Ds 2013:56

Sweden's sixth national report under the Convention on Nuclear Safety

Swedish implementation of the obligations of the Convention

REGERINGSKANSLIET

**Ministry of the Environment
Sweden**

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Foreword

This report is issued according to Article 5 of the Convention on Nuclear Safety. Sweden signed the Convention on 20 September 1994, the first day it was open for signing, during the ongoing General Conference at the IAEA. The Convention was ratified about a year later, on 11 September 1995 and it entered into force on 24 October 1996.

The first national report on the Swedish implementation of the obligations under the Convention was issued in August 1998. The second national report was issued in August 2001, the third in August 2004, the fourth in August 2007 and the fifth in August 2010. All reports are available on the CNS website as well as on the website of the Swedish Radiation Safety Authority (www.ssm.se). The reports were well received at the review meetings held in 1999, 2002, 2005, 2008 and 2011.

A summary of highlights and issues raised about Sweden during the fifth review meeting held 4-14 April 2011 can be found in section A 6. This section also includes an overview of the issues Sweden was asked to report on in its sixth national report (the present report).

A four person working group with two representatives of the regulatory body, the Swedish Radiation Safety Authority, and one representative of each of the reactor owners, Vattenfall AB and E.ON Sweden AB, produced the present report on behalf of the Government. The Swedish Radiation Safety Authority was assigned the task to co-ordinate the work. The advisory committee to the Swedish Radiation Safety Authority on reactor safety has been informed about the report.

The present report is structured in the same manner as the five previous Swedish national reports. Part A includes basic facts and information about the Swedish nuclear programme to provide the reader with a frame of reference. Part B includes facts and information to substantiate compliance with the obligations of the Convention. Each chapter under part B corresponds to one Article of the Convention. Chapters 9-19 have a similar basic structure where information is provided about the regulatory requirements related to the corresponding Article. In addition, information is provided about measures taken by the licence holders to comply with the regulatory requirements as well as facts about their own safety initiatives. Finally, information is provided about the means used by the regulatory body to supervise the measures taken by the licence holders. Taken together, this information will provide evidence for meeting the obligations of the Convention.

Recommendations on the report structure issued as INFCIRC 572 Rev. 4 have been taken into account.

The second extraordinary meeting of the contracting parties to the Convention on Nuclear Safety resulted in a number of topics to be considered while preparing national reports for the sixth review meeting. The agreed topics are discussed and the results presented in the report.

The general conclusions on Swedish compliance with the obligations of the Convention are reported in the executive summary.

List of abbreviations

ALARA	As Low As Reasonably Achievable (a principle applied in radiation protection)
ANS	American Nuclear Society
ANSI	American National Standard Institute
ASME	American Society of Mechanical Engineers
BAT	Best Available Technique
BSS	The Basic Safety Standards Directive of the Euratom
BWR	Boiling Water Reactor
CAP	Corrective Action Programme
CCF	Common Cause Failure
Clab	Central Interim Storage Facility for Spent Nuclear Fuel
DBA	Design Basis Accident
BDBA	Beyond Design Basis Accident
ENISS	European Nuclear Installations Safety Standards
ENSREG	European Nuclear Safety Regulators Group
EPRI	Electric Power Research Institute
EUR	European Utility Requirements
FKA	Forsmarks Kraftgrupp AB
FSAR	Final Safety Analysis Report
I&C	Instrumentation and Control
IEEE	Institute of Electrical and Electronics Engineers
INES	International Nuclear Event Scale
INPO	Institute of Nuclear Power Operations
IRRS	IAEA Integrated Regulatory Review Service
KSU	KärnkraftSäkerhet och Utbildning AB (the Swedish Nuclear Training and Safety Center)
KTH	Kungliga Tekniska Högskolan (Royal Institute of Technology)
LER	Licensee Event Report
LOCA	Loss of Coolant Accident
MTO	Interaction between Man-Technology and Organisation
NDT	Non Destructive Testing
NPP	Nuclear Power Plant (including all nuclear power units at one site)
NUREG	Nuclear Regulatory Guide (issued by the USNRC)
OEF	Operational Experience Feedback
OKG	OKG AB (licence holder of Oskarshamn NPP)
OLC	Operational Limits and Conditions

OSART	Operational Safety Review Team (a service of IAEA)
PSA	Probabilistic Safety Analysis (or Assessment)
PSAR	Preliminary Safety Analysis Report
PSR	Periodic Safety Review
PWR	Pressurized Water Reactor
R&D	Research and Development
RAB	Ringhals AB
RPS	Reactor Protection System
SAR	Safety Analysis Report
SFR	Final repository for short-lived radioactive waste
SKB	Svensk Kärnbränslehantering AB (the Swedish Nuclear Fuel and Waste Management Company)
SKC	Swedish Centre of Nuclear Technology
SKI	Statens kärnkraftinspektion (Swedish Nuclear Power Inspectorate)
SSI	Statens strålskyddsinstitut (Swedish Radiation Protection Authority)
SSM	Strålsäkerhetsmyndigheten (Swedish Radiation Safety Authority)
SSMFS	Strålsäkerhetsmyndighetens författningssamling (the SSM Code of Statutes)
STF	Säkerhetstekniska driftförutsättningar (Technical Specifications, Operational Limits and Conditions)
SVAFO	Swedish company engaged in management of radioactive waste
SWEDAC	Swedish Board for Accreditation and Conformity Assessment
TMI	Three Mile Island (a US NPP)
UPS	Uninterruptible Power Supply
USNRC	US Nuclear Regulatory Commission
VTT	Finnish Technical Research Centre
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators’ Association

EXECUTIVE SUMMARY: GENERAL CONCLUSIONS

The national reports for the review meetings according to Article 5 of the Convention call for a self-assessment of each Contracting Party with regard to compliance with the obligations of the Convention. For Sweden, this self-assessment has demonstrated compliance with all the obligations of the Convention, as shown in part B of this national report.

Nuclear power safety in Sweden is under strong development. Major investments are being made or have been made by the industry in the ten operating reactors to improve safety and prepare for long-term operation. The Swedish Government's amendments to nuclear legislation, which have been passed by the Riksdag (Parliament), provide the conditions for controlled generational shifts in the Swedish nuclear power industry.

The reactor-specific modernization programmes are still ongoing. These programmes were initiated by regulation SSMFS 2008:17 (formerly SKIFS 2004:2) and the general advice on its interpretation, which entered into force on 1 January 2005. Due to the fact that many measures have proven to be more extensive and complex than expected, the original time schedules have been extended to 2015. These programmes require the full effort of the operating organizations as well as the regulatory body, while not compromising the attention to day-to-day safety.

Following the severe accident at the Fukushima Daiichi nuclear power plant in 2011 and the EU stress tests completed in 2012, a Swedish national action plan covering all Swedish nuclear power plants has been developed to implement lessons learned from the accident and to deal with the conclusions from the second extraordinary meeting under the Convention on Nuclear Safety in 2012. The Swedish action plan mainly contains crosscutting and comprehensive measures and presents investigations whose aim is to determine and consider which technical and administrative measures are fit for purpose, how they shall be implemented and the appropriate time schedule for implementation. The measures listed in the Swedish national action plan, which consists of further analyses and investigations, 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 from this investigation. In these cases, the deadline will not include any technical or administrative measures that the investigations' reports are expected to propose.

In addition to the national action plan, a number of measures to increase the level of safety at Swedish nuclear power plants were implemented within a year after the accident at the Fukushima Daiichi nuclear power plant. These measures were mainly identified in connection with investigative work linked to the licensees' international forum, WANO, and in connection with the stress test assessments conducted by Swedish nuclear facilities. A majority of the measures had been completed by the end of 2012. These measures are relatively straightforward measures, 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 were being carried out at the Swedish nuclear power plants at the time of this report.

Further information related to the actions taken in Sweden following the accident at the Fukushima Daiichi nuclear power plant is presented in section A7 and in sections B10.4, B.16 and B.17.

The second extraordinary meeting of the Contracting Parties to the Convention on Nuclear Safety resulted in a range of topics to be considered in the preparation of national reports for the sixth review meeting. Each topic agreed at the meeting is discussed and presented in the respective section of this report.

In September 2011, the IAEA Action Plan on Nuclear Safety was adopted by the IAEA's Board of Governors and subsequently unanimously endorsed by the IAEA General Conference. The ultimate goal of the Action Plan is to strengthen nuclear safety worldwide. The success of this Action Plan in strengthening nuclear safety is dependent on its implementation through the full cooperation and participation of Member States as well as other stakeholders. Sweden has responded to the IAEA Action Plan as presented in in Appendix 4 to this report.

There were no events during the review period indicating a serious degradation of safety and radiation protection at Swedish nuclear power plants. Since the Forsmark event in July 2006, that revealed design weaknesses in electrical systems while also demonstrating the importance of having strong safety management in place, the licensees have focused more on plant modification analyses and improving a vital safety culture. However, some events that occurred during the review period were correlated to modifications of the plants as well as to processes and safety culture. One example is the fire event inside the containment of Ringhals 2 during a regular integrated containment air test.

The regulatory body performed follow-ups on these issues during the latest review period. Particular importance is not only attributed to developing good formal management systems, but also to monitoring and analysing system performance in day-to-day work at the plants.

Besides the special operating conditions issued and in force since July 2009 for the Ringhals NPP, a decision was taken by SSM in December 2012 concerning implementation of measures and specific conditions for operation of the Oskarshamn NPP.

IAEA OSART missions were performed at all three Swedish reactor sites during the period 2008-2010, and subsequent follow-up missions between 2010 and 2012.

In the 2010 appropriation directions for SSM, the Government requested an investigation into the present and future national competence needed for the Swedish nuclear programme and the activities of SSM. This investigation was completed and reported on in early 2011.

In April 2010, the Government assigned SSM to investigate the long-term development of nuclear safety at Swedish nuclear installations, especially in the view of extended operation of the reactors (> 50 years). In the assignment, SSM was also to perform an assessment of the Swedish supervisory model in comparison with international standards and experience. SSM reported on this assignment in October 2012.

A full-scope IAEA IRRS mission to Sweden was performed during the period 6-17 February 2012. The purpose of this IRRS mission was to review the effectiveness of the Swedish regulatory framework for safety within the competence of SSM. Special attention was also given to the review of the regulatory implications of the Fukushima Daiichi NPP accident within the Swedish framework for safety. The mission resulted in a total of 22 recommendations, 17 suggestions and 15 cases of good practice. The results of the IRRS were transformed into an action plan with measures to be taken prior to the IRRS follow-up mission preliminarily scheduled for 2014.

SSM is currently revising regulations related to nuclear activities and radiation protection. Experience has demonstrated the need to clarify and broaden the regulations in order to create more predictability for the licensees and to improve the regulatory support for SSM in its supervisory activities. The need for a consistent and more comprehensive set of regulations and general advice was also highlighted during the IRRS mission to Sweden. Another reason for this revision is that the Swedish Government has ordered SSM to develop regulations for new nuclear power plants.

In parallel with the SSM regulatory review, Swedish acts regulating nuclear activities and radiation protection are undergoing a review. In March 2011, an inquiry presented its suggestions for new and integrated legislation encompassing harmonization with provisions of the Environmental Code. The Government has completed an extensive consultation process.

As of 2008, SSM has received additional staff resources for strengthening its regulatory supervision and developing safety regulations for new nuclear power plants. In addition, the application submitted by Vattenfall AB in July 2012 for permission to replace old reactors with new reactors will require SSM to expand its human resources so that it is able to review the application.

The generally positive impression reported to earlier review meetings under the Convention still stands. Therefore Sweden would like to point out the following strong features of its national work in the area of nuclear safety:

- The Swedish legal framework is well developed and the responsibility for safety is well defined. The legislation provides for public insight into the activities of the licensees. A review of current legislation is being performed.
- The Swedish Radiation Safety Authority, which was formed in July 2008, has completed its buildup phase. An IRRS mission has been performed. New resources have been allocated. There is an open and constructive dialogue between the regulatory body and the licensees.
- The owner companies are well established and have good financial records. They demonstrate a commitment to maintain a high level of safety in their nuclear power plants and to take strong measures to correct deficiencies.
- The financial support provided to higher research and education in nuclear safety and radiation protection is continuously sustained and developed.
- The average collective radiation doses at the nuclear power plants remained stable during the review period, despite a substantial increase in work load at the reactors.
- The designs of the nuclear power plants have developed over the years as a response to development of regulations and safety standards. Large-scale programmes are currently in place to modernize the designs in line with modern safety standards.

Sweden would like to point out the following areas in which further development should be given special attention in relation to the obligations under the Convention:

- Some design issues related to delays and quality have been observed in the modernization and power uprate programmes at the nuclear power plants. These cases have not had a significant impact on radiation safety. However, they underline an important area for future planning and implementation of design changes.
- The success of the ongoing modernization and safety upgrades performed, both at the utilities and at the regulatory body, depends on continued access to human resources and necessary expertise on the national level. The efforts to strengthen education, facilitate generational shifts and attract young people to the nuclear power and nuclear safety sectors must continue. The situation in terms of expertise and human resources must be monitored continuously and, when required, the necessary actions taken.
- Based on safety-related maintenance shortcomings, which resulted in special supervision at the Oskarshamn NPP, all licensees are required to devote greater attention to leadership and the quality of their management systems.

Further development in these areas will be reported in Sweden’s seventh national report under the Convention on Nuclear Safety.

A. INTRODUCTION

1. Current role of nuclear power in Swedish power production

In 2011 annual nuclear power output reached 58 TWh, compared to 75 TWh in the record year 2004. The aftermath of earlier years' extensive modernization projects led to continued disruptions in 2011. Wind power output amounted to over 6 TWh while other thermal power accounted for close to 17 TWh. The year's output at Swedish hydropower plants was 66 TWh. Sweden's aggregate electrical output was 146.9 TWh and the country's total electricity usage was just over 139.7 TWh[1] (147.0 in 2010), a decrease of 5.5%. This is mainly due to milder weather in the autumn and some cyclical slowing in the industrial sector. Sweden's net import of 2.1 TWh in 2010 was replaced by an export of 7.2 TWh in 2011.

Electric power generation in Sweden was about 161 TWh in 2012 which is 10 per cent higher than in 2011 and the highest level of production ever. The year 2012 was also a record year in terms of net electricity export. The large-scale electricity generation gave overproduction of 19.6 TWh which were exported. This can be compared with 2011 when, as mentioned above, the net export was 7.2 TWh. It was basically the excessive rain in 2012 that gave the hydropower production a record level of net export. Total hydropower production was 77.7 TWh and was the major contribution to electric power generation during the year at 48% of the total production. Wind power's share of the production was 4.4%, which was a record at 7.1 TWh. This represents an increase of 17% on the previous year.

Nuclear power increased its production from the above-mentioned 58 TWh in 2011 to 61.2 TWh in 2012. This level of production is higher than in 2011 but nevertheless lower than what is considered to be normal.

The electrical power market has been deregulated since 1996 and in principle is competitive for both the production and sale of electricity. The national high voltage grid is managed by a state authority: Svenska Kraftnät. Regional and local grids are operated by various grid companies as regulated monopolies. A Nordic marketplace, "Nord Pool", has been created for the trade of electricity. Spot market prices have fluctuated considerably during the operational life of Nord Pool. Prices fell to very low levels during the first few years after deregulation, but the most recent years' average prices have been higher, largely depending on the availability of hydro and nuclear power. The market coupling the Nordic electricity market is also linked to countries abroad. A cable between Finland and Estonia serves as a link to the Baltic States. A stronger connection to the Netherlands, Luxembourg, Belgium, France and Germany has been in place since November 2010.

2. Development of nuclear power in Sweden

In Sweden, nuclear engineering was launched in 1947, when AB Atomenergi was established to realise a development programme resolved by Parliament. As a result, the first research reactor went critical in 1954. This was followed by the first prototype nuclear power plant (PHWR), Ågesta, located in a rock cavern in a suburb of Stockholm. The Ågesta reactor was mainly used for district heating and operated between 1964 and 1974, when it was permanently shut down. The first commercial nuclear power plant, Oskarshamn 1, was commissioned in 1972 and was followed by another eleven units sited at Barsebäck, Oskarshamn, Ringhals and Forsmark up until 1985. The twelve commercial reactors constructed in Sweden comprise nine BWRs (ASEA-ATOM design) and three PWRs (Westinghouse design). As a result of political decisions, the twin BWR units Barsebäck 1 and 2 were shut down permanently in 1999 and 2005, respectively.

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[1] According to statistics from the organisation "Swedish Energy".

In 2004, Studsvik Nuclear AB decided to shut down the two research reactors (R2 and R2-0) on the Studsvik site. They were closed in June 2005 and are currently undergoing decommissioning.

An application for a licence to construct, own and operate a nuclear facility consisting of one or two nuclear power reactors with adjacent facilities was presented to the Swedish Radiation Safety Authority in July 2012. The applicant, Vattenfall AB, intends to replace old units by the planned new capacity from operation by 2025 - 2035.

3. Political development of the Nuclear Power Issue

In December 2008, the Government decided to appoint a special investigator to review legislation in the areas of nuclear technology and radiation protection. The Inquiry's remit was extended in April 2009 to include drafting of new legislation making controlled generational shifts possible in the Swedish fleet of nuclear power facilities, and extended again in August 2009 to include analysing matters of liability in the event of radiological accidents.

Due to the suggestions from the Inquiry, certain legislative changes entered into force on 1 January 2011. Amendments were made to the Act on Nuclear Activities (1984:3) and the Environmental Code to make it possible to gradually replace existing nuclear power reactors with new ones. One precondition for obtaining permission to construct new reactors in Sweden is that the new reactor must replace one of the older reactors that have been permanently shut down. The new nuclear power reactors may only be constructed at one of the sites where the present reactors are in operation. This legislation is to enable controlled generational shifts in Swedish nuclear power. Also, the Nuclear Power Phase-Out Act (1997:1320) was abolished and the prohibitions in the Act on Nuclear Activities (1984:3) on the construction of new nuclear power reactors removed.

Furthermore, Parliament has passed the new Act on Liability and Compensation in the event of Radiological Accidents (2010:950) that will replace the existing Nuclear Liability Act (1968:45) and has given the Government the powers to decide when the Act will enter into force. The new act imposes unlimited liability for radiological damage on the owner of a facility and regulates the extent to which the operator of a facility must provide financial guarantees for compensation to those affected by a radiological accident.

In its final proposal, the Inquiry has suggested amendments to several acts and ordinances in order to coordinate the regulation of activities in the areas of nuclear technology and radiation protection. The Inquiry's main suggestion is for the provisions of the Act on Nuclear Activities (1984:3) and the Radiation Protection Act (1988:220) to be harmonized and integrated with the provisions of the Environmental Code. These proposals are currently being processed by the Government Offices.

4. Nuclear power installations in Sweden

At present, in May 2013, there are ten nuclear power reactors in operation in Sweden, as specified in Table 1. Three power reactors have been permanently shut down, namely Ågesta, Barsebäck 1 and Barsebäck 2. Figure 1 shows the geographical location of the Swedish nuclear facilities, all of them situated in southern Sweden.

Name	Licensed thermal power level MW	Electrical gross output MW	Type	Operator	Construction start	Commercial operation
Power reactors						
Ågesta	105	12	PHWR	AB Atomenergi Vattenfall	1957	1964-1974[2]
Barsebäck 1	1800	615	BWR	Barsebäck	1970	1975-1999
Barsebäck 2	1800	615	BWR	Kraft AB	1972	1977-2005
Forsmark 1	2928	1022	BWR	Forsmarks	1971	1980
Forsmark 2	3253	1181	BWR	Kraftgrupp AB	1975	1981
Forsmark 3	3300	1229	BWR		1978	1985
Oskarshamn 1	1375	492	BWR	OKG Aktiebolag	1966	1972
Oskarshamn 2	1800	661	BWR		1969	1975
Oskarshamn 3	3900	1450	BWR		1980	1985
Ringhals 1	2540	887	BWR	Ringhals AB	1968	1976
Ringhals 2	2660	900	PWR		1969	1975
Ringhals 3	3160	1117	PWR		1972	1981
Ringhals 4	2783	981	PWR		1973	1983

Table 1. Main data for nuclear power installations in Sweden

All the BWRs were designed by the domestic vendor ASEA-ATOM (later ABB Atom, now Westinghouse Electric Sweden AB) and all the PWRs, except Ågesta, by Westinghouse USA.

Eight of the power reactors (including Barsebäck 1 and 2) were uprated during the period 1982-1989 between 6% and 10% from the original licensed power levels. Further uprating is ongoing. An overview of all current plans is given in section B6.3. In total this programme, including measures on the conventional side, will add about 1200 MWe.

Ownership, organisation and staffing

The ownership of the Swedish nuclear power plants is to a large extent characterised by cross ownership as shown in

Figure 2 Utility and ownership structure

2. During 2008 and 2009 the conditions for the present cross ownership was analysed by a group of government officials. However, in 2010, after discussions with all involved parties, it was concluded that no regulations should be introduced. The Swedish State owns 100% of the stocks of Vattenfall AB.

2 Maintained by Vattenfall AB and AB SVAFO. All fuel and heavy water as well as parts of the primary system (some of the steam generators) have been removed from the installation.

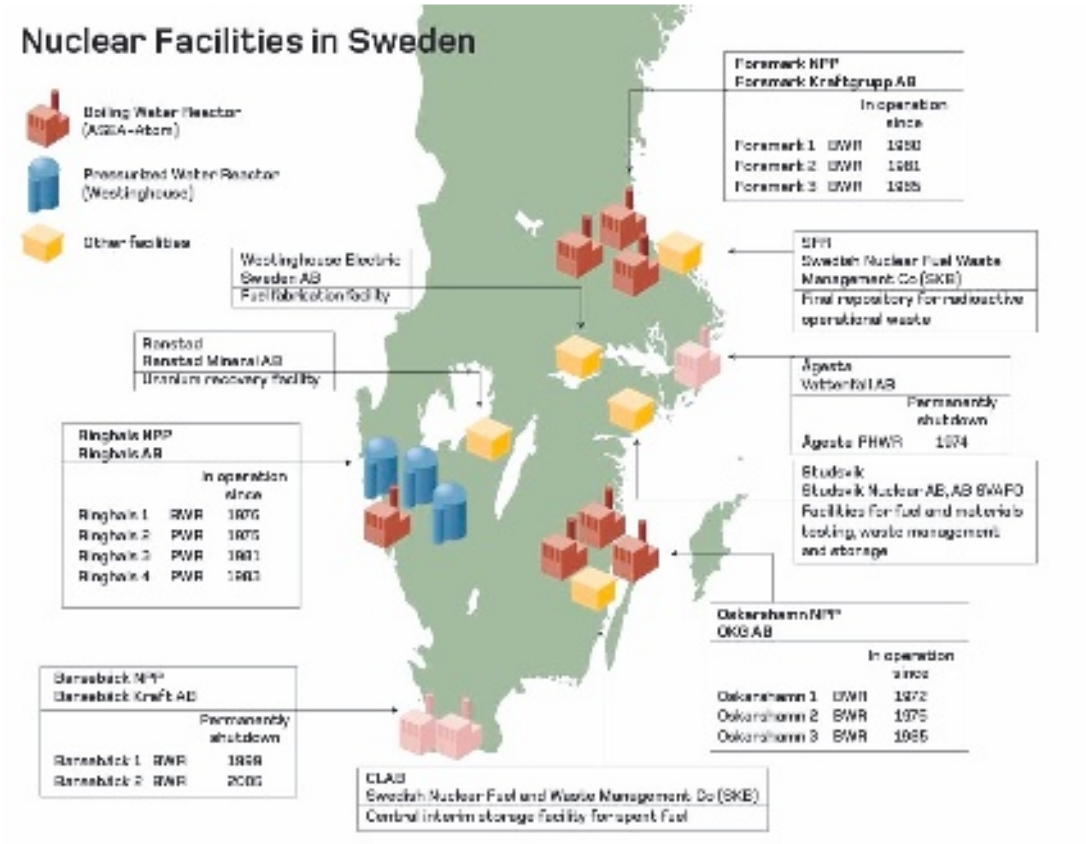

Figure 1 Location of the nuclear facilities in Sweden

The numbers of employees at the different sites are shown in Table 2.

Nuclear power plant	Employees 2012	Employees 2007	Employees 2003	Employees 1998
Barsebäck	40	40	344	430
Forsmark	970	860	794	850
Oskarshamn	900	850	837	1050
Ringhals	1600	1430	1162	1200

Table 2 Numbers of employees at Swedish nuclear power plants in 2012 compared with 2007, 2003 and 1998.

After a period of rationalisation and outsourcing as a result of deregulation, the number of people employed at the plants is increasing again. There is a strong coupling between the figures for Barsebäck and Ringhals as many people from Barsebäck have been transferred to the Ringhals organisation subsequent to the permanent shut-down of both units in Barsebäck. The Oskarshamn organisation is also growing, although 70 people have been transferred to SKB, the Swedish Nuclear Fuel and Waste Management Company, following the transfer of operations of the spent fuel storage Clab. Section B 11.3 provides more details about the current staffing situation.

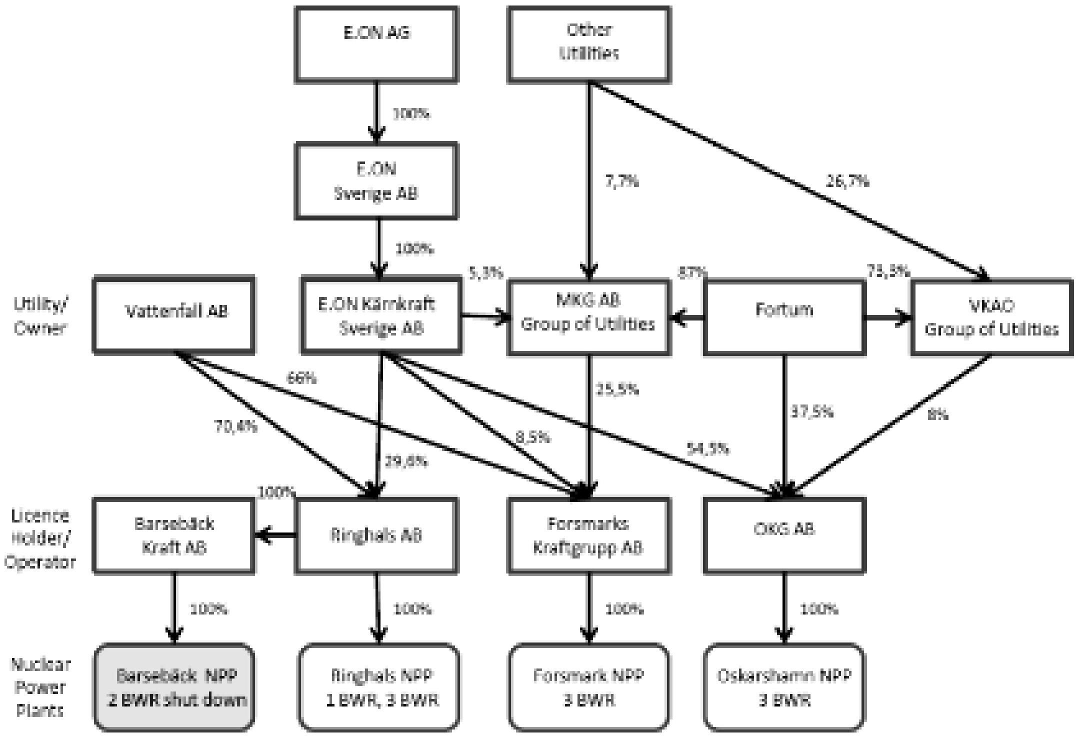

Figure 2 Utility and ownership structure

Own support organizations

The Swedish nuclear power plant operators jointly own the following support organizations:

- KSU AB (Nuclear Safety and Training): provides operational training, including simulator training, on a contractual basis for all the Swedish nuclear power plants. KSU also analyses international operational experience and provides the results to the Swedish operators. In addition KSU publishes regular reports about operational experience from Sweden and provides other energy- and nuclear related information to politicians and decision makers.
- SQC (Swedish Qualification Centre): a company for independent qualification of NDT systems (Non Destructive Testing) to be used by NDT-companies in Swedish nuclear power plants.
- ERFATOM: a cooperation between the Swedish and Finnish BWRs operators and Westinghouse Electric Sweden AB (former ABB Atom) to carry out experience feedback analysis of events in Swedish and Finnish BWRs as well as of international operational experiences.
- SKB (Swedish Nuclear Fuel and Waste Management Company): a company for dealing with spent nuclear fuel and radioactive waste. SKB owns and operates the central interim storage facility for spent nuclear fuel (Clab) in Oskarshamn and the final repository for short-lived radioactive waste (SFR) in Forsmark. SKB is also responsible for the R&D-work in connection with the technical concept and location of the final repository for the spent fuel, including the Äspö Hard Rock Laboratory and the canister laboratory in Oskarshamn.

Other commercial services in the nuclear power field

The supply of services in the nuclear field has been concentrated to a few companies I the recent years. The main Swedish vendor ASEA-ATOM, later ABB Atom, is now included in the Westinghouse Corporation owned by Toshiba under the name Westinghouse Electric Sweden

AB. Other active vendors on the Swedish market are Areva, Westinghouse USA, General Electric, Siemens, and Alstom Power.

According to Swedish law, a licence holder needs a permit from the Government or SSM for contracting out a major part of the nuclear activity. For minor portions it is sufficient under certain conditions to notify SSM that a contract has been awarded (see further section B 7.1). SSM requires the licensees to make the necessary check of quality and competence of a contractor and to take full responsibility for the work done by the contractor. There is, however, no formal licensing of contractors for normal commercial services, except for NDT-companies where an accreditation by SWEDAC is required, or for companies handling asbestos.

The Swedish nuclear power plant licensees have noticed over the last few years that fewer companies are bidding on qualified technical projects and services. This reflects the concentration of vendors and service companies on the market and also the increasing demand as a result of the extensive upgrading of the Swedish reactors and the nuclear construction project in Finland.

Studsvik Nuclear AB is a contractor for materials testing and nuclear fuel investigations. The materials testing reactors are closed but the company cooperates with the Halden reactor in Norway and the hot-cell laboratory is maintained. Studsvik Nuclear AB also provides decommissioning and waste treatment services.

Nuclear waste

The quantity of spent fuel to be disposed of from the Swedish nuclear power programme, amounts to about 12,000 tonnes of uranium (counted as uranium). The programme, including the Studsvik facilities and the Westinghouse Electric Sweden AB fuel fabrication plant in Västerås, will also generate approximately 60,000 m^3 of short-lived low and intermediate level waste, 10,000 m^3 of long-lived low and intermediate level waste and 160,000 m^3 of decommissioning waste (based on 50-year operation of Forsmark and Ringhals and 60-year operation of Oskarshamn). The typical total annual generation of low and intermediate level radioactive wastes at the nuclear facilities is 1,000 – 1,500 m^3.

In addition to waste management practices at the NPPs, the following practices exist: The waste treatment facilities at Studsvik, the repository for short-lived radioactive waste (SFR), shallow land burials, the interim storage facility for spent nuclear fuel (Clab), the transportation system and the use of clearance.

SFR is a repository for short-lived LILW resulting from the operation of the Swedish nuclear programme. In addition to this, small amounts of radioactive waste from hospitals, research institutions and industry are disposed of in SFR. SFR consists of four rock caverns and a silo. The facility is situated on the coast of the Baltic Sea at a depth of 50 m in the bedrock, 5 m below sea level. Construction started in 1983 and it was taken into operation in 1988. The total capacity is 63,000 m^3. By the end of 2012 a total volume of 34,356 m^3 of waste had been disposed of. An extension of SFR, to allow for decommissioning wastes and longer operational periods, is in the planning stage and an application is expected to be submitted in late 2013. SKB plans to start operation of the extended part in 2023. The final repository including the extension will have a waste disposal capacity of 200,000 m^3.

The nuclear power plants at Ringhals, Forsmark and Oskarshamn as well as the Studsvik site have shallow land burials for short-lived very low-level waste. The licence conditions for the burials at the power plants imply time limits for authorized disposal between the years 2060 and 2075 and limitations on the waste volumes between 10,000 and 17,000 m^3. Each of these burials is licensed for a maximum total activity of 100-200 GBq (maximum concentration of alpha-emitters a factor of one thousand lower) except for Ringhals, the site with PWR reactors, for which 1100 GBq is allowed, accounting for up to 900 GBq of Ni-63 in the wastes.

The spent nuclear fuel from all Swedish nuclear power reactors is stored in Clab, situated at the Oskarshamn nuclear power plant. The fuel is stored in water in storage pools in bedrock caverns with a rock cover of about 25 m. Construction started in 1980 and the facility was taken into operation in 1985 with a storage capacity of 5,000 tonnes of spent fuel. Clab has been expanded in the form of a second rock cavern with storage pools. The current total storage capacity is approximately 8,000 tonnes of spent fuel, with 5,222 tonnes in storage at the end of 2011. Transport of spent nuclear fuel and nuclear waste is largely by sea, since most of the nuclear facilities are situated on the coast. The transportation system has been in operation since 1982 and consists of the transport ship M/S Sigyn, a custom-made ship for transporting spent fuel and radioactive waste from nuclear power plants to Clab and SFR, as well as transport casks and containers and terminal vehicles for loading and unloading. SKB has recently commissioned a new ship, M/S Sigrid, to eventually replace M/S Sigyn.

Although clearance is not a ‘facility’, it is a component in the waste management system. Material may be cleared for unrestricted use, for example recycling, or for treatment as conventional non-radioactive waste.

Four major waste facilities are foreseen to be designed, sited, constructed and licensed: A plant for the encapsulation of spent nuclear fuel, a disposal facility for spent fuel, a disposal facility for long-lived low, and intermediate level waste and the extension of SFR for the waste from decommissioning. Additional land burials may also be constructed.

In November 2006, SKB submitted a licence application under the Act on Nuclear Activities for the construction of an encapsulation plant. Extensive supplements were submitted in September of 2009. In March 2011, SKB submitted a licence application under the Act on Nuclear Activities for a disposal facility for spent nuclear fuel. At the same time, SKB also submitted a licence application for establishment of a system for disposal of spent nuclear fuel; i.e. the application under the Environmental Code covers both the encapsulation plant and the disposal facility for spent fuel. The regulatory review of the applications under the Act on Nuclear Activities (1984:3) is being coordinated with the review of the application under the Environmental Code by the environmental court.

Nuclear education, research and development

In Sweden, higher education in nuclear technology is mainly concentrated at the Royal Institute of Technology in Stockholm (KTH), Chalmers University of Technology in Gothenburg (Chalmers) and Uppsala University. The three Swedish nuclear power plants, Westinghouse Electric Sweden and SSM jointly support these three universities through the Swedish Centre of Nuclear Technology (SKC), an organization for sponsoring and coordination that has been in existence since 1992. The Centre supports undergraduate education, graduate schools as well as research.

However, the fact that industry and the Authority jointly finance education and research at universities is a unique solution that will soon come to an end. When SKC was set up, there was a decision pending on closure of nuclear power plants and the enrolment of students for nuclear studies was very low. In that situation, industry and the regulatory authority faced similar challenges in competence development in general and staff renewal in particular.

As mentioned in section A3, the decision to close nuclear power plants was subsequently overturned, followed in 2011 by a new law allowing new builds of reactors to replace old ones. Consequently Vattenfall, the largest Swedish nuclear power operator, submitted in 2012 an application for construction of new reactors. In this new landscape, in which the regulator will assess an application for new builds, SSM found it unsuitable to have joint activities with the same industry that is the subject of an assessment. SSM has therefore announced it will leave SKC when the present six-year contract expires by the end of 2013. However, SSM will continue to support the same universities on the same fiscal level, and the same holds for the four industrial parties that will form the new, somewhat smaller SKC. SSM has been offered, and accepted, an observer's status in the new SKC to obtain and provide information on the respective funding for different purposes.

The last three years have represented an all-time high in funding to the Swedish universities since 1980. This is the result of two separate one-off projects. First, a special grant on Generation-IV research was issued in 2009 by the Swedish Research Council, and a year later, an even larger project on joint research and education with France was established. The latter was part of building a deeper collaboration with France, in which France co-finances the ESS (European Spallation Source) materials research laboratory under construction in Lund, and Sweden has increased its scientific cooperation with France in many areas, nuclear power being one of them. Within this programme, 15 Swedish PhD students spend a significant part of their study period at French laboratories. This includes involvement in development of a sodium-cooled fast reactor and its fuel cycle.

Thus, at the PhD and Masters level, the output from universities is presently satisfactory. At the lower level, the situation is not equally positive. The number of Bachelor's degrees is far below the needs of society. This is not a problem unique to the nuclear industry; it affects all industries. For each student graduating, two employees retire. Swedish nuclear power plants have jointly financed a new Bachelor degree programme on nuclear power at Uppsala University (UU) that has partly remedied the situation. There is an ambition in industry to raise the educational level of its employees, motivating another such programme. Discussions are in progress with Chalmers on launching a similar programme.

Moreover, long-term cooperation is established between the nuclear industry and UU for training staff in nuclear technology and radiation protection. This effort has resulted in improved education as well, because places not used by industry are filled by university students.

Vattenfall AB was one of the founding shareholders of ENELA, the European Nuclear Energy Leadership Academy, an initiative that was motivated by the nuclear renaissance in Germany in 2009. The political changes in the aftermath of the Fukushima Daiichi NPP accident have, however, made many of the rationales for ENELA obsolete, and ENELA has been closed down. Discussions are in progress about establishing similar nuclear industry training programmes having a different organizational base.

5. Swedish participation in international activities to enhance nuclear safety and radiation protection

The regulatory body

The international nuclear safety cooperation is substantial; SSM is involved in about 140 international groups. The majority of groups are related to nuclear safety and radiation protection issues. The cooperation takes place within the frameworks of IAEA, OECD/NEA and EU, but also in connection with the international conventions ratified by Sweden and in non-governmental organizations such as the Western European Nuclear Regulator's Association (WENRA), Heads of European radiation Control Authorities (HERCA), and the International Nuclear Regulator's Association (INRA).

In addition to multilateral collaboration, SSM has bilateral agreements with nine countries to exchange information and to cooperate on agreed issues (e.g. nuclear safety, emergency preparedness, occupational exposure, environmental radiological protection and radioactive waste management). These are Australia, Canada, Germany, Japan, Lithuania Ukraine, Russia, South Africa, and USA. Additionally Sweden has special agreements with the Nordic Countries (Denmark, Finland, Iceland and Norway) regarding emergency preparedness and information exchange on the technical design of nuclear facilities.

SSM contributed significantly to WENRA's benchmarking project which made a systematic comparison of national reactor safety requirements and their implementation against jointly agreed reference levels[3] (see section 7.5). SSM participates actively in ENSREG (European Nuclear Safety Regulators Group), an expert body of senior officials from national regulatory or nuclear safety authorities from all 27 EU Member States and leads the ENSREG Working Group on Waste Management.

Following the severe accidents that started at the Fukushima Daiichi NPP on 11 March 2011, the European Council requested in March 2011 that a comprehensive safety and risk assessment, in light of preliminary lessons learned, be performed on the part of all EU nuclear power plants. The request of the Council included 'stress tests' performed at national level, supplemented by a European peer review. SSM took an active role in this process as a member of ENSREG's stress test peer review board, moreover acting as leader of the topical review process for the topic 'loss of safety systems'.

SSM contributes to the work performed within the Convention for the Protection of the Marine Environment of the North-East Atlantic (OSPAR) and The Helsinki Commission (HELCOM) conventions for reduction of releases of radioactive substances from nuclear facilities. SSM has taken active part in the development of new international safety standards for protection against harmful effects of ionising radiation. This work has been performed both directly (draft EU BSS Directive) and via NEA (International BSS).

Apart from the regulatory issues, SSM is engaged in research projects, mostly within the cooperation of the EU research programme, NEA and the IAEA. Sweden is active in networks for research and cooperation in radiobiology, radioecology and biological dosimetry. SSM staff has also been involved in many international expert missions, for example as experts in IAEA review service teams.

Having been submitted a principle application for building new nuclear power reactors, in December 2012 SSM applied for membership in the OECD/NEA Multinational Design Evaluation Programme (MDEP) launched by regulatory authorities to foster cooperation on safety of new reactors.

International development and cooperation programmes

The Swedish Radiation Safety Authority is involved in development and cooperation programmes with countries in Central and Eastern Europe. The aim is to enhance safety at nuclear power plants in the region and improve radiation protection of people and the environment. SSM also works towards increasing awareness about nuclear non-proliferation and strengthening its control in the region. The cooperation projects are mainly with Russia and Ukraine but there are also some projects with Georgia and Moldova. The development cooperation programme is based on Government decisions and is financed by the Ministry for Foreign Affairs, the Ministry of the Environment and Sweden's International Development Cooperation Agency. The total budget is on the order of 50 million Swedish kronor per year.

Utilities

The utilities in Sweden have traditionally been quite active in international cooperation to enhance nuclear safety by sharing experience, contributing to work with international regulation and guidelines and participating in safety assessments and peer reviews. This is today primarily accomplished through memberships in WANO, in owner's group associations of the major European and US vendors, and by participation in the Foratom initiative European Nuclear Installations Safety Standards, the European Utilities Requirements project, IAEA activities, and various task forces representing most of the disciplines in nuclear facilities.

Swedish utilities and authorities have for a long time cooperated in international projects and research organizations. Particular examples are the Nordic Safety Research Project (NKS) – ongoing since 1977 – and programmes and projects within EPRI and NRC in the US and OECD

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[3] Report by the WENRA Reactor Harmonisation Working Group, January 2006 and WENRA Reactor Safety Reference Levels, January 2008 are available at: www.wenra.org.

and EU in Europe. Common experience of all these projects and organizations is that they all have been adapted to today's needs and conditions and are now controlled in a stricter way than was previously the case.

ISOE (Information System on Occupational Exposure) is an example in the field of radiation protection, where Sweden is a member and an active participant on both the utility and regulator side.

European Nuclear Installations Safety Standards

Vattenfall AB, representing all Swedish nuclear licensees, was an active part when 2005 the European nuclear industry formed, under the Foratom organisation, the European Nuclear Installations Safety Standards, ENISS. ENISS has representation from all of the 17 European countries which operate commercial nuclear power plants.

The primary objective of ENISS was to have a forum for the European nuclear operators to prepare their position in interaction with WENRA.

In recent years an additional task has been added, namely the review of new or revised IAEA Requirements and Guidelines. ENISS has in this aspect taken a coordinating role in the European industry contacts with IAEA. This means that the European nuclear utilities can join the IAEA revision process at an earlier stage than they normally did before.

The most recent task of ENISS is the currently ongoing review of the new WENRA study "Safety Objectives for New Power Reactors" (December 2009).

The final idea/concept for the initiative is to bring together decision makers and specialists from the industry with the regulators in an effort to establish safety targets, safety rules and measures and to arrive, in the end, at a set of common and harmonized European Nuclear Installations Safety Standards (ENISS).

European Utility Requirements

Vattenfall has been a member of the European Utility Requirements (EUR) group since 1996. The EUR requirements have undergone detailed reviews by peer utilities worldwide, as well as by vendors and regulators.

Utilities have recently put their participation on standby according to the evolution of their respective national nuclear policy. The need to modernize EUR has been recognized. For this reason, EUR promotes the issue of revision D of the document of October 2012. However, to take into account the effects of the Fukushima accident, further work needs to be assessed. The next revision E is currently being discussed but the way the future safety framework will be assessed by Swedish utilities is still an open question.

WANO membership

Vattenfall and E.ON have direct membership in WANO. Previously, membership was on a country basis, when KSU coordinated this membership on the part of all the plants in Sweden.

6. Highlights and issues in the discussion about Sweden at the 5th review meeting held in 2011

The following observations and aspects were highlighted and documented by the rapporteur during the discussion about the Swedish national report:

- The Swedish Nuclear Power Inspectorate and the Swedish Radiation Protection Authority were merged to form the Swedish Radiation Safety Authority (SSM) and the number of staff involved in regulation and supervision of nuclear activities has increased
- The Act on Nuclear Activities was amended to permit construction of new reactors only to replace existing reactors.

- The Swedish Government set up the National Crisis Centre to facilitate integrated government response for emergency situations
- SSM special supervision, and improvement of leadership, the management system, safety culture and operating experience programme at Ringhals are ongoing
- Reduction of releases of radioactive substances into the environment will be continued.

It was agreed that Sweden complied with the obligations of the Convention. The following item was highlighted as a good practice:

- In response to operating experience, Sweden has implemented comprehensive safety assessments at all its nuclear power plants over the past three years, including the performance of OSART missions.

The following were mentioned as challenges for Sweden over the years to come:

- Completion of NPP modernization programs
- Amendment of ageing management programs of licensees
- Inclusion of on-site radiation protection as well as radiation protection of the general public and the environment in the PSR.

7. Summary of actions taken in light of the Fukushima Daiichi nuclear power plant accident

The Fukushima Daiichi NPP accident of 2011 has resulted in several different actions in Sweden.

Stress tests: Swedish National Report

Following the severe accidents that took place at the Fukushima Daiichi nuclear power plant, the European Council of 24-25 March 2011 requested stress tests to be performed on all European nuclear power plants. On the basis of the proposal of WENRA, 12-13 May, the European Commission and ENSREG members reached an agreement on the criteria and methodology on how to perform 'stress tests' applied to European reactors. National reports have been required to be presented and be subject to a peer review process in the areas of natural/external hazards, loss of safety systems and severe accident management.

The Swedish national report was completed on 31 December 2011 and all the national reports underwent peer reviews between January and April 2012. Consequently a consolidated report was issued by ENSREG before the European Council by June 2012.

In addition to this, the second extraordinary meeting of the contracting parties to the Convention on Nuclear Safety gave a range of topics to be considered while preparing national reports for the sixth review meeting.

ENSREG issued an action plan on 25 August 2012 whose aim was to help ensure that the lessons from Fukushima were addressed by the national regulators in a consistent manner. In October, the European Commission issued reports regarding the stress tests to communicate with the European Council. In these reports, the reactors at the Forsmark NPP were clearly identified as particularly vulnerable to loss of AC power.

For the purpose of overall management of such activities, a Swedish national action plan has been developed, after consultation with the Swedish NPPs, with an intention to deal with all plant weaknesses identified by the EU stress tests as well as by the above-mentioned second extraordinary meeting under the Convention on Nuclear Safety.

Swedish National Action Plan

The Swedish action plan was issued by SSM in December 2012. 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.

This is because it is crucial to consider the significance to safety of the measures in relation to other measures to improve safety that are in progress or are planned but 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.

For some topics, the Swedish national action plan is in many ways comparable to the list of measures identified in the ENSREG report, the compilation of recommendations and suggestions from the peer review of stress tests performed on European nuclear power plants. The plan also includes specific measures identified in the Swedish national stress test report and the Swedish peer review report as well as in the second extraordinary meeting under the Convention on Nuclear Safety.

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 form the basis of the Swedish national action plan, although each individual site or unit-specific measure has not yet been reviewed. However, SSM assumes that the licensees, to the extent that is reasonable and possible, are already now beginning the work on implementing measures that are currently identified as suitable to implement.

Regarding the measures presented in topics and conclusions, measures are in addition to the lessons learned from the nuclear accident at the Fukushima Daiichi NPP in 2011 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 preparedness organization during and after the Fukushima Daiichi NPP accident. This includes experiences gained when the emergency preparedness 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, which consists of further analyses and investigations, are scheduled in three different categories, each category with its own deadline when the measures must be completed.

The categories are as follows:

2013 Measures to be completed by 31 December 2013

2014 Measures to be completed by 31 December 2014

2015 Measures to 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.

External events and Natural hazards

In the Swedish national report on the stress tests, external events have been described for different types of accidents, starting from design basis accidents where the plants can be brought to safe shutdown without any significant nuclear fuel damage, 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 followed the work of WENRA and ENSREG to develop a methodology for assessing margins for cliff-edge effects due to external events.

Actions to be performed by the licensees

The following areas define the measures to be performed by Swedish licensees in relation to natural hazards:

- Seismic plant analyses
- Investigation regarding secondary effects of an earthquake
- Review of seismic monitoring
- Investigation of extreme weather conditions
- Investigation of the frequency of extreme water levels
- Flooding margin assessments
- Evaluation of the protected volume approach
- Investigation of an improved early warning notification
- Investigation of external hazard margins
- Develop standards to address qualified plant walk-downs

Actions to be performed by the regulator

- Research project regarding the influence of paleoseismological data
- Estimation of extreme weather conditions

Design issues

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 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. The assessment started from design basis events where the plants can be brought to safe shutdown without any significant nuclear fuel damage, and finalized with events more severe than the situations considered during the construction of the plants which result in severe accident conditions involving core meltdown or damage to the spent nuclear fuel in the storage pool. Please note that the severe accidents involving core melt and melt-through of the reactor pressure vessel are discussed separately as a specific topic in this action plan.

Actions presented in this part 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 second extraordinary review meeting for the CNS which took place in Vienna 27-31 August 2012.

Actions to be performed by the licensees

The outcome of the evaluations and reassessments shall result in a number of technical and/or administrative measures that need to be implemented including when in time they will be fully implemented. The evaluations and reassessments shall be completed according to the schedule above. All licensee actions may not be applicable to all reactors. However, if an action is judged not to be applicable for a specific reactor, a sufficiently detailed and clear justification must be presented by the licensee. The technical and/or administrative measures are as follows:

- Reassess primary and alternative AC power supplies and AC power distribution systems
- Reassess DC power supplies and DC power distribution system
- Reassess the integrity of the primary system
- Reassess the operability and habitability of the main and emergency control rooms as well as the emergency control centre
- Reassess the instrumentation and monitoring

- Reassess the integrity of the spent fuel pools
- Evaluate the need for mobile equipment
- Reassess and update equipment inspection programs
- Reassess and update training programmes
- Evaluate the need for consumables
- Evaluate the need for resources
- Evaluate the accessibility of important areas
- Investigate the effects of simultaneous events affecting all reactors at the site
- Reassess the use of severe accident mitigation systems
- Reassess the procedures and operational training
- Evaluate the need for external support
- Reassess the risk of criticality and/or re-criticality

Actions to be performed by the regulator

No specific actions to be performed by the regulators have been identified for this area. Generic review actions related to the overall time schedule as well as for implementation of the results from the analysis of long-term safety are nevertheless valid.

On-site accident management and severe accident management and recovery

Severe accident management (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 the 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 must 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 at 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 over at least 24 hours.

Actions to be performed by the licensees

The implementation of technical and administrative measures must as far as possible seek the most robust solution in all situations. Therefore, decisions must be based on complete and verified analyses and data. For this reason, many of the measures highlight the need for further evaluations and reassessments.

These are the technical and administrative measures to be performed by the licensees:

- Implementation of the demonstrations of design basis in the SAR
- Define design basis for alternate cooling and alternate residual heat removal
- Reassess primary and alternative AC power supplies and AC power distribution systems
- Reassess DC power supplies and DC power distribution system
- Reassess the integrity of the primary system
- Reassess the operability and habitability of the main and emergency control rooms as well as the emergency control centre
- Reassess the instrumentation and monitoring
- Reassess the integrity of the spent fuel pools
- Evaluate the need for mobile equipment

- Reassess and update equipment inspection programme
- Reassess and update training programmes
- Evaluate the need for consumables
- Evaluate the need for resources
- Evaluate the accessibility of important areas

Actions to be performed by the regulator

No specific actions to be performed by the regulators have been identified for this area. Generic review actions related to the overall time schedule as well as for implementation of the results from the analysis of long-term safety are valid.

Emergency preparedness and response and post-accident management (off-site)

The Swedish stress tests have resulted in a new focus on different aspects of an emergency response in extreme conditions that must 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 exercise that took place between February and April 2011, an evaluation of the accident management at the Fukushima Daiichi NPP and the results of a recent IAEA IRRS review.

Actions to be performed by the licensees

At present, 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).

- Clarify the responsibility for decontamination stations outside the site for personnel during shift turnovers and how equipment is to be replaced.
- Investigate the course of action during a long-term need for personnel.
- An investigation is suggested to ascertain advantages and disadvantages in replacing the present substitute Command Centre with a suitable office outside the site.
- It shall be investigated whether some of the functions included in the emergency preparedness organization staffing are sufficient, to sustain shifts around the clock.
- Calling in personnel presently depends on a functioning phone network. An improvement in this area shall be investigated.
- 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.
- The Command Centre shall be connected to its own auxiliary power supply that is independent of the regular power supply at the plant site.

Actions to be performed by the regulator

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 Sweden but nevertheless having implications for the country. The work is aimed at two aspects that have arisen from handling the accident at the Fukushima Daiichi NPP. 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.

- Updating and formalization of pre-defined criteria on countermeasures and the implementation of measurable operational intervention levels and routines for application of intervention levels.

- SSM and licensees 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.
- Implementation of the revised Swedish regulation, SSM's Regulations concerning Emergency Preparedness at Certain Nuclear Facilities.
- Updating and formalization of protective measures for the public in early and intermediate phases of a nuclear or radiological emergency – to be published as "The Nordic Flag Book".

Remaining modernization and safety upgrading of all Swedish nuclear power plants

Experiences from the Fukushima accident have led to planned actions or actions being considered in Sweden. The ten power reactors operating in Sweden have different prerequisites for complying with general regulations on design and construction. This is due to different design and age of the reactors. 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.

At the present time, a significant share of identified measures has been implemented, but some measures remain to be performed. All modernization and safety upgrading of all Swedish nuclear power plants must be completed before the end of 2015. Some remaining measures are still to be implemented in the following areas:

- Independence of safety functions
- Improvement of physical and functional separation
- Diversification of safety functions
- Accident management measures
- Robustness to local dynamic effects from pipe breaks
- Resistance to external and internal events

The measures listed above are already covered by earlier SSM decisions 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 area and how the measures listed above are implemented.

International cooperation

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.

Actions to be performed by the licensees

- Expanding the scope of WANO peer reviews
- Expanding the frequency of WANO peer reviews
- Developing a world-wide integrated event response strategy

Actions to be performed by the regulator

- Accede to the 2004 Protocol to amend the Paris and Brussels Conventions on Third Party Liability in the field of nuclear energy
- Assessment and improvement of international crisis communication and information dissemination
- IRRS recommendation to SSM to establish and implement guidance for dissemination of all significant operating experience and lessons learned to all relevant authorized parties

- Actively participate in information exchange after the Fukushima accident: international organizations
- IRRS recommendation: Improved compliance with relevant IAEA Standards
- More strategic coordination and follow-up of the work in the different IAEA Safety Standards Committees
- Fulfilment of WENRA reference levels

Information on enhancement of openness and transparency

Specifically with regard to experiences gained from the Fukushima Daiichi NPP accident, clearer and more stringent demands are placed on radiation protection of personnel and the communications infrastructure at a power plant. The revision of SSM's regulations on emergency preparedness is in its final review stage and the revised regulations will be implemented starting in 2013. The regulations impose 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 a more stringent demand on having an alternative command and control centre not located near the power plant and having alternative communications possibilities. To communicate uncertainties is difficult, but important to maintain the confidence of the public. Thus, this ability needs to be improved and exercised regularly in order to assure the capability to communicate such possible uncertainties.

Measures by licensees

To fulfil their action plans reported to SSM, the licensees have initiated the following projects: FOSH (Forsmark), BUSTER (Ringhals) and KENT (Oskarshamn). The measures are separated into three implementation horizons: short-term, medium-term and long-term measures. More information on these actions is presented in section B10.4.

B. COMPLIANCE WITH ARTICLES 4 TO 19

4. Article 4: IMPLEMENTING MEASURES

Each Contracting Party shall take, within the framework of its national law, the legislative, regulatory and administrative measures and other steps necessary for implementing its obligations under this Convention.

The legislative, regulatory and other measures to fulfil the obligations of the Convention are discussed in this report.

5. Article 5: REPORTING

Each Contracting Party shall submit for review, prior to each meeting referred to in Article 20, a report on the measures it has taken to implement each of the obligations of this Convention.

The present report constitutes the sixth Swedish report issued in compliance with Article 5.

6. Article 6: EXISTING NUCLEAR INSTALLATIONS

Each Contracting Party shall take the appropriate steps to ensure that the safety of nuclear installations existing at the time the Convention enters into force for that Contracting Party is reviewed as soon as possible. When necessary in the context of this Convention, the Contracting Party shall ensure that all reasonable practicable improvements are made as a matter of urgency to upgrade the safety of the nuclear installation. If such upgrading cannot be achieved, plans should be implemented to shut down the nuclear installation as soon as practically possible. The timing of the shut-down may take into account the whole energy context and possible alternatives as well as the social, environmental and economic impact.

Under this article Sweden provides information about major events that have occurred at the nuclear power plants during the last three years as well as conclusions drawn from these events. Furthermore, information is provided about planned measures for safety upgrades and plans for uprating of the reactors. Basic information about the design of the reactors and safety upgrading measures already implemented is provided in Chapter 18.

Summary of developments since the last national report

During the current review period, the following developments are of relevance with regard to the obligations of article 6:

- The safety improvement programmes on design and construction of nuclear power reactors have continued with a schedule up to and including 2015. The programmes are being implemented in accordance with the regulations SSMFS 2008:17.
- The licensees have applied for major power uprating of seven reactors and a minor uprating of one reactor. The remaining part of the uprate programme will add some 600 MWe to current nuclear power capacity in Sweden.

6.1 Overview of major events since the last national report

In its annual reports to the Government for the years 2010, 2011 and 2012, SSM pointed out that no events occurred indicating a serious degradation of safety and radiation protection at Swedish nuclear power plants. In total, three events were classified as Level 1 on the International Nuclear Event Scale (INES) during the period (see section 19.2). An overview of the most significant events during the period 2010-2012 is provided below.

6.1.1. CCF in RPV level switches

Recurring earth faults due to CCF

During startup after an outage in Ringhals 1 in December 2010, four ground faults occurred in the level switches. After the investigation, it became evident that all 18 of the float level switches had been insufficiently installed.

A worst case scenario implies that actuation of ECCS would not occur if needed. The cables inside the switch junction boxes are qualified for a working temperature of 220ºC. Because of inadequate insulation, the operating temperature actually reached 270ºC. The float level switch housings must be thermally isolated, but not the junction boxes. This was not understood by the persons who replaced the cables. During installation, a problem with the junction boxes was identified. They have a sharp edge at their electrical penetration and the design of the installed new cable made the boxes difficult to install. To protect the cable, shrinkable tubing was installed around the cable, but this shrinkable tubing is qualified for 130ºC working conditions (250ºC for short periods of time). The solution using shrinkable tubing remained undocumented.

No actuation due to CCF

During the outage in November 2011, the float level switches were tested. It was found that two of the switches did not work properly. The investigation showed that the problem was metallic chips on the magnet inside one of the float level housings. Another magnet was displaced in relation to the specification. As a countermeasure after these identified deficiencies, Ringhals decided to investigate all the float level switches.

A total of ten level switches did not have verified status. Although the risk of failed operation has been assessed as low since eight of them did work during the operational readiness procedure and would probably operate as intended if needed. The switch failures are significant to safety, although their de facto consequences were limited. The safety significance is represented by the fact that the root causes of these failures are generic in nature and that CCF could have affected several components of crucial safety instrumentation.

The presence of metallic chips is attributed to a deficiency in the mounting and installation checks, and that inspection of the affected RPV level switches is difficult as the work space is cramped, hot and subject to a high radiation level. The malfunctioning of the switch due to displacement had a loose magnet with a deviation. The magnet could easily have been affected mechanically and shifted at high temperatures. The displacement of the magnet is assessed to be caused by a manufacturing deficiency. During casting, the cast mass that constitutes the magnet holder did not penetrate the magnet groove that fixes the magnet in the correct position.

6.1.2. Degraded monitoring for EDG startup

During testing, a weakness in the safety bus bars was identified at Ringhals 2. It was shown that if a disturbance on the grid initiates an undervoltage on the safety bus bar that is below 70% voltage and has a duration of more than 1.2 seconds but less than 1.5 seconds, this might violate the EDG start-up sequence. The reason for this is that processors were not adequately synchronized. If this happens, the safety bus bar will be blocked. The identified weakness was applicable to all four safety trains, hence it has CCF aspects. However, the scenario that can cause such a disturbance during operation has low probability. The weakness had been installed 16 months earlier. The event was classified as INES-1.

6.1.3. Fire in Containment

Ringhals 2 had a refuelling outage in May 2011. Related to the availability of a time window, the Ringhals 2 management decided to modify the outage planning and to perform the Containment Air Test (CAT,) in operational state DT7 (all nuclear fuel in the fuel building and open RPV). Normally, the CAT is performed with the unit in operational state DT5 (core re-fuelled, reactor cavity empty, reactor pressure vessel (RPV) closed, outage works completed and housekeeping/clean-up of the containment and the unit finished).

During the CAT, no transient fire load is allowed in the containment and no equipment is allowed to be electrically connected. This is the normal procedure when CAT is conducted at the end of the outage just before start-up and the containment is cleaned to the same level as during power operation. This time the outage schedule was changed and the CAT was conducted earlier in the outage schedule. The plant’s operational procedure required the same elimination of transient fire load, but some equipment that had to be used for the refuelling was allowed to be left in the containment during the CAT.

Post-event investigations have concluded that the cause behind the ignition of the fire was that a short circuit (arcing) developed in one of the electrical motor connections of a vacuum cleaner, which had been left connected to a wall socket. The fire load has been estimated to represent about 30 kg of plastic and 5 kg of rubber material. An aluminium ladder was also found to be partly melted.

The event did not result in any consequence for the public or the environment. The event did not result in any fuel damage, as all the nuclear fuel was in the fuel building and the cooling of the fuel pools was not endangered. There was no direct impact on any safety system.

The upper part of the containment was covered with black soot particles. Soot also covered containment parts below the fire. Other direct fire consequences for the unit were minor.

Due to the significant contamination by chlorides, soot and some other elements/compounds, about 4,500 components in the containment, and the containment itself, had to be cleaned and verified to be in proper condition before it was possible to start up the unit. This event resulted in a remarkably long production loss for cleaning up and restoration tasks of the containment and of all components located inside it.

Containment spray not verified

During cleanup after the fire, the containment spray system was found to be at risk. Equipment was found inside the system that in the event of an activation of the system might have obstructed the functionality.

The amount of objects in the system could have caused a flow reduction of about 10%. The system has 200% capacity. This equipment has probably been in place since 1988. The cause is probably inadequate cleanup following a modification at Ringhals 2 in 1988. The safety significance of the event is considered to be low.

After these findings, SSM issued an injunction to all licensees to systematically review and evaluate all their operational readiness verification for all safety systems and safety functions to ensure that tests are appropriate and performed in a way that verifies the criteria presented in the Safety Analysis Report (SAR).

At Ringhals 4, the licensee found unauthorized welding equipment parts in their safety systems:

- 40% capacity in 1 of 2 100% capacity trains in the containment spray system could have been affected if it had been activated.
- 60% capacity in 1 of 2 100% capacity trains in ECCS could have been affected

The two deficiencies in combination in Ringhals 4 were rated INES-1.

In Forsmark 2 parts were found in the post DBA mitigating system.

In Oskarshamn 3, parts were found in the containment spray system that could lead to 10% reduced capacity in 1 of 4 trains.

All foreign-made products have been in place for quite some time now (approx. 20 years) and can be derived from rebuilds or installation and are the result of poor cleanup management following rebuild projects.

6.1.4. Weakness in protection against lightning

Forsmark 3 has four redundant safety grade divisions which are normally fed from the grid, but are isolated and fed by diesel generators in the event of a grid power interruption. Each division of the low voltage distribution includes safety grade and non-safety grade uninterruptable power supplies (UPS) supplying sensitive loads which cannot fully sustain a power interruption. However, each UPS also includes a static switch (with thyristors) for a fast transfer to a direct feed from the diesel generator backed bus, in the event the inverter in the UPS fails. This static switch is normally energised but not switched on (i.e. conducting). A mechanical by-pass switch is also present, which can be closed in case the static switch fails or during maintenance on the UPS.

In June 2012, Forsmark 3 was in cold shutdown status. The ordinary 400 kV grid was disconnected for maintenance and the unit was powered from the backup 70 kV grid.

Maintenance work was ongoing in two out of four divisions. These trains consequently had a low load due to testing.

A lightning strike induced an impulse on the 70 kV grids, which propagated down to the safety grade medium voltage buses and to the low voltage UPS static switches. One static switch failed fatally and several similar switches were degraded. A possible contributing factor might be that the load on the train was low. However, as the unit was in shut down and the fatal failure only occurred in one division, the incident had no immediate safety impact.

The backup 70 kV grid incoming line has less equipment than the normal 400 kV grid incoming line which could mitigate the impact of a lightning strike. As the static switch was damaged, the improper conduction of this static switch caused an undervoltage and a load unbalance and, after some time, overheating of the supply transformer. The undervoltage also caused temporary functional failure of several sensitive loads such as signals in the control room, part of the radio communication system and emergency lights.

The event itself has low safety significance, but the nature of the failure could have had a severe impact on safety. As this type of overvoltage hits all safety grade divisions, it might result in simultaneous failures of several redundant sets of equipment. The potential failures are not limited to UPS systems, but also apply to other safety grade power electronics such as rectifiers for DC supply and variable speed drives. A CCF in safety grade DC rectifiers or speed drives could in fact have a much more serious impact than in a UPS system (where direct feeds from diesel generators through mechanical by-pass switches are often possible).

6.1.5. Flow requirements in HHSI not sufficient due to modified check valves

In the final commissioning tests of the High Head Safety Injection system (HHSI), the measured flow during the late phase of the outage in 2012 at Ringhals 4 did not meet the flow requirements of the HHSI system.

The reason was found to be related to the recently replaced check valves placed in the injection lines. The replacement check valves were specified to have the same system properties and dimensions as the existing valves but were modified for service reasons. The Factory Acceptance Test (FAT) that was made did not include flow or functions tests, since the new check valves were of a proven design.

Computerised analyses and practical tests performed after the failure of the final commissioning test of the HHSI system showed that the disc behaviour, when opening, was unsatisfactory. The disc did not open completely in all situations and the flow was for this reason restricted. This was because evacuation of fluid from the volume above the disc was not possible.

The event was caused by the design – valid for all twelve valves in the HHSI system – and must therefore be classified as a Common Cause Failure. As the low flow capacity of the HHSI system was identified during the commissioning tests and effective measures were taken before startup, the safety consequences were insignificant. However, the event indicates inadequacies in the licensee’s internal design verification before replacement of components in the plant.

6.2 Ongoing and planned safety improvement programmes of the nuclear power reactors

The ongoing and planned safety improvement programmes of the Swedish reactors presented in this section started long before the Fukushima Daiichi NPP accident of 2011. The accident and the stress tests conducted have nevertheless added several new safety issues which will be addressed in these safety programmes.

Safety improvements at Swedish nuclear power plants have traditionally been conducted through successive plant modifications and special projects as a result of events and problems identified in the own plant, other Swedish plants and from events in international plants. These successive modifications have been based on newer reactor designs, which have indicated possible safety improvements, and new insights gained through safety analyses and research. This process has to some extent been driven and confirmed by the periodic safety reviews.

Examples of problems that have led to this type of facility modification include the "strainer incident" at Barsebäck in 1992 when it was found 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 all Swedish reactors. The problem has also been recognised internationally as a major generic safety issue.

After the strainer incident the Swedish licensees made a major effort to revisit the safety analysis reports of their reactors and started a project to define a safety standard for the remaining operating time. This standard aimed to provide guidance for planned investment programmes. An extensive upgrading of the oldest reactor Oskarshamn 1 was made 1995–2002. In connection with the decision on licensing conditions for this upgrading, and the fact that the industry standard had been delayed, the regulatory authority decided to issue guidelines for modernization and safety upgrading of the Swedish reactors for their remaining operational life. As this work proceeded, and a series of meetings were held with the licensees to discuss interpretations and consequences, SSM realised that several issues raised in the guidelines could not be considered as recommendations but had to be included in legally binding regulations. Therefore it was decided to issue general regulations on design and construction of nuclear power reactors. These regulations, now SSMFS 2008:17, and general advice on their interpretations came into force 1 January 2005 with transitional provisions (see further section B 7.3).

The regulations are 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. However, the new regulations do not cover all aspects of a design standard but those issues which are considered important to regulate for the Swedish reactors.

Since the 10 operating power reactors in Sweden have different prerequisites to comply with general regulations on design and construction, an assessment of the consequences was made for each reactor. This assessment included whether further analyses and back fitting were needed in relation to each paragraph of the regulations. A cost estimate was made for each measure and summarized for the specific reactor. The licensees were given until 31 December 2005 to submit more detailed programmes and time schedules for implementation of measures for each reactor based on the assessment of the consequences. During 2006, the regulatory authority reviewed these programmes and decisions were issued in December 2006 on the programmes for Forsmark 1–3 and in May 2007 for Oskarshamn 1–3 and Ringhals 1–4.

The following is an overview of remaining measures included in the decisions for the different reactors. For practical reasons, the measures have been listed under the main issue to be addressed. The year indicated for the different reactor is the period of time for implementation. In a number of cases a more in-depth investigation had to be made before the detailed technical measures could be defined.

In some cases, the licensees have requested postponement of the deadline because modernization has proved to be more extensive and complicated than was originally expected, and design work in order to identify the technical solutions that best meet the safety requirements has needed significantly more time and resources than both the licensees and their suppliers could have foreseen. These requests are accepted if SSM agrees with the arguments presented by the licensees and SSM does not perceive any safety risks in connection with the postponements.

Actions to cope with issues revealed by the Fukushima Daiichi NPP accident are presented in section B10.4.

6.2.1. Improvement of physical and functional separation

- Separation of operation and safety systems within the switchgear (R1: 2013)
- Replacement of all safety classified electrical and I&C systems (including reactor protection systems) to strengthen the separation of operation and safety systems and the physical separation of the different subdivisions in the safety classified electrical and I&C systems (O2: 2014)
- Analysis of dependencies between the hydraulic scram system and the pressure relief system, including measures if necessary (O1–2: 2015/2014)
- Measures to make the auxiliary feed-water system independent, including a new water supply (R2: 2013; application to extend completion time until 2015 expected)
- Physical separation within the ventilation system in the auxiliary systems building (R2: 2014)
- Analysis of the physical separation within the power system in the auxiliary systems building and the containment, including measures if necessary (R2: 2014)
- Separation within component cooling system (R2: 2014)

6.2.2. Diversification of safety functions

- Automation of the boron system for reactor shut-down (O1-2: 2014)
- Analysis of the requirement on two different parameters to identify the need of initiation of the reactor protection system, including measures if necessary (F3: 2013, O1-2: 2014)
- Installation of a new digital reactor protection system (RPS) and a diversified non digital reactor protection system (DPS), control room modernization and installation of a new emergency control room (identical to the main control room from a safety aspect) (O2: 2014)
- Installation of diversified relief valves (ADS) for the RPV (verified for two phase flow) (O2: 2014)
- Installation of new diversified residual heat removal systems (two trains) (O2: 2014)
- Installation of four new emergency diesel generators. Two of them diversified from the other two and with diversified cooling systems (O2: 2014)
- Installation of diversified detection of plant initiating events (O2:2014)

6.2.3. Accident management measures

- Strategy for long-term cooling of a severely damaged core, including physical measures if necessary (R1: 2015, O1, 2, R2-4: 2014)
- Change to two phase flow relief valves (R1: 2014)
- Measures to vent incondensable gases from the reactor vessel (R1: 2015)
- Analysis of the emergency control post, including measures if necessary (R3-4: 2013)
- Installation of a new emergency control room (O2: 2014)

6.2.4. Withstanding local dynamic effects from pipe breaks

- Analysis of local loads (R3-4: 2013), including measures if necessary (R3-4: 2015)
- Supports for several containment isolation valves (R2: 2014)

6.2.5. Withstanding external events

- Analysis of natural phenomena, including measures if necessary (O1–2: 2014, R3–4: 2013)
- Analysis of earthquake (R1: 2011), including measures if necessary (R1–2: 2013)
- Implementation of new electrical, I&C and process systems as well as modifying existing process systems due to earthquake (O2: 2014)

- Reinforcement of the control room ceiling to withstand an earthquake (O1–2: 2014)
- Fire hazards analysis (O3: 2010), including measures if necessary (R2: 2014)
- Improvement of the fire protection (O2: 2014)
- Analysis of strong wind, snow, tornado and tornado induced missiles including measures (O2:2014)
- Reinforcement of the reactor building to withstand flooding (O2: 2014)
- Measures due to risk of turbine missiles (O2: 2014)

6.2.6. Operational aids

- Improvement of the back panels in the control room (R1: 2013)
- New main control room and emergency control room including e.g. new safety panel and safety desk and advanced operational readiness monitoring of safety systems (O2:2014)
- Update of the environmental qualification inside the containment, including measures if necessary (O1:2014, O3:2014)

6.2.7. Environmental qualification and surveillance

- Update of the environmental qualification outside the containment, including measures if necessary (O1: 2014, R1-4: 2015)

The total cost for the upgrading programme has been estimated at 8 billion SEK (700 million euros). The heaviest costs are associated with measures to improve the physical and functional separation, diversification measures and upgrading the emergency control posts.

The work has been performed over a relatively concentrated period of time and will be fully implemented at the end of 2015. During the same period, power uprates will have been implemented at several reactors (see section B 6.3). Altogether, this work, as well as normal maintenance activities, has entailed major challenges for the licensees and their suppliers. SSM has noted that the operating organizations' workload is heavy and, as a result, time schedule delays occur in addition to a backlog in their documentation work.

The limited number of contractors and support companies on the market also creates a need for strict time planning; also, the plants are dependent upon each other. A delay in one project at one plant might cause a delay in a project at another plant.

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

6.3 Uprating programmes of Swedish nuclear power reactors

Nine of the originally twelve power reactors were uprated during the period 1982-1989 with power increases of 6-10% from the originally licensed thermal power levels. This was possible due to better utilization of existing margins, better methods of analysis and improved fuel design. Major plant modifications were not necessary during that period. The current programmes for uprating include major uprates of seven reactors and a minor uprate of one reactor. The power levels are shown in Table 3. The complete ongoing programme will add some 1200 MWe to the previous nuclear power production capacity. The operating licence, issued by the Government, stipulates the highest allowed thermal power level. To further increase the power level, the licensee has to apply to the Government for a new licence in accordance with the Act on Nuclear Activities (1984:3).

A power increase can affect the facility in a number of different ways and to a varying degree, depending on the size of the increase. The conditions and parameters which can affect safety must therefore be identified and analysed in order to show that the safety requirements are met.

A number of components and systems in the nuclear power plant must be verified as having a capacity corresponding to the higher power. The impact on safety is due mainly to the fact that the core will contain more reactivity. The inventory of radioactive substances in the fuel will increase. The neutron irradiation of components around the reactor core will increase. The residual heat of the reactor is proportional to the operating power and will therefore increase. The systems that supply coolant to the reactor and remove the residual heat must therefore have increased capacity.

F= Forsmark, O= Oskarshamn, R= Ringhals

Reactor	Original power level		Current power level		Planned power level		Total thermal uprate %
	Thermal	Electrical gross output	Thermal	Electrical gross output	Thermal	Electrical gross output	
F1	2711	900	2928	1022	3253	1168	20.0
F2	2711	900	3253[4]	1181	3253	1181	20.0
F3	3020	1100	3300	1229	3775	1407	25.0
O1	1375	460	1375	492	1375	492	0
O2	1700	580	1800	661	2300	840	35.3
O3	3020	1100	3900[5]	1450	3900	1450	29.1
R1	2270	750	2540	887	2540	887	11.9
R2	2440	785	2660	900	2660	900	9.0
R3	2783	915	3160	1117	3160	1117	13.5
R4	2783	915	2783	981	3300	1140	18.6
Total	**24813**	**8405**	**27699**	**9920**	**29516**	**10582**	

Table 3 Power levels of the Swedish operating reactors.

[4] F2 is presently under test operation at this power level

[5] O3 is presently under test operation at this power level

A power uprate case comprises several steps as illustrated in Table 4. To begin with, SSM carries out an initial, broad safety evaluation which is the basis of its statement to the Government prior to the Government's decision. If the licensee's application to uprate is granted by the Government, subsequent stages are handled by SSM which is authorised to issue the necessary permits. A licence is also needed according to the Environmental Code (see section B 7.1). SSM's detailed process for handling power increase cases is described in the report, "Authorization and Supervision of the Thermal Power Uprating in Nuclear Reactors"[6].

Step 0	Step 1	Step 2	Step 3	Step 4
INFORMATION	**PRINCIPAL REVIEW AND DECISION**	**PSAR PLANT MODIFICATION**	**SAR TEST OPERATION**	**SAR ROUTINE OPERATION**
Information exchange	Licensee's Preparation of -Principal safety review -Environmental impact statement -Application to Government	Licensee's Preparation of -PSAR -Application to SSM	Licensee's Preparation of -SAR and test operation program -Application to SSM	Analysis of operational experience "Clean table" SAR amendments Application to SSM
Planning	SSM review SSM statement to Government	SSM review	SSM review	SSM review
Agreement on licensing process application	Government decision	Acceptance of PSAR permits for -construction -implementation	Acceptance of SAR Permit for -testing operation	Acceptance of SAR Permit for -routine operation

Table 4. The power uprating process

The following cases are currently being handled:

In December 2007 Ringhals applied for a licence to uprate the thermal power level of Ringhals 4 from 2783 MWth to 3300 MWth. After review of the application and its technical basis, SSM recommended the Government in January 2009 to approve the application. However, SSM recommended against the Government approving the application as long as Ringhals is under *"special supervision"* (see section B 10.3), which is why the process is on hold.

In September 2007, OKG applied for a licence to uprate the thermal power level of Oskarshamn 2 from 1800 MWth to 2300 MWth. After a review of the application and its technical basis, performed by SSM, the Government has approved the application. For the second step, OKG AB submitted a PSAR to SSM for operation at the higher power level in October 2011. The review by SSM should be completed by the first half of 2013. OKG has decided to postpone the measures related to a power uprate in Oskarshamn 2 until 2015 in order to first complete the safety improvement programme (see section 6.2.1).

In January 2010, the Government resolved to allow Forsmark to uprate Forsmark 1 and 2 from 2928 MWth to 3253 MWth. The Government also resolved that FKA was allowed to uprate Forsmark 3 from 3300 MWth to 3775 MWth. Since then, Forsmark Kraftgrupp AB has moved forward with the power uprate for Forsmark 2. SSM approved test operation in September 2012. Test operation started in March 2013. Forsmark Kraftgrupp AB has not yet decided if or when to proceed with the power uprates for Forsmark 1 and 3.

Uprating is not done for safety reasons, but planning as well as reviewing an uprating case is an important aspect of safety. In its regulatory review, SSM checks that the licensee is in

6 Authorization and Supervision of Thermal Power Uprating of Nuclear Reactors. SSM-PM 2008/1210. Swedish Radiation Safety Authority, March 18, 2009, available in Swedish.

compliance with all applicable safety requirements. Pre-existing issues are followed up and SSM's position is that a 'clean table' is a prerequisite. An application for uprating is, in this sense, an opportunity to revisit and verify the entire safety case.

6.4 Conclusion

The Swedish nuclear power plants have been analysed, maintained and improved in a continuous process since the start of the nuclear programme. Events and new insights have been used to make important modifications when needed. The Swedish licensees have decided to make major safety investments in their plants to make them fit for 50 or more years of operation.

The Swedish reactors are in a process of modernization, safety upgrading and power uprating. These programmes are ambitious and quite concentrated in time. This imposes additional challenges on safety management, since the operating organizations may become overloaded and lose focus on operational safety. The Forsmark 1 event 2006 showed that such shifts of focus can backlash in terms of forced extended outages with associated power generation losses and high costs. The current situation in Ringhals and in Oskarshamn is similar. SSM has Ringhals under special supervision since 2009, the same also applies for Oskarshamn since December 2012, see section 10.3.

These management challenges need further attention during the years to come. However, the licensees have shown that they are learning from experiences gained and are improving both their safety management work and their planning abilities. Continued awareness and preparedness for corrective actions is however needed.

Sweden complies with the obligations of Article 6.

7. Article 7: LEGISLATIVE AND REGULATORY FRAMEWORK

1.	*Each Contracting Party shall establish and maintain a legislative and regulatory framework to govern the safety of nuclear installations.*
2.	*The legislative and regulatory framework shall provide for:* *(i) the establishment of applicable national safety requirements and regulations;* *(ii) a system of licensing with regard to nuclear installations and the prohibition of the operation of a nuclear installation without a licence;* *(iii) a system of regulatory inspection and assessment of nuclear installations to ascertain compliance with applicable regulations and the terms of licences;* *(iv) the enforcement of applicable regulations and of the terms of licences, including suspension, modification or revocation.*

Summary of developments since the last national report

During the current review period, the following developments are of relevance with regard to the obligations of article 7:

- Swedish legislation has been amended to allow for replacement of the ten existing reactors by new reactors at the same sites
- A major review of Swedish nuclear safety and radiation protection legislation has been conducted, but no changes have yet been decided.
- The Act on Nuclear Activities(1984:3) has been updated to include requirements on inspection and enforcement under the Environmental Code relating to nuclear activities and activities using radiation to be taken over by SSM
- A major review of SSM’s regulations has been launched
- SSM has updated its regulation SSMFS 2008:1 to comply with WENRA reference levels

7.1 Nuclear safety legislation and the regulatory framework

7.1.1. Basic nuclear safety and radiation protection legislation

The following five acts[7] constitute the basic nuclear safety and radiation protection legislation of Sweden:

- The Act on Nuclear Activities (1984:3),
- The Radiation Protection Act (1988:220),
- The Environmental Code (1998:808),
- The Act on the Financing of Management of Residual Products from Nuclear Activities (2006:647), and
- The Nuclear Liability Act (1968:45).

With the exception of the Nuclear Liability Act, all acts are supplemented by a number of ordinances and other secondary legislation which contain more detailed provisions for particular aspects of the regime.

Operation of a nuclear facility can only be conducted in accordance with a licence issued under the Act on Nuclear Activities (1984:3) as well as with a licence issued under the Environmental Code. The Act on Nuclear Activities is mainly concerned with issues of safety and security,

7 All Swedish Acts and Ordinances are published in the Swedish Statute Book, hereinafter referred to as “SFS”.

while the Environmental Code regulates general aspects of the environment and the possible impacts of “environmentally hazardous activities”, to which nuclear activities are defined to belong.

The objective of the Radiation Protection Act is to protect people, animals and the environment from the harmful effects of radiation. The Act applies to radiation protection in general and, in this context, it provides provisions regarding worker’s protection, radioactive waste management, and the protection of the general public and the environment.

The Act on the Financing of Management of Residual Products from Nuclear Activities contains provisions concerning the future costs of spent fuel disposal, decommissioning of reactors and research in the field of nuclear waste. Means for that purpose have to be available when needed.

The Nuclear Liability Act implements Sweden’s obligations as a party to the 1960 Paris Convention on Third Party Liability in the Field of Nuclear Energy and the 1963 Brussels Convention Supplementary to the Paris Convention.

Other relevant acts are the Act on Control of Export of Dual-use Products and Technical Assistance (SFS 2000:1064) and the Act on Inspections according to International Agreements on Non-proliferation of Nuclear Weapons (SFS 2000:140). Emergency preparedness matters are regulated by the Civil Protection Act (2003:778) and Ordinance (2003:789).

On 18 December 1997 the Swedish Parliament adopted the Act on the Phasing-Out of Nuclear Power (SFS 1997:1320), which entered into force on 1 January 1998. The Act was part of the inter-party agreement on guidelines for energy policy, which was initiated by the Swedish Government in 1995 to create conditions for the efficient use and cost effective supply of energy. Based upon provisions in this Act, the two boiling water reactors at Barsebäck were shut-down in 1999 and 2005, respectively. It is now suggested that this Act should be abolished (see section B 7.2).

An extensive overview of the Swedish legal system was given in the first Swedish national report. In the following, focus will be given to an overview of the safety legislation, the licensing procedures and planned major amendments in the core legislation.

7.1.2. The Act on Nuclear Activities

As stated above, the Act on Nuclear Activities (1984:3) applies to all nuclear activities. Nuclear activities are defined as:

- The construction, possession and operation of a nuclear installation
- Acquisition, possession, transfer, handling, processing, transport or other dealings with nuclear substances and nuclear waste
- Import of nuclear substances and nuclear waste
- Export of nuclear waste

Nuclear activities can only be conducted in accordance with a licence issued under the Act. The licence holder is fully responsible for the safety of every aspect of the operation. All safety measures needed in order to prevent a radiological accident shall be taken. As well as having a general responsibility to maintain safety, the licence holder is responsible for ensuring the safe handling and final storage of nuclear waste arising from the activity and the safe shut-down and decommissioning of plants in which nuclear activities are no longer conducted.

The Act also contains a wide set of means for efficient supervision by the regulatory authority. Among these are administrative and criminal sanctions for non-compliance (see section B 7.8).

Furthermore, the Act provides for public insight into the safety- and radiation protection work of the licensee through local safety councils established in the communities hosting major nuclear facilities. The licensee has to give the council any information, documents and access to the installations it requires in order to be informed and in turn to inform the public.

Decisions made by SSM with reference to the Act can be appealed to the Government. If the decision calls for urgent measures, they have to be taken while the appeal is handled by the Government.

7.1.3. Licences for Operation of Nuclear Installations

With a few exceptions, licences for nuclear installations are decided upon and issued by the Government. SSM is given the mandate to decide and attach safety conditions to any licence issued under the Act on Nuclear Activities (1984:3) (see Chapter 8). An application for a licence to construct, possess or operate a nuclear installation shall – along with the particular documents concerning construction and nuclear safety – contain an Environmental Impact Statement (EIS).

Procedures regarding the EIS are laid down in the Environmental Code. These provisions are also applicable in the licensing procedures according to the Act on Nuclear Activities (1984:3). The purpose of the EIS is to assess the effects of the planned operation on human health and the environment and on the management of natural resources. Prior to the drafting of an EIS, the operator must obtain and compile available data and consult other parties, authorities and organizations involved, including the general public.

If an licensee fails to comply with conditions attached to the licence or with safety obligations arising in any other manner under the Act on Nuclear Activities (1984:3), the Government or SSM has the authority to revoke the licence altogether. The decision lies with the authority that has issued the particular licence.

7.1.4. Rules on the use of Contractors in Nuclear Operations

All contractors whom the licence holders plan to use in nuclear operations need approval – upon application – by SSM. On 1 July 2006, more strict requirements on the use of contractors for nuclear activities8 entered into force. According to the new wording of the Act on Nuclear Activities (1984:3), Section 5, at most two contractors are allowed to be involved in a specific task. This means that it is no longer possible to run a system where one general entrepreneur has several sub-contractors. Based on the amendment of the Ordinance (1984:14) on Nuclear Activities, the regulatory authority issued regulations on some specific exemptions from the requirement of approval of contractors9. A simplified notification procedure can be used for most types of nuclear activities, provided that the prescribed management and control measures, as well as satisfying assessment of contractors, has been conducted. Such exemption from approval is only allowed in cases with a single (one) contractor.

7.1.5. The Protection of the Environment against Harmful Radiation Effects

In 1998 the Act on Nuclear Activities (1984:3) was amended to incorporate references to the Environmental Code (SFS 1998:808). The amendments, which entered into force on 1 January 1999, state that the general rules of consideration and the environmental quality standards of the Environmental Code shall apply when considering matters under the Act on Nuclear Activities (1984:3). In the preparatory work to the Environmental Code the operation of a nuclear installation and handling of radioactive waste are specified as examples of hazardous activities.

The general rules of consideration state that operations must be conducted and measures taken so that harm to human health and to the environment is avoided, and that the following fundamental principles are properly followed:

- the burden of proof principle,

8 For instance, according to Swedish nuclear legislation manufacturing of components that are to be installed in a nuclear power plant is not a nuclear activity – however, the installation of components is.

9 The Swedish Nuclear Power Inspectorate's Regulations on Exemption from the Requirement on Approval of Contractors (now SSMFS 2008:7.)

- the knowledge requirement,
- the precautionary principle,
- the best possible (available) technology principle (BAT),
- the appropriate location principle,
- the resource management and eco-cycle principles,
- the product choice principle, and
- the principle of reasonableness.

The environmental quality standards specify the maximum levels of pollution or disturbance to land, water, air or the environment in general, and that humans may be exposed to without any significant risk. Permits, approvals or exemptions may not be issued for a new operation that would contravene an environmental quality standard unless precautionary measures to alleviate the negative effects are taken.

The rules of the Environmental Code are on an overall level and do not generally specify limits for various operations or detail how to balance between different interests. Many operations that fall within the scope of the Code are also subject to other acts, which apply in parallel with the Code – e.g. for nuclear activities the Act on Nuclear Activities (1984:3) and the Radiation Protection Act (1988:220).

All operations and measures, which may be detrimental to human health or to the environment are covered by the Code and must therefore pursue its objectives. Licences issued under the Code are tried by special courts of law, the Environmental Courts.

7.1.6. Licensing procedure according to the Act on Nuclear Activities

A licence application for nuclear activities to the Government is handed in to the Swedish Radiation Safety Authority, SSM. SSM assesses whether the following provisions have been satisfactorily complied with (or executed):

- The safety regulations according to the Act on Nuclear Activities (1984:3),
- The general rules of consideration in Chapter 2 of the Environmental Code and the measures proposed by the applicant to avoid any environmental hazards,
- Relevant environmental quality standards in Chapter 5 of the Environmental Code, and
- The Environmental Impact Assessment (EIA) and Statement (EIS), contents and report of the consultations held with concerned parties.

SSM will, as part of the procedures for such a licence application, collect opinions and statements from concerned parties, local authorities etc. Concerned parties are given the opportunity to express their views at local hearings. Before handing over the application to the Government for its decision, SSM attaches its expert opinion and any special conditions that it deems necessary to be part of a future licence, such as precautionary measures to minimize the involved hazards.

7.1.7. Licensing Procedure according to the Environmental Code

A permit under the Environmental Code is also required. An application including EIA/EIS, similar to those submitted to SSM, shall be handed in to an Environmental Court for consideration under the Environmental Code. During its deliberation, the court will assess whether the provisions in the Code have been complied with satisfactorily and thus that all kinds of emissions and disturbances are considered, i.e. also those caused by radioactive substances and ionising radiation.

If the application concerns a new nuclear facility, the Environmental Court shall, together with its opinion, always hand over the matter to the Government for its consideration of permissibility.

7.1.8. The Government's Consideration of Permissibility

Since normally the Environmental Court refers the question of permissibility to the Government, the Government has a fundamental role in both licensing procedures. In the case according the Act on Nuclear Activities (1984:3), the Government itself takes the final decision, often referring the questions on different conditions regarding nuclear safety and radiation protection to SSM. The Government takes the expert opinions of SSM and the Environmental Court under consideration before making its decision. The case according to the Environmental Code is returned to the Environmental Court for final trial, after the Government has decided on the issue of permissibility.

7.1.9. Considerations made by Other Parties Concerned

During the procedure of completing the Environmental Impact Assessment, the applicant must consult with those that may be or are concerned, e.g. local organizations and the public. Such stakeholders are thereby given the opportunity to express their opinions and have them considered in the process. Notification of the application as well as the Environmental Impact Statement shall be published, in order to give everyone concerned an opportunity to comment before the matter is decided.

7.1.10. Licenses for the nuclear plants under the Environmental Code

The Environmental Code replaced several different Environmental Acts at its entry into force on the first of January 1999. The Environmental Courts have earlier decided on licences under the Environmental Code for the operations of Ringhals 1-4 and Oskarshamn 1-3 in decisions taken in March and August of 2006 respectively, as reported in the fourth national report.

The operator of Forsmark 1-3, FKA received a licence under the Environmental Code by a decision of the Environmental Court on 21 august 2008. The licence includes permission to operate the reactor units at the thermal power levels foreseen after planned uprates (3253 MW for Forsmark 1 and 2, and 3775 MW for Forsmark 3) and to construct storage facilities for different wastes (including internal reactor parts). In the decision, the Court also gave permission for FKA to remove an existing threshold at the cooling water outlet of Forsmark 3. The licence conditions require, at the end of 2011, radioactive releases to the water recipient to be cleaned with at least the same efficiency as achieved at Forsmark 3 in 2005 and additional measures to be taken aiming at a 50% reduction in aerosol releases.

7.2 Decided and planned changes in Swedish legislation

On the 11 December 2008, the Swedish Government decided to appoint a special investigator to review the legislation in the area of nuclear technology and radiation protection.

The Inquiry's remit was extended through supplementary terms of reference adopted on 8 April 2009. Under them the Inquiry was to draft proposals for new legislation for the public examination of new facilities that will make controlled generational shifts possible in the fleet stock of Swedish nuclear facilities. One precondition for obtaining permission to construct new reactors in Sweden is to be that the new reactor replaces one of the older reactors and that the older reactor is permanently shut down. The new nuclear reactor unit may only be constructed on one of the sites where reactors currently in operation are located. The Inquiry was also charged with drafting proposals to make it possible to abolish the Nuclear Phase-Out Act (1997:1320) and to remove the ban in the Act on Nuclear Activities (1984:3) on the construction of new nuclear power reactors.

The Inquiry's remit was extended on 19 August 2009 to include analysing whether unlimited liability for radiological damage should be imposed on the owner of a facility and considering and proposing to what extent the operator of a facility shall provide financial guarantees for compensation for those affected by a radiological accident.

In October 2009 a first, partial inquiry report, covering the issues of generational shifts in the Swedish nuclear power fleet and nuclear liability including proposed changes in the Act on Nuclear Activities (1984:3), Environmental Code and other legislation was presented. The report was circulated for comment to the parties concerned, including several Swedish Authorities, the nuclear industry, professional and industrial organizations and interest groups.

On 23 March 2010, two different bills were sent to the Swedish Parliament: 2009/10:172 on the preconditions for generational change of nuclear reactors, and 2009/10:173 on the issue of increased liability for owners of nuclear power reactors. Parliament passed these bills in mid-June 2010. The main content of the legislative changes adopted by the Parliament is as follows:

- Authorisation to build and operate a new nuclear power reactor can be granted if it replaces an existing reactor, is built on a site with existing nuclear reactors in operation, and the replaced reactor unit is permanently shut down when the new reactor is operational.
- The Nuclear Phase-Out Act (1997:1320) has been annulled.
- Certain tasks concerning inspection and enforcement under the Environmental Code relating to nuclear activities and activities using radiation are to be taken over by SSM.
- Requirements on periodic safety reviews of the nuclear safety and radiation protection at a nuclear facility are now mandatory by law.
- Sweden will accede to the 2004 amendments of the Paris Convention and the Supplementary Convention on liability. It has been decided that the Nuclear Liability Act (SFS 1968:45) will be replaced by a new act concerning liability. When this act enters into force, the owner of a nuclear facility will have unlimited liability and the owner of a nuclear reactor will be required to provide financial guarantees amounting to up to 1,200 million euros. The owners of non-reactor facilities will be required to provide financial guarantees of a minimum of 700 million euros.
- The legislative amendments to allow for replacement of existing reactors entered into force on 1 January 2011. The Parliament has given the Government the powers to decide when the new liability legislation will enter into force.

In March 2011, the Inquiry presented its final report which included several proposals for legislative changes. In this work, the Inquiry studied the possibilities of bringing together the provisions of the Act on Nuclear Activities (1984:3) and the Radiation Protection Act (1988:220) in a single act and will also consider the possibilities for better coordination with the provisions of the Environmental Code. The aim is to simplify the structure and formulation of the provisions and make them more effective. Today's parallel application of the Environmental Code, the Act on Nuclear Activities (1984:3) and the Radiation Protection Act (1988:220) results in a 'dual' licensing process with significant overlapping of the regulatory processes and the issuance of two permits with similar legal requirements.

The plans for the consolidation of the legislation into a single act are progressing and the Government has completed an extensive consultation.

7.3 National safety and radiation protection regulations

7.3.1. SSM's nuclear safety and radiation protection regulations

With reference to its legal mandate, the Swedish Radiation Safety Authority (SSM), issues legally binding safety and radiation protection regulations for nuclear facilities in its Code of Statutes SSMFS. SSM has reissued all earlier regulations in the SSMFS series. In the following, regulations with relevance to the safety and radiation protection at nuclear installations, as defined by the Convention, are addressed[10].

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10 For additional information see Sweden's third report under the Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management, Ds 2008:73, ISBN 978-91-38-23062-6, ISSN 0284-6012.

In addition, general advice on the interpretation of most of the safety regulations is issued. The general advice is not legally binding per se, but cannot be ignored by the licensee without risking sanctions by the regulatory body. Measures should be taken according to the general advice or, alternatively, methods justified to be equal from the safety point of view should be implemented. The regulations and the general advice, listed below, all entered into force on February 1, 2009.

SSM's regulations also implement binding EU legislation and international obligations. In preparing SSM's regulations, IAEA safety standards, international recommendations, industrial standards and norms, and the rule-making of other Swedish authorities are considered. The SSM regulations are issued according to an established management procedure which stipulates technical and legal reviews of the draft. In accordance with governmental rules, a review of the final draft by authorities, licensees, various stakeholders, and industrial and environmental organizations is performed.

7.3.2. Regulations concerning safety in nuclear facilities (SSMFS 2008:1)

These regulations were developed for nuclear power reactors but are applicable, in a graded way, on all licensed nuclear facilities. Minor amendments regarding the requirements on safety program, safety analysis, safety analysis reports and technical specifications were made in the SSM regulations. The regulations aim at specifying measures needed for preventing and mitigating radiological accidents, preventing illegal handling of nuclear material and nuclear waste and for conducting an efficient supervision:

- Application of multiple barriers and defence-in-depth
- Handling of detected deficiencies in barriers and the defence-in-depth
- Organisation, management and control of safety significant activities
- Actions and resources for maintaining and development of safety
- Physical protection and emergency preparedness
- Basic design principles
- Assessment, review and reporting of safety
- Operations of the facility
- On-site management of nuclear materials and waste
- Reporting to SSM of deficiencies, incidents and accidents
- Documentation and archiving of safety documentation
- Final closure and decommissioning

General advice on the interpretation of most of the requirements is given.

In 2012, changes were made to SSMFS 2008:1. These include some new requirements and amendments, mainly in the areas of nuclear waste and decommissioning, justified by a desire to bring together provisions currently found in several of SSM's regulations. Some of the changes were also made in order to obtain better agreement with the reference levels developed within the framework of WENRA cooperation.

7.3.3. Regulations on control of nuclear material (SSMFS 2008:3)

These regulations with general advice include requirements on measures needed to prevent the spread of nuclear weapons and illegal possession of nuclear material, disposed spent nuclear fuel, nuclear equipment and associated software and techniques. The requirements cover organizational aspects, competence and the authority of staff, procedures concerning international control (IAEA, EC, and ESA) descriptions of the facility, nuclear material control system, reporting, notification, and filing procedures. The regulations also stipulate requirements regarding nuclear research, manufacture of nuclear equipment, and import and export control.

7.3.4. General advice on the interpretation of Section 5 in the Act on Nuclear Activities (1984:3) on the use of contractors (SSMFS 2008:6)

SSM has issued general advice on the interpretation of Section 5 in the Act on Nuclear Activities regarding the use of contractors. Contractors are defined as every physical or legal person to whom the licensee hands over an activity (provides a contracted service). This means that companies belonging to the same corporation as the licensee, as well as staffing agencies, are regarded as contractors. If a contractor is approved by SSM and a permit is issued (see section B 7.1), although the overall responsibility for safety rests with the licensee, the contractor has legal duties and obligations for the nuclear activities defined by the contract and permit. SSM can decide on safety conditions for the contract. A contractor cannot, without an additional permit, use a subcontractor for activities within the contract. A subcontractor is not allowed to engage a sub-subcontractor (fourth party).

7.3.5. Regulations on exemption from the requirement on approval of contractors (SSMFS 2008:7)

The Act on Nuclear Activities (1984:3) provides rules regarding the allowed use of contractors (see also section B 7.1). In general, a licensee cannot contract out an activity included in the nuclear licence without a permit by the Government or SSM. However, if the licensee controls and follows up on the contractor's work, for certain activities the permit procedure can be replaced by a notification to the regulatory body. SSM is authorized by the Government to specify the prerequisites for such exemptions.

The regulations contain a list of activities that can be contracted out without a permit. This list includes building and construction work, decommissioning activities, maintenance and inspection work, training, qualified expert tasks that cannot reasonably be done with own staff and filing (archives) of safety documentation. It is pointed out that exempted activities must not be all or major parts of the licensed nuclear activity. Furthermore, exempted activities must not include security measures or activities for storage and disposal of nuclear materials or wastes.

The regulations specify that exempted activities must be conducted under the management and control of the licensee. If SSM finds, after notification, that a contract includes activities of principal importance, the authority can decide that the contract must not be awarded without a permit by the Government or SSM.

7.3.6. Regulations on physical protection of nuclear facilities (SSMFS 2008:12)

These non-classified regulations with general advice contain requirements on the organisation of the physical protection, clearance of staff, tasks for the security staff, central alarm station, perimeter protection, protection of buildings, protection of compartments vital for safety, access control for persons and vehicles, protection of control rooms, communication equipment, search for illegal items, handling of information about the physical protection and IT security. Design details about the physical protection shall be reported in a classified attachment to the SAR of the facility.

7.3.7. Regulations concerning mechanical components in certain nuclear facilities (SSMFS 2008:13)

These regulations contain requirements for the use of mechanical equipment, requirements on limits and conditions, damage control, and accreditation of control organizations and laboratories, requirements on in-service inspection and control, requirements in connection with repair, exchange and modification of structures and components, requirements on compliance control and annual reporting to SSM. The regulations contain rather precise requirements for design specifications and their assessment when plants are to be modified. The regulations contain stringent requirements for the assessment of the safety impact of continued operation with components that are degraded to a certain level. The general advice focuses on important aspects to be considered when applying different qualitative and quantitative risk oriented approaches (see section B 14.1).

7.3.8. Regulations on emergency preparedness at certain nuclear facilities (SSMFS 2008:15)

The regulations apply to the planning of emergency preparedness and radiation protection measures in the case of an emergency or a threat of an emergency in nuclear facilities of threat category I, II or III according to the IAEA Safety Requirements GS-R-2: *Preparedness and Response for a Nuclear or Radiological Emergency Safety Requirements*. The regulations address alarm criteria and alerting, emergency facilities, evacuation plans, training and exercises and other issues related to emergency preparedness (e.g. iodine prophylaxis, personal protective equipment, monitoring, ventilation filters, meteorological data).

7.3.9. Regulations on design and construction of nuclear power reactors (SSMFS 2008:17)

The regulations with general advice contain specific requirements for nuclear power reactors on design principles and the implementation of the defence-in-depth concept, withstanding of failures and other internal and external events, withstanding of environmental conditions, requirements on the main and the emergency control room, safety classification, event classification, requirements on the design and operation of the reactor core.

Transitional rules to the regulations stipulate that measures to comply with certain paragraphs shall be implemented at the latest at time points decided by SSM. The reason for this is that the licensees must be given time to investigate in depth, specify, procure, install, test, and safety review the back fitting measures needed to comply with the regulations. SSM has reviewed and decided on these plans (see section B 6.2).

7.3.10. Regulations on protection of human health and the environment from discharges of radioactive substances from certain nuclear facilities (SSMFS 2008:23)

These regulations are applicable to releases of radioactive substances from nuclear facilities that are directly related to the normal operation at each facility. The limitation of releases of radioactive substances from nuclear facilities shall be based on the optimisation of radiation protection and shall be achieved by using the best available technique. The optimisation of radiation protection shall include all facilities located within the same geographically delimited area. The effective dose to an individual in the critical group from one year of releases of radioactive substances to air and water from all facilities located in the same geographically delimited area shall not exceed 0.1 millisievert (mSv).

7.3.11. Regulations on radiation protection managers at nuclear facilities (SSMFS 2008:24)

These regulations require any licence holder shall appoint a radiation protection manager[11] at the facility, with formal and good knowledge in radiation protection competences, in order to promote active radiation protection work and check on the implementation of the radiation protection legislation (laws, regulations, licence conditions). Furthermore, this control function also includes the tasks: to advice on competence- and staffing issues, to oversee the optimisation of radiation protection, to control that the required reporting to SSM is carried out. SSM formally approves the appointment of the radiation protection manager and his/her substitute.

11 This radiation protection manager should not be confused with the appointed managers in the line organisation. This person should have an independent, controlling function, and at Ringhals and Forsmark this person is named “radiation protection controller”.

7.3.12. Regulations on radiation protection of workers at nuclear facilities (SSMFS 2008:26)

These regulations apply to the radiation protection of workers at nuclear facilities. They contain provisions on the optimisation of radiation protection; procedures for information and education; local radiation protection instructions and their content; procedures for controlled areas; monitoring of work places; individual dose monitoring and exposure assessments; the calibration of, and instructions for, instruments and equipment; procedures connected to work with fuel elements; and documentation, reporting and archiving of radiation dose data.

7.3.13. Regulations on the competence of operations personnel at reactor facilities (SSMFS 2008:32)

These regulations and general advice include requirements on competence analysis, competence assessment, authorization by the licensee, recruitment and training for a position, and retraining of operations personnel belonging to the categories operations management, control room personnel and field operators. If an individual satisfies all requirements regarding competence and suitability, the licensee may issue an authorization valid for three years. Every year, an intermediate follow up shall be done in order to check that the essential competence is maintained. The regulations require the use of full scale simulators for operational training.

7.3.14. Regulations on archiving at nuclear facilities (SSMFS 2008:38)

These regulations apply to the archiving of documents that are drawn up or received in connection with the operations of a nuclear facility, record-keeping and the archives. They specify which documents and records that must be filed and how long they must be kept. They refer to requirements and general advice by the Swedish National Archives on the selection of materials and data carriers, transfers etc. They contain some provisions on the design of archives at the nuclear facilities. If the nuclear facility is decommissioned and the activities ceases, the archives shall be transferred to the National Archives or the regional state archives of Sweden.

7.3.15. Regulations concerning clearance of materials, rooms, buildings and land in practices involving ionising radiation (SSMFS 2011:2)

The regulations stipulate requirements on procedures for clearance of material, rooms, buildings and land. The regulations also stipulate nuclide specific clearance levels for different objects subject to clearance. Among others, the regulations contain requirements on written procedures, competence of the responsible personnel, recording of measurement results and reporting to SSM. Clearance levels are given for clearance of materials for reuse or for disposal as conventional waste, as well as for clearance of rooms or buildings after cessation of practices or decommissioning of facilities. The clearance levels are based on recommendations from the European Commission (reports RP 113 and RP 122 part 1).

7.3.16. Regulations on basic requirements for the protection of workers and the public in connection with work with ionising radiation (SSMFS 2008:51)

The regulations are general and apply to the exposure of workers and the public in both planned and emergency exposure situations. They are based on European provisions in the EU BSS[12]. They contain fundamental requirements on the licensee/operator for justification of the activities, optimisation of the radiation protection and limitation of individual doses (dose limits). They address the categorisation of workers and work places; stipulate Swedish dose limits for workers (including apprentices) and the public, and address the required information and protection of pregnant or breast-feeding women. The regulations address dose-limitation in connection with emergency exposure situations. The regulations give rules for measurements and registration of

12 Council Directive 96/29/Euratom of 13 May 1996, laying down basic safety standards for the health protection of the general public and workers against the dangers of ionising radiation [O. J. L-159 of 29.06.1996].

individual radiation doses and how these should be reported to the national dose register. The regulations contain provisions on medical surveillance, classification and medical records of workers. The regulations contain rules for the accreditation of laboratories for individual dose monitoring and performance requirements of individual dose meters. The regulations refer to the European technical recommendations for monitoring individuals exposed to external radiation (EUR 14852 EN, 1994).

7.3.17. Regulations concerning outside workers who work with ionising radiation (SSMFS 2008:52)

These regulations apply to outside workers of category A, working within controlled areas in Sweden and when Swedish workers of category A perform similar tasks in other countries. The regulations put obligations on both the licensee (e.g. operator of a nuclear facility) and the outside workers undertaking. The EU Directive (90/641/Euratom) which these regulations are based on require that the EU Member State’s competent authorities, in Sweden SSM, can issue individual radiological monitoring documents to outside workers, as necessary. The regulations stipulate the necessary procedures to be followed and data to be available when such “dose passports” are issued by the authority.

7.3.18. Major revision of the Authority’s regulations

SSM has now begun a major review of its regulations. There are three main reasons for performing major revision of the Authority’s regulations and making supplements to them. These reasons are as follows:

In the appropriation directions for the financial years 2012 and 2013, SSM been commissioned by the Swedish Government to develop regulations for new nuclear power plants.

SSM's own application experience has demonstrated the need to clarify and supplement the regulations in order to create more predictability for the licensees and improve the regulatory support for SSM in its supervisory activities. These clarifications and additions are necessary in a situation where continuing safety modernization of the existing nuclear power plants will take place and where the plants now gradually enter into ‘long-term operation’ (LTO). The regulations also need to be revised to encompass experiences from the Fukushima Daiichi NPP accident and subsequent stress tests of Swedish nuclear power plants.

The report on the IRRS review of SSM's activities performed by the IAEA during the period 6-17 February 2012 concluded that the Swedish regulations for nuclear facilities have historically emerged as the need for regulation arose. The report also notes that the IAEA's safety standards were used as the basis for the Swedish nuclear safety rules or referenced therein, but not in a systematic way. The IRRS review team highlighted examples of this by pointing to areas that they considered to be inadequately regulated relative to those required by the IAEA Safety Standards. Therefore, the report recommended that SSM review the existing regulatory framework and make it clearer, more consistent and comprehensive. This is now one important part of the SSM action plan to deal with recommendations and suggestions from the IRRS review.

Moreover, the need for revision of the regulations is also part of the conclusions contained in the SSM report to the Swedish Government presented in October 2012 concerning an analysis of long-term safety in the Swedish nuclear power industry (see section 8.8).

Other events that will lead to further changes to the regulations include the ongoing review of Swedish Acts concerning nuclear safety and radiation protection, as described above in section B 7.2, and the new, revised European Basic Safety Standards Directive which will supersede the Council Directive 96/29/Euratom of 13 May 1996.

The work to revise SSM's regulations will be an ongoing process for many years to come.

7.3.19. Safety documentation supporting major plant modifications - structure and content of the SAR

As stated above in the short description of SSMFS 2008:1, amendments were made in the reissued SSM version of these regulations. The introduced changes cover the requirements and general advice on safety analyses and the safety analysis report. The analyses and SAR constitute the fundamental safety documentation which always should be accessible and up-to date for the safety work at the nuclear facilities as well as for the regulatory body in their supervision. An important motive for the introduced changes was experiences from the ongoing activities with modernization and power uprates. Another important motivation was the expected application for to build, test and operate an encapsulation plant for spent nuclear fuel and an application for to build a repository for such encapsulated spent nuclear fuel.

7.4 The European Nuclear Safety Directive

On 25 June 2009 the EU issued Council Directive Euratom/2009/71 establishing a Community framework for the nuclear safety of nuclear installations in the Member States. Sweden has transposed the Directive into the national regulatory framework.

7.5 The WENRA Reactor Harmonization Project

The final report of the WENRA Reactor Harmonization Project, issued in 2006, and the list of reference levels updated in January 2008 can be found on the WENRA website (www.wenra.org). As a result of the harmonization project, WENRA members prepared national action plans on measures needed to align the national requirements and corresponding implementation measures at the nuclear power plants with the reference levels. It was agreed to align the legislation with the reference levels by 2010. On the part of Sweden, no major gaps were identified between the national requirements and the reference levels. The gaps identified were mainly dealt with by updating regulation SSMFS 2008:1.

The ongoing safety upgrade programmes at the nuclear power plants assure compliance with most of the reference levels in terms of implementation. A few remaining gaps are related to performing additional safety analyses and upgrading the supplementary control posts at some reactors.

As a consequence of the Fukushima Daiichi NPP accident, WENRA RHWG received a mission from ENSREG, which suggested an update of the existing reference levels. This work is ongoing and SSM is also participating actively in this update.

7.6 Licensing system

The Act on Nuclear Activities (1984:3) includes the basic legal requirements on licensing and the legal sanctions to be imposed on anyone who conducts nuclear activities without a licence. For major installations and activities, the licence is granted by the Government on the recommendation by the regulatory bodies. For all the existing Swedish nuclear power plants, the licences are valid without time limit, although licence conditions can be issued for a limited time and their renewal function as a control station. Revoking a licence for other reasons than safety, as in the Barsebäck 1 and 2 cases, requires the application of a special law.

If the licensee complies with all legally binding safety requirements, a prolongation of the licence cannot be denied on grounds of principle. A licence can be revoked if licence conditions are not complied with, or for other serious safety reasons. As explained in section B 14.1, there is a legal requirement to conduct a safety review of every reactor unit every 10 years of operation. One purpose of the review and its regulatory assessment is to establish whether a unit still complies with existing regulations and licensing conditions, and that safety and safety culture work are being developed as required.

The concept of "*life-time extension*" has no formal meaning in Sweden. The expression "*40 years technical life time*" was earlier used by the licensees in their long-term planning. The plants were prepared for 40 years of operation and beyond. Ongoing and planned modernization works are assumed to increase the technical life time of plants. Originally, 40 years was the technically "*guaranteed*" life time with large margins for the major passive structures and components. Today, based on international operational experience, a technical life time for similar rector designs is expected to be around 60 years. The investment analyses for planned modernizations are based on operational life times of 50-60 years, although investments will be profitable even with life times of 40 years.

Government assignment on long-term safety

On 8 April 2010, the Swedish Government assigned the Swedish Radiation Safety Authority (SSM) to, by 31 October 2012, present an analysis of long-term safety in the Swedish nuclear power industry [SSM 2010/1557-10]. The analysis was to include:

- an overall evaluation of the fulfilment of the upgraded safety requirements on the power reactors
- an assessment of the additional requirements on safety improvement as well as conditions that would be necessary for extended periods of operation

Following completed analyses and investigations, SSM is of the view that safety at Swedish nuclear power plants can be maintained over the long term as well, provided that additional safety improvements are made and that the licensees apply effective ageing management, and that this is examined regularly in the time ahead in the form of in-depth and periodic safety reviews (PSR). Furthermore, it is essential that a good safety culture is maintained while also ensuring other safety-related conditions pertaining to organisations and human resources as well as safety-related administration.

Using this as a point of departure, SSM intends to adopt a standpoint on long-term operation of nuclear power plants on the basis of periodic safety reviews under the requirements imposed by the Act on Nuclear Activities (1984:3) and the Authority's regulations. Clarification and more precise wording of SSM's regulations and general advice concerning periodic safety reviews are being planned, for instance in terms of described aspects of importance for long-term operation. SSM has nevertheless already established that the reporting of a licensee's periodic safety review that is to serve as the basis of the Authority's standpoint on long-term operation needs to encompass analyses describing the plant's ageing status over time for certain key parameters, such as irradiation embrittlement of reactor pressure vessels, component fatigue and tensioning force loss in the reactor containment tendons, for example. This also applies to analyses and when condition monitoring safety-critical electrical cables, instrumentation and control equipment.

7.7 Regulatory inspection and assessment

See section B 8.3

7.8 Enforcement

SSM has extensive legal powers to enforce its decisions. According to Section 17 of the Act on Nuclear Activities (1984:3), a licensee has to provide SSM with all information, documentation and access to facilities that are needed for the regulatory supervision. According to Section 18 of the Act, SSM is authorized to decide on measures that are needed and issue orders and prohibitions in individual cases in order to enforce the Act, regulations or licensing conditions issued with support of the Act. If a licensee fails to take necessary action, SSM is authorized to carry out the action on the licensee's expense. According to Section 22, SSM can also decide on fines in cases of non-compliance with licence conditions or regulations.

According to Section 22 of the Act, it is a criminal offence to violate the Act as well as conditions or regulations issued with support of the Act. SSM hands over suspected cases of criminal violations to a public prosecutor. This has been done in a few cases where it was evident, in the opinion of SSM, that the licensee had violated a legally binding requirement. Normally however, SSM uses a scale of administrative sanctions in cases where the licensees deviate from the regulations of SSMFS. The different steps are:

- Issuing a remark on issues to be corrected by the licensee
- Ordering of an action plan to be developed and actions to be taken within a certain time period
- Ordering of specified actions to be taken within a certain time period and the results submitted to SSM for review and approval
- Ordering of suspension of operations until deficiencies are corrected and taken measures are reviewed and approved by SSM

If SSM discovers non-compliance with rules or regulations issued under the Radiation Protection Act (1988:220), court orders or prohibitions with or without a penalty in the form of a fine can be used as means to enforce compliance by the licence holder. Criminal sanctions apply in the case of serious breaches of the Act and radioactive substances or equipment in such a breach may be confiscated.

The SSM management system provides guidance on the type of sanction that shall be used in a specific case. The SSM legal service always takes part in enforcement cases.

7.9 Conclusion

Sweden complies with the obligations of Article 7.

8. Article 8: REGULATORY BODY

1.	*Each Contracting Party shall establish or designate a regulatory body entrusted with the implementation of the legislative and regulatory framework referred to in Article 7, and provided with adequate authority, competence and financial and human resources to fulfil its assigned responsibilities.*
2.	*Each Contracting Party shall take the appropriate steps to ensure an effective separation between the functions of the regulatory body and those of any other body or organisation concerned with the promotion or utilization of nuclear energy*

Summary of developments since the last national report

During the current review period, the following developments are of relevance with regard to the obligations of article 8:

- The number of staff involved in regulation and supervision of nuclear activities has increased, and will continue to increase in forthcoming years.
- The application from Vattenfall AB in July 2012 to replace old reactors with new ones means new regulatory challenges for SSM and will entail a heavy workload for the Authority over the coming years.
- SSM has presented an investigation, assigned by the Government, on the competence situation in the disciplines of importance to the Authority. This report addresses both internal and national needs. One conclusion was that SSM had a lack of redundancy in some areas of competence in nuclear safety.
- IAEA has completed a full-scope IRRS mission[13] of SSM in February 2012 and the resulting recommendations have been addressed in an action plan at SSM.

8.1 The regulatory body and its mandate

8.1.1. General

The Swedish Radiation Safety Authority (SSM) was established on July 1, 2008. SSM took over the responsibility and tasks from the Swedish Nuclear Power Inspectorate and the Swedish Radiation Protection Institute when these were merged into the new authority. SSM works towards protecting people and the environment from harmful effects of radiation, now and in the future. The main motive for the merger was to strengthen and reinforce the supervision of both nuclear and non-nuclear activities, relating to nuclear safety and radiation protection, but also a general ambition by the Government to make civil service more efficient by reducing the number of administrative authorities.

The mission and tasks of SSM are defined in an ordinance with instructions for the authority and in the annual government appropriation directions, containing detailed objectives and reporting obligations. Other authorities with supervisory responsibility for the nuclear power plants are the Swedish Civil Contingencies Agency, the Swedish Work Environment Authority, and the National Electrical Safety Board.

SSM is a central administrative authority reporting to the Ministry of Environment. According to the Swedish constitution, the administrative authorities are quite independent within the legislation and statutes given by the Government. An individual minister cannot interfere in a specific case handled by an administrative authority. The Cabinet as a whole is responsible for all

13 IRRS stands for Integrated Regulatory Review Service

governmental decisions. Although in practice a large number of routine matters are decided upon by individual ministers, and only formally confirmed by the Government, the principle of collective responsibility is reflected in all forms of governmental work.

The Director General of the Swedish Radiation Safety Authority is appointed by the Government, normally for a period of six years. SSM has no board; the Director General is exclusively responsible and reports the authority activities directly to the Government. The authority has an advisory council with a maximum of ten members which are appointed by the Government. Those are usually members of the parliament, agency officials or independent experts. The functions of the council are to advise the Director General and to ensure public transparency (insight) in the authority's activities but it has no decision-making powers.

The requirements on SSM for openness and provision of information services to the public, politicians and media are very high. Swedish official documents are public unless a decision is made to classify them according to the Public Access to Information and Secrecy Act (SFS 2009:400). The reasons for secrecy could be those of national security, international relations, commercial relations, or the individual right to privacy. No-one needs to justify a wish to see a public document or to reveal her/his identity to have access to a document. After September 11, 2001, more safety systems documentation related to nuclear power plants became classified information and SSM has established more stringent security practices.

As all Swedish authorities, SSM issues an annual activity report to the Government summarizing major results, effects, revenues and costs. The Government carries out follow-up work and evaluates the agency's operations based on this report. In addition, SSM submits an annual report to the Government on the status and management of nuclear safety and radiation protection at the Swedish nuclear plants. The report summarizes major findings and conclusions on operational experience, regulatory inspections and reviews: technical safety status, radiation protection work, environmental impact, waste management, emergency preparedness as well as organizational matters, safety culture, physical protection and safeguards.

SSM publishes reports to inform interested parties and stakeholders. The SSM website is used for information on current events and authority decisions. All the publications of the SKI and SSI are still available and in the SSM report series; R&D-reports and central regulatory assessments are published. All reports issued by SSM can be ordered. Most of them are available for download from the SSM website.

SSM maintains a function on duty "around the clock" to respond to incidents and other urgent matters. In case of severe events, the emergency staff will be mobilised. SSM also has one employee available for press contacts and IT support during outside office hours.

8.1.2. The Swedish Radiation Safety Authority (SSM)

SSM's missions and tasks are defined in the Ordinance (SFS 2008:452) with instructions for the Swedish Radiation Safety Authority and in annual appropriation directions. In the latter, the Government issues directives for authorities including the use of appropriations. After the merger of SKI and SSI into SSM, more direct formulations about nuclear safety or radiation protection are less frequent and the Ordinance is mostly formulated in terms covering all of the authority's fields of expertise, when not directly addressing issues connected to duties of international agreements or conventions.

The Ordinance declares that SSM is the administrative authority for protection of people and the environment against harmful effects of ionising and non-ionising radiation, for issues on nuclear safety including physical protection in nuclear technology activities as well as in other activities involving radiation, and for issues regarding non-proliferation.

SSM shall actively and preventively work for high levels of nuclear safety and radiation protection in the society and through its activities act to:

1. prevent radiological accidents and ensure safe operations and safe waste management at the nuclear facilities,
2. minimize risks and optimise the effects of radiation in medical applications,
3. minimize radiation risks in the use of products and services, or which arise as a by-product in the use of products and services,
4. minimize the risks with exposure to naturally occurring radiation, and
5. contribute to an enhanced level of nuclear safety and radiation protection, internationally.

SSM shall ensure that regulations and work routines are cost-effective and uncomplicated for citizens and enterprises to apply/understand. SSM shall handle financial issues connected with the management of radioactive wastes from nuclear activities. The Authority shall inform the Nuclear Waste Fund about the size of payments and disbursements from the fund, planned or forecasted, by each reactor operator or other relevant licensee, and of SSM's own activities regarding financing issues, so that the Nuclear Waste Fund can fulfil its tasks[14]. SSM is in charge of the Swedish metrology institute for ionising radiation. SSM shall operate a national dose register and, as appropriate, issue national individual dose passports. SSM shall furthermore:

- carry out Swedish obligations according to conventions, EU-ordinances/directives, and other binding agreements (e.g. contact point, report drafting, and to be the national competent authority);
- supervise that nuclear material and equipment is used as declared and in agreement with international commitments;
- carry out international cooperation work with national and multinational organisations;
- follow and contribute to the progress of international standards and recommendations;
- coordinate activities needed to prevent, identify and detect nuclear or radiological events. SSM shall organise and lead the national organisation for expert advice to authorities involved in, or leading, rescue operations;
- contribute to the national competence development within the authority's field of activities;
- provide data for radiation protection assessments and maintain the competence to predict and manage evolving issues; and
- ensure public insight into all the authority's activities.

The annual appropriation directions were changed recently to focus more on short-term issues and funding of the authorities' activities. In the latest appropriation directions, dated 20 December 2012, SSM was among other things assigned to:

- Formulate radiation safety regulations for new nuclear power plants and no later than 30 October 2013 report on the work's progress.

SSM's work can be divided into supervision of the safety and radiation protection work connected with non-ionising and ionising radiation. As far as concerns ionising radiation, the main regulatory areas are: the use of nuclear technology and power production, the medical sector with therapy and diagnostics, the use of radiation sources and x-ray equipment in industry, the public use of sources and devices in commodities, the use of detectors and scanning equipment for security reasons and exposure to ionising radiation from naturally occurring radioactive material (NORM). In this report, the focus is on the nuclear facilities as defined by the Convention on Nuclear Safety. The missions are conducted within five main sectors: reactor and nuclear materials safety, radiation protection, nuclear non-proliferation, nuclear waste safety and, since 2007, nuclear waste financing. In addition, SSM is involved in international

[14] *The Nuclear Waste Fund* is a government authority which manages the fees paid by the power companies and the owners of other nuclear facilities in Sweden.

development cooperation within the areas of reactor safety, radiation protection, nuclear waste safety and non-proliferation. Figure 3 displays the organisation of SSM as of 1 July 2013.

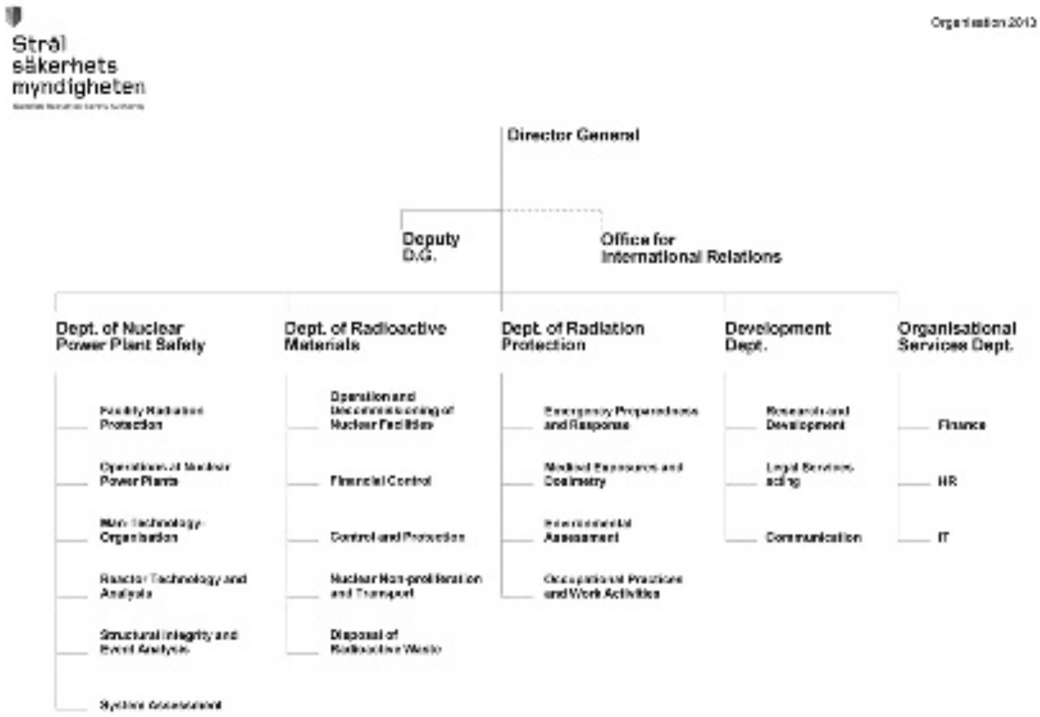

Figure 3 SSM's organisation

The work within reactor and nuclear materials safety and related radiation protection is mainly performed within the Department of Nuclear Power Plant Safety but some units of the Department of Radioactive Materials and the Department of Radiation Protection are also involved. Achievements in these tasks are annually assessed and reported back to Government.

Within SSM there exists a Delegation for Financial Issues Connected with the Management of Rest Products from Nuclear Activities which is an advisory body in the annual matters of suggesting the fees and the basis for calculating the fees, to the Nuclear Waste Fund. SSM also suggests the sizes of the supplementary guarantees the utilities must have available. The delegation is led by the Director General and has at most eight other members, decided by the Government and representing other authorities and independent institutions with relevant competence.

SSM has, related to safety of nuclear facilities, permanent advisory committees on reactor safety, radioactive waste and spent nuclear fuel, and research and development. SSM also has advisory committees in other fields such as UV, electromagnetic fields, and the use of ionising radiation in oncology.

8.2 Human and financial resources for regulatory activities

8.2.1. Staffing

SSM has (end of 2012) staff totalling 294 persons, which is an increase by 45 persons since 2009. The average age is 47 years. Of the staff, 26% are younger than 40 years, 33% are between 40 and 49 years of age, and 41% are 50 years of age and older. Around 14% of SSM employees will retire (65 years) within five years, but one can opt to work until the age of 67.

In 2012, 54 persons were recruited (26 women and 28 men) and their average age was 41. The staff turnover rate, excluding retirements, was 4% in 2012, which is normal. SSM is working on a long-term plan for its competence needs and this work will continue in 2013.

In 2010, the Government assigned SSM to investigate and report on the competence situation in the disciplines of importance to the Authority, taking into account both internal and national needs. In the report, dated February 2011, it was concluded that SSM had a lack of redundancy in some competence areas within nuclear safety, for example I/C, PWR operation, maintenance, instrumentation and PSA, and that SSM was dependent on a few key persons within these areas. The competence situation has now (2013) improved and SSM strives to recruit persons within these areas of competence.

The *Department of Nuclear Power Plant Safety* has (end of 2012) a staff of 78 persons who work with supervision of nuclear safety and radiation protection at the ten nuclear power reactors in operation. Of the 78 staff members, 19% have a postgraduate degree and 68% have a Bachelor's or Master's degree. SSM has designated one inspector for each plant as a *'site coordinator'* who serves as the main point of contact between the respective facility and the Authority.

The 64 persons belonging to the *Department of Radioactive Materials* use about 10-12 person-years on issues of waste management, spent fuels and nuclear non-proliferation towards the operation of nuclear power plants. This department mainly work with inspections of non-power producing nuclear installations (e.g. fuel factory at Västerås, waste treatment and material investigation facilities at Studsvik), decommissioning, financial issues, nuclear security, radioactive wastes and releases from non-nuclear facilities, and with planned or existing off-site spent fuel and waste management facilities, including final repositories (see Sweden's 3rd national report under the Joint Convention).

The 65 persons at the *Department of Radiation Protection* devote some (roughly 20 person-years) of their work resources to the national emergency preparedness activities, laboratory measurements, calibrations and use of radiation sources, x-ray equipment, etc. related to the operation of the Swedish nuclear facilities.

The "steering and supportive sections" of SSM account for 61 persons in total. They include the Director General's staff (with legal services), the communication department, the administrative unit (including human resources unit), the finance unit and the IT unit.

The educational background of SSM staff at the end of 2012 is shown in Table 5:

Education	Percentage
Post graduate degree	21
Bachelor's/Master's	65
Upper secondary school	13
Other	1
Total	100

Table 5 Educational background of SSM staff

Compared with many other authorities, the staff of SSM has a rather high educational level. This is a result of the many specialist areas covered by the authority, and to some extent the fact that there is no Technical Support Organisations in Sweden to support the regulatory body with specialist knowledge.

Comparing internationally, the number of regulatory staff in Sweden is small for the size of the nuclear programme. Many staff members are typically involved in several tasks, such as inspections, regulatory reviews and approval tasks, revision of regulations, handling research contracts, and participation in public information activities, each activity requiring his or her expertise. When comparing the sizes of staff between different countries, it is however important not only to count the staff members per reactor, but also to consider the types of legal obligations put on the licensees and the different oversight practices.

8.2.2. Long-term planning and resources

Since a couple of years SSM experiences a high workload depending on the safety modernizations of the Swedish reactors (see section B 6.2), upgrading of the physical protection of the plants, as well as applications to uprate the power levels of several reactors (see section B 6.3). This makes it important to implement a good long-term planning and to develop the necessary assessment and administrative tools to deal with the tasks without overloading the staff. Such planning is being carried out. Special procedures were developed for review of the power uprate applications and the authority presently re-examines its processes for reviews and assessments.

The authority costs for managing applications for new licences and for safety reviews (including periodic safety reviews) are now covered by fees to the licensees, in accordance with the *Swedish Radiation Safety Authority Ordinance* (SFS 2008:463). This new system made it possible to employ some additional staff for work with such licence applications and safety reviews.

The *Department of Nuclear Power Plant Safety* has since the last occasion of reporting increased its staff significantly so that the number of employees at the end of 2013 will total around 100 analysts and inspectors. The increased human resources are both intended for conducting supervision of present nuclear installations and to be able to process the application submitted by Vattenfall on 31 July 2012 for permission to replace one or two reactors with new ones. Furthermore, the increased level of resources will also enable SSM to partake in more extensive international regulatory cooperation in the light of the Fukushima Daiichi NPP accident.

8.2.3. Internal staff training

Competence development has been conducted in all departments and units in 2012 and about 1,633 days have been used for training (including the supervisory programme described below); this is an average of 5.5 days per employee.

Work has been launched to develop a basic training programme in the following areas: authority role, occupational health, safety and SSM’s core operations. The aim is to foster a deeper understanding of the Authority's activities and to give new employees an important network.

SSM also launched a development programme in skilled supervision in spring 2012. The programme concerns all employees involved in supervisory work at SSM. The aim is for them to have the same basic skills and perform supervision consistently regardless of the supervised entities. So far, a total of 288 days have been used in this programme, which will continue in 2013.

There are plans to further develop employees’ supervisory skills at the Authority. Planning involves our exchanging experiences internationally with sister agencies that have come further than us in this respect.

In 2012 SSM started a general analysis of the Authority in the area of expertise. The purpose of the skills survey is to provide SSM's leadership and managers with a clear picture of the Authority's current skills and, based on this, perform a gap analysis. With this analysis we can determine the skills we need in the short and long term in order to deal with current and future tasks.

During the year, ongoing development efforts were undertaken on the part of the entire management group. The content of this work was based on the skills profiles of identified managers at SSM. Efforts have included both pure leadership issues as well as issues related to the organization and systems.

During the year, we conducted around 70 joint agency training sessions in the areas of supervision, preparedness, monitoring, skills exercises and the work environment.

Courses are also given covering the internal processes of the management system, the legal framework for regulatory activities, IT and security routines, project management, inspection methodology, nuclear technology, nuclear power plant and systems courses, as well as media training. For technical training, SSM also uses the licensee training programmes for operations staff, including simulator training. Newly employed SSM staff were also given the opportunity to observe on-site work in a control room for several weeks.

8.2.4. Financial resources

As mentioned in previous national reports, the regulatory activities of SSM are financed by the State budget. The costs are largely recovered from the licensees in the form of fees covering the cost of regulatory activities and related research. The amounts of the fees are proposed annually by SSM but decided by the Government. The budgets for 2011, 2012 and 2013, including the funding of the separately financed international cooperation and development work are shown in Table 6.

In addition, some additional resources (at most a few million kronor per year) are from fees for reviewing special applications or licensing work that are paid directly to the Authority. The financial resources of the regulatory body have increased in real terms as compared to what was reported for 2010 in the fifth Swedish national report. The 2013 budget for SSM has been increased further and totals approximately 500 million SEK.

Budget item	2011	2012	2013	Source of funding
Nuclear safety, emergency preparedness and radiation protection (including administration)	232.0	256.6	280.2	Mainly fees
Supervision of nuclear facilities (proportion of above)	97.4	113.3	123.7	Fees
Licensing of new nuclear facilities	10.4	13.0	45.3	Fees
Scientific research and development work	78.0	73.9	80.3	Mainly fees
Final disposal of radioactive waste	43.1	63.6	70.7	Fees
Historical wastes etc.	0.9	1.3	2.0	Tax funded
Crisis management[15]	25.0	22.3	6.6	Tax funded
International co-operation and development	47.6	49.6	45.1	Tax funded
Total (million SEK)	**436.9**	**480.3**	**530.2**	

Table 6 Budget of SSM in million SEK - 1 SEK is about 0.1 Euro

15 These funds are received via the Swedish Civil Contingencies Agency (MSB)

8.3 Regulatory inspections and assessments

Regulatory inspections and safety assessments are carried out by SSM as authorized by the Nuclear Activities Ordinance, and Radiation Protection Ordinance, and as instructed by the Government.

8.3.1. SSM's supervisory practices

SSM has continued to develop its supervisory methods, which are also documented as part of SSM's overall management system. Inspection policies and routines that were established during 2009 have been updated and new routines, including harmonization between procedures in different supervisory areas, have been issued. The following list exemplifies (i.e. is not complete) relevant documents from SSM's management system:

Supervisory policy	2010-08-24
Rules of access to facilities under the Authority's supervision	2009-05-19
Reviews	2010-04-23
Special supervision	2013-01-08
Compliance inspections	2009-09-21
Surveillance inspections	2009-09-21
Rapid investigations	2009-12-11
Processing notifications from the nuclear facilities	2011-01-24
Integrated safety assessments	2012-05-01
Compliance assessments and sanctions in supervision	2013-02-27
Investigations in supervision	2012-09-04

The following describes SSM's supervisory practices for nuclear power plants.

In total, 17 areas are defined for which the corresponding requirements are found in regulations, licensing conditions and to some extent in regulatory decisions. The ambition is to successively cover these areas in a basic inspection programme and to document the inspection findings. Moreover, the same 17 areas are applied in the annual assessments of the licensees (SSM's integrated safety assessments, see below) as well as in the periodic 10-year safety reviews. In this way, SSM is able to systematically supervise the safety situation and monitor developments. When new assessments are begun, previously performed and documented assessments of the areas can be consulted and any emerging picture consolidated. The idea is to apply the regulatory information and knowledge in a more efficient way. In order to further guide inspections and safety assessments, there is also a sub-structure in each of the 17 areas. The areas applied are:

1. Design and construction of facilities, including modifications
2. Organisation, management and control of the nuclear activity
3. Competence and staffing of the nuclear activity
4. Operations, including handling of deficiencies in barriers and the defence-in-depth
5. Core and fuel issues and criticality issues
6. Emergency preparedness
7. Maintenance, including materials- and control issues with special consideration of degradation due to ageing
8. Primary and independent safety review, including the quality of notifications to SSM
9. Investigation of events, experience feedback and external reporting

10. Physical protection

11. Safety analyses and safety analysis report

12. Safety programme

13. Archiving, handling of plant documentation

14. Management of nuclear material and radioactive waste

15. Nuclear non-proliferation, exports control and transport safety

16. On-site radiation protection

17. Radiation protection of general public and the environment

As a result of assessments within these areas, safety conclusions can be drawn in terms of the integrity of the physical barriers and the functioning of the five levels of the defence-in-depth. In the regulations SSMFS 2008:1 the areas 1-15 are found in the general advice section (Chapter 4, Section 4) on periodic reviews of the nuclear safety. The licensees are encouraged to analyse and report on their activities according to these areas. The added areas 16 and 17 cover issues regulated by the Radiation Protection Act (1988:220).

SSM evaluates how regulatory time "on site" is used and how to optimise time allocated to compliance inspections and surveillance inspections as described below in order to be able to assess actual work practises at the plants, however without taking over inspection issues already under third party control.

8.3.2. Nuclear safety and radiation protection inspections

The number of compliance and surveillance inspections performed by SSM in 2012 is shown in Table 7. Some of those inspections focused on the following themes:

- Management and assessment of incidents
- Experience feedback and handling of events
- Start-up procedures after outages
- Control room working environment
- Competence and staffing
- Competence of operational staff in shift work
- Operator aids and tools
- Safety assessment of operating instructions
- Independent safety assessment
- Management of weak signals
- The role of the safety department in the organization
- Safety leadership
- Safety culture activities
- Criticality safety
- Control of areas containing safety equipment
- Management of station changes
- Management of plant degradation due to ageing
- Management of test results in connection with modernization and power uprate projects
- Internal auditing procedures and activities

- Monitoring of the radiation safety environment within the plant, including management of radiation protection experiences, personal protective equipment and hand-held monitoring instruments

The compliance inspections are carried out by teams composed of the site inspector(s) and one or more experts on the subject matter of the inspection. An exit meeting is held where preliminary results are communicated to the licensee. The inspection report documents the purpose and objects of the inspection, observations, compliance and deviations from requirements, an assessment of the significance of any deviations, and a proposal on any further regulatory actions. After most of the inspections during 2012 it was concluded that the licensees complied with the requirements, although in some cases with deviations. In a few cases SSM issued an order to the licensee to improve the activities.

In addition to compliance inspections, SSM carries out surveillance inspections to be informed on power production, safety problems and overall activities at the plants. Normally these surveillance inspections include 3-4 annual meetings with each reactor operations management, two annual meetings with the safety department, one inspection at each outage and yearly meetings to review safety and internal audit programmes. Special inspections are made in connection with events, to follow up organizational change and other current issues such as findings from earlier inspections. In many cases these inspections have also focused on non-technical issues, such as safety management and safety culture.

The preparation and documentation of surveillance inspections are simplified in comparison with compliance inspections, but results are systematically documented and reported at SSM management meetings. Each surveillance inspection typically takes 1-2 days on site for 1-2 inspectors. Often a specialist on the subject matter for the visit accompanies the inspector.

Year	Forsmark	Oskarshamn	Ringhals	Total
2012 compliance inspections	7	3	6	16
2012 surveillance inspections	33	31	39	103
2009 compliance inspections	7	5	11	23
2009 surveillance inspections	32	33	23	88

Table 7 Compliance inspections and surveillance inspections (excluding waste management) performed by SSM in 2009 and 2012

SSM also has an instrument called "special supervision". The use is decided by the Director General and is applied when the authority is dissatisfied with the safety performance of a licensee. It can also be applied for other special safety reasons, e.g. during test operations after a large plant modification. The special supervision regime means that more inspections are done and particular progress reporting is required. Special supervision has been applied in a several cases; the ongoing cases are both Oskarshamn and Ringhals where SSM more closely wants to follow the safety developments (see section B 10.3).

Inspection of the licensee programmes, activities and results of surveillance and in-service inspection of mechanical components are done, according to SSM regulations, by an accredited control body ("*third-party control*"). If the requirements are fulfilled, a "*compliance certificate*" is issued by the control organisation (see Chapter 14).

8.3.3. SSM's integrated safety assessments

SSM's integrated safety assessments are annual nuclear safety and radiation protection assessments of each major facility under SSM supervision, and are performed by a specific group of persons at the department of nuclear power plant safety. Based on all compliance inspections, surveillance inspections, reviews, authority decisions and other relevant information, evaluations and a general appraisal are made of the nuclear safety, radiation protection and non-proliferation control status of the facility in relation to relevant requirements. The basic material should also cover earlier information and conclusions in order to identify trends that could otherwise be difficult to detect in a short-term perspective. A draft report, covering the status in the 17 areas mentioned above, is prepared by the group.

Of importance when drafting the report is the traceability from the basis of data, via the analysis, to the final conclusions and the appraisal. It should be clearly described how SSM evaluated the relevant issues and it should be comprehensible to interested parties lacking expert knowledge in the assessed areas. In order to perform the integrated safety assessments more effectively and to improve the quality of the assessment, SSM has developed a database with the aim of covering all identified deficiencies and issues from performed supervisory activities. The database was taken into operation in 2012.

In accordance with the Authority's established procedures, the draft report is distributed for comments in the organisation. The report is ultimately approved by SSM's Director General and presented at top level management meetings with all licensees.

8.4 Regulatory research

Based on what is stated about research in the *Ordinance* (SFS 2008:452) *with instruction for the Swedish Radiation Safety Authority,* the main purposes for SSM research is to:

- Maintain and develop the competence of importance for radiation protection and nuclear safety work.
- Ensure that SSM has the knowledge and tools needed to carry out effective regulatory and supervisory activities.

SSM supports basic and applied research and also development of methods and processes (usually not products). However for development work the intention is that the developed method or process should be used solely by the authority, in support of the authority work. One aspect is the clear separation between research and authority support. The latter is not in the interest of the broader society and must be put out to tender.

Research is a prerequisite for SSM to be able to conduct its regulatory activities. Research to support supervision in the nuclear area is focused on strategic areas such as safety assessment, safety analysis, reactor technology, material and fuel questions, human factors, emergency preparedness and non-proliferation. In the area of radiation protection, research and development work relating to source terms, production and spread of activated corrosion products, new detection and measurement methods, and waste treatment are of importance. More general research on radioecology, radiation biology and radiation dosimetry is also of long-term importance. Depending on the political and the electricity market decisions, applications to build new power reactors would generate substantial new research needs.

SSM financed basic research in 2012 at an amount of about 40 MSEK following a normal application procedure with external and internal experts judging relevance and scientific quality in the selection process.

In order to contribute to national competence and research capacity SSM and the nuclear industry support the Swedish Centre of Technology within a long-term contract (presently 2008-2013). From originally having been support to PhD students at KTH in Stockholm, the Centre evolved and now supports professorships, lecturer posts, and post-graduate education in subjects related to the nuclear field at KTH, Chalmers University of Technology in Gothenburg (CTH) and Uppsala University (UU).

SSM finances three higher research posts in radiation biology, radioecology and dosimetry until 2013; with further optional prolongation. Stockholm University formed the Centre for Radiation Protection Research to co-ordinate the Swedish resources in the area and SSM supports this important activity.

Nuclear safety research is performed within bilateral agreements with Finland but also within NKS (*Nordic Nuclear Safety Research*) in two programme areas, *Reactor safety* and *Emergency preparedness.* The latter area actually also includes some waste management research. SSM, Ringhals AB and the SKB support two postgraduate positions at UU where accelerator cross-section measurements are performed. The objective of the SSM support is the nuclear physics competence at UU.

To fulfil research needs, SSM contracts universities and consulting companies. A dominating share goes to research organizations in Sweden. However, since national resources are limited, SSM actively participates in international research. There is, since many years, a clear trend of increasing international cooperation, also in safety research. SSM cooperates on research conducted by EU and OECD/NEA and takes part in a large number of projects.

A close cooperation with NRC is prioritised in order to have access to developed models and computer programs for three-dimensional coupled thermal hydraulics and neutron kinetic calculations. An important work is the validation of the advanced computer codes with real events. For some phenomena which can occur in a reactor in the shut-down mode, it is sometimes advantageous to use multi-dimensional calculations techniques, *Computational Fluid Dynamics* (CFD). These calculation techniques need to be validated for use in the nuclear reactor context, e.g. regarding thermal transients, local variations in boron concentrations, hydraulic loads etc.

The Halden Project in Norway conducts research of importance for fuel, materials and human factors. An example of an OECD/NEA international project performed in Sweden is the fuel project SCIP (Studsvik Cladding Integrity Project). Since Sweden joined the EU, the importance of joint European work has increased. SSM is itself actively participating and supporting Swedish organizations participating in European Commission projects and intends to support such projects in the future. Furthermore, in the safeguards area, important joint work is performed in ESARDA (European Safeguards Research and Development Association).

The Forsmark event in the summer 2006, see section B 10.4, led to the identification of areas where further research is needed. As a result of the international cooperation, four areas were identified for further work: 1) Norms, standards and requirements and the need for their development; 2) Strategies for control and tests of construction, installation and operation of electrical systems; 3) A survey of models and methods used for the analysis of the dynamic behaviour of electrical systems; 4) Strategies for using an integrated approach in analysing electrical systems. The Forsmark event also emphasised the need for developing assessment criteria for the maintenance philosophy used for electrical systems and I&C systems.

Other examples of research where Sweden participates in international projects are bench-marking of experience feedback systems and development of PSA-tools. SSM is also involved in the assessment of computer platforms with applications, and analysing the safety aspects of the use of “smart devices” and COTS (Components On The Shelf) products. Sweden is active in standardisation work performed within International Electrotechnical Commission (IEC) and the Institute of Electrical and Electronics Engineers (IEEE), e.g. regarding questions of environmental qualification of equipment.

8.5 Quality management of regulatory activities

8.5.1. SSM's process-based and integrated management system

SSM has an integrated and process-based management system which is certified in the areas of environment, quality management and work environment management in accordance with SS-EN ISO 14001:2004, SS-EN ISO 9001:2008 and the Swedish Work Environment Authority's regulations AFS 2001:1. The management system encompasses all activities of SSM. The system will be supplemented with a section on *Information Security* following SS-ISO/IEC 27001:2006. Internal and external audits are performed yearly, which are the basis for continuous improvements to the system. Figure 4 displays SSM's present process scheme.

An interactive process model highlighting the sequence and interaction of all key processes has been developed, validated and published on the intranet. Component sub-process information and associated guidance materials can be readily accessed by way of the process model, dedicated intranet pages and a robust document management system. Assigned process ownership applies to the key processes. The process map follows an iterative cycle from left to right: Planning process, Implementation process and the Follow-up process. Various support processes and processing of items of business (Registrar, registration and archiving) are grouped below the category Supporting processes.

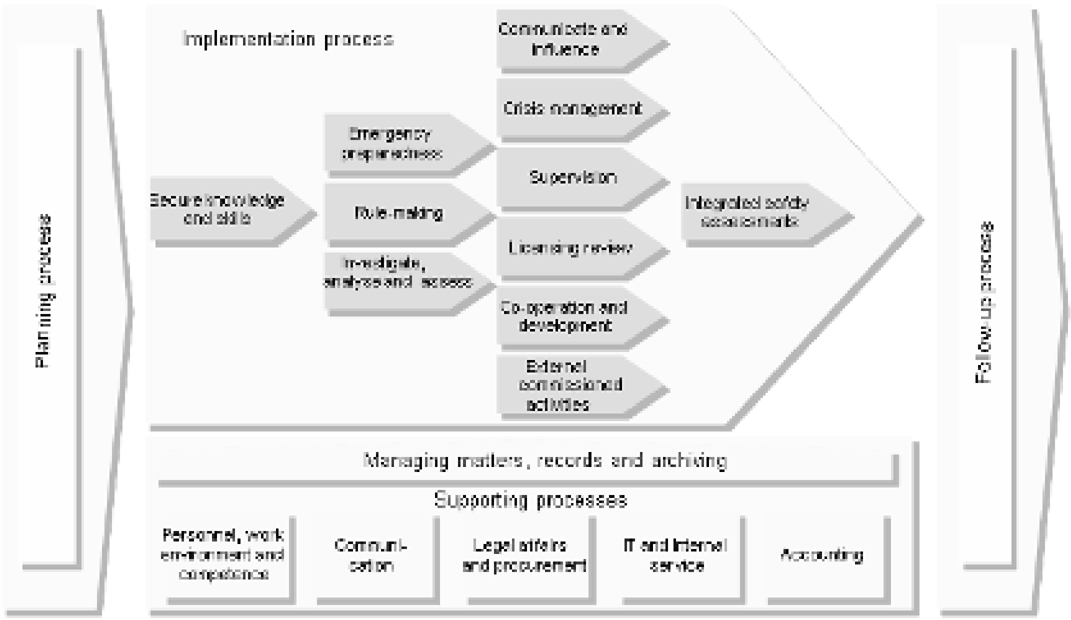

Figure 4 SSM process scheme

8.5.2. Implementation of audits

SSM ensures that annual internal and external audits of the authority's activities are carried out, in addition to audits of *the Swedish National Audit Office*. The SSM management system should account for internal and external requirements; the latter such as those of ISO-standards, statutes and legal provisions, e.g. work environment management and information security.

SSM is currently revising the programme for the next few years. The objective of internal audits is to follow up the activities of the Authority on all levels, to check compliance with external and internal requirements, to investigate how the 'shared values' are integrated in the day-to-day work, and to check if the management system is effective and adapted to its purposes. The internal auditors are appointed by the Director General on suitable audit teams on the basis of experience, competence and audit objectives.

External audits are carried out every year. In addition to the annual report and finances, the Swedish National Audit office performs checks on the effectiveness of SSM's management system. The requirements of ISO 9001, ISO 14001, the *Swedish Work Environment Authority's* regulations AFS 2001 and other relevant requirements are audited by contracted external auditors, accredited by *the Swedish Board for Accreditation and Conformity Assessment*, an authority under the *Ministries for Foreign Affairs* and *Enterprise*, *Energy and Communications*.

The latest external review was carried out in November 2012. In February 2012, on a request by the Swedish Government, the IAEA conducted a full-scope IRRS mission in Sweden. The mission was preceded by an extensive self-assessment involving a large proportion of the staff. The subsequent action plan is a basis for continuous improvements.

8.5.3. New system for document management

In January 2010 it was decided that SSM should acquire a new document management system to the authority (largely following ISO 15489). The implementation will be gradual during a 3-year period and starts during 2010 with project work, education of the staff and implementation of some parts. The diary part will be introduced during 2011. The objective of the new system is to allow for effective handling of documents and applications. External contacts should be able to fully use Internet and e-mail for their dialogue with SSM. A careful scan of the legal requirements (archiving, freedom of the press, public information, secrecy, confidentiality etc.) is performed. The possibility to use electronic signature (procedures for establishing a legal validity of signed documents sent by Internet or e-mail) will be studied.

8.5.4. Communication

SSM's communication policy, established in April 2009, emphasises the key values of integrity, reliability and openness while defining their implementation (availability, proactive information, good quality, no unnecessary delay). Other strategy documents, also imbued with the key values, include a communication strategy, a media strategy and an Internet strategy. The crisis communication strategy, established in June 2012, was formed through the experience gained during the accident at the Fukushima Daiichi NPP. The aim of the SSM website is to be transparent and comprehensible, thus giving stakeholders the opportunity to monitor the Authority's work.

8.6 Independence of the regulatory bodies

The de jure and de facto independence from political pressure and promotional interests are well provided for in Sweden. The laws governing SSM concentrate solely on nuclear safety, radiation protection (also security, physical protection, and non-proliferation, but outside of the scope addressed in this convention). SSM reports to the Ministry of Environment, which is not involved in the promotion or utilization of nuclear energy. These issues are handled by the Ministry of Enterprise, Energy and Communications. An individual minister cannot interfere with the decision making of a governmental agency according to fundamental Swedish law. This is a matter for the Government, in plenum.

8.7 IRRS review

Between 6 and 17 February 2012, an IRRS review was performed of activities in Sweden and at SSM in the fields of nuclear safety and radiation protection. The review mission was mainly a 'full scope review', that is, the review mission largely encompassed the entire fields of nuclear safety and radiation protection. However, the areas of physical protection and non-ionising radiation were not reviewed.

Prior to the review mission, SSM conducted a self-assessment of its work activities. Part of the self-assessment included responding to a very large number of questions compiled by the IAEA on the basis of the set of safety requirements and standards mentioned in section 4.3.2, and conclusions were drawn on how the Swedish system and regulatory authority fulfil the requirements and meet the standards. This self-assessment was one of several forms of input used by the IRRS peer review team.

The IRRS peer review was conducted by 18 experts from 16 countries in addition to six experts from the IAEA. The peer review team's overarching conclusion was that the Swedish system for nuclear safety and radiation protection is stable and well-developed, with e.g. an independent supervisory authority that is open and transparent, that learns from experience and is open to feedback. The team emphasised areas of good practice as well as areas of improvement. The team presented 15 examples of 'good practice' that may be relevant for other countries and regulatory authorities to learn from. In the field of nuclear safety, this was for instance about SSM having its own good MTO expertise that is used as part of regulatory supervision and that SSM's regulation has brought about a wide-ranging safety upgrade program. The team also submitted 22 'recommendations' and 17 'suggestions' on improvements to the Swedish system.

Eight of these recommendations were directed at the Swedish Government, urging it to, among other things:

- take measures to maintain national competence in the fields of nuclear safety and radiation protection
- increase SSM's resources for regulatory supervision and licensing reviews
- establish an ongoing process that keeps legislation up to date
- ensure that SSM has legal potential to conduct inspections of suppliers
- clarify the mandate and authority for the purpose of withdrawing/terminating licences

Important recommendations and suggestions that directly or indirectly relate to SSM's work vis-à-vis nuclear power plants concern the regulations, SSM's management system with the internal management process and guidance, in addition to resources and securing competence.

As far as concerns SSM's regulatory framework for reactor safety, the team established in the report that Swedish regulations concerning nuclear facilities have evolved historically in pace with the need for regulation. The peer review team has also established that the IAEA's safety standards were being used as a basis for Swedish nuclear safety regulations, or the regulations have referred to them, but not in a systematic way. The peer review team highlighted examples of this by pointing out areas/sub-areas considered to be unsatisfactorily regulated in relation to what ensues from the IAEA's safety standards. These examples cover regulations for reactor containments, electrical and control equipment, taking into account external events, PSAs, safety classification, fire safety, management systems and designing nuclear power plants. For this reason, the team recommends that SSM revise the present regulations to make them clearer, more consistent and comprehensive.

As far as concerns SSM's regulatory supervision, the review team established that the inspection activities largely focus on licensee management systems and their use in practice by interviewing personnel at different levels of the facilities' organisations and in different functions. The team also established that SSM performs few unannounced compliance inspections at the nuclear power plants. This is why SSM is recommended to consider performing more unannounced compliance inspections and inspections in more areas while also observing activities and performing technical inspections more frequently.

In the IAEA's General Safety Requirements, GSR Part 1, it is stated that national regulatory bodies are to analyse and evaluate events and other safety-related operating experience, nationally and internationally, so that they can draw conclusions that may be of importance for regulatory supervision and the regulatory framework. The peer review team established that in terms of nuclear power plants, SSM has a satisfactory system for following up events that take place at Swedish facilities. However, the team noted that the Authority does not disseminate information to the relevant stakeholders about events that have occurred, nor is there a formalized system for informing the parties concerned about the conclusions drawn by SSM from events that have occurred. This applies to cases where the events have neither resulted in a particular inspection nor review. Here, SSM disseminates the reports to the relevant licensees.

It emerged from both SSM's self-assessment and the IRRS review that the Authority's management system needs to be developed further in different respects. SSM needs to develop more specific guidance on how to pursue work on various review and inspection tasks. These processes and written routines should also be communicated to applicants, licensees and other interested parties. The peer review team has also recommended that SSM consider introducing formal competence requirements and compulsory training programmes for all personnel with supervisory tasks, especially for different kinds of technical experts.

Based on the results from the self-assessment and IRRS review, SSM has produced an action plan showing how and when the Authority is to rectify deficiencies and tackle areas of improvement.

8.8 Need for changed regulation and regulatory supervision

The assignment for SSM referred to in section 7.6 also included conducting an analysis of the Swedish regulatory model for reactor safety.

The analysis shows that SSM currently has a satisfactory model for regulation and regulatory supervision in the field of reactor safety. This model stands up relatively well in relation to international standards and practice, but it needs to be developed in various respects. The model mainly represents regulation and regulatory supervision focusing on licensees' management and control of their activities and has evolved over the past 20 years within the regulatory authority. The principles for this model were established in a situation where all Swedish nuclear power plants were to have been shut down by 2010. Among other things, this situation implied that the focus of the regulatory model came to be placed on safety issues related to operation and maintenance. Part of this model includes a general kind of regulation imposing generally worded requirements on the work activities at Swedish nuclear power plants, also with supervisory work oriented at the licensees' management, control and follow-ups of the organisation's work.

The results of the IRRS review and modifications to nuclear activities in Sweden, such as extensive safety upgrades at the facilities, planned long-term operation plus increased international regulatory collaboration and a higher level of harmonisation of nuclear safety regulatory supervision, show that the model applied needs to be developed and made more precise. The present analysis shows that this further development and modification work needs to encompass not only the regulatory framework, in the form of regulations and general advice, but also regulatory supervision.

SSM's regulatory framework needs to become more comprehensive and be based on international safety standards and European practice, while also demonstrating improved predictability about the implications of the requirements imposed. SSM is now preparing this regulatory revision. The challenge for SSM will be to supplement and clarify regulations and general advice concerning nuclear power safety to enable achievement of these objectives while not going too far in terms of detailed regulation in a way that leads to unclear circumstances about a licensee's safety responsibility. Key points of departure as part of the regulatory framework's revision will include the IAEA's new safety standards and the 'safety reference levels' and other documents agreed between nuclear regulatory authorities in the European Union within the WENRA collaboration.

As up until now, and in agreement with the Government's communication to the Riksdag, regulatory supervision is to have its foundation on the controlling element in the supervision, but with an orientation and execution that are more adapted to the varying nature of the matters of supervisory work. The objective for the further development and this change is for each situation having a correct orientation of regulatory supervision that is pursued in a way that is fit for purpose and effective.

SSM will consequently, at the same time as the revision of the regulatory framework takes place, be refining strategies and approaches for conducting regulatory supervision in the field of reactor safety. In order to achieve a regulatory supervision that is more effective and even more appropriate for purpose, approaches and strategies need to be developed for various areas of regulatory supervision and be adapted to the nature of the areas and the matters of regulatory supervision as well as their importance for safety. The starting point for this work will be the findings of the present studies within international co-operation concerning regulatory approaches and strategies.

This means that SSM will be defining the areas of supervision for which different supervisory strategies are to be developed. For each area, it is defined which combinations of approaches are to be applied and serve as the basis for the strategy per area. This strategy is also to be designed so as to facilitate application of the graded approach. In certain areas, consideration will also be given to recommendations from the IRRS review mission, as well as recommendations from public sector collaboration as part of CNRA, WENRA and ENSREG.

This for example applies to PSRs of the facilities that are to be conducted at least every ten years. The requirements imposed on these kinds of safety reviews have for a long time now been stipulated in the authority's regulations, but were incorporated in the Act on Nuclear Activities (1984:3) in 2010 on the justification that these reviews are of principal importance. Even internationally, these kinds of PSRs are of key significance for ensuring that operational experience, new knowledge and new safety standards are taken into consideration and have an impact at the facilities. Against the background of the Fukushima Daiichi NPP accident, it may also be anticipated that PSRs will be attributed greater importance internationally in the regulatory authorities' work on regularly evaluating the validity of the applied design bases, assumptions and safety analyses. SSM will monitor this international development and adapt the application of the periodic safety reviews thereafter. SSM also intends to give the periodic safety reviews a formal role when it comes to adopting a position on long-term operation of Swedish nuclear power plants in accordance with recommendations from CNRA and other bodies.

Other areas that have been emphasized by the IAEA, as part of public sector collaboration as well as by the present report, and which will be encompassed by SSM's revision of its regulatory model, include:

- supervision of ageing management during long-term operation
- supervision of the licensees' control and quality assurance of work performed by suppliers and contractors
- analyses and follow-ups of operating experience

SSM will also continue with development work initiated at the Authority, including annual integrated safety assessments of the nuclear power plants and a more extensive follow-up of safety culture matters.

8.9 Conclusion

Sweden complies with the obligations of Article 8.

9. Article 9: RESPONSIBILITY OF THE LICENCE HOLDER

Each Contracting Party shall ensure that prime responsibility for the safety of a nuclear installation rests with the holder of the relevant licence and shall take the appropriate steps to ensure that each such licence holder meets its responsibility.

Summary of developments since the last national report

During the current review period, the following developments are of relevance with regard to the obligations of article 9:

- Follow-up OSART missions to all plants have been finalized by the IAEA since the last CNS review meeting.

9.1 Regulatory requirements

The Act on Nuclear Activities (1984:3) is clear about the prime responsibility for safety:

> Section 10: The holder of a licence for nuclear activities shall ensure that all measures are taken which are needed for
>
> (1) maintaining safety, taking into account the nature of the activities and conditions under which they are conducted,
>
> (2) the safe management and disposal of nuclear waste arising in the activities or therein arising nuclear material which is not reused, and
>
> (3) the safe decommissioning and dismantling of facilities in which no longer nuclear activities are carried out.

This paragraph, SFS 1984:3, Section 10, was amended in 2006 as follows:

> The holder of a licence for nuclear activities shall, in connection with near-accidents, threats or other similar circumstance, without delay to the regulatory body report such information which is of consequence for the assessment of safety.

In the pre-work to the Act on Nuclear Activities (1984:3) it is stated that the licensee shall not only take measures to maintain safety but also measures to improve safety where this is justified.

SSM shall ensure that regulations and used procedures are cost effective and useful for individuals as well as companies. They must be written so that the regulatory body does not take over the prime responsibility for safety and radiation protection.

SSM supervision shall ensure that the licensees have good control over the safety of the plants and that safety work is conducted with a satisfactory quality.

The SSM regulations (SSMFS 2008:1) on safety in nuclear facilities specify the responsibility of the licensee through a number of fundamental requirements on safety management, design and construction, safety analysis and review, operations, nuclear materials-/waste management and documentation/archiving. In addition it is clearly pointed out in these regulations (Chapter 2, Section 9, item 8) that safety shall be monitored and followed up by the licensee on a routine basis, deviations identified and corrected so that safety is maintained and further developed according to valid objectives and strategies. The meaning of this provision is that a continuous preventive safety work is legally required, including safety reassessments, analysis of events in the own and other facilities, analysis of relevant new safety standards and practices and research results. Any reasonable measure useful for safety shall be taken as a result of this proactive and continuous safety work and be documented in a safety programme that shall be updated annually (Chapter 2, Section 10).

The SSM regulations spell out three basic control principles, making the roles clear between licensee and regulator:

- Approval by SSM (in specified matters) after primary and independent safety review by the licensee.
- Notification of SSM (in specified matters) after primary and independent safety review by the licensee.
- Self-inspection by the licensees according to their own management systems.

The basic safety documentation (SAR including OLCs, plans for emergency response and physical protection) must be formally approved by SSM. Plant and organizational modifications and changes in the safety documentation are to be notified and SSM can, if needed, impose additional conditions and requirements. All other issues are handled under the licensee self-inspection. SSM examines how this liability is managed.

9.2 Measures taken by the licence holders

A number of measures give evidence that the Swedish licensees accept the prime responsibility for safety. The following can be mentioned as examples where activities are more or less constantly ongoing:

9.2.1. Safety policies

Vattenfall AB and E.ON have developed corporate nuclear safety policies. The safety policies are the highest-level documents expressing the most important corporate values, and are valid for all divisions and subsidiaries of each company. The policies contain a basic view on the safety issues and establish ambition levels and priorities, such as:

- Always put safety first,
- Take own safety initiatives,
- Maintain an open dialogue with the regulators and with other companies on safety issues,
- Regard regulations as the minimum standard, and to be met with conservative margins,
- Take an active and leading role in research and development,
- Strive for the continuous improvement of safety.

Vattenfall's and E.ON's policies can be found in Appendix 1.

Implementation of the safety policies is further described in section B 10.2.

9.2.2. Continuous improvements of the plants

The principles used to improve the nuclear power plants are discussed in sections B 6.2 and B 18.2. It is clear from these descriptions that the utilities take substantial initiatives of their own to assess and improve the reactors.

9.2.3. International reviews

International reviews are performed at the initiative of the licensees.

OSART follow-up at Oskarshamn

In March 2009, an OSART review was conducted at OKG. It resulted in 8 recommendations and 9 suggestions. Action plans were developed in order to propose suitable measures.

The OSART team returned to OKG during the autumn of 2010 to perform a follow-up of the review. OKG gave an account of the status of the measures and there was also time for elucidating any misunderstandings. The result was that 9 of the issues found had been resolved and the resolution of 8 issues had reached satisfactory progress.

WANO Peer Review at Oskarshamn

WANO performed a Peer Review at OKG in 2011. It resulted in a number of areas for improvement and proposed measures. These are being dealt with as part of OKG's development programme called the Development Journey, which was initiated in 2012.

OSART review of Ringhals

IAEA has conducted an OSART review of Ringhals. This means that all Swedish reactors have been subject to OSART reviews since February 2008 (Forsmark) and March 2009 (Oskarshamn).

The OSART team concluded that the managers of the Ringhals NPP are committed to improving the operational safety and reliability of their plant. The team found good areas of performance, including the following:

- A comprehensive site commitment to realistic training evidenced by the Testen maintenance training facility, the creation of a practical training facility for radiological protection and the Barsebäck training centre where the workforce have the opportunity to conduct realistic in-plant tasks in a low dose environment.
- The use of in-situ gamma spectrometry to determine the surface activity concentrations of radionuclides on the internal surfaces of plant systems to evaluate the effectiveness of the plant's source term reduction initiatives.
- The reduction of Argon-41 emissions from the plant by using a gas transfer membrane system.
- The close cooperation with local authorities on response to hostile events at the plant.

A number of proposals for improvements in operational safety were offered by the team. These included the following:

- The plant has a self-assessment programme in place to monitor and improve its safety performance. The team determined that this self-assessment programme could be made more effective to ensure that continuous improvement takes place at the plant. This could include more extensive use of performance indicators and the systematic use of other inputs such as audits and previous action plans.
- Management has expectations on operational activities, but they should always be followed-up, particularly regarding the status of systems and equipment, the control of operator aids, housekeeping, reactivity management and the reporting of anomalies.
- The management system for operational experience should include coordinating departmental operational experience to ensure that the process is used consistently and effectively.
- Contamination control measures are in place but these should be enhanced to minimize the potential for spreading radioactive contamination.

The team also determined that there was too much consideration, at times, given to expert judgment and/or individual experience being used at the plant and that this had not been captured in procedures. Good international practice and the IAEA safety standards place a heavy reliance on procedural guidance to ensure that all expert judgment and individual experience is taken into account to ensure a consistent approach to operational safety.

Ringhals' management expressed a determination to address the areas identified for improvement and indicated a willingness to invite a follow-up visit in about eighteen months.

WANO Peer Review at Ringhals

WANO performed a Peer Review at Ringhals in February 2013. The proposed areas of improvement will be handled by Ringhals.

Participation in international reviews

Several Swedish nuclear power plant staff members participate each year in WANO as well as OSART review missions outside of Sweden. Participation as an expert is considered to be of great value to the individuals as well as to their plant organizations.

9.3 Conclusion

As the final stage in a series of OSART review missions (including follow-up) to all Swedish nuclear power plants during the period 2008-2012, an IAEA OSART seminar was held in May 2013. Exchange of experience and discussion of results including measures taken were the main objectives of the seminar and of the participating utilities as well as on the part of SSM and IAEA staff.

Sweden complies with the obligations of Article 9.

10. Article 10: PRIORITY TO SAFETY

Each Contracting Party shall take the appropriate steps to ensure that all organizations engaged in activities directly related to nuclear installations shall establish policies that give due priority to nuclear safety.

Summary of developments since the last national report

Significant developments during the current review period related to article 10 are the following:

- All Swedish plants have acted upon the experience from the Fukushima Daiichi NPP accident.
- All licensees have further developed their performance indicators.
- In December 2012, SSM placed OKG under special supervision in order to more closely monitor the safety situation. OKG has initiated an evaluation of the contributing factors to the highlighted deficiencies and is also currently formulating an action plan in order to address the same deficiencies.

10.1 Regulatory requirements

Policies that give due priority to safety can be understood as normal safety policies and safety strategies but also safety management provisions and tools to manage a nuclear power plant in such a way that safety is prioritized and a good safety culture is created and maintained. A good safety culture that gives safety issues the attention warranted by their significance, is also a prerequisite for a solid implementation of a management system.

A basic requirement in SSMFS 2008:1 (Chapter 2, Section 1) is that radiological accidents shall be prevented through a facility-specific and a fundamental design which shall include multiple barriers as well as a facility-specific system for defence-in-depth.

The general advice on this paragraph summarizes the following priorities in order to develop and maintain an effective defence-in-depth system. This can be interpreted as the key elements of a safety policy to be implemented by an appropriate operating organisation with an effective management system:

- safety takes priority over commercial operations,
- sufficient financial resources are available for implementation of safety measures,
- sufficient adequately trained staff is available,
- conservative criteria are applied in the design and operation of the plant,
- safety is monitored and followed-up, failures and deficiencies are identified in a timely manner and corrected,
- the operating organisation has a strong programme in place to learn from their own and others' mistakes so that safety deficiencies do not recur,
- quality management is applied in all activities,
- possibilities to improve safety are evaluated continuously and implemented appropriately,
- the organisation as a whole is characterized by a good safety culture.

These key points are further included in SSM regulations on safety in nuclear facilities, SSMFS 2008:1 Chapter 2, Sections 7 to 9, as legally binding requirements on safety management aimed at giving safety the right priority:

- The operating organisation shall have the necessary economical and personnel resources and be designed to maintain safety.

- A management system shall be implemented and kept up to date so that requirements on safety are met in all relevant activities.
- There shall be documented safety objectives and safety strategies so that safety is always prioritised.
- Responsibilities, authorities and cooperation shall be defined for staff with tasks of importance for safety.
- Activities shall be planned in such a way that necessary time is allocated for safety measures and safety reviews.
- Safety decisions shall be preceded by sufficient safety investigation and review, for instance an independent safety committee should be used to review issues of principal importance for safety.
- Staff shall be given the working conditions needed to work in a safe manner.
- Relevant operational experience shall be assessed continuously and reported to the relevant staff.
- Safety shall be assessed and followed up on a routine basis, deviations identified and corrective measures taken so that safety is maintained and developed according to the established safety objectives and strategies.

SSMFS 2008:1, Chapter 2, Section 10 requires that the licensee has a living safety programme: After being taken into operation, the safety of a facility shall be analysed continuously and assessed in a systematic manner. Necessary technical and organisational measures that need to be taken as a result of this analysis and assessment shall be included in an established safety programme. This programme shall be evaluated and updated annually and identify priorities and time schedules for measures to be taken.

The continued analysis and assessment should include technical and organisational experience from the plant's own activities as well as from other similar plants, results of relevant R&D-projects and development of safety standards. Organisational experience means for instance, results of MTO analyses, evaluation of organisational changes, evaluation of work conditions and self-assessments of the working climate and safety culture.

10.2 Measures taken by the licence holders

10.2.1. Safety policies

The safety policies (chapter 9 and Appendix 1) issued by Vattenfall AB and E.ON AB express the most important corporate values regarding nuclear safety. They have been interpreted and further developed in the safety policy documents for each nuclear power plant management. The safety policies of the owner companies are reviewed periodically by the respective Safety Councils and the policies of the plant managements are reviewed by external and internal safety audits.

10.2.2. Safety management provisions

All licensees have safety committees in order to review major and principal safety issues and to follow up and assess the safety situation at the plants. E.ON also utilizes the E.ON Safety Council, whose goal is to improve safety and set a common standard for nuclear safety within the E.ON Group. The objectives of the E.ON Safety Council are shown in Appendix 2. Furthermore, local safety review committees are established since many years at plant level to advise on principal safety issues. The structure is comparable to Vattenfall AB.

All licensees have a similar structure in place for safety management and review where the responsibilities and authorities of the different levels of management are clearly defined. The basic principles are the following:

- **Safety management level 1** is represented by the plant manager. Level 1 is responsible for the overall safety review process, and for specific safety issues forwarded to him from lower levels (2 and 3). Level 1 responsibility includes issuing policies, the safety management system and company directives for nuclear safety, as well as sanctioning deviations.
- **Safety management level 2** is represented by the production unit manager, responsible for long-term safety issues, manuals and procedures. Level 2 is also responsible for the unit related safety reviews. Additionally Level 2 has to ensure that the unit safety report (SAR) is up-to-date and reflects sound safety practices. Level 2 shall follow up on deviations, trends and operating experience. Deviations from regulations, company norms and policies should be reported at Level 1. Level 2 shall also sanction routines for the extent of work on safety related equipment, and ensure that documentation fulfils the requirements.
- **Safety management level 3** is represented by the operations department manager and responsible for safe operation within the limits of procedures and technical specifications. Level 3 is also responsible for all work permits on safety related equipment. Safety related deviations should be reported to Level 2.

Independent safety reviews are carried out by the departments of Safety & Compliance. Furthermore, when the plant manager takes decisions on important safety issues, or matters of principal, such as restart of the reactors after an outage, plant modifications in safety equipment etc., the principle is that the manager consults with the company safety review committee.

The management structure also outlines:

- Reporting criteria and requirements
- Criteria for periodical (daily and weekly) operational meetings including criteria for shift change-over
- Issues to be handled within the company safety review committee
- Requirements regarding plant modifications (technical and organisational)

All licensees have safety programmes in place as required by SSM regulations SSMFS 2008:1. The programmes are part of the management system documentation. They contain priorities and time schedules for technical, organisational and administrative measures to be implemented as a result of safety analyses, audits, safety culture surveys and other evaluations done at the plant.

The level of safety in plant operations is monitored in several ways, including the use of performance indicators.

The indicators are classified into four groups: Assessment and Decision Making, Maintenance Process, Plant Modification Process and Safety Culture. The Quality Indicators measure (for instance) backlog, fuel integrity, self-assessment, analysis and follow-up, and compliance to rules. Following the OSART review at FKA in 2008, this set of 21 indicators has been expanded to include more than 60 indicators and the routines for management review of the indicators. The indicators are periodically reviewed (monthly or quarterly) by the management team. Deviation from expected performance is analysed and actions for improvement are decided on by the plant manager.

The OKG performance indicators are currently under development. The structure is based on IAEA TECDOC 1141, "Operational safety performance indicators for nuclear power plants".

This development is taking place to create a structure consisting of different levels. This will create a possibility to monitor the organisation through key performance indicators, which consist of a set of sub-indicators. The number of sub-indicators will increase as complementary actions are performed in order to monitor the organisation in a more efficient manner. WANO indicators will be included in a more clear way, as WANO indicators will be examined through one-year values and will be managed the same way as other indicators.

The results will be trended, analysed and communicated and actions initiated where the goals have not been met. A monthly evaluation is carried out as previously by the OKG upper management. In addition, a yearly meeting is held where results from the indicators and potential actions are reviewed by the OKG upper management. Each quarter, selected indicators, their results and potential corrective actions to improve performance are presented to the OKG board. At OKG, all results are presented on the intranet under the header "Goals and Safety Indicators".

10.2.3. Use of WANO Performance Indicators

All licensees utilize the entire WANO programme of Performance Indicators (PI) including the WANO Indicator Index. This is a weighted index consisting of ten specific indicators. The calculation of the Indicator Index was developed by INPO and is used for evaluation and setting goals for NPPs.

10.2.4. Vattenfall Safety Governance

Vattenfall has over the past year increased its governance and oversight of the nuclear facilities belonging to Vattenfall.

Although the operating licences apply to the respective plants and facilities, Vattenfall has, as their owner, established an ambition to exercise clear governance and to perform oversight. This includes increasing competence and resources on a corporate level.

Reorganization in the beginning of January 2013 focused on gathering all nuclear businesses in one division, thus minimizing decision-making while also forming the basis for closer cooperation.

10.2.5. Safety culture programmes

Maintaining a strong safety culture in the operation of nuclear plants is considered vital by the Swedish utilities and is emphasised in the policies of the different plants and in their strategic plans. Management at all levels, including the managing directors, is involved in activities to enhance the safety culture and to stress the responsibility of all personnel to work actively in maintaining and developing the safety culture standard.

10.2.6. The OKG safety culture programme

A long-term programme, referred to as the "Action Plan for Safety Culture at OKG", was implemented in early 2004. It is carried out by the section "Organisational and Competence Development" (HO) and is organised under the Human Resources Department. An annual follow-up of the action plan and of the work methodology is carried out.

The aim of the general efforts is to enhance the understanding of every individual's possibility to influence safety and to put safety on everyone's personal agenda through safety culture education, workshops and cross-group seminars.

The structure described above has undergone development since 2010. The year 2010 was characterised by planning and implementation of Human Performance Tools. The Human Performance Tools have been an integral part of the safety culture programme at OKG since 2009. Four different education programmes in Human Performance Tools were conducted. Even advanced training programmes in the area were developed and carried out in 2011. The target group for this training was workers and managers in the field. The Human Performance Tools that were focused on were Risk Assessment and Job Analysis, Pre Job Brief and Post Job Debrief. Furthermore, the large and overall safety effort called "The Organization as a Safety Factor" was completed and evaluated. A meta-analysis was conducted during the autumn and the HFS council was reappointed in 2010 after a few years' break. Also, the work with the Safety Culture Ambassadors proceeded as intended.

In 2011 there was a strong focus on managing the results and findings from the meta-analysis of 2010 as well as the development, execution, evaluation and workshops linked to the safety culture survey. Plenty of work was also devoted to coaching managers in the organizations. In summary, all audits and analyses showed that there were significant areas for improvements regarding the application of Human Performance Tools, work which was already in progress since 2010.

In 2012 the priority was further integration of the safety culture programme in the management and the organizations' workflows. The purpose of this focus was to effectively influence the professionalism of the organization. In this work the focus was on selected Human Performance Tools and root cause analysis, but work also began in terms of facilitating the work situation for managers and employees to reinforce a professional behaviour. An example of this work is the Safety Coaching programme, which will be applied to outages at the plant. The work with the Safety Culture Ambassadors also proceeded.

10.2.7. The Ringhals safety culture programme

Ringhals' safety culture work is defined in a three-year programme that is updated annually. The programme contains activities planned for all departments in the organisation.

The update of the programme for 2010–2012 included a new approach by basing it on the principles of the WANO guidelines for a strong safety culture. Assessments in relation to the attributes of the guidelines give an indication of strong areas as well as areas of improvement, thus helping to direct resources for improvements. The data for an assessment comes in the form of analyses, survey results and trending of observations and deviations.

The safety culture programme provides a structured and long-term focus of the improvement work. It is now integrated in the general planning of activities for each department. In order to ensure progress of the programme, each department has a contact person appointed, who is tasked with driving the efforts of the programme within their respective departments, but also participating in further development together with other departments.

10.2.8. The Forsmark safety culture programme

FKA has over the past decade undertaken a series of targeted measures aimed at developing the safety culture within the company. The starting point for more extensive and controlled measures was SSM's decision on special supervision in September 2006 which required establishment of an action plan.

The action plan to comply with SSM's decision has now been completed. Continued development of safety culture is part of the normal routines contained in the management system, driven by the reactor safety programme. The programme is revised annually and approved by the Chief Executive Officer.

Surveys of the safety culture at FKA are performed annually. They include both quantitative and qualitative follow-up. The results are analysed and fed back to the management team for decisions of relevant measures. FKA also performs an annual comprehensive evaluation of the safety culture, which is documented and reported in FKA's safety committee to decide on measures. This evaluation includes a comprehensive assessment of how events in the plants have been handled with respect to conservative decision making, a summary of the most important and frequent feedback from employee dialogues, and a safety culture survey in freeform text, evaluation of trends in indicators, and comments from IAEA/OSART, WANO and SSM reviews/inspections.

10.3 Regulatory control

SSM takes a number of regulatory actions to make sure that licensees give adequate priority to safety. Examples are the following:

- Inspections, most major and minor inspections as described in section B 8.3, are targeted to assess how safety is prioritized. Examples are inspections of the licensee safety programmes, management of organisational changes, management of safety review, management and assessment of incidents (conservative decision making).
- Investigations in connections with events (SSM has a special methodology, RASK, for rapid response inspections) and assessments of event reports (see Chapter 19). Decision making by licensees regarding the operational status of the reactor in connection with events and identified deficiencies have received increased attention over recent years.
- The integrated safety assessments (see section 8.3) provide an updated comprehensive regulatory assessment of the safety of the facility. A meeting between the management of the licensee and SSM is held following each integrated safety assessment.
- Regular top management meetings with the licensees. The Director General of SSM and the department directors meet with the management group of each nuclear power plant and other major facilities at least once a year to discuss current issues and safety priorities. There are also annual meetings with the corporate executives of the utilities.
- SSM follows the licensees work with safety culture issues mainly through minor inspections. The role of SSM in this context is to ensure that the licensees have proactive safety management. SSM expects the licensees to create and maintain a strong safety culture. One important part of this, of great interest for SSM, is that the licensees react in a timely manner to indications of deficiencies in their safety culture. If such deficiencies are not corrected, the ability of the operating organisation to handle difficult situations and maintain safety will deteriorate.

10.3.1. Special supervision of Ringhals

In July 2009, SSM placed Ringhals under special supervision in order to more closely monitor the safety situation on the premises of the licensee. SSM issued a decision including special conditions for the operation of Ringhals. The background of the decision was a number of safety-related events over the course of several years (2005-2009).

SSM has monitored the corrective programme established by Ringhals as a response to SSM's decision. Ringhals has allocated a great deal of resources in order to come to grips with the organizational weaknesses and SSM has observed clearly positive developments at Ringhals over the years, including:

- strengthened leadership,
- continuous monitoring of the safety culture,
- enhanced operational experience activities,
- following documented routines, and
- safety assessment.

SSM still sees a need for improvement in Ringhals' management system.

10.3.2. Special supervision of OKG

In December 2012, SSM placed OKG under special supervision. Part of the background was four scrams at Oskarshamn 1 in two and a half weeks' time in the autumn of 2011, after which SSM conducted a rapid investigation. The findings of SSM's investigation resulted in SSM issuing decisions, for example requiring OKG to investigate and explain why there had been known deficiencies in the prerequisites for, or in, the defence-in-depth. OKG prepared two investigative reports and presented five areas of improvement:

- strategy and prioritization
- plant status needs analysis and needs description
- leadership and management
- organization
- work processes

SSM could not see, based on the documentation presented by OKG, that the licensee had described adequate corrective activities for the identified areas of improvement. A new decision issued by SSM included requiring OKG to prepare a corrective action plan explaining how OKG planned to correct the identified weaknesses. The correction programme report from OKG as a response to the decision was reviewed by SSM and was found to be inadequate due to meagrely described correction activities concerning their purpose, method, goal, expected effect and how the activities were intended to be followed up and evaluated.

In December 2012, SSM issued a decision including special conditions for the operation of OKG. The decision was based on the presented OKG rectification programme and several findings from SSM's regulatory supervision concerning leadership, management and safety assessment and included four items that had to be reported to SSM before 2 August 2013. These items entailed an order to OKG to produce additional information and clarification of the content in their correction programme for each corrective action and the overall programme, including goals, intended effects, timeline and measuring of the effects, and further investigation and comprehensive documentation of the causes of the weaknesses identified. SSM is awaiting the documentation from OKG and intends to monitor the safety situation at OKG more closely.

10.4 Actions to cope with issues revealed by the Fukushima Daiichi NPP event

As mentioned in section A7, as a result of the European stress tests, the Swedish National Action Plan has been prepared in order to cover all the issues identified in the review process on national and European levels. 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. Measures as a response to ENSREG's request are listed in the report. The report is a summary by topics covering all measures that all licensees must respond to:

- Natural hazards
- Design issues
- Severe accidents and recovery
- National organizations
- Emergency preparedness and response and post-accident management (off-site)
- International cooperation

For implementation of all the measures in the areas stated above, the licensees have initiated the projects FOSH (Forsmark), BUSTER (Ringhals) and KENT (Oskarshamn). As required in the national plan, the measures are separated into three implementation horizons: short-term, mid-term and long-term measures depending on the scope and type of action to be taken.

Forsmark

The conclusion of the FOSH project is that listed measures are fulfilled through the following actions:

- Diversified core cooling system
- Mobile auxiliary feed water
- Mobile electrical power

- Mobile air cooling for diesels
- Spent fuel pool: Feed & Boil
- New sensors
- Flooding protection
- Fire diesel automated like Forsmark 3
- Prepared pipe connection for water filling of the containment

Ringhals

The conclusion of the BUSTER project is that listed measures from the ENSREG stress test are fulfilled through the following actions:

- Mobile "FLEX" equipment
- Requalification of buildings within the design basis
- Qualification of the containment beyond design basis
- Enhanced battery capacity
- Enhanced possibilities to charge batteries
- New protections of reactor coolant pump sealing to prevent loss of core cooling. Valid only for PWR.
- Strengthening of control rod housing support structure (PWR)
- Robustness measures for cooling of the spent fuel pool

Oskarshamn

The conclusion of the KENT project is that listed measures are fulfilled through the following actions, where the results of analysis can lead to hardware changes if necessary:

- Seismic analysis of relief pipes between the reactor containment and the scrubber building
- Perform a limited Seismic Margin Assessment with focus on seismic induced fire
- Enhancement of the spent fuel pool cooling
- Conduct analyses of how the fuel oil supply to the diesel generators at Oskarshamn 1 and 2 can be enhanced
- Analysis regarding possibilities for diversified cooling of heat exchanger at Oskarshamn 3
- Installation of an additional direct diesel driven fire water pump to supply Oskarshamn 1 and 2
- Diversified core cooling system
- Installation of a shut-off valve or a check valve in the storm water system at Oskarshamn 3
- Analysis of the plants' capability to cope with ice storms
- Analyses of how extreme weather conditions may affect the accessibility to the plant
- Implementation of automatic connection of the gas turbine backed power supply to Oskarshamn 3
- The stress tests performed proved the robustness of the existing gas turbine generators during various scenarios. In order to maintain this robustness in the future, analyses will be conducted with regard to assessing when it would be suitable to replace the existing gas turbine generators
- Conduct analyses and possible hardware measures needed to prolong the endurance of the battery-backed system if the ordinary system for recharging existing batteries is postulated as malfunctioning
- Oskarshamn 2 and 3: Access to another mobile diesel generator for the mitigating systems

- Analysis of the potential to deal with and limit a potential accumulation of hydrogen gas in the reactor building
- Analysis of any negative effects due to scrubber (MVSS) shared between Oskarshamn 1 and 2
- Implementation of new computer software in order to be able to conduct analyses of various beyond design basis events
- Survey of the emergency preparedness organisation taking into consideration that more than one unit may be affected at the same time
- Establishment of an off-site command centre

10.5 Measures taken by SSM to prioritise safety

One of the basic ideas of SSM's management system is that SSM is to devote its supervisory resources to the most important safety issues. The annual activity-planning process has as its starting point the current regulatory challenges, which are documented, as well as input from SSM's integrated safety assessments and other regulatory processes. The new database for integrated safety assessments (see section 8.3) will also be an important tool to support SSM in prioritizing the forthcoming supervisory activities related to the most important safety issues.

Inspection results, international work and research and other inputs could indicate that SSM needs to devote regulatory resources to specific facilities and safety issues. Furthermore, the general safety regulations (SSMFS 2008:1) allow SSM a flexible approach with regard to the review of modifications to the plants, safety cases and technical specifications. The licensees have to notify SSM of such modifications. SSM has an established procedure with specified criteria to assess the notifications and to decide which are important from a safety point of view (see section 14.3.5). This system allows SSM to concentrate its review resources on the most important safety issues and at the same time retain full insight and control over the measures taken by the licensees.

10.6 Conclusion

Sweden complies with the obligations of Article 10.

11. Article 11: FINANCIAL AND HUMAN RESOURCES

1.	*Each Contracting Party shall take the appropriate steps to ensure that adequate financial resources are available to support the safety of each nuclear installation throughout its life.*
2.	*Each Contracting Party shall take the appropriate steps to ensure that sufficient numbers of qualified staff with appropriate education, training and retraining are available for all safety-related activities in or for each nuclear installation, throughout its life.*

Summary of developments since the last national report

During the current review period, the following developments have been made with regard to the obligations of article 11:

- About 15 billion SEK (1.74 billion EUR) is planned to be invested in Swedish nuclear power plants over the forthcoming years.
- Transfer of competence is still of high priority at all Swedish nuclear power plants.

11.1 Regulatory requirements

In order to obtain a licence in Sweden, large economical resources must be committed in order to manage the far reaching safety obligations required in the Act on Nuclear Activities and SSM regulations. Every presumptive licensee must be assessed in this respect. In addition to this basic requirement, licensees must pay a fee on every produced kWh to a state controlled fund, the Nuclear Waste Fund, according to the Act (2006:647) on Financing of Management of Residual Products from Nuclear Activities. This is to ensure the financing of decommissioning, handling and disposal of spent fuel and nuclear waste, including the research needed for these activities. The amount is calculated based on an operating time of 40 years. In the event of a longer operating time, fees for the handling the additional spent fuel will have to be paid, but all the fixed costs are included in the cost estimate for 40 operating years. In order to account for earlier shut down, the licence holders must also provide financial securities to the Nuclear Waste Fund[16.] Licensees also have to pay regulatory and research fees invoiced by the regulatory body. These fees are determined in Ordinances and are paid to the Government (see also Chapter 8).

Regarding human resources, the SSM general safety regulations (SSMFS 2008:1) are clear about the staffing, competence and training of personnel at the nuclear facilities. The licensee has to ensure that the staff has the competence and suitability needed for all tasks of importance for safety and this has to be documented. Long-term planning is required in order to ensure enough staff with sufficient competence and suitability for the safety related tasks are available. A systematic approach should be used for the definition of competence requirements, planning and evaluation of all safety related training. Annual competence assessments shall be performed. These general requirements apply also to the extent applicable on the use of contractors. It is also a requirement that there is a careful balance between the use of in-house personnel and contractors for safety related tasks. The competence necessary for ordering, managing and evaluation of the results of contracted work should always exist within the organisation of a nuclear installation. For operational staff at the nuclear power plants and research reactors there are more specific regulations (SSMFS 2008:32, see section B 7.2). These regulations also include operations managers and plant managers to the extent the latter are involved in the operational decision-making. Operational staff must be formally authorized by the licensee for the specific position. The authorization is valid for three years under certain conditions.

[16] The average fee for 2010 is 0.010 SEK/kWh. Required financial securities amount to 14 billion SEK.

11.2 Financial resources to support the safety of the nuclear installations

The majority owners of the Swedish nuclear power plants are Vattenfall AB and E.ON Sverige AB, with ownership shares as shown in

Figure 2 Utility and ownership structure

2 of section A 4. As mentioned there, the Swedish state is the sole owner of Vattenfall AB while the largest owner of shares in E.ON Sverige AB is the German utility E.ON AG.

The Vattenfall Group and the E.ON Group are the largest electrical power producers in Sweden. Besides the nuclear power plants they also have substantial assets in hydropower, thermal power, and wind power. Both groups are financially stable and have good financial records. Some key figures from 2012 are given in Table 8.

Utility Group	Earnings MSEK[17]	Total assets MSEK	Electricity sales TWh	Equity/Assets Ratio %	Investments MSEK
Vattenfall	27,747	528,364	178.9	29.4	20,802
E.ON SE	9,269	136,851	45.4	53.1	7,153

Table 8 Financial records of the utility groups in Sweden

All safety investments in the nuclear power plants have so far been financed by corporate funds, as decided by the utility boards, on commercial grounds for the licensees. This means that realistic plans for writing off the investment have to be made. Costs for safety improvements are considered to be an integrated part of the operating costs. A high safety level, demonstrated by a good safety record, is considered an essential component of the total business concept. Extensive investments are now being made in all the Swedish nuclear power plants. In total, about 15 billion SEK is planned to be invested. The priorities are enhancing safety and otherwise modernizing the plants to provide for longer-term operation (50 to 60 years).

11.3 Staffing and training for safety related activities at the nuclear power plants

11.3.1. Staffing situation

The Swedish operating organizations were previously considered to be small when compared with most other nuclear power plants around the world. The low number of staff has to some extent been compensated by the use of a large number of consultants and contractors, among these the original vendors.

A complicating factor in the continued use of consultants is that several with experience from the start of the nuclear programme, have now retired and are no longer available. The number of contractors used during a unit refuelling outage, normally lasting between 2-5 weeks, is as before between 500 and 1000.

The staffing and competence planning at the plants has been reinforced over recent years. The need for high-level competence in specific areas has been identified and competence profiles have been defined for all positions. By comparing these profiles with the available expertise, the need for development and training of employees and for recruiting has been assessed.

The need to "rejuvenate" the nuclear power plant organizations is obvious when considering the average age of the plants, as the average employee working at OKG today is 46 years old. In addition to these figures, about 20 employees per year are due to retire from OKG over the

[17] Before taxes and minority share.

forthcoming years. Of OKG's 900 present employees, the ratio is 80/20 male-female. The situation is comparable to those of Forsmark and Ringhals.

All licensees work actively to transfer knowledge from experienced staff, who will soon retire, to the next generation. The planning builds on mapping of strategic competence needs and individual plans to replace key personnel. Other approaches include trainee programmes and the involvement of young engineers together with highly experienced staff in modernization and development projects as well as in international R&D projects. Current planning at the different sites is described below.

11.3.2. Transferring of competence at OKG

During the past review period, no major changes have been made regarding the procedure for transferring competence at OKG.

The short term objective is still to:

- in every group create a plan for the next five years for transferring of competence, and
- from this plan create individual plans for those who will be leaving the company within the next three years.

In a longer-term perspective:

- to create an environment in day-to-day operations that stimulates transfer of competence.

OKG perform yearly staffing and competence analyses. In the forthcoming years, about 20 employees per year will leave OKG due to retirement. The main objective is to maintain OKG's strategic competencies. Each group leader identifies key competencies that need replacement in the forthcoming ten-year period due to changes in staff. The group leaders assess how vulnerable the organisation is in relation to how many employees possess certain competence, or if the dependency on consultants within a certain field is excessive. OKG also has a "55 plus list" where senior employees are automatically monitored with regard to transferring competence.

The process of transferring competence consists of different steps:

1. mapping the need to transfer competence in order to achieve an updated programme,
2. engage resources, e.g. through recruitment or other personnel, to identify nestors and adepts,
3. produce individual plans,
4. implement the plans, and
5. evaluate/follow up the plans.

11.3.3. Transferring of competence at Ringhals

In the next few years, about 30 employees are expected to retire each year from Ringhals. Strategies to transfer the important competencies are based on an annual competence- and staffing plan, containing future needs and the balance between Ringhals employees and contractors/consultants. The need for competence transfer is an annual process. . "Competence transfer" means an intentional learning with a clear goal in a situation where a person (mentor) with important knowledge retires, resigns or where Ringhals from a vulnerability perspective needs to change a specific skill. The mentor then transfers the competence to one or more persons (adepts) so that the knowledge is left at Ringhals.

The competence and staffing plan is based on an annual inventory regarding what strategic competencies Ringhals needs to fulfil the short- and long-term company goals.

A specific method for competence transfer has been developed during 2009. The method involves the following steps:

Inventory: To annually create an overall list of the persons who may be candidates for skills transfer.

Selecting: To determine which persons' competence should be transferred.

Competence Inventory: To create an understanding of the skills and that each mentor is expected to transfer. And select one or several "adepts" and to assess the need for support from RH to implement all the skill changes.

Training: The purpose of this training is that stakeholders are to have a common understanding of the following areas: what skills transfer is, what each role entails, the areas included in the transfer of skills and the support/assistance that is available.

Competence Shift Plan created: To create a skills transfer plan that describes in detail how the work will be performed in terms of objectives and activities. Find forms for monitoring and starting skills exchange.

Competence Exchange Activities implemented: To implement the planned activities to achieve the set of competence transfer goals.

Monitoring and evaluation conducted: Follow up so that the objectives of competence shift are achieved and to look at experience for further process development.

11.3.4. Transferring of competence at Forsmark

The goal for transferring competence is set in the business plan. To create a positive attitude the Human Resource department and the respective managers have to be engaged and take responsibility for carrying out the action plans.

The process in transferring competence (knowledge, skills and attitude) consist of several steps:

- Whose competence is important to transfer?
  - The identified need of transferring of necessary long-term competence is documented in the annual strategic action plans, following a dialogue between the respective managers and HR people.
- What kind of competence?
  - The chosen individuals work in groups developing the existing task analysis, focusing on specific competencies of each person. In view of explicit and tacit knowledge by for example interviews, observations and verbal records, new information is gathered on performance of the tasks.
- To whom shall the competence be transferred?
  - The results of renewed and deeper competence task analysis are used to complement available work methods for the competence transfer and documentation, e. g. instructions, material for training, work rotation, supervising/guidance, pre-job briefing, and daily working practise. Depending on the level of knowledge and experience recipients/adepts and suitable methods are identified. The measures have to be discussed in the development dialogues and documented in the personal development plans.
- How to transfer competence and by whom?
  - Several methods can be used depending on the recipients/adept and supervisor/guidance. For those employees who shall act as supervisor/guidance the measures have to be discussed in the development dialogues and documented in the personal action plans.

11.3.5. Training of nuclear power plant staff

All licensees have a systematic approach in place for the training of operators. Training programmes are developed based on task analysis and definitions of required competence. A systematic method is also used to define the annual re-training that is required. The training programmes include theoretical courses, on-site training with experienced colleagues and full scope replica simulator training, as well as training performed in a workplace environment.

For control room personnel an internal promotion schedule is applied in which the operators begin as field operators. The qualification time to become a reactor operator is about 5 years, and to become a shift supervisor not less than 7 years.

The mandatory training programmes typically include basic courses in nuclear technology and safety, plant knowledge including systems, processes and dynamics, operational limits and conditions (Tech-Spec), radiation protection, plant organisation and work routines. Operational personnel is given extended courses on systems, processes and dynamics, transients and accident scenarios, operational procedures, emergency operating procedures and Tech-Spec.

The control room operators receive about 10 days annual re-training, partly on a simulator, divided into two periods, one focused on normal operation start up and shut down procedures and one on transients and accidents. All simulator sessions are evaluated systematically.

Competence assessments are performed every year by operations management against specified criteria to check the required competence for the specific position and to define further training needs. Every three years a more extended check is made also with regard to fitness for duty. This extended check is required in order to issue the authorization which is valid for three years. The systematic approach is being extended to maintenance staff and other groups with tasks of importance for safety.

The line managers of the operating organizations are responsible for the training of their staff and for providing the necessary resources. KSU (the Swedish Nuclear Training and Safety Centre) has been contracted by the licensees to carry out most of the operator training and annual re-training. The training and competence follow up systems are audited by the licensees on a regular basis to ensure that they fulfil specifications and requirements. Procedures for plant- and safety documentation modifications ensure that such modifications are introduced into the training programmes. The annual training inventories ensure that domestic and relevant international operational experience is fed into the training programmes.

KSU has significant resources for training and production of training material. In 2012 the company had 285 employees of whom 136 were located at local centres. About 4,900 training-days were provided during 2012 (3,964 in 2009). KSU also has an extensive instructor training programme for its own staff with several qualification levels.

Year	Training Days
2010	4050
2011	4300
2012	4900

Table 9. Training days per year during the current review period

Since 2000 most operator training has been moved from the KSU central facility in Studsvik to the local centres situated near the power plants. Full scale simulators for most operating reactors are now located at these local centres. The old Barsebäck simulator is used for special projects and the general training will also remain in Studsvik. Table 9 provides an overview of the training situation.

Since 2008 KSU also utilizes the decommissioned Barsebäck 1 and 2 power plants for training of maintenance personal in realistic environments. Training is also provided to operational personnel in areas in which a real environment enhances the training but the use of an operating plant would be impossible.

The amount of training has increased significantly over the past few years. This increase has many reasons. Amongst the more important is the increasing number of new staff at the power plants due to the current age distribution and large retirement figures. Another important factor is the intensified modernization work that has also created a demand for training on new equipment.

11.4 Regulatory control

The licensee's compliance with SSM's requirements on competence assurance is satisfactory. The required systematic approach is in place to ensure long term staffing and competence, including health checks, as well as systems for ensuring the competence of consultants and contractors.

However, SSM has over several years observed delays and quality problems in the modernization and power uprate programmes at the nuclear power plants. It is paramount that these problems do not affect radiation safety negatively. SSM is therefore continuing to focus attention on the licensees' systems for ensuring quality of services purchased, e.g., assuring supplier and consultant competence.

Furthermore, SSM has a general concern about the licensees' reliance on contractors and consultants. A large number of contractors might risk the licensees' customer capability for ensuring adequate competence in procurement, management and evaluation of the results of work performed by contractors.

All three licensees have, following internal reviews of contractors, identified and informed SSM about weaknesses in the routines concerning notification about engaging contractors and approval of contractors. The licensees have looked at their routines governing the notifications to ensure compliance with the Act on Nuclear Activities and the regulatory code in the future.

11.5 Situation with regard to the national availability of qualified experts in nuclear safety and radiation protection

In its annual appropriation directions for 2010, SSM was tasked with investigating its own, as well as the national human resources and knowledge management situation within the Authority's areas of responsibility. SSM should specifically report on:

- The present access to expertise and human resources within the Authority's areas of responsibility;
- Predictions of future needs and access to expertise and human resources; and
- An assessment of how nuclear safety and radiation protection could be influenced by these assessments.

SSM presented its report to the Government on 21 February 2011 (SSM2011-741). In summary, SSM's analysis shows that the availability of competence in the nuclear field is satisfactory. However, the generational shift among the staff employed in the nuclear industry might in the future give rise to skill shortages in certain areas. In addition, the application from the industry to replace nuclear reactors with new ones has introduced new challenges, and it is important to closely monitor the developments in this area. However, in the area of radiation protection, the analysis shows some weaknesses in the skills situation, although mainly outside the nuclear field. SSM's conclusion is that no special measures are presently needed in the nuclear field.

11.6 Conclusion

Sweden complies with the obligations of Article 11.

12. Article 12: HUMAN FACTORS

Each Contracting Party shall take the appropriate steps to ensure that the capabilities and limitations of human performance are taken into account throughout the life of a nuclear installation.

Summary of developments since the last national report

During the current review period, the following developments are of relevance with regard to the obligations of article 12:

- All licensees work continuously on development of the safety culture at the plants, as reported in section 10.2.5.
- All licensees have established departments for human and organizational issues.

12.1 Regulatory requirements

Most of the initiatives regarding control room design and evaluation, staff working conditions, safety management and organizational issues, earlier discussed with the utilities, are now included as requirements in the safety regulations (SSMFS 2008:1 and SSMFS 2008:17).

The regulations SSMFS 2008:1 contain extensive requirements related to human factors on:

- the operating organisation, economical and personal resources,
- management system,
- safety objectives and strategies,
- responsibilities and authorities,
- planning of the nuclear activities,
- preparation for safety decisions,
- competence assurance, fitness for duty,
- staff working conditions,
- operational experience feedback,
- monitoring and follow up of safety, and
- design adapted to human capabilities and limitations.

The regulations SSMFS 2008:17 contain more specific requirements on

- design to allow operators sufficient time to understand the situation and take safe actions,
- design of the central control room and the secondary control room/control post,
- evaluation of the control room design as well as verification and validation of new solutions, and
- design requirements to detect and control core instability.

SSM requires that the licensees have adequate staff competent on human factors, to make independent safety reviews (see Chapter 14) of relevant issues. There is no explicit requirement to have staff with behavioural science competence in the line organisation of the operators, but SSM recommends this in order to integrate the MTO perspective early in connection with plant modifications, experience feedback, investigation of events, review of working conditions, assessments of safety culture etc.

12.2 Measures taken by the licence holders

Today the MTO concept has become an established component in the nuclear safety work at all Swedish nuclear power plants, supported by policies, responsibilities and organizational structures which differ between the plants and the different subject areas. Today, all the licensees have MTO specialists with a behavioural science background in their independent safety review functions (see Chapter 14). All the licensees have departments whose work focuses on human and organizational issues. The responsibility for these departments is to gather competence (both technical and behavioural) and to work with MTO issues, experience feedback, safety culture, management development and organizational issues.

Typically, MTO competence is used at the plants for the following activities:

- review of plant modifications, especially control room design issues,
- review of organizational modifications,
- verification and validation of procedures and operational tools,
- event analysis and trending,
- staff training,
- safety culture programmes,
- review and audits of management procedures, and
- specific development and analysis projects.

The Swedish licensees use a specific method for the analysis of human factors events called MTO analysis. The method is based on the Human Performance Enhancement System, originally developed by NASA and later modified by INPO. KSU has adjusted the methodology for application in Sweden, and considerable experience has been gained from the Swedish nuclear power plants.

R&D projects in MTO have been conducted over the years on

- design assessment of control rooms,
- operability verification,
- assessment of plant changes,
- non-destructive testing from a human factors perspective,
- development of methods for human reliability assessments,
- event analysis,
- good practices in the control room,
- evaluation of the control room function during outages,
- team training of control room operators,
- safety climate surveys,
- safety diagnosis of the plant organisation and
- assessment of organizational modifications.

12.2.1. Current projects

Organizational change

All licensees have formal procedures for the assessment and review of organizational changes. These procedures ensure that relevant safety aspects are considered when such changes are notified to SSM and reviewed in the same manner as technical changes.

Safety culture

An overview of the current safety culture programmes at the plants is given in section B10.2. Safety culture questionnaires, with same questions as a basis, are used regularly at all the plants, and are seen and used as an important tool for development of the safety culture together with other activities. A common initiative by the power plants has been taken to improve the questionnaire.

Human performance and Safety Culture

A network for Human performance and Safety Culture (HUSC) involving the power plants in Sweden and Finland, SKB, KSU and Westinghouse is still functional and aims to exchange information and to develop knowledge in the area.

Human factors engineering

All licensees take into account the human factors perspective in plant modifications, which affect the work of operators and other personnel, to ensure that their work performance is not negatively affected. This is done through a number of analyses and by dealing with known issues in the existing configuration. The modifications are ultimately subject to a verification and validation process in order to ensure safe operation. Generally, the human factors engineering process is very similar to the U.S. NRC's Human Factors Engineering Program Review Model, NUREG 0711.

Design

Research on the design of alarm systems is being carried out at the Chalmers University of Technology in Gothenburg. A similar research initiative regarding human factors in the design of control rooms using large screen presentation and alarm reduction is being performed at the IFE Halden research reactor in Norway together with utilities in Sweden and Finland.

12.3 Regulatory control

The MTO section at SSM is completely integrated with the technical sections and participates in inspections, safety reviews and other regulatory activities. Ten professionals, an increase by two persons in recent years, have a behavioural science background and work in the MTO section (recruitment of an additional two persons is currently in progress).

Current issues for the MTO section include inspections and reviews of

- Management systems
- Organisations and organisational change
- Safety culture
- Safety management
- Competence, training, staffing, fitness for duty
- Working conditions for safety
- Plant modernizations, MTO perspective of plant modifications
- Investigation of events

Current regulatory research initiated by the MTO section includes projects on:

- Leadership in safety critical industry
- Permanent changes to the safety culture
- Human capability to deal with unexpected events
- Conditions for sustaining and developing well-functioning event investigation and operational experience programmes

- Characteristics of well-functioning management systems in safety critical industry
- Training of control room operators
- Mental workload

Besides these R&D projects, SSM finances one associate professorship in Man-Technology-Organisation at Stockholm University and several postgraduate studies. For many years now the Authority has also provided support to the Halden Reactor Project.

12.4 Conclusion

Sweden complies with the obligations of Article 12.

13. Article 13: QUALITY ASSURANCE

Each Contracting Party shall take the appropriate steps to ensure that quality assurance programmes are established and implemented with a view to providing confidence that specified requirements for all activities important to nuclear safety are satisfied throughout the life of a nuclear installation

Summary of developments since the last national report

During the current review period, the following developments are of relevance with regard to the obligations of article 13:

- All licensees work continuously on improvements to their management systems.
- Vattenfall have established a peer network at corporate level in order to support further development of its management systems.
- A review programme has been launched at Vattenfall's corporate level in order to help ensure and confirm that the requirements from the owners are adhered to as well as that the right level of governance is in place at both corporate and nuclear power plant level.

13.1 Regulatory requirements

The SSM general safety regulations SSMFS 2008:1, Chapter 2, Section 8 require that nuclear activities with regard to design and construction, operation and decommissioning, shall be managed, controlled, assessed and developed through a management system so designed that requirements on safety will be met. The management system, including the necessary routines and procedures, shall be kept up to date and be documented. This view on quality and safety being integrated with other business concerns into a total integrated management system is in line with the IAEA Safety Requirements on Management Systems, GS-R-3.

It is further required in SSMFS 2008:1 that the application of the management system, its efficiency and effectiveness, shall be audited systematically and periodically by a function having an independent position in relation to the activities being audited. An established audit programme shall exist at the plant.

In the general advice to the regulations it is made clear that the management system should cover all nuclear activities at the plant. Furthermore, it should be clear from the management system how contractors and vendors are to be audited, and how to keep results from these audits up to date.

The internal audit function should have a sufficiently strong and independent position in the organisation and should report to the highest management of the plant. The audits should have continuity and auditors should have good knowledge about activities being audited.

Audit intervals should take into account the importance with respect to safety of the different activities and special needs that can arise. Normally all audit areas should be audited as a minimum every four years.

The auditing activity itself and the management function of the plant should also periodically be audited.

13.2 Measures taken by the licence holders

13.2.1. Current development of management systems

All the licensees have integrated management systems in place and work continuously to improve their systems. Since the fourth national report, no changes in the basic principles have been made to any of the management systems currently in use by the licence holders.

At corporate level at Vattenfall, a peer network consisting of representatives from the licence holder has been set up tasked with supporting further development of integrated management systems at each level. Principles based on IAEA Safety Standard GS-R-3 have been developed that support all management systems to be aligned with this standard. The first chapters to analyse and derive principles from the standard are “General requirements” (2.1 – 2.4) and “Process implementation” (5.1 – 5.10) of the above-mentioned standard.

Management system reviews in compliance with IAEA Safety Standard RS-R-3 are performed by the licence holders in order to ensure the continuing suitability and effectiveness of the management systems in use.

Forsmark:

Continuous improvement of the management system is a priority, including a high level of involvement and commitment from the management team.

Recent examples include clarifying responsibility for the line organisational structure and process governance, clarifying line organization responsibility for implementation of external requirements and reducing the number of functions for internal requirements. Improvement of the routine for monitoring of legal, regulatory and corporate requirements is currently in focus.

Forsmark is in compliance with the current version of GS-R-3. A management system review will commence to identify potential gaps when the new issue of GS-R-3 is published.

The programme for internal audits has been developed in recent years to include audits of processes. Weaknesses in the interface between different organizational units are now more readily identified, thus improving the overall efficiency of the management system. Developing a more effective audit process for outages and occupational hazard issues is a new priority due to the OHSAS 18001 certification.

Ringhals:

The Ringhals Management System, RVS, has been developed continuously over many years now. To meet the increasing complexity of technology and rate of change, Ringhals has decided to increase its speed and ambitions in this development work. One improvement project is currently developing an improved structure and transparency of the management system.

The ambition is for Ringhals to, with a safety margin, fulfil external requirements on management systems, derived from nuclear as well as conventional industry models. More systematic and structured management, steering and development of the business towards set targets should be developed. The goal is a modernized and user-friendly management system with well-adapted structures, an integrated process perspective and clear steering and coordination of business development within the framework of the management system.

Oskarshamn:

Continuous work is in progress at OKG on development and an update of the management system. The steering documents have for instance been developed further with a major focus on clarifying the allocation of responsibility, authorizations and delegations.

All departments and sections also have their own management manuals. Training sessions on the management system and its structure have been held throughout the organisation.

13.2.2. Audit programmes

At Vattenfall's corporate level, a review programme has been launched to help ensure and confirm that the requirements from the owners are adhered to as well as that the right level of governance is in place at both corporate and nuclear power plant level.

All licensees have a process for performing audits and an audit programme, which is used to monitor how well the quality system is implemented at different levels and applied to the organisation, as well as the efficiency of the system to ensure quality and safety. Such quality audits are performed on a regular basis so that all areas are covered over a four-year period. Audit teams consisting of 2-4 individuals, experienced in the review area and an audit team leader, normally perform the audits. The audit programmes in use fulfil the requirements on independent assessment in the IAEA Safety Guide GS-G-3.1.

The staff for performing audits at FKA has been increased from a nominal two persons to a nominal four persons.

Ringhals and Forsmark have introduced different methods for self-assessment. The management system at both plants requires that self-assessments shall be performed at different levels in the organisation. The methodologies for performing self-assessments are based on IAEA Safety Guide GS-G-3.1.

During this review period, changes were implemented within the internal quality audit organisation at OKG. As from 2010 the same audit areas and methods are used as during an OSART review. Established teams review one and the same area for a period of three years and there is also an assigned counterpart for each audit area.

13.2.3. Audits of suppliers

Audits of suppliers have been carried out in terms of long-term cooperation between the Swedish nuclear power plants. There is also a joint group for management and supervision of supplier audits. There is also a shared procedure for executing a supplier audit, which is maintained and developed as a collaborative effort between the Swedish nuclear power plants.

13.3 Measures taken at SSM

See section B 8.5.

13.4 Regulatory control

SSM has reviewed the management systems of all the plants and is of the opinion that they comply with the regulatory requirements. Each year, SSM checks the licensees' work to improve their systems. In addition, SSM meets with each licensee annually to review which internal audits have been carried out and their results. The view of SSM is that the internal audits at all plants are managed and conducted in a satisfactory manner. However, SSM has observed needed improvements at OKG to deal with weaknesses in a systematic approach and management of the audits.

13.5 Conclusion

Sweden complies with the obligations of Article 13.

14. Article 14: ASSESSMENT AND VERIFICATION OF SAFETY

> *Each Contracting Party shall take the appropriate steps to ensure that:*
>
> *(i) Comprehensive and systematic safety assessments are carried out before the construction and commissioning of a nuclear installation and throughout its life. Such assessments shall be well documented, subsequently updated in the light of operating experience and significant new safety information, and reviewed under the authority of the regulatory body.*
>
> *(ii) Verification by analysis, surveillance, testing and inspection is carried out to ensure that the physical state and the operation of a nuclear installation continue to be in accordance with its design, applicable national safety requirements, and operational limits and conditions.*

Summary of developments since the last national report

During the current review period, the following developments have taken place with regard to the obligations of article 14:

- SSM is of the view that safety at Swedish nuclear power plants can be maintained over the long term as well, provided that additional safety improvements are made and that the licensees apply effective ageing management.
- The licensees are still finalizing their work to update the safety analysis reports in order to comply with the requirements of SSMFS 2008:1.

14.1 Regulatory requirements

14.1.1. Safety assessment

Requirements on safety assessment, safety review and reporting are collected in a separate chapter (Chapter 4) of the general safety regulations SSMFS 2008:1. The legally binding requirements are summarized in the following points:

- A comprehensive deterministic safety analysis shall be performed before a facility is constructed and before it is taken into operation. The analysis shall subsequently be kept up-to-date. The analyses shall be based on a systematic inventory of events, event sequences and conditions which can lead to a radiological accident. In addition to the deterministic analysis, the facility shall be analysed using probabilistic methods in order to provide a more complete picture of safety. The regulations' general advice helps to determine the acceptability of using probabilistic arguments when assessing the design and operation of a reactor facility.
- A preliminary safety analysis report shall be prepared before a facility may be constructed. The safety analysis report (SAR) shall be renewed before trial operation and completed before the facility may be taken into routine operation. The SAR shall contain information as specified in the regulations. All stages of the SAR shall be reviewed by the licensee as required, and reviewed and approved by SSM. Thereafter the safety analysis report shall be kept up-to-date.
- The SAR shall reflect the plant as built, analysed and verified and show how the valid safety requirements are met. All plant structures, systems and components of importance for the defence-in-depth shall be described in the SAR, not only the safety systems. New safety standards and practices, which have been assessed by the licensee and found applicable, shall be documented and incorporated into the SAR as soon as the corresponding modifications or other plant measures have been taken.
- After being taken into operation, the safety of a facility shall be analysed continuously and assessed in a systematic manner. Any need for safety improvement measures, engineering as

well as organizational, resulting from such analyses and assessments shall be documented in a safety programme. This programme shall be updated on an annual basis.

- At least once every ten years, an integrated holistic analysis and assessment shall be conducted of the safety of the facility (PSR). The analyses, assessments and measures resulting from these shall be documented and submitted to SSM. This requirement has been stipulated in the Act on Nuclear Activities since 2011. The purpose of a PSR should be to check how the facility complies with the current safety requirements and assess whether it can be operated safely until the next PSR, taking into account developments in science and technology. In the general advice on the periodic safety review, 17 safety areas (see also section B 8.3) are pointed out where the plant must be assessed with regard to current regulations, licensing conditions and applicable safety standards, as well as against applicable new safety standards and practices. Deviations from current requirements must be corrected without delay. Deviations from newer requirements, standards and practices should be assessed with deterministic or probabilistic methods or engineering judgement, with reasonable practicable measures defined and included in the safety programme of the plant. The review methodology used must be specified in the report.

14.1.2. Verification of the physical condition and operation

Sweden has since the beginning of its nuclear programme had specific requirements on surveillance, testing and in-service inspection to ensure that the operation and the material condition of the reactors comply with design requirements and operational limits and conditions.

SSMFS 2008:1, Chapter 5 on operations includes requirements on continuous surveillance, maintenance and testing of structures, systems and components to ensure that they meet the safety requirements. Programmes are required for maintenance, surveillance, inspection and testing as well as for ageing management. The programmes shall be documented and kept up to date. The ageing management programme should include identification, surveillance, handling and documentation of all ageing mechanisms, which could affect structures, systems and components of importance for safety.

Functional testing to verify operability has to be performed periodically as well as before structures, systems, and components are taken in operation after maintenance or other interventions. Programmes for testing active components should reflect consequences for malfunction and the probability of this occurring. The functional testing has to be carried out with the frequency and scope that provide confidence that the equipment will function as credited in the safety analyses. Integral tests of the entire safety function should be performed. If it is not possible to fully verify the safety function by testing, it should be justified that the function can be verified sufficiently despite limitations of the testing.

As mentioned in section B 7.3, specific regulations (SSMFS 2008:13) cover mechanical components. They contain requirements for the use of mechanical equipment, limits and conditions, damage control, accreditation of control organizations and laboratories, requirements on in-service inspection and control, requirements concerning repair, replacement and modification of structures and components, as well as requirements on compliance control and annual reporting to SSM.

14.1.3. Verification of safety decisions

SSMFS 2008:1, Chapter 4, Section 5 stipulates that technical or organizational modifications to a facility which can affect the conditions specified in the safety analysis report, as well as essential modifications to the report shall be subjected to a so-called twofold safety review. Before the modifications may be implemented, SSM shall be notified of the modifications.

Chapter 4, Section 3 specifies the requirements for the safety reviews. The objective is to make sure that all relevant aspects of a safety issue have been taken into account and that all relevant requirements concerning the design, function, organisation and activities of a facility are met. The review shall be carried out systematically and be documented.

The safety review shall be performed in two steps. The first step, the primary review, shall be carried out within those parts of the licensee's organisation which are responsible for the specific issues. The primary safety review should be as complete as possible and not take credit for the outcome of an independent review. The second step, the independent review, shall be carried out by a safety review function, established for this purpose and with an independent position in relation to the organisation responsible for the specific issues. The independent review should not duplicate the primary review but apply another perspective and focus on:

- whether the matter has been handled in a correct manner by the line organisation,
- whether conclusions and proposals have been justified in a professionally correct way,
- whether all relevant safety aspects, including physical protection, have been considered and the relevant safety requirements been met, and
- whether the proposed measures will result in a maintained or increased level of safety.

SSMFS 2008:1 also includes requirements on use of the twofold safety review in other cases than those to be notified to SSM. One example is the review of emergency operating procedures and beyond design basis accident management guidelines.

SSMFS 2008:1 also stipulates (Chapter 2, Section 9, item 4) that decisions on safety issues shall be preceded by sufficient preparation and gathering of advice so that all aspects of the issues are considered. In addition to the twofold safety review, a safety committee should be established to provide advice to the Chief Executive Officer on principal safety issues.

14.1.4. Inquiry into the safety situation during Swedish nuclear power production

The assignment for SSM referred to in sections 7.6 and 8.8 also included conducting an analysis of the Swedish regulatory model in the field of reactor safety.

According to the analysis results, SSM is of the view that safety at Swedish nuclear power plants can be maintained over the long term as well, provided that additional safety improvements are made and that the licensees apply effective ageing management, and that this is examined regularly in PSRs. Furthermore, it is essential that a good safety culture is maintained while also ensuring that other safety-related conditions pertaining to organisations and human resources as well as safety-related administration outside the proposed measures are maintained and developed.

The regulations concerning the design and construction of nuclear power reactors (SSMFS 2008:17) entered into force on 1 January 2005 with transitional action plans which originally covered the period 2005 to 2013. This work proved to be much more complicated and time consuming than was foreseen when the licensees produced their proposals and the action plans were decided. Up until 30 June 2012, altogether for the ten reactors' modernization programmes, approximately 60 per cent of the decided measures had been implemented. For this reason, SSM has intensified its regulatory supervision and follow-ups of licensee work so that remaining measures for fulfilment of the requirements do not take longer than necessary for their safe implementation.

SSM assesses that the measures taken and planned to fulfil the requirements imposed by SSMFS 2008:17 strengthen the protective system of the nuclear power reactors' barriers, mainly through increased redundancy and separation, which is the primary purpose of the regulations. Also, when fully implemented, the measures imply a strengthening of the defence in depth system of all facilities. Another safety-related consequence of these measures, other than the purely physical modifications of the facilities, is the improved level of knowledge about the facilities' characteristics that the analyses vis-à-vis the legal requirements of SSMFS 2008:17 have resulted in among the licensees, as well as the fact that the technical documentation concerning the plants has been improved. These conditions are crucial prerequisites for ensuring safe nuclear power plants.

In an international comparison, it appears as if the Swedish nuclear power plants, with these measures taken and planned, are at the forefront in terms of their scope and, to some extent, their progress as far as concerns safety improvements to ageing reactors. In addition to this, Swedish facilities introduced accident mitigation functions at an early stage.

SSM has however drawn the conclusion that further measures will be needed beyond the scope of the licensees' action plans for fulfilment of the requirements of SSMFS 2008:17. The results of the comprehensive risk and safety assessments due to the Fukushima Daiichi NPP accident (stress tests) also indicate the need for measures in order to strengthen resilience against extreme natural phenomena, a loss of power and a loss of main heat sink. Furthermore, the facilities' emergency preparedness and capability for emergency response management need to be strengthened in various respects (see section A7).

SSM has made the assessment that the nuclear power reactors also need to be provided with systems for independent coolant makeup. This kind of system reduces the risk of core melt and thus also the risk of a melt-through of the reactor pressure vessel in the event of a loss of the ordinary coolant makeup system.

A review of the capability of licensees and the state to protect the facilities against antagonistic threats also indicates that protection against sabotage needs to be strengthened further. Investigations are in progress at SSM to ascertain which additional measures are needed and revisions of the Authority's regulations in the area are under preparation.

Although many systems and components at the facilities have been replaced over the years in connection with safety upgrades, other refurbishing or rebuilding work and repairs, and most critical building structures, systems and components remain in their original design. The licensees' ageing management is for this reason a key area when it comes to safe long-term operation.

The extensive research conducted nationally and internationally over the past 30 years or so has resulted in increased knowledge about the ageing and degradation mechanisms that can give rise to damage at nuclear power plants. Consequently, these mechanisms can be dealt with satisfactorily with the inspection and ageing management programmes applied today. In turn, these programmes should give good potential for safe operation, also in connection with long-term operation. There are, however, a number of areas in which ongoing inspections and analyses, in addition to development of methods and knowledge, are prerequisites so that these programmes can more effectively detect early indications suggesting safety deficiencies due to ageing over extended periods of operation. These programmes also need to be designed so that they as far as possible are capable of detecting completely unknown damage mechanisms and also known damage mechanisms that manifest themselves in unexpected places.

What is crucial as to whether a reactor can be operated further over extended periods with a sustained level of safety is the licensee applying a thorough and effective ageing management programme. In the present analysis of ageing issues in connection with long-term operation, SSM has pointed out a large number of measures that need to be taken prior to adopting a position on such operation.

14.2 Measures taken by the licence holders

14.2.1. Safety analysis reports

Before constructing and commissioning the Swedish nuclear installations, comprehensive and systematic analyses and assessments of safety were performed. The analyses and assessments were documented in a final safety analysis report (FSAR), for each unit and submitted to the regulatory authority for review and approval.

The different units in the Swedish nuclear power programme were built over a time period of about 20 years up to 1985. This period was characterized by extensive development which was reflected in the scope and comprehensiveness of the FSAR documents of the units, from the first rather limited one for Oskarshamn 1, up to the very comprehensive FSARs for Forsmark 3 and Oskarshamn 3.

As a consequence of the temporary shutdown of the five oldest BWR reactors in 1992 and 1993, in order to improve the emergency core cooling systems, the utilities initiated major reassessments of the FSAR. The reassessments started with pilot projects in 1993/94 and were scheduled for completion before 2000. The objectives were:

- to develop complete modern safety analysis reports (SAR) for all units and to verify the basis for the reports,
- to identify and present any deficiencies in safety, so that corrective measures can be taken by the operating organizations, and
- to recommend further measures, taking into account the recent international development in relevant safety requirements and practices.

These projects have been described in earlier national reports. Considerable work has been performed, especially for the older reactors, and it has been necessary to extend the time schedules. The last project ended in 2005.

As a result of more stringent regulations in SSMFS 2008:1 the work to supplement the SARs with additional information has continued. Some additions that recently have been made or are in progress are:

- Information on how the requirements on design and construction in SSMFS 2008:17 are being met.
- Extending of the systems descriptions beyond the safety systems to include other SSCs of importance for the defence-in-depth.

The licensees have nearly completed this work. When the work is complete all nuclear units will have up to date SAR's complying with the Swedish regulations.

Still the SARs will need to be updated continuously over the next years with the plants modifications following from the ongoing modernization and uprating programmes (see sections B 6.2 and B 6.3). SSM requires that for major plant modification projects, such as the modernization and uprating projects, a PSAR is submitted which is then renewed before trial operations and completed before routine operation. This strategy ensures the relevant updating of the SAR documents.

The safety requirements in the SAR are assessed continuously for their applicability, and the licensees have specific procedures in place to evaluate new or revised codes and standards. These procedures include:

- Periodical check-up on the release of new codes and standards
- Assessment of the applicability of international standards and requirements
- Decision on specific application to the plant
- Revision of the requirements in the SAR

As an example, the licensees have norm committees which hold periodical meetings. If it is concluded that the SARs should be updated, the matter is handed over to the department of technology and reactor safety.

14.2.2. Deterministic safety assessments

The safety analyses of the Swedish plants in the FSARs from the beginning were essentially structured according to the US rules. The events to be analysed were divided into different classes depending on the expected frequency and significance (severity) of the event. The highest class contains the DBA, typically a large loss of coolant accident: double ended guillotine break of the largest pipe. The evaluation models were essentially based on 10 CFR 50.46 Appendix K. Design criteria to be fulfilled comprise limited fuel cladding damage and no zirconium-water reaction (maximum cladding temperature 2200 deg. F). Although the DBA did not include core melt, it was postulated that a large part of the fission products would be released to the containment. It was then shown that the containment would contain the radioactive material, so that the radiation dose to the critical group in the environment was acceptably low.

The introduction of the severe accident mitigation requirements in 1986 meant that a new class of accidents, including severe fuel damage (core melt), had to be introduced, and the FSAR analyses needed to be extended to show that the criteria for this case (see section B 18.1) were satisfied.

As a result of the new regulations SSMFS 2008:17, the need for an update and extension of certain analyses was identified and these tasks were included in the reactor specific implementation plans (see section B 6.2). The review and update work necessary consists mainly of a few external events and some beyond design basis events.

14.2.3. Probabilistic safety assessments

Deterministic safety criteria and analysis will continue to serve as the licensing basis for design and construction. Various risk-informed applications are being developed and used as a complementary tool in the safety work at the plants.

The PSA programme was started in the late 1970s with limited assessments of Oskarshamn 1, Forsmark 3 and somewhat later of Ringhals 1. When the PSR programme was initiated in the early 1980s, a basic PSA study (level 1, internal events) had to be included in the first cycle. In the second PSR cycle a more comprehensive PSA was required.

Extensive development of the methods and tools for PSA has been performed over the years. As a result, up-to-date software and considerable expertise is at hand both within the Swedish utilities, the authority and at the consultants/vendors. One item of particular importance is the reliability data base accumulated from operational experience. This data base is available in the so-called reliability handbook (the T-book), which provides specific reliability data of high quality for a large number of components since 1977. Extensive development of CCF data was also performed in the last decade within an OECD project. These dependency data are now in the process of being transferred into the domestic PSA models.

According to the safety regulations SSMFS 2008:1, all Swedish reactors have to be analysed with probabilistic methods to supplement the basic deterministic safety studies. All power reactors have to perform complete level-1 and level-2 PSA studies including all operating modes and all relevant internal and external hazards for the sites. Today, all power reactors have performed level 1 and level 2 studies. The level-1 studies have been updated continuously with regard to plant modifications. Work has been performed to fill gaps in the level-1 studies and to finalize studies for low power operation, area events and external hazards.

The basic PSA studies are expected to be updated every year taking into account the past year's plant modifications which have an impact on the PSA-result. In principle most licensees are moving towards practising a so-called *"Living PSA"*.

PSA results are also used routinely by the licensees to support decisions concerning significant modification of the designs, modification of operations, documentation and assessment of events.

As mentioned in earlier national reports, the numerical PSA figures are not regarded as a definitive and exact value of the actual risk level. There are no requirements related to numerical

PSA results, although the licensees have such safety objectives. The studies should be sufficiently detailed, comprehensive and realistic to identify weaknesses in the designs and to be used to assess plant modifications, modifications of technical specifications and procedures as well as assessment of the risk significance of events.

A large number of safety improvements based on PSA have been implemented over the past years. Generally, they cover measures to protect against CCF, improvement of fire protection, improvement of operator support and improvements in maintenance and testing. Other important safety improvements projects are installations of new surveillance and control (I&C) techniques, due to the aged original analogue technique.

Historically, the PSA results were an important input for the modernization of Oskarshamn 1, which took place some years ago, as well as for Ringhals 1 and Ringhals 2. PSA results have during the current review period been of great importance for the further modernization of Oskarshamn 1 and 3 and the ongoing modernization project for Oskarshamn 2. The PSA tool has also been used in planning measures to be taken to comply with the new construction regulation SSMFS 2008:17. For newer reactor generations, for which deterministic requirements are more feasible to comply with, PSAs have been used less frequently for justification of the planned measures.

14.2.4. PSA methods and data development in Sweden

The Nordic PSA Group (NPSAG) was founded in December 2000 by the nuclear utilities in Finland and Sweden. SSM participates as observer and also contributes to the funding of many of the projects. NPSAG is a common forum for the discussion of issues related PSA of nuclear power plants, with a focus on research and development needs. The group follows and discusses current issues related to PSA both nationally and internationally, as well as PSA activities at the participating utilities. The group initiates and co-ordinates research and development activities and discusses how new knowledge shall be used.

Over the years, international contacts have increased, especially with partners in Europe. This is in line with the group's aim to create a common and lasting basis for the performance of PSA and for risk informed applications of PSA in Europe.

14.2.5. Periodic safety reviews

Periodic safety reviews started in Sweden in the early 1980s as a result of the Three Mile Island accident. The requirements regarding the reviews have developed over the years and are now quite similar to those recommended in the IAEA safety standards. The first and second cycle of PSRs is completed for all reactors and also the third cycle for seven of the reactors.

The licensees are required to submit a PSR of each reactor unit at least every 10 years. The review shall verify that the plant complies with the current safety requirements as well as having the prerequisites for safe operation until the next periodic safety review, taking into account advances in science and technology. The analyses, assessments and proposed measures as a result of the review shall be submitted to SSM.

Starting in 2005 the PSR included 15 defined safety areas as well as an integrated assessment. The areas are the same as those used in the SSM inspection programme (see section B 8.3). From 2009 SSM has included two new areas in the PSR process: *On-site radiation protection* and *Radiation protection of the general public and the environment*. The current status of the programme is shown in Table 10.

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Reactor unit	Expected licensee report completed	SSM review report completed
Oskarshamn 1	2012 (fourth)	2013
Ringhals 2	2014 (fourth)	2015
Oskarshamn 3	2017 (third)	2018
Forsmark 3	2015 (third)	2016
Ringhals 1	2015 (fourth)	2016
Oskarshamn 2	2010 (third)	2014
Forsmark 1 and 2[18]	2018 (fourth)	2019
Ringhals 3 and 4	2018 (fourth)	2019

Table 10 Latest versions of periodic safety reviews

The PSRs are submitted to SSM, who performs a comprehensive review and assessment of the report and its references. The results of the regulatory assessment are reported to the Government.

The licensee must take the initiative to begin a PSR and must inform SSM when the planning starts. A meeting is held with SSM to discuss the proposed scope, contents and methodology of the review. Typically a project is formed to conduct the review, involving 15-20 staff of the operating organisation. One goal is to include a few young engineers in every project in order to transfer knowledge. The total work effort is calculated to be of the order of 8-10 man years.

Aging management is an important issue in the forthcoming PSRs. When performing the fourth PSR of a reactor, the licensee must specifically address the safety issue of long-term operation and demonstrate (through sufficient analyses) that the plant is able to operate safely beyond 40 years of operation.

14.2.6. Safety programmes

All licensees have safety programmes in place as required by SSM regulations SSMFS 2008:1. The programmes are part of the management system documentation. They contain priorities and time schedules for technical, organizational and administrative measures to be implemented as a result of safety analyses, audits, safety culture surveys and other evaluations performed at the plant.

14.2.7. Verification of safety

A number of different verification programmes are used in order to ensure that the physical state and the operation of the nuclear installation continue to be in accordance with its design, safety requirements, and its operational limits and conditions. These programs can be gathered in the groups: surveillance, in-service inspection, preventive maintenance and safety reviews. The programs have been described in earlier national reports. The following are the most important points.

Surveillance

The operational limits and conditions (OLC) are described in the operational limits and conditions document. The document is commented in more detail in Chapter 19. The OLC document also clarifies what types and with what frequency functional tests are to be carried out in order to verify that components and systems are ready for operation. These tests are carried out in accordance with documented procedures and all test results are reviewed and documented.

[18] One common PSR is allowed for twin units if the conditions for safety are the same.

Special attention has been paid to the verification of the operability of safety systems when going from shut-down to a power operating mode, and is ensured today by the use of a large number of parameters, computerised tools and new procedures. However, more can still be done to further improve the verification of safety system operability. The operability is further commented on in Chapter 19.

In-service inspection

In order to document the industry's interpretation of the regulations SSMFS 2008:13, the Swedish nuclear plants have revised their earlier common document serving as an industry standard. This document is divided into general, technical, quality control, and in-service inspection requirements; and has served as support for the development of plant specific documents in these areas.

Organizations required for the qualification of NDT systems and techniques as well as for carrying out and evaluating such inspections have been established in accordance with regulatory requirements.

The regulations require that all safety related components be assigned to specific inspection groups related to their safety significance. The assignment to inspection groups is documented together with relevant information concerning the inspection in question. The assignment is reviewed and approved by the plant organisation. The overall objectives of the total inspection programme and the fulfilment of the requirements of the regulations are also reviewed by a specifically accredited inspection body. The information concerning inspection group assignments and inspection areas is maintained by the plant organisation in a database, and forms the basis for the creation of the inspection programmes to be performed at given inspection times.

The inspection group assignment is reviewed annually, and modified if deemed necessary, depending on plant modifications, damage found in Swedish or foreign power plants, or new relevant research information. The volume of inspections is high, between 1,000 - 5,000 inspections and tests per site are performed every year.

Extensive replacement of piping, found to be sensitive to specific damage mechanisms, has been carried out in power plants. Many of these replacements were carried out to mitigate future damage as knowledge was gained on damage mechanisms. In other cases replacements were carried out when damage occurred.

Preventive maintenance

Maintenance is optimised with regard to the relation between corrective and preventive maintenance. The preventive maintenance implemented at the Swedish nuclear power plants includes predictive (condition-based), periodic and planned maintenance, and serves the purpose of maintaining equipment within its design and operating conditions and extending its life, thereby eliminating, or at least minimizing, the risk for failures that can limit safe and reliable plant operation, or result in forced outages. A well-balanced preventive maintenance programme is based on engineering analysis in which safety as well as economic aspects are considered. The programme is well defined and periodically revised as additional operational experience is gained.

Predictive maintenance results are used to trend and monitor equipment performance so that planned maintenance can be performed prior to equipment failure. Examples include the following:

- Vibration monitoring and diagnostics
- Acoustic analysis
- Lubrication oil and grease analysis
- Non-destructive examination

- Bearing temperature analysis
- Insulation analysis
- Valve diagnostics/Active power measurement

Periodic maintenance consists of activities performed on a routine basis, and may include any combination of external/internal inspection, alignment or calibration, overhaul, and component or equipment replacement. Typically, any deficiencies found by predictive or periodic maintenance are addressed by corrective or planned maintenance.

Planned maintenance includes activities performed prior to equipment failure and is typically carried out during outages, or on spare or redundant equipment that is available during plant operation. The safety regulations SSMFS 2008:1 allow preventive maintenance to be performed during operation, if specific conditions are met. This is specified in the OLCs and lies within the conditions analysed and described in the Safety Analysis Report (SAR).

Optimization is also carried out in order to find the right balance between maintenance and equipment modification.

Modification activities are also carried out as part of the Plant Life Management (PLM) programme, that deals with the life expectancy of components, to fulfil the total plant life expectancy. Various PLM-programmes exist at all the nuclear power plants. They are part of the long-term plans and strategies included in the safety programmes.

14.2.8. Safety reviews

In order to verify that the operation of the nuclear power plant is in accordance with the applicable national safety requirements and standards, different types of safety reviews are performed regularly at the plants. The regulation on nuclear safety, SSMFS 2008:1, requires a dual safety review for all safety related issues at the plant, e.g. operations events, changes in OLCs, plant modifications etc. First, a primary review is carried out by the operations department, which is primarily responsible for reactor safety. If needed, resources from other departments are utilized.

A second, independent, review is then performed by the safety department within the plant organisation, which has not been involved in the preparation or execution of the issues under review. The safety department reports directly to the plant manager. Typically the independent review function consists of 10-15 experienced engineers with competence profiles to cover all forthcoming matters. In very specific cases consultants are used to back up the function. The objective of the secondary review is to assess whether the primary review has included the relevant types of analyses and investigations, and that it is of sufficient quality, rather than to repeat the primary review. The results of the reviews are documented and viewpoints are clearly formulated and documented. The safety department also engages in different forms of continuous observation and following up on the daily operations of the plant. Certain issues, according to the regulations, then require an application or notification to the regulator. Both the primary and the independent reviews are carried out according to written instructions, developed specifically for the purpose.

A third type of review is performed by the safety review committees and councils at different levels of the power plant organization. There are review committees at the operating unit level, and also at the power plant level (see section B 10.2). They are manned by individuals representing different disciplines in order to achieve a broad view of the subjects discussed. The members are appointed on the basis of their personal qualifications and knowledge. On some committees and councils there is also one or more external member. Committees working at the operating unit level deal with daily operational matters of safety, such as event and scram reports, operational experience from other plants, and safety issues linked to OLC and to plant modifications. Committees working on the power plant level focus on issues of principle such as safety policy and strategy, the plants' adherence to the authority regulations, and general reviews of the safety and quality activities.

14.2.9. International reviews

See sections B 9.2 and B 10.2

14.3 Regulatory control

14.3.1. Safety analyses and safety analysis reports

SSM has reviewed updated safety analysis reports as a result of notifications related to the modernization programmes to comply with SSMFS 2008:17 and the PSARs required as part of the application for a power uprate. This review process will continue over the next few years. SSMs review aims to check that the updated SAR complies with the requirements on structure and contents stipulated in SSMFS 2008:1. SSM has noticed visible improvements in the submitted safety documentation, but in some cases SSM is not satisfied with parts of it and has required further efforts. In order to make the expectations more clearly, SSM has issued additional general advice on the requirements in SSMFS 2008:1 concerning the structure and contents of the SAR (see further section B 7.3).

Review of updated PSAs will be a continuous task for SSM. As before, SSM will concentrate its review on the overall quality of the PSA-studies submitted. Some detailed review samples may be taken using consultants, but SSM has no intention to penetrate the studies in detail. So far SSM has been generally satisfied with the studies submitted.

The PSRs are submitted to SSM, which makes a comprehensive review and assessment of the submitted report and its references. This regulatory assessment is submitted to the Government. In its regulatory review, SSM uses all the material available from inspections and assessments of the reactor over the 10 year period. In general, the regulatory reviews of the PSR reports have supported the safety improvement programmes adopted by the licensees. In addition, the regulatory body has typically issued a number of recommendations. However, to date no periodic safety review has resulted in questioning of the operating licence. In the future the PSR will have an important role as the basis for decisions on long-term (extended) operation.

14.3.2. Inspection and testing

The regulation SSMFS 2008:13 specifies requirements for mechanical equipment, including design review, materials, welding, manufacturing supervision, manufacturing inspection, installation and in service inspection. The regulation also requires that an independent, nationally accredited, inspection body reviews the power plant's fulfilment of the regulations. In some cases the regulation requires that the accredited inspection body independently carries out inspections. In addition, for in service inspection, there are independent NDT Qualification bodies, approved by SSM, that qualify NDT systems that are to be used. An overview of the system for in service inspections is given below.

As far as concerns Ringhals, 2-4 quantitative risk-informed models are used to optimize the inspection programmes. In these programmes, probabilistic pipe failure models are combined with consequence evaluations from the PSA to guide inspections of piping components. The rationale for using these models is to perform inspections where it is most justified in terms of the relative risk of core damage or risk of release of fission products. SSM must ensure that the changes in the inspection programmes can be implemented without an increased risk of core damage and releases to the environment. SSM has imposed strict requirements on input data and validation of the models as well as improvement of the models as new information and data become available.

The Forsmark and Oskarshamn power plants use qualitative risk-informed models for in service inspection, which have been developed over a great number of years. These models have also been reviewed and approved by SSM.

SSM has recently inspected the management of in-service-inspection at the plants in connection with broad inspections of safety management at all plants.

14.3.3. Regulatory control of inspection and testing of plant structures, systems and components

The regulation SSMFS 2008:13, sets requirements for certain inspections and inspection intervals of specified components, such as the reactor pressure vessel and its nozzles. In addition to such compulsory inspections, the power plant is required to allocate the mechanical components of the plant to a number of inspection groups. The inspection groups determine the extent of the in-service inspections. The principles and rules for allocating inspection groups have been reviewed and approved by SSM. The inspection programme resulting from the use of the principles shall be reviewed by the accredited inspection body to certify that the program fulfils the regulations and additional SSM decision rulings.

Three inspection groups, A, B and C, are used where A includes components with the highest relative risk and C those with the lowest. The relative risks can be assessed with qualitative or quantitative methods as described above. In inspection groups A and B, the non-destructive inspection systems used shall be qualified by a NDT qualification body to detect, characterize and size any existing defects to the required standard.

As well as the division into inspection groups, mechanical components shall also be divided into five quality classes. The principles for this shall also be approved by SSM. The division into quality classes shall take into account the safety significance of the integrity of the respective mechanical component for safety in all plant states up to, and including, design basis accidents. The quality classes determine the design requirements and the quality assurance measures needed for repairs, replacements and plant modifications.

Hence, the Swedish system builds on the regulator, SSM, setting up a framework (the regulations) including principles, methods and modes for inspections and testing. An accredited inspection body reviews the inspection programmes in detail and issues certificates of compliance with the SSM regulation. A qualification body, approved by SSM, qualifies the non-destructive testing systems used and certifies their suitability for the component and application in question. The inspection companies (laboratories) conducting the inspections must be accredited for the tasks and methods they use with regard to quality system, technical procedures and competence by a national accreditation body. In Sweden, this is the Swedish Board for Accreditation and Conformity Assessment (SWEDAC). SWEDAC makes annual inspections and follow-ups of the accredited inspection bodies. SSM, as the competent authority for nuclear matters, supports SWEDAC in this supervision of the inspection bodies.

14.3.4. Ageing management

As stated in section B 14.1, SSMFS 2008:1 requires an integrated programme for management of degradation due to ageing. The programme needs to include all structures, systems and components of importance for safety. This was a new requirement in the earlier issued regulations in 2004, and licensees were required to submit ageing management programmes to the regulator (SSM) no later than 31 December 2005.

In 2006, the Swedish regulatory body reviewed the submitted programmes and found that amendments and improvements were needed to a varying extent. Some programmes were limited to passive components with long lives. For active components references were made to ordinary inspection, testing and maintenance programmes. This meant that the integrated programmes needed to be supplemented and extended and it was needed to clarify how the existing programmes on surveillance, in-service inspection and testing should be included in the integrated management of ageing at the plants. Therefore, SSM decided that all licensees should have extended and defined the ageing management programmes in more detail by the end of 2008 as well as amending the management systems in order to assure effective and comprehensive ageing management.

In accordance with the authority's decision of 2006, the plants completed their ageing management programmes by the end of 2008. SSM has received the extended programmes for ageing management as well as the updated management systems. In 2012, SSM initiated a more comprehensive and detailed review which will continue for several years to assess the effectiveness of these programmes. Furthermore, the ageing management programmes will be devoted special attention in the periodic safety review for plants planning for long-term operation.

14.3.5. Review of notifications

As mentioned above, the licensees have to notify SSM of all plant and organizational modifications affecting conditions reported in the SAR, as well as modifications to the SAR itself and the OLC. The statement of the independent safety review made by the licensee must be attached to the notification. A standing group of experts (ABG) has been established by SSM in order to make a first assessment of all notifications. The group makes a proposal to the reactor safety management meeting regarding each notification:

- No further action
- To be postponed until the notification meets the expected quality
- The notification should be further reviewed in specified aspects
- The proposed modification shall not be allowed until SSM has reviewed the documentation further

For this first assessment, a set of criteria has been developed on the safety significance of the notification, other relevant circumstances, and the degree of confidence SSM has in the independent safety review process of the licensee. For instance, if a notification has to do with new or complex technology, is of high safety significance or if confidence is low, there is a high probability that a notification will be reviewed further. The department head makes the final decision whether to review or not.

SSM has over ten year experiences from this process. The pre-review of notifications is today a well-functioning routine which works well and meets the expectations of SSM. It is also clear that SSM has the necessary regulatory control of the modifications, without having to review everything in detail and issue approvals. This has enabled SSM to allocate resources to more important safety tasks. The ABG criteria in use sort about 20-25% of all notifications into the recommendation "review to be performed".

In 2010, a total of 146 technical, organisational and documentation change notifications were submitted to SSM from the operating NPP licensees. Forty of these notifications resulted in a review by SSM. The corresponding figures for 2011 are 167 notifications, of which 61 were reviewed further, and the number of notifications in 2012 was 135, of which 54 were reviewed in more detail.

The statistics of recent years can be seen in Table 11 Number of notifications to SSM from the operating nuclear power plant licensees, 2010-2012

11. The table illustrates the review workload of SSM in connection with the modernization projects and power uprating projects of the plants. This situation will continue over the coming years.

Year	Licensee	Number of notifications	Further review
2010	FKA	48	16
	OKG	55	9
	RAB	43	15
2011	FKA	50	17
	OKG	48	8
	RAB	69	33
2012	FKA	43	11
	OKG	49	24
	RAB	43	19

Table 11 Number of notifications to SSM from the operating nuclear power plant licensees, 2010-2012

14.4 Conclusion

Sweden complies with the obligations of Article 14.

15. Article 15: RADIATION PROTECTION

Each Contracting Party shall take the appropriate steps to ensure that in all operational states the radiation exposure to the workers and the public caused by a nuclear installation shall be kept as low as reasonable achievable and that no individual shall be exposed to radiation doses which exceed prescribed national dose limits.

Summary of developments since the last national report

During the current review period, the following developments are of relevance with regard to the obligations of article 15:

- Despite a substantial increase in the work load at the reactor units, the average total collective dose and the individual doses remained relatively stable during the review period. The focus is on work aimed at decreasing high individual doses.
- Radiation protection education and training has been reviewed and strengthened.
- Efforts to reduce releases of radioactive substances to air and water have had effect and the activity amounts, as well as the resulting doses, have decreased. The work is continuing to further decrease the releases of radioactive substances to make them as low as reasonably achievable.

15.1 Regulatory requirements

15.1.1. Occupational radiation protection

The Swedish occupational radiation protection requirements aimed at the nuclear facilities are similar to those of other EU Member States since they follow the binding requirements of the *Council Directive 96/29/Euratom of 13 May 1996, laying down basic safety standards for the health protection of the general public and workers against the dangers of ionising radiation*. The requirements were summarized in the 4th Swedish national report. The principal provisions are found in the regulations SSMFS 2008:24, SSMFS 2008:26, SSMFS 2008:51, and SSMFS 2008:52 which are described in section B 7.3. The most important provisions in the context of the Nuclear Safety Convention are briefly summarized below.

Optimisation

Anyone who conducts a practice with ionising radiation shall ensure that the radiation protection measures are optimised, and that no radiation dose limit is exceeded. The licence-holder shall ensure that documented goals and actions for the optimisation work are established and that the necessary resources are available in order to perform the actions and work towards the established goals.

Dose limits for workers

The limit for a worker regarding effective dose is 50 mSv in a calendar year, with the additional limit that the integrated effective dose over five consecutive years must not exceed 100 mSv. The equivalent dose limit to the lens of the eye and to the skin, hands and feet is 150 mSv and 500 mSv in a year, respectively. Lower limits apply to apprentices, breastfeeding and pregnant women. Fulfilments of the additional requirements ensure that the dose to a foetus does not exceed 1 mSv for the remaining period of a pregnancy. Individual radiation doses are recorded in the national dose register. Dose records are retained until a person has reached the age of 75 or at least until 30 years after one's work with ionising radiation has ceased.

Medical examination

A worker must each year arrange for a new doctor's certificate as proof of that he/she is fit for service.

Supervised and controlled areas

Zoning of the workplace and a division into *supervised* and *controlled areas* is required. Areas shall be marked and radiological information given (dose rates, sources, contamination levels, entrance restrictions, etc.).

If there is a risk that the spread of contamination or the annual effective dose could exceed six mSv, the workplace shall be classified as a controlled area. The access is then more restricted, protective clothing and personal protection equipment could be mandatory, specific information/education is required, and a personal dosimeter shall be worn. Within a controlled area, premises shall be specially marked and admittance restricted (locked with special keys) if the risk of receiving an annual effective dose of more than 50 mSv is non-negligible.

Visitors

Visitors are allowed if guided by designated persons and a strict, pre-arranged visit plan is followed. No high-dose areas may be visited.

Information and education

All personnel, permanent staff and contractors, shall be informed about radiation risks and have proper education prior to work within a controlled area. The training shall be adjusted to the scope and type of the work to be performed and to the existing radiological working environment.

Site-specific instructions, radiation protection manager

The licence holder shall ensure that site-specific instructions for radiation protection are established. The licensee shall also appoint a radiation protection manager. This person shall be approved by SSM as a radiation protection expert and have sufficient competence in matters related to radiation protection to be able to promote active radiation protection work and to check on the implementation of the radiation protection legislation.

Instruments and equipment

All instruments used for radiation protection and the control of radiation doses shall be calibrated and undergo regular functional checks.

Policy in the event of fuel failures

A documented policy with a strategy for avoiding fuel failures and how to manage fuel failures if they occur is mandatory. The aim is to minimize the negative impact of radiation doses to workers and the public.

Reporting

Annual reports describing the radiation protection work, the progress and evaluation of the optimisation work, and experience from the outages are required. In the case of an accident or events that led or could have led to contamination spread or high doses, rapid communication to the regulatory body is required. Various other reports are required. The radiation protection manager keeps track of the timely and accurate reporting.

Clearance of materials, rooms, buildings and land

New regulations have been issued concerning clearance of materials, rooms, buildings and land in practices involving ionising radiation (SSMFS 2011:2). See section B7.3.15.

15.1.2. Environmental radiation protection

The Swedish Radiation Safety Authority's regulations (SSMFS 2008:23) concerning the protection of human health and the environment from discharges of radioactive substances from certain nuclear facilities apply to nuclear power reactors under normal operations as described in section B 7.3. The most important provisions are described below.

Public dose limits, dose constraints and critical group

The effective dose limit for members of the public is 1 mSv per year. A dose constraint for the discharges of radioactive substances to water and air (authorized releases) is 0.1 mSv per year and site. Compliance with the constraint is shown by calculating the dose (using a dose model) to the most exposed individual (critical group). The dose models used are approved by SSM.

The 0.1 mSv dose constraint is compared with the dose resulting from one year's release integrated over a 50 year period. The dose consists of the sum of the effective dose from external exposure and the committed effective dose from internal exposure. If the total dose exceeds 0.01 mSv per year, realistic calculations of the individual radiation doses, using measured dispersion data, food habits etc., shall be made for the most affected area.

Discharge limits

The discharge limit is achieved through the restriction of the radiation dose to the critical group. There are no legal nuclide-specific discharge limits in Sweden.

Optimisation and Best Available Technology

Limitation of releases shall be based on optimisation of radiation protection and with the use of the Best Available Technology (BAT).

Release monitoring

The release of radioactive substances shall be measured. All non-monitored releases shall be investigated and an upper boundary for possible undetectable leakage to air and water from each facility shall be set.

Releases via the main stacks of nuclear power reactors shall be controlled by continuous nuclide-specific measurements of volatile radioactive substances such as noble gases, continuous collection of samples of iodine and particle-bound radioactive substances, as well as measurements of carbon-14 and tritium.

Discharges of radio-nuclides to water shall be controlled through measurements of representative samples from each release pathway. The analyses shall cover nuclide-specific measurements of gamma and alpha-emitting radioactive substances as well as, where relevant, strontium-90 and tritium.

Controls and testing

The function and efficiency of measurement equipment and release limiting systems shall be checked periodically and whenever there are any indications of malfunctions.

Environmental monitoring

Environmental monitoring in the areas surrounding nuclear facilities shall be performed according to monitoring programmes determined by SSM. The programmes specify the type and sampling frequency, sample treatment, radio-nuclides to consider, reporting etc.

Sampling is performed at and outside the facilities. The samples are analysed by the nuclear facilities or by external laboratories which have adequate quality assurance systems. To verify compliance, SSM performs inspections and takes random sub-samples for control measurements at SSM or at other independent laboratories.

Reporting

The nuclear reactor licensees report annually to SSM adopted or planned measures to limit releases of radioactive substances, with the aim of achieving their specified target values. If established reference values are exceeded, the planned measures to achieve the reference values shall be reported.

Releases of radioactive substances to the air and water as well as results from environmental monitoring shall be reported twice a year to SSM. Events that lead to a substantial increase in releases of radioactive substances from a nuclear facility shall be reported to SSM as soon as possible, together with a description of the actions taken to reduce the releases.

15.1.3. New legislative work

In 2009 and 2011 a review of the legislation in the fields of nuclear technology and radiation protection was performed by a chief investigator appointed by the Swedish Government (see section B 7.2). The aim of the inquiry was to study the possibilities for combining the provisions of the Act on Nuclear Activities (1984:3) and the Radiation Protection Act (1988:220) in a single act and also to consider the possibilities for better harmonization with the provisions of the Environmental Code. The Swedish Government is presently evaluating the result of the review.

A revised European Basic Safety Standards Directive, due to be ready in 2013, will also influence the present regulations. One expected change is to harmonize the provisions on annual dose limits so that an effective dose for workers of 20 mSv in a year will be the maximum dose allowed in planned exposure situations, but with possibilities for exemptions. SSM has not noted any obstacles preventing implementation of this lower value.

15.2 Measures taken by the licence holders

The earlier national reports include descriptions of the measures taken by the licensees to comply with the radiation protection regulations. The following sections describe the current situation at the nuclear facilities. The sections chosen are only examples and give no complete picture of the ongoing work.

15.2.1. The organisation of radiation protection at the nuclear power plants

The radiation protection resources are centralised at the Swedish nuclear facilities but normally, some persons are allocated to specific units. The plant operators frequently hire external RP personnel, particularly during outages. The fraction of hired RP personnel can be as high as 70-80%.

The radiation protection responsibilities follow the organisational structure. The RP units are responsible for performing assessments and providing other radiation protection services. Responsibility to follow the instructions rests with the work management. Planning and discharging of resources is carried out within the overall processes for production, refurbishment, outages, project work etc. except for special services (e.g. dosimeter service, whole-body counting, RP instruments, some monitoring & surveillance etc.). Management plans the RP work in conjunction with the overall management of the plant, and in particular in connection with the overall health and safety activities.

15.2.2. Internal procedures for radiation protection

Work is ongoing to harmonize the procedures at a site (and between sites) and to only have unit-specific procedures when necessary. This includes behaviour-related instructions, such as rules for passage of “step overs” and usage of prescribed personal protective equipment (PPE) in controlled areas. Other examples are clearance of materials, radioactive waste handling and release monitoring.

15.2.3. Education

A total review and upgrade of the stipulated radiation protection information, given to all personnel prior to working within a supervised or controlled area, have been carried out. An additional practical part has recently been added to that information where the participants train on, among other things, stepping over shoe benches. A brand new supervisor education programme has been produced in which hands-on radiation protection training is included. The latter RP training is a shortened and simplified version of the in-depth RP training programme provided to all personnel working with matters related to radiation protection.

The specific education of all personnel working with clearance of materials (which includes all RP personnel) was ongoing during the review period. The course on handling of radiation sources has been redone.

15.2.4. Activities to stop spread of contamination

The activities to stop the spread of contamination have been enforced at all the sites. The activities cover individual follow-ups of alarms at the exit gates, changes in work procedures, new possibilities for checks closer to workplaces, new measurement equipment for tools and small items and increased information and education efforts.

15.2.5. System radioactivity measurements

On-line dose rate measurements at several places, primarily in the reactor water cooling and clean-up systems, are carried out in order to follow the changes in dose rates continuously. During outages, complementary measurement campaigns are performed as input for determining additional protective measures during the outage, but also to cover long-term trends in specific measurement programmes.

As a complement to periodic measurements of activity build-up and dose rates in various reactor systems, four of ten operating Swedish reactor units, Ringhals 1 and Oskarshamn 1-3, have on-line nuclide-specific activity measurement systems for assess the activity build-up on system surfaces. The measurements allow the operators to follow the effect of transients in the reactor water due to changes in water chemistry on system surfaces, changes in water flow rates, regeneration of water filters or changes in reactor power levels.

At the Forsmark plant, all the units have on-line off-gas nuclide-specific gamma measurement systems, as a tool for early detection of fuel failures.

15.2.6. Dose reduction and ALARA programmes

The alpha value, used by the Swedish nuclear facilities in the optimisation process, has been 10 million SEK per man-Sievert (10 MSEK/manSv) since 2008. The following are examples of measures taken by the licensees during the review period to reduce the dose rates and the radiation doses at the nuclear power plants:

- Avoid using the cobalt alloy Stellite in replacement of valves.

- Systems decontaminations have been carried out prior to outages at several reactor units during the review period.
- All operators have a fuel failure policy that gives guidance on how to avoid failures and when to stop power production for replacement of failed fuel.
- Foreign material exclusion (FME) programmes decrease the risk of fuel failures and improve the radiological working environment around the lower plenum. All Swedish nuclear power plants provide obligatory information/education on the content and requirements of the FME programmes to all personnel working in controlled areas and to other targeted groups using an interactive web-based program with a final test to check their understanding.
- All plants continue to improve the radiation protection activities by using the principle of optimization of protection in a long term perspective as well as in day-to-day work. In recent years the focus has turned to concentrate more on reducing high individual exposures as a complement to focusing on collective doses.
- The use of PJB (pre-job briefings) and targeted information on protective measures has increased significantly at all plants in the past few years. In addition, the use of PJD (post-job debriefings) is presently increasing.
- At Ringhals 4 fuel decontamination has been performed.

15.2.7. Programmes to reduce the release of radioactive substances

The plans and action programmes to reduce the release of radioactive substances from nuclear power plants to the environment are still ongoing. Some examples of measures implemented are given here.

Ringhals

Ringhals has developed new methods for removing water borne activity and conventional chemicals from different sources.

Installation of a 3000 m^3 storage tank at Ringhals 1 for the re-use of reactor pool water during outages.

The renovation of the Ringhals 1 evaporator has been delayed due to technical problems, but will be taken into operation in 2013.

Programmes for separation and minimization of different types of waste water have been successfully implemented. This has altogether resulted in reduced volumes of waste water as well as reduced activity discharges.

Reduction of the releases to air from Ringhals 1 by minimizing the leakage of air into the turbine.

A new method for leak-testing using ultra sound has been introduced with good results instead of the traditional helium. At Ringhals 2 the membrane filtration system has been permanently installed in the feed water tank system. A new and improved membrane filtration system with even better capacity is under development and is planned to be taken into operation in 2014.

To reduce the releases to air from the PWRs, the main focus has been on delaying the “quick routes” for releases and thereby reducing the short-lived radionuclides.

The total cost for the implementation of the discharge reduction programme at the Ringhals facility during 2005-2012 has been estimated at 20 million euro.

At Ringhals, the dose to the critical group (most exposed individual) is mainly due to C-14 and H-3. The release of other radio-nuclides contributes less than 5% of the total dose.

Oskarshamn

At Oskarshamn 2, HWC chemistry has been used together with an oxygen generator in order to obtain the lowest possible offgas flow. This results in longer decay times for noble gases before their release to the atmosphere.

Installation of cyclone-filtration in the feed water systems at Oskarshamn 2 and 3, in order to mitigate fuel damage, has been done.

Charcoal columns for the reduction of gaseous releases are planned to be installed at Oskarshamn 2 in 2015.

In 2009 Oskarshamn 3 had a long outage due to the uprating from 3300 MWth to 3900 MWth and Oskarshamn 2 changed LP turbines for the upcoming uprating of the unit. These changes have resulted in increased offgas flows. A strategy for handling the increased offgas flows has been formulated.

Installation of in-core filters in Oskarshamn 3 aiming at capturing foreign debris in the reactor core has been done. The filters are of the same size as the fuel assemblies and are placed in the reactor core.

Programmes for reducing and optimising water usage at the fan site, which includes both administrative and technical measures.

Forsmark

At Forsmark the reduction of aerosols is the main focus of the release discharge reduction programme.

The releases of aerosols from the Forsmark facility are, due to the already low contribution from noble gases, the dominating dose contributor to the critical group not taking the contribution from C-14 into account. The aerosol reduction programme has focused on identifying the sources of the aerosols and identifying methods for avoiding or reducing such releases. New methods for cleaning the reactor water basins have been introduced as well as new methods for handling the fuel transport cask.

An example of other measures is filtration of the ventilation air from the reactor hall. Also, mobile fans and filters will be used at certain identified workplaces identified as potential sources of aerosols.

Most of the measures were implemented in 2012, but some will be finalized in the next few years. It is therefore too early to see any trends in the releases of aerosols.

General

All sites have programmes for separation and minimization of different types of waste water. This has altogether resulted in reduced volumes of waste water as well as reduced activity discharges.

Efforts to avoid fuel failures are ongoing and include education and training as well as introducing new techniques to stop foreign debris from entering the reactor systems.

15.2.8. Other events and activities during the review period

Increased difficulties in planning and managing major programmes within time schedules and dose budgets were reported in the fifth Swedish national report. The situation has unfortunately not improved as much as expected during the recent review period and the licensees need to address this issue over the coming years.

The moisture content in the steam to the turbine side at Forsmark 2 was reduced in 2009 when new steam separators were installed. The existing moisture separator reheaters were replaced in preparation for the planned power uprate, an action which has decreases turbine dose rates significantly. The same replacements were done at Forsmark 1 in 2011. Baffles positioned on the steam separators of the reactor tank at Forsmark 3 were introduced during the 2007 outage in order to decrease vibrations. This unfortunately led to an increase in steam moisture and a factor of two higher dose rates on the steamlines.

15.3 Impact of the Swedish nuclear facilities

15.3.1. Worker protection

The work to improve the radiological environment and to optimise the radiation doses at the reactors is described in the plant ALARA programmes. In 2011 the Authority inspected the power plants' work on optimization of radiation protection. The findings were that the integration of optimization of radiation protection in the line organisation could be clearer and this area seems to have improved thereafter.

The amount of work performed at the nuclear facilities has been extensive, especially in 2011. This is a result of planned and ongoing activities involving reactor safety upgrades, refurbishment and power uprates, but also due to unforeseen events. The collective dose at some reactors was unusually high due to extensive planned work activities. Despite this, there was no large increase in the total national collective dose. The average individual dose was marginally affected and the number of high individual doses was kept low.

Figure 5 shows the collective radiation doses at Swedish nuclear power plants during the period 2003 - 2012. As observed, the total collective dose is relatively stable over the last five years with an average of 9.2 ± 1.1 manSv. The average individual dose over the same 5-year period was 1.8 ± 0.1 mSv as can be seen in Figure 6. The average number of persons who received an annual effective dose above 20 mSv was during the same period 0.2 ± 0.2. Table 12 shows some statistics on the last ten years' radiation doses at Swedish NPPs, and in Figure 7, one can see the distribution of the average number of persons in different dose intervals during the period 2008-2012.

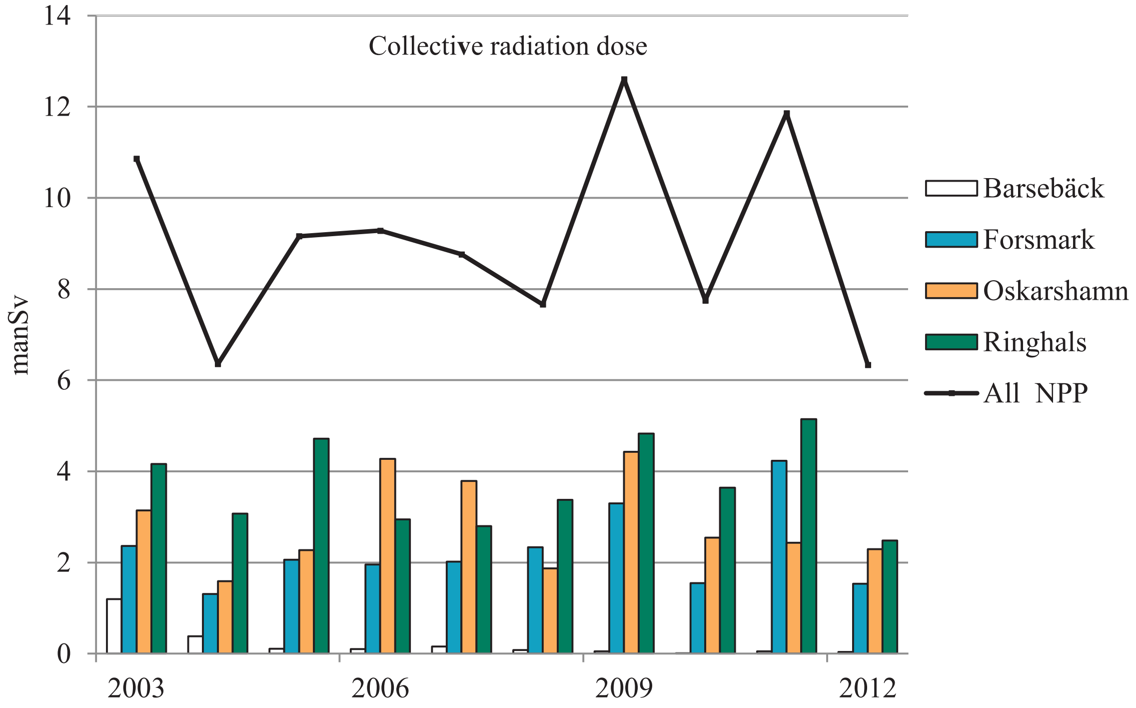

Figure 5 Collective radiation doses at Swedish nuclear power plants during the period 2003-2012. The radiation levels at the nuclear power plants are stable and variation in collective dose reflects the amount of work and work in "high" radiation areas.

The radiation exposure is mainly due to contamination of surface layers by Co-60. However, fairly low radiation levels are achieved as a result of continuous efforts to reduce production and distribution of Co-60 in the reactor systems.

The average number of intakes during the last five years (committed effective dose > 0.25 mSv) is 0.2 ± 0.2 per year. The low number of intakes reflects low contamination levels and effective work procedures.

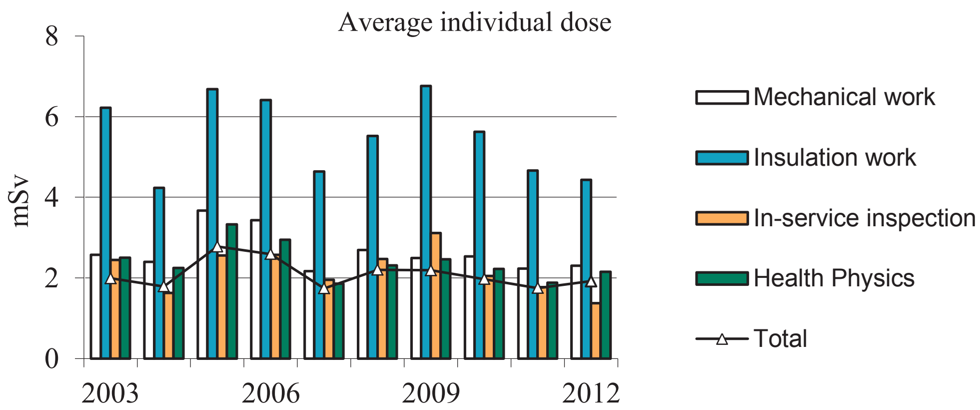

Figure 6 Average individual doses to selected worker categories. Only doses for workers with a registered radiation dose > 0.1 mSv in any monitoring period (≤ 1 month) are used when calculating averages.

Year	Total dose (manSv)	Average dos (mSv)	Highest dose (mSv)	# Persons with a dose > 20 mSv	# Persons with a registered dose (≥ 0.1 mSv)
2003	10.9	2.7	26.7	7	4073
2004	6.4	1.7	19.5	0	3646
2005	9.2	2.2	23.6	3	4159
2006	9.3	2.2	25.0	2	4238
2007	8.8	2.0	19.5	0	4347
2008	7.7	1.8	18.6	0	4294
2009	12.6	2.0	22.8	1	6403
2010	7.8	1.7	16.9	0	4462
2011	11.9	2.0	19.3	0	5838
2012	6.3	1.5	17.5	0	4251

Table 12 Radiation dose statistics for Swedish nuclear power plants over the last ten years

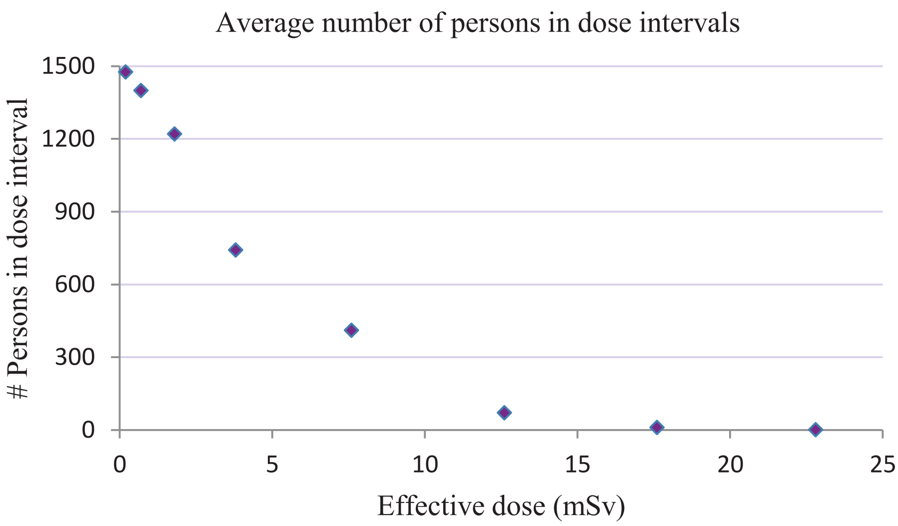

Figure 7 Distribution of average number of persons in each dose interval during the time period 2008-2012

15.3.2. Public doses and releases to the environment

SSM has issued regulations on the limitation of releases of radioactive substances from nuclear installations to the environment. The regulations limit the calculated effective dose to representative individuals in the critical group. There are no formal limitations of releases of specific radio-nuclides. However, all liquid and atmospheric releases of radio-nuclides shall be measured. The dose constraint is 0.1 mSv per year and site and is independent of the number of release points at the site. The calculation of doses includes six different age groups, and the dose limit is applied to the age group that is receiving the highest dose during the year. Figure 8 displays the estimated radiation doses resulting from the discharge of radionuclides during the period 2004-2011 at the Swedish nuclear power plant sites.

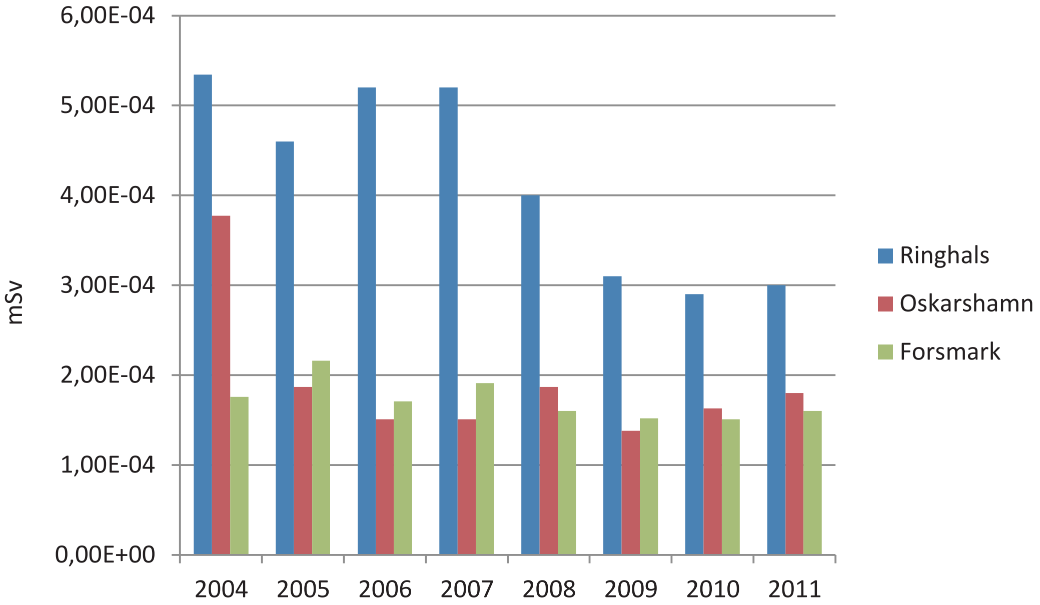

Figure 8 Estimated radiation doses in millisievert (mSv) to the representative individuals of the critical group from releases of radionuclides for the period 2004-2011.

The effort to reduce the releases of radioactive substances, by administrative and technical means, has had effect and the released activity amounts, as well as the resulting doses to the most exposed individuals (< 1 µSv/year and site), have decreased in recent years. The releases to water and air from Swedish reactors are mostly at the same level as the releases from other reactors of the same type and size in other countries. Further actions to reduce the gaseous and liquid effluents are planned.

The concepts *reference values* and *target values* are used for nuclear power reactors as a measure of the application of *Best Available Technique* (BAT) for reducing releases of radionuclides. These values are defined by the licensees and are valuable in reaching the long-term objective of reducing the releases and effluents of radioactive substances. Technical measures to further reduce the releases are planned at the nuclear power plants as an integrated part of the ongoing power uprate projects which may result in an increase of the discharges to the environment.

Figure 9 shows some results from the environmental monitoring programme. A decrease in specific activity has been observed in eels outside the Ringhals facility. The decrease is mostly due to the effects of the Chernobyl accident.

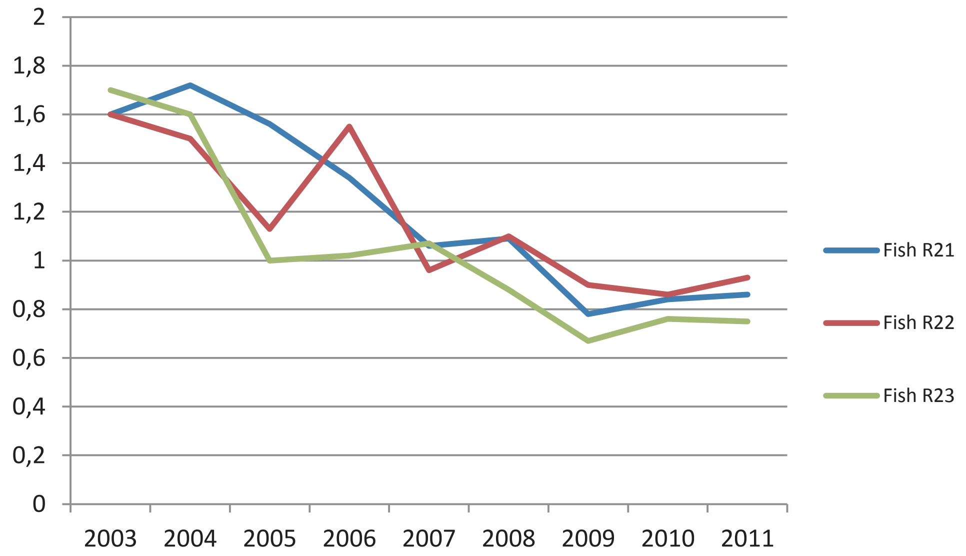

Figure 9 Cs-137 concentrations in eel (Anguilla anguilla) in three sample location in subdivision 12. Radionuclide concentrations are given in Bq kg^{--1} wet wt.

15.4 Regulatory control

SSM inspection activities are described in section 8.3.

15.5 Conclusions

Sweden complies with the obligations of Article 15.

16. Article 16: EMERGENCY PREPAREDNESS

1. *Each Contracting Party shall take the appropriate steps to ensure that there are on-site and off-site emergency plans that are routinely tested for nuclear installations and cover the activities to be carried out in the event of an emergency. For any new nuclear installations, such plans shall be prepared and tested before it commences operation above a low power level agreed by the regulatory body.*
2. *Each Contracting Party shall take the appropriate steps to ensure that, insofar as they are likely to be affected by a radiological emergency, its own population and the competent authorities of the states in the vicinity of the nuclear installation are provided with appropriate information for emergency planning and response.*
3. *Contracting Parties which do not have a nuclear installation on their territory, insofar as they are likely to be affected in the event of a radiological emergency at a nuclear installation in the vicinity, shall take the appropriate steps for the preparation and testing of emergency plans for their territory that cover the activities to be carried out in the event of such an emergency.*

Summary of developments since the last national report

During the current review period, the following developments are of relevance with regard to the obligations of article 16:

- Experiences gained from SSM's supervision and the Fukushima Daiichi NPP accident have led to a revision of the regulations concerning emergency preparedness, SSMFS 2008:15.
- A full-scale exercise focusing on a nuclear power plant accident at OKG, SAMÖ/KKÖ 2011, was conducted between February and April 2011.
- Sweden took part in a joint Nordic and Baltic State exercise in March 2013 in which a nuclear reactor accident was simulated at the Loviisa NPP in Finland.
- The IRRS review in Sweden in 2012 included emergency preparedness and response.
- SSM is developing on-line, real-time access to NPPs' operational and safety parameters, which is scheduled to be completed in 2016.
- SSM is currently extending the national gamma monitoring system for gamma monitoring stations to cover the areas near nuclear facilities.
- 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.
- Predefined criteria on countermeasures and the implementation of measurable operational intervention levels and routines for application of intervention levels have been updated and formalized.
- The use of Rakel, the Swedish national digital radio system for public safety and security, has been consolidated further within the nuclear emergency and response community, including SSM.

16.1 Regulatory requirements

Requirements on on-site emergency activities and plans for the nuclear facilities are included in several legally binding documents:

- The Civil Protection Act (SFS 2003:778) regarding protection against accidents with serious potential consequences for human health and the environment,

- The Civil Protection Ordinance (SFS 2003:789) regarding protection against accidents with serious potential consequences for human health and the environment,
- The Emergency Preparedness and Heightened Alert Ordinance, (2006:942),SSM regulations (SSMFS 2008:1) concerning safety in nuclear facilities, and
- SSM regulations (SSMFS 2008:15) concerning emergency preparedness at certain nuclear facilities.

The overarching objective of the Civil Protection Act (2003:778) is the provision of equal, satisfactory and comprehensive civil protection for the whole country – with consideration given to local conditions – for life, health, property and the environment against all types of incident, accident, emergency, crisis and disaster. The Act requires preventive measures and emergency preparedness to be arranged by the owner or operator of a facility with dangerous activities. The Act further defines the responsibilities for the individual, the local communities, and the state in cases of serious accidents, including radiological accidents. The Act contains provisions as to how the community rescue services shall be organized and operated and also stipulates that a rescue commander with a specified competence, with far-reaching authority, is to be engaged for all rescue operations. According to the Act, the County Administrative Board is responsible for the rescue operations in cases where the public needs protection from a radioactive release from a nuclear installation or in cases where such release seems imminent.

The Civil Protection Ordinance (2003:789) contains general provisions concerning emergency planning and is more specific about reporting obligations, information to the public, and the responsibility of the county authority for planning and implementing public protective measures, contents of the off-site emergency plan, competence requirements on rescue managers and inner emergency planning and monitoring zones around the major nuclear facilities. The County Administrative Board is obliged to make a radiological emergency response plan. The Swedish Civil Contingencies Agency (MSB) is responsible, at the national level, for the coordination and supervision of the preparedness for the rescue services response to a radioactive release. SSM decides on necessary measures for emergency planning at the nuclear installations and supervises the nuclear installations when it comes to these plans.

The Civil Protection Act and Ordinance do not regulate technical infrastructural solutions or time requirements; the Government has thus assigned SSM, through the Nuclear Power Ordinance (1984:14) and the Radiation Protection Ordinance (1988:293), the mandate to issue regulations for the licence holders in the fields of nuclear safety and radiation protection.

The aim of the Emergency Preparedness and Heightened Alert Ordinance (2006:942) is to ensure that governmental authorities at national and regional level, through their work, reduce vulnerabilities in the society and develop a good capacity for handling their tasks during emergencies, crises and during heightened alert. The ordinance demands, among other things, each authority being affected by a crisis, for example radiological release, to carry out necessary measures to manage the consequences of the crisis. In crisis situations the authorities shall cooperate and support each other.

SSM's regulations SSMFS 2008:1 require the licensee, in the event of emergencies, to take prompt actions in order to:

- classify the event according to the alarm criteria,
- alert the facility's emergency preparedness organisation,
- assess the risk for and size of possible releases and time related aspects,
- return the facility to a safe and stable state, and
- inform the responsible authorities.

The actions shall be documented in an emergency preparedness plan which is subject to safety review by the licensee and must be approved by SSM. The plan shall be kept up to date and validated through regular exercises. SSM shall be notified of changes in the plan. The licensee has to assign staff, provide suitable facilities, technical systems, tools and protective equipment needed to solve the emergency preparedness tasks.

The emergency planning should include all design basis accidents, as well as beyond design basis events, including severe events, and combinations of events, such as fire or sabotage in connection with a radiological accident.

The SSM regulations SSMFS 2008:15 on emergency planning and preparedness at nuclear installations have a radiation protection perspective. They are mainly based on the IAEA Safety Standards GS-R-2: *Preparedness and Response for a Nuclear or Radiological Emergency* and include requirements on:

- Emergency planning
- Alarm criteria and alarming
- Emergency rooms/premises/facilities
- Assembly places
- Iodine prophylaxis
- Personal protective equipment
- Evacuation plan
- Training and exercises
- Contacts with SSM
- Radiation monitoring
- Emergency ventilation
- Collection of meteorological data

Depending on which category a facility belongs to (categories I, II or III depending on the radiological hazard potential at the facility), the requirements regarding radiation monitoring, emergency ventilation, and collection of meteorological data differ.

16.2 Measures taken on-site and off-site

The measures taken on-site and off-site in cases of a nuclear emergency in Sweden were described in the earlier national reports and are not repeated here. The following describes the current and up-to-date roles and responsibilities of national Swedish organizations during a nuclear accident.

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 (coupled) large and negative cross-sector or cross-regional economic, environmental or other detrimental societal effects occurs, this will require decisions and actions by the Government.

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

The Crisis Management Coordination Secretariat within Sweden’s central government offices is responsible for policy intelligence and situation reporting, crisis management, crisis communications and analysis and is a central contact point at the government offices. The Secretariat gathers information, assesses a situation and recommends Government actions. The Prime Minister’s Office, with the support of the Crisis Management Coordination Secretariat, must ensure that the necessary cooperation within the central government offices and with the relevant authorities is rapidly established. To facilitate cooperation between all authorities concerned, a crisis management advisory body has been formed within the central government offices. The State Secretary of the Prime Minister chairs the advisory body, which is composed of the National Police Commissioner, the Supreme Commander and the Director Generals of the state utility Svenska Kraftnät (Swedish National Grid), the Swedish Civil Contingencies Agency (MSB), the National Board of Health and Welfare and the Swedish Radiation Safety Authority. The advisory body also has as its members a county governor, representing the county administrative boards, and representatives from the Ministries of the authorities concerned. The State Secretary can also co-opt additional members.

MSB has the responsibility in preparedness work to support the coordination of preparedness measures taken by local, regional and national authorities. MSB also provides communication networks for the competent authorities during extraordinary events. MSB has the overall responsibility for the Swedish national digital communication system ('Rakel') that connects national emergency services and others in the fields of civil protection, public safety and security, emergency medical services and healthcare during emergency situations, and is currently being implemented or already used by municipalities, counties, national agencies and even commercial entities. MSB will also support the Swedish Government Offices by providing documentation and information in the event of serious crises or disasters and providing methods for crisis communication and the coordination of official information to the public.

The Swedish Radiation Safety Authority (SSM) has the responsibility to coordinate the necessary emergency preparedness and response measures for preventing, identifying and detecting nuclear and radiological events that can damage human health or the environment. In the event of an accident involving nuclear technology in Sweden, or outside of Sweden with consequences for Sweden, SSM is the appointed National Competent Authority (NCA) and is responsible for providing advice and recommendations concerning protective measures regarding radiation protection, radiation measurements, clean-up and decontamination following a release of radioactive substances, for maintaining and leading a national organization for measurement and expert support, and for providing advice and recommendations to the public and the public authorities assigned with managing the impact of the event. SSM is also responsible for keeping the Government informed about the situation, developments, expected developments, available resources and taken as well as planned measures, and, following a request by the Crisis Management Coordination Secretariat at the Prime Minister's Office, or by MSB, providing the information needed in order to provide an overall picture of the situation.

A number of authorities, organizations and laboratories will cooperate or operate as supporting functions to the national organizations listed above in the event of a nuclear or radiological emergency. Participating authorities that have cooperating roles for crisis management include, for example, the National Food Administration, which is responsible for taking decisions on action levels for the content of radioactivity in foodstuffs, and the Board of Agriculture, which is responsible for taking decisions on action levels regarding agricultural practices and products. Other authorities that have responsibilities during crises and that cooperate with or receive advice and recommendations from SSM include the County Administrative Boards, MSB, the Swedish Board of Health and Welfare, Swedish Customs, the Swedish Meteorological and Hydrological Institute, Swedish National Police Board, Swedish Coast Guard and the local rescue leader, police and medical personnel.

The Swedish Meteorological and Hydrological Institute (SMHI) assists SSM by providing weather forecasts, weather data and some dispersion calculations in the event of a radiological or nuclear emergency.

In an international context, and in regards to the Community arrangement on early exchange of information, it is SSM's responsibility as both an EU- and IAEA-designated Competent Authority, to promptly inform the European Commission, neighbouring countries that might be affected and the IAEA in accordance with the IAEA's Conventions on assistance and early warning and the European Commission's Convention on early warning. Furthermore, SSM is also responsible for continuously providing information on the measures that Sweden intends to take due to an emergency situation.

In the event of an emergency at a Swedish nuclear power plant or other nuclear facility, the licensee is responsible for immediately contacting the national alarm centre (SOS Alarm), which will in turn alert the authorities and organizations responsible for handling the situation, see Figure 10. In the event of a radiological or nuclear emergency abroad (with a possible request for assistance), the alarm will go to the Swedish Meteorological and Hydrological Institute (SMHI), which is the national contact point (National Warning Point, NWP).

The next step in the alarm process is contacting the officers on duty at SSM and MSB. SSM initiates the following step in the alarm process through automated contact with other officers on duty at designated central and regional authorities and Government ministry offices. Central and regional authorities with roles and responsibilities in the acute phase of a nuclear accident or event are required by an ordinance and a Government decision to have an officer on duty (SFS 2006:942, Ordinance on Emergency Preparedness and Heightened State of Alert). Although Government ministry offices are not covered by this Ordinance, the ministries in charge of authorities having responsibilities relevant for crisis management maintain their own officer on duty.

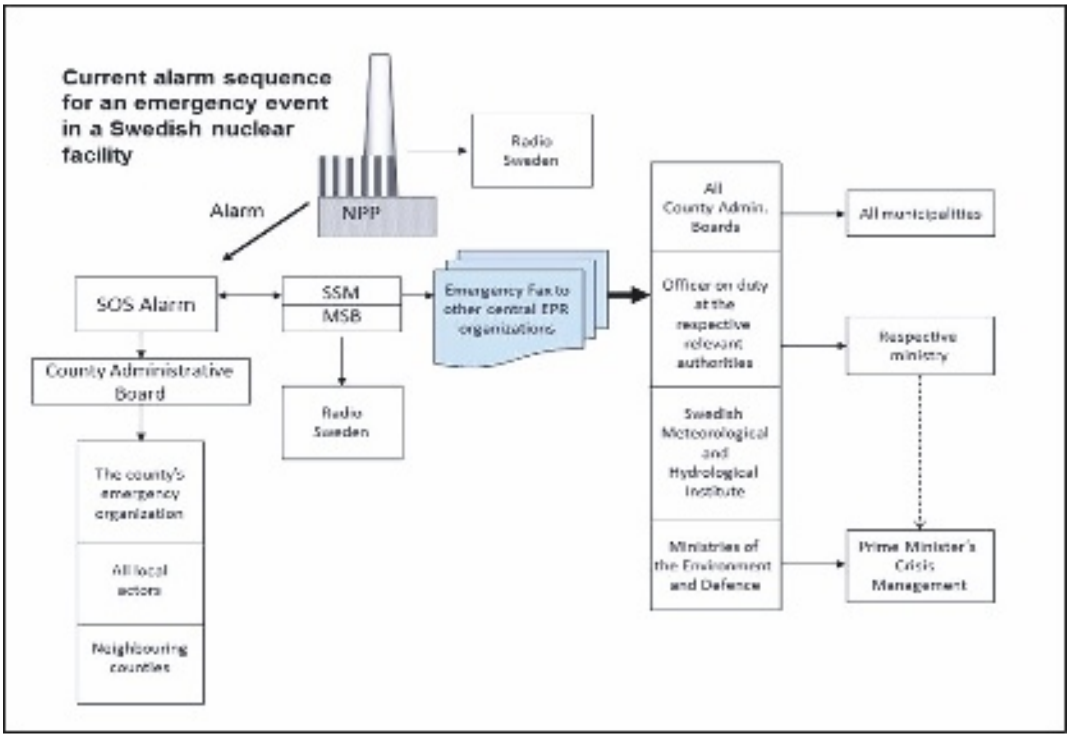

Figure 10 Current alarm sequence for an emergency event at a Swedish nuclear facility.

The responsibilities for security and safeguards at a national level of authority are shared between the Swedish Radiation Safety Authority, the Swedish Defence Research Agency (FOI) and the Swedish Agency for Non-Proliferation and Export Controls (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.

16.3 National monitoring

Authorities, organizations and laboratories that comprise the national expert response organization and, among other duties, participate in radiological monitoring and measurements following nuclear and radiological emergencies, are shown in Figure 11 with a summary of the contracted responsibilities covering fixed laboratory measurements, field and airborne mobile measurements and weather and plume dispersion prognoses. In addition to the tasks shown in Figure 11, the laboratories are also contracted for providing expert advice.

Figure 11 National expert response organization for nuclear and radiological emergencies

Also, the Swedish Armed Forces and a number of voluntary organizations such as the Women's Voluntary Defence Service, the Women's Motor Transport Corps and the Women's Auxiliary Veterinary Corps, are prepared to provide assistance in the event of a radiological emergency. The Swedish Armed Forces have a deployable laboratory for radiological analysis which frequently takes part in exercises. One area of assistance that the voluntary organizations are extensively trained and organized for is the rapid collection of agricultural field samples for transport to the national laboratory network for measurement. This will allow for early decision-making on agricultural countermeasures.

Sweden has acquired a new, modern gamma monitoring network which presently has 28 permanent stations spread around the country designed to provide warning and rapid information on radiation levels. Each gamma station records the radiation level continually and if the integrated 24-h radiation dose differs from the previous 24-h period value by more than 10 per cent, the radiation protection officer on duty at SSM will be alerted. The alarm level can be changed according to prevailing conditions. There is also a fixed alarm level that is currently set at 300 nanosieverts per hour (300 nSv/h). Sweden also has six sensitive and permanent air filter stations which sample the air continuously and can reveal the type of plant from which radioactive releases originate. The system is sensitive enough to measure activity levels in the order of tens of microBq/m^3 (corresponding to approx. 100 atoms per cubic meter) and is therefore also used for environmental monitoring.

The gamma monitoring system is supplemented by radiation level data collected by the environmental and health care offices of the local authorities at permanent measurement points every seventh month in the municipalities, providing a background measurement base. The results of the measurements after deposition can be compared with these reference measurements which have been registered at 2 – 4 measurement points in each municipality. These data are collected from the municipalities by the county administrative board which compiles and transmits the readings to a national database.

The Geological Survey of Sweden and the county police force are contracted for the use of aircraft and helicopters for airborne measurements of radiation. More detailed measurements are made to serve as a basis for decisions concerning, for example, declaring pasture land free of contamination for grazing.

16.4 Medical emergency preparedness

The county administrative board is responsible for medical disaster preparedness. Injured persons are cared and treated through qualified medical care in the injury area, or in hospitals or at medical health centres.

At the major national hospitals, such as Karolinska hospital in Stockholm, more advanced treatment and care can be arranged. Cooperation and sharing of resources also take place between European hospitals in the event of major accidents.

The Nuclear Medical Expert Group (N-MEG), appointed by the Swedish National Board of Health and Welfare, has an on-call operation and is available for giving advice, even in connection with minor incidents. Medical doctors from the medical fields of haematology, oncology, radiology, and catastrophe medicine are represented in N-MEG. In the event of a major accident, relevant members of the group can be summoned to the national emergency centre located at SSM and are provided with information on radiation levels, meteorological conditions, etc. Using the information available, N-MEG performs a medical risk assessment and delivers the information and suggestions for measures primarily directed to the medical doctor in charge at the county administrative board’s rescue work management group. N-MEG advises and informs the treating medical doctors and the medical care centres in the county.

To facilitate medical emergency preparedness in Sweden, the National Board of Health and Welfare has established the Centre for Radiation Medicine, located at the Karolinska Institute in Stockholm. The tasks of the Centre include contributing through healthcare information, education and advice and conducting research activities in areas related to medical effects of ionising radiation. Close collaboration has been established with SSM and various other national and international bodies.

16.5 Exercises

A number of emergency preparedness exercises of varying scope are conducted annually in Sweden. These vary in complexity from simple tests of alarm systems to full-scale exercises. Periodical tests of the alert systems between the power plants and the authorities involved are performed each year.

The County Administrative Boards in the counties with nuclear power plants conduct, at intervals of a few years, a full-scale exercise to check the plans and the capabilities of the on-site and off-site organizations. The full-scale exercises are designed to enable evaluation of command at the regional level, national inter-agency cooperation and public information. The full-scale exercises are often also used for testing international communications.

A full-scale exercise focusing on a nuclear power plant accident, SAMÖ/KKÖ 2011, was conducted in Sweden between February and April 2011 after a nearly two-year planning phase. Consequently, this exercise cannot be recognized as having been planned as a result of the lessons learned from the nuclear accident at the Fukushima Daiichi NPP, since the acute phase of the accident was carried out in February 2011. However, it was carried out in three stages, ending in April 2011. Lessons learned from handling the Fukushima Daiichi NPP accident were included in the later stages of the exercise, especially the final seminar held in April 2011.

The exercise involved all levels of society for the management of both the short-term and long-term consequences. The goal of the exercise was to evaluate whether the organizations participating in the exercise had the capability to, both separately and in cooperation, handle the consequences of an accident from both a strategic and an operative perspective with the aim of maintaining and restoring functions important to society. Many organizations, including both national and international organizations, authorities and licensees, observed or participated in the exercise. MSB and the County Administrative Board in Kalmar County were in charge of managing the exercise and, as the affected nuclear site, the Oskarshamn (OKG) NPP's emergency organization had an important role. The national emergency preparedness exercise that was implemented from the point of view of an accident at OKG showed that OKG's organization and activity functioned well. All actions performed by other participants lay outside OKG's jurisdiction. The cooperation was well established and well trained. In summary, the evaluation of the exercise showed that the overall goals of the exercise were met.

OKG's entire emergency preparedness organization participated. The needs identified by OKG included evaluating whether the alternative command centre should be placed outside the OKG site in order to avoid access difficulties. Other identified needs concerned evaluation of additional technical equipment such as Rakel units, possible satellite telephones and other equipment for internal needs.

The exercise SAMÖ/KKÖ was started about one month before the Fukushima Daiichi NPP accident and the scenario in the exercise was by coincidence very similar to the event at Fukushima Daiichi, simulating a core melt penetrating the reactor pressure vessel followed by radiological releases to the surroundings. The results from SAMÖ/KKÖ basically demonstrate the same needs as shown later in connection with the stress tests.

In addition, a number of more limited on-site functional exercises are conducted at all the Swedish plants every year. Specific plans exist for these exercises. Exercised functions are for instance accident management, communication within the emergency preparedness organisation, environmental monitoring and sampling, assessment of core damage and source terms and assessment of total environmental consequences of a scenario. The rescue forces are exercised regularly, as well as first aid and emergency maintenance. One or several off-site organizations normally participate in these exercises. SSM frequently participates in such exercises both as an observer, in its supervisory role, or to exercise the Authority's own emergency staff.

During recent years, other exercise scenarios have included physical protection events such as sabotage, armed intrusion and the taking of hostages in order to exercise coordination between the special police forces and other actors.

Sweden also participates in regional exercises to test capabilities for handling a nuclear power plant accident outside of Sweden, but near enough to test the emergency plans for an accident abroad having direct consequences for Sweden. During a joint Nordic and Baltic State exercise in March 2013, a nuclear reactor accident was simulated at Loviisa, a Finnish reactor, giving Sweden the opportunity to exercise an accident in a bordering country with possibly direct consequences for Sweden. The responsibilities of national and regional authorities were tested as well as communication routines between the Nordic countries. The results of this exercise are currently being analysed.

Sweden has a long tradition of participating in international emergency preparedness exercises. This allows for testing of aspects related to bilateral and international agreements on early notification and information exchange. Sweden participates regularly in the IAEA Convention Exercises (CONVEX) and the OECD/NEA International Nuclear Emergency Exercises (INEX) and the yearly EU ECURIE exercises. Another example is the cooperation between the Nordic countries established in 1993, Nordic Emergency Preparedness (NEP). This cooperation includes emergency planning, experience and information exchange and joint exercises. Within the framework of this cooperation Finland and Sweden strive to participate in at least one of each other's exercises each year.

16.6 Measures taken to inform neighbouring States

Sweden has ratified the International Convention on Early Notification and the Convention on Assistance in the Case of a Nuclear Accident. An official national point of contact has been established that is available around the clock. Sweden has registered field and laboratory resources with the international assistance programme RANET, managed by the IAEA, under the Convention on Assistance in the Case of a Nuclear Accident.

Sweden has bilateral agreements with Denmark, Norway, Finland, Germany, Ukraine and Russia regarding early notification and exchange of information in the event of an incident or accident at a Swedish nuclear power plant or abroad. An agreement at regulatory body level has also been signed with Lithuania. Sweden uses the ECURIE information system for information exchange within the European Union and the ENAC/Emercon system for notification and information exchange between the IAEA member states.

The five Nordic countries of Denmark, Finland, Iceland, Norway and Sweden have compiled a Nordic Manual describing communication and information routines between the countries for an extensive list of scenarios and which has been agreed upon by these five countries. Communication exercises are performed five times per year by these countries.

16.7 Nuclear accidents abroad

As demonstrated by the effects on Sweden from the Chernobyl accident of 1986, Sweden can be affected by radiological consequences from a nuclear accident abroad. Although the foreseeable consequences are such that the use of iodine tablets, sheltering or relocation of people due to fallout is not likely, the impact on agriculture, animal breeding, forestry, hunting, recreation and private household activities (fishing, picking mushrooms, game hunting, vegetable gardening, etc.) and on the environment can be substantial due to the uptake and concentration of radioactive substances in plants, animals and human food chains.

The responsibility of SSM and other authorities to distribute information is strengthened in this situation. The local county administrative boards that are affected still have the responsibility to inform and take any protective action in their region according to the above-mentioned legislation. During the Fukushima Daiichi NPP accident, where no direct impact on Sweden took place, SSM and other central authorities such as the National Board of Health and Welfare and MSB were responsible for providing information on the consequences of the event.

Emergency preparedness and crisis management on a national level involves a number of national organizations and authorities as well as the Government. During the nuclear accident at the Fukushima Daiichi NPP, many national organizations were activated and the Swedish Radiation Safety Authority had its crisis organization activated around the clock during the period 11-31 March 2011 in the Emergency Response Centre located in 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, the Ministry for Foreign Affairs, the Ministry of the Environment and the Swedish Defence Research Agency (FOI). The activities throughout this period 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 Swedish Defence Research Agency (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.

The nuclear accident at the Fukushima Daiichi 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 Daiichi NPP accident were incorporated in the committee's inquiry. The results of the inquiry were delivered to the Government on 27 April 2012.

16.8 New developments in emergency preparedness

Experiences gained from SSM's supervision of emergency preparedness at certain nuclear facilities as well as experience gained from the Fukushima Daiichi NPP accident have led to a need for revision of the Swedish regulation SSMFS 2008:15, the Swedish Radiation Safety Authority's Regulations concerning Emergency Preparedness at Certain Nuclear Facilities. Specifically with regards to experiences gained from the Fukushima Daiichi NPP accident, the proposed revised regulation should make clearer and more stringent demands regarding radiation protection of personnel and the communications infrastructure at a nuclear power plant. Furthermore the revised regulation makes specific demands regarding more stringent requirements for the licensee to be able to deal with the consequences and the evolution of those events that are used as the basis for emergency planning, for example with respect to initial response time, staffing, endurance, equipment and facilities. The emergency planning at each site shall be formulated to be able to deal with an emergency over a period of at least two weeks. There shall also be logistical centres outside of the power plant grounds to act as a collection point for incoming equipment to the site. There are also 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 a more stringent requirement on having an alternative command and control centre not located near the power plant and having alternative communications possibilities.

At the request of the Government of Sweden, an international team of senior safety experts met with representatives of the Swedish Radiation Safety Authority (SSM) between 6 and 17 February 2012 to conduct an Integrated Regulatory Review Service (IRRS) mission. The mission took place at the headquarters of SSM in Stockholm. The IRRS review team carried out the review in several areas including emergency preparedness and response. The conclusions of the mission relevant for emergency preparedness included the following recommendation from the IRRS team. Action on this area at Swedish government level is pending.

IRRS Recommendation: The Government should consider establishing a government level coordination body (committee, board, etc.) that would be responsible for the coordination of the national efforts to cope with the longer term consequences of a severe emergency. A national radiation emergency response plan, which would describe the responsibilities and concepts of operation of this governmental body and the other response organizations, should also be drafted.

The IRRS team also suggested that SSM should consider developing on-line, real-time access to NPPs' operational and safety parameters. SSM is responsible for providing the County Administrative Boards with recommendations concerning the protection of people and the environment in the event of a nuclear accident. In an emergency situation, SSM requires credible and accurate information from the licensee in order to produce a well-founded recommendation. Information necessary for assessing source term and plant status is especially important. However, the plant parameters that would provide the basis for the thorough assessment of the situation and the predictable accident progression and radionuclide release are not available on-line in the Emergency Response Centre of SSM. Presently, such information is sent manually by the licensee to SSM via open fax lines using an existing paper template. In an emergency situation, the pressure and stress on personnel can be overwhelming. Hence, a project enabling automatic electronic transmission of relevant site parameters via a secure transmission line from each nuclear reactor to the regulator was initiated in 2012. By 2016, when the project is finished, the incoming parameters will be analysed by software to give a better estimate of the source term. It will also be possible for the plant status to be visualized and monitored in real time, hopefully allowing SSM to better assess the whole scope of the situation during an ongoing accident.

Monitoring of gamma radiation in the vicinity of the nuclear facilities is not a part of the Swedish automatic gamma monitoring system operated by SSM. One of the suggestions of the IAEA IRRS review of the Swedish regulatory system was that SSM should consider extending the national gamma monitoring system for gamma monitoring stations to cover the areas near nuclear facilities. This work was already in progress, but not completed before the IRRS review. The procurement process is now ongoing and the present schedule is to have 20 measurement stations installed around each NPP by the end of 2014. The measurement stations will be located in a circle at an approximate 5 kilometre distance from the NPP with one measurement station in each 15-degree sector facing land and slightly less densely in directions facing the North and Baltic Seas. There is an option in the procurement to install 10 additional measurement stations around each nuclear power plant at distances up to 50 kilometres from the NPP. If SSM decides to use this option, these additional measurement stations will be operational by the end of 2015.

The IRRS team also concluded the following *Good Practice*. SSM has established its state-of-the-art Emergency Response Centre, equipped with all the necessary tools and procedures as well as a national network of mobile and stationary laboratories to manage emergency response.

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, 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.

The use of Rakel, the Swedish national digital radio system for public safety and security, has been further consolidated within the nuclear emergency and response community, including SSM. Work is currently in progress to enable the transmission of data from monitoring networks around the Swedish nuclear power plants over the Rakel network; the rationale for this work being the fact that the network is designed to withstand serious disturbances in societal infrastructure, including events such as disruption of the power supply and an overload of public communication networks. The Rakel network is based upon the TETRA standard. The Swedish Civil Contingencies Agency (MSB) has the overall responsibility for development, coordination and support of the network.

SSM has supported further developments in Sweden's dispersion modelling capabilities in cooperation with the Swedish Meteorological and Hydrological Institute (SMHI) and the Swedish Defence Research Agency (FOI). SSM now has routine access to a suite of modelling tools, including Eulerian, Lagrangian as well as Gaussian models, the latter one being implemented at SSM whereas the former ones are being implemented within the dedicated nuclear emergency computation cluster at SMHI. The resolution of the dispersion prognoses has been further enhanced by using higher resolution weather forecasts. The optimization of the handling of the numerical weather prediction datasets at the SMHI has enabled the possibility to perform dispersion calculations for any location on the northern hemisphere with short notice.

A national action plan, including a variety of projects, aiming at enhancing and coordinate emergency planning and response for nuclear power plant accidents and incidents has been established. The projects are on-going and have different responsible authorities and different completion dates, the latest being in 2015. The projects addresses for example mitigating identified needs in the organisation of education and exercises, coordinating communication, coordinating national and regional measurement and analysis teams, further development and coordination of sanitation procedures and creating a national information strategy.

16.9 Conclusion

Sweden complies with the obligations of Article 16.

17. Article 17: SITING

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

(i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;

(ii) for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;

(iii) for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;

(iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

Summary of developments since the last national report

During the current review period, the following developments are of relevance with regard to the obligations of article 17:

- SSM is currently revising regulations related to nuclear activities including clarifying existing requirements related to 'siting'.
- The licensees have revisited the site impact analyses of their designs and will take actions in accordance to the Swedish national action plan with the aim of improving robustness and safety. This includes activities to update the dimensioning values related to external hazards and to implement measures at the NPPs.

17.1 Regulatory requirements

SSM is currently revising regulations related to nuclear activities. This review includes clarifying existing requirements related to 'siting'. When revising regulations related to nuclear activities, SSM will consider current IAEA Safety Standards, lessons learned from the accident at the Fukushima Daiichi NPP including the outcome of the 2nd extraordinary meeting of the conventions on nuclear safety and the outcome of the EU stress tests, results from the IRRS mission in Sweden in 2012, the WENRA reference levels, research, experience (incl. operational experience), new knowledge and other international best practices. For further information, see section 7.3.

All Swedish nuclear sites are located on the coast with access to sea water for cooling and possibilities for sea transportation of large components and spent fuel. The sites were originally selected taking into account relevant factors such as the above-mentioned, and the population density at various distances. The final acceptance decisions were taken by the Government after investigation by a special committee that all legal requirements were met.

Appendix 2 in regulation SSMFS 2008:1 contains a requirement stating that all relevant site aspects that can affect the plant, such as for instance hydrological-, geological- and seismic conditions and ongoing nearby activities, shall be described in the safety analysis report of the facility.

The regulations SSMFS 2008:17 on the design and construction of nuclear power reactors are more specific about natural phenomena and external events. In Section 14 it is stated that the reactor shall be dimensioned to withstand natural phenomena and other events originating outside or inside the facility with the potential to cause a radiological accident. For all such events dimensioning values for the design shall be established. Natural phenomena and events with such a fast development, that protective measures cannot be taken when they occur, shall be regarded as initiating events. For each natural phenomenon an action plan shall be developed for those situations where the dimensioning values for the design risk being exceeded.

In the general advice to these requirements, examples are given on what events to include in the safety analyses. Among those are different extreme weather conditions, extreme water levels, biological conditions affecting the water intake, seismic events and events such as fire, explosion, flooding and airplane crash.

Assessment of new nuclear power plants

The framework and process for issuing a licence for a new NPP are described in section 7.1. According to the Act on Nuclear Activities, a licence for constructing a new nuclear power reactor will only be granted if the new reactor will replace an existing unit and if the new reactor will be located at an existing NPP site.

Applications for construction of new nuclear facilities are processed by SSM. This involves conducting an initial assessment as to how SSM's safety requirements will be fulfilled at the modified or new facility. SSM reviews and analyses documents and materials describing and illustrating the possible location of a facility, in addition to its design, construction and subsequent operation.

Licensing of nuclear activities requires submission of an environmental impact assessment (EIA) in connection with the application, which will be reviewed by SSM and other applicable central government authorities. See section 7.1.7.

SSM subsequently submits a statement of its views to the Government and the applicable environmental court. If SSM assesses that the safety requirements will be fulfilled, SSM will propose its statement of views to the Government for its decision-making on granting the applicant authorisation to carry out the activity. In this document, SSM also proposes that the Government take a decision on the licence conditions to be fulfilled by the licensee. After this stage, the Government considers the application under the Act on Nuclear Activities (1984:3), and the environmental court examines it under the Swedish Environmental Code. The same legislation, rules and procedures apply to nuclear power plants' plans for a power uprate.

When the Government and the court have taken a decision concerning authorisation, SSM conducts a step-wise review process to examine fulfilment of licence conditions. SSM's review and analysis work is performed in several steps. SSM reviews and analyses safety analysis reports, other technical documents, procedures, the organisation and training programmes for personnel. Only then can SSM take a decision on whether to permit the licensee to pass from one stage to the next in terms of constructing or commissioning a facility. SSM takes decisions in the following steps:

- whether construction may begin
- whether it may begin commissioning with test operation
- whether it may begin routine operation

Re-evaluation of site- related factors

Nuclear activities within Sweden can only be conducted in accordance with a licence issued under the Act on Nuclear Activities (1984:3). Under this Act, a party that holds a licence to possess or operate a nuclear facility shall, at least every ten years, conduct an overall assessment of the facility's safety and radiation protection. The assessment shall be conducted in relation to developments in science and technology. It shall include analyses and descriptions of:

1. the way in which the facility's design, function, organisation and operations fulfil the requirements imposed by this Act, the Environmental Code and the Radiation Protection Act (1988:220) in addition to regulations and conditions issued and decided under such legislation, and

2. the prerequisites for compliance with these regulations and conditions up to the next overall assessment.

As a result of current regulations and the lessons learned from the accident at the Fukushima Daiichi NPP, all licensees have revisited the site impact analyses of their designs and will take actions in accordance to the Swedish national action plan. The Swedish national action plan aims to increase the level of robustness and safety and includes activities to update the dimensioning values related to external hazards and to implement measures at the NPPs.

Consulting Contracting Parties in the vicinity of a proposed nuclear installation

The Swedish government concluded agreements in 1976 with the governments of Denmark, Norway and Finland to notify them of proposed new nuclear installations and to provide all necessary information on the siting and design as well as future changes to the licensing conditions. Any party can request deliberations on the matter. A similar agreement was concluded with Germany in 1990.

17.2 Measures taken by the licence holders and SSM

EU stress tests

Following the nuclear power accident in Japan, the Council of the European Union agreed that all EU Member States were to conduct a comprehensive assessment of risk and safety, or 'stress tests', for their respective nuclear power plants.

The Swedish Radiation Safety Authority is responsible for reviewing and reporting stress tests of Swedish nuclear power plants and the interim storage facility for spent nuclear fuel, CLAB. The Authority presented a report to the Swedish Government in December 2011. The report to the Government included the results for the nuclear power plants and CLAB.

The Swedish Radiation Safety Authority was subsequently assigned to submit a national report to ENSREG containing the results of Swedish nuclear power plants' stress testing. This report was submitted on 31 December.

In spring 2012 a specially appointed group of international experts, a 'peer review team', reviewed the respective countries' reports. On 25 April 2012, ENSREG presented the results from these reviews in an integrated report covering all the countries.

The initial step in the EU stress tests included a reassessment of the pre-existing safety analysis reports of the facilities based on the experience gained following the accident at the Fukushima Daiichi NPP. This also included identifying safety margins and areas of improvement as the facilities are subjected to hypothetical disruptions beyond what they were originally designed for.

The Swedish Radiation Safety Authority has as a result of the stress tests imposed requirements on more in-depth analyses in certain areas, and has demanded actions to be taken in accordance to the Swedish National Action Plan. In April 2013, a peer review of the respective countries' action plans was conducted within ENSREG.

All Swedish reports related to the EU stress tests are available through SSM's website (www.ssm.se) or ENSREG's website (www.ensreg.eu).

Results from the EU stress test regarding earthquakes

In Sweden, only the two newest reactors, Oskarshamn 3 and Forsmark 3, were originally designed to withstand earthquakes. The other Swedish reactors became subject to general requirements imposed on resilience against earthquakes when the Swedish Nuclear Power Inspectorate's regulations concerning the design and construction of nuclear power reactors entered into force in 2005. In order to allow licensees sufficient time to take the measures and fulfil the requirements, separate decisions were taken giving the licensees a certain period of time to plan and take the requisite measures to fully comply with the above-mentioned regulations, now designated as SSMFS 2008:17. The deadline for taking measures under these 'transitional decisions' is the year 2013. However, it should be noted in this context that the licensees also previously took resilience against earthquakes into consideration, primarily in terms of mechanical equipment in connection with modernization work and plant modifications.

In their design and other analyses, the licensees apply a dimensioning earthquake within a radius of twenty kilometres of a strength corresponding to a magnitude of approximately 6.0 on the Richter scale and with a probability of once per 100,000 years (10^{-5}). According to SSM, this is an acceptable DBE.

As far as concerns consequence-mitigating systems, a dimensioning earthquake has been applied of a magnitude approximately four times more powerful and having a probability of once per 10 million years (10^{-7}). SSM also assesses that the application of a severe earthquake scenario with a probability of 10^{-7}/year is feasible for the evaluation performed of systems and buildings necessary for preventing the release of radioactive material to the environment.

In the documentation submitted, SSM currently assesses that data is somewhat lacking for demonstrating that functions needed to bring the reactors Oskarshamn 2, Forsmark 1, Forsmark 2, Ringhals 2, Ringhals 3 and Ringhals 4 to a safe state will perform as intended during and after an earthquake as stipulated by the dimensioning requirements. SSM generally assesses that the licensees have not taken the measures required under the Authority's regulations for some of the reactors. For this reason, SSM will order the licensees to produce detailed action plans on how and when these detailed analyses and investigations shall be performed. The same situation applies to the additional analyses needed for achieving a more accurate estimation of the margin for safe shutdown and implementation of the improvements identified in the updated safety evaluations. As far as concerns Forsmark and Ringhals, a more detailed analysis also needs to be conducted in terms of earthquake-induced flooding.

Results from the EU stress test regarding flooding

Swedish nuclear power plants are dimensioned for sea water levels of between two and three metres above the average water level. All of the plants can nonetheless withstand a sea water level of 3.0 metres above the average water level without resulting in core damage. The licensees assess that this level has a probability of 10^{-5}/year (a probability of once per 100,000 years).

High ground water level is of particular concern for Ringhals 2. The internal water level in the plant that is assumed to cause fuel damage is 3.0 metres below the average sea water level and the period of time between pump failures and a critical situation is very uncertain. Further evaluations need to be performed due to the uncertainties and due to the fact that the drainage pumps are connected to the off-site power.

Combination effects of waves and high water levels are not included in the stress tests for all facilities. Moreover, investigations are needed for these kinds of combination effects, including dynamic effects.

The estimated frequency for the three-metre level is 10^{-5}/year based on statistics from SMHI (the Swedish Meteorological and Hydrological Institute). SSM is nevertheless conducting investigations for an assessment of extreme natural phenomena, to which flooding belongs. When these investigations have been completed, SSM will adopt a standpoint in terms of both the three-metre level as well as the expected frequency.

Results from the EU stress test regarding extreme weather conditions

Extreme weather conditions are initially broken down into rapid and slow processes. 'Slow processes' refers to weather situations in which the facility can be brought to a safe state and time allows for compensatory measures to be taken before the extreme weather conditions have fully developed. This category for example includes high and low water levels and air temperatures.

The facilities' characteristics have been evaluated in relation to extreme weather conditions. The evaluation indicates that the facilities are robust against these kinds of conditions. However, certain areas need more investigation with the aim of further strengthening the facilities. Examples of these include analyses of procedures for the working staff in terms of requisite measures in the event of large quantities of precipitation in addition to requisite measures in the event of extreme temperatures. Other examples of areas needing further investigation include extreme weather conditions combined with consequential events. Also, the bearing capacity of certain roofs needs to be analysed in terms of snow load.

Ice storms are not covered by the nuclear power plants' safety analysis reports (SAR) and have not been analysed in detail in the stress tests. However, an ice storm would be expected to knock out the offsite power and also risk blocking ventilation systems. This is a deficiency in relation to current regulations and SSM intends to order the licensees to conduct analyses of facility robustness against ice storms and to take any action that is needed.

SSM is currently conducting investigations into extreme natural phenomena in terms of precipitation, temperatures, wind speeds, etc. that the facilities are to be capable of withstanding under the regulations. While awaiting completion of these investigations, the values used by the licensees are deemed acceptable.

Results from the EU stress test regarding loss of electrical power

The ordinary auxiliary power systems are, as far as concerns all Swedish nuclear power plants, dimensioned to manage a seven-day loss of offsite power. However, it has become evident that some facilities would need refilling of lubricant within a few days. Access to and storage of lubricant at the facilities needs to be investigated further and the possible need for increased storage capacity should be evaluated.

Alternative auxiliary power systems in the form of gas turbines are also available within or close to the facilities. However, these auxiliary power systems have not been safety classified. The licensees' investigations indicate that these alternative auxiliary power systems could be crucial during a sequence of emergency events; also, the need for auxiliary power systems should be investigated further, particularly when considering situations where several reactors are affected simultaneously.

In the event of a loss of offsite power, failed house load operation in addition to loss of ordinary and alternative auxiliary power, what remains operational then is a battery-backed uninterruptible power supply for instrumentation and manoeuvring of components. These batteries are only dimensioned for one to two hours of operation according to the relevant SARs, although they are deemed capable of functioning for a longer period of time. An analysis of battery capacity needs to be conducted in order to further improve the level of robustness.

In the event of a loss of offsite power, failed house load operation in addition to loss of ordinary and alternative auxiliary power, various mobile units can be used, such as diesel-powered pumps and generators. The analyses nevertheless indicate that the capacity and number of mobile units are insufficient for all kinds of events, particularly if several reactors are affected simultaneously.

Results from the EU stress test regarding loss of ultimate heat sink (failed removal of heat to the sea or atmosphere)

All Swedish nuclear power plants are dimensioned to be brought to a safe state if the salt water intake is blocked and to keep the facility in this state. However, as far as concerns Ringhals 3 and 4, it is not documented in SAR if and how fulfilment of this requirement is verified. An update of design basis events and verifying analyses needs to be conducted.

Simultaneous blockage of both intake and outlet would involve significantly more difficult situations than the above-mentioned design basis events and would require crucial action by personnel at the facilities. An analysis of requisite manual measures and available resources needs to be performed. This also needs to consider the personnel's access to the facility on the basis of assumed accident sequences and their impact on the work environment.

Analyses of beyond design basis accidents also demonstrate the major significance of independent core cooling, where both permanent and alternative systems as well as mobile units strengthen the facilities' safety and robustness. Evaluations of independent core cooling should be conducted and any need for further enhancements should be investigated.

The analyses also illustrate the importance of available water volumes for the purpose of extending the period of time before serious core damage is unavoidable in connection with severe accidents. A survey of water volumes in various storage tanks and set minimum levels in them needs to be performed. Also, a survey of available water volumes at and in connection with the various sites should be performed and the possible need for reinforcement should be evaluated.

Manual intervention is required to maintain cooling of fuel ponds during a situation where both the water intake and outlet are blocked. Further investigations are also required into the need for additional cooling, both by means of permanent installations and by mobile units. A key prerequisite in connection with these investigations is that the environment surrounding the ponds allows the personnel access for manual action.

Airplane crash

The containments were designed with good margins to withstand an airplane crash of small plane (sports plane) and the risk of larger crashes has been analysed and found to be tolerably low based on available air traffic statistics.

As a result of the events in USA on 11 September 2001, all Swedish reactors have been assessed against deliberate airplane crash. An open version of the SKI review report is published on the SSM website (www.ssm.se). The conclusion was that consequences of a deliberate airplane crash are difficult to assess, and depend on many factors.

A crash of a commercial airplane of the normal types flying in the airspace near to the sites could be managed without any radioactive releases. If a crash of the largest plane fully loaded with fuel is postulated, it cannot be excluded that damage will include radioactive releases. In particular the consequences of consequential fires are difficult to assess. In these cases however, the passive filtered venting systems will provide good protection. SSM has chosen to publish an open version of this report, without giving any details, in order to serve the public interest on this issue.

In October 2012, SSM participated in a meeting organized by ENSREG and the European Commission to discuss airplane crashes in the context of nuclear safety.

External event PSA

In 2003 the SKI presented the report "Guidance for External Events Analysis", giving a common framework for analysis of external events as part of a nuclear power plant probabilistic safety assessment. The report was developed under a contract with the Nordic PSA Group (NPSAG), which has members from all the Swedish and Finnish plants as well as SSM. The licensees have since developed the basic methodology further and are now performing analyses based on this methodology.

Plant specific PSAs taking into account relevant external events, except seismic events, have been completed for all plants.

Regarding further regulatory actions in relation to safety assessments and safety analysis reports, see Chapter 14.

17.3 Conclusion

Sweden complies with the obligations of Article 17 as applicable.

18. Article 18: DESIGN AND CONSTRUCTION

Each Contracting Party shall take the appropriate steps to ensure that:

(i) the design and construction of a nuclear installation provides for several reliable levels and methods of protection (defence in depth) against the release of radioactive materials, with a view to preventing the occurrence of accidents and to mitigating their radiological consequences should they occur;

(ii) the technologies incorporated in the design and construction of a nuclear installation are proven by experience or qualified by testing or analysis;

(iii) the design of a nuclear installation allows for reliable, stable and easily manageable operation, with specific consideration of human factors and the man-machine interface.

Summary of developments since the last national report

During the current review period, the following developments have taken place with regard to the obligations of article 18:

- The licensees are continuously working with the safety upgrading modifications as reported in section 6.2.
- Further measures at the plants are to be expected in the light of the Fukushima Daiichi NPP accident as reported in section 10.4.
- The following major modification/replacement measures have been completed during the period 2010-2012:

Forsmark 1 and 2:

- Strengthening of auxiliary buildings to withstand external hazards.
- Exchange of moderator tank lid
- Exchange of moisture separator
- Exchange of steam separator
- A new diversified reactor shutdown system
- Robustness measure to prevent pipe-break
- Measures on new I&C in the Emergency Control Room
- Earthquake measures
- Diversification of sensors and actuation of RPS
- Ventilation measures in electrical building to segregate fire compartments
- New hook-on devices for the containment for external mobile decay heat cooling units

Forsmark 3:

- A new diversified reactor shutdown system
- Separation of safety classified electrical equipment from non safety
- Measures to diversify the residual heat removal
- Security measures
- Robustness measure against pipe-break

Oskarshamn 1:

- Enhancement of the fire separation in the reactor building.

- Replacement of obsolete valves in the blading and feed heater systems.
- Valve replacements in the residual heat removal system.
- Reactor core sprinkler system - Installation of additional shut off valves in the pressure boundary to non-essential part
- Valve replacements in the fire protection water system.
- Environmental qualification of equipment
- Reinforced roof in the main control room
- Digital control equipment system – Improvements in the operator interface
- Measures taken concerning the feed water distributors in the reactor pressure vessel
- Measures taken concerning the supports of the coolant water pipes for diesel generators A & B
- Reconstruction of pressure surveillance and pressure regulation in the water tanks belonging to the scram system.
- Measures taken regarding the decontamination pipes for the isolation condenser
- New starting motors to the emergency diesel generators sub A and B to improve reliability

Oskarshamn 2:

- Oskarshamn 2 is awaiting the large PLEX (Plant Life Extension)-outage, beginning in June 2013.
- The modernization and power uprate project PLEX completed erection of buildings.
- Start install of new safety I&C, bus bars, auxiliary power diesels.
- Deep water intake completed.
- Start install of the new diversified residual heat removal.
- Verification of the operability of long shaft pumps during accident condition in low pressure core cooling system and residual heat removal system based on events in PWR in France. The verification was performed at the shut down Barsebäck plant by electrically heating up the condensation pool.

Oskarshamn 3:

- Changed turbine bearings
- Increased manoeuvrability and instrumentation of the reactor protection functions in the emergency control room
- Replacement of 400kV switchgear
- Replaced internal parts of the reactor pressure vessel (shroud head, steam separators and steam dryers)

Ringhals 1:

- Measures on RPS (isolation logic train blockage during tests enhanced)
- Robustness measures on electrical systems (from Forsmark event of 25 July 2006)
- A new diversified reactor shutdown system
- Security measures
- Post-Accident measure system

Ringhals 2:

- Separation of RPS

- Diverse actuation system
- New severe accident monitoring systems

Ringhals 3 and 4:

- Diversified Protection System
- Redundant check valves
- PORV qualification for containing liquid
- Steam line break protection
- Steam generator and pressurizer replacement (Ringhals 4)

18.1 Regulatory requirements

The general safety regulations SSMFS 2008:1 contain the basic requirements on the design and construction. The fundamental requirement is the following:

"Nuclear accidents shall be prevented through a basic facility-specific design which shall incorporate multiple barriers as well as a facility specific defence-in-depth" (Chapter 2, Section 1). The general principles behind achieving defence-in-depth are further specified. Regarding further definitions of the defence-in-depth, a reference is made to the report INSAG-10[19]. This means that five levels of defence are applied in Sweden.

More specific requirements on design and construction, in order to achieve what is required in the fundamental paragraph, are given in Chapter 3 of SSMFS 2008:1. These can be summarized in the following points.

The design shall

- be able to withstand component and system failures,
- be reliable and have operational stability,
- be able to withstand such events and conditions which can affect the safety function of the barriers or defence-in-depth, as well as
- make it possible to maintain, inspect and test structures, systems and components and as far as reasonable facilitate a safe future decommissioning.

It is further required that design principles and design solutions shall be tested under realistic conditions, or if this is not possible or reasonable, have undergone the necessary testing or evaluation with regard to safety. Design solutions shall be adapted to the ability of the personnel to manage the facility in a safe manner as well as to manage abnormal events, incidents and accidents. Functionally based safety classification is also required. In the general advice on these legally binding requirements, guidance is given on their interpretation and application.

SSMFS 2008:1 stipulates that guidelines shall be developed to manage beyond design basis events but the regulations do not include any specific design requirements to deal with severe accidents. Requirements on release mitigation in the event of severe accidents were given in a governmental decision in February 1986[20], as a condition for operation after 31 December 1988. This decision states that, in the event of an accident involving severe core damage, including core melt, releases should be limited to a maximum of 0.1% of the core content of caesium 134 and caesium 137 for a reactor core having a thermal power of 1800 MW. This is on condition that corresponding fractions of other nuclides that have a significant role in ground contamination also are retained. Severe accident sequences with an extremely low probability, such as reactor pressure vessel rupture, need not be taken into account.

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[19] Defence in Depth in Nuclear Safety. A report by the International Nuclear Safety Advisory Group. IAEA, 1996.

[20] Swedish Government Decree, February, 1986 (in Swedish).

During the 1980s, these release mitigation requirements led to major back-fitting of the Swedish reactors, such as filtered containment venting systems and diversified containment cooling[21]. Plant-specific accident management procedures were also required in the governmental decision and introduced at the end of the eighties. The objective of these procedures is to enhance the capability of bringing a severe accident sequence under control and achieving a stable final state, with a damaged core covered by water and cooled, with the containment depressurised and with integrity preserved.

In December 2006, SKI and SSI completed an investigation entitled "Radiological consequences for the environment in connection with incidents and accidents at nuclear power plants[22]". The investigation resulted in a proposal of analysis assumptions and reference values for radiological environment consequences in connection with anticipated operational occurrences and design basis accidents, to be used in safety analyses and when establishing design criteria for barriers and safety systems, e.g. limits on air and water leakage from reactor containments. Release criteria for normal operation are established in the regulations SSMFS 2008:23 (see section 7.3)

Based on this study, SSM decided in April 2009 on analysis assumptions and reference values for radiological environment consequences to be used by the licensees in the deterministic safety analyses. These decisions apply until the regulations are updated.

Requirements concerning protection from intentional damage such as sabotage are posed in separate regulations SSMFS 2008:12 on physical protection of nuclear facilities (see section 7.3). These regulations have been in force since January 1, 2007.

More specific design requirements are posed in separate regulations on the design and construction of nuclear power reactors, SSMFS 2008:17. SSM has decided on reactor specific plans for complying with the regulations. According to these plans, back fitting will continue over the next few years and be finalised around 2013. An overview of the back fitting programmes is given in section 6.2.

There were no immediate safety reasons behind the decision to issue these supplementary regulations. As mentioned in section 6.2, the authority several years ago planned to issue guidelines for modernization and safety upgrading of the Swedish reactors for the rest of their operating time. When modernization programmes were also planned also for the other reactors to make them fit for operation for 40 years and beyond, the regulatory authority decided to issue general regulations on design and construction valid for the foreseeable future.

The new regulations were based on the recent development of knowledge gained through domestic and international operational experience, safety analyses, results from R&D-projects, current IAEA Safety Standards and applicable industrial standards.

On a number of issues the new regulations imply more stringent requirements. On other issues the requirements are already implemented through licensing conditions or regulatory decisions. In the latter cases the regulations will gain, through their general format, more transparency and it will be possible to communicate as a whole to different stakeholders.

The requirements are grouped under the following headings:

- General design principles for the defence in depth
- Withstanding of failures and other internal and external events
- Environmental qualification and impact on other plant systems
- Requirements on the main control room and emergency control panels
- Safety classification
- Event classification

[21] Release-Limiting Measures for Severe Accidents. Swedish Nuclear Power Inspectorate - Swedish Radiation Protection Institute Report to Government, December, 1985 (in Swedish).

[22] In Swedish only.

- Requirements on the design and operation of the reactor core

There are requirements on:

- The basic safety functions up to design basis accidents, with regard to
  - redundancy, diversification, physical and functional separation of safety functions
  - automatic initiation of reactor protection functions
  - fail-safe conditions
  - operations systems which do not challenge systems with safety function
  - withstanding single failures and CCF
  - degree of physical- and functional separation of the redundant part of safety systems
  - withstanding global and local dynamic effects of pipe breaks
  - withstanding of internal and external events
  - fire analysis
  - maintenance during operation
  - environmental qualification and environmental impact of equipment on safety functions
  - control and monitoring from the main control room
  - control and monitoring from the emergency control post
  - design and operation of the reactor core
- Design extension for dealing with beyond design basis events, including severe accidents, with regard to
  - design of the containment and release mitigating systems
  - instrumentation
  - cooling of the core/core melt in the long term
  - control and monitoring from the main control room and emergency control post

Safety classification should be done according to the principles in the US standards ANSI/ANS 51.1 for PWR and 52.1 for BWR. Initiating events shall be classified in the following event categories, depending on the probability of occurrence: normal operation, anticipated events, unanticipated events, improbable events (DBAs) and very improbable events (BDBAs). For every category, analysis assumptions and acceptance criteria have to be specified. Analysis of beyond design basis events may be done with realistic assumptions and modified acceptance criteria.

Active components of the safety functions shall be able to withstand a single failure in connection with all events within the design basis envelope including active components belonging to the mitigating systems. Passive single failures are assumed to occur at the earliest 12 hours after the initiating event.

A reasonable diversification in order to withstand CCF should be applied in the design of the safety functions for events up to and including unanticipated events (except LOCAs).

The regulations are formulated to allow different solutions, which can be shown to meet the intentions in a reasonable way. A reactor specific consequence assessment was made before the regulations were decided. This assessment served as basis for the reactor specific back fitting plans submitted by the licensees and, as mentioned, now approved by SSM (see section 6.2).

18.2 Measures taken by the licence holders

18.2.1. Original design concepts

The Swedish power reactors represent the design generations II and III as shown in Table 13 Design generations of Swedish nuclear power plants.

3. The original designs were made in the late 1960s and 1970s. The reactors were mainly designed to fulfil the US 10CFR 50 Appendix A: General Design Criteria and US industrial standards existing at the time, such as ASME, ANSI/ANS and IEEE. The Swedish BWR designer added some specific features, advanced for the time, and the state utility Vattenfall made some further modifications to the reactors ordered for Ringhals.

The early BWRs comprising five units have external main recirculation loops, while the latest four units have internal recirculation pumps with no large pipes connected to the reactor vessel below core level. All have fine motion control rod drives and hydraulic shutdown systems. For the first two generations, diversification was used in the emergency cooling systems, but for the later generations this was replaced by increased reliability in the electrical supply and a higher degree of redundancy.

BWR

Unit	Design generation	Main design features
Oskarshamn 1	Gen II	External main recirculation loops. No explicit requirements regarding physical separation. Diversification by auxiliary condenser. Fine motion control rods, diversified shut down system with rods. The unit incorporates evolutionary improvements in design developed during the lifetime.
Ringhals 1	Gen II	Similar to Oskarshamn 1 plus improved physical separation of the safety systems. Partial four-train electrical separation. Diversification by steam driven emergency cooling and auxiliary feed water pumps. The unit incorporates evolutionary improvements in design developed during the lifetime.
Barsebäck 1 and 2 and Oskarshamn 2	Gen II	Stronger requirements on physical separation of the safety systems. Full two train redundancy of the safety systems. Improved electrical supply reliability instead of diversification.
Forsmark 1 and 2	Gen II+	Four-train redundancy of the safety system. Internal main recirculation pumps. The unit incorporates evolutionary improvements in design developed during the lifetime.
Forsmark 3 and Oskarshamn 3	Gen III	As Forsmark 1-2 plus complete physical separation of the safety systems. Designed for seismic events. The unit incorporates evolutionary improvements in design developed during the lifetime.

PWR

Ringhals 2	Gen II	Three loop PWR. Diversification by steam driven auxiliary feed water pumps. Partial four-train electrical separation. The unit incorporates evolutionary improvements in design developed during the lifetime.
Ringhals 3 and 4	Gen II+	As Ringhals 2 plus improvements in physical separation. The unit incorporates evolutionary improvements in design developed during the lifetime.

Table 13 Design generations of Swedish nuclear power plants.

The BWR containments are all of the pressure suppression (PS) type with various solutions and layouts of the pressure suppression pools.

In some areas specific Swedish requirements have been added, e g. the so-called 30-minute rule. This rule requires that all measures, which need to be taken within 30 minutes from the initiating event, involving risk for radioactive release, have to be automated. The rule is implemented in the BWRs, and with some exceptions in the PWRs.

Another area where stricter Swedish rules were applied relates to fire protection and separation of safety related equipment. In the four youngest BWR units the safety systems are designed with four independent trains, which are completely physically separated in the two youngest units. In the older units at least two independent and physically separated loops are installed, in one case, Oskarshamn 1, this was done in the late 1970s as a modification to the original design.

18.2.2. Evolution of the design

Requirements and practices with regard to safety analyses and assessments in order to develop the design are described in Chapter 14. Various back fitting measures have been introduced to all the reactors over the years. The latest implemented modifications are listed in the introduction to this chapter. An overview of the modifications implemented up until 2006 is provided in Appendix 3.

These are the backgrounds of the back fitting measures:

- A strainer clogging event occurred in Barsebäck 2 in 1992. Here, the emergency core cooling systems of the BWRs with external main circulation pumps did not operate as anticipated in the safety analysis reports. This event triggered large modifications of most Swedish reactors as well as major projects to revise and update the safety analysis reports.
- International accidents/incidents e.g. TMI-2 in 1979, which triggered the so far most comprehensive back-fitting measures, the severe accident mitigation programme completed in 1988, comprising diversified cooling and filtered venting of the containment. The Chernobyl accident in 1986 did not provide input for technical modifications of the Swedish plants, but highlighted other issues, such as safety management and safety culture.
- Insights from PSA and other safety analyses, e.g. the importance of CCF and thereby an increased focus on diversification.
- Results from R&D projects, e.g. on severe accidents and on man/machine interaction.
- Development of applicable industrial standards and IAEA Safety Standards (regarding the procedure, see section 14.2).
- New Swedish regulations (see sections 7.3 and 18.1).
- New measures in the light of the Fukushima Daiichi NPP accident (see section 10.4).

Back-fitting measures are basically taken to strengthen the safety concept of multiple barriers and defence-in-depth, now clearly stipulated by SSM's regulations. Important principles in this work remain the following:

18.2.3. Proven technology

When the first plants were designed they were mostly based on the light water technology developed, tested and proven in the United States. In those cases where the Swedish designed plants contained unique features, careful analysis and test programmes were carried out. In some cases new verification tests have had to be performed when the original tests have proved to be inadequate. One example of this is the extensive testing programme leading to new strainer designs in the emergency cooling systems. Resources and laboratory facilities for advanced thermo-hydraulic and mechanical tests are available both at the vendor, Westinghouse-Atom, at the Vattenfall laboratories in Älvkarleby and at the Studsvik facilities. In Studsvik advanced equipment for materials and mechanical testing of radioactive material is available in the hot cell laboratory.

In order to ensure the function of the safety-related systems, and to obtain correct and reliable information from the process in the event of an emergency, the components inside the reactor containment have been environmentally qualified. This qualification was preceded by detailed inventorying of all equipment in the reactor containment. At the same time requirements concerning function and duration, when the equipment is supposed to work, were specified. These requirements were different in part from those based on the DBA conditions used when the reactors were designed and constructed. Not least the TMI accident has contributed with extended information concerning requirements during emergency situations.

A comprehensive test programme was worked out and components identical to those installed in the containment were tested in an environment representative for the conditions that can be expected in the containment, if a serious event takes place. The testing included all types of equipment like electromagnetic and motor operated valves, instrumentation, CRD-motors and cables.

Equipment that did not meet the specified requirements was replaced with new equipment that could withstand and work in the expected environment. In particular cables have had to be replaced. In most cases when equipment was replaced, this was due to the fact that equipment is also affected during normal operation in the environment in which it works, leading to its ageing.

In spite of the measures taken by the operators, continued research and development has been going on in this area. Attention is paid not only to factors like temperature, humidity, radiation and vibrations, but also to electromagnetic and chemical environments. This work is performed in cooperation between the Swedish licensees and SSM and in close contact with efforts abroad.

In the modernization programmes, the use of up-to-date but proven technology is also one of the basic criteria. Requirements on environmental qualification have been extended to safety important equipment outside the containments and procedures have to be in place to following up the environmental impact on the safety systems during the operating life time of the reactor. In the modernization work, the specification of all new instalments is carefully checked with respect to environmental requirements.

18.2.4. Reliable, stable and easily manageable operation

The Swedish nuclear plants were all designed with the goal of high inherent stability and few operational disturbances. The control rooms were designed based on experience and design rules within each owner organisation. In the completed as well as in the ongoing modernization projects including control room upgrading, MTO and the man-machine interface have been paid considerable attention and the experience from earlier operation has been an important input.

The technical development in the area of I&C is very fast and fundamental and much of the equipment from the construction phase of the Swedish nuclear plants is becoming obsolete. Several programmes concerning various extents for modernization of I&C systems and control rooms have, therefore, been carried out in most plants and further programmes are expected. Somewhat different approaches have been taken in the I&C modernization work by the different plants, in particular with respect to the introduction of digital technology.

For BWR core stability, several measures have been taken to ensure a stable operation within the operational region. Stability is initially ensured by core design, but if power oscillations should occur nevertheless they are readily detected and suppressed by a redundant oscillation amplitude monitor and a selected rod insertion system.

18.2.5. Measures to improve physical and functional separation and diversification

The separation of systems, physically and functionally, is an important area in which a number of back-fitting measures have been implemented over many years as reported previously. In many cases, the need for improved separation was identified through PSA analyses. Swedish reactors have been retrofitted to comply with the regulatory requirement of functional diversification. The functions of: (1) reactivity control, (2) overpressure protection, (3) core cooling, (4) residual heat removal, and (5) the containment shall have a diversified backup. Some measures remain to be installed between 2013 and 2015 on the PWRs.

18.2.6. Design extension for mitigation of severe accidents

After the TMI-accident in 1979, a reactor safety commission appointed by the Government proposed that the Swedish reactor containments should be back fitted with filtered venting systems. This was the start of a joint safety study, FILTRA, conducted by SKI, SSI, ASEA-ATOM, Studsvik and the utilities. The FILTRA study was in turn the start of another joint extensive research and safety analysis programme on severe accidents: Reactor Accident Mitigation Analysis (RAMA), which finally resulted in criteria and guidelines on release mitigation.

Based on the safety studies, requirements on back fitting were decided by the Government in 1980 for the Barsebäck plant and in 1986 for the other nuclear plants. Back-fitting measures consisted of filtered containment venting to protect against overpressure and (with the exception of Barsebäck) diversified containment cooling to handle a core melt in the containment. Also symptom based accident management procedures were required. Radiological criteria to be met are described in section 18.1. The first filter system installed in Barsebäck was a passive stone filter system designed to prevent containment overpressure in a LOCA with a failing PS function. For the other BWRs and the PWRs, the filtered venting system (water scrubbers) were designed, according to another principle with improved PS reliability, to prevent late over pressurization, and a separate unfiltered pressure relief system protects the containment in the event of early over pressurization. Two umbrella events were generally analysed as design basis events for the mitigating systems:

1/ large LOCA in combination with loss of PS function, and

2/ transient in combination with station black out and loss of steam driven emergency core cooling systems. This means loss of all cooling systems.

A core melt passing through the bottom of the pressure vessel is assumed and the damaged core/core melt has to be handled in the containment without major environmental consequences.

This Swedish strategy for dealing with a core melt, to let it fall into deep water in the containment is quite unusual. Only a few reactors in the world apply this strategy. Since the strategy is special, relatively little international research exists addressing it, even if there is international research on phenomena which can occur also in Swedish plants.

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 is understood not to be an issue. However, steam explosions if the melt falls into the filled cavity and the coolability of the core melt in the containment are important topics to gain more knowledge in. The severe accident research is now targeted to show that the chosen solution can adequately protect the environment.

Since the Government decision in the 1980s, Swedish utilities and the regulatory body, SSM, have in collaboration continued to conduct research on severe accidents and to follow international research on this topic. At present the APRI-8 project (Accident Phenomena of Risk Importance) is being run for the three year period 2012-2015, with research at KTH on core melt sequences and research at the Chalmers University of Technology (CTH) on chemical conditions in the containment. Experimental resources have been built at KTH with the assistance of EU funding. Sweden also cooperates with the USNRC within CSARP (Cooperative Severe Accident Research Program) and CAMP (Code Application and Maintenance Program).

Vattenfall is part of NUGENIA, the European research network. This network covers research in eight different areas, of which safety and risk assessment, severe accidents and research related to emergency crisis management are a few of the areas worth mentioning.

18.3 Regulatory control

Regulatory review of design solutions is mostly carried out in connection with notifications to SSM before implementation of plant modifications or changes in the safety documentation (see also section 14.3). The notifications have to be substantiated and justified in such a way that SSM can assess that they comply with the regulations. SSM occasionally makes its own analyses to verify the calculations submitted by the licensees. The independent safety review required of the licensee also has to be submitted in the notification. SSM checks that this independent review has sufficient quality. If SSM is not satisfied with a notification, the licensee has to supplement it, or SSM can pose further requirements or conditions on the proposed solution before it may be implemented. If more investigation time is needed, SSM can stop the implementation until the case has been investigated further. Notifications dealing with new or complex technology are most often reviewed further by SSM, if necessary assisted by external experts. Larger plant modifications have to be notified as a PSAR in order to systematically clarify all the interactions with the existing safety case. Before test operations, the PSAR shall be supplemented to get a pre-operation SAR (POSAR), which justifies the finalised detailed design of the plant and presents a demonstration of its safety. The final report (SSAR) incorporates any necessary revisions to the POSAR following the commissioning and licensing process for the first entry into routine operation of the as-built nuclear power plant.

The reactor specific back fitting programmes as a result of SSMFS 2008:17 were reviewed by SSM to ensure that they comply with the regulations. More detailed review of different design solutions has been performed in connection with notifications.

SSM's overall assessment is that the measures taken to date owing to the requirements imposed by SSMFS 2008:17 have improved safety at the ten nuclear power reactors in Sweden. The main capability that has been improved is their control over conditions that might arise in the event of design basis accidents. The operation of the nuclear power reactors and monitoring of the barriers' surveillance have also been substantially improved by implementing new or upgraded control equipment.

Viewed in relation to all the plants, more than half of the analysis and modernization work has now been completed as per the decided action plans. This means that many measures remain to be taken, particularly at a few of the facilities. SSM's regulatory supervision includes monitoring the licensees' progress on the action plans and adopting a subsequent standpoint as to whether the measures fulfil the requirements imposed by SSMFS 2008:17 to the extent that this is feasible. An overall assessment of compliance is however not possible to conduct at the present time, since both analysis work and modifications to the facilities remain to be done in the form of site modifications and rebuilding work. Some of the requirements imposed by SSMFS 2008:17 can govern several measures, and one measure can contribute to fulfilment of several requirements. Thus, this situation makes it more difficult to assess the overall fulfilment of requirements for each facility until all the measures have been taken and they have been reviewed by SSM.

18.4 Conclusions

Sweden complies with the obligations of Article 18.

19. Article 19: OPERATION

Each Contracting Party shall take the appropriate steps to ensure that:

(i) The initial authorization to operate a nuclear installation is based upon an appropriate safety analysis and a commissioning programme demonstrating that the installation, as constructed, is consistent with design and safety requirements;

(ii) Operational limits and conditions derived from the safety analysis, tests and operational experience are defined and revised as necessary for identifying safe boundaries for operation;

(iii) Operation, maintenance, inspection and testing of a nuclear installation are conducted in accordance with approved procedures;

(iv) Procedures are established for responding to anticipated operational occurrences and to accidents;

(v) Necessary engineering and technical support in all safety-related fields is available throughout the lifetime of a nuclear installation;

(vi) Incidents significant to safety are reported in a timely manner by the holder of the relevant licence to the regulatory body;

(vii) Programmes to collect and analyse operating experience are established, the results obtained and the conclusions drawn are acted upon and that existing mechanisms are used to share important experience with international bodies and with other operating organizations and regulatory bodies;

(viii) the generation of radioactive waste resulting from the operation of a nuclear installation is kept to the minimum practicable for the process concerned, both in activity and in volume, and any necessary treatment and storage of spent fuel and waste directly related to the operation and on the same site as that of the nuclear installation take into consideration conditioning and disposal.

Summary of developments since the last national report

During the current review period, the following developments are of relevance with regard to the obligations of article 19:

- An overview of recent years' operational events is given in section 6.1.
- The number of licensee event reports (category 2 LERs) varies in the range of 20-70 per year and reactor over the past few years.

19.1 Regulatory requirements

The general safety regulations SSMFS 2008:1 contain legally binding requirements relevant to all obligations of Article 19. These requirements are summarized below:

19.1.1. Initial authorization

As mentioned in section 14.1, a comprehensive deterministic and probabilistic safety analysis is required before the plant is constructed and taken into operation. These analyses shall subsequently be kept up to date. To show how the plant is built, analysed and verified and how the safety requirements are met, a PSAR shall be supplemented to get a pre-operation SAR (POSAR), which justifies the finalised detailed design of the plant and presents a demonstration of its safety. The final report (SSAR) incorporates any necessary revisions to the POSAR following the commissioning and licensing process for the first entry into routine operation of the as-built nuclear power plant (Chapter 4, Sections 1 and 2).

Documented up-to-date OLCs are required containing the necessary limits and conditions, as further specified in a separate annex to the regulations. The OLC shall together with the operational procedures ensure that the conditions which are postulated in the safety analysis report are maintained during the operation of the facility (Chapter 5, Section 1). The OLC shall be subjected to a twofold safety review by the licensee and submitted to SSM for approval. SSM shall be notified about any changes which must also be subjected to a twofold safety review by the licensee.

19.1.2. Approved procedures

Suitable, verified and documented procedures established by the licensee are required for all plant states including accidents. Symptom based procedures shall be in place for a nuclear power reactor, in order to re-establish or compensate for lost safety functions and to avoid core damage. Management guidelines are required to control and mitigate consequences of beyond design basis accidents. These guidelines should be developed to the extent possible and reasonable with regard to the need for protection of the public and the environment. The guidelines should be well coordinated with the emergency procedures. The procedures for operability verification as well as procedures and guidelines used in other plant states than normal operation shall be subjected to a twofold safety review by the licensee. A full scale simulator should be used if possible and to a suitable extent for verification of operational procedures. Procedures for maintenance which are important to safety are also included in the requirement. Maintenance programmes shall be documented. Inspection and testing of mechanical components shall be carried out according to qualified methods and verified procedures (Chapter 5, Sections 2 and 3, and SSMFS 2008:13).

19.1.3. Engineering and technical support

The licensee shall ensure that adequate personnel is available with the necessary competence and suitability needed for those tasks which are important for safety, and also ensure that this is documented. A long term staffing plan is required (Chapter 2, Section 3, item 5). The requirement also covers contractors to an applicable extent. The use of contractors as opposed to own personnel should be carefully considered in order to develop and maintain adequate in-house competence. The necessary competence should always exist in-house for ordering, managing and evaluating the result of work important for safety which is carried out by contractors.

19.1.4. Reporting of incidents in a timely manner

SSMFS 2008:1 contains a chapter about reporting requirements and an annex specifying these requirements for various types of events (chapter 7 and annex 4). The following is a brief summary:

- Reporting within one hour: emergency alarm events, scram with complications and events and conditions in category 1 (see below)
- Reporting within 16 hours: INES events at level 2 or higher
- Reporting within 7 days: a comprehensive investigation report about alarm events or events and conditions in category 1
- Reporting within 30 days: a comprehensive investigation report of events and conditions in category 2, INES events at level 1 and scram reports

In addition, there are requirements on daily reporting of the operational state, power level and the occurrence of any abnormal events or disturbances, such as scrams, and requirements on a comprehensive annual report summarizing all experience important for the safety of the plant. Specifications are given about the contents of the different reports and further interpretation of the reporting requirements is given in the general advice.

In one of the basic paragraphs of SSMFS 2008:1, requirements are given on actions to be taken by the licensee in cases of deficiencies in barriers or in the defence-in depth system. These actions include the first assessment and classification, adjustment of the operational state, implementation of necessary measures, performing of safety review and reporting to SSM. A graded approach is allowed here. In Appendix 1 of the regulations, events and conditions are specified which require different responses, depending on the category of events they belong to. Three categories are defined in this annex:

19.1.5. Category 1

Severe deficiency observed in one or more barriers or in the defence-in-depth system, as well as a founded suspicion that safety is severely threatened. (In these cases the facility must be brought to a safe state without delay).

19.1.6. Category 2

Deficiency observed in one barrier or in the defence-in-depth system, which is less severe than that which is referred to in category 1, as well as a founded suspicion that safety is threatened. (In these cases the facility is allowed to continue operation under certain limitations and controls).

19.1.7. Category 3

Temporary deficiency in the defence-in-depth system which arises when such an event or condition is corrected and which, without measures, could lead to a more severe condition, and which is pre-analysed in the OLCs. (In these cases the facility is allowed to continue operation under necessary limitations during the implementation of the corrective measures.)

In all three cases, corrective measures shall be subjected to a twofold safety review by the licensee. The results of these reviews shall be submitted to SSM. After a category 1 event, SSM has to approve the measures taken before the licensee is allowed to restart the plant.

Regarding category 3 events, there is no requirement to make a specific report to SSM. It is sufficient to make a compilation of these events in the annual report.

The regulations also include an important general clause saying that the plant shall without delay be brought to a safe state if it is found to function in an unexpected way or in cases where it is difficult to determine how serious an identified deficiency is.

19.1.8. Programmes to collect and analyse operating experience

The licensee shall ensure that experience of importance for safety from the own activities, and from similar activities in other relevant facilities, is continuously analysed, acted upon and communicated to the personnel concerned (Chapter 2, Section 3, item 7). It is further required that all events and detected conditions which are important to safety are investigated in a systematic manner, in order to determine sequences and causes, as well as to establish the measures needed in order to restore the safety margins and to prevent recurrence. The results of the investigations shall be disseminated within the organisation and shall contribute to the development of safety at the facility (Chapter 5, Section 4). Results of investigations shall also be reported to SSM (see above) SSM ensures event reporting to the proper international organizations and other regulatory bodies.

19.1.9. Generation of radioactive waste, conditioning and disposal

Since 1 November 2012, requirements regarding handling, processing and storage are stipulated in regulation SSMFS 2008:1. The regulations of SSM include requirements on:

- Measures for the safe on-site handling, storage or disposal of radioactive waste and spent nuclear fuel shall be described in the safety analysis report of the facility. The measures for on-site handling shall consider the requirements on safety imposed by the continued handling, transport and disposal of the radioactive material.
- Legally binding requirements to minimize radioactive waste to a reasonable extent.
- When designing and operating a facility concerning space for storage, the need to inspect the stored radioactive waste and spent nuclear fuel must be met as well as the need for extra space for moving radioactive materials.

- Plans for the management, including disposal, of all radioactive material present at the facility that is likely to arise at the facility or is brought to the facility in other ways. The plans shall for example include amounts of different categories of the radioactive material, estimated nuclide-specific content and sorting, treatment and interim storage of the radioactive material. The plans shall be included in the safety analysis report before the facility is taken into operation.
- Only packages approved by SSM may be transported to a geological repository (such as the SFR facility) for disposal. For such approval, the waste packages must comply with the conditions stated in the safety analysis report of the repository.
- An up-to-date inventory of the radioactive waste on-site. The inventory of nuclear materials including spent nuclear fuel is regulated in SSMFS 2008:3.
- Waste acceptance criteria shall be derived based on the properties of the radioactive material that can be received for storage, disposal or some other management. These criteria shall, to the extent that is feasible and possible, be formulated while taking into account safety and radiation protection throughout all stages of the ongoing management. The waste acceptance criteria shall form part of the safety analysis report.
- Procedures must also be in place for management of radioactive material that does not meet the waste acceptance criteria in that it is returned to the consignor, or by taking measures to rectify identified deviations.

For shallow land burial facilities, the waste acceptance criteria are stated in the licence conditions.

19.2 Measures taken by the licence holders

19.2.1. Initial authorization

No nuclear units have been commissioned in Sweden since 1985, when Forsmark 3 and Oskarshamn 3 went into commercial operation and no more units are currently planned or under construction.

As described in Chapter 14, all the Swedish units in operation have been analysed and have followed commissioning programmes in order to demonstrate their consistency with the design and safety requirements, specified in laws, regulations and standards, that existed when they were started up, see also Chapter 14. The objective of this programme was to develop a PSAR before commencing the design, construction and erection of the unit, and later a FSAR, and through extensive operational tests to verify both the function of the different individual systems and their joint function. Permission to start up the units was given in steps by SSM after completion of the different operational tests, and reporting the results of the startup stages. Permission for commercial operation was granted when the operational tests were completed satisfactorily and reported, and FSAR and technical specifications had been accepted.

19.2.2. Operational limits and conditions

The operational limits and conditions of the reactor units are included in an operational document named STF in Sweden (Säkerhetstekniska driftförutsättningar = Technical Specifications). This document is considered one of the cornerstones in the governing and regulation of the operations of the Swedish plants. As required by SSM, all control room operators and operations managers as well as engineers on duty at the plants are given extensive training, and annual retraining, on the intent and content of this document. Every STF is unit-specific and is in its basic version approved by SSM. STFs for the older BWRs were produced in close cooperation between the nuclear utilities and, consequently, the structure of the documents is similar for all STFs in the country. STF for the PWRs have followed the Westinghouse Owners Group (WOG) approach. The scope and contents of the Swedish STFs are similar to those used in other European countries.

The original STF for each unit is derived from the safety analyses in FSAR, where the behaviour of the unit, when different transients and abnormal events occurred, was described. However, several revisions have been made in all STFs since the first versions were issued. Corrections and updating takes place, when new and better knowledge is available, either from research and tests or operational experience. Suggestions for changes in STF are subjected to a twofold safety review (see section 14.2) and are notified to SSM. Today the STF are integrated into the plant management systems in order to ensure adequate use and updating of the document.

Parts of STF, which have been developed after commissioning of the plants are the specific chapters concerning the conditions during refuelling outages, and the description of the background to the document (STF BASIS). The STF documents are now part of the SAR documentation and further efforts are under way to describe all the SAR conditions upon which STF is based. SSM has increased its requirements on the scope of STF, for instance it should also cover non-safety system equipment of importance for the defence-in-depth, such as fire protection systems, certain electrical systems and the feed-water systems. For these, requirements on operability have been included to a varied extent in the STF.

The STF of the Westinghouse PWRs in Ringhals have been updated in a specific project using the MERITS concept (Methodically Engineered Restructured and Improved Technical Specifications) documented in NUREG 1431 rev 1 and following experience within the Westinghouse Owners Group, documented in NUREG-1431 rev. 2. The new STFs have been approved by SSM.

19.2.3. Operability verification

Before equipment is accepted for continuous operation after maintenance or in-service inspection it must pass an operability test, which verifies that the equipment fulfils the specified operational requirements. Integral tests to verify the complete system function are being used more frequently, instead of component testing. After some events in the plants, large efforts have been invested to improve the procedures and tools for the verification of operability.

19.2.4. Approved procedures

All activities that directly affect the operation of the plants are governed by procedures of different kinds. Normal operation, emergency operation and functional tests are included in this category. Maintenance activities according to an approved maintenance programme are also to a great extent accomplished according to procedures, however, not always as detailed as operating procedures, where activities are described in sequences step by step. Signing of steps carried out in the procedures is mandatory in most cases, in order to confirm their completion and facilitate verification. Temporary modifications and special conditions are controlled by operation notices (DM, *driftmeddelanden*) with limited validity. These are reviewed and issued by the operations department according to a special procedure.

The operations personnel are deeply involved in the production and revision of operating procedures. Normally, the different process systems are ”distributed” among the shift teams and one part of the team ownership is the responsibility to develop, review and revise the related operating procedures.

The development of procedures follows specified directives, which include reviewing the documents, normally, by more than one person other than the author, before being approved by the operations manager or someone else at the corresponding level. The same applies for revising procedures. Revising procedures is to be carried out continuously, or particularly in the case of maintenance procedures, when new experience is obtained.

The full-scale simulators of the units are used as far as possible when verifying a new or revised operating procedure.

19.2.5. Response to anticipated operational occurrences and accidents

Emergency procedures have been developed in order to deal with anticipated operational occurrences and accident conditions. Emergency procedures for individual systems are complemented with symptom based emergency operating procedures for all units (*Övergripande störningsinstruktioner*, ÖSI). ÖSI are used by the shift supervisors and represent a link to the safety panel display system (SPDS) which exist in different layouts at all Swedish units as part of the accident management system. The emergency management procedures are also the link to the emergency planning and its criteria for raising an alarm. The common structure of procedures is shown in Figure 12.

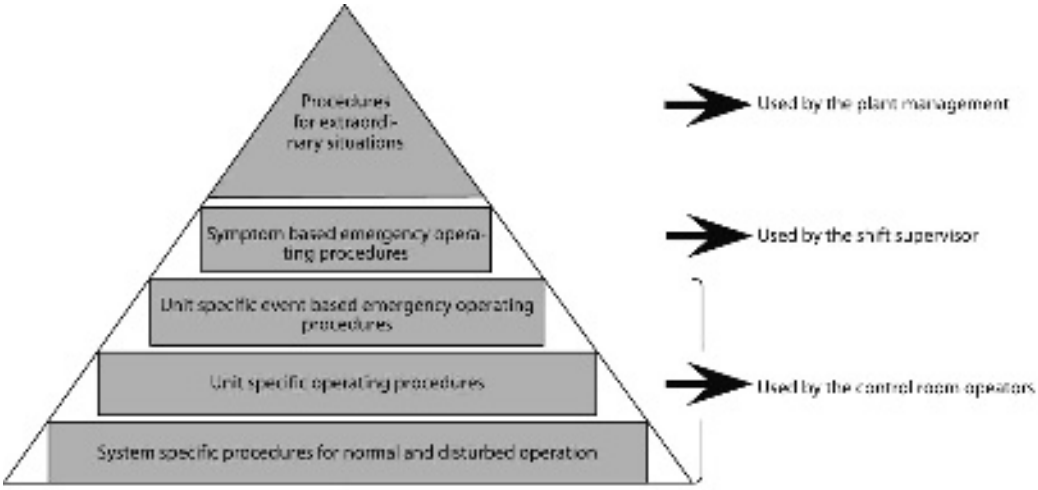

Figure 12 Overview of the main procedures applied during emergency situations. Other documents exist as reference to the main procedures. The level of the detail and the number of procedures decreases with the height of the pyramid

Procedures for extraordinary situations, at the top of the pyramid, include procedures for the engineer-on-duty, the operative emergency response plan, and technical handbooks for dealing with accidents beyond design, including severe accidents.

19.2.6. Engineering and technical support

The nuclear power plants are staffed with personnel to be able to account for the responsibilities of the licensees. All licensees have these competences available in their organisation. This means that even if some external support still must be used, the plants have the competence and the capability of evaluating the results of analyses, calculations, etc. performed.

The former engineering group (VPC) within Vattenfall acted previously as an internal consultant. It has been incorporated as a line function, Project & Services, since January 2013.

19.2.7. Incident reporting

Incidents significant to safety are reported according to the non-routine reporting requirements in the STFs. These have been updated to comply with the latest regulations of SSM, SSMFS 2008:1. Two types of licensee event reports (LER) exist. The more severe one, called category 1, requires that the plant inform SSM within an hour. An extensive report shall be submitted within seven days from the time of the event and the full analysis of the event and appropriate measures to prevent recurrence shall be approved by SSM before the re-start of the reactor. Only a very limited number of events of this category have occurred at the Swedish plants over the years. These events are typically also of such a dignity to warrant fast reporting (level 2 or higher) according to INES.

The other type of LER, called category 2, is used for less severe events. This type of event is mentioned in the daily report, which is sent to the regulatory body, followed up by a final report within 30 days (see section 19.3.4).

Events that have resulted in a reactor shut down are analysed by the operations department and independently reviewed by the safety department and on some sites by the safety committee before the re-start of the unit. The reports are reviewed at different levels within the operating organisation and approved by the operations or production manager before submittal. As well as a wide distribution within the own organisation and to the regulatory body, the reports are sent to the other Swedish nuclear power plants.

The front side of the standardised report form describes the event in general: identification number, title, reference to the relevant STF paragraph, date of discovery and length of time for corrective actions, conditions at the time it occurred, system consequences, a contact person at the plant and activities concerned by the event. On the reverse side of the document the event is described under the following headings:

- Event course and operational consequence
- Safety significance
- Direct and root causes
- Planned/decided measures
- Lessons learned by the event

If the description of the event is extensive, additional pages are added to the form.

Reports are also required in accordance with STF when the permitted levels of activity release from the plant are exceeded, or in the event of unusually high radiation exposure to individuals at the plant.

An overview of INES events, classified as INES Level 1 and above at nuclear facilities and reported by Sweden between 2003 and 2012, is given in Figure 13. Of these events, one event at a nuclear power plant (Forsmark 1 in 2006) was classified as INES Level 2. The other events were rated as INES Level 1 or as below the scale.

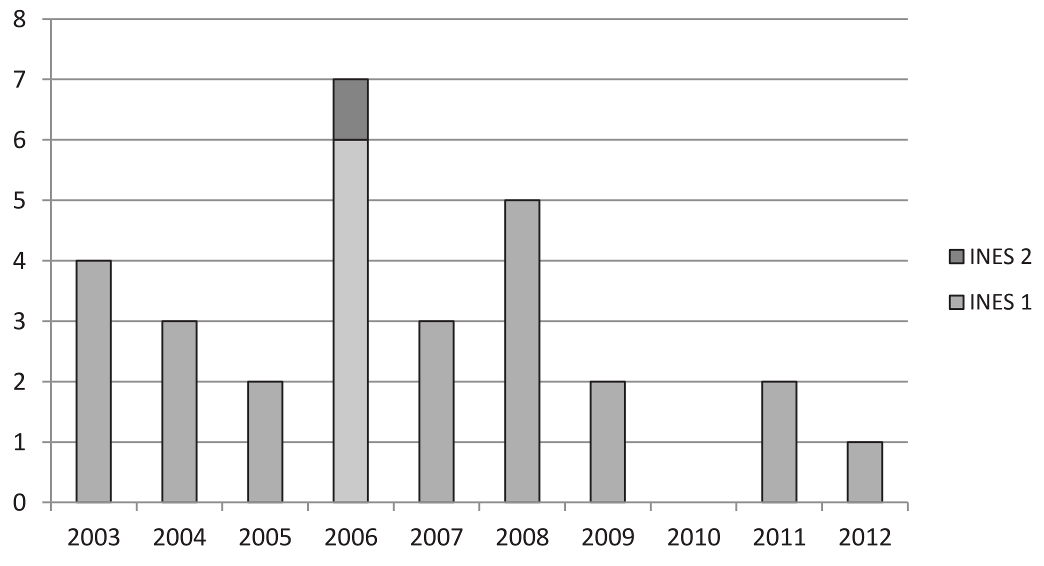

Figure 13 Events in Sweden classified as INES 1 or above during the period 2003-2012.

19.2.8. Operating experience analysis and feedback

The objective of the operating experience analysis and feedback programme is to learn from experience, own plant and others, and prevent recurrences of events, particularly those that might affect the safety of the plants. The operating experience process consists of a wide variety of activities within the plant organisation as well as externally. A number of activities are described briefly below.

The major operating experience feedback comes from the plant itself and consequently the largest plant analysis effort is focused on the events in their own reactors. The event reports constitute an essential input into this analysis task, together with specific operating experience reports that are written for events. The reports include events not meeting the event criteria for LERs, minor events and near-misses.

SSM has strict requirements on systematic investigations and analyses of events. The event sequence has to be fully clarified including circumstances that could have prevented or stopped the sequence, causes and root causes identified, consequences clarified and measures defined to prevent recurrence. MTO analysis is used when root-causes and analysis in-depth are deemed necessary or relevant. MTO analysis is an established methodology (see section 12.2) executed by a team of trained investigators available at all plants. In recent years, up to 10 MTO analyses have been made each year at Ringhals, Oskarshamn and Forsmark.

Analyses of scram and other event reports from Swedish, as well as Finnish BWRs, and also certain international information, are performed by ERFATOM, which is a group formed by the Swedish and Finnish BWR operators and Westinghouse Electric Sweden AB. The analysis work is performed by representatives of the organizations above, and the result of the work is reported to the plants every other week, complemented with topical and annual reports. The event reports are classified. Severe events also include recommendations (REK) directed towards the Swedish and Finnish operators.

The procedure for operating experience feedback (OEF, termed ERF in Swedish) describes the requirements, the organisation and the working principles for experience feedback in the Nordic system. A common organisation reviews experience feedback from the reactor safety, environmental and occupational safety areas. Other experience feedback initiated by ERFATOM, or any other internal organisation, is also reviewed and placed in a common database.

The working principles of the Nordic system include screening by different organizations:

- KSU is responsible for collecting and assessing foreign events for the ERFATOM process. The sources are mainly WANO, IAEA, OECD-NEA, USNRC and NucNet and is collected, reviewed, screened and sorted by KSU. The events are classified on a 6 grade scale.
- ERFATOM assesses all events, including scram reports, from the Nordic BWR reactors, and when appropriate, also related to PWR reactors. International events, classified 1-3 by KSU, are also assessed by ERFATOM as:
  - Category A: Significant importance to reactor safety
  - Category B: Moderate importance to reactor safety, or
  - Category C: Minor importance to reactor safety
  - Category N: Not applicable for Nordic BWRs
- The task of OEF is to collect, evaluate, document, and follow-up experience from the Nordic system.
- The OEF database to register and manage issues and measures taken.
- All ERFATOM Category "A" events, WANO SOERs, and ERFATOM recommendations are managed in the respective plant OEF system.

For the PWRs, a process was established in Ringhals after the TMI-2 accident to systematically collect and analyse safety issues relevant for the Swedish units. Various sources of information have been used: NRC, INPO and WANO documents as well as information from Westinghouse and Framatome Owners Groups. More recently the same process has also been used to evaluate information from international sources, relevant for the Ringhals 1 BWR.

All Swedish event reports are registered in the ERFATOM event database, operated by KSU. The database is intended for the use by the operators, who have direct access and can use it for specific purposes.

The plants report events to the WANO Event Reporting Program. The events are selected by WANO criteria and are sent for world-wide distribution.

KSU also produces an annual report summarizing the performance of the Swedish nuclear power plants, unit by unit, but also containing special articles about interesting events. The annual report is also issued in English in order to make the information available to foreign operators.

As mentioned, the Swedish utilities also participate in various owners groups. Some plants also have direct cooperation with other plants (i.e. Forsmark with the Finnish plant TVO and the German plant Gundremmingen and Oskarshamn cooperate with other E.ON plants). Participation in owners groups is considered valuable, although it is a more demanding task to screen out the operating experience relevant to a specific plant design.

19.2.9. Operating experience feedback function at Ringhals

All the licensees have functions for operating experience feedback. Ringhals is described in detail below as an example.

The operating experience function at Ringhals is divided into two key areas. These are the "deviation programme" (Corrective Action Programme) and the OPEX, which consists of one internal and one external function.

Corrective Action Programme (CAP)

CAP shall identify deviations/lessons learned in daily operation, implement corrective actions and follow them up. In addition CAP provides input to the internal experience feedback.

Every department manager is responsible to promote the reporting of deviations (observations) from expected (status, quality, etc.) and the operations managers are accountable for ensuring that the process screening-analyses-corrective action and follow up, is working.

The number of observations (condition reports) has increased during recent years and this process is promoted by the managers. Observations are deviations from normal, near misses, etc., normally called low level reporting.

The CAP-processes (see Figure 14) are carried out at four different locations in Ringhals and they all provide input to the internal OPEX by addressing relevant observations to the central OPEX-group.

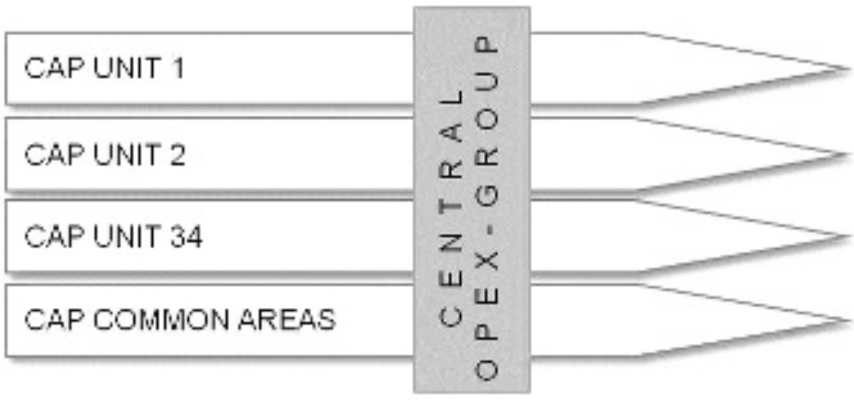

Figure 14 CAP-processes at Ringhals.

Internal OPEX

Every department is responsible for handling OPEX within their organisation and this is done in different ways. The section for Human performance (RQH) is the secretariat and administers the OPEX system support. This section also has the responsibility for the OPEX process.

The purpose is to identify and spread lessons learned between units/departments in order to enhance reactor safety and plant performance. Internal and human performance related events / experiences are managed by a central OPEX group with weekly meetings. The Operation-, Maintenance-, Radiological protection-, Technical support (TS)-departments and Human Performance section are represented in the central OPEX group. Other departments have interfaces to this group.

Department managers appoint members to the internal OPEX-group. Experience, analytic approach and credibility in the organisation are considered necessary qualities for this role.

Input to the central OPEX-group consists of observations that could be of interest to other units/departments, information from colleagues from the other nuclear plants in Sweden and from ERFATOM.

External OPEX

The Production unit's safety board (SPS) meets 3-4 times per year and constitutes the decision-making body for the external experience feedback. The SPS chooses members to the external OPEX-group based upon technical skills and organizational position.

The overall objective is to enhance reactor safety by making use of external events/lessons learned.

Selected technical issues with a possible impact on nuclear safety are investigated within the organisation and then evaluated by a multidisciplinary technical group composed of 10 persons. The group meets 11 times a year. The SPS decides upon recommendations and if actions are to be taken or not.

19.2.10. Operating experience feedback function at Forsmark

In October 2007 a new department for operating experience feedback (OEF) and analysis support was established at FKA. The department is composed of 9 persons qualified in plant operation, personnel training and human performance.

One main task for this office is to manage all OEF in a systematic and structured way. This includes implementation of a process for CAP. The other main task is to supply and support the entire organisation with adequate knowledge to perform root cause analysis for events that affect the interplay between Man, Technology and Organisation (MTO).

To support handling and processing of OE matters all main departments at FKA have OE-coordinators who are responsible to ensure that matters are handled as specified by the OEF process and to ensure that actions are taken within their unit. The following units have their own coordinator: Main plant operations units Forsmark 1, 2, and 3; Maintenance Unit; Technical Support Unit; Human Resources Unit; Safety and Environment Unit and Services and Facilities Unit.

19.2.11. Operating experience feedback function at Oskarshamn

All departments and sections are responsible for applying experience feedback in the daily work within their own area of activity. Departments and sections at OKG principally obtain experience feedback from engineers from the quality department and from OKG's ERF group (Operational Experience Feedback), consisting of key members from various parts of the organisation. Production managers handle deviations and events with regard to reactor safety at the daily operational review meetings, held every weekday. Specific key issues are dealt with at the operations assessment meetings, where the production managers require a broad illustration and a cause analysis of the issues being dealt with. Depending on the nature and complexity of the event, MTO analysis on different levels is conducted, in order to as far as possible be able to focus resources and examination time on events that require special examination. External issues are assessed with regard to the possibility that a similar event may occur at OKG. In this assessment it is vital not to exclude any issues based on dissimilarities found, such as an object, but instead looking for associated similarities and details.

Corrective action programme (CAP)

OKG works with a CAP to manage events, nonconformities and suggestions for improvement. These are referred to collectively as 'observations'. The main objective of the observations is to identify the right measures to reduce the risk of recurrence, but also to eliminate the risk of more serious events.

All employees at OKG are trained to report observations. Managers and other key roles are trained to actively manage observations, perform analysis and execute proposed actions. Experiences from the plant are shared through the CAP process by CAP coordinators assigned to each production unit. The expectations are that all nonconformities and improvement proposals are dealt with in the process, which visualizes the drive for continuous improvements and making it clear when setting priorities.

Nearly 10 people work with coordination, training and providing support to the organization in the process.

19.2.12. Operating experience for training at KSU

OEF is included in the KSU training programmes for plant personnel. A special unit at KSU is responsible for screening and selection of OEF suitable for the training programmes. OEF information is forwarded to the training departments in the form of OEF modules sorted by the training categories. The international OE information suitable for training is selected from WANO, IAEA and NRC reports. The trainers can also consult the OE engineers for additional suitable OEs for training of operating personnel.

19.2.13. Management of spent nuclear fuel and radioactive waste

Spent fuel

Spent fuel is stored in the fuel pools at the nuclear power plants, usually for an average of two years while awaiting transportation by m/s Sigyn to the central interim storage facility (Clab) located at the Oskarshamn plant. This transportation is a routine operation.

Waste management, general objectives

The general objectives of the waste management at the locations of the nuclear power plants are to:

- minimize the amount of waste,
- ensure that all nuclear waste is handled and conditioned for disposal according to existing regulatory requirements, and
- accomplish the waste management in a safe and cost-efficient way with the least possible impact on human health and the environment.

Waste minimization is in certain cases substituted by optimising the waste generation, in which consideration is taken to radiation doses and costs. Minimization of the amount of waste is, for example, achieved by reducing the amounts and kinds of materials brought into radiological controlled areas, and by separation of waste at source.

Radioactive wastes generated at the nuclear power plants belong to different categories, and consequently they are treated and disposed of stored in various ways, as described briefly below.

Intermediate-level waste

This type of waste is dominated by filters and spent ion exchange resins, which are commonly solidified with cement or bitumen in steel drums, or in moulds of reinforced concrete or carbon steel. The cement or bitumen immobilises the waste, while the moulds contain the waste forms, and in the case of concrete moulds also provide radiation shielding. Some intermediate-level resins with lower activity content are packaged in concrete tanks and dehydrated without solidification.

Metal scrap, and other kinds of solid wastes above a certain level of activity, also belong to this category and are packaged in concrete or steel moulds, compacted, if possible, and grouted with concrete.

Low and very low-level waste

After segregation, with respect to activity content and combustibility, the low-level waste is compacted into bales or packaged in drums or cases, which are placed in standard freight containers. Some waste with very low activity level is disposed of in shallow land burial sites at the nuclear power plants. To minimize infiltration the waste is covered with bentonite liners and/or compacted clays. The sealing layers are protected by an approximately 1 meter thick layer of moraine. Some combustible low-level waste is shipped to Studsvik, where it is incinerated in a special facility. The ashes are collected in steel drums, which in turn are grouted with concrete in overpacks of steel.

Registration, storage and disposal of waste

For all waste management at the sites registration and documentation is required. Examples of data concerning the waste that is documented and entered into a database are:

- Identity
- Type of package
- Date of production
- Category of waste
- Weight
- Activity content, nuclide composition and dose rate at the surface or at a distance of 1m
- Position during intermediate storage

The production and storage of radioactive waste at the plants is reported annually to SSM and SKB.

The intermediate and low-level waste at the nuclear power plants is stored temporarily in rock caverns or storage buildings awaiting transportation to the repository SFR, located near the Forsmark nuclear power plant. Prior to shipping to SFR the types of waste packages have to be approved by SSM with regard to safety during transport and for disposal (waste acceptance).

19.3 Regulatory control

19.3.1. Operational limits and conditions

Notifications about changes in STF and exemptions from STF are reviewed as described in section 14.3. SSM is of the opinion that the STFs are updated regularly at all plants.

19.3.2. Procedures

Operational, emergency and maintenance procedures are normally not reviewed by SSM. Only in connection with event investigations or specific inspections would SSM ask for a procedure to be submitted for review.

19.3.3. Engineering and technical support

Except for the independent safety review functions and involvement in the national competence situation as reported in Chapter 11, SSM has not so far specifically reviewed the engineering and technical support available at the nuclear power plants. In connection with other inspections and reviews, the specialist staffing situation has occasionally been commented upon.

19.3.4. Incident reporting

The number of licensee event reports (category 2 LERs) varies in the range of 20-70 per year and reactor over the past few years. The total number is approximately 350-400 LERs each year.

For more serious incidents, SSM has a procedure for making an on-site rapid investigation. This procedure has been used in a few cases over the past few years. Licensee reporting has improved over the past few years and in most cases, provides the necessary information, together with SSM verifications on-site, for making the needed regulatory decisions.

19.3.5. Experience feedback analysis

All reports from the licensees are screened each week by a group of 6-8 persons from the reactor safety department. These persons have different expert knowledge and make a first assessment as to whether these reports need further regulatory attention. The licensees are asked for clarifications if necessary. If there are any regulatory concerns, the issue is brought up at the management meeting of the department and further measures to be taken by SSM are decided. The event analysis group can also issue Information Notices to raise concerns in a broader sense.

All LERs and scram reports from the Swedish nuclear power reactors have been registered in a database at SSM ('ASKEN') since the 1970s. All events are indexed and searchable and can easily be trended across many parameters.

19.3.6. Radioactive waste

Inspection of the on-site management of radioactive waste is carried out by SSM inspectors. SSM also inspects the radiation protection aspects of the waste handling. A major effort by the specialists at SSM is to review and approve the types of waste packages produced at the nuclear power plants for disposal in SFR.

19.4 Conclusion

Sweden complies with the obligations of Article 19.

C. PLANNED ACTIVITIES TO IMPROVE SAFETY

Activities planned to improve the safety situation include ongoing retrofitting to comply with SSM regulation SSMFS 2008:17 and modernization and new measures as a response to ENSREG's stress tests following the accident at the Fukushima Daiichi NPP.

Retrofitting to comply with regulation SSMFS 2008:17 - Design and Construction of Nuclear Power Reactors

Work to enhance safety at Swedish reactors has been ongoing since 2004. Regulation SSMFS 2008:17 was initially issued in 2004. Most of the measures have already been taken. These are:

- Diversification of safety functions;
- Redundancy in connection with fire;
- Segregation as protection against internal events;
- Protection against pipe break;
- Enhancements of coolability in connection with severe accidents;
- Automatic liquid boron injection system;
- Updating of environment qualification; and
- Protection against external hazards.

Activities that remain to be implemented are:

Forsmark 1-3

- Separation measures in some I&C rooms (F1/F2)
- Measures to enable RPS to be initiated with two diverse sensors (F3)

Ringhals 1-4

- Environment Qualification update (R1, R2)
- Installation of diversified pressure relief valves (R1)
- Measures on isolation valves (R2)
- Piping to be able to reach cold shutdown at certain pipe breaks (R2)
- Measure at feedwater system (R2)
- Separation measures against internal events (R2, R3, R4)
- Seismic measures (R2)
- Long term coolability (R1, R2, R3)
- Loads from pipe breaks (R3, R4)
- Emergency control room (R3, R4)

Oskarshamn 1-3

At Oskarshamn 2, the eight-month safety modernization outage beginning in June 2013 consists of a large number of actions aimed at enhancing safety, of which many are shown in the list of measures below. The following measures remain to be implemented at the Oskarshamn plant:

- Measures on isolation valves (O2)
- Environmental qualification (O1/O3)

- Measures to improve diversification of wide level transmitters and the in-core instrumentation system (O3)
- Analysis of dependencies between the hydraulic scram system and the pressure relief system, including measures if necessary.
- Implementation of automatic liquid boron injection system (O1/O2)
- Long-term coolability (O1/O2)
- Modernization of I&C in order to improve separation and diversification (O2)
- Measures for protection against external events (O2)
- Measures to enable RPS to be initiated by two diverse sensors (O1/O2)
- Measures against pipe breaks (O1/02)
- New emergency control room (O2)
- Measures due to risk of turbine missiles (O2)
- Installation of diversified relief valves (ADS) for the RPV (verified for two phase flow) (O2)
- Installation of new diversified residual heat removal systems (two trains) (O2)
- Installation of four new emergency diesel generators. Two of them diversified from the other two and with diversified cooling systems (O2).

Measures following the Fukushima Daiichi NPP accident

The European Council requested that stress tests be performed on all European nuclear power plants. On the basis of the proposal of WENRA, the European Commission and ENSREG, the members decided to agree upon criteria and methodology for performing “stress tests” applied to European reactors.

The national reports were completed in December 2011 and a consolidated European report was presented to the European Council in June 2012. ENSREG issued an action plan on 25 August 2012 whose objective was to ensure that the lessons from Fukushima Daiichi were addressed by the national regulators in a consistent manner. In October, the European Commission issued reports regarding the stress tests in order to communicate with the European Council. In these reports, Forsmark plant units were clearly identified as reactors that are particularly vulnerable to a loss of AC power.

The Swedish action plan was issued by SSM in December 2012. It was developed with the intention of managing all plant weaknesses identified by the EU stress tests as well as by other fora 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. This is because 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, which consists of further analyses and investigations, are scheduled in three different categories, 2013, 2014 and 2015, corresponding to the year when the measures shall be completed.

See sections A7 and B10.4 for more details.

Modernization and safety

Improvement of leadership, management system, safety culture and operating experience programme at Ringhals

In July 2009, SSM placed Ringhals under special supervision to more closely monitor the safety situation at the plant. A decision was issued, including four special conditions for operation and four separate items that were to be reported back to SSM.

Ringhals has compiled a comprehensive report based on the decision. The report is in many parts based on Ringhals' preparation programme for the OSART review (performed in March 2010) and focuses on strengthened leadership and improvements to the quality of the management system and programmes for safety culture and operating experience. Ringhals strives for effects on the number of safety-related events, number of deviations in internal audits, number of decisions from the regulatory body and increased station quality shown through a reduced number of production disturbances. Details are given in section B 10.3.

Ringhals reports the status of these initiatives to the regulator every six months. To date, a number of actions have been taken and some are still ongoing.

Leadership improvements include "leaders in the field", leadership support and training and work/life balance for leaders. Work on the management system has been initiated and will continue until March 2015. The implementation of Nuclear Safety Culture Process, an assessment of WANO's eight principles for safety culture, was started in 2012 with a pilot study, which will be assessed in order to decide on the way forward. There have also been a number of workshops as part of the Vattenfall initiative "Hearts & Minds". Initiatives have been taken to improve reporting and trending of operating experiences. Areas that still need improvement include understanding of the OPEX system, lower level event investigations and use of different sources for sharing experiences.

Ringhals has also initiated work to improve procedures and to analyse trends in indicators.

Need for improvements in leadership, management and safety assessment at OKG

In December 2012, SSM placed OKG under special supervision. A detailed background to this decision is given in section B10.3.2.

OKG has initiated an evaluation of the contributing factors behind the identified deficiencies. OKG is currently developing an action plan in order to address these deficiencies, a schedule for the identified actions, as well as strategies for evaluating the desired effects from performed actions. The documentation is to be sent to SSM for review by early August 2013.

Review of SSM's regulatory framework as a result of a self-assessment[23]

On 8 April 2010, the Government tasked SSM with performing a self-assessment of the regulatory model, its performance and the long-term evolution of safety on the part of the Swedish nuclear programme [SSM 2010/1557-10]. Following the accident at the Fukushima Daiichi NPP, the task was broadened to also incorporate the conclusions drawn from the stress test activities.

In the view of SSM, the regulatory framework is effective and long-term nuclear safety can be maintained, provided that more enhancement work is performed and the licensees succeed with efficient ageing management programmes. Regulations need to be clearer and expressed in more detail while emanating from international (IAEA) and European practice (WENRA) and SSM has in 2013 started the drafting of new as well as revised regulations.

New injunctions are foreseen by SSM:

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[23] Assignment from the Swedish Government

1. SSM has concluded that more actions need to be taken to fulfil the requirements imposed by SSMFS 2008:17.
2. New actions as a result of the stress tests of ENSREG.
3. Actions to strengthen the capability to withstand external hazards and loss of electrical power and ultimate heat sink. Also, actions on enhancements to severe accident management will be a requirement.
4. SSM is preparing new requirements on independent core cooling.

Continued financial support of higher nuclear education and research

In the areas of higher nuclear education and research, collaboration is ongoing between the Swedish nuclear industry and SSM to help finance the Swedish Centre of Nuclear Technology. This will change starting in 2014 when the present agreement, in effect during the period 2008-2013, expires. Due to the recent new build application submitted by Vattenfall, a process is in place to separate activities to avoid conflicts of interest. Hence, as of 2014, financial support to institutions of higher education will be provided by industry and SSM at amounts similar to previous years, but in two separate flows: one directly from SSM and one from a joint consortium of industry partners. Details are given in sections A 4 and B 11.5.

Further reduction of releases of radioactive substances to the environment

The results of the programme to reduce radioactive releases to the water and air are satisfactory. There is a trend showing improvement and the facilities demonstrated good performance over the past two years. No cases of fuel damage occurred at the nuclear power plants, allowing for good quality working conditions as well as a low level of releases to the air. There is, however, a trace of an old event from the 1980s at R2 that makes it difficult to reduce I-131 releases to the air. There is a need for technological solutions for further reduction in releases to the air from the nuclear power plants.

Releases of radioactive particles to water might be reduced when the evaporator condense separation is in place. However, this measure requires a sustainable solution for radioactive waste treatment at SFR. Work is ongoing to resolve the issue. Further details are presented in section B15.3

Appendix 1

Vattenfall Nuclear Safety Policy *(ID GP 12)*

Nuclear power is one of Vattenfall's major energy sources, and will, due to its very low CO_2 emissions, excellent environmental performance, competitiveness and safe operation continue to be an important part of the energy system for the foreseeable future.

Safe Nuclear Operation is the product of:

- People who are well trained, informed, empowered and dedicated and uphold the highest personal and professional standards
- An organisation that has a positive and strong Nuclear Safety Culture
- Processes that are robust, and consider problem identification and resolution
- Facilities, that are well designed, well operated and well maintained

In operating our nuclear facilities, our greatest responsibility is to protect the public, the environment and our employees from the potentially adverse effects of our operations.

Vattenfall aims to attain leading global position in Nuclear Safety, and to be recognised for it. To achieve this:

WE PUT SAFETY FIRST: In all activities, sufficiently conservative margins should be applied in a proactive manner with regard to nuclear, radiological, environmental and industrial safety. We comply with existing laws and regulations, meet national and international safety standards, and our goal is a leading global position in Nuclear Safety.

WE SHALL HAVE A POSITIVE AND STRONG SAFETY CULTURE: A high degree of competence, motivation and commitment shall be maintained at all levels of the organisation. Nuclear Safety is the responsibility of every individual in our nuclear operations as well as of leadership and corporate.

WE SHALL HAVE A STRONG SAFETY MANAGEMENT: We shall apply challenging standards and expectations. We shall verify safe operation through our daily work and through periodic self-assessment. We shall validate our performance through independent reviews. We shall reinforce safe performance and behaviour.

WE SHALL USE CONTINUOUS IMPROVEMENTS: We shall actively search for best global praxis and strive for continuous improvements supported by proactive internal and external exchange of experience, new technology and R&D.

WE SHALL BE OPEN AND EAGER TO LEARN FROM OTHERS: We shall be open to learn from other nuclear operators and other sectors of society, and be willing to share our own experiences. Competition should not affect the exchange of safety-related information. Openness to the public and to media is of special importance in strengthening confidence for Vattenfall as a competent nuclear power utility.

EKS (E.ON Kärnkraft Sverige AB) Nuclear Safety Policy *(ID GP 12)*

Nuclear Safety Policy

The safety of our nuclear power plants is an indispensable prerequisite for the long term operation of these, as well as for protecting members of the public, our staff and investments. Hence, safety is a prerequisite for the public acceptance and economic efficiency, which in turn benefits our stakeholders and our name.

We have a clear safety strategy – Safety always has the utmost priority

We have a high standard of safety awareness

We strongly encourage and implement a culture of continuous improvement towards safety

We recognise our responsibilities and will communicate in an open and direct manner

We encourage a self-critical culture

We need and use information for all issues relating to safety

We systematically analyse the technological, organizational and human resources factors in order to identify weaknesses. We then prioritise deficiencies and implement corrective measures.

We are active in the research and development of issues related to safety and are thus

able to evaluate and implement the results

We use internal and external operating experience to prevent events to be repeated

We have clear responsibilities for safety related issues

We have an efficient organisation and fixed procedures which clearly define the responsibilities that enhance the individual obligations concerning safety, thus ensuring the safe management of plant operation

Our Safety Management System ensures that all prerequisites for safe and reliable operation are maintained

We have the appropriate qualified and experienced personnel, who are able to undertake safety related tasks

Sufficient staff will always be available for the safe operation of the plant

Each employee is responsible for his or her own tasks and is considered to be a professional in his area

Working constantly with safety

In order to have a good safety culture, the group culture and the management commitment are of essential importance

We comply with the instructions and procedures laid down for working safely and improve them when required

Our plants are permanently maintained at a high safety standard

We are committed to openness and will communicate on all issues related to nuclear safety

We are a company that is prepared to learn and continuously endeavours to improve safety culture and safety management

We work with suppliers who ensure us that they can provide a high level of competence

Appendix 2

E.ON's Nuclear Safety Council

The overall goal is to improve safety and set a common standard within the E.ON Group for nuclear safety.

The goal is to review the operation of nuclear power plants by using for instance different safety data, safety indicators, safety program and trends in the area of safety culture.

The council will promote safety development by, for instance, exchange of experience, good practice and evaluation of research.

On a general level, the objectives of the Safety Council are the following:

1. To follow up and assess the safety based of the E.ON Nuclear Safety Policy and to propose changes or modifications in order to promote safety
2. To follow up and assess safety as reflected by the use of safety indicators and periodic reviews, and to identify trends. In particular, the Council shall promote internal safety audit programs at the plants and monitor and assess the outcome of such planning
3. To follow up how nuclear safety issues are managed and prioritized in the long-term planning
4. To follow up and assess operational experiences and research
5. To follow up the developments of new guidelines and requirements
6. To promote that a positive development of the safety culture will take place
7. To promote a common view/standards related to issues important to safety for the nuclear power plants
8. To promote the exchange of experience and good practice in the safety area

Members of the Safety Council are encouraged to propose important safety issues to be included in the meeting agenda. The members are chosen from both the German and Swedish organizations of E.ON including representatives from the power plants. Some members are external not belonging to E.ON. The E.ON Nuclear Safety Council gives advice to the CEO of the Global Unit Generation.

Appendix 3

Implemented modifications at Swedish reactors 1995-2009

A summary of major modifications undertaken between 1995 and 2009 is provided below. The most recent modifications are listed in section B 18.1 and planned future modifications in section B 6.2.

Oskarshamn 1

The major renovation of Oskarshamn 1 in the early 1990s showed that the reactor pressure vessel was in good condition and capable of operating for more than its 40-year design lifetime. The utility OKG therefore decided to further modernize the unit in order to ensure safe and economical operation for at least another 20 years. Projects performed included:

- further checking of the reactor pressure vessel and main circulation pipes, and exchange of reactor internals (moderator vessel, moderator vessel head and steam separators)
- further safety improvements in the core cooling systems, electric power system (two additional trains) and the I & C system (introducing digitalised systems for neutron flux monitoring and the reactor protection system) including modernization of the control room
- improvement of the turbine (main exchange of HP and LP turbines) to increase availability and thermal efficiency, adding at least 20 MWe to the power output.

This modernization programme was implemented during extended outages and completed in 1999.

By 2002 the following further measures were completed, and the corresponding functions and systems ready for operation:

- a new safety concept based on the safety requirements for modern nuclear power plants
- new and modernized systems for performing safety functions
- a modified concept for the reactor protection system and safety I&C including a new emergency control room
- a modified concept for electrical power supply, and
- a new emergency control building, as well as some modifications to existing buildings.

The modernization of the safety systems was achieved by a functional group concept consisting of three diversified possibilities for emergency core cooling and residual heat removal. The first group comprises the unique auxiliary condenser and a new independent demineralised water supply line connected to the demineralised water storage tank. The second group comprises the twofold auxiliary feed-water system, the four power-operated relief valves and the two-train containment heat removal system, while the third group consists of the two-train low-pressure emergency core cooling system (100% each) and the two-train containment heat removal chain. The installations and components of the third group are designed and qualified to withstand seismic loads.

The emergency power supply system consists of four separated safety trains. Two of them are powered by two new diesel generator sets, while the other two are powered by the re-qualified existing diesel generator sets.

The new I&C system for safety systems and the new reactor protection system are of a fourfold redundant design with total physical and functional separation.

A completely new emergency control building was erected to house the new systems and components. The following main components were installed in the building:

- two diesel generators including auxiliary systems and fuel tanks, completely physically separated
- two secondary cooling water pumps and heat exchangers for safety systems
- two auxiliary feed-water booster pumps
- a pump for supplying demineralised water to the auxiliary condenser basin
- switch gears, batteries and bus bars for the redundant safety trains
- a physically separated four-train reactor protection system and other I&C equipment
- a redundant ventilation system

The building has been designed to withstand all types of external events, including the seismic loads defined for Oskarshamn 1. Installations and electrical and mechanical equipment in the building have also been designed and qualified to withstand seismic loads.

The original main control room is completely modernized in areas in which new equipment has been installed, whereas existing control equipment and panels have been maintained to which no changes have been made. A safety desk has been installed having the same function as a safety display panel. The emergency control room contains a replica of the safety desk and the control functions. Upgraded cooling of the condensation pool was performed in 2004 at the same time as a diversified power supply for the programmable reactor protection system was implemented.

During the previous review period the following modifications were made at Oskarshamn 1:

- A monitoring system was installed to detect core instability/power oscillations
- Recombiners installed in the turbine off-gas system to reduce radioactive discharge to the environment
- Ventilation valves installed on top of the reactor to evacuate non-condensable gases following a loss of coolant accident

Oskarshamn 2

The modernization project started as a pre-study in 1996 based on an inventory of known weaknesses and experience from operation of the units. The modernization measures include a chemical decontamination of the reactor pressure vessel (RPV) and the primary systems, as in Oskarshamn 1, in order to reduce the dose rates, followed by tests of the RPV and its internal parts.

Examples of measures already completed are

- replacement of piping, penetrations and valves in the primary systems within the reactor containment
- replacement of reactor internals, i.e. steam separators, and core spray nozzles and piping
- changes in the reactor protection system including addition of a new condition for reactor scram
- improvements of some fire protection systems
- improvements to reduce risks for hydrogen explosions in piping systems
- upgrading of feed water control system to programmable I&C equipment.
- separation of safety and non-safety related equipment in some I&C systems.

The ongoing PLEX project includes modifications to comply with SSMFS 2008:17 as well as replacement of critical components in order to achieve a 60-year life. The 2007, 2009 and 2013 outages are the periods of time for performance of the main work. The following modifications were performed at Oskarshamn 2 during the previous review period:

- Modernization of the feed water system inside the containment involving the exchange of inboard isolation valves, installation of pipe break valves and cyclone filters

- New turbine I&C including operator interface in the control room
- Environmental qualification of components outside the containment
- Modernization and power uprate project began erecting buildings intended for new safety I&C, bus bars, auxiliary power diesels and diversified cooling chain
- Recombiners installed in the turbine off-gas system to reduce radioactive discharges to the environment
- Ventilation valves installed on top of the reactor to evacuate non-condensable gases following a loss of coolant accident
- Replacement of the low pressure turbines
- Deep water intake construction implemented and commissioned
- Preparatory work performed for the new diversified cooling chain executed

Oskarshamn 3

Major safety modifications have been implemented at Oskarshamn 3 in recent years. The PULS (Power Uprate with Licensed Safety) project included a power uprate, modifications to comply with SSMFS 2008:17 as well as replacement of critical components in order to achieve a 60-year operating life. The power uprate of Oskarshamn 3 to 3900 MWth and 1450 MWe gross is complete. This corresponds to 129% of the original design (3020 MWth). The uprated plant is planned for operation until 2045 (60-year lifetime). The main part of the work was performed during the 2009 outage.

A great number of modifications were made in order to improve safety. For example, nuclide-specific on-line measurement was installed in the turbine offgas system with the purpose of achieving early detection of fuel failures. Experience from the events at Forsmark 1 on 25 July 2006 resulted in the redesign of the auto switching automatics for the diesel bus bars at voltages of less than 85%.

Some other examples of the modifications implemented during the PULS-outage are listed below:

- Replacement of internal parts in the RPV
- Replacement of main steam isolation valves
- Installation of new aggregate and station transformers
- Installation of a new generator
- Replacement of high-pressure turbine and all low-pressure turbines
- Installation of two new scram modules in system 354
- Replacement of all main circulation pumps in system 313
- Replacement of all main cool water-pumps in system 441
- Installation of new logic chains
- Installation of new diversified cooling chains

Forsmark 1–3

The first comprehensive modernization programme for the Forsmark plant, Program 2000, started in 1995, and was completed in 2000. Another strategy and modernization plan was then adopted, Program P40+, that contained modernization items, of which 70% are aimed at maintaining technical status, 20% for safety upgrades and 10% for dose reduction and environmental improvements.

The following major measures have been completed:

- removal of the core spray nozzles in the reactor pressure vessel after analyses showing that all safety requirements are met with injection only. The advantages are: less non-destructive testing will be required in the future, releasing resources for other safety work; avoiding the risk for costly repairs; and lower doses to the personnel
- core grids and other reactor internals have been replaced in units (F1–2)
- replacement of equipment in the main circulation pumps to reduce transients on the fuel at loss of external power
- prevention of oxy-hydrogen in steam systems
- diversified reactor vessel level measurement
- new equipment for physical protection
- improved fire safety and security systems
- alteration of the reactor's auxiliary cooling circuits, separation of power supplies and increase in Capacity (F1)
- replacement of electrical control boards in the main control room (F2)
- replacement of 6 kV switchboards (F1, F2)
- modification of the reactor pressure vessel head sprinkler (F2)
- modernization of the power measurement system (F2)
- modification of the cooling chain for increased capacity and separation of power supply connections (F2)
- new automatic stop of reactor building ventilation in case of loss of heating system for the building (F3)
- new low pressure turbines (F1-2005, F2-2006, F3-2004)

Forsmark 1

- Modernization of instrumentation for activity measurement in the off-gas system. These modifications comprise detectors as well as electronics.
- Measures to deal with slowly decreasing voltage in the external grid. Relay protection modification to disconnect the external grid if the voltage decreases to less than 85% for 10 sec.
- Improved capacity and physical separation of cooling chains to the condensation pool. These cooling chains are now divided in four sub divisions.
- Partial scram upgraded. Modification comprises design as well as conditions for the activation of partial scram.
- Installation of cyclone filters in the feed water system inside the containment. The purpose of these filters is to collect debris that could cause fuel damage.
- Redesign of the sequence for control rod screw activation in order to fulfil requirements on diversity.
- Replacement of the power range monitoring system. The new system contains protection against power oscillations.
- Improved fire protection of safety functions by additional spray nozzles in culverts containing power and I&C cables.
- New high voltage switchgear for connection of Forsmark 1 to the 400kV grid.

Forsmark 2

- Partial scram upgraded. Modification comprises design as well as conditions for the activation of partial scram.

- Replacement of the power range monitor system. The new system contains protection against power oscillations
- Modernization of instrumentation for activity measurement in the off-gas system. These modifications comprise detectors as well as electronics.
- Measures to handle slow decreasing voltage in the outside grid. Relay protection modification to disconnect the external grid if the voltage decreases to less than 85% for 10 sec.
- Improved fire protection of safety functions by additional spray nozzles in culverts containing power and I&C cables
- New RPV-internals. Moderator vessel head, steam and moisture separators installed.
- Diversified reactivity control implemented. Automatization of the initiation of the boron injection system
- New main steam inboard isolation valves installed
- Reconstruction of the sequence for control rod screw activation in order to fulfil requirements on diversity
- New high voltage switchgear for connection of Forsmark 2 to the 400kV grid
- New high pressure turbines installed in 2009

Forsmark 3

- Measures to handle slow decreasing voltage in outside grid. Relay protection modification to disconnect the outside grid if the voltage decreases to less than 85% for 10 sec.
- Diversified source for emergency feed water to the RPV
- Partial scram upgraded. Modification comprises design as well as conditions for the activation of partial scram
- New nuclide-specific on-line measurement equipment in the stack
- Separation of operational and safety functions in the power system with battery back-up

Ringhals 1–4

The renewal programme for the Ringhals plant was initiated in 1997, and the following major measures have been completed.

- the SPRINT project (replacement of primary system piping) (R1)
- verification and improvement of piping supports (R1)
- exchange of control rod indication and manoeuvring system (R1)
- introduction of alarm for core instability (R1)
- separation of electric power supply of core cooling systems (R1)
- improvements in fire protection systems (R1, R2, R3, R4)
- improvements of the safety valves of the pressurizer (R2, R3, R4)
- replacements and improvement in the electrical supply systems for improved separation and safety (R2)
- modernization of the radiation monitoring system (R2, R3, R4)
- modernization of the safety injection pumps including vibration monitoring (R3, R4)
- upgrading with redundant cooling of the charging pumps at shut-down (R3, R4)
- modernization of vibration measurement/monitoring of the reactor coolant pumps (R3, R4)
- introduction of cavitation alarms on the residual heat removal pumps (R3, R4)
- fire system modernizations (R1, R2, R3, R4)

- measures to cope with containment sump blockage during design basis accidents (R2, R3, R4)
- improved battery capacity during station black-out (R2, R3, R4)
- securing of piping for the pressurizer. (R2, R3, R4)
- a new main fire water ring installed for the site of units1 and 2
- pressurizer relief valves replaced/modified (R2)
- replacement of toroid plates (R2)
- modernization of 110 V DC systems with new switchboards (R2)
- a fourth level measurement channel installed in the steam generators (R2)
- completions for the Twice-project, replacement I & C equipment including the main control room (R2)
- reactor pressure vessel heads replaced (R3, R4)
- pressurizer relief valves replaced/modified (R3, R4)
- new emergency core cooling strainers fitted in the bottom of the containments (R3, R4)

Ringhals 1

- Part two of fire protection modernization programme completed.
- Diversified source for feed water to the core spray system installed.
- Modernization project RPS/SP2 completed. The main purpose of these modifications is to increase the level of separation in order to strengthen protection against fire and to mitigate common cause failures, i.e. to improve diversity in safety functions. Major modifications consist of modernization of the reactor protection system and improvement of the residual heat removal systems.

Ringhals 2

- Passive autocatalytic recombiners installed in the containment
- Implementation of the TWICE-project. I&C equipment replaced with new technology. Modifications include new main control room (MCR), all I&C and cables connected to MCR together with sensors and measuring apparatus in the plant.

Ringhals 3 and 4

- Diesel back up power supply to the spent fuel pool cooling systems installed
- Passive autocatalytic recombiners installed in the containment
- The GREAT power uprate project completed, thermal power increased to 3144 MW (R3)
- Upgraded capacity in the heat exchangers for the spent fuel pool cooling systems
- Power operated relief valves of the pressurizer qualified to withstand water blowing
- Improved fire protection in the relay and cable spreading rooms
- Environmental qualification of components in the turbine and auxillary building

Appendix 4

Swedish response to IAEA action plan

Safety assessments in the light of the accident at TEPCO's Fukushima Daiichi Nuclear Power Station

Sweden has through the participation in the EU stress tests undertaken assessment of the safety vulnerabilities of nuclear power plants in the light of lessons learned to date from the accident.

IAEA peer reviews

Sweden has hosted and sent experts to participate in IAEA peer review missions. Further information is found in B.9.

Emergency preparedness and response

Sweden has performed and participated in national and international exercises and implemented a number of measures to strengthen the national emergency preparedness and response, which are further described in sections A.7 and B.16.

National regulatory bodies

In 2012 SSM presented an investigation to the Government that included an assessment of the Swedish supervisory model as compared to international standards and experience. Sweden is also hosting an international workshop on regulatory strategies and effectiveness in cooperation with OECD/NEA.

Operating organizations

Maintaining a strong safety culture in the operation of nuclear plants is considered vital by the Swedish utilities and is emphasised in the policies of the different plants and in their strategic plans. Management at all levels, including the managing directors, is involved in activities to enhance the safety culture and to stress the responsibility of all personnel to work actively in maintaining and developing the safety culture standard.

IAEA OSART missions have been performed at all three Swedish reactor sites in the period 2008-2010, and subsequently follow-up missions in 2010-2012. The utilities in Sweden have traditionally been quite active in international cooperation to enhance nuclear safety by sharing experience, contributing to work with international regulation and guidelines and participating in safety assessments and peer reviews such as WANO peer reviews. Several Swedish nuclear power plant staff members participate each year in WANO as well as OSART review missions outside of Sweden. Participation as an expert is considered of great value to the individuals as well as their plant organizations

IAEA Safety Standards

Sweden is a member of CSS, RASSC, NUSSC, WASSC and TRANSC and participates in the review and strengthening of IAEA Safety Standards

International legal framework

Sweden is a member of all the relevant conventions and represented in the Effectiveness and Transparency working groups

Capacity building

All licensees actively work to transfer knowledge from experienced staff, soon to retire, to the next generation. The planning builds on mapping of strategic competence needs and individual plans to replace key personnel. Other approaches include trainee programmes and the involvement of young engineers together with highly experienced staff in modernization and development projects as well as in international R&D projects. Additionally SSM provides funding of research and educational programs at university level to maintain a high level of expertise within Sweden.

Protection of people and the environment from ionising radiation

New developments in emergency preparedness led to a revision of Swedish regulations. There are new requirements for obtaining protective equipment in drawn out or long-term events and improvements in increased demands on having an alternative command and control centre not located near the power plant and having alternative communications possibilities. Also, a national digital radio system for public safety and security has been further consolidated within the nuclear emergency and response community.

Departementsserien 2013

Kronologisk förteckning

1. På vägen till en grönare framtid – utmaningar och möjligheter.
   Delutredning från Framtidskommissionen. SB.
2. Delaktighet i framtiden – utmaningar för jämställdhet, demokrati och integration.
   Delutredning från Framtidskommissionen. SB.
3. Framtida utmaningar för sammanhållning och rättvisa.
   Delutredning från Framtidskommissionen. SB.
4. Fysioterapeut
   – ny skyddad yrkestitel för sjukgymnaster. S.
5. Permanent utvidgad målgrupp för etableringslagen. A.
6. Utbildningar för nyanlända elever. Mottagande och skolgång. U.
7. Om katastrofmedicin som en del av svenska insatser utomlands m.m. S.
8. Framtidens välfärd och den åldrande befolkningen.
   Delutredning från Framtidskommissionen. SB
9. Lätt byte. Enklare att välja ny leverantör av elektroniska kommunikationstjänster. N.
10. Domstolsdatalag. Ju.
11. Ändringar i bestämmelser om straff och administrativa sanktioner vid fiske. L.
12. Marknadskontroll av varor och annan närliggande tillsyn. UD.
13. Regionalt utvecklingsansvar i Västernorrlands län och Norrbottens län. S.
14. Regionalt utvecklingsansvar i Örebro län och Gävleborgs län. S.
15. Gemensamt konsumentskydd i EU. Ju.
16. Prospektansvar. Fi.
17. Straffavgift vid bristande kreditprövning. Ju.
18. Genomförande av Europaparlamentets och rådets direktiv om rätten till information vid straffrättsliga förfaranden. Ju.
19. Svenska framtidsutmaningar
    slutrapport från regeringens Framtidskommission. SB.
20. Vissa lagförslag med anledning av trepartssamtalen. A.
21. Lagvalsregler på obligationsrättens område
    – Rom I- och Rom II-förordningarna. Ju.
22. Behandlingen av personuppgifter vid Statens kriminaltekniska laboratorium. Ju.
23. Tid för undervisning
    – lärares arbete med skriftliga individuella utvecklingsplaner. U.
24. Ersättning för polisbevakning. Ju.
25. Skriftlig bekräftelse av vissa telefonavtal. Ju.
26. Viss kreditgivning till konsumenter. Fi.
27. Ett teknikoberoende skydd för den enskildes integritet vid kreditupplysning. Ju.
28. Straffansvar för eftersupning
    – om användning av alkohol och andra berusande medel efter färd. Ju.
29. Märkning av textilprodukter. Ju.
30. Skyndsamhetskrav och tidsfrister i ärenden med unga misstänkta och unga målsägande. Ju.
31. Allmänhetens insyn i partiers och valkandidaters finansiering. Ju.
32. Genomförande av det ändrade direktivet om varaktigt bosatta tredjelandsmedborgares ställning. Ju.
33. Vägval i en globaliserad värld. Fö.
34. Den nya polisorganisationen – kompletterande författningsändringar. Ju
35. Vägval för premiepensionen. Fi.
36. Förändrade åldersgränser och ökad flexibilitet i föräldraförsäkringen. S.
37. Ett uppföljningssystem för jämställdhetspolitiken. U.
38. Ränteskillnadsersättning m.m. vid bolån. Ju.
39. Kompletterande bestämmelser till EU-förordningen om sprängämnesprekursorer. Fö.
40. En samlad organisation på det funktionshinderspolitiska området. + Lättläst + Daisy. S.
41. Mellanchefsstrukturen i domstol och nya befordrade domaranställningar utan chefskap m.m. Ju.
42. Utbetalning av barnbidrag och flerbarnstillägg. S.
43. Olovlig hantering av avkodningsutrustning. Ku.
44. Lag om resenärers rättigheter
    – kompletterande bestämmelser. Ju.
45. Finansiell stabilitetspolitik
    – ett nytt politikområde under utveckling. Fi.

46. Förslag på förändringar inom det statliga bilstödet. S.
47. Skydd av personuppgifter för hotade och förföljda personer. Ju.
48. Informationsutbyte för bekämpning av allvarlig brottslighet
– genomförande av samarbetsavtal med Förenta staterna. Ju.
49. Högskolestiftelser
– en ny verksamhetsform för ökad handlingsfrihet. U.
50. Tid för undervisning
– lärares arbete med åtgärdsprogram. U.
51. En översyn av läkemedelslagen. S.
52. Den nationella organisationen för Horisont 2020. U.
53. Gymnasieingenjörsutbildning
– Vidareutbildning i form av ett fjärde tekniskt år i gymnasieskolan. U.
54. Kommunal medfinansiering av forsknings-infrastruktur inom Eric-konsortier. Fi.
55. Skärpt straff för mord. Ju.
56. Sweden's sixth national report under the Convention on Nuclear Safety
Swedish implementation of the obligations of the Convention. M.

Departementsserien 2013

Systematisk förteckning

Finansdepartementet

Utbildningsdepartementet

Landsbygdsdepartementet

Miljödepartementet

Näringsdepartementet

Kulturdepartementet

Arbetsmarknadsdepartementet

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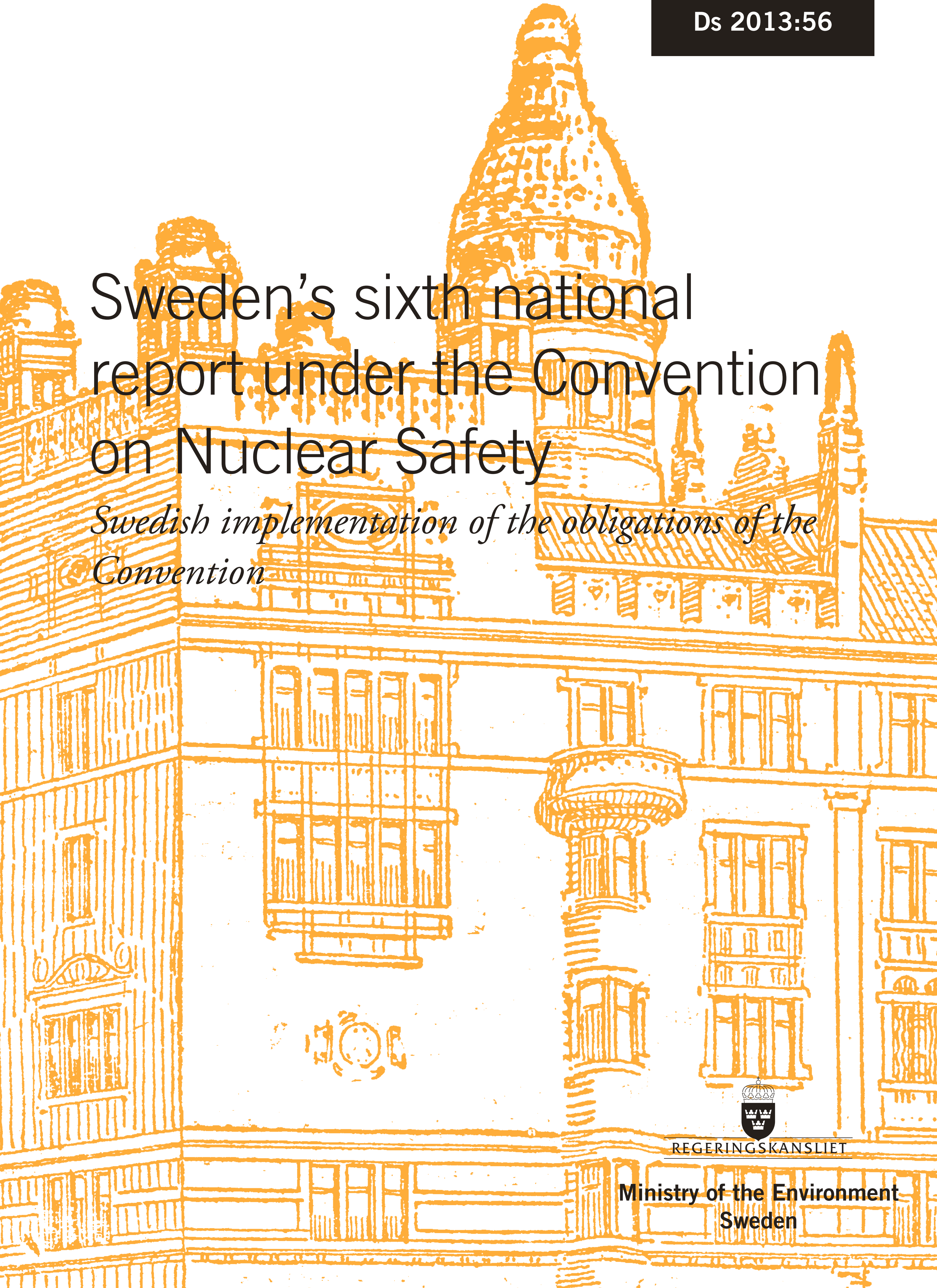

Sweden's sixth national report under the Convention on Nuclear Safety

Swedish implementation of the obligations of the Convention

REGERINGSKANSLIET

Ministry of the Environment
Sweden