure compliance with relevant IAEA Standards*	2013	*The internal guidelines are updated and controlled against IAEA-guides.*
T6.RA.6	*More strategic coordination and follow-up of the work in the different IAEA Safety Standards Committees*	2015	*The work is ongoing*
T6.RA.7	*Fulfillment of WENRA reference levels (RLs)*	2015	*The work is ongoing*

GENERIC			
G.RA.1	*Implementation of the results from the analysis of long-term safety*	2015	*According to plan.*
G.RA.2	*Review of actions belonging to category 2013*	2013	*The reports are continuously followed up, by SSM, and actions are undertaken when needed.*
G.RA.3	*Review of actions belonging to category 2014*	2014	*SSM will follow up the action described by the licensees during 2015.*
G.RA.4	*Review of actions belonging to category 2015*	2015	*According to plan.*

Table 2: Summary of actions which are already handled or going to be performed by the regulators, December 2014 update.

8.4 Summary of actions to be performed by national organizations

In the following section, the actions which are already handled or going to be performed by the licensees are summarized, see Table below.

Action ID National organizations Action (NA)	**Action**	**Category** Completed	**Comments**
TOPIC 4 – NATIONAL ORGANIZATIONS			
T4.NA.1	Processing the result from the evaluations of the country-wide exercise focusing on a nuclear power plant accident – SAMÖ/KKÖ	2013	*The result has been processed.*
T4.NA.2	Processing the result from the evaluations of the performances of the national organizations throughout the first month of the accident at the Fukushima Dai-ichi NPP	Ongoing	*Work in progress*
T4.NA.3	Evaluation of the Swedish Defense Research Agency's (FOI) role during a radiological or nuclear	Ongoing	*Work in progress*

	emergency		
T4.NA.4	A country-wide exercise focusing on a nuclear power plant accident – Havsörn	2013	*Completed in Dec 2013*
T4.NA.5	The evaluation of the exercise finished with a final report from the evaluation team – Havsörn	2014	*The final report evaluating the exercise has been produced by the County Board of Uppsala.*
T4.NA.6	Processing the result from the evaluations of the country-wide exercise focusing on a nuclear power plant accident – Havsörn	2014	*This is taken care of within the framework of the Action Plan "The Swedish preparedness for radiological and nuclear accidents in 2015". Various development projects have been initiated to increase the ability to manage a nuclear event. The Action Plan is updated annually.*

Table 3: Summary of actions to be performed by the national organizations, December 2014 update.

Strålsäkerhetsmyndigheten
Swedish Radiation Safety Authority

PART V

9 Progress on implementation and update of the Action Plan

9.1 Response/clarification on any issues identified in the rapporteur's report from the 2013 workshop.

The following in section 9.1 is the rapporteur's report completed with the Swedish response under the headline "Clarification".

9.1.1 Compliance of the national action plan with the ENSREG Action Plan:

The National Action Plan of Sweden contains a compilation of conclusions and recommendations derived from the Compilation of Recommendations of ENSREG, key topics of the 2nd Extraordinary Meeting under the CNS, the state review of stress test results and findings of the Peer Review Country Report.

The country followed the structure proposed in the ENSREG Action Plan. National EU Stress test results were considered as well as ENSREG and CNS aspects.

The measures for Topics 1-3 are listed according to the national classification. There are no explicit references to the corresponding ENSREG recommendations and suggestions, Country Peer Review recommendations and aspects from CNS. Such references would have been helpful for assessing the content of the NAcP.

Clarification:

These references were addressed and clarified during the Post-Fukushima National Action Plans Workshop 2013.

9.1.2 Adequacy of the information supplied, taking into account the guidance provided by ENSREG.

The overall structure of the Swedish NAcP follows the ENSREG guidance. The proposed outline was adopted with Parts I – IV as recommended by ENSREG. An introductory section provided general date about the sites and plants, including measures already taken due to the Fukushima accident.

It is notable that the central Swedish spent fuel storage facility CLAB was included in the national stress test.

In the presentation at the Workshop, it was shown that relevant measures for severe accident management had already been taken in the 80s. Further measures were taken after a new regulation entered into force in 2005.

Clarification:

As mentioned earlier in this report Sweden took actions after the TMI accident in the United States 1979. The Swedish Government decided that all Swedish nuclear *power reactors shall be capable of withstanding a core melt accident without any casualties or ground contamination of significance to the population. This resulted in an extensive back-fitting for all Swedish nuclear power reactors.*

Furthermore, due to the background of different incidents, SSM decided to issue general regulations on the design and construction of nuclear power reactors. These regulations named SSMFS 2008:17 (previously SKIFS 2004:2) and the general advice on their interpretations entered into force on 1 January 2005 with transitional provisions.

9.1.3 Assessment of the content of National Action Plan

How has the country addressed the recommendations of the ENSREG Action Plan?

It is stated in the Swedish NAcP that most of the actions described in the NAcP are investigations for which the aim is to determine and consider which measures are fit for purpose, how they shall be implemented, and the time for implementation. All actions of the plan are prescribed to all plants; the measures which will result from the investigations are likely to be more plant-specific. The Swedish NAcP is based on site-specific action plans which have been presented by the licensees but not yet been reviewed by SSM; definitive establishment and completion of the site-specific action plans will be the first step of implementation of the NAcP. The interplay between planning on national and site level is complicated and not fully explained in the NAcP, but was clarified in presentation and discussion at the WS. SSM will in early 2013 issue a decree to the licensees, including parameters and parameter values to clarify the level of ambition of the measures in the NAcP, in order to establish a framework for a consistent and quality assured process to further improve reactor safety. The further process will be monitored (annual status report from licensees to authority) and followed up with new decrees by SSM to secure implementation of measures.

The actions listed in the Swedish NAcP cover all of the ENSREG and Country Peer Review recommendations. In the absence of explicit references to these recommendations, it is difficult to establish the correspondence between actions and recommendations in each case. However, the consideration of the recommendations was clarified in the presentation and the discussion at the workshop. The only case where this could not be fully verified, ENSREG recommendation 3.3.16 (Severe Accident Studies), is of minor importance.

It should also be noted that the methods applied for investigations and analyses of natural hazards (Section 1.2 of NAcP) are not fully described.

Clarification:

For all natural hazards a return frequency of 10-5/year is used for plant reviews and backfitting. Cliff-edge effects below a return frequency of 10-5/year have also *been identified. A physical model is used for the flooding margin assessments for the Baltic Sea. For other natural phenomena the main methods used are based on available statistics as far as possible, combined with models were suitable. These extreme weather estimations are mainly made by the Swedish Meteorological and Hydrological Institute.*

Especially for seismic activities, national input data from the Swedish "Project Seismic Safety" with probabilistic assessment of seismic ground motion characteristics for Swedish hard rock sites have been used.

9.1.4 Schedule of the implementation of the NAcP

The measures listed in the NAcP are scheduled in three categories: Completion by the end of 2013, by the end of 2014 and by the end of 2015. It has to be noted that this mostly concerns investigations, as pointed out above. Implementation of the necessary technical and administrative measures, as a consequence of the investigations, will follow afterwards (until 2020 at the latest).

In the NAcP, it is stated that SSM considers it as highly likely that the majority of necessary technical and administrative measures will be implemented before 2020 to make sure that implementation takes place as soon as reasonably possible. However, no definite deadlines or milestones are defined between 2015 and 2020.

Clarification:

For new milestones see further the requirements regarding independent core cooling in chapter 9.3, "Main changes in the NAcP since the 2013 workshop with justification"

9.1.5 Transparency of the NAcP and of the process of the implementation of the tasks identified within it

The NAcP contains comprehensive information on the actions planned post-Fukushima, as well as background information on the European context of the activities and on the Swedish nuclear power plants.

The process to plan the activities in Sweden, for example the interplay between planning on the national and the site level, could be better described. Also, the lack of direct referencing between actions and ENSREG and Country Peer Review Recommendations renders it difficult to get an overview for the review of the implementation of these recommendations. The NAcP is accessible both on the regulator's and the ENSREG website. Its implementation will be closely monitored by SSM, and the implementation process is to be transparent for all stakeholders. The annual status reports will be published.

Clarification:

The licensees produce an annual status report in December every year. The reports are continuously followed up, by SSM, and actions are undertaken when needed. For example the construction criteria and implementation plan for the Independent Core Cooling actions are followed in detail by SSM. Annual meetings are also held with different NGO's. Furthermore, the implementation of improvements as a result of the requirements in SSMFS 2008:17 ¨Regulations concerning the Design *and Construction of Nuclear Power Reactors¨ is an established process that is of great help in monitoring the NAcP. The continuous work with the NAcP can be followed at SSM's website.*

9.1.6 Commendable aspects (good practices, experiences, interesting approaches) and challenges

Specific safety goals in terms of timespans for keeping a safe plant state (e.g. in case of total loss of AC power) have been set in Sweden, which can be regarded as a good practice. It is also commendable that the implementation of severe accident management measures has begun in the 1980s.

A return frequency of 10^{-5}/year is used for plant reviews and backfitting for all natural hazards. The time schedule presented in the NAcP focusses on investigations, and does not provide detailed information on the schedule for the resulting technical and administrative measures. Establishing appropriate, comprehensive and consistent schedules for these measures constitutes a challenge and will need comprehensive planning, also taking into account that the pre-Fukushima modernization program is still on-going. The final deadline provided for all related activities (2020) is later than most other countries. However, the implementation of the majority of the measures is expected before this year, but the definite deadlines cannot be provided before the investigations are completed.

Clarification:

Due to the long period of time for implementing final installations, SSM has issued a decision on requirements for transitional solutions for considerable reinforcement of the core cooling function's independence that must be implemented on all reactors by December 31, 2017. By the deadline of 30 June 2015, licensees are required to submit an implementation plan for the measures to be taken by 2017. These transitional solutions are considerable reinforcement of the core cooling function's independence. For the reactors that licensees intend to shut down over the next few years after 2020, these licensees may apply for changes to the conditions on required installation of an Independent Core Cooling system.

An implementation plan for the final Independent Core Cooling system must be submitted not later than December 31, 2015.

9.1.7 PEER-REVIEW Conclusions

The NAcP follows the structure proposed in the ENSREG Action Plan. It contains comprehensive information on the actions planned in the aftermath of Fukushima, as well as background information on the European context of the activities and on the Swedish nuclear power plants.

The actions listed in the Swedish NAcP cover the ENSREG and Country Peer Review recommendations as well as CNS recommendations. However, there are no explicit references to the corresponding recommendations which would have been helpful for the review.

The NAcP mainly presents investigations for which the aim is to determine and consider which measures shall be implemented, and the time for their implementation. So far, there is a clear and relatively tight schedule for the activities. However, the subsequent implementation of the technical and administrative measures resulting from the investigations is a complex task which will constitute a challenge to generate an appropriate, comprehensive and consistent schedule for these measures. The final deadline provided for all related activities (2020) is later than most other countries. However, the implementation of the majority of the measures is expected before this year, but the definite deadlines cannot be provided before the investigations are completed. It is notable that the central spent fuel storage facility CLAB has been included in the stress test. Specific safety goals in terms of timespans for keeping a safe plant state (e.g. in case of total loss of AC power) have been set in Sweden, which can be regarded as a good practice.

It is also commendable that the implementation of severe accident management measures has begun in the 1980s and that Sweden applies continues improvements and is implementing extensive modernization programs. The implementation of the independent core cooling systems should be considered with high priority and will be regarded as a challenge.

Clarification:

See earlier clarifications

9.2 Progress on implementation and update of the NAcP.

The work is generally following the NAcP structure with specified questions and/or analysis tasks to be addressed each year (2013, 2014 and 2015). A yearly report is prepared and submitted by each licensee to SSM, where actions driven by that year's item are briefly described. In some cases, the assessments already made as part of the stress tests have been considered as sufficient. One issue has strongly dominated the work with implementation of the NAcP; the question regarding a new function for independent core cooling (T3.LA.2). Based on the proposed design basis presented by the licensees as part of the 2013 reporting, SSM issued a draft decision that formally requested industry comments and a basis for a consequence assessment and finally in December 2014 issued a decision of implementation until 2017 and 2020. Implementation of this part of the NAcP has caused the licensees to reformulate their original strategy for post stress test measures. This particular requirement will continue to dominate the work with implementation of the NAcP.

9.3 Main changes in the NAcP since the 2013 workshop with justification, including:

- Additional measures

Due to the long period of time for implementing final installation, SSM has also issued a decision on requirements for a transitional solution for considerable reinforcement of the core cooling function's independence. This solution is required to be in place by 31 December, 2017.

- Measures removed or modified

No measures have been removed or modified.

- Changes in the schedule

Two issues dealing with Independent Core Cooling are described in the action plan: T3.LA.24 and T2.LA.25. According to the action plan, analyses/investigations of the issues shall be finalized by the end of 2013 regarding T3.LA.2, and in late 2015 regarding T2.LA.2.

A new milestone has been added in the schedule. SSM issued a decision on the 15 December 2014 requiring an independent Core Cooling function to be in place by 31 December 2017 for all reactors. These transitional measures do not have to fully meet the design basis for the independent Core Cooling. Furthermore the measures consist mainly of enforcement of the emergency power with upgrading of present gas turbines and new mobile equipment, with new connection points and new power feed trains.

9.4 Technical basis leading to the main changes identified in the NAcPs.

The need to increase the reliability of core cooling in a nuclear power reactor by introducing an independent function was brought up already when drafting the Swedish Nuclear Power Inspectorate's (SKI) regulation SKIFS 2004:2 in the early 2000s. This regulation corresponds to SSM's present regulations (SSMFS 2008:17) concerning the design and construction of nuclear power reactors. The objective of the system was to; during a severe accident (Swedish event class H5)–"total loss of all non-battery-backed emergency systems (SBO)"–add water over a 24 hour period to the reactor pressure vessel by connecting a water reservoir located outside of the reactor containment. The pumping of water would have to be activated independently of the reactor protection system, and also require a separate power supply.

For this reason, an early draft version of the proposed new regulation SKIFS 2004:2 contained the following proposal:

"In order to reduce the risk of core melt and reactor pressure vessel melt-through, it should be possible to add water to the reactor pressure vessel by connecting an independent water reservoir located outside of the reactor containment. Activation of pumping should be possible independently of the reactor protection system, and the system should also have a separate power supply."

The knowledge base, especially regarding potential negative effects of introducing this kind of function, was judged as insufficient for deciding on a regulation at that stage. SKI therefore came to the conclusion that further investigation was necessary. This further investigation was finalised in March 2009.1 The need for Independent Core Cooling received further attention after the Forsmark 1 event on 25 July 2006, as well as after the serious accident at the Fukushima Daiichi nuclear power plant. After the Fukushima accident the work to update and complete this memorandum has been ongoing.

On the basis of this memorandum and a consequence assessment, SSM decided in December 2014 on the implementation of Independent Core Cooling. In connection with this decision, SSM also provided guidance for the licensee analyses of the capability of a potential response force to withstand antagonistic threats, including assumptions on antagonists' possible entry and use of explosives in the plant, particularly on the Independent Core Cooling.

Transitional measures

Due to the complexity of the system to be implemented, SSM will impose a requirement on a system being in place by 2020 for Independent Core Cooling having a design that fully meets the proposed design requirements stated in this memorandum. SSM issued a decision on the 15 December 2014 requiring an independent Core Cooling function to be in place by 31 December 2017 for all reactors. These transitional measures do not have to fully meet the design basis for the independent Core Cooling. Furthermore the measures consist mainly of enforcement of the emergency power with upgrading of present gas turbines and new mobile equipment, with new connection points and new power feed trains. The licensee may choose to apply this transitional solution in part or in its entirety as a component of the final design. The transitional solution may be applied during the remaining period of operation to reactors that the licensees only intend to operate for a limited period of time after 2020. In those cases the licensees have the opportunity to apply for exemptions.

9.5 Relevant outcomes of studies and analyses identified in the NAcPs, and completed since the 2013 workshop.

The results so far are achieved in several areas. One important area relates to increased knowledge and understanding of severe accidents and multi-unit events which includes the ability to use the Containment Filtered Venting Systems as heat sink in long-term sequences. Furthermore, early warnings systems are established, including the Swedish Meteorological and Hydrological Institute, SMHI, to get warnings of severe weather conditions. Based on the increased knowledge several procedures and instructions have been updated.

All analyses/studies/investigations requested 2013 and 2014 have been performed.

9.6 Good practices and challenges identified during implementation so far.

The Independent core cooling system is the most important safety measures in the Swedish National Action Plan. Therefore, most of our work connected to the action plan during the last years is related to this issue. During 2014 SSM made a decision about the basic design requirements. Because of a relatively long time for the final full scope implementation Sweden also decided on transitional measures implemented before 31 December 2017.

The time is very limited for such extensive modifications, and it has been a necessity that SSM early formulated requirements on the basic design criteria. There has also been a successful strategy with a joint group with members from all licensees and the owners, KSKG. The group identified critical key issues that needed to be solved or clearly described in the requirements. A series of meetings have also been held between SSM and KSKG to implement the understanding of the requirements.

Transitional solutions will primarily focus on actions that provide the greatest possible increase of the safety levels. Because of different generations and different designs of the Swedish NPPs, the transitional solutions will be different. The measures are based on the results from the Stress tests and PSA studies have verified their importance. For most of the plants the transitional solutions will mainly increase the independence of the emergency power for the existing core cooling systems.

Finally, worth stressing is another important success factor - the comprehensive safety modernization carried out in Sweden between 2006 and 2014. The main areas for the safety modernization has been reinforced independence, diversification, increased separation and the measures performed to fulfill the requirement that the facilities should be able to withstand extreme natural phenomena. These measures have created good conditions to meet the requirements currently foreseen, linked to the experience after the nuclear accident in Fukushima.

A general challenge worth mentioning is that many questions in NAcP have a relatively open formulation, i.e. "an investigation shall be performed", "a study shall be performed", "… shall be further analyzed and reassessed", etc. The fact that all licensees have identical questions to address in the NAcP has stimulated cooperation and dialogue, which is positive.

Due to the fruitful exchange of opinions, possible solutions and discussions regarding gained benefits it made the most important solutions to be chosen first. Also the use of PSA to point out the most relevant measures to be performed has showed that the SSMFS 2008:17 requirements have increased the safety at the Swedish plants.

References

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3. **SSM, SSM2011-2063 to 2065.** *Förnyad säkerhetsvärdering av tålighet mot vissa händelser.* 2012.

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5. **Ministry of the Environment, Ds 2012:18.** *Concention on nuclear safety 2012 extra ordinary meeting. The Swedish National Report.* 2012.

6. **Forsmark Report FQ-2012-0742.** *Forsmarks Kraftgrupp AB - Redovisning av planer för åtgärder i syfte att ytterliggare stärka anläggningarnas tålighet mot vissa händelser (SSM2011-2063-16).* 2012.

7. **Oskarshamn Report 2012-19682.** *OKGs planer för åtgärder i syfte att ytterliggare stärka anläggningarnas tålighet mot vissa händelser (Föreläggande SSM2011-2064-17).* 2012.

8. **Ringhals Report 2204434.** *Ringhals 1-4: Redovisning av åtgärdsplan enligt SSM beslut (SSM2011-2065-15).* 2012.

List of Acronyms

AC	Alternating Current
ATWC	Anticipated Transient Without all Control rods
ATWS	Anticipated Transient Without Scram
BWR	Boiling Water Reactor
CNS	Convention of Nuclear Safety
DBE	Design Base Earthquake
DBF	Design Base Flooding
DC	Direct Current
EC	European Commission
ENSREG	European Nuclear Safety Regulators Group
EU	European Union
EXWE	Extreme Weather
F1	Forsmark unit 1
F2	Forsmark unit 2
F3	Forsmark unit 3
FOI	The ministry of the environment and the Swedish defense research agency
HERCA	Heads of European Radiological Competent Authorities
IAEA	International Atomic Energy Agency
ICRP	International Commission on Radiological Protection
INRA	International Nuclear Regulators Association
IRRS	Integrated Regulatory Review Service
ISP	The Swedish Agency for Non-Proliferation and Export Controls
LOCA	Loss Of Coolant Accident
MSB	The Swedish civil contingencies agency
MTO	Man-Technology-Organization
MVSS	Multi-Venturi Scrubber System
NPP	Nuclear Power Plant
NUSSC	The Nuclear Safety Standards Committee
O1	Oskarshamn unit 1
O2	Oskarshamn unit 2
O3	Oskarshamn unit 3
OECD/NEA	The Nuclear Energy Agency (NEA) within the Organization for Economic Co-operation and Development (OECD),
PS	Pressure Suppression
PSA	Probabilistic Safety Assessment
PSR	Periodic Safety Reviews

PWR	Pressurized Water Reactors
R1	Ringhals unit 1
R2	Ringhals unit 2
R3	Ringhals unit 3
R4	Ringhals unit 4
RASSC	Radiation Safety Standards Committee
SAFIR	The Finnish research programme on nuclear power plant safety
SAM	Severe Accident Management
SAR	Safety Analyses Report
SBO	Station Black Out
SKI	Swedish nuclear power inspectorate
SMA	Seismic Margin Assessment
SMHI	The Swedish Meteorological and Hydrological Institute
SSM	The Swedish radiation safety authority
TMI	Three Mile Island
TRANSSC	The Transport Safety Standards Committee
UD	The ministry for foreign affairs
WANO	The World Association of Nuclear Operators
WASSC	Waste Safety Standards Committee
WENRA	Western European Nuclear Regulators' Association