Strål
säkerhets
myndigheten
Swedish Radiation Safety Authority

Swedish action plan
for nuclear power plants

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Abstract

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 will 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 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.

SSM will perform reviews of the licensee actions belonging to each category and thereafter decide 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. 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.

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I General data about the sites and plants

I.1 Background

Following the severe accidents which took place in the Fukushima Dai-ichi nuclear power plant, the European Council of 24/25 March 2011 requested stress tests to be performed for 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 focused 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 one 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 will in these cases 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 the Swedish NPPs 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 heading to be 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.

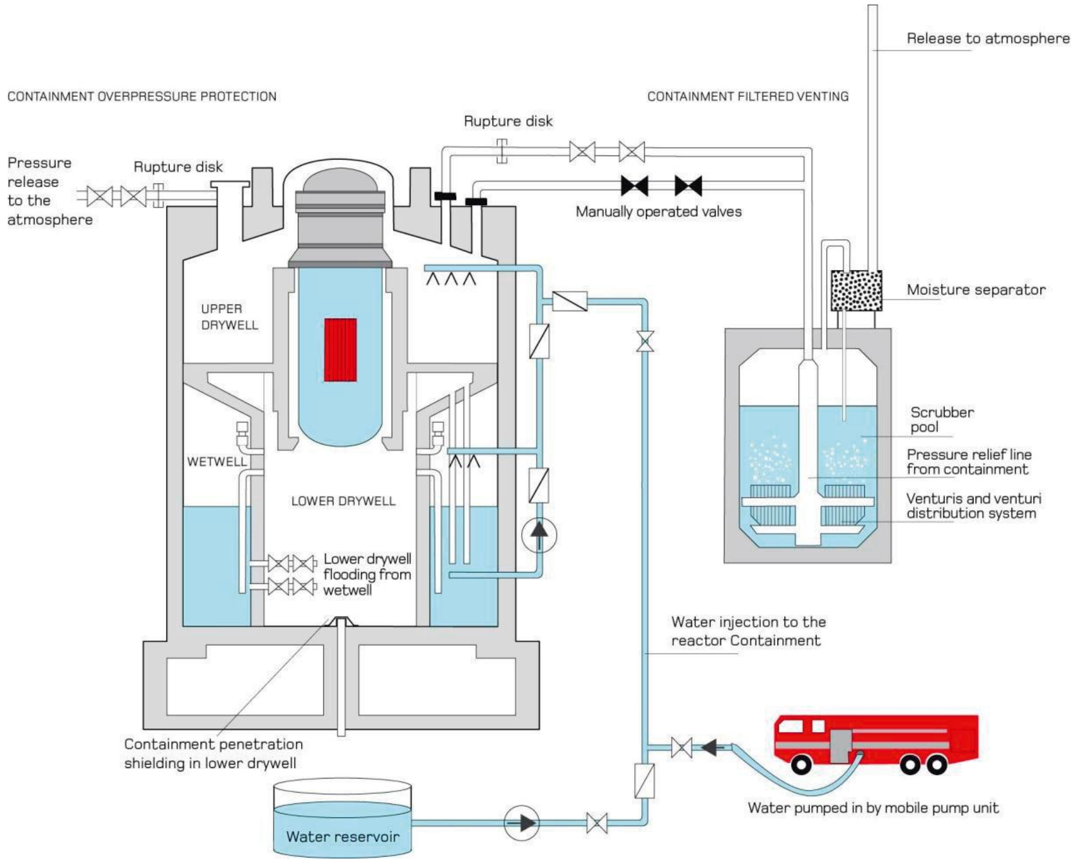

Figure 1 - Schematic view of the severe accident mitigation features installed in Swedish BWRs.

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.

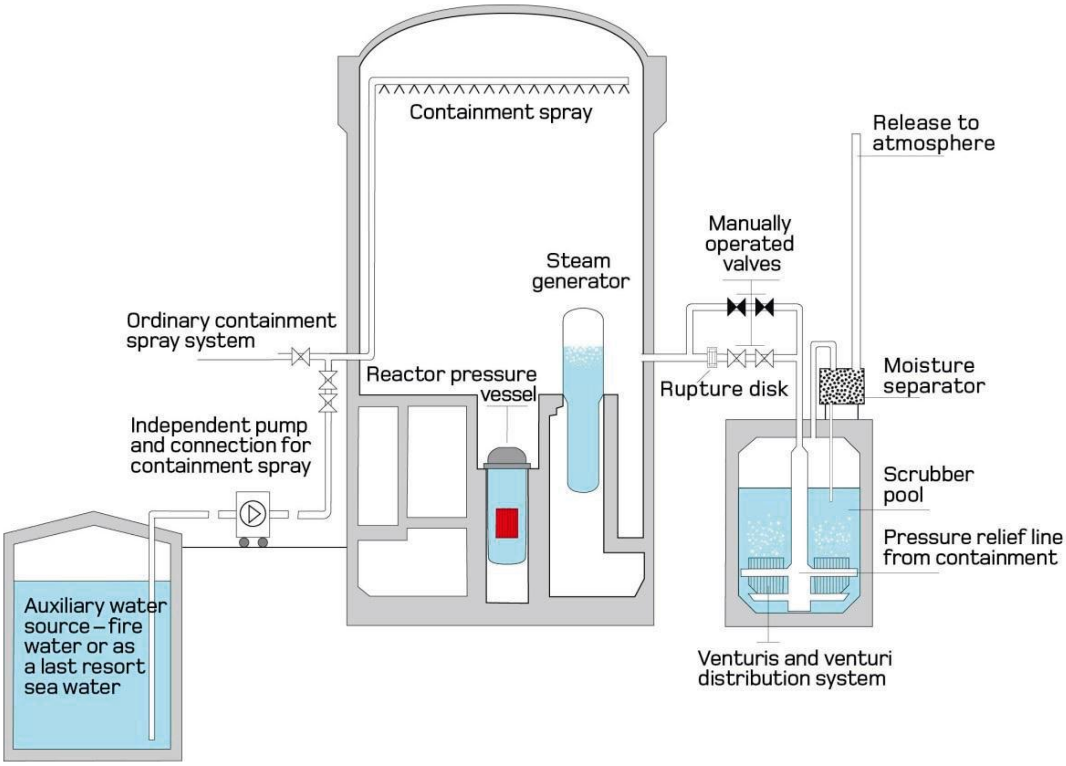

Figure 2 - Schematic view of the severe accident mitigation features installed in Swedish PWRs.

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 already taken at Swedish nuclear power plants due to 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 the most robust solution in all situations. Therefore decisions shall be based on complete and verified analyses and data. For this reason, many of the measures highlight the need for 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 the schedule in Chapter 8.

All licensee actions (LA) may 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 8.3.1. The following generic measures in Section 8.3.1 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 3.

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 the most robust solution in all situations. Therefore decisions shall be based on complete and verified analyses and data. For this reason, many of the measures highlight the need for 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 the schedule in Chapter 8.

All licensee actions (LA) may 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 – Reassess 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 simultaneous 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 8.3.1. The following generic measures in Section 8.3.1 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, 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 the most robust solution in all situations. Therefore decisions shall be based on complete and verified analyses and data. For this reason, many of the measures highlight the need for 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 the schedule in Chapter 8.

All licensee actions (LA) may 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 the 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 in long-term
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 shall 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 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 8.3.1. The following generic measures in Section 8.3.1 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 with regards to the on-site evacuation plans. 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.

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)

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)
- 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 ceiling 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, R2)
- 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 will 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.

8.2 Summary of actions to be performed by the licensees

In the following section, the actions which are going to be performed by the licensees are summarized, see Table 1 below.

Action ID Licensee Action (NA)	**Action**	**Category** Completed
TOPIC 1 – NATURAL HAZARDS		
T1.LA.1	Seismic plant analyses	2013
T1.LA.2	Investigation regarding secondary effects of an earthquake	2014
T1.LA.3	Review of seismic monitoring	2014
T1.LA.4	Investigation of extreme weather conditions	2015
T1.LA.5	Investigation of the frequency of extreme water levels	2015
T1.LA.6	Flooding margin assessments	2014
T1.LA.7	Evaluation of the protected volume approach	2014
T1.LA.8	Investigation of an improved early warning notification	2013
T1.LA.9	Investigation of external hazard margins	2015
T1.LA.10	Develop standards to address qualified plant walk-downs	2014
TOPIC 2 – DESIGN ISSUES		
T2.LA.1	Implementation of the demonstrations of design basis in SAR	2013
T2.LA.2	Define design basis for alternate cooling and alternate residual heat removal	2015
T2.LA.3	Reassess primary and alternative AC power supplies and AC power distribution systems	2014
T2.LA.4	Reassess DC power supplies and DC power distribution system	2014
T2.LA.5	Reassess the integrity of the primary system	2013
T2.LA.6	Reassess the operability and habitability of the Main and Emergency Control Rooms as well as emergency control center	2013
T2.LA.7	Reassess the instrumentation and monitoring	2015
T2.LA.8	Reassess the integrity of the spent fuel pools	2013

T2.LA.9	Evaluate the need for mobile equipment	2015
T2.LA.10	Reassess and update equipment inspection programs	2013
T2.LA.11	Reassess and update training programs	2015
T2.LA.12	Evaluate the need for consumables	2014
T2.LA.13	Evaluate the need for resources	2015
T2.LA.14	Evaluate the accessibility of important areas	2015
T2.LA.15	Investigate the effects of simultaneous event affecting all reactors at the site	2015
T2.LA.16	Reassess the use of severe accident mitigation systems	2015
T2.LA.17	Reassess the procedures and operational training	2015
T2.LA.18	Evaluate the need for external support	2015
T2.LA.19	Reassess the risk of criticality and/or re-criticality	2014
TOPIC 3 – SEVERE ACCIDENT MANAGEMENT AND RECOVERY (ON-SITE)		
T3.LA.1	Consider improvements of the capability to cool the spent fuel pool	2014
T3.LA.2	Define the design basis for an independent core cooling system	2013
T3.LA.3	Investigate instrumentation of spent fuel pool	2014
T3.LA.4	Investigate the need for measuring radiation levels	2014
T3.LA.5	Develop a plan to handle more than one affected unit	2014
T3.LA.6	Improve the strategies for managing re-criticality	2014
T3.LA.7	Develop the strategies for managing loss of containment integrity	2014
T3.LA.8	Evaluate the accident management programmes	2014
T3.LA.9	Consider an extended scope of training and drills	2014
T3.LA.10	Investigate the need for a new call-in system	2014
T3.LA.11	Analyze the management of hydrogen in long-term	2014
T3.LA.12	Investigate the need for means to manage large volumes of contaminated water	2015
T3.LA.13	Reassess personal safety issues	2014
T3.LA.14	Secure the accessibility of the emergency control center	2014
T3.LA.15	Set up action plans for support to local operators	2014
T3.LA.16	Reassess the use of containment filtered venting system in the long-term	2014

T3.LA.17	Investigate long-term handling of the containment chemistry	2014
T3.LA.18	Evaluate the need for common resources available at the site	2014
T3.LA.19	Investigate the performance of the common system for filtered containment venting	2014
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
T5.LA.2	Investigate the course of action during a long-term need for personnel	2014
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
T5.LA.4	It shall be investigated whether some of the functions included in the emergency preparedness organization staffing are sufficient, to sustain shifts around the clock	2014
T5.LA.5	Presently calling in personnel depends on a functioning GSM/Telenet. An improvement in this area shall be investigated	2014
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
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
TOPIC 6 – INTERNATIONAL COOPERATION		
T6.LA.1	Expanding the scope of WANO Peer Reviews	2015
T6.LA.2	Expanding the frequency of WANO Peer Reviews	2015
T6.LA.3	Developing a world-wide integrated event response strategy	2015

Table 1: Summary of actions to be performed by the licensees

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. The Authority 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.

8.3.2 Summary table of actions to be performed by the regulators

In the following section, the actions which are going to be performed by the regulators are summarized, see Table 2 below.

Action ID Regulator Action (RA)	**Action**	**Category** Completed
TOPIC 1 – NATURAL HAZARDS		
T1.RA.1	Research project regarding the influence of paleoseismological data	2013
T1.RA.2	Estimation of extreme weather conditions	2013

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
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
T5.RA.3	Implementation of the revised Swedish regulation SSMFS 2008:15, SSM's Regulations concerning Emergency Preparedness at Certain Nuclear Facilities.	2013
T5.RA.4	Update and formalize protective measures for the public in early and intermediate phases of a nuclear or radiological emergency – to be published as "The Nordic Flag Book".	2013
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
T6.RA.2	Assessment and improvement of international crisis communication and information dissemination.	Ongoing
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
T6.RA.4	Actively participate in information exchange after the Fukushima accident – International organizations	Ongoing
T6.RA.5	IRRS-recommendation: Better ensure compliance with relevant IAEA Standards	2013
T6.RA.6	More strategic coordination and follow-up of the work in the different IAEA Safety Standards Committees	2015
T6.RA.7	Fulfillment of WENRA reference levels (RLs)	2015
GENERIC		
G.RA.1	Implementation of the results from the analysis of long-term safety	2015

G.RA.2	Review of actions belonging to category 2013	2013
G.RA.3	Review of actions belonging to category 2014	2014
G.RA.4	Review of actions belonging to category 2015	2015

Table 2: Summary of actions to be performed by the regulators

8.4 Summary of actions to be performed by national organizations

In the following section, the actions which are going to be performed by the national organizations are summarized, see Table 3 below.

Action ID National organizations Action (NA)	**Action**	**Category** Completed
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
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
T4.NA.3	Evaluation of the Swedish Defense Research Agency's (FOI) role during a radiological or nuclear emergency	Ongoing
T4.NA.4	A country-wide exercise focusing on a nuclear power plant accident – Havsörn	2013
T4.NA.5	The evaluation of the exercise finished with a final report from the evaluation team – Havsörn	2014
T4.NA.6	Processing the result from the evaluations of the country-wide exercise focusing on a nuclear power plant accident – Havsörn	2014

Table 3: Summary of actions to be performed by the national organizations

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2. **ENSREG Post Fukushima accident.** *Peer review country report Sweden - Stress tests performed on European nuclear power plants.* 2012.

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.

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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