Ds 2010:30

Sweden's fifth 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 September 20, 1994, the first day it was open for signing, during the ongoing General Conference at IAEA. The Convention was ratified about a year later, on September 11, 1995 and it entered into force on October 24, 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 and the fourth in August 2007. 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 and 2008 respectively.

A summary of highlights and issues raised about Sweden during the third review meeting 14-25 April 2008 can be found in section A 6. This section also includes an overview of those issues Sweden was asked to report about in its fifth national report (the present report).

A four persons working group with two representatives of the regulatory body the Swedish Radiation Safety Authority and one representative each of the reactor owners Vattenfall AB and E.ON Sweden AB has 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 four 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. Chapter 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 their own safety initiatives. Finally, information is provided about the means used by the regulatory body to supervise the measures taken by the license holders. Taken together this will provide evidence for meeting the obligations of the Convention.

Recommendations on the report structure issued as INFCIRC 572 Rev. 3 have been taken into account.

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

List of abbreviations

ALARA	As Low As Reasonable Achievable (a principle applied in radiation protection)
ANS	American Nuclear Society
ANSI	American National Standard Institute
ASME	American Society of Mechanical Engineers
BKAB	Barsebäck Kraft AB
BSS	The Basic Safety Standards Directive of the Euratom
BWR	Boiling Water Reactor
CAP	Corrective Action Programme
CCF	Common Cause Failure
CTH	Chalmers Tekniska Högskola (Chalmers University of Technology)
DBA	Design Basis Accident
BDBA	Beyond Design Basis Accident
DiDELSYS	OECD project on Defence In Depth of ELectrical SYStem
ENISS	European Nuclear Installations Safety Standards
ENSREG	European Nuclear Safety Regulator Group
EPRI	Electric Power Research Institute
EUR	European Utility Requirements
FKA	Forsmarks Kraftgrupp AB
FSAR	Final Safety Analysis Report
GDC	General Design Criteria
HRA	Human Reliability Analysis
HPES	Human Performance Enhancement System (a programme developed by INPO to improve human reliability)
I&C	Instrumentation and Control
ICRP	International Commission on Radiological Protection
IEEE	Institute of Electrical and Electronics Engineers
INES	International Nuclear Event Scale
INPO	Institute of Nuclear Power Operations
KSU	KärnkraftSäkerhet och Utbildning AB (the Swedish Nuclear Training and Safety Center)
KTH	Kungliga Tekniska Högskolan (Royal Institute of Technology)
LBB	Leak Before Break
LER	Licensee Event Report
LOCA	Loss of Coolant Accident
MTO	Interaction between Man-Technology and Organisation
NDT	Non Destructive Testing

NEA	Nuclear Energy Agency within OECD
NPP	Nuclear Power Plant (including all nuclear power units at one site)
NSMI	Vattenfall Nordic Safety Management Institute
NUREG	Nuclear Regulatory Guide (issued by the USNRC)
OEF	Operational Experience Feedback
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
QA	Quality Assurance
RAMA	Reactor Accident Mitigation Analysis
R&D	Research and Development
SAR	Safety Analysis Report
SKB	Svensk Kärnbränslehantering AB (the Swedish Nuclear Fuel and Waste Management Company)
SKI	Statens kärnkraftinspektion (Swedish Nuclear Power Inspectorate)
SKIFS	Statens kärnkraftinspektions författningssamling (the SKI Code of Statutes)
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)
SWEDAC	Swedish Board for Accreditation and Conformity Assessment
TMI	Three Mile Island (a US NPP)
TSO	Technical Support Organisation
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
WOG	Westinghouse Owners Group

EXECUTIVE SUMMARY: GENERAL CONCLUSIONS

The national reports to 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.

The Swedish nuclear power programme is under strong development. Major investments are being made or have been made in the 10 operating reactors to prepare for long-term operation. The Swedish Government has furthermore suggested amendments to the nuclear legislation which, if accepted by the Parliament, would make it possible to replace a permanently shut down reactor with a new one at the same sites.

The years 2007-2009 were characterized by major modifications of the nuclear power plants. The programmes to upgrade safety with regard to design and construction are still going on with a schedule to 2013. The remaining part of the planned power up rates is expected to add some 600 MWe to the current installed capacity. These programmes require a full effort of the operating organizations as well as the regulatory body, while not compromising the attention to day-to-day safety.

The Forsmark event in July 2006 revealed several design weaknesses in electrical system as well as it showed the importance of having a strong safety management in place and maintaining a vital safety culture. The regulatory body has followed up on these issues during the last review period. Of particular importance is not only to develop good formal management systems, but also to monitor and follow up how the systems function in the daily work at the plants.

Immediately after the Forsmark event, Forsmark, Ringhals and Oskarshamn verified that the units at the plants were operable. Analyses and plant modifications in some of the units ensured that the units met the requirements. Among other things the three licensees have performed updates of the SARs, issued new instructions, overhaul of maintenance instructions, development of the concept of diversification, redundancy and CCF-issues.

In July 2009 special operating conditions were issued for Ringhals after shortcomings were identified within the leadership and management for safety.

IAEA OSART-missions were performed at all three Swedish reactor sites in the period 2008-2010.

In April 2010, the Government asked SSM to investigate the long-term development of nuclear safety at the Swedish nuclear installations, especially with the view of extended operation of the reactors (> 50 years). SSM shall also make an appraisal of the Swedish supervision model as compared to international standards and experience. SSM has arranged for a full-scope IRRS-mission to Sweden in February 2012.

The government has in the 2010 appropriation letter for SSM asked for an investigation of national competence needed for the activities of SSM now and in the future. This investigation will be finished by early 2011.

The limited number of contractors and support companies on the market creates the need for strict time planning and the plants are dependent on each other. A delay of one project at one plant can cause a delay of a project in another plant. A few large contractors maintain high competence but there is a risk that they need to recruit less competent personnel to cut the workload peaks.

On July 1, 2008, the Swedish Radiation Safety Authority, SSM, was formed by merging the earlier nuclear safety and radiation protection authorities, SKI and SSI. The build-up of the authority is close to completion and although this required extra efforts and some temporary limitations, the supervising capacity was never jeopardised. SSM received extra staff resources but the full use of these will not be realised until 2010-2011. SSM is currently investigating its own and the expected anticipated national competence needs in the areas of the regulatory body control and supervision.

The Swedish acts regulating nuclear activities and radiation protection are currently under review. An inquiry is expected to present suggestions for new, integrated legislation in December 2010. Harmonization with provisions of the Environmental Code is expected.

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

- 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 the current legislation is being performed.
- A new strong regulatory body, the Swedish Radiation Safety Authority, was formed in July 2008 and its build-up is near completion. New economical resources have been allocated. There is an open and constructive dialogue between the regulatory body and the licensees.
- The owner companies are well established with 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. This has been demonstrated in recent years when plants and owner organizations have taken firm measures to deal with issues revealed by the Forsmark event in 2006.
- The economical support to higher nuclear and radiation protection research and education is maintained and developed.
- The average collective radiation doses at the 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 programmes are currently in place to modernise the designs in line with modern safety standards.

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

- Some design problems, such as delays and quality problems have been observed in the modernization and power up rate programmes at the nuclear power plants. These problems should not be allowed to negatively affect radiation safety.
- The success of the on-going modernisation and safety up-grade work, 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, and nuclear safety sector must carry on. The expertise and human resources situation must be continuously monitored and, when required, necessary actions taken.
- The licensees have to pay further attention to leadership and the quality of the management systems, as a result of new shortcomings found at some nuclear power plants.
- Broken and cracked control rod shaft extenders were found in Oskarshamn 3 and Forsmark 3. The problem is not yet solved due to its complexity, but measures are planned to be taken in the next years.

After its self-assessment Sweden concludes that it complies with the obligations of the Convention.

Sweden looks forward to reporting on the further development of these issues in its 2014 national report to the Convention.

A. INTRODUCTION

1. Current role of nuclear power in Swedish power production

The electric power consumption in Sweden was about 138 TWh in 2009 as compared with 144 TWh in 2008 and 146 TWh in 2007[1]. The total electric power production was 133 TWh in 2009 as compared with 146 TWh in 2008 and 145 TWh in 2007. The nuclear power production was 50.0 TWh in 2009, which is low compared with 61.3 TWh in 2008 and 64.3 TWh in 2007. The reason for the low power production in 2009 is the long outages due to extensive modernization and power upgrades in some of the nuclear power plants. The low production was compensated by import of electric power and a relatively low electric power consumption. The hydropower production during 2009 was 65.3 TWh as compared with 68.4 TWh 2008 and 65.5 TWh 2007. Fossil- and bio fuel power production amounted to about 15.9 TWh. Wind power production was 2.5 TWh. In a normal year, hydropower and nuclear power produce over 90 % of the total electricity production with about equal shares. The renewable sources bio- and wind power, which are favoured by the taxation system, are slowly gaining larger production shares.

The electrical power market has been deregulated since 1996 and in principle is competitive for both the production and sales 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. The first years after deregulation prices fell to very low levels but the last year's average prices have been higher, depending to a large extent on the availability of hydro and nuclear power.

2. Development of nuclear power in Sweden

In Sweden, nuclear technology started in 1947, when AB Atomenergi was constituted to carry out a development programme decided by the 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 from 1964 until 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 in the time period up to 1985. The twelve commercial reactors constructed in Sweden comprise 9 BWRs (ASEA-ATOM design) and 3 PWRs (Westinghouse design). As a result of political decisions, the twin BWR units Barsebäck 1 and 2 were finally shut down in 1999 and 2005 respectively.

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

3. Political development of the nuclear power issue

In December 2008 the 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 in April 2009 to draft new legislation making controlled generational shifts possible in the Swedish fleet of nuclear power facilities. The Inquiry was also charged with drafting proposals to make it possible to abolish the Nuclear Power Phase-Out Act (1997:1320) and

1 According to statistics from the organisation "Swedish Energy". The figures are corrected for the average outside temperature.

remove the prohibition in the Nuclear Activities Act (1984:3) on the construction of new nuclear power reactors.

One of the Inquiry's main tasks has been to propose amendments to the Nuclear Activities Act and the Environmental Code that will 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 replaces one of the older reactors that has been permanently shut down. The new nuclear power reactors may only be constructed at one of the sites where present reactors are in operation. The legislation is to provide the conditions for controlled generation shifts in Swedish nuclear power.

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

The legislative changes of relevant laws are suggested to enter into force on January 1, 2011. The Government suggests that the Parliament will empower the Government to decide when the new liability legislation will enter into force.

In its further work the Inquiry will consider the conditions for the coordinated regulation of activities in the area of nuclear technology and radiation protection and propose necessary amendments to acts and ordinances. In this work the Inquiry will study the possibilities of bringing together the provisions of the Nuclear Activities Act and the Radiation Protection Act in a single act and will also consider the possibilities for better coordination with the provisions of the Environmental Code.

4. Nuclear power installations in Sweden

At present, in May 2010, there are 10 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.

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 Barsebäck 2	1800 1800	615 615	BWR BWR	Barsebäck Kraft AB	1970 1972	1975-1999 1977-2005
Forsmark 1 Forsmark 2 Forsmark 3	2928 2928 3300	1022 1035 1229	BWR BWR BWR	Forsmarks Kraftgrupp AB	1971 1975 1978	1980 1981 1985
Oskarshamn 1 Oskarshamn 2 Oskarshamn 3	1375 1800 3900	492 661 1450	BWR BWR BWR	OKG Aktiebolag	1966 1969 1980	1972 1975 1985
Ringhals 1 Ringhals 2 Ringhals 3 Ringhals 4	2540 2652 3144 2775	887 900 1105 981	BWR PWR PWR PWR	Ringhals AB	1968 1969 1972 1973	1976 1975 1981 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 up rated during the period 1982-1989 between 6-10 % from the original licensed power levels. Further up rating is ongoing. An overview of all current plans is given in section B 6.3. 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 1. 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.

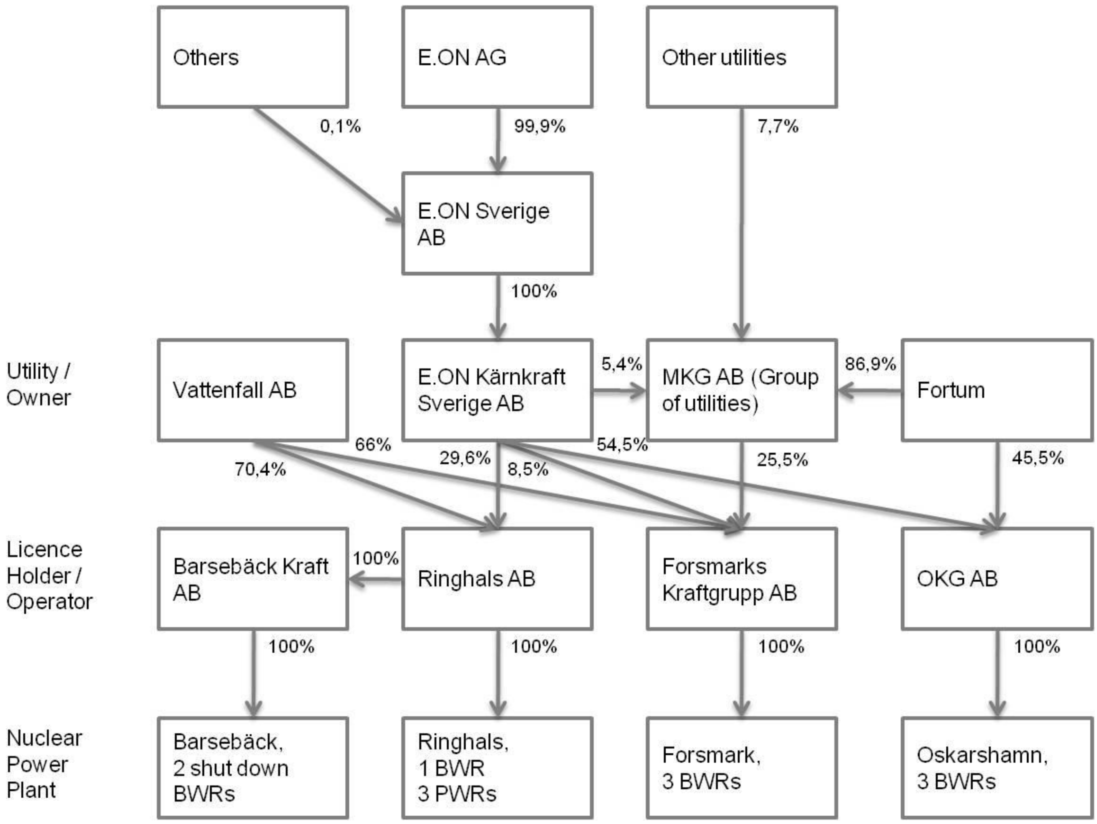

Figure 1. Utility structure and owner relations.

The staff figures for the different sites are shown in Table 2.

Nuclear power plant	Staff 2010	Staff 2003	Staff 1998
Barsebäck	40	344	430
Forsmark	1000	794	850
Oskarshamn	960	837	1050
Ringhals	1550	1162	1200

Table 2. Staffing of the Swedish nuclear power plants 2010 compared with 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 following the transfer of operations of the spent fuel storage CLAB. Section B 11.3 provides more details about the current staffing situation.

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.
- SKB (Swedish Nuclear Fuel and Waste Management Company): a company for dealing with spent nuclear fuel and radioactive waste. SKB owns and operates the intermediate storage of spent fuel (Clab) in Oskarshamn and the final storage for low and medium level 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.

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 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 an important 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 Swedish nuclear power programme, including the Studsvik facilities and the Westinghouse Electric Sweden AB fuel fabrication plant in Västerås, will generate approximately 25,000 m^3 spent fuel, 60,000 m^3 short-lived low and intermediate level waste, 16,000 m^3 long-lived low and intermediate level waste and 160,000 m^3 decommissioning waste (based on 50-years operation of Forsmark and Ringhals and 60-year operation of Oskarshamn.). The typical total annual production of low and intermediate level radioactive wastes (LILW) at the nuclear facilities is 1 000 - 1 500 m^3.

Existing waste management practices are the waste management at the facilities; the waste treatment facilities at Studsvik; the repository for radioactive operational waste, SFR; shallow land burials; the interim storage for spent nuclear fuel, Clab; the transportation system; and the use of clearance.

SFR is a repository for LILW resulting from the operation of Swedish nuclear programme. In addition 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 under the 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 2009 a total volume of 33,308 m^3 had been used. An extension of SFR, to allow for decommissioning wastes and longer operational periods, is in the planning stage and is expected to be operational by 2020. The final repository including the extension will have a waste storage 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 licences for the burials at the power plants are valid until 2025-2040 and limit the waste volume to 10,000 – 17,000 m^3 for each facility. Each of these burials is licensed for a maximum total activity of 100-200 GBq (maximum concentration of alpha-emitters a factor of thousand lower) except for Ringhals, the site with PWR reactors, for which 1100 GBq is allowed, accounting for up to 900 GBq of 63Ni in the wastes.

The spent nuclear fuel from all Swedish nuclear power reactors is stored in a central interim storage (Clab) situated at the Oskarshamn nuclear power plant. The fuel is stored in water pools in rock caverns at a depth of 25 m in the bedrock. Construction started in 1980 and it was taken into operation in 1985. The facility was subsequently extended with a second rock cavern and the total storage capacity is now 8,000 tonnes of spent fuel. 5,050 tonnes uranium were being stored there at the end of 2009.

Transportation 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 ship M/S Sigyn, transport casks and containers, and terminal vehicles for loading and unloading.

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 final repository for spent fuel, a repository 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.

The development work for the final repository of spent nuclear fuel has continued according to plan and in 2009 the SKB and their owners selected Forsmark as the site for the location of the final repository. In 2010 SKB will apply for the permits needed for the final repository in accordance with the Swedish Nuclear Activities Act. The SKB will simultaneously apply for permits for the interim storage facility (Clab), the encapsulation facility and the final repository in accordance with the Swedish Environmental Code. A licence application for the encapsulation plant according with the Nuclear Activities Act was made in 2006.

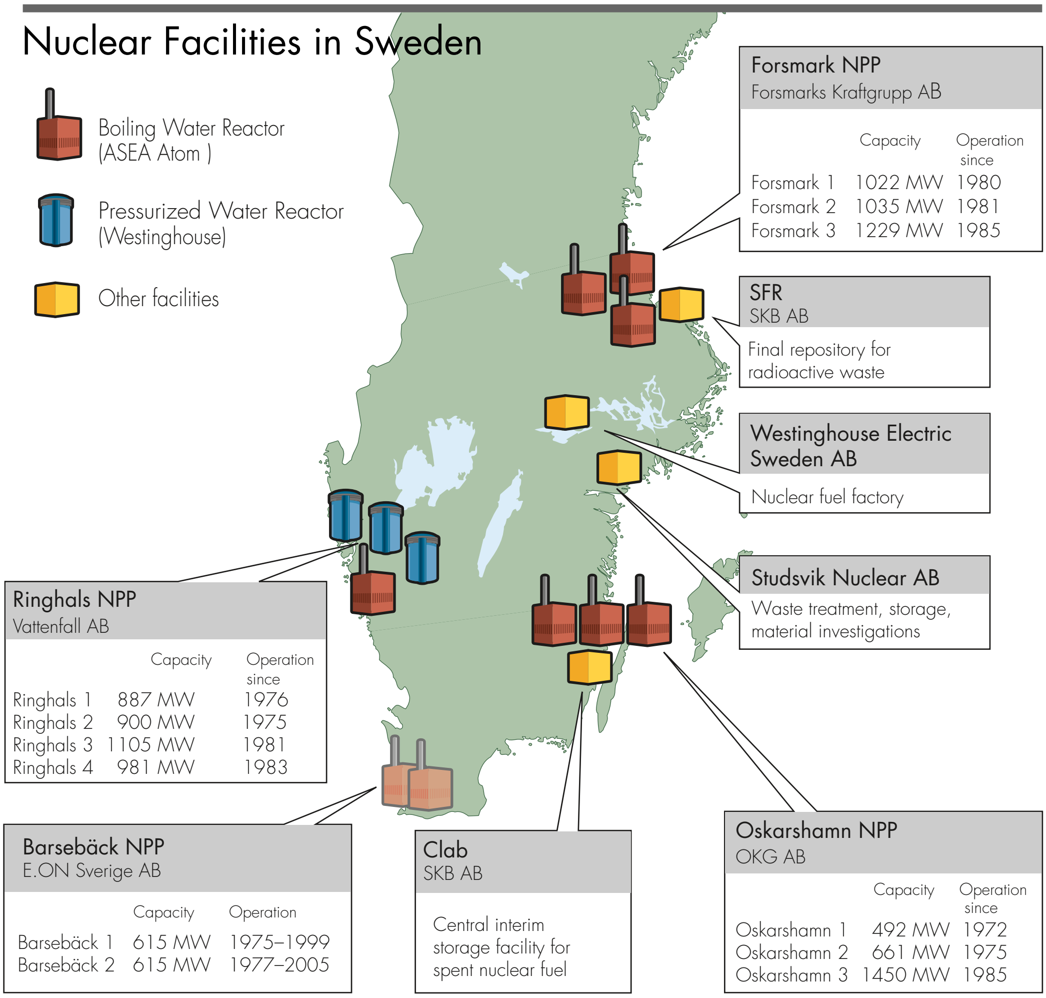

Figure 2. Location of the nuclear facilities in Sweden

Nuclear education, research and development

As mentioned in the fourth national report, the academic education in nuclear technology in Sweden is mainly concentrated to the Royal Institute of Technology in Stockholm (KTH), Chalmers University of Technology in Gothenburg (Chalmers) and Uppsala University (UU). At KTH the Swedish Centre of Nuclear Technology has existed since 1992. From having been oriented mainly towards KTH and support to doctoral students, the Centre now has as its aim also to support professor- and lecturer posts and post-graduate education in the nuclear field at the three universities. Ten professorships with a specific nuclear technology or human factors profile and twenty lectureships exist in Sweden for higher nuclear education and research. During 2008 about 370 students attended a nuclear course at the mentioned universities, but the actual number of students is less as students that participated in several courses have been counted more than once. This is however a considerable increase since the fourth Swedish national report, when the number of 200 students a year was reported. KTH and Chalmers have also started to give master courses with more applicants (about 50) than was originally expected.

Sweden has taken a systematic approach to maintain basic academic resources for higher nuclear education and research. This is in part done by an agreement between the Swedish nuclear industry and SSM to economically support the Swedish Centre of Nuclear Technology during a period of several years. The present agreement is valid 2008-2013 and there are efforts to expand the support by including more members in the Centre.

Cooperation between the nuclear industry and UU for training staff in nuclear technology and radiation protection was started and this effort has resulted in improved education.

Vattenfall AB is one of the founding shareholders of ENELA, European Nuclear Energy Leadership Academy - an initiative that will, among other things, strive to strengthen and expand the European pool of expertise. ENELA will have a one-year programme on nuclear energy management and will also run a programme to provide professionals and senior managers with a broad understanding of the global nuclear energy scene, in order to prepare them to take on more and larger responsibilities.

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.

SKI (now 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 further chapter 7). SSM participates actively in ENSREG (European Nuclear Safety Regulator Group), an expert body of senior officials from national regulatory or nuclear safety authorities from all 27 EU member states.

SSI (now SSM) was active in the work of the International Commission on Radiological Protection (ICRP); both chair and secretary were until recently from Sweden. 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 takes 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 (draft 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. The SSM staff has also been involved in many international expert missions; for example as experts in IAEA review service teams.

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.

International development cooperation programmes

The Swedish Radiation Safety Authority is involved in development cooperation with countries in Central and Eastern Europe. The aim is to enhance the safety at nuclear power plants in the region and improve radiation protection of people and the environment. SSM also works towards increasing the knowledge about and strengthening the control of nuclear non-proliferation in the region. The cooperation projects are mainly with Russia and the Ukraine but there are also some projects with Armenia, Georgia and Belarus. The development cooperation programme is based on Government decisions and is financed by the Foreign Ministry, the Environment Ministry, Sweden's International development Cooperation Agency, and the European Union. The total budget is of the order of 70 million Swedish crowns in a 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) – on-going since 1977 – and programmes and projects within EPRI and NRC in the US and OECD 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, and is today representing all the Swedish utilities. The EUR generic requirements have undergone detailed reviews by peer utilities worldwide, as well as by vendors and regulators, and the EUR document is now complete. The overall objective for the Swedish participation has been to obtain a basis for further development of the safety of the existing plants.

The EUR document today includes all the parts that were foreseen when the work started. Two sets of generic requirements have been developed: one dedicated to LWR nuclear islands the other two power generation plants. The document has been benchmarked vs. other sets of safety requirements: EPRI-URD, US regulatory requirements, and the IAEA requirements and guides. Beside the sets of generic requirements of EUR, the EUR promoters have produced evaluations of seven selected LWR designs that may be offered on the European market. Brought together, they make up volume 3 of the EUR document. The EUR document was also used as the base for the call for bids of the fifth Finnish nuclear unit that is currently under construction.

The number of participants has increased over the years, and the EUR group now involves the following partners: British Energy, Electricité de France, Fortum, Iberdrola, Nuclear Research & Consultancy Group, Rosenergoatom, Società gestione impiante nucleari, Tractebel, Teollisuuden Voima Oy, Swissnuclear, Vattenfall, VGB Powertech, EnergoAtom , CEZ, ENEL, and Endesa.

The EUR organisation analysed the WENRA reference levels mentioned above with regard to the last published issue of the EUR safety requirements, revision C of volumes 1 and 2, and the results were presented to WENRA. Together with ENISS, EUR is currently reviewing the new WENRA study: “Safety Objectives for New Power Reactors”.

Vattenfall WANO membership

Since 2009 Vattenfall has, as the first Swedish utility its own direct membership with WANO. The background is the Vattenfall ownership of nuclear facilities in both Sweden and Germany, and a wish from Vattenfall to have a stronger engagement in WANO activities. Earlier, membership was by country and then KSU coordinated this for all the plants in Sweden.

6. Highlights and issues in the discussion about Sweden at the 4th review meeting 2008

During the discussions it was clarified that there were no plans for new power plants in Sweden. The conditions for operations were stable and the existing nuclear power stations would continue to operate. The Swedish Government had decided to merge the two supervising authorities SKI and SSI into one authority. The merger was to be performed according to a well-defined plan but no extra resources would be available which could lead to some short-comings under a transitional period.

The modernization programmes at the nuclear facilities are planned to be completed around 2013. The programmes were judged to be extensive and would result in a significant workload, both at the nuclear facilities and at SKI (now SSM).

It was judged that the work load to deal with large modernization projects, up rates, emissions reductions and oversight of operating power plants is expected to be high and will be a challenge.

Sweden’s report was assessed to give a good overview of staffing and capability management and the various actions taken to secure adequate competence and resources, both at the nuclear facilities and at the regulatory authorities. Some staff increases had occurred and increases to handle the anticipated workload and retirements were approved.

Sweden had, over the period, been very active in the international safety cooperation work, for example within WENRA and WANO.

The Forsmark event, see section B 10.4, indicated the need for more focus in areas of safety culture and management and both SKI and the licensee had intensified their efforts in this area. The SKI had performed about 80 inspections related to the event. Sweden gave an open and honest account of the event and the follow-up actions. The follow-up was first performed at a very technical level and then followed up by the SKI. A management and cultural review examined the Forsmark plant, the corporate office of the company and looked at the adequacy of the regulatory practices. In addition it was noted that Sweden had requested IAEA OSART missions to all three operating sites. During the discussions it was encouraged that the Swedish plants use as many opportunities as possible to get independent input from peers – particularly in areas that will be under heavy demand during the modernization programmes.

Worker doses at the Swedish nuclear power plants remained below industry average and were judged to be a strong point of the Swedish programme. The radiation doses to the public (to the "critical group") from emissions are well below regulatory limits but benchmarking review indicated that emissions of radioactive substances are still high relative to international benchmarks. Sweden was actively pursuing further reductions.

Powers up rates at the power plants were expected to add 1275 MW of electrical power to the Swedish production capacity.

It was agreed that Sweden complied with the obligations of the Convention. The following points were lifted as good practices:

- There is currently a large programme committed and scheduled for modernization of the existing plants to be in line with modern safety standards
- The owner companies are well established with good financial records and demonstrate a commitment to maintain a high level of safety in their plants as evidenced by the large investment to up rate the facilities
- There is a focus to support higher nuclear research and education with committed funding
- There is a good open dialogue between Regulator and Licensees
- In response to the event at Forsmark in July 2006, assessments have been completed and necessary changes are being made. Assessments included reviews of plants, corporate organizations and the Regulatory Body. In addition, independent assessments (via OSART Missions) were requested for all Swedish nuclear plants to provide additional assurance of the accuracy of the corrective measures. Sweden's discussion of the event and lessons learned had been open and honest at International forums.

As challenges for Sweden during the years to come were mentioned:

- The work to modernize the Swedish nuclear power plants is very large and will require additional focus from licensees and oversight by the Regulatory Body to execute error free
- The releases to the environment of radioactive substances, when compared internationally are relatively high. Further actions to reduce emissions are planned.
- Additional measures are required to effectively monitor and assess the implementation of the management systems at the nuclear power plants as part of the Safety Culture work.
- Additional capable resources will be needed by the Regulatory Body (and likely the Licensees) to cope with the expected work load in the next several years coming from up rates, modernization, environmental emissions reduction and follow-up to the Forsmark event.
- The merger of SKI and SSI will pose some transitional issues while integrating the regulatory practices.

Sweden was asked to report in particular at the next review meeting on the following planned measures to improve safety:

- Progress in the modernization of the existing nuclear power plants according to the modernization plan which sets a completion time 2013. This report is found in chapter B 18.
- Complete follow-up actions from the Forsmark event. These include a number of specific actions by the Regulatory Body, licensees and owner companies plus OSART Missions to Forsmark, Oskarshamn and Ringhals and increased involvement with WANO. This report is found in section B 10.4.
- Progress in the programme for further reduction of releases of radioactive substances to the environment. This report is found in sections B 15.2 – 15.3.
- Amendment of SKI (now SSM) regulations on safety in nuclear facilities to clarify the required safety documentation in support of major plant modifications and on the structure and content of the SAR. This report is found in section B 7.2, before start of B 7.3.
- Continued funding of higher education programming as part of the strategy to have adequate capable staff and continue improvements to the knowledge management programming that is currently in place. This report is found in section B 11.5.
- Continue the current efforts to establish a set of Regulatory indicators to assess the safety of the nuclear power plants and decide on the use of them. This report is found in section B 10.5.
- Progress with the Centre for Crisis Management in the Government Office. This report is found in section B 16.2.

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 fifth 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 conclusion 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 given in chapter 18.

Summary of developments since the last national report

- The years 2007-2009 have been characterized by major plant changes related to the modernization and power up rating.
- The safety upgrading programmes on design and construction of nuclear power reactors continue with a schedule to 2013. The programmes are being implemented in accordance with the regulations SSMFS 2008:17.
- The licensees have applied for major power up rating of seven reactors and a minor up rating of one reactor. The remaining part of the up-rate programme will add some 800 MWe to the current nuclear power capacity in Sweden.
- Broken and cracked control rod shaft extenders were found in Oskarshamn 3 and Forsmark 3. The problem is not yet solved due to its complexity.

6.1 Overview of major events since the last national report

In their annual reports to the Government for the years 2007, 2008 and 2009, SSM and the former Swedish regulatory bodies SKI and SSI pointed out that there were no events indicating a serious degradation of safety and radiation protection at Swedish nuclear power plants. In total ten events were classified as level 1 on the International Nuclear Event Scale (INES) during the period (see section 19.2). The following is an overview of the most significant events during the period 2007-May 2010.

6.1.1. One out of four trains in low pressure safety injection (LPSI) system unavailable

After the shutdown of Forsmark unit 2 for the annual outage in 2008, an integrity tests was performed on one of the containment isolation valves, in one of four redundant trains in the low pressure safety injections system. A service valve was found to be in the closed position. This valve shall always be in the locked-open position during power operation. The valve has been locked in the wrong position since the end of the refuelling outage in August 2007.

The consequence of the locked, closed valve was that the affected train of the LPSI system was unavailable during the entire operation period of 359 days. The LPSI system consists of four redundant trains each with 50% capacity. During this period other trains had been unavailable due to planned maintenance according to criteria in the Technical Specifications. Thus two trains had been simultaneously unavailable during brief periods of time, less than 7 days in total. The event was classified as a level-1 event on the INES-scale.

6.1.2. Broken and cracked control rod shaft extenders

During the 2008 annual maintenance and refuelling outage of Oskarshamn unit 3, a tilted control rod was observed. When trying to lift the control rod, it was found that the control rod shaft extender was broken. The licensee of Oskarshamn 3 (OKG AB) initially assumed that the broken extender represented a one of a kind failure, but during further controls cracks were detected in several control rod extenders. Based on these findings, OKG categorised the event as a "category 1 event" according to SSM regulations. 25% of all control rod shafts had cracks of different sizes and orientations. Based on this information Forsmark 3, that has the same design of the control rod tubes, decided to shut down and examine their control rods. One broken extender and several others with cracks were found.

It was concluded that the cracking was caused by thermal fatigue through thermal oscillations when the cold crud flow water (60 deg. C) meets the warm reactor water (276 deg. C). Corrective actions were taken and Forsmark 3 and Oskarshamn 3 could continue to operate for a couple of months. During next outage new cracks were detected even after this short time of operation. All rods of this design have now been removed. Both events were classified as level-1 events on the INES-scale. The events at both Forsmark 3 and Oskarshamn 3 were classified as level 1 on the INES-scale.

6.1.3. Insufficient flow rate from the auxiliary feed water system

During the annual refuelling outage of Ringhals 2 in 2008 routine testing of the two electrically driven auxiliary feed water pumps was performed. It was observed that the pumps did not fulfil the acceptability flow criteria according to the Safety Analysis Report (SAR). It was concluded that procedures for testing the pumps had not been adequate since the steam generator replacement in 1989. The event was classified as a level-1 event on the INES-scale. Ringhals 2 is still (May 2010) restricted to operate at a maximum of 94 % power due to this finding.

6.1.4. Pressure peaks in ECCS system

In September 2008, when the emergency core cooling system was tested in Ringhals unit 1 after the annual refuelling outage, unexpected pressure peaks were identified. There had been problems previously with a valve in this cooling system. The cause of the problem was at the time thought to drive from gas in the system. In 2009 a more extensive testing was performed, which showed pressure peaks from fluctuations that were above the limits of the SAR. The system was rebuilt to lower the pressure peaks. Due to the measures taken, the outage lasted until December.

6.1.5. Control rod system out of order

During start-up and testing of the scram system in Ringhals unit 1 in December 2008, two groups of control rods were out of order. Two valves to transmitters were in the wrong position and this lead to a situation where the nitrogen pressure tanks were not pressurised.

6.1.6. Fluctuations in the flow of the emergency core cooling system (ECCS)

During a shutdown of Ringhals unit 1 in December 2008, the cooling-down rate was too fast and led to a false signal for low water level in the reactor pressure vessel. The ECCS was activated automatically. The flow fluctuations meant that the flow at the peaks was too low to fulfil the specified system function, and by that also too low to avoid the limit for an acceptable NPSH margin to avoid cavitations in the pumps.

The analysis of the activation of the ECCS system showed that the system had been outside the limits specified in the SAR, saying that the flow should not be under nor over 240 kg/s. This information was not taken care of, and the unit began start-up for tests at 20% power. The unit returned to cold shutdown, and started to investigate the event. The event was classified as a level 1 on the INES-scale.

6.1.7. Violated dry-out limits

In June 2008 lightning struck the offsite grid, which resulted in an under voltage transient. The transient propagated into the electrical systems of Forsmark unit 2. All reactor coolant pumps tripped, which resulted in a decrease in the reactor power. The pumps stopped too fast, due to a premature trip of the pump energy storage device inverters, which should have given the power supply to the pumps in a pre-programmed coast-down. A manual reactor scram was actuated because of power oscillations in the core less than three minutes after the initial grid disturbance. The dry-out limit was shortly (seconds) violated in 18 core channels. 84 fuel elements were unloaded for further analysis. There was no damage to the fuel elements.

6.1.8. Reactor protection system partly out-of-service during power operation

During outage on Ringhals unit 1 2009 it was observed that the rector protection systems' containment isolation function for internal pipe break, had been blocked since previous outage, for a period of 72 days. The automatic actuation of the system was blocked, but activation from the control room was available during the entire period. All information to the control room was adequate. The event was reported to SSM as a serious human factor failure event. The event was classified as a level-1 event on the INES-scale. This event was one of the reasons for SSM to place Ringhals under special supervision.

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

Safety improvements of the 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 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, SKI decided to issue guidelines for modernization and safety upgrading of the Swedish reactors for the remaning of their 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, SKI 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 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 time for implementation. In a number of cases a more in-depth investigation has to be made before the detailed technical measures can be defined.

6.2.1. Improvement of physical and functional separation

- Physical separation within the 220 V systems (F1: 2011, F2: 2012)
- Separation of operation and safety systems within the switchgear (R1: 2013)
- Analysis of the possibility for physical separation in rooms for relays, including measures if necessary (F1: 2011 F2: 2012)
- Modernization of reactor protection system to strengthen the separation of operation and safety systems (O2: 2012)
- Analysis of dependencies between the hydraulic scram system and the pressure relief system, including measures if necessary (O1–2: 2012, O3: 2010)
- Installation of a new pipe for safety injection, due to secondary effects of pipe break (R2: 2012)
- Measures to make the auxiliary feed-water system independent, including a new water supply (R2: 2011)
- Physical separation within the ventilation system in the auxiliary systems building (R2: 2011)
- Analysis of the physical separation within the power system in the auxiliary systems building and the containment, including measures if necessary (R2: 2011)
- Separation within component cooling system (R2: 2012)

- Physical separation to reduce the consequences of steam in connection with a pipe break (R2: 2011)

6.2.2. Diversification of safety functions

- Automation of the boron system for reactor shut down (R1 & O1–3: 2012, F1–3: 2010)
- Analysis of the requirement for two different parameters to identify the need of initiation of the reactor
- Protection system, including measures if necessary (F1: 2011, F2: 2012, F3: 2013, R3–4: 2012, O1–3: 2012)
- Analysis of the requirement for diversified measurement of the reactor pressure vessel level, including measures if necessary (F3: 2010)
- Installation of an external water supply for emergency core cooling (O3: 2010)
- Installation of a new digital reactor protection system and control room modernization (O2: 2012)
- Installation of two phase flow relief valves (O2: 2012)
- Installation of new logic for the pressure relief system (O3: 2010)

6.2.3. Accident management measures

- Additional assessment of the containment integrity in the event of a severe accident, including measures if necessary (all reactors: 2012)
- Strategy for long term cooling of a severely damaged core, including physical measures if necessary (all reactors: 2012, some measures before 2012)
- Change to two phase flow relief valves (R1: 2011)
- Measures to vent incondensable gases from the reactor vessel (R1: 2012)
- Analysis of the emergency control post, including measures if necessary (O3: 2012, R3–4: 2012)
- Installation of a new emergency control post (F1: 2011, F2: 2012, O2: 2012)

6.2.4. Withstanding local dynamic effects from pipe breaks

- Analysis of local loads (F1–3 2010, O1–3 2010), including measures if necessary (F1–3 2011, O1 2012, O2 2007– 2012, O3 2010, R1 2010, R2–4 2011)
- Supports for several containment isolation valves (R2 2011)

6.2.5. Withstanding external events

- Analysis of natural phenomena, including measures if necessary (O1–2: 2012, O3: 2010, R3–4: 2013)
- Analysis of earthquake (R1: 2011), including measures if necessary (R1–2: 2013)

- Measures to the I&C system due to earthquake (O2: 2012)
- Reinforcement of the control room ceiling to survive an earthquake (O1–2: 2012)
- Fire hazards analysis (O3: 2010), including measures if necessary (R2: 2013)
- Improvement of the fire protection (F1: 2010, F2: 2011, O2: 2012)
- Analysis of strong wind, including measures if necessary (O2: 2012)
- Measures to withstand the consequences of strong wind (F2: 2010)
- Reinforcement of the reactor building to withstand flooding (O2: 2012)
- Update of the PSA of flooding caused by pipe break in the salt water system, including measures if necessary (R2: 2012)
- Measures due to risk for turbine missiles (O2: 2012)

6.2.6. Operational aids

- Improvement of the back panels in the control room (R1: 2011)
- Detection of, and automatic protective measures against local core instability (F3: 2010)

6.2.7. Environmental qualification and surveillance

- Update of the environmental qualification (F3: 2010), including measures if necessary
- Update of the environmental qualification outside the containment (O1: 2012, O3: 2010), including measures if necessary (O1: 2012, O3: 2010)

The total cost for the upgrading programme has been estimated at about 8 billion SEK (800 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 will be conducted over a relatively concentrated period of time, up to about 2013. During the same period, power up-rates are also planned at several reactors (see section B 6.3). Altogether, this work as well as normal maintenance activities will entail major challenges for the licensees and their suppliers over the next years. SSM has already noticed that the workload of the operating organizations is heavy and, as a result, time schedule delays occur as well as a backlog in the documentation work.

The limited number of contractors and support companies on the market also creates a need for strict time planning and the plants are dependent upon each other. A delay of one project at one plant could cause a delay of a project in another plant. A few large contractors maintain high competence but there is a risk that they will have to recruit less competent personnel to cut the workload peaks.

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.

SSM will have to face major challenges with reviews and other supervisory activities that will be needed during the coming years (see further chapter 8).

6.3 Up rating programme of the nuclear power reactors

Nine of the originally twelve power reactors were up rated during the period 1982-1989 with power increases between 6-10 % from the original 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. The current programmes for up rating which are being implemented during the period 2005-2014 include major up rates of seven reactors and a minor up rating of one reactor. The power levels are shown in Table 3. The complete ongoing programme, including measures on the conventional side, 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 Nuclear Activities Act (SFS 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 establish whether the safety requirements are met with the necessary safety margins.

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. Since the total energy generation from the reactor will increase, the burn-up of fissile material (U-235) will increase. At most, this increase will be in proportion to the power increase.

F= Forsmark, O= Oskarshamn, R= Ringhals

Reactor	Original power level		Current power level		Planned power level		Total thermal up rate %
	Thermal	Electrical gross output	Thermal	Electrical gross output	Thermal	Electrical gross output	
F1	2711	900	2928	1022	3253	1168	20.0
F2	2711	900	2928	1035	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	1450	3900	1450	29.1
R1	2270	750	2540	887	2540	887	11.9
R2	2440	785	2652	900	2652	900	8.7
R3	2783	915	3144	1105	3144	1051	13.0
R4	2783	915	2775	981	3300	1140	18.6
Total	24813	8405	27333	9762	29483	10570	

Table 3. Power levels of the Swedish operating reactors.

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 up rate is granted by the Government, subsequent stages are handled by SSM whichis 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 Up-rating in Nuclear Reactors"[4].

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

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 operation 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 up rating process

The following cases are currently being handled:

In October 2005, the Government decided to allow up rate of Ringhals 3 from 2783 MWth to 3160 MWth. Ringhals planned to perform this up rate in two steps. The first step was performed 2005-2006. For the second step, Ringhals AB submitted a PSAR to SKI for operation at the higher power level in September 2007. After a review of the PSAR, SKI approved the application in June 2008. In December 2007, Ringhals AB submitted the application for test operation at 3144 MWth. SSM reviewed the application and approved it in May 2009.

In December 2007 Ringhals applied for a licence to up rate 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 the Government not to approve the application as long as Ringhals is under *"special supervision"* (see section B 10.3).

In September 2007, OKG applied for a licence to up rate 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 have approved the application.

In January 2010, the Government decided that Forsmark was allowed to up rate Forsmark 1 and 2 from 2928 MWth to 3253 MWth. The Government also decided that FKA was allowed to up rate Forsmark 3 from 3300 MWth to 3775 MWth. Forsmark Kraftgrupp AB has submitted a PSAR for Forsmark 2 for operation at the higher power level to SSM during the spring of 2010 and will apply for test operation at 3253 MWth during 2010. SSM plans to perform the review of the PSAR during fall 2010.

Up rating is not done for safety reasons but the review of an up rating case is an important safety issue. In the regulatory review, SSM checks that the licensee complies with all applicable safety requirements. Older issues are followed up, and SSM:s position is that there shall be a "clean table". An application for up rating 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. Despite political uncertainties about the future use of nuclear power, the Swedish licensees have decided to make major safety investments in their plants to make them fit for 50 or more years operation.

The Swedish reactors are in a process of modernization, safety upgrading and power up rating. 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 is similar. SSM has put Ringhals under special supervision, see section 10.3, and the extensive modernization programmes in Ringhals unit 1 and 2 have resulted in outages that are much longer than originally planned.

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

- The Government has in a bill to the Parliament proposed that the ten existing reactors can be replaced by new ones at the same sites.
- A major review of the Swedish nuclear safety and radiation protection legislation has started.
- The licensing under the Environmental Code of all Swedish operating reactors, including foreseen power up rates, is completed.
- The Swedish Radiation Safety Authority has reissued former SKI and SSI regulations in its Code of Statutes, SSMFS.
- The SSM has updated the regulatory requirements on the content and use of SAR in the regulations SSMFS 2008:1.

7.1 Nuclear safety legislation and regulatory framework

7.1.1. The basic nuclear safety and radiation protection legislation

The following five acts[5] constitute the basic nuclear safety and radiation protection legislation of Sweden:

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

5 All Swedish Acts and Ordinances are published in the Swedish Statute Book, hereinafter referred to as "SFS".

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 Nuclear Activities Act as well as with a licence issued under the Environmental Code. The Nuclear Activities Act is mainly concerned with issues of safety and security, 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 Nuclear Activities Act

As stated above, the Nuclear Activities Act 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 license 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 Nuclear Activities Act (se 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 Nuclear Activities Act. The purpose of the EIS is to assess the effects of the planned operation on the 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 Nuclear Activities Act, the Government or the 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 the SSM. On 1 July 2006, more strict requirements on the use of contractors for nuclear activities[6] entered into force. According to the new wording of the Nuclear Activities Act (1984:3) § 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, SKI (now SSM) issued regulations on some specific exemptions from the requirement of approval of contractors[7]. 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 Nuclear Activities Act was amended to incorporate references to the Environmental Code (SFS 1998:808). The amendments, which entered into force on 1 January 1999, state that

6 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.

7 The Swedish Nuclear Power Inspectorate's Regulations (SKIFS 2006:1, now SSMFS 2008:7) on Exemption from the Requirement on Approval of Contractors.

the general rules of consideration and the environmental quality standards of the Environmental Code shall apply when considering matters under the Nuclear Activities Act. 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,
- 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 Nuclear Activities Act and the Radiation Protection Act.

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 nuclear activities act

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

- The safety regulations according to the Nuclear Activities Act,
- 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 Nuclear Activities Act, the Government itself takes the final decision, often referring the questions on different conditions regarding nuclear safety and radiation protection to the SSM. The Government takes the expert opinions of the 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 up rates (3253 MW for F1 and F2, and 3775 MW for F3) and to construct storages 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 license 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 F3 in 2005 and additional measures to be taken aiming at a 50 % reduction in aerosol releases.

7.2 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 Nuclear Activities Act (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 to those affected by a radiological accident.

In October 2009 a first, partial inquiry report was presented covering the issues of generational shifts in the Swedish nuclear power fleet and nuclear liability including proposed changes in the Nuclear Activities Act, 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 March 23, 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 nuclear power owners. The Parliament votes on these bills are expected in the middle of June 2010. The main content of the bills, after adjustments by a Parliament committee, are as follows:

- It is proposed that a licence for building and operating a new nuclear power reactor can be granted if it replaces an existing reactor, is built on a site with existing operating nuclear reactors, and the replaced reactor unit is finally shut down when the new reactor starts to operate.
- The Nuclear Phase-Out Act (1997:1320) is suggested to be cancelled.
- The Government suggests that a periodic safety review of the nuclear safety at a reactor will be mandatory by law.
- Sweden will accede to the 2004 amendments of the Paris Convention and the Supplementary Convention on liability. It is suggested that the Nuclear Liability Act (SFS 1968:45) will be replaced by a new law on liability.
- It is suggested that the owner of a nuclear facility will have unlimited liability and that the owner of a nuclear reactor should provide financial guarantees up to 1200 million Euros. The owners to other nuclear facilities than reactors should provide financial guarantees to a minimum of 700 million Euros.
- The legislative changes for replacement of existing reactors are suggested to enter into force on January 1, 2011. Some other changes are suggested to enter into force on earlier. The Government suggests that the Parliament will empower the Government to decide when the new liability legislation will enter into force.

In its further work the Inquiry will consider the conditions for the coordinated regulation of activities in the area of nuclear technology and radiation protection and propose the amendments that will need to be made to acts and ordinances. In this work the Inquiry will study the possibilities of bringing together the provisions of the Nuclear Activities Act and the Radiation

Protection Act in a single act and will also consider the possibilities for better coordination with the provisions of the Environmental Code. The final inquiry report is to be submitted no later than December 22, 2010.

7.3 National safety and radiation protection regulations

7.3.1. SSM 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 by the SKI and SSI 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[8].

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 related general advice, listed below, all entered into force on February 1, 2009.

SSM's regulations also implement binding EU legislation and international obligations. When 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, to all licensed nuclear facilities. Minor amendments regarding the requirements for safety programme, 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 through the following:

- Application of multiple barriers and defence-in-depth
- Handling of deficiencies detected 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

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8 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.

- 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 are given.

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 equipments and with 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 5 § of the Nuclear Activities Act (SFS 1984:3) on the use of contractors (SSMFS 2008:6)

The SSM has issued general advice on the interpretation of the 5 § in the Nuclear Activities Act 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 the SSM and a permit is issued (see section B 7.1), although the overall responsibility for safety rests with the licensee, a contractor has legal duties and obligations for the nuclear activities as defined by the contract and permit. SSM can decide on safety conditions for the contract. A contractor cannot, without additional permit, use a subcontractor for activities within the contract. In no case is it allowed for a subcontractor to use a sub-subcontractor (fourth person).

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

The Nuclear Activities Act (SFS 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 the 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 the entire 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 may 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, accreditation of control organizations and laboratories, requirements on in-service inspection and control, requirements in connection with repair, replacement and modification of structures and components, requirements on compliance control and annual reporting to SSM. The regulations contain relatively detailed 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 the 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 the time decided by SSM. The reason for this is that the licensees must be given time to investigate in depth, specify, procure, install, test, and perform safety reviews on 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 planning before and during decommissioning of nuclear facilities (SSMFS 2008:19)

The regulations contain provisions concerning the planning of decommissioning of nuclear facilities regarding matters of importance for radiation protection. The regulations contain requirements on decommissioning planning, staffing, monitoring and control, and administrative measures such as documentation before and during decommissioning and necessary reporting to SSM at different stages of the facility's life-cycle.

7.3.11. Regulations on the management of radioactive waste at nuclear facilities (SSMFS 2008:22)

The regulations contain provisions concerning the planning and quality assurance of the radioactive waste management at nuclear facilities, the documentation and registration of radioactive wastes, and also the reporting required by SSM.

7.3.12. 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).

7.3.13. Regulations on radiation protection manager at nuclear facilities (SSMFS 2008:24)

These regulations require any licence holder shall appoint a radiation protection manager[9] 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 the SSM is carried out. The SSM formally approves the appointment of the radiation protection manager and his/her substitute.

7.3.14. Regulations on radiation protection for 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 equipments; procedures connected to work with fuel elements; and documentation, reporting and archiving of radiation dose data.

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9 This radiation protection manager should not be confused with the appointed managers in the line organisation. This person should have an independent position and, controlling function

7.3.15. 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 operating 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.

7.3.16. 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.

7.3.17. Regulations on clearance of goods and oil from nuclear facilities (SSM FS 2008:39)

These regulations stipulate the levels for clearance of slightly contaminated goods and oil from nuclear facilities. They also regulate on instructions regarding measurements, and documentation and reporting of measured and cleared materials. Materials can be cleared for unrestricted use or for disposal as conventional non-radioactive waste.

7.3.18. 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[10]. 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 to 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 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).

10 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].

7.3.19. Regulations on outside workers at 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.

7.3.20. Amendments and revisions under way

The SSM has internal procedures to review and assess the adequacy of the current regulations. This assessment is done against regulatory experiences and the international development of safety standards and legal instruments such as the EU-legislation. Several updates and amendments of regulations were cancelled or postponed in connection with the establishment of the new authority SSM; instead focus was put on merging and reissuing the existing regulations of the former SKI and SSI as presented above.

Some amendments, and updates have however already been prepared, decided or under preparation concerning the following regulations:

- *Regulations concerning mechanical components in certain nuclear facilities* (SSMFS 2008:13) - minor administrative and technical changes;
- *Regulations on clearance of goods and oil from nuclear facilities* (SSM FS 2008:39);
- *Regulations on outside workers at work with ionising radiation* (SSMFS 2008:52), amendments apply from June 2010.

Other regulations were planned revisions and updates are postponed but will subsequently be done are:

- *Regulations concerning safety in nuclear facilities* (SSMFS 2008:1) - implementation of regulatory experiences and remaining details of the WENRA reference levels. (see section B 7.5);
- *Regulations on radiation protection for workers at nuclear facilities* (SSMFS 2008:26) – issues regarding education, classification of work places and internal exposures.

Other events that will lead to further changes of the regulations are the on-going overview 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.

7.3.21. 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 on-going activities with modernization and power up-rates. Another important motivation was the anticipated application 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 June 25, 2009 EU issued Council Directive Euratom/2009/71 establishing a community framework for the nuclear safety of nuclear installations in the member states. Sweden does not foresee any difficulties in transposing the directive into national legislation. Member States shall bring into force the laws, regulations and administrative provisions necessary to comply with this Directive by 22 July 2011.

7.5 The WENRA Reactor Harmonization Project

SKI (now SSM) took active part in WENRA's (Western European Nuclear Regulators' Association) reactor harmonization project which was carried out between 2000 and 2006. In this project, national requirements and implementation work at the nuclear power plants were systematically benchmarked against agreed reference levels, mainly based on the IAEA safety standards. The final report issued 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 legal side with the reference levels by 2010. For Sweden no major gaps were identified between the national requirements and the reference levels. However, the SKI (now SSM) regulations needed to be amended with some details of the reference levels. A proposal for the update of SSM:s general safety regulations (SSMFS 2008:1) has been prepared. Work is also under way to investigate needs also for updating of the regulations on design and construction of nuclear power reactors (SSMFS 2008:17). This update is planned for 2011 depending on the outcome of consultations with other Swedish authorities and suggested changes of the Nuclear Activities Act (see section B 7.2), making it possible to replace existing reactors with new ones.

The ongoing safety upgrade programmes at the nuclear power plants assure compliance with most of the reference levels on the implementation side. A few remaining gaps have to do with making additional safety analyses and upgrading of the supplementary control posts at some reactors.

7.6 Licensing system

The Nuclear Activities Act (SFS 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 operation and beyond. On-going 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 reactor 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.

The first Swedish reactor, Oskarshamn 1, will have been operating for 40 years in 2012, even though with some years of shut down for refurbishment and upgrades. The SSM has to date no specific assessment plan for reactors operating beyond 40 years. It can be expected that the periodic safety review (PSR) instrument (see section B 14.1) will be used with added emphasis on analyses of maintenance, materials, inspection and testing issues with special consideration to degradation due to ageing. The Swedish Government has given SSM the mission to investigate the long-term development of nuclear safety at the nuclear installations which includes an appraisal of under which conditions it is possible to continue operating a reactor for extended time periods with adequate levels of safety (see section B 14.1).

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 17 § of the Nuclear Activities Act (SFS 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 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 22 §, SSM can also decide on fines in cases of non-compliance with licence conditions or regulations.

According to 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. The SSM refers 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, the 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 an action plan to be developed and actions to be taken within a certain time period
- Ordering specified actions to be taken within a certain time period and the results submitted to SSM for review and approval
- Ordering 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, 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 department is always involve 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

- The Swedish Radiation Safety Authority, SSM, was established July 1, 2008.
- The number of staff involved in regulation and supervision of nuclear activities has increased.
- The Government has tasked SSM to investigate present and future competence needs in areas of relevance to nuclear safety and radiation protection.
- The SSM has arranged for an IAEA full-scope IRRS-mission[11], in February 2012.

8.1 The regulatory body and its mandate

8.1.1. General

The Swedish Radiation Safety Authority (SSM) was established on July 1, 2008. The SSM took over the responsibility and tasks from the Swedish Nuclear Power Inspectorate (SKI) and the Swedish Radiation Protection Institute (SSI) when these were merged into the new authority. The 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 the SSM are defined in an ordinance with instructions for the authority and in the annual government letter of appropriation, 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 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. The SSM has no board; the Director General is

11 IRRS stands for Integrated Regulatory Review Service

exclusively responsible and reports the authority activities directly to the Government. The authority has an advisory council with a maximum of ten members appointed by the Government. Those are usually members of the parliament, officials from other agencies or independent experts. The functions of the council are to advise the Director General and to ensure public transparency (insight) into the authority's activities. It has no powers to make decisions.

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 obtain access to a document. After September 11, 2001, more documentation related to safety systems in nuclear power plants became classified information and the SSM has established more stringent security practices.

As all Swedish authorities, the 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, the 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.

The 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. In June 2010 the SSM will publish the first issue of its new periodical, Strålsäkert ("Radiation Safe").

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

8.1.2. The Swedish Radiation Safety Authority (SSM)

The SSM missions and tasks are defined in the Ordinance (SFS 2008:452) with instruction for the Swedish Radiation Safety Authority and in an annual letter of appropriation. In the latter the Government issues directives for the authorities including the use of appropriations. After the merger of the SKI and the SSI into the 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.

The SSM shall work actively and preventively 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. The 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 the SSM's own activities regarding financing issues, so that the Nuclear Waste Fund can fulfil its tasks[12]. The SSM is in charge of the Swedish metrology institute for ionising radiation. The SSM shall operate a national dose register and, as appropriate, issue national individual dose passports. The SSM shall furthermore:

- carry out Swedish obligations according to conventions, EU-ordinances/directives, and other binding agreements (e.g. contact point, report drafting, and 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. The 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 letter has lately changed, focussing more on short-term-issues and the funding of the authority activities. In the latest appropriation letter, dated December 21, 2010, the SSM was inter alia given the assignment to:

- Investigate and report on the human resources situation in disciplines of importance to the SSM, both the internal as well as the general Swedish situation should be assessed. The SSM shall predict developments and estimate the future expertise and human resources needs.
- Investigate and identify necessary changes in SSM's duties, responsibilities and ambitions regarding emergency preparedness due to changes in the funding of these activities.
- Report on February 1, 2011 at the latest, on how a licensing procedure of new Swedish nuclear power reactors could be formed; in line with the Governments intent to create the requisites for controlled generational shifts of the Swedish nuclear power plants.

The SSM work can be divided into supervision of the safety and radiation protection work connected with non-ionising and ionising radiation. For 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 equipments for security reasons, the exposure of ionising radiation from naturally occurring radioactive material (NORM). In this report the focus is on the nuclear facilities as defined by the Convention of Nuclear Safety.

[12] *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.

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 economy. In addition SSM is involved in international development cooperation within the areas of reactor safety, radiation protection, nuclear waste safety, and non-proliferation. Figure 3 displays the present organisation of the SSM. The international development cooperation work is managed by the unit Cooperation and Development in the Department of International Affairs.

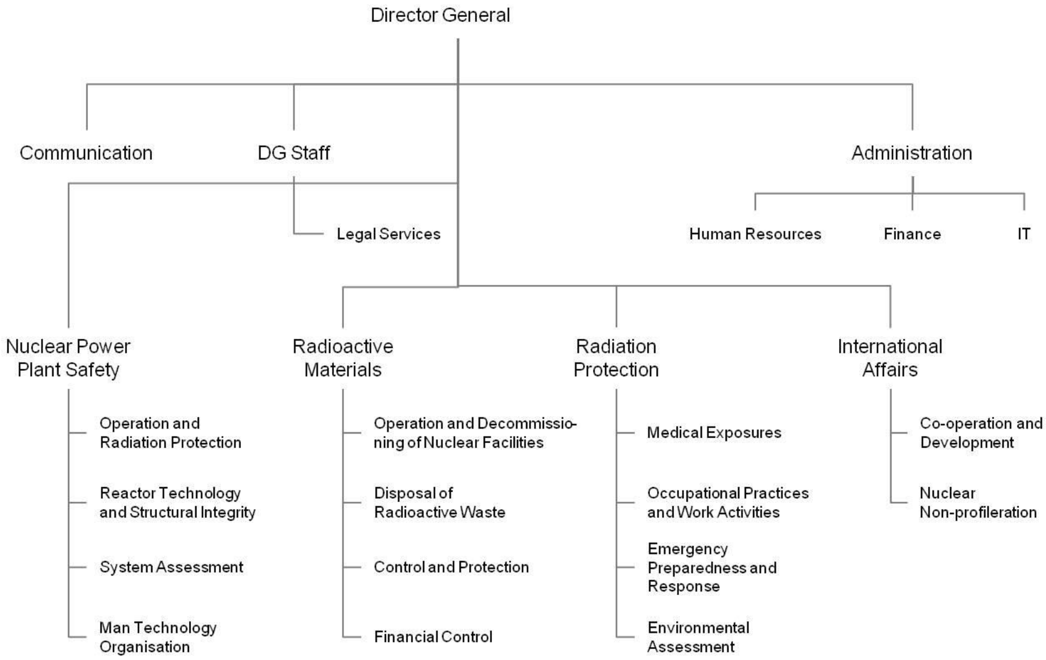

Figure 3. The SSM organisation

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 assessed annually and reported back to Government.

Within the SSM there is a Delegation for Financial Issues Connected with the Management of Rest Products from Nuclear Activities which is an advisory body in the matters of suggesting the annual fees and the basis for calculating the fees, to the Nuclear Waste Fund. The 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, appointed 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 had (end of 2009) a staff of 247 persons; the same number of employees as SKI and SSI had at the end of 2006 (246). The average age is close to 50 years. Of the staff, 21 % are younger than 40 years, 30% are between 40 and 49 years, and 50 % are older than 50 years. About 20 %

of the SSM employees will retire (65 years) within 5 years but one can opt to work until the age of 67.

During 2009, 47 persons were hired (23 women and 24 men) and their average age was 40 years. The staff turnover rate, excluding retirements, was 5 % during 2009 which is normal. SSM works with a long-term plan for its competence needs and this work will continue in 2010. In addition, the Government has given SSM an assignment to investigate and report on the competence situation in the disciplines of importance to the authority; taking into account both the internal and the national needs (See section 8.1).

The *Department of Nuclear Power Plant Safety* has a staff of 60 persons, which work with the supervision of nuclear safety and radiation protection at the 10 operating nuclear power reactors. Of their 60 staff members, 18 % have a post graduate degree, and 67 % have a bachelors or a masters degree. The SSM has designated one inspector for each plant as *"site-coordinator",* serving as the main contact point between facility and authority.

The 47 persons belonging to the *Department of Radioactive Materials* use 10 -12 person-years on issues of waste management, spent fuels, and authorized release of radioactive substances connected to the direct 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 investigations 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 59 persons at the *Department of Radiation Protection* use a fair fraction, roughly 20 person years, of their work resources on the national emergency preparedness activities, environmental monitoring issues, laboratory measurements, calibrations and use of radiation sources, x-ray equipments etc related to the operation of the Swedish nuclear facilities. The Nuclear Non-Proliferation unit at the Department for International Affairs uses about 6-8 person years of its resources towards the nuclear facility operations.

The "administrative and supportive sections" of the SSM is in total 47 persons. This includes the DG staff (with legal services), the communication unit, the administrative unit (including human resources unit), the finance unit, and the unit for IT issues.

The educational background of the SSM staff at the end of 2009 is shown in Table 5:

Education	Percentage
Post graduate degree	24
Bachelor/master	58
Secondary high school	15
Other	3
Total	100

Table 5. Educational background of the SSM staff

Compared with many other authorities, the staff of SSM has a relatively 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 TSO in Sweden to support the regulatory body with specialist knowledge.

In an internationally comparison, 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 up-rate 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 up-rate applications and the authority presently re-examines its processes for reviews and assessments.

The authority's 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 Safety* staff is planned to increase from 60 (end of 2009) to 70 persons until the end of 2010. The actual figure will depend on the success of the recruitment process and the available competence on the labour market.

In April 2009, after discussions with the Ministry of Environment and the nuclear facilities, the SSM concluded, despite strengthened resources and long-term possibility to hire more staff, to prioritise amongst applications for power up-rates and other modernization projects during the period 2009-2010. One basis was that the Authority only could review and assess two modernization/power up-rate projects annually.

8.2.3. Internal staff training

SSM has a relatively large volume of internal staff training, organized by the human resources unit. During 2009, about 1000 days – some 4 days per employee - were used for competence development.

During spring 2009 a development programme for the management group was finished. The programme has contributed to a common view of the authority's tasks and objectives and an increased understanding of the manager position. A new long-term development programme for managers has started; it is extended over 2010 and the goal is to strengthen abilities to lead, influence and work towards common objectives.

The SSM has launched a development programme on leadership where 10 motivated and suitable co-workers, selected from 55 applicants, will be given the opportunity to prepare for a management career. The education and development programme, from September 2010 until May 2011, will in total consist of 25 days or about 15 % of the candidates total working hours.

Introductory training is mandatory for new employees as well as emergency preparedness training for the emergency staff, among those all inspectors. Except for this, the training programme is tailored to meet specific needs in relations to the competence profile of each position. The newly hired staff varies in knowledge and experience – from those having a solid knowledge about the nuclear power plant design and operation to those who come directly from the technical high school/university. Annual dialogues are held between respective manager and staff to assess training and educational needs.

Courses are also given on internal processes in 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, and media training. For the technical training SSM also uses the licensee training programmes for operating staff including simulator training. Newly employed SSM staff has also been given the opportunity to follow the work in a control room on site for several weeks. Some SSM inspectors have practiced for a period at the US NRC.

8.2.4. Economical resources

As mentioned in earlier national reports (as for SKI and SSI), the regulatory activities of SSM are financed over the state budget. The costs are largely recovered from the licensees as fees covering the regulatory activities and the related research. The sizes of the fees are proposed annually by the SSM but decided by the Government. The budgets for 2009 and 2010, except for the funding of the separately financed international cooperation and development work performed within the Department of International Affairs, are shown in Table 6.

In addition, some extra resources (at most a few million per year) are fees for reviewing special applications or licensing work, paid directly to the Authority. The economical resources of the regulatory body have increased in real terms as compared with what was reported 2006 in the 4th Swedish national report. The total resources for the SKI and SSI for 2006 were 316 MSEK. The 2010 budget for the SSM was further increased.

Budget Item	2009	2010	Source of funding
Nuclear safety, emergency preparedness, and radiation protection (including administration)	214,350	233,400	Mainly fees
Supervision of nuclear facilities (fraction of above)	177,000	195,000	
Scientific research and development work	90,000	96,000	Mainly fees
Final storage of radioactive waste	6,000	28,200	Fees
Historical wastes etc.	2,700	2,000	Tax funded
Crisis management[13]	29,000	27,000	Tax funded
Total (kSEK)	**342,050**	**386,600**	

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

8.3 Regulatory inspections and assessments

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

8.3.1. SSM practices

SSM presently develops its supervision methods in several planned projects. A first phase was completed at the end of 2009. Policies for inspections and new routines were gradually established during 2009, as part of the general SSM management system. In a second phase, which started during 2010, harmonization between procedures in different supervision areas, as

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

well as further development of the supervision procedures will take place. The following list exemplifies (not complete) relevant documents from the SSM management system:

1.	Supervision policy	2009-07-01
2.	Access rules to facility's under the authority's supervision	2009-05-09
3.	To inspect	2010-04-23
4.	To conduct minor inspections	2009-09-21
5.	Processing notifications from the nuclear facilities	2009-12-28
6.	Integrated safety assessments	2009-12-11
7.	Sanctions related to the SSM supervision and control	2009-05-25

The following describes the SSM supervision practice (for nuclear installations) during 2008 and 2009, after the Swedish Radiation Safety Authority was established - largely adapted versions of the earlier SKI practices.

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 used in the annual assessments of the licensees (SSM integrated safety assessments, see below) as well as in the periodic, 10-year safety reviews. Like this, the SSM is able to maintain a systematic picture of the safety situation and to monitor the development. When new assessments start, already performed and documented assessments of the areas can be consulted and emerging pictures can be consolidated. The idea is to use 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 used areas 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 (section 4, 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* (SFS 1988:220).

SSM evaluates how regulatory time "on site" is used and how to optimise time allocated to inspections and "minor inspections" as described below. Some new issues were identified after the 2006 Forsmark event (section B 10.4). At the time it was clear that established routines, positively assessed by SKI, were not followed at the plant. The SSM inspection practices should therefore be strengthened with regard to assessing actual work practices at the plants, however without taking over inspection issues already under third party control.

8.3.2. Nuclear safety and radiation protection inspections

During 2009 SSM carried out 23 inspections focused on the following themes:

- Experience feedback and handling of events
- Start-up procedures after outages (test programmes, system operational verifications, etc.)
- Control room working environment
- Operator aids and tools
- Competence and staffing
- Handling of work orders and work permits
- Management of station changes
- Management of identified project deficiencies
- Management of test results in connection with modernization and power up rate projects
- Education for staff at shift work
- Internal revision procedures
- On-site emergency preparedness organizations
- Source term calculations for postulated radiological accidents
- Management and assessment of incidents
- Management of radiation protection experiences, personal protection equipment and hand-held monitoring instruments
- Radiation protection in connection with modernization projects or other major projects
- Survey and classification of radiological areas

The 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 2009 inspections, it was concluded that the licensees complied with the requirements, although some deviations were found. In a few cases the SSM issued an order to the licensee to improve the activities.

In addition to inspections, SSM carries out "minor" inspections to be informed on power production, safety problems and overall activities at the plants. Normally these 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 "minor" inspections are simplified in comparison with inspections, but results are systematically documented and reported at the SSM management meetings. Each minor 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
2006 inspections	8	5	7	20
2006 "minor" inspections	32	27	26	85
2009 inspections	7	5	11	23
2009 "minor" inspections	32	33	23	88

Table 7. Inspections and minor inspections (excluding waste management) performed by SSM in 2006 and 2009

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 few cases; an ongoing case is Ringhals where SSM wants to follow the safety developments more closely (see section B 10.3). This is reflected in the increased number of inspections at Ringhals during 2009 as seen in Table 7 above. Special supervision is formally terminated when SSM is satisfied with the licensee's improvements or the specific safety reason is no longer valid.

Inspection of the licensee programmes, activities and results of surveillance and in-service inspection of mechanical components are carried out in accordance with 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 integrated safety assessments

The *SSM integrated safety assessments* are annual nuclear safety and radiation protection assessments of each major facility under SSM supervision. Based on all inspections, "minor" 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 basis material should also cover earlier information and conclusions, in order to find trends which 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 appointed persons at the inspection department.

Of importance in drafting the report is the traceability from the original data base, via the analysis, to the final conclusions and the appraisal. It should clearly be described how SSM evaluated the relevant issues and it should be understandable to interested parties, lacking expert knowledge in the assessed areas.

In connection with the final drafting of the report, a so called *"Forum"* is often arranged. All concerned regulators, interested SSM staff from other departments, sections or units discuss and review the content of the report. It is then possible to raise views on, and object to, the suggested evaluations and appraisals.

In accordance with the Authority's established procedures, the final report is sent for comment in the organisation. The report is finally approved by the SSM Director General and presented at top level management meetings with all licensees.

8.4 Regulatory research

The Swedish Radiation Safety Authority (SSM) was formed on July 1, 2008 and one of the immediate tasks was to develop a research programme for the new Authority. In the work programme for 2008 it was decided that the DG staff should develop a research strategy for the proceeding five years with a special focus on year 2009. It was later decided to split the work into two parts, a 2009 research programme, to be ready in February 2009, and a 2010-2014 research strategy which should form a basis for the annual research plans from 2010 and onwards. The SSM 2008-2009 research work was largely based on strategies taken over from the SKI and the SSI if not otherwise mentioned in the 2009 research programme.

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 are 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.

The 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 performed in the interest of the broader society and is therefore 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.

The SSM financed basic research during 2009 to an amount of 6 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 the 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 (Royal Institute of Technology) 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).

The SSM supports a visiting professor in radiation biology at Stockholm University (SU) until 2011. SSM finances three higher research posts in radiation biology, radioecology and dosimetry until 2010; with optional prolongation for three more years. SU formed the *Centre for Radiation Protection Research* to co-ordinate the Swedish resources in the area.

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 models and computer programs developed for three-dimensional coupled thermal hydraulics and neutron kinetic calculations. An important work is the validation of the advanced computer codes using 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 feed-back 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. The process-based, integrated SSM management system

SSM has a management system which is certified on the issues of environment, quality management and work environment management in accordance with the ISO standards ISO 14001, 9001 and the Swedish Work Environment Authority regulations AFS 2001:1. The management system is process based. During 2010, the system will be supplemented with a section on *Information Security* following ISO standard 27001. Internal and external revisions are performed yearly.

Before the SSM was established, structure and layout of processes and the complementing documents of the regulatory body were extensively discussed. Also, at the beginning, the priority was on overall structure, description of the main processes and the main policy and instructions. The system is still under development. The process map follows an iterative cycle from left to right: *Planning process*, *Implementation process* and the *Follow-up process*. Various support processes and the handling of affairs (diary, registration and archiving) are held together under the name *Supporting processes*.

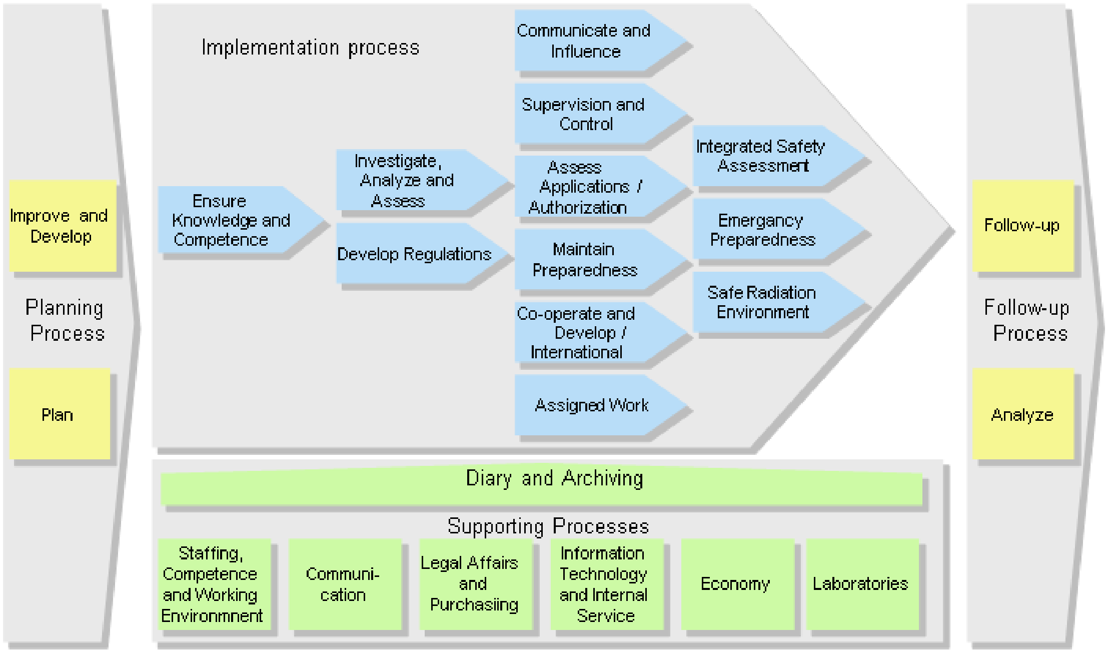

Figure 4. SSM process scheme

8.5.2. Scope of management system

The management system encompasses:

- Over-arching description of the management system
- Mission, shared vision and tasks of the regulatory body
- The management control of the regulatory body (including policy for quality, environment, working environment and information security)
- The authority's main processes for planning, implementation and follow-up as well as supporting processes
- The organisation, tasks and duties (rules of procedure, decision-making and preparation schemes)
- Analyses (environmental scanning, working environment risk analysis, activities, security protection, information security etc. and environmental aspects) and plans of action
- Description and assessment of external interested parties
- External requirements (*Ordinance* (2008:452*) with instructions for the SSM*, annual Government letters of appropriation, Acts, etc.)
- Environmental inquiry and environmental action plan
- Procedures for document control
- Internal established steering documents
- Accounting documents
- Programme and plans for internal and external reviews
- Methods for measuring the impact and effect of each process

- Competence management and education plans
- IT based support displaying processes, supporting documents and relation between processes
- IT based activity management system for planning and follow-up (SINUS)

8.5.3. 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. management of the working environment and information security.

The SSM follows a plan for internal reviews 2009-2011. The objective of these 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 "common values" are integrated in the practical work, and to check if the management system is effective and adapted to its purposes. The internal auditors are appointed by the DG and put together in suitable audit teams; considering experience, competence and audit objectives.

External audits are carried out two times every year. The auditors control how SSM follows the requirements of ISO 9001, ISO 14001, the *Swedish Work Environment Authority* regulations AFS 2001, and other relevant requirements. The external auditors are accredited by *Swedish Board for Accreditation and Conformity Assessment*, an authority under the *Ministries for Foreign Affairs and Enterprise*, & *Energy and Communications*.

The latest external review, in October 2009, determined that more work concerning quality aspects of the SSM management system still was needed. The major divergences were found in the area of systematic management of the working environment. The SSM promptly implemented actions to rectify deviations.

In February 2012, on request by the Swedish Government, the IAEA will conduct a full-scope IRRS mission in Sweden. The mission scope has been determined, and further planning is underway. At the SSM, preparations have started. The adherent regulatory self-assessment will be carried out at the beginning of 2011.

8.5.4. New system for document management

In January 2010 it was decided that the 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 the 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.

8.6 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). The 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 government agency according to fundamental Swedish law. This is a matter for the Government, in plenum.

8.7 Actions initiated at the regulatory body after the Forsmark event

8.7.1. Inspection staff

One conclusion after the Forsmark event (see section 10.4) was the need to more closely follow the work at the utilities; especially how the internal rules are followed, how the safety culture develops, and if safety is prioritised and conservative decision-making is applied. A prerequisite for this was an increase of the SSM inspection staff. As a consequence of merging SKI and SSI into the SSM and the physical move of the SKI staff to the premises of the SSI, some staff was lost and in particular 3 – 4 inspectors left for other careers. These immediate losses were the first priority for action.

The new authority SSM was given additional resources (to be used for strengthening inspections in the nuclear and medical field) following requests from the earlier SKI and SSI. The number of inspectors is restored and is presently higher than before, 4 inspectors per site focus on nuclear safety issues and a higher degree of site presence is therefore possible.

8.7.2. Changes in inspection philosophy

A consultant inquiry into the SKI inspection practices was carried out 2007. These inquiry conclusions were based on SKI staff interviews and a review of the SKI management system and documented supervision activities (reports, inspection protocols etc.). As already reported in the 4th national report also internal SKI investigations were performed and it was decided to:

- modify the strategy for review and assessment of the safety culture of the plants,
- extend the review and follow-up on the implementation of the licensees management systems including internal audits,
- conduct more rapid investigations of occurring events, and
- increase the number of inspections and minor inspections.

These implementations were temporarily delayed by the SKI/SSI merger with its partial loss of staff. As can be seen in section B 8.3, comparing 2006 and 2009, the SSM presence at the sites is still about the same but focus has shifted to more direct control of how safety policy, safety work and internal instructions are followed. In fact, one reason for special supervision at Ringhals AB (See section 10.3) was weak safety culture and failure to follow internal instructions and documentation.

8.7.3. Expectations on information

An experience in connection with the Forsmark event in 2006 was the need to be quickly able to inform about an event and to supply documents to the general public and the media. The communication unit of the SSM has a completely new staff and has more resources. In order to decide on the quick release of documents, the legal staff of the SSM has been reinforced. SSM has a vision for its work and core values which form the basis on which the authority perform its work, which is characterized by *integrity, trustworthiness and openness.*

A new communication policy was established in April 2009 which emphasises the core values and shows how they are implemented (*availability, pro-active information, good quality, no unnecessary delay*). A web-site and communication strategy were developed. The new SSM documentation system and the ongoing up-grade of the SSM web-site will improve access to the regulatory body's documents and decisions. However, there will always be restrictions for what information can be freely shared due to legislation on classified information, security, commercial rights, and protection of personal data.

8.8 Conclusion

The Swedish Radiation Safety Authority was established on July 1, 2008. With reported reinforcements and in relation to its supervision programmes and practices, the staffing and competence situation is so far satisfactory. Additional resources will be available during 2010 and 2011. The situation will be addressed in a full-scope IRRS-mission[14], in February 2012.

Sweden complies with the obligations of Article 8.

14 IRRS stands for Integrated Regulatory Review Service

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

- IAEA has carried out OSART missions to all plants since last CNS review meeting.

9.1 Regulatory requirements

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

> 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 from the activities or therein arising nuclear material which is not reused, and
>
> (3) the safe decommissioning and dismantling of facilities in which nuclear activities no longer are carried out.

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

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

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

The 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.

The 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 functional 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, § 9 point 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 shall be documented in a safety programme that is to be updated annually (Chapter 2, § 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 to 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 by the licensee through self inspection. SSM examines how this liability is managed.

9.2 Measures taken by the license holders

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

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, to be met with reassuring 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.

SSM has concluded that Ringhals has shown signs of shortcomings within leadership and management for safety, see further section B 10.3.

9.2.2. Continuous upgrading of the plants

The principles used to upgrade 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 upgrade the reactors.

9.2.3. International peer reviews

International peer reviews are performed at the initiative of the licensees.

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

As a result of the Forsmark 1 event (see section B 10.4) the licensees asked the Government to request IAEA OSART- missions to Forsmark in February 2008, to OKG in February 2009 and to Ringhals in February 2010. The results of these reviews are public.

9.2.4. OSART review at Forsmark

An OSART team performed a review at Forsmark in February 2008. The final report has been made public.

A number of recommendations were identified, i.e.:

- The organisation should implement an independent high level safety review with responsibility to maintain safety accountability separate to the operating organisation.
- The plant should rigorously apply the control and review process of operational documentation, emergency preparedness procedures and operator aids.
- The plant should implement clear chemistry management expectations for the chemistry department and implement appropriate chemistry specifications
- At the time of the "25 July 2006 event" there was a lack of integrated operational experience feedback programmes and *Corrective Action Programme* at Forsmark. This was coupled with the weak use of a systematic analysis methodology. While technical issues were investigated in-depth, utilizing the expertise of experienced and knowledgeable staff, underlying organizational issues took longer to recognise and were later requested by the regulatory authority.

The OSART team also found good areas of performance, including:

- A very well structured management manual which supports communication of management expectations and commitments
- To use the training simulator to describe complex events and to demonstrate the work methods in the control room, following a disturbance, to the media and other key groups.
- Effective management of fire cells in order to prevent the spread of any fire and associated fumes.
- Structured cooperation with the original equipment manufacturer Westinghouse for operating experience dissemination for the improvement of safety.

In November 2009 OSART made a follow-up of the review. Of the 24 issues that were identified during IAEA's first review in 2008, Forsmark had achieved "Issue resolved" in 19 areas and "Satisfactory progress" in the remaining 5.

9.2.5. OSART performed at OKG

An OSART review was performed at OKG during the period February 17 to March 5, 2009. The review was performed within the areas: Management, organisation and administration, Training and qualification, Operation, Maintenance, Technical support, Operating experience feedback, Radiation protection, Chemistry, Emergency planning and preparedness.

The review identified 17 different deficiencies, (8 recommendations, 9 suggestions) and 11 examples of good practice.

Examples of identified deficiencies:

- OKG is recommended to implement a suitable system for demarcation and marking in order to protect co-workers as well as equipment
- OKG is recommended to categorise and prioritise in a clearer manner the modification requirements in the plant based on stated safety requirements
- OKG is recommended to define the deviations that are to be reported and that also require analysis in relation to root cause and trends

Examples of good practice are:

- OKG has developed an integrated management system that is user-friendly and has a good quality structure and connections to documentation
- OKG has high standards of training material
- OKG has an extensive and well functioning programme for in-service inspections, comprising planning as well as testing and reporting of results

Based on the deficiencies identified in the review, OKG has developed an action plan describing how OKG intends to handle these deficiencies. The progress of this work in handling the measures is regularly followed up at the management group meeting for OSART. In order to further follow up that the measures taken have had the intended effect OKG performs its own reviews to establish that the deficiencies have been attended to.

During the period November 29 – December 3 in 2010, IAEA did once again visit OKG to follow up on how the deficiencies identified in the review performed in 2009 had been handled.

9.3 Conclusion

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

- All plants have acted upon the experience from the Forsmark 2006 event.
- Vattenfall has, based on independent external reviews performed after the Forsmark event, made significant changes to its corporate safety governance.
- In July 2009, SSM issued a court order including special conditions for operation of Ringhals and also put Ringhals under special supervision in order to more closely follow the safety development at the licensee. In response to the regulatory intervention Ringhals has put together a programme for improvement of the leadership, quality of the management system, safety culture and operating experience.

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, 1 §) is that radiological accidents shall be prevented by a basic design including multiple barriers against releases and a defence-in-depth adapted to the plant.

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 economic 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, 7-9 §§, 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, 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 (interaction Man-Technology-Organisation), 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

Safety Councils have been established at the corporate levels in order to review major and more principal safety issues and to follow up and assess the safety development at the plants. As an example, the objectives of the E.ON Safety Council are shown in appendix 2. Furthermore, local safety review committees are established since many years at the plant levels to advise on principal safety issues.

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 oversight 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 oversight 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 oversight 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. Ringhals and Forsmark NPPs have for several years used a safety index which is aggregated from a number of different indicators. The Forsmark Safety Index is shown in Figure 5. In recent years Forsmark has expanded their set of performance indicators. The first approach was to develop “Quality Indicators” in order to measure the effects of the vast improvement programme that was performed after the Forsmark event in 2006, and the subsequent special supervision performed by the regulator. These indicators were sorted 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 (see Figure 6). Following the OSART review in 2008 at FKA 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 is decided on by the CEO.

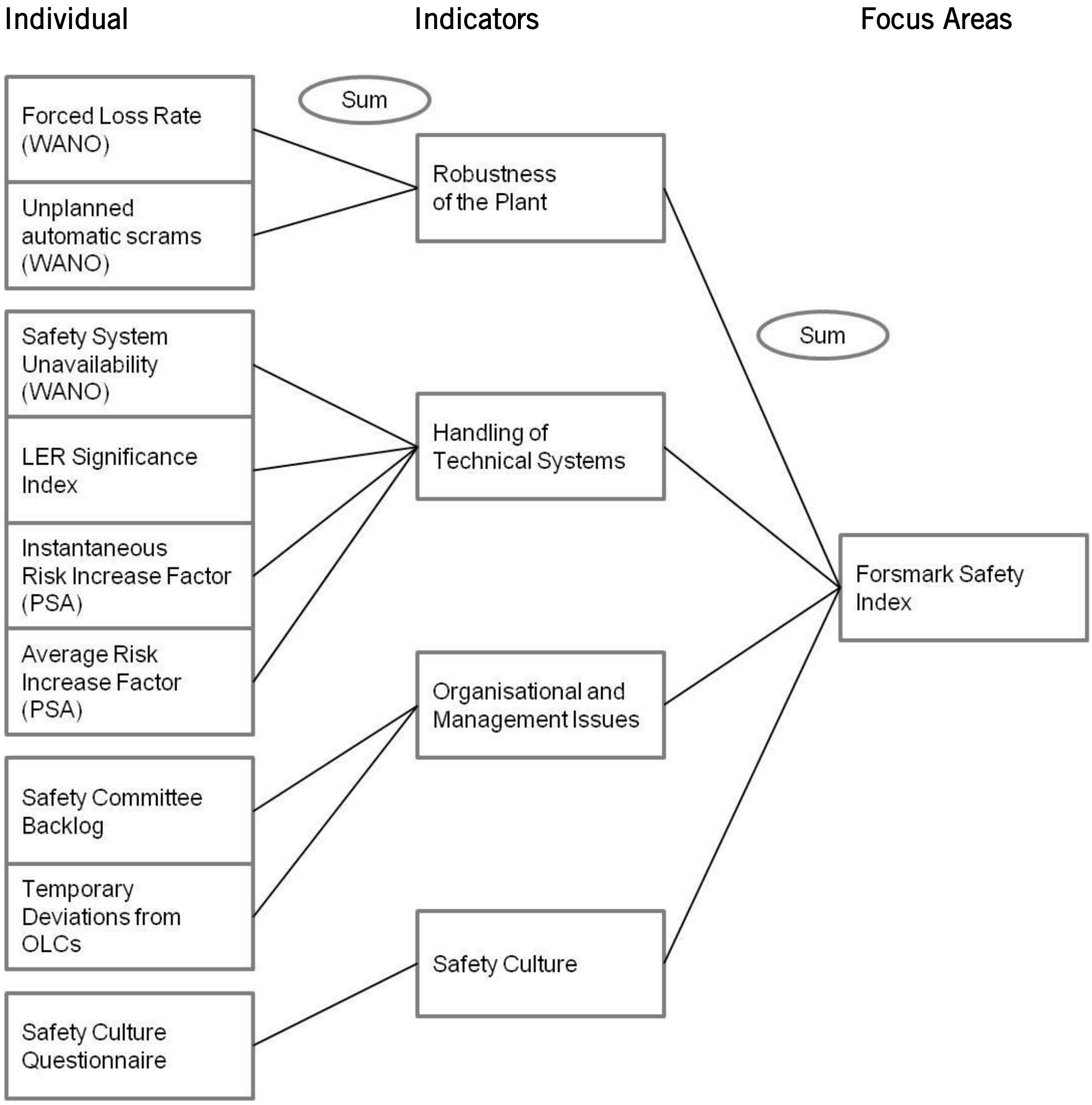

Figure 5. The Safety Index used in Forsmark (FSI)

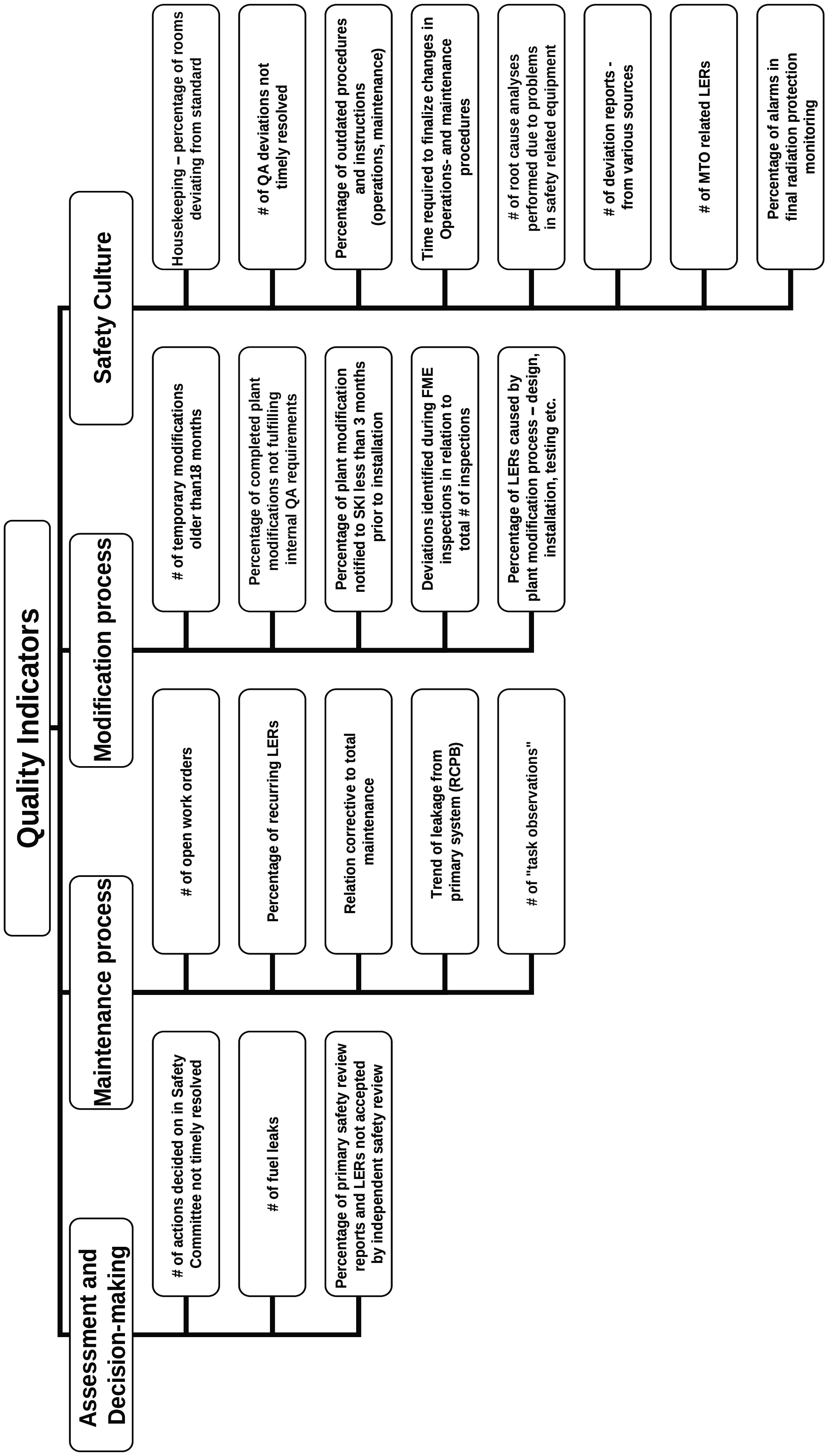

Figure 6. Quality indicators used in Forsmark

- The quality assurance systems (see further chapter 13) has been developed for all plants towards management systems and constitute an essential part of the safety management provisions, based on a quality policy and outlined in management- and quality handbooks.

10.2.3. Use of WANO Performance Indicators

Vattenfall Corporate as well as OKG 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.

Vattenfall Corporate presents and analyses the trends of the WANO PI Index annually.

At OKG, all results are presented on the intranet under heding Goals and Safety Indicators. On this page all together 27 indicators are presented. Of those 27 indicators 11 exactly follow the WANO definitions and are updated quarterly. The results are trended, reviewed, communicated and used to take corrective actions. The WANO PIs are used for:

- Evaluation of performance is made by the OKG upper management at least once a month. Furthermore once a year a special meeting is dedicated to evaluate indicator performance.
- In monthly meetings by the operating management the changes in results are presented.
- In the board meeting the results of the WANO PIs are presented once a year.
- Results are reported to E.ON Nuclear Safety Council.

10.2.4. NSMI, Vattenfall Nordic Safety Management Institute

NSMI is an institute initiated to support learning and research in the domain of safety management. The institute focuses on safety science issues associated with management of power plants, such as; operational and strategic decision making, safety management systems design, safety culture, risk analysis, accident theory, etc. A five-day pilot course was held at Ringhals in 2006. Since then a large number of managers and supervisors within the nuclear organisations at Forsmark and Ringhals, as well as personnel from the corporate office, have completed the course. In 2010 a shorter re-training course will be provided for previous participants. Researchers from various disciplines are invited to elaborate on safety management issues and to support in-depth discussions of, for example, safety culture development and decision-making. The institute is also supporting and carrying out research in the domain of safety management.

In the spring of 2010 NSMI and Business Unit Nuclear gave a 3-day introductory education on nuclear safety governance for the new CEO of Vattenfall and his staff.

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

OKG has since the beginning of the 1990s worked on improving the Safety Culture. A number of surveys and analyses have been conducted. A long-term programme, referred to as the "Action Plan for Safety Culture at OKG" was implemented early in 2004. It is carried out by the section Organisational and Competence Development (HO) and is organised under the Human Resources Department. A number of part-time Safety Culture-Ambassadors from all over OKG participate to run the programme. An annual follow up of the action plan and of the work methodology is carried out.

The performance of systematic Safety Culture activities is one way of working strategically with safety. The Action Plan for Safety Culture at OKG depicts how the company will attain a strengthened Safety Culture. The plan is based on three vital principles, the long-term basis, continuity and the systematic approach. Those principles together create the necessary foundations for a work process in which the Safety Culture is slowly but surely improved over the course of time. The activities incorporated in the Action plan for Safety Culture at OKG consist of both continuously repeated activities and analysis as well as of specific activities to make improvements in Safety Culture.

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

Any indications of deficiencies and weaknesses must be taken care of through specific efforts. These efforts will be adjusted to the nature of the deficiency or weakness and its organizational origin. Such efforts could be special courses, training, education, seminars, coaching and suchlike.

- A **quantitative survey** is carried out continuously. The result of the survey is presented to the OKG management. The middle management is given the results from their own groups in order to carry out workshops with their staff. The general OKG survey results are also posted on the OKG website. The total compilation of the results from the workshops is communicated in the cross-group seminars.
- A **qualitative interview investigation** is carried out continuously resulting in a report. The report and its result, as well as the planning of the specific efforts, are communicated to the whole organisation through the cross-group seminars.
- A **meta-analysis** is carried out continuously with the ambition to create a comprehensive picture of the safety culture situation at OKG. The meta-analysis is based on actual occurrences, conducted investigations, points collected during seminars and workshops, LERs and other material that is relevant to Safety Culture and interviews with personnel at all levels in the company as well as contractors. The result of the meta-analysis is communicated at workshops with the senior management, seminars with middle management as well as during cross group seminars. On the basis of the meta-analysis measures are taken to improve the safety culture.

10.2.7. The Ringhals safety culture programme

For Ringhals, the safety culture work is described in a 3-year programme that is updated annually. The programme contains planned activities for all departments of the organisation.

The update of the programme for 2010 – 2012 includes a new approach by letting it be based upon the principles of the WANO guidelines for a strong safety culture. The guidelines should assist in providing clear goals. Assessments against the attributes of the guidelines give an indication on strong areas as well as on areas for improvement, and thus aids in focusing resources for improvements. The data for the assessment comes in the form of analyses, questionnaires 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 supposed to push the efforts of the programme within their respective departments, but also to participate in further developments together with other departments.

In 2010 Ringhals will prepare material for the departments to perform self assessments of their safety culture improvement work. The goal is to reach continual improvement in the results of the annual questionnaires “MyOpinion” and Safety Culture.

10.2.8. Forsmark safety culture initiatives

FKA has over the past three years 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 for special supervision in September 2006 which required that an action plan was established. Within this action plan a large number of measures have been taken, including:

- Development of new approaches to evaluation and decision making on safety issues
- Education within the Vattenfall Nordic Safety Management Institute (NSMI)
- Seminars for operational management and shift engineers
- Establishing management review meetings regarding safety
- Developing quality indicators for monitoring the safety culture
- Clarification of management's expectations in the management system including group-wide reviews of these expectations
- A new approach to operating experience feedback
- Commitment to MTO-skills and root cause analysis
- Implementation of cross organizational employee dialogues for all staff
- Strengthening leadership for all managers

The action plan to meet the SSM decision is now complete. Continued development of safety culture is part of the normal routines in the management system, driven through the reactor safety programme. The programme is revised annually and approved by the CEO.

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 (se section 8.3) provide an updated comprehensive regulatory assessment of the safety of the facility. A management meeting follows each SSM 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 put Ringhals under special supervision in order to more closely follow the safety development at the licensee (See section 8.3). The background for this were a number of safety related events in recent years (2005-2009). Ringhals had been aware of these deficiencies but the correction programmes which were initiated had not been sufficienly effective. SSM concluded that Ringhals had shown indications of shortcomings within the leadership and management of safety.

SSM issued on July 7, 2009, a decision including special conditions for the operation of Ringhals. The decision included four separate items that had to be reported to SSM before November 1, 2009, and 4 specific conditions for operation. These items were:

- Investigate and explain why documented routines in the management system not are followed in the manner intended
- Investigate and explain why earlier and current corrective programmes in areas such as management, controlling, traceability and acting according to established routines, have not been sufficiently effective
- Prepare and report a correction programme for how to manage the deficiencies identified under the items above
- Prepare and report how Ringhals intends to measure and follow up the effectiveness of the correction programme

Ringhals prepared a comprehensive report based on the items 1 – 4 in the decision. The report is in many parts based on the Ringhals preparation programme for the OSART review and focuses on:

- Strengthened leadership
- Improved quality of the management system, including operation and maintenance procedures

- Safety culture programme, according to WANO guidelines
- Operation Experience Programme (including a Corrective Action Programme, CAP)

This was reported to SSM at the end of October 2009.

Ringhals has set up the following efforts to strive for (regarding plant and organisation):

- Reduced number of safety related events
- Reduced number of deviations in internal audits
- Reduced number of decisions from the regulatory body
- Increased station quality shown through decreased number of production disturbances

This gives focus on "Safe and Stable Operation". The management's assessment of progress is supported by a number of indicators and trends that are being followed up on a quarterly base.

10.4 Actions to cope with issues revealed by the Forsmark event

10.4.1. Background

The incident on 25 July 2006 in Forsmark unit 1 revealed a number of technical and administrative weaknesses at the plant. The event started when the reactor scrammed as a result of a short circuit in the offsite 400kV switchyard in connection with maintenance work done by Svenska Kraftnät (the national grid company). The voltage and frequency variations that followed resulted in failure of the emergency diesel generators of train A and B. The event was classified as a level-2 event on the INES-scale, due to the CCF characteristic. The event was fully described in 4th Swedish national report.

10.4.2. Forsmark actions

The main deficiencies were corrected before restarting the units. Other technical and procedural issues identified by operations, maintenance and technical departments were included in a long-term, 60-step programme. These issues were ranked into four groups. The following are examples on issues of priority 1, which were analysed/completed by mid 2007:

- Installation of parallel power supply to the speed measurement device on the emergency diesel generators in two of the four divisions
- Verification of the shortage protection in the 400kV grid switchyard
- Correction of inaccuracies in the Safety Analysis Report (SAR) and procedures
- Analyses of enhancements concerning displays, signals and event registration in the main control room
- Investigation that the breakers, connected to the diesel-supported grid, will reengage automatically in case of loss of power
- Correcting the testing routines concerning phase order dependencies
- Analyses of routines and equipment for work on 400kV grids (SVK, The Swedish Power Distribution Board)
- Analysis of optimal behaviour of the generator breaker after a turbine trip
- Analysis of whether extended protection against overload is necessary

Further actions to resolve some of the issues revealed include:

- Modifications against slowly falling voltages
- Modifications in the excitation system (voltage regulator)
- Extra over-voltage protection in the UPS system
- Modifications to increase robustness against disturbances from the grid in the reactor internal pumps
- New out-of-step protection

FKA personnel have since the Forsmark event been deeply involved in the OECD/NEA DiDELSYS project (Defence In Depth ELectrical SYStem), see further information below.

In October 2007 a new department for operating experience feedback (OEF) and analysis support was established at FKA. Further description is included under section B 19.2.

10.4.3. Ringhals actions

Immediately after the Forsmark event Ringhals verified that the four units at the plant were operable. Events in some aspects similar to the Forsmark event had occurred frequently in Ringhals during the 1970's and 1980's due to pollution from the sea to the outdoor switchyard. No failures of the essential electrical power systems, AC or DC, occurred in conjunction with these events. A systematic review of the electrical power systems confirmed that the design could cope with the voltage and frequency variations to the essential electrical power systems when grid faults are cleared and the unit switch to island operation or remains connected to the grid.

Further work concluded that the design bases for the on-site electrical power systems were not always documented in sufficient detail or easy to retrieve. With scheduled safety upgrades and necessary replacements of obsolete equipment these design bases are essential.

The goal of the coordinated effort, started after the Forsmark event, was robustness of electrical power systems. The robustness depends on a number of different issues as illustrated by Figure 7.

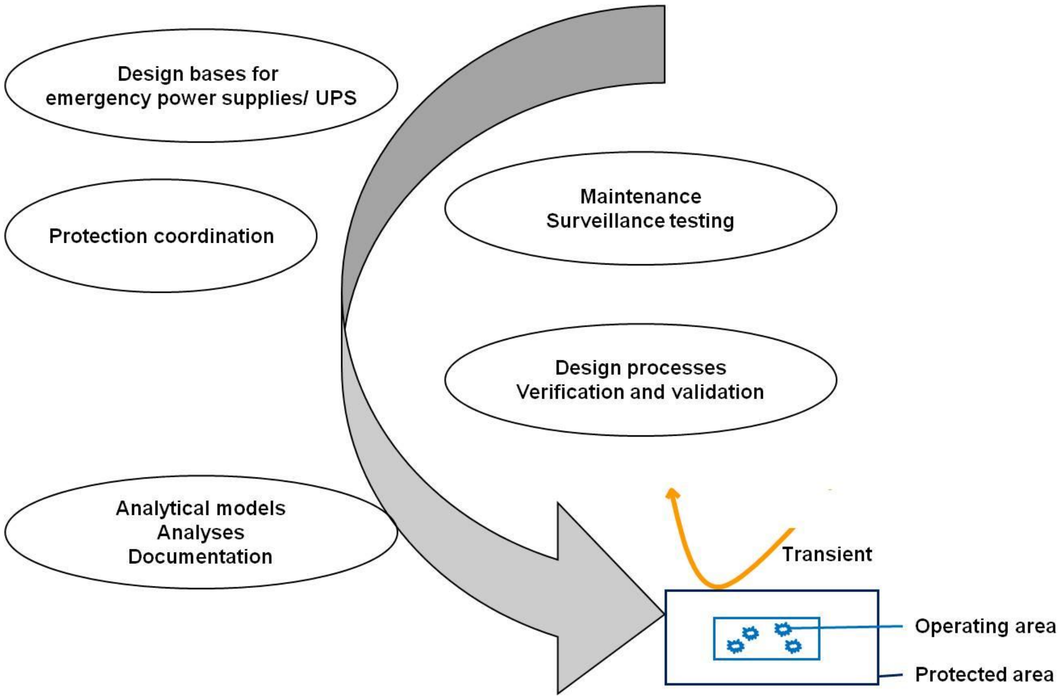

Figure 7. Robust electrical systems

During the reporting period Ringhals has participated in international conferences as well as in IAEA work in this area, such as the update of the IAEA Safety Guide NS-G-1.8, *Design of Emergency Power Systems for Nuclear Power Plants.*

10.4.4. Oskarshamn actions

Analyses and plant modifications implemented at Oskarshamn 1, 2 and 3 after the Forsmark event 2006 ensure that the units comply with the Safety Analysis Report (SAR) and meet the requirements which form the basis for the short- and long-term plant modification shown below.

Short Term: The following issues were considered essential to implement within a 3-month period after the incident:

- Update the SARs
- Changes the design basis requirements for the over voltage
- SAR should describe the voltage transients the plant should withstand
- Important parameters for the design of the electric systems were missing and should be implemented
- Basic data in form of transient analysis was needed followed by the corresponding update of SAR
- Generate instructions describing the procedures used for the work in the external switchyard.

Long-Term: The following long-term measures were identified, some were performed in collaboration with other nuclear plants in Sweden:

- An overhaul of the plant's surge over voltage protection
- Consideration of the recommendations from the experience report on various situations in the control room during disturbances

- Investigation of the required information for operators and analysts during and after a disturbance
- Work out instructions that clearly describe how the testing and commissioning should be carried out.
- Overhaul maintenance instructions for control of inputs to all types of protection equipment
- Development of the concept of diversification, redundancy and CCF-issues
- Coordination with other NPPs regarding planned and conducted confirmatory testing of electrical components
- An evaluation of the generator protection equipment settings based on experience of past failures
- Investigation to verify the rectifiers and the DC bus bars behaviour during disturbances in the external grid.
- Extensive analysis into why the UPS units were not dimensioned for transients of the same type that Forsmark experienced
- Investigations to verify the DC systems and the uninterruptible AC systems behaviour during disturbances in the external grid
- Apply new routines for the plant modifications and for evaluation of events including categorization according to SSMFS 2008:1

Soon after the Forsmark 1 incident, and following an analysis of the electric auxiliary power systems, the battery backup and the diesel backup bus bars the decision was made to shut down Oskarshamn 1 and Oskarshamn 2. The aim of the analysis was to show that the systems were robust in the event of a grid failure.

In October 2008 unit 3 was shut down because of the results of the new safety analysis (profiles) indicated some weaknesses in the plant's ability to manage operations when a particular combination of faults occurred simultaneously. If the voltage decreases slowly and continues to fall below 85%, there is a risk that motors can trip due to their own overload protection. In order to cope with this issue, a new level of under voltage protection (85%) was implemented at Oskarshamn 3. At a voltage below 85% the safety consumers will be fed from the emergency diesel units.

10.4.5. Vattenfall Corporate actions

The Forsmark event also led to some questions about Vattenfall corporate nuclear safety management. In September 2007 the result of an independent review on nuclear safety governance within Vattenfall (its Swedish operations) was published. Most of the recommendations from that review have been implemented, i.e.:

- On Group level a Chief Nuclear Officer, CNO, was appointed, and a Nuclear Safety Council with external members has been operational since 2008
- Several basic documents have been issued on Group level, e.g.
  - A new Safety Policy (see Appendix 1)
  - A Directive on nuclear safety outlining how to reach the ambition to regain a leading position regarding safety and availability
  - A Vattenfall Nuclear Opinion Paper
- Corporate resources for nuclear management have been strongly increased through a new pan-European organisation (in operation since 2009) with a dedicated Business Unit Nuclear,

managing Vattenfall's Swedish and German nuclear operations. One attribute of the new organisation is that it performs on a quarterly basis a "second opinion" of safety performance, forming one piece of a strengthened self-assessment process within Vattenfall.

During 2009 the new BU Nuclear performed a major strategic work aiming at measures to achieve the goals as of the Group level Directive on nuclear safety, and along the lines of Vattenfall's strategic ambitions. A large number of strategic initiatives have been proposed, and some are already (late 2009) being introduced, i.e.:

- Gain sufficient knowledge of plant conditions to make the right investment and maintenance decisions
- Develop the leadership towards nuclear business acumen (defined as "the insight, knowledge and ability to manage the unique interaction between technology, economics, people and safety in a changing nuclear generation environment")
- Free management time for increased focus on daily operations, to increase / maintain quality in daily operations
- Identify, prioritise and streamline most important processes
- Develop a harmonised human performance programme

Other measures taken, at least partly in the light of the Forsmark events include:

- Postponement of major projects (e.g. power up rates) in order to relieve the organisations and increase the focus on operations in the near-term.
- Reporting on nuclear safety at all Vattenfall Supervisory Board meetings.
- Education on nuclear safety, within the framework of NSMI, for board members and corporate personnel and managers
- In order to strengthen its international engagement, Vattenfall is since 2009 its own member of WANO

10.4.6. SSM actions

On 21 July, 2009, SSM decided to lift the special supervision of Forsmark. SSM judged that Forsmark had implemented the necessary safety measures to an extent that special supervision was no longer motivated. Forsmark had worked very hard to implement the safety improvements required by SSM and also implemented other measures, based on the recommendations from the OSART review in Forsmark.

The information and reporting from Forsmark regarding the ongoing safety improvements gives SSM a good basis to follow future safety improvements.

SSM hosted an international seminar in Stockholm in September 2007 to discuss the event in Forsmark 2006.

After the 2007 seminar OECD/NEA/CSNI decided to form a group of safety authorities to present a report on defence-in-depth issues of electrical systems in nuclear plants. In 2009 the report was presented to the CSNI to get authorization for a more detailed investigation with the aim to strengthen the robustness of the electric systems.

A meeting was held at SSM in September 2009. The CAP was approved by CSNI in December 2009. In the discussions it was decided that FKA should represent the Swedish nuclear owners in this group. This work started in April 2010.

10.5 Measures taken by SSM to prioritise safety

One basic idea behind the SSM management system is that SSM shall devote its supervision resources to the most important safety issues. The annual activity-planning process takes as its starting point the current regulatory challenges, which are documented, as well as input from SSM integrated safety assessments and other regulatory processes. 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. As described in the second national report, 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. 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.

10.5.1. Regulatory indicators

SSM has the ambition to develop and use a system of indicators in the area of nuclear and radiation safety. The aim is to support the annual integrated safety assessments carried out by the SSM for each of the nuclear power plants, and to support the priority of forthcoming oversight and regulatory activities.

A pilot project on regulatory indicators, previously performed by SKI, ended in 2008. SSM is presently evaluating the outcome and the experience obtained in the pilot project. After the evaluation, SSM will decide how to proceed with the future development of an indicator system.

10.6 Conclusion

Sweden complies with the obligations of Article 10. The Swedish plants and owner organizations have taken firm measures following the Forsmark event in 2006.

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

- About 30 billion SEK (3.26 billion EUR) will be invested in the Swedish nuclear power plants.
- An agreement has been reached between SSM and the industry to continue the economical support of the Swedish Centre of Nuclear Technology for the period 2008-2013.
- Within the area of radiation protection the situation with regard to the national supply of qualified experts has improved since 2008 when SSI (now SSM) could support three lectureships in radiobiology, radioecology and dosimetry, each either with an additional postgraduate position or a post-doctorate fellowship, and basic resources for the associated research activities.
- The government has in the 2010 appropriations instructions for SSM asked for an investigation of the national competence necessary for the activities of SSM now, and in the future. This will reported early in 2011.
- Transfer of competence is a high priority at all nuclear plants.

11.1 Regulatory requirements

In order to obtain a licence in Sweden, large economical resources must be committed in order to manage the farreaching safety obligations required in the Nuclear Activities Act 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[15]. 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

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

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 operatal 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. Operatal staff must be formally authorized by the licensee for the specific position. The authorization is valid for three years under certain conditions.

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 1 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 2009 are given in Table 8.

Utility Group	Earnings MSEK[16]	Total assets MSEK	Electricity sales TWh	Equity/Assets Ratio %	Investments MSEK
Vattenfall	17,734	602,127	194.6	24	102,989
E.ON AG	117,610	1,480,569	815.9	29	116,342

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 30 billion SEK will be invested. The priorities are enhancing safety and otherwise modernize the plants to provide for longer-term operation (50-60 year life times). The ongoing power up rates will in total add some 1200 MWe by 2014.

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

11.3.1. Staffing situation

The Swedish operating organizations have always been considered 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.

[16] Before taxes and minority share.

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 age distribution figures from Forsmark shown in Figure 8 and Figure 9. As can be seen in these diagrams, the average age of the staff has increased steadily over the last 20 years, and is now just under 45 years. About 220 persons are due to retire within the next 10 years. The situation is similar for the other nuclear power plants. About 220 persons are due to retire within the next ten years from OKG and about 360 from Ringhals.

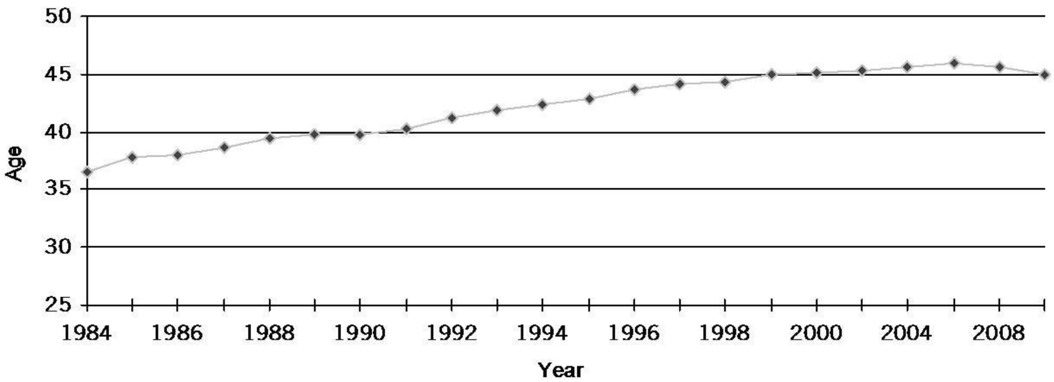

Figure 8. Average age of Forsmark NPP staff

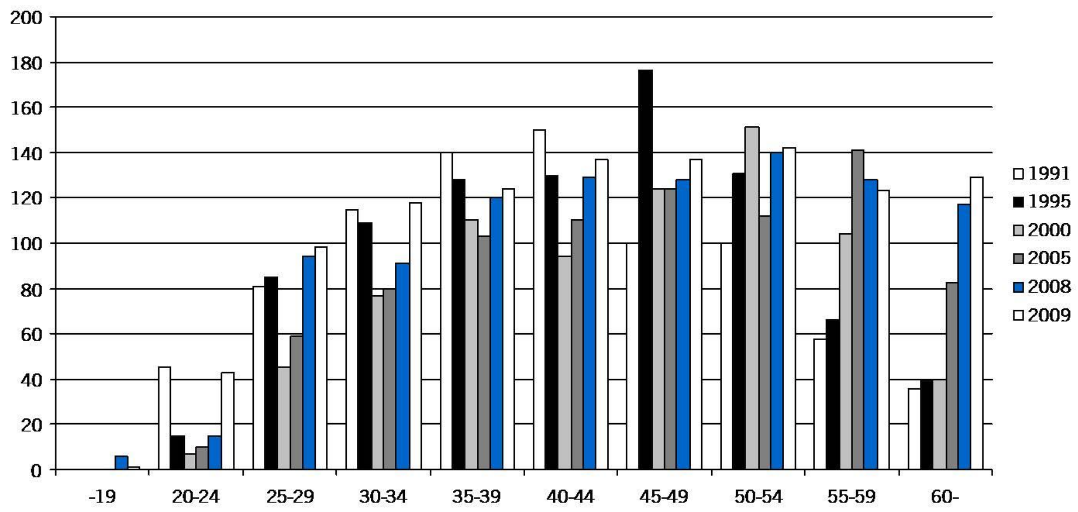

Figure 9. Age structure at Forsmark NPP

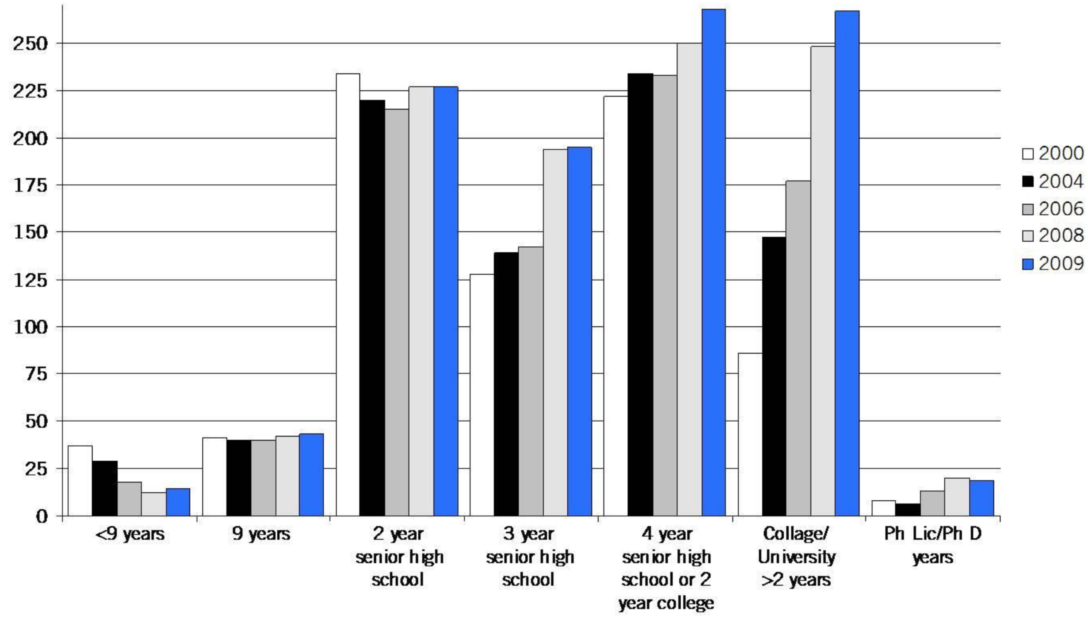

Figure 10. Education of Forsmark NPP staff

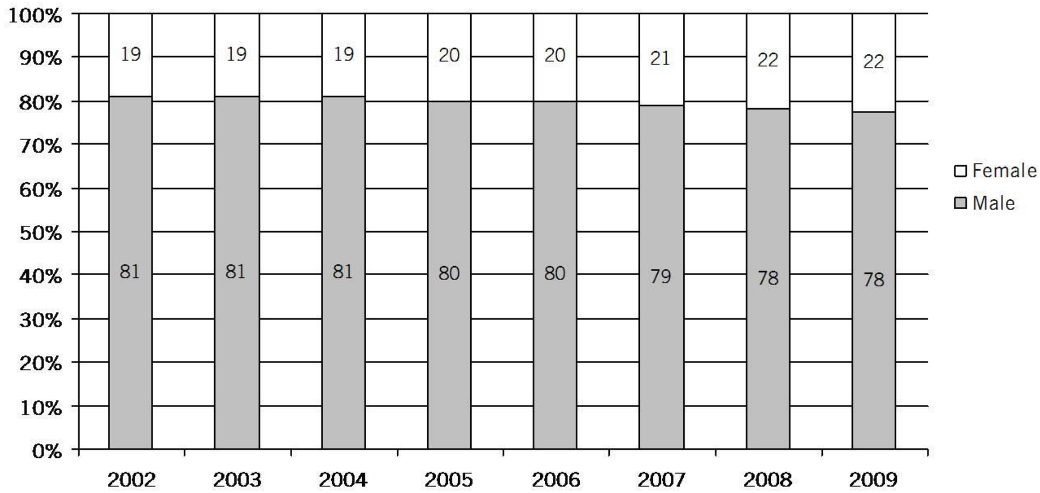

Figure 11. Gender distribution at Forsmark NPP

All licensees have planning in place 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. Current planning at the different sites is reflected below.

It is also interesting to note in the diagrams from Forsmark that the share of university trained staff has increased quite a lot over the last six years. The gender distribution has been very stable with about 80 % men, but now the number of women is slowly increasing.

11.3.2. Transferring of competence at OKG

The short term objective is to:

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

In a longer perspective:

- to create an environment in daily working practice that stimulates transfer of competence.

Within the next ten years 220 employees of 900 will leave OKG, most due to retirement. About 50 (mostly in maintenance and engineering) of this 220 have been chosen to participate in a programme “Transferring competence”. The main objective is to maintain OKG’s strategic competences. Other objectives are to reduce the dependency on consultants, avoid vulnerability because of insufficient personnel and to compensate a lack of competence amongst suppliers.

OKG has identified three levels of strategic competence where gaps will create problems to achieve the business goals:

- significant nuclear specific competence, e.g. in operations, maintenance (reactor and primary system), engineering (analysis and calculation, construction of safety systems) and radiological environment.
- important general competence, e.g. fire-protection, maintenance (turbine, electric power), engineering (conventional construction), chemistry
- other competence that “has to be carried out” e.g. storage, decontamination and administration

The process of transferring competence consists of different steps:
1. mapping the need to transferring competence, in order to achieve an updated programme,
2. engage resources, e.g. throughrecruitment 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 resource plan, containing future needs and the balance between Ringhals employees and contractors/consultants, and the need for competence transfer is assessed on an individual level. A "need for competence transfer" is defined as an activity lasting for at least 6 months and involving parallel service, participation in specific projects or other forms of transferring competence.

The competence- and resource 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:

Identification of tasks - In order to capture the work that needs competence transfer, mentor and/or the manager identifies the tasks that the employee performs.

Valuation of work - Validation of the effort to learn to carry out the task. The valuation also involves "Score of impact" and "Valuation of frequency".

Develop activity plan - The tasks and the actions needed are documented in an activity plan.

Competence transfer in the daily work

Follow-up of knowledge - It is important to monitor how the knowledge transfer is progressing and how cooperation between the mentor and the adept works.

11.3.4. Transferring of competence at Forsmark

Within the next ten years more than 220 employees are due to retire from FKA. 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, parallel practice with experienced colleagues and full scope replica simulator training.

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 STF.

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 factored 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 2009 the company had 270 employees of whom 130 were located to local centres. About 3 964 training-days were provided during 2009 (2 219 in 2006). KSU also has an extensive instructor training programme for its own staff with several qualification levels.

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. The Figure 12 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 during the last 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.

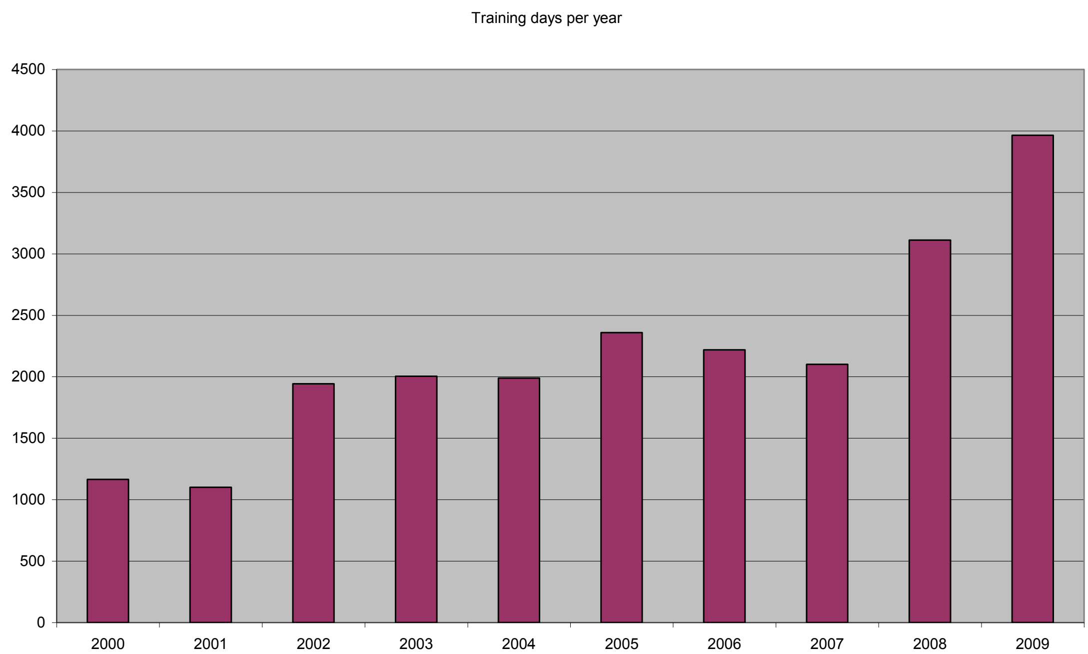

Figure 12. Training days per year the last ten years

11.4 Regulatory control

The licensee's compliance with the SSM requirements on competence assurance was inspected a few years ago at all nuclear power plants. SSM concluded that the required systematic approach is in place to ensure long term staffing and competence. Since then, SSM has performed follow-ups to ensure continued use of this approach. A follow-up of the competence assurance of consultants was done 2007. SSM concluded that the licensees do have adequate systems for assuring the competence of consultants.

However, SSM has observed delays and quality problems in the modernization and power up rate programmes at the nuclear 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 assuring quality of services purchased, e.g., assuring supplier and consultant competence.

Starting in 2010, SSM is also focusing attention on the licensees' work to ensure adequate and required health controls of their personnel.

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

Since the first national report, in which concerns were expressed over the future supply of nuclear experts against the background of the uncertainty of the future of nuclear power in Sweden, the situation has changed considerably. In the fourth national report a more optimistic picture was painted and it was stated that at that time neither the industry nor the authorities experienced severe problems to recruit the necessary technical staff.

However, today both the industry and SSM have experienced difficulties to recruit qualified experts. The reason for this is that the nuclear industry is in its most intensive phase since the construction phase in the 1970's and beginning of 1980's due to modernization, power up rates and extension of plant life beyond periods analysed in the original design.

In the nuclear area there is an agreement between SKI (now SSM) and the industry to cooperate in the Swedish Centre of Nuclear Technology to support the technical universities. In the beginning, from 1992, the support was concentrated on PhD students, but from 2002 the support also includes professor chairs. A new agreement for the years 2008 – 2013 is now in effect. The support is now more open. The progress of the research and courses is closely monitored. The effect of the support to the technical universities has recently been analysed. The investigation came to the conclusion that the support to the technical universities is extremely important to cover the national demands for key nuclear competence and should be continued and developed.

In radiation protection the situation has improved since 2008 when SSI (now SSM) could support three lectureships in radiobiology, radioecology and dosimetry, each with either an additional postgraduate position or a post-doctorate fellowship and basic resources for the associated research activities. Each research position was for three years. In the autumn of 2010 SSM will evaluate if these research positions should be extended for an additional three year period.

In its annual appropriation letter for 2010 SSM was tasked to investigate its own, as well as the national, human resources and knowledge management situation within the authority's areas of responsibility. In its next annual report SSM shall specifically report on:

- The present access to expertise and human resources within the authority's areas of responsibility;
- Predictions of future needs and access of expertise and human resources; and

- An assessment of how nuclear safety and radiation protection could be influenced by these assessments.

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

- A network regarding Human performance and Safety Culture has been established between the power plants in Sweden and Finland, SKB, KSU, and Westinghouse.

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, such as allowing time for consideration, adequate information- and annunciator systems in the control rooms and good ergonomic design supporting cooperation and communication within the team, design solutions have to be evaluated in a realistic environment.

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 in all Swedish nuclear power plants, supported by policies, responsibilities and organizational structures, which differ between the plants and the different subject areas. All licensees today have MTO specialists with a behavioural science background in their independent safety review functions (see chapter 14). OKG has established a department focused on human and organizational issues. The responsibility for this department is to gather competence (both technical and behavioural) and to work with MTO issues, experience feedback, safety culture, management development, and organizational issues. FKA have established a department with responsibility for MTO-analysis and operating experience feedback. This initiative have resulted in both improved quality in the analysis performed and a larger number of analysis reports being completed. In 2008 Ringhals established a department with responsibility for MTO-analysis, safety culture, operating experience feedback and human performance tools.

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.

MTO R&D projects 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 introduced 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 B 10.2. 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.

In an ongoing cross-functional research project at Ringhals unit 1 conducted by VTT in Finland, focuses on the development of methods for safety evaluations of organisation.

Human performance and Safety Culture

A network regarding Human performance and Safety Culture has been established between the power plants in Sweden and Finland, SKB, KSU and Westinghouse in order to exchange information and to develop knowledge in the area.

Method development for Integrated System Validation

The purpose of the project is to support the Swedish authorities regarding the development of methods' for Integrated System Validation. The project is being carried out by FOI (Swedish Defence Research Institute) together with the Swedish utilities.

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 in the research reactor at IFE Halden in Norway together with utilities in Sweden and Finland.

12.3 Regulatory control

The MTO-section of SSM is completely integrated with the technical sections and participates in inspections, safety reviews and other regulatory activities. Eight professionals, an increase by three in recent years, with a behavioural science background work in the MTO-section.

Current issues for the MTO-section are inspections and reviews of

- Management systems
- Economy and safety
- Organisation and organizational 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
- Maintenance

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

- Bonus systems and their impact on safety
- Preconditions and aspects when evaluating validations of control room changes.
- Methodology for performance-based validation of control rooms – experience from plant modernizations and research issues
- Indicators of safety culture – selection and effects of leading safety indicators
- Evaluation of safety critical organizations
- Purchasing within the Nuclear Power industry; Quality and Safety

As well as these R&D-projects, SSM supports one professorship in Man-Technology-Organisation at the Stockholm University and several post graduate studies. Since many years SSM (earlier SKI) has also supported the Halden Reactor Project for many years.

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

- No licence holder has made any principle changes in the management system since the fourth national report.
- During 2009 the FKA contract for operating SFR, the repository for low and intermediate level radioactive wastes ended, which meant major changes in the management systems for Forsmark.

13.1 Regulatory requirements

The SSM general safety regulations SSMFS 2008:1 chapter 2, 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 the management systems

All licensees have integrated management systems in place and are working 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.

As was mentioned in the fourth national report, Vattenfall has required that Ringhals, Forsmark and SKB should make comparative studies of their management systems against IAEA safety standard GS-R-3. Such comparative studies have been carried out as part of the preparations for the IAEA OSART peer reviews that were performed in 2008 at Forsmark, in 2009 at Oskarshamn and in 2010 at Ringhals. The gaps that were identified during these analyses have led to plant specific changes in the management systems at all three nuclear power plants. However, the comparative studies have not led to any changes to the basic principals of the system. The OSART peer reviews performed have not resulted in any issues concerning the management systems.

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:

In 2009 the FKA contract for operating the repository for low and intermediate level radioactive wastes ended. After the contract ended, SKB resumed full responsibility for the operation of the repository. These changes led to major changes in the management systems for both FKA and SKB.

Ringhals:

The Ringhals Management System, RVS, developed over many years. To meet the increasing complexity of technology and rate of change, Ringhals has decided to increase its speed and ambitions in this development work. A pre study has been initiated to create provisions for an improved structure and transparency of RVS. This study will be the basis for a decision on further improvements.

The ambition is that Ringhals should with margin fulfil external requirements on management systems, derived from nuclear as well as conventional industry models. A 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 frame of the management system.

Oskarshamn:

In OKG recent development of its integrated management system includes the mapping of the processes of OKG:s entire business, and also a model for describing the management and control of OKG:s business in a clear manner.

OKG has also implemented a new process for handling new or changed legal, regulatory or corporate requirements, and has established a new Quality department with responsibility to maintain and develop the integrated management system and also to develop the methods for continuously improvement of the processes within the entire company.

OKG received an OSART Good Practice during the review in 2009 for their management system, for the simple and easily understood computer based structure and that all employees receive training on how the management system works. It is also easy for each worker to access the documentation.

The management systems of OKG and SKB were changed because SKB took over the full responsibility for the operation of the interim storage for spent nuclear fuel (Clab), which is located at the Oskarshamn nuclear power plant site.

13.2.2. Audit programmes

All licensees have a process to conduct audits and an audit programme, which is used to monitor how well the quality system is implemented at different levels and applied of 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 of 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.

At OKG the audit programme has been changed to reflect the development of process maps. 25 audit team leaders supported by approximately 80 auditors are used to perform the annual internal audit programme. The programme consists of 20-25 audits each year.

13.2.3. Audits of suppliers

Audits of suppliers have been carried out for a long time cooperation between the Swedish nuclear power plants and there is a common group for management and supervision of supplier audits. There is also a common 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. SSM follows the work of the licensees to improve their systems each year. 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.

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

- The Government has tasked SSM to investigate the safety development at thenuclear reactors, the adequacy of supervision methods, and how extended operation (beyond 50 years) will influence safety requirements.
- The SSM has issued new general advice on the structure and contents of the plant safety analysis reports (SAR).
- The licensees are finalising their work to update the safety analysis reports in order to comply with the requirements of SSMFS 2008:1.
- SSM has ordered some of the licensees to amend their newly submitted ageing management programmes.
- From 2009 SSM has included two new areas in the PSR process: *On-site radiation protection* and *Radiation protection of general public and the environment.*

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 with probabilistic methods in order to provide a more complete picture of safety.
- 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. The analyses, assessments and the measures resulting from these shall be documented and submitted to SSM.

  The purpose with this periodic safety review (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.

General advices are issued on the interpretation and application of the legally binding requirements. In these recommendations the safety analysis conditions are specified. As to scope: the PSA for a reactor facility should include an analysis of the probability of core damage (level 1), as well as the probability of releases of radioactive substances to the environment (level 2). Power operation, shut down and start up, outage and refuelling should be considered as well as all relevant internal and external hazards.

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. The deterministic safety studies should be verified and developed by PSA in order to achieve a better basis for the design. In the general advice to the regulations, some advice is given on the acceptability of using probabilistic arguments when assessing the design and operation of a reactor facility.

In the general advice on the periodic safety review, 15 safety areas (see also section B 8.3) are pointed out where the plant shall 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 have to be corrected without delay. Deviations from newer requirements, standards and practices should be assessed with deterministic or probabilistic methods or engineering judgement, reasonable practicable measures defined and included in the safety programme of the plant. The review methodology used has to 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.

As a result of the broken control rod shafts extenders in Oskarshamn 3 and Forsmark 3 (see section B 6.1) SSM will include specific requirements for control rods in the next revision of SSMFS 2008:13.

14.1.3. Verification of safety decisions

SSMFS 2008:1 chapter 4, 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, 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 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, 9 § point 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 on principal safety issues.

14.1.4. Inquiry on the safety development at the Swedish nuclear power production

In April 2010 the Swedish Government charged SSM to investigate the long-term development of nuclear safety at the Swedish nuclear installations. The objective is to provide the Government with an up-to-date picture of nuclear safety, its long-term development, including the inspection methods used by SSM. The background to this is the ageing reactors and their particular safety needs, challenges in connection with safety upgrade work and planned power up rates, the utility owner's efforts to rationalise and optimise operations, and plans for extended operation of the reactors.

SSM must constantly develop its supervision and test how well the applied principles and control methods used are against the changes in the world around and at the supervised utilities/activities. With this and the planned IAEA IRRS-mission in February 2012 in mind, SSM shall report on the following:

- An appraisal of how well the nuclear power reactors fulfil the safety modernization requirements that SSM prescribed in the regulations SSMFS 2008:17, and how this influence safety.
- An appraisal of the conditions necessary for operating the nuclear power reactors for extended periods (over 50 years) and any requirements for a safety review and safety improvements which follow from such extended operating periods.
- An appraisal of the main conditions which determine whether it is possible to continue to operate a reactor during extended time periods with a retained level of safety.
- An appraisal of the Swedish supervision model within the area of nuclear reactor safety compared to international standards and experience.
- The international experience on safety improvements at reactors as a basis for decisions on the extension of operating periods.

The SSM shall report the results of the investigation to the Ministry of Environment by November 1, 2012.

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 SKI 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 up rating programmes (see sections B 6.2 and B 6.3). SSM requires that for major plant modification projects, such as the modernization and up rating 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 new requirements
- Decision on specific application to the plant
- Revision of the requirements in the SAR

As an example, OKG has a norm committee with nine members which holds monthly 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 design basis accidents (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 1970's with limited assessments of Oskarshamn 1, Forsmark 3 and somewhat later of Ringhals 1. When the periodic safety review programme (PSR) was initiated in the early 1980's, 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. The latest version of the T-Book has number 7 and it was published in February 2010.

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 current situation is summarized in Table 9 where the latest basic version of the PSA studies is shown.

Unit	Level 1	Level 2	Fire, Flooding	Low power, Refuelling	Start up- and shutdown	External events
Forsmark 1 and 2	2009 *2010*	2009 *2010*	2009 *2010*	2009 *2010*	2009 *2010*	2009 *2010*
Forsmark 3	2007 *2010*	2007 *2010*	2007 *2010*	2007 *2010*	2007 *2010*	2007 *2010*
Oskarshamn 1	2005	2005	2005	2005	2005	2005
Oskarshamn 2	2007	2007	2007	*2007*	*2007*	*2007*
Oskarshamn 3	2007, 2008	2008	2007	2008	2008	2008
Ringhals 1	2009 *2011*	2006 *2011*	2009 *2011*	2006 *2011*	2006 *2011*	2006 *2011*
Ringhals 2	2009 *2011*	2009 *2011*	2009 *2011*	2001 *2011*	2009 *2011*	2009 *2011*
Ringhals 3	2008 *2011*	2008 *2011*	2004 *2011*	2008 *2011*	2008 *2011*	2008 *2011*
Ringhals 4	2004 *2011*	2004 *2011*	2007 *2011*	2004 *2011*	2004 *2011*	2004 *2011*

Table 9. Year for update of the PSAs, Italics=planned updates and completion of limited studies

The basic PSA studies are now updated every year taking into account the past year's plant modifications which have an impact on the PSA-models. 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 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 very important per se in Sweden. 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 in the recentover the past years. Generally, they cover measures to protect against common cause failures (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.

PSA results were an important input for the modernization of Oskarshamn 1, which took place some years ago, and more recently for Ringhals 1 and Ringhals 2. The PSA tool has also been used in planning measures to be taken to comply with the new construction regulation SSMFS 2008:17. Another current applications of principle interest is the development of a risk-informed in-service inspection programme for the piping of Ringhals 2, based on a procedure developed by the Westinghouse Owners Group.

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 to probabilistic safety assessment (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

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*.

Periodic safety reviews started in Sweden in the early 1980's 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 PSR's are completed for all reactors and the third cycle is complete for the three oldest reactors. The current status of the programme is shown in Table 10.

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)	2011
Forsmark 1 and 2[17]	2008 (third)	2010
Ringhals 3 and 4	2008 (third)	2010

Table 10. Latest versions of periodic safety reviews.

The PSR's 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 has to inform SSM when the planning starts. A meeting is held with SSM to discuss the proposed scope, contents and methodology of

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

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.

Since all nuclear plants continuously assess safety and the working processes, a PSR seldom detects a new safety issue that has to be handled in order to continue operations. The greatest value of the reviews is to verify that the safety issues have been managed in an acceptable way and that organizational learning has taken place.

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 can be gathered in the groups: surveillance, in-service inspection, preventive maintenance and safety reviews. The programmes 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.

Special attention has been paid to the verification of the operability of safety systems when going from shut-down to a power operating mode after some earlier incidents, and is ensured today by the use of a large number of parameters, computerised tools and new procedures. However, more can still more to be done 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 new 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 were established in accordance with earlier regulatory requirements.

The assignment of components to specific inspection groups is documented together with relevant information concerning the inspection area. The assignment is reviewed and approved by the plant organisation, but the objectives and the volume of the total inspection programme are reviewed by the accredited inspection body. The information concerning inspection group assignments and inspection areas is maintained in a database, and forms the basis for the creation of inspection plans that are part 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, damages found in Swedish or foreign installations, or new research information with relevance to the safety of mechanical equipment in the nuclear power plants. 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 damage, have been carried at all reactors. Many of these replacements were made for preventive reasons as knowledge was gained on damage causes and mechanisms. In other cases replacements were made when a damage was found.

Preventive maintenance

Maintenance in systems important for reactor safety, and also in other systems and structures, 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 a piece of equipment within 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 economical 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 (megging)

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 make it generally possible to perform preventive maintenance during operation, if this is specified in the OLCs and is within the conditions analysed and described in the basic 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 compared to the 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 reactor is in accordance with the applicable national safety requirements and standards, different types of safety reviews are performed regularly at the plants. The primary safety reviews of events, changes in OLCs and plant modifications etc. are carried out by the operations department, which is responsible for reactor safety. If needed, resources from other departments are utilized.

Applications to SSM and issues to be notified to SSM as well as other important safety issues are reviewed a second time by the safety department within the plant organisation, but not involved in the preparation or execution of the issues under review. The safety department reports directly to the plant manager. Typically the secondary review function consist of 8-10 experienced engineers with competence profiles to cover all forthcoming matters. In very specific cases consultants are used to back up the function. Procedures have been developed for carrying out the independent safety reviews. 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 view-points 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.

A third type of review is performed by the safety review committees and councils at different levels of the utility organization. They exist in some cases at the unit level, normally on the site, and also at the utility 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 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 site or at the utility 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 peer 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 power up rate. 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 PSR's 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

SSM has inspected the management of in-service-inspection at the plants in connection with broad inspections of safety management at all plants. A principle for the control of mechanical equipment is that the detailed review of design specifications, design calculations, welding procedures, manufacturing procedures and also observation of these activities, are performed by accredited inspection bodies. In addition there is an independent NDT Qualification body. This body qualifies NDT-systems that are to be used for in-service-inspection, as required in SSM regulations SSMFS 2008:13. An overview of the control system is given below.

For Ringhals 2 quantitative risk-informed models are used to optimise the inspection programmes. In these models probabilistic mechanical break models are combined with probabilistic safety analyses of the plant. The primary motive for using these models is to reduce the costs for inspection and testing and, in some cases to reduce radiation doses. SSM must ensure that the changes in the inspection programmes can be implemented without increased risks for core damage and releases to the environment. SSM has posed strict requirements on indata and validation of the models.

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

In SSMFS 2008:13, SSM requires certain inspections and inspection intervals of specified components, such as reactor pressure vessel nozzles. In addition to such compulsory inspections, the licensees have to divide the mechanical components of the plant into quality classes and inspection groups. The inspection groups determine the extent of the in-service inspections. The principles for making this division have to be approved by SSM. The inspection programme resulting from the use of the principles shall be approved by an accredited inspection body certifying that the programme follows the SSM decision.

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. In inspection groups A and B, non-destructive testing systems shall be used which are qualified to detect, characterize and determine the size of damage that can affect the component. Such qualification is assessed and approved by an independent qualification body approved by SSM.

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 decisions by SSM on principles, methods and modes for inspections and testing. Accredited inspection bodies review the inspection programmes in detail and issue certificates of compliance with SSM decisions. A qualification body approves the non-destructive testing systems used and certifies their suitability for the component and application in question. Laboratories conducting the inspections have to be accredited for the tasks and methods they use with regard to quality system, technical procedures and competence. Another authority, the Swedish Board for Accreditation and Conformity Assessment (SWEDAC) makes the decisions concerning the accreditation of laboratories and inspection bodies. SSM makes the decisions concerning the approval of qualification bodies. SWEDAC makes annual inspections and follow-up 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, SKIFS 2004:1, and licensees were required to submit ageing management programmes to SKI at the latest by 31 December 2005.

In 2006, SKI 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, SKI 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 SKI decision in 2006 the plants completed their ageing management programmes by the end of 2008. SSM has reviewed and approved the documentation of the ageing management programmes in the plant safety analysis reports and the quality assurance systems. The effectiveness of these programmes will be assessed as part of the periodic safety review and through SSM’s routine surveillance activities.

14.3.5. Review of notifications

As mentioned abov, 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 years 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 2007, a total of 222 technical, organisational and documentation change notifications were submitted to SSM from the operating NPP licensees. 44 of these notifications resulted in a review by SSM. Corresponding figures for 2008 are 204 notifications of which 47 were reviewed further and the number of notifications during 2009 was 196 of which 46 were reviewed in more detail.

In year 2009 there is a notable trend break – preliminary assessment of a large number of notifications had to be postponed due to incomplete notifications. The possible cause for this is that the regulations (SSMFS 2008:1) was changed early in 2009, stating that SAR documentation also has to be provided with all notification to the SSM.

The statistics of recent years can be seen in Table 11. The table illustrates the review burden of SSM in connection with the modernisation projects and power up rating projects of the plants. This situation will continue over the coming years.

Year	Licensee	Number of notifications	Further review
2007	FKA	56	15
	OKG	84	14
	RAB	82	15
2008	FKA	25	2
	OKG	99	26
	RAB	80	19
2009	FKA	43	15
	OKG	68	8
	RAB	84	23

Table 11. Number of notifications to SSM from the operating nuclear power plant licensees 2007-2009

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

- Despite a substantial increase in the work load at the reactor units, the average total collective dose and the individual doses remained stable during the review period. Focus is given to work aimed at decreasing high individual doses.
- Radiation protection education and training, including new practical moments, has been reviewed and strengthened.
- From 2008 the alpha-value for averted dose, used in radiation optimisation, was raised to 10 MSEK/manSv.
- IAEA reviewed the radiation safety work at Forsmark, Oskarshamn and Ringhals during OSART missions in February 2008, February/March 2009, and February 2010 respectively.
- 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.

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 constraint 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 skin, hands and feet is 150 mSv and 500 mSv in a year, respectively. Lower limits apply for apprentices, breast-feeding and pregnant woman. 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 kept in the national dose register. Dose records are saved until a person has reached 75 years, and at least until 30 years after work with ionising radiation has stopped.

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 expert

The licence holder shall ensure that site-specific instructions for radiation protection are established. The licensee shall also appoint a radiation protection expert. This person shall be approved by SSM 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 radiological impact on 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.

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 in the following.

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 to the most exposed individual (critical group). The dose models used are approved by the SSM.

The 0.1 mSv dose constraint is compared with the sum of a) the effective dose from the annual external exposure, and b) the committed effective dose resulting from a yearly discharge. A 50-year integration time is used for the committed effective dose. If the calculated sum 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.

The Swedish Board of Fisheries performs sampling at and outside the facilities. 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 radio-active releases 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 an 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

As reported in the fourth national report, updates to existing radiation protection regulations had been prepared. Some of these planned updates were put on hold due to the merger of SKI and SSI into one authority, SSM. Instead, efforts to reissue existing regulations of SKI and SSI (with minor amendments) in the Swedish Radiation Safety Authority's Code of Statute, as SSMFS were prioritised. See chapter 7.

The Swedish Government has appointed an chief investigator to review the legislation in the area of nuclear technology and radiation protection (See section B 7.2). The inquiry will study the possibilities of combining the provisions of the Nuclear Activities Act and the Radiation Protection Act in a single act and will also consider the possibilities for better coordination with the provisions of the Environmental Code.

The new European Basic Safety Standards Directive, due to be ready during the period 2011-2012, will also influence the present regulations. One expected change is to harmonize the provi-sions on annual dose limits so that an effective dose for workers of 20 mSv in a year will be the maximum allowed in most planned exposure situations. Sweden sees no difficulties with implementing this lower value.

15.2 Measures taken by the licence holders

The four 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 on-going 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 line organisation and the RP units are services, not with prime responsibility for the radiation protection work. 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

There has been a trend to harmonize the procedures at a site (and between sites) and only have unit specific procedures when necessary. For example at the Forsmark and Oskarshamn sites there are harmonized procedures regarding some RP areas, such as radioactive waste handling and release monitoring, leading to the need for only a minimum number of unit specific procedures.

15.2.3. Education

During the review period, actions to improve education and training in radiation protection were taken. Some new practical courses are described further below in connection with *the Barsebäck site*. A formal review, reformulation and upgrade of stipulated education and training for RP technicians and RP officers has been carried ut. This work covered RP contractors (divided into category A, B or C) as well as the facilities' own RP staff. The stipulated retraining in radiation protection for all contractors, e.g. some basic information on local rules, alarms, security, work procedures etc., can now be performed on-line using new software applications.

15.2.4. Activities to stop spread of contamination

At all the sites, there are plans and measures that have been implemented or are to be introduced to reduce the spread of contamination and unnecessary alarms at exit gates. The Forsmark and Oskarshamn radiation protection organizations have progressed further in this work whilst the Ringhals organisation is implementing and planning further measures. This work entails individual follow-up of alarms at the exit gates, changes in work procedures, new possibilities for checks closer to work places, new measurement equipment for tools and small items and increased information and education efforts. At both the Forsmark and Oskarshamn sites the progress is continuously monitored.

15.2.5. System radioactivity measurements

On-line dose rate measurment 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 measurements 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 Forsmark, all the units have on-line off-gas nuclide-specific gamma measurement systems, as a tool for early detection of fuel failures. These systems were modernized in 2007. At Forsmark, all the reactor units use normal water chemistry and there is no need for zinc injection.

15.2.6. Dose reduction and ALARA programmes

In a decision from 2008, the alpha-value used in the optimisation process, was raised to 10 million SEK per man-Sievert (10 MSEK/manSv) at the Swedish nuclear facilities. The following list updated since the 4th Swedish national report, exemplifies measures for reducing the dose rates and the radiation doses at the nuclear power plants.

- Programmes for replacement of valves containing the cobalt alloy Stellite continue.
- All operators have a fuel failure policy that gives guidance on how to avoid failures and when (apt timing) to stop power production for replacement of failed fuel. This has resulted in low uranium levels on reactor cores, lower radiation levels and discharges of radio-nuclides to the environment.
- Foreign material exclusion programmes decrease the risk for fuel failures and improve the radiological working environment around the lower plenum. All Swedish nuclear power plants give obligatory information/education on the content and requirements of the FME (Foreign Material Exclusion) programmes to all personnel working in controlled areas and to other targeted groups using an interactive web-based programme with a final test to check understanding.
- Zinc injection started in the reactors Oskarshamn 1 and 2 in 2003. OKG AB follows the effect of the zinc injection on the radiation levels continuously. The dose rates on pipes in unit 2 in 2009 were four times lower than dose rates before decontamination and zinc injection was started.
- Forsmark has an ALARA group which meets 3-4 times a year to evaluate and develop their ALARA programme. Focus has turned from collective doses to concentrate more on individuals with annual dosesof more than 10 mSv. The number of persons with annual doses above 10 mSv should be less than 1 % from 2009 forwardand onwards. The mean annual collective dose during the 3-year period 2006-2008 was 2.1 manSv. A formal goal is that nobody should receive a radiation dose exceeding 0.3 mSv from internal contamination.
- The use of PJB (pre-job briefings) and targeted information on protective measures has increased significantly at Forsmark over the last few years. This is a result of increased resources for such activities.
- Forsmark 3 performed a partial decontamination of the residual heat removal and core spray systems in connection with piping replacements in 2001. In 2009, the overall radiation levels were still only 35 % of the early values.
- At Ringhals a constraint was created through setting dose target values at department and work group levels. This stimulates the lower level managers to become actively engage in dose reduction work. As a tool to follow-up a *dose rate index* was created. This includes a number of readings at measurement points (37 in one unit) at the plant and together with nuclide specific measurements in a few positions this creates a solid feed-back base for operations and chemistry performance.

- Ringhals continues its efforts with optimisation of chemistry conditions in PWR reactors to minimize the production of activated radio-nuclides and their deposition on system surfaces.

15.2.7. Discharges reduction programmes

Renewed plans and action programmes for the reduction of releases from nuclear power plants, implementing power up rates have been prepared and implementid. Some examples of release reduction measures are given below.

A fuel failure in Ringhals 1 in 1992 had a long-term effect on the Ringhals discharges. Due to extensive technical and administrative measures the discharges were reduced to levels comparable with other comparible reactors. Figure 13 sows the releases (excluding H-3) to the water phase from Ringhals 1.

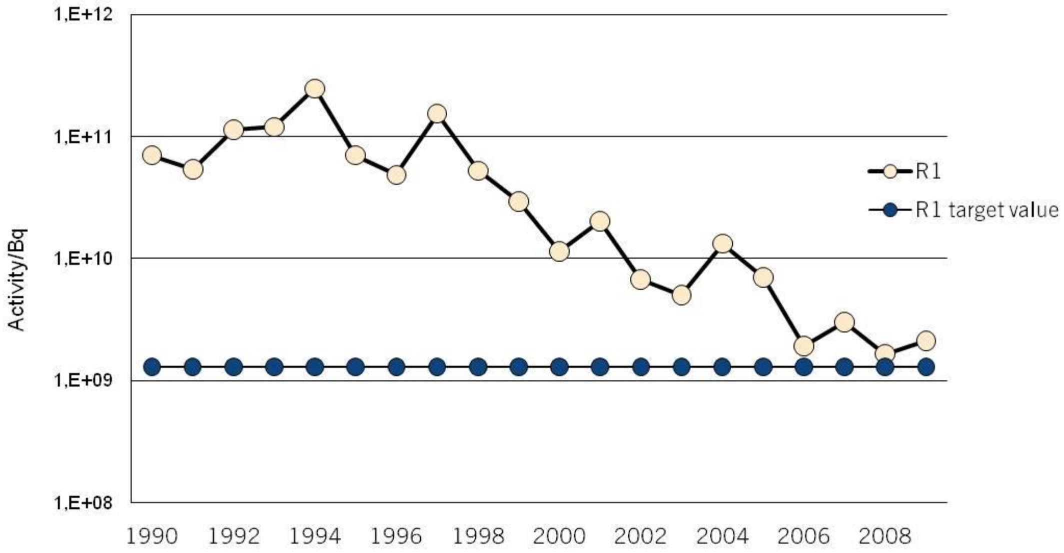

Figure 13. Releases of radioactive substances to water from Ringhals 1

Examples of measures taken at the Ringhals facility to reduce the release of radioactive nuclides to air and water are listed below.

- Ringhals has developed new methods for cleaning water-borne activity and conventional chemicals from different sources. 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.
- Installation of a 3000 m^3 storage tank at Ringhals 1 for the re-use of reactor pool water during outages.
- Renovation of the Ringhals 1 evaporator which is planned to be operational in 2010.

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 were implemented, including education and training as well as introducing new techniques to stop foreign debris entering the reactor systems.

Reduction of the releases to air from Ringhals 1 by minimizing the leakage of air into the turbine. A new method for leaktesting using ultra sound has been introduced with good results instead of the traditionally helium method.

An investigation concerning the installation of charcoal columns in Ringhals 1 was carried out, but no decision on installation has yet been taken.

At Ringhals 4 membrane filtration has been installed in the feed water tank system. The results are promising. No decision has been taken to install the same technique in Ringhals 2-3.

To reduce the releases to air from the PWRs the main focus has been to delay the "*quick routes*" for releases and thereby reduce the short lived radio-nuclides.

Examples of similar measures at the other nuclear facilities are:

- Installation of recombiners at Oskarshamn 1 and 2 in 2008. At Oskarshamn 2 HWC-chemistry has been used together with an oxygen generator in order to obtain the lowest possible offgas flow. This consequently 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.
- Policy for the management of fuel failures that gives guidance on when to stop the reactor for fuel replacement. This has resulted in lower uranium contamination on the reactor cores, which subsequently has lowered the radiation levels in the stations as well as reduced radio-nuclide discharges to the environment.
- The OKG and FKA "Clean system" programmes aim at preventing foreign material intrusion, an important factor to reduce the releases since it decreases the risk for fuel failures.
- Installation of in-core filters in Oskarshamn 3 aiming at catching foreign debris in the reactor core. 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 Oskarshamn site which includes both administrative and technical measures.
- A programme for aerosol reduction at the Forsmark site. The release of aerosols from the Forsmark facility is due to the already low contribution from noble gaseous the dominating dose contributor to the critical group not taking the contribution from C-14 into account.

15.2.8. Other events and activities during the review period

During the review period, increased difficulties in planning and managing major programmes within time and dose budget have been identified. Planning units within the modernization/refurbishment projects find it difficult obtain the necessary and correct input data from external contractors/sub-contractors in a timely fashion. Another reason is the lack of experience in managing large projects and insufficient or strained human resources at the facilities. SSM has raised the issue during inspections and has in some cases required that measures be taken to ensure adequate radiation protection work. At several reactor units, within a broader scope than RP work, uncertainties and insufficient preparations have led to deferral of modernization activities for a year or more (e.g. at Ringhals 1, Ringhals 2, Oskarshamn 3 and Forsmark 1).

In 2008 ruptured and cracked control rod shafts were found at Forsmark 3 and Oskarshamn 3. This led to investigations, technical changes and other measures at the Swedish BWRs which contributed to the higher collective doses.

The Barsebäck Site

The two closed reactor units at the Barsebäck site went through a full system decontamination in December 2007 and January 2008 using the AREVA Cord-UV method with good overall results. Pending dismantling, reactor units are being used for educational courses for staff that will work at operating power plants but also courses on measurement and detection methods in radiation protection and emergency preparedness are offered. The education is organized by KSU, the Swedish Nuclear Training and Safety Centre, or by the Swedish universities. For 2010 more than 300 course days are planed with about 700 participants.

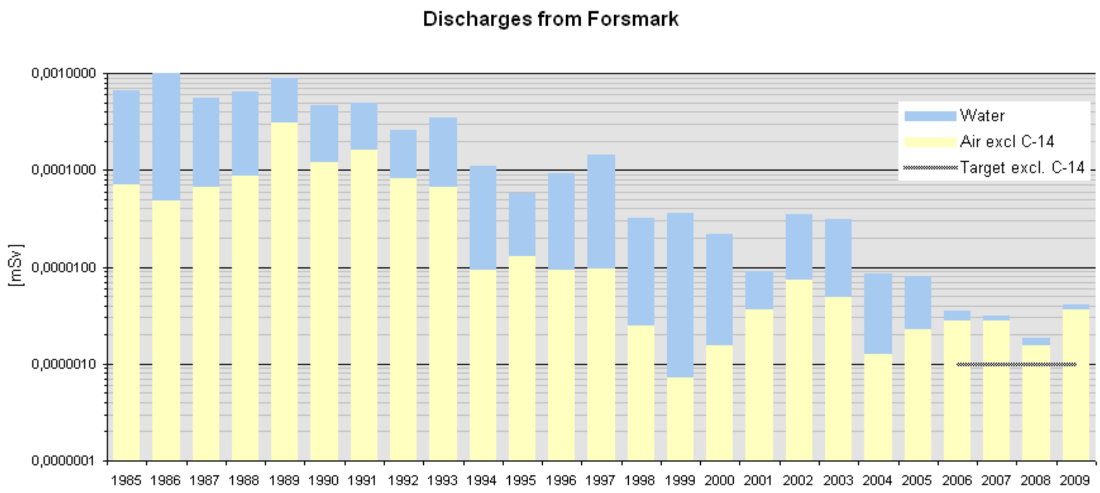

Figure 14. Contribution to radiation doses from the Forsmark site in millisievert (mSv) to the representative individual in the critical group from releases of radio-nuclides for the period 1985-2009. Doses from carbon-14 are excluded.

The Forsmark Site

In February 2008 IAEA reviewed the operational safety (OSART) at Forsmark 2. Although there was a good overall impression of radiation safety work, a recommendation for improvements in the survey programmes for the laboratories and a suggestion of improvements in waste sorting procedures were given. A PSR, including radiation protection, of the three Forsmark reactors will be ready for regulatory review in 2010.

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 up rate, an action which has decreases turbine dose rates significantly. The same replacements are planned in 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.

Work has started at the Forsmark site to lower radiation doses from on-site waste management. The work at the decontamination work shop has been analysed in order to identify possible improvements.

The electronic (work) dosimeter system used at Forsmark will be replaced in 2011 and a pre-study of possible alternatives is almost completed.

In Forsmark 1 fuel spacer corrosion is suspected in some of the fuel elements. These spacers contain Inconel and increasing levels of Co-58 and Cr-51 activity in the reactor water have been measured. This could influence the releases of radio-nuclides to the environment as well as the radiological work environment negatively. Measures to mitigate such corrosion effects of are presently being investigated.

The OKG Site

A new work dosimeter system (EPD) has been introduced at the Oskarshamn plant which enables a better follow-up of dose and dose rate development.

At the end of February 2009 the IAEA started its review of the operational safety (OSART) at Oskarshamn 2. The radiation safety work was judged to be well organized and competent. The unique RP technician competence evaluation system used at the plant was identified as a good practice. Use of effective decontamination methods (AMDA) for the plant's high radioactive systems during outages was also acknowledged as a good practice. It was suggested that the measures to prevent the spread of radioactive contamination, within the controlled area, could be further enhanced.

A fairly high release rate of Cobalt-60 from stored fuel at Oskarshamn 1 has been observed. This release rate does not create a major problem in the reactor hall but leads to high dose rates at plate heat exchangers in the cooling and clean-up system of the fuel storage pool. A root cause analysis is being performed and possible remedial actions are being investigated.

During the outage at Oskarshamn 2 in 2007, incomplete planning information led to work with replacement of piping and installation of a cyclone filter taking more dose than planned. In 2009, similar planning problems were encountered.

A fuel failure detected in Oskarshamn 3 in 2007 led to a secondary failure with uranium released to the primary system. During a short stop in February 2008 the damaged fuel was replaced. Despite efforts to reduce fuel failures by educational and other measures (e.g. ban of equipment and procedures which could lead to the release of foreign materials in reactor systems), in 2007 it was realised that the problems would not be solved. So called cyclone filters were introduced into the feed-water system in Oskarshamn 2 in 2008. In Oskarshamn 3, four in-core fuel element positions at Oskarshamn 3 were replaced in 2009 by "in-core filters" to collect and trapp debris during operations. Two of these filters will be emptied and inspected annually, the efficiency of these new measures will be followed closely.

Presently a new strategic plan for waste management at the site is being prepared and a special plan for handling ion exchange resins produced at Oskarshamn 3 has been prepared.

The Ringhals Site

During the review period, power up rates were made in Ringhals 1 and Ringhals 3. No unexpected radiation protection consequences have been identified. A power up rate is also planned for Ringhals 4.

A number of radiography incidents have occurred during outages often related to insufficient isolation off of work areas. No serious exposures have resulted but similar incidents have also occurred at other sites. These events have led to increased information and changes in administrative procedures at the plants. The incidents underline the need for cooperation between operators and contracted firms regarding all work at the plants.

Several replaced steam generators were successfully transported off-site for melting and waste treatment at the Studsvik site. These efforts have liberated storage place at the Ringhals site, much needed for future planned measures.

Radiation levels measured during 2008 remained relatively stable at all four reactor units with one excaption: Ringhals 3 where a 15-20 % increase around the heat exchanger in the chemistry and volume control system (CVCS) and in the residual heat removal system were observed. One possible reason is a reduction of the operational cleansing time (12 to 6 hours) prior to the outage.

Ringhals 1 and Ringhals 2 have undergone extensive refurbishment during 2009. At Ringhals 2 a complete change of the I&C systems was carried out. The work was time consuming but did not result in large worker doses. Part of the work was performed in temporarily de-zoned areas. The major doses during outages instead resulted from painting of internal walls and the cleaning up following this touch-up work.

An IAEA OSART mission to Ringhals took place in February 2010. In preparation for the visit a GAP-analysis and a subsequent action programme constituted a major efforts in radiation protection and “safety at work” during 2009.

15.3 Impact of the Swedish nuclear facilities

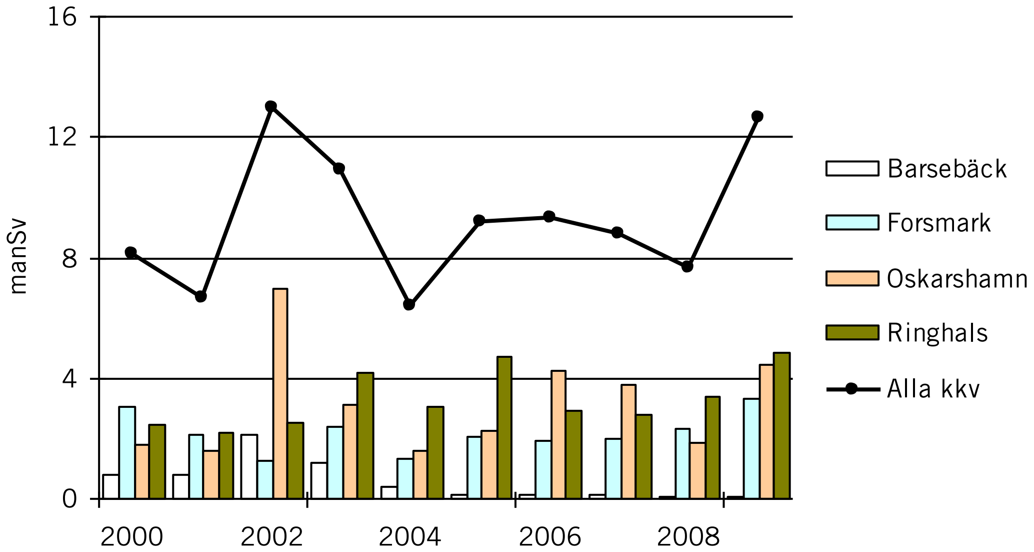

Figure 15. Collective radiation doses at Swedish nuclear power plants during 2000-2009. The radiation levels at the nuclear power plants are stable and variation in collective dose reflects the amount of work and work in “high” radiation areas.

15.3.1. Worker protection

Figure 15 displays the collective radiation doses at Swedish nuclear power plants during 1999 - 2009. As observed, the total collective dose is stable over the last five years with an average of 9.5 ± 0.9. The average individual dose over the same 5-year period was 2.1 ± 0.1 mSv. The average number of persons who annually received an effective dose above 20 mSv was during the same period 1.2 ± 0.6.

The radiation exposure is mainly due to contamination of surface layers with ^{60}Co. However, fairly low radiation levels are achieved as a result of continuous efforts to reduce production and distribution of ^{60}Co in the reactor systems. The average number of intakes during the last five years (committed effective dose > 0.25 mSv) is 0.8 ± 0.5 per year. The low number of intakes reflects low contamination levels and effective work procedures. During 2009 no intakes were registered at the power plants.

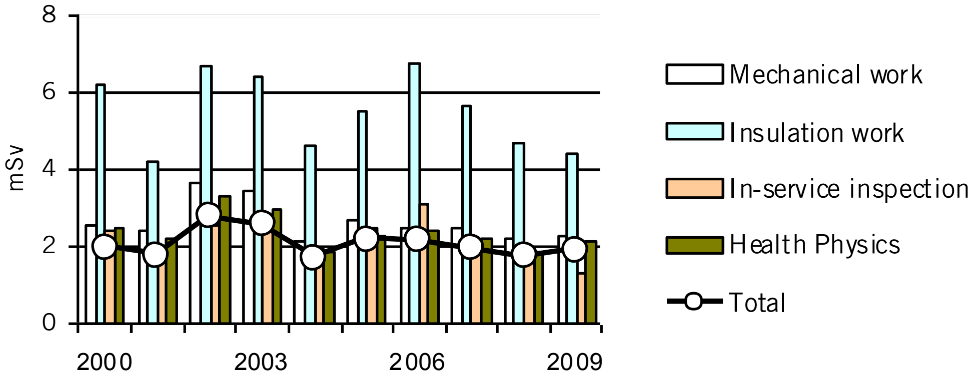

Figure 16. Average individual doses to selected worker categories. Only doses for workers with a registered radiation dose > 0.1 mSv in any monitoring period (≤ 1 month) are used when calculating averages.

Year	Total dose (manSv)	Average dose (mSv)	Highest dose (mSv)	# persons with a dose > 20 mSv	# persons with a registered dose (≥ 0.1 mSv)
2000	8.1	2.0	20.7	1	3967
2001	6.7	1.8	19.6	0	3636
2002	13.0	2.9	27.0	9	4506
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

Table 12. Radiation dose statistics for Swedish nuclear power plants over the last ten years

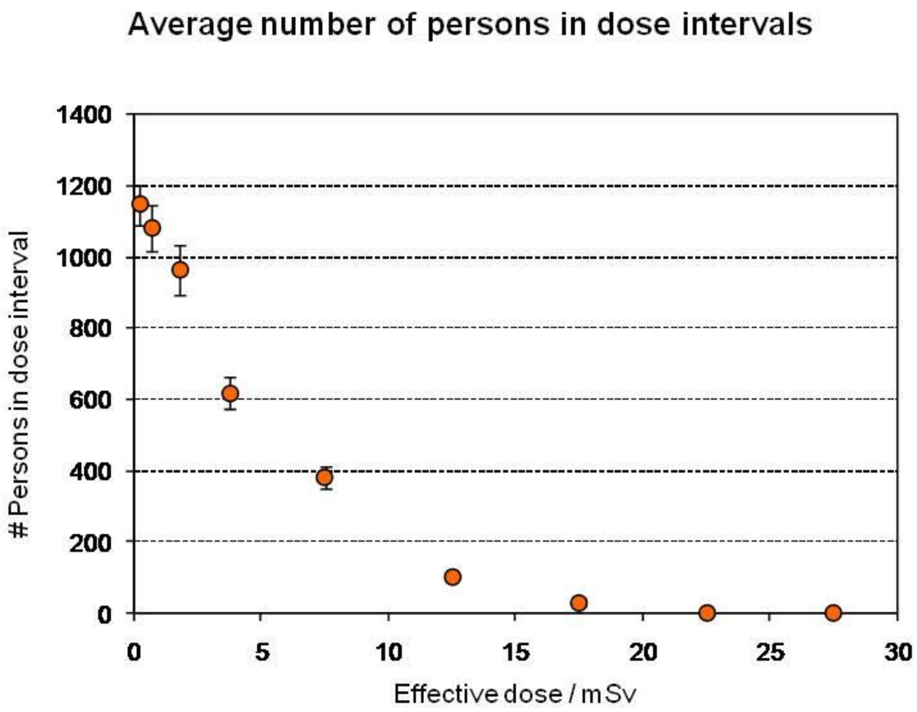

Figure 17. Distribution of average number of persons in each dose interval during the time period 2000-2009

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 18 displays the estimated radiation doses resulting from the discharge of radio-nuclides during the period 2003-2009 at the Swedish nuclear power plant sites.

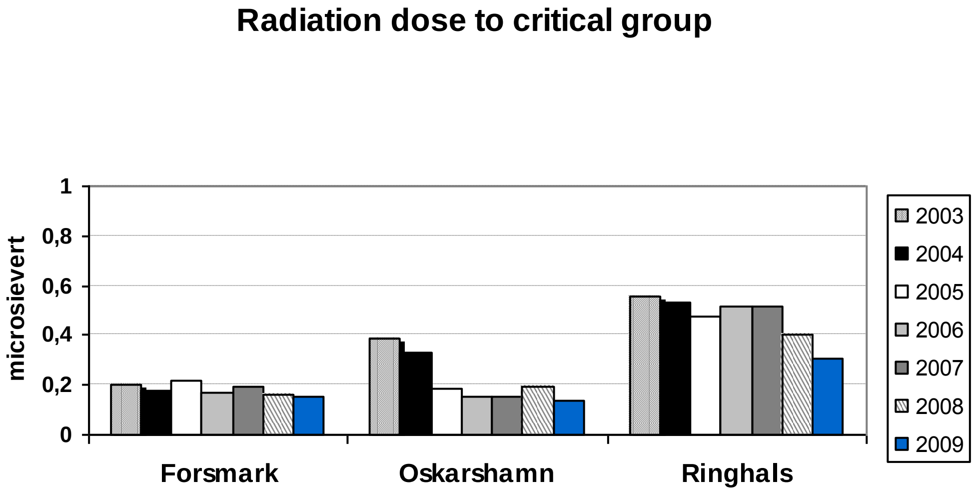

Figure 18. Estimated radiation doses in microsievert (µSv) to the representative individuals of the critical group from releases of radio-nuclides for the period 2003-2009.

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 radio-nuclides. 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 power plants as an integrated part of the on-going power up-rate projects which may result in an increase of the discharges to the environment.

In Figure 19 some results from the environmental monitoring programme are given and a decrease in specific activity observed in blue mussels outside the Ringhals facility can be observed.

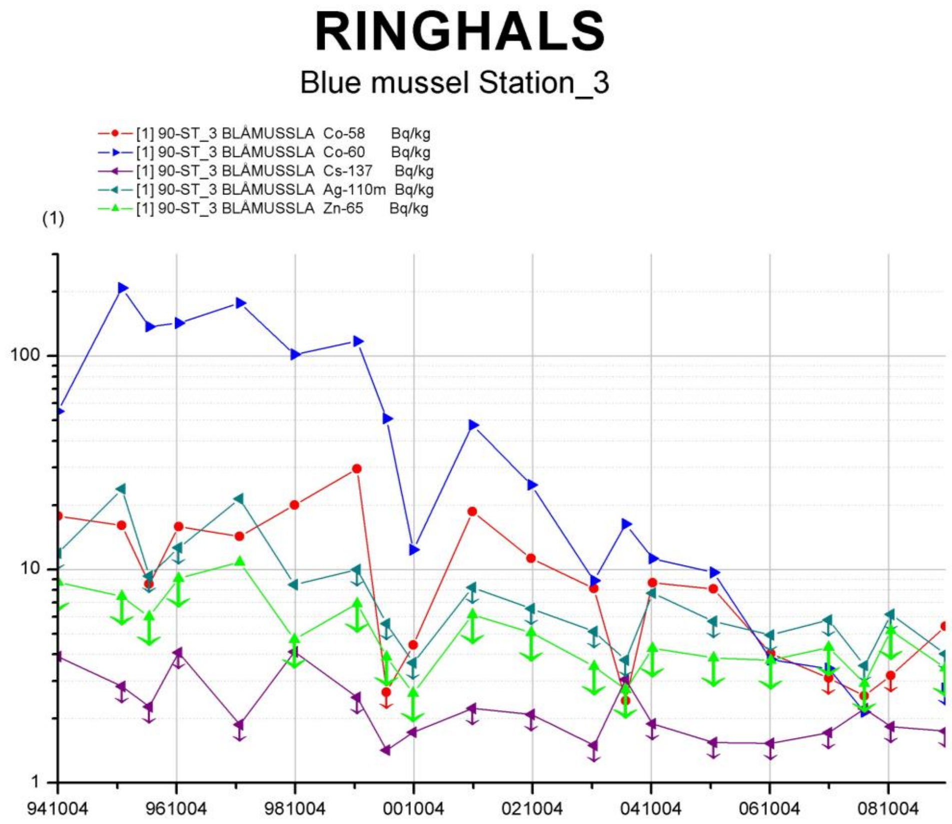

Figure 19. Examples of the results of the environmental monitoring programmes. Radio-nuclides measured in blue mussels collected outside Ringhals nuclear power plant. A decrease in the specific activity is observed during the sampling period.

15.4 Regulatory control

SSM inspection activities are described in section 8.3.

15.5 Summary

The amount of work performed at the nuclear facilities has been high, especially during 2009. This is a result of planned and on-going activities with reactor safety upgrades, refurbishment, and power up rates but also due to unforeseen events (e.g. damaged control rod shafts at Oskarshamn and Forsmark). The collective dose at some reactors was unusually high due to large planned work activities. Despite this, no very large increase in the total national collective dose resulted and the number of high individual doses was kept low.

The overall collective radiation dose remains around 10 manSv (9.5 ± 0.9 manSv over the last five years) in spite of increased work efforts. This has resulted in an average collective dose which is less than 1 manSv per rector and operational year. The average individual dose is maintained at a low value: 2.1 ± 0.1 mSv.

The work to improve the radiological environment and to optimise the radiation doses at the reactors is described in the plant ALARA programmes. Valuable feed-back and information was received during the IAEA OSART review missions to all three Swedish reactor sites, carried out 2008-2010.

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.

15.6 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

- The merging of the authorities SSI and SKI into the new authority SSM also led to the merging of the respective responsibilities for emergency preparedness of the two former authorities. Consequently, a new crisis organisation has been developed at SSM encompassing the responsibilities of the previous authorities. SSM's regulations on emergency planning and preparedness came into force on July 1, 2008.
- The regulatory supervision of the emergency planning at the plants has been strengthened as a result of the merging of the separate supervisions of the previous two authorities.
- The Swedish Emergency Management Agency (KBM) and the Swedish Rescue Services Agency (SRV) were merged into a new agency, the Swedish Civil Contingencies Agency (MSB). The task of the MSB is to enhance and support societal capacities for preparedness for and prevention of emergencies and crises.
- The earlier web-based information system used by all responsible parties involved in a nuclear accident has been replaced by a new national web-based information system which is used for all types of crises.
- The national gamma monitoring system was replaced and modernized during 2008 - 2009.
- A third alarm level has been incorporated at all nuclear installations to be used when the normal organisation (warrants) needs extra support during unusual events that are of a lower class than those classified as *increased preparedness*.
- At all nuclear power plants the organisation has been strengthened to ensure that key persons are available at an early stage during an unusual event.

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,
- 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 (2003:779) 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 is responsible, at the national level, for the coordination and supervision of the preparedness for the rescue services response to radioactive release. SSM decides on necessary measures for and supervises the nuclear installations.

The SSM-regulations SSMFS 2008:1 require the licensee, in case 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 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 first and second national reports. The basic measures reported there are still in effect with the only change that the measures earlier performed separately by the SSI and SKI are now merged into a single organisation at the SSM and the measures earlier performed separately by the KBM and SRV are now merged into a single organisation at MSB. An overview of the current national organisation is given in Figure 20.

The Crisis Management Co-ordination Secretariat was established in March 2008 within the Government Offices of Sweden to strengthen the crisis management and communication capability. The responsibilities include policy intelligence and situation reporting, crisis management and crisis communications, analysis, and being a central contact point at the Government Offices.

Nearly all accidents and crisis situations are handled by appointed central or regional authorities who, with their allocated resources, manage these situations. However, if a national crisis with the potential to affect many citizens with (coupled) large, cross-sector negative economical, environmental or other detrimental societal effects occurs, it will require decisions and actions by the Government. The Secretariat gathers information, assesses the situation, and recommends Government actions. The Prime Minister's Office, with the support of the Crisis Management Secretariat, shall ensure that the necessary cooperation within the Government Offices and with the relevant authorities is rapidly established.

A Crisis Management Advisory Body was later formed to cooperate with the authorities concerned. 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, the Swedish Civil Contingencies Agency, the National Board of Health and Welfare, and the Swedish Radiation Safety Authority. The Advisory Body also has as 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. The Crisis Management Advisory Body has been assembled on a few occasions.

On January 1, 2009 the Swedish Civil Contingencies Agency (MSB) was formed, merging three earlier central authorities with emergency preparedness, and civil defence responsibilities. The MSB co-ordinates emergency preparedness funding and work, and oversees the planning of the regional County Administrative Boards. MSB, together with other concerned authorities, started a long-term work to strengthen the national nuclear emergency preparedness planning and response work. The focus is, as earlier suggested by the Swedish National Audit Office, on ensuring needed economical means, improving the quality of risk and threat analysis, improving supervision of necessary training and education, further developing procedures for follow-up and experience feed-back, and ensuring due consideration of long-term and post-accident effects in the emergency preparedness planning and work.

SSM is taking part in the national planning and development process. Some actual results of these efforts are an enhanced national emergency response centre and a countrywide measurement, sampling and analysis expert organisation for radiological and nuclear accidents and events.

The two national alarm levels earlier in effect for nuclear power plants emergencies, 1) increased preparedness and 2) emergency alarm, have been complemented by a third, lower level alarm. This alarm level is used when the normal organisation (warrants) needs extra support during unusual events that are of a lower class than those classified as *increased preparedness*.

Two of the nuclear power sites have installed "rapid-reach" computerised systems for alarming the on-site organizations. These systems automatically dial predetermined numbers. The emergency staff of each nuclear power plant is included in the general systems used at the plants for staffing, competence analysis, and training and annual competence assessment.

During recent years, in connection with other development and refurbishment works, the owners of the power plants have improved their emergency facilities.

Relevant meteorological data is now electronically transferred directly into SSM's dispersion modelling database, enabling improved dispersion calculations to be performed on the national level.

To improve the flow of external information between all responsible parties involved in a nuclear accident, a new web-based system for national crisis information management has been introduced. The system aims at exchanging information and decisions taken in the event of an emergency, and is used nationally for all types of emergencies through the national agency MSB. The system has been used in exercises and improvements are made after evaluations. Currently, applications to improve system security are being investigated.

In order to make the first information transfer faster and more accurate between the affected plant and the off-site authorities, a standard electronic format has been recently developed. This format is now in regular use during incidents and exercises.

16.3 National monitoring

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 percent, 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 500 nanosieverts per hour (500 nSv/h). Sweden also has six sensitive 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, e.g., for measuring the caesium emitted from the combustion of biomass.

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 Swedish municipal measurement system provides a base and is a system for quickly mapping the country in the event of radioactive fallout, and allows for detecting even small increases in radiation level at the reference points.

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. SSM has agreements with laboratories around Sweden mostly at universities, under the terms of which they maintain a state of preparedness for making measurements and analyses and providing expert advice. SSM has also an agreement with the voluntary organizations of the Armed Forces, e.g. the Women's Voluntary Defence Service, the Women's Motor Transport Corps, and the Women's Auxiliary Veterinary Corps, for collecting needed field samples.

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, like Karolinska hospital in Stockholm, more advanced treatment and care can be arranged. Cooperation and sharing of resources also exists between the European hospitals in case of major accidents.

If there is an accident involving nuclear technology, the SSM is activated. In the next alarm chain, the Swedish National Board of Health (SoS) is activated along with the Nuclear and Radiological Medical Expert Group (NR-MEG) appointed by the SoS. Several other authorities are also activated at the same time, depending on the scenario. Medical doctors from the medical areas haematology, oncology, radiology, and catastrophe medicine are represented within NR-MEG. The group has an on-call operation and is available for giving advice, also in connection with minor incidents, by contact through the officer on duty at the SoS. In case of a large accident, the group is summoned to the national emergency centre at SSM and is provided with information on radiation levels, meteorological conditions, etc. With the information available NR-MEG performs a medical risk judgement 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. NR-MEG advises and informs the treating medical doctors and the medical care centres in the county.

To facilitate medical emergency preparedness in Sweden, SoS has established a Centre for Radiation Medicine, located at the Karolinska Institute in Stockholm. Among the tasks of this centre it has to contribute with health care information, education, advice and carry out research activities in areas related to medical effects of ionizing radiation. A close collaboration has been established with SSM and various other national and international bodies.

16.5 Exercises

A number of emergency preparedness exercises of various sizes are conducted annually in Sweden. These vary in complexity from simple tests of alarm systems to full-scale exercises. Periodical tests of the alerting systems between the power plants and the authorities involved are performed during each year.

Every second year a “total” exercise is performed at one of the three nuclear power sites to check the plans and the capability 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.

The respective county authority where the plant is located has the responsibility for planning these exercises, often with the assistance of the national agency MSB, which is also responsible for the evaluation and follow-up analyses. SSM participates in the planning as well as in the evaluation. Usually between 15 and 30 organizations participate in these exercises including the regulatory bodies and the government.

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 observer, in its supervisory roll, or to exercise the authorities’ 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. In the fall of 2008 Sweden had a large exercise with the scenario of a nuclear power plant accident outside but near Sweden’s border in order to test the emergency plans for a foreign accident with consequences for Sweden.

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 regularly participates in the IAEA Convention Exercises (CONVEX) and the OECD/ NEA International Nuclear Emergency Exercises (INEX) and yearly 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 common exercises. Within the framework of this cooperation, Finland and Sweden have agreed to dispatch liaison officers to each other’s country should a nuclear emergency occur. 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, available 24 hours all days.

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 the authority level also exists with Lithuania. Sweden uses the ECURIE information system for information exchange within the European Union and the ENAC/Emercon system for information exchange between the IAEA member states.

The Nordic authorities involved in radiological emergency planning have agreed to exchange data on a routine basis from the automatic gamma monitoring stations in the respective countries. The five Nordic countries 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, which has been agreed upon by these five countries.

16.7 Nuclear accidents abroad

As demonstrated by the Chernobyl accident 1986, Sweden can be affected by a nuclear accident abroad. Although the foreseeable consequences are such that the use of iodine tablets, sheltering or relocation of people due to fall-out is not likely, the impact on agriculture, animal breeding, forestry, hunting, recreation, and private house-hold 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 earlier mentioned legislation. During the national exercise South Wind in 2008 the responsibilities of national and regional authorities were tested. Ambiguities in allotment of rolls and responsibilities were analysed.

The Swedish Meteorological and Hydrological Institute, SMHI, performs transport and deposition simulations regularly using the program MATCH (a 3-dimensional "off-line" Eulerian atmospheric transport code) and the actual weather. A hypothetical standard release of radioactive substances from the Swedish and some of the nuclear reactors in operation in other countries around the Baltic Sea is tracked by this computer code and the calculations are updated every sixth hour using actual weather. The transport, spread, and concentration of the simulated, released radio-nuclides are displayed.

Furthermore, the MATCH-trajectory simulations are also available for tracing the source regions for recorded measurements at specific measurement points. For a few selected places in Sweden, such backward direction trajectories can be followed for the last 72 hours.

16.8 New developments in emergency preparedness

SSM has completed a research project on nuclear power plant technical alarm criteria. Alarm criteria provide a basis for the definition of alarm levels, which in their turn are used for decision of initial actions from off-site organizations, should an accident occur. The project formally started in March 2007 and reviewed a set of categories of initiating events and evaluated the reliability of the correlation between initiating events and the symptoms through which they would manifest themselves. The project evaluated the possibility for further harmonization between the nuclear power plants of the site-specific alarm criteria.

The SSM has started to use RAKEL, a common digital system, using so called TETRA technology, for communication between municipalities, counties, and national agencies involved in emergency preparedness work and in crisis management. The MSB has the overall responsibility for development, coordination and support of the RAKEL system.

SSM has supported further developments in Sweden's dispersion modelling capabilities in cooperation with the SMHI and the Swedish Defence Research Agency. The resolution of the dispersion prognosis has been enhanced by using higher resolution weather forecasts. A code for urban dispersion modelling has been developed with special emphasis on wind field modelling in urban environments. This can be applied locally to the topography at the Swedish plants. SSM is currently compiling high resolution topographical data sets for all the Swedish nuclear installations thereby enabling better estimates of the near field dispersion. This is further enhanced by the new feature of local weather data at each plant being sent electronically directly to the database for the dispersion modelling in real time.

The merging of the SSI and SKI into a single regulatory authority, SSM, has resulted in a more effective thorough supervision of the nuclear installations in Sweden.

The County Administration Boards in the counties that have nuclear plants and the national authorities MSB and SSM have established an action plan including a variety of projects aimed at enhancing a coordinated emergency planning and response for nuclear power plant accidents and incidents. These projects are ongoing and have different completion dates, the latest being in 2012. These projects aim at mitigating identified needs in the organisation of education and exercises, coordinating communication, coordinating national and regional measurement and analysis teams, further developments in and coordinating of sanitation procedures and creating a national information strategy.

16.9 Regulatory control

After the implementation of the SSI regulations concerning emergency preparedness at certain nuclear facilities in 2006, a series of inspections was carried out in 2007 and 2008 at all of the nuclear facilities that were covered by the regulations to insure implementation had been properly carried out. The conclusion was that the licensees complied with the requirements of the regulations. At all sites, however, aspects for further improvements were identified and SSM has followed up on these findings during 2008 - 2009.

The merging in July of 2008 of the SSI and SKI into a single authority, SSM, has provided the conditions for a more clear and consistent picture of the requirements that came from the combined regulations of the two earlier authorities. Supervision of emergency preparedness regulations is now concentrated to one national coordinating authority and the main responsibility for the supervision is organised within one section at that authority, which also provides a basis for a clearer supervisory roll at the authority. The various relevant competences within the authority that are needed for the supervisory work are available and can be more effectively integrated in the supervision work than was possible earlier. This has led to more effective developments in the supervisory work as well as an increased number of inspections in a year.

One development which began during 2009 and is currently progressing concerns a review of the regulations (SSMFS 2008:15) and (SSMFS 2008:1) which came from the earlier SSI and SKI, respectively, with the intention to combine and harmonize all aspects of regulating emergency preparedness at the licensees, and to use the earlier experiences from the implementation of the regulations to revise the regulations with the expected result of clearer and stronger requirements on the nuclear installations.

16.10 Conclusion

Sweden complies with the obligations of Article 16.

Swedish Government OFFICES

The Prime Minister's Office Crisis Management Coordination Secretariat (contact point, crisis management and communications, analysis, policy intelligence and situation reporting, supports Prime Ministry's Office)

Ministry of Defence (defence policy, emergency preparedness, severe peacetime emergencies)
Ministry of the Environment (nuclear safety and radiation protection, environmental issues)

CENTRAL AUTHORITIES

The Swedish Civil Contingencies Agency (MSB)
Coordinates emergency preparedness funding
Coordinates national emergency preparedness work
Supervises the emergency planning of the County Administrative Boards
Designs and holds training and education courses

Swedish Meteorological and Hydrological Institute (SMHI)
National contact point, relaying international alarms
Performs weather forecasts, dispersion calculations

Swedish Radiation Safety Authority (SSM)
Advises on radiation protection and on technology
Supports the information work
Coordinates national measurement and analysis organization
Co-ordinates expert advice of other authorities at Swedish emergency response centre
Estimates source terms and evaluates technical causes

Swedish Board of Agriculture Swedish
National Board on Health and Welfare
Swedish Coast Guard
National Food Administration
Swedish Police Service

REGIONAL LEVEL

The County Administrative Board
Plans and leads regional emergency preparedness work
Decides on measures to be taken to protect the public
Provides warning and information to the public
Decontamination after radioactive fall-out, releases

<u>Some cooperating bodies:</u>
County councils
Rescue services
Police forces
Hospitals
National contract laboratories
Universities

The nuclear power plants/operators
Plans the emergency activities at its own site
Reports any malfunction or unplanned releases to the County Administration, and the SSM
Resources for measurement and sampling
National contract laboratories, Universities

LOCAL LEVEL

The Municipality
Adopts central and regional steering to the conditions, and measures to be taken, within its borders

<u>Some cooperating bodies:</u>
Health centres
Companies
Local police and rescue units

Figure 20. A schematic layout of the Swedish national emergency preparedness organisation.

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

- No major developments occurred during the review period

17.1 Regulatory requirements

All the 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.

According to the Nuclear Activities Act § 5 a, it is not permissible to license a new nuclear power reactor in Sweden. Therefore, at present only the subparagraphs (iii) and (iv) of the Article 17 are applicable to the Swedish situation.

Requirements on evaluation and re-evaluation of site related factors exist in the general safety regulations SSMFS 2008:1, in connection with requirements on design and safety analysis. Also, in connection with new activities in the neighbourhood of a nuclear power plant, analyses have to be made to show the possible impact on the nuclear power plant safety functions. Only if this impact is acceptable is permission given for the new activity.

There is also a requirement 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 § 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 for Sweden, extreme water levels, biological conditions affecting the water intake, seismic events and events such as fire, explosion, flooding and airplane crash.

As a result of these regulations some licensees will have to revisit the site impact analyses of their designs (see section 6.2) and all will update the dimensioning values for the designs.

Regarding 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 of the licensing conditions. Any party can ask for deliberations on the matter. A similar agreement was concluded with Germany 1990.

17.2 Measures taken by the licence holders and SSM

Originally, external events were considered to a very limited extent for the oldest reactors. Only the two latest units; Forsmark 3 and Oskarshamn 3 were fully qualified for seismic events in their original designs. Over the years, some back fitting has been made on the basis of limited analysis of external events, including seismic.

Special precautions have been taken to avoid problems associated with location on the west coast of Sweden. These precautions consist of special means to prevent clogging of cooling water inlets by sea weed and jellyfish and spray systems to clean the switch-yards from salt deposits from the sea during storms.

As mentioned in chapter 14, the need for updating and the extension of certain deterministic analyses have been identified and included in the reactor specific implementation plans (see section 6.2) as a result of the new regulations SSMFS 2008:17. This has to do with seismic analyses, analysis of strong winds and external fire for some reactors. Dimensioning values for the design will be generally revisited.

Site characteristic natural events are defined using historic weather data for the region. A safe shut down earthquake is defined as a 10^{-5} earthquake using seismic data from Sweden modified with a Japanese response spectrum to provide conservatism. This means that a peak ground acceleration of 0.15 g has been used in the analyses[18].

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 homepage, www.ssm.se.

SKI concluded 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 flyin 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 damages 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.

[18] Characterization of seismic ground motions for probabilistic safety analyses of nuclear facilities in Sweden. SKI Technical Report 92:3, April 1992.

In 2003 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 (see also section 14.2). According to WENRA ‘s reference levels for PSA, seismic events shall be addressed.

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

- Major safety upgrading programmes have been decided for the reactors as reported in section 6.2.
- The following major modification/replacement measures have been completed 2007-2009:

Forsmark 1:

- 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 outside grid if the voltage decreases to less than 85% for 10 sec.
- Capacity and physical separation of cooling chain to the condensation pool improved. 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 containment. The purpose of these filters is to collect debris which could cause fuel damage
- Reconstruction of the sequence for control rod screw activation in order to fulfil requirements on diversity
- Replacement of the power range monitor 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 switch gear 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 outside 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 switch gear 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 theactivation of partial scram
- New nuclide specific on-line measurement equipment in the stack
- Separation of operation and safety functions in the power system with battery back-up

Oskarshamn 1:

- Monitoring system 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:

- 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 up rate project Plex (Plant Life Extension) began erection of 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 started
- Preparatory work for the new diversified cooling chain executed

Oskarshamn 3:

- Nuclide specific on-line measurement installed in the turbine offgas system with thepurpose to achieve early detection of fuel failures
- Learnings from events in Forsmark 1 on 25 July 2006 resulted in the reconstruction of yhe auto-switching automatics for the diesel bus bars at voltage less than 85%
- Modernization and power up rate project Puls (Power Up rate with Licensed Safety) implemented. The main purpose of the modernization is to improve reactor safety, increase the power output and extend plant life. The power up rate of Oskarshamn 3 to 3900 MWth and 1450 MWe gross is complete. This corresponds to 129 % of the original design (3020 MWth). The up rated plant is planned for operation until 2045 (60 years lifetime).

Scope of the project:

- Cooling Systems - increased capacity
- Main Control Room - unchanged
- Replacement of:
- Reactor Recirculation Pumps
- Reactor Internals
- Main Steam Line Isolation Valves
- LP and HP Turbines
- Generator
- Auxiliary Power Transformers
- 400kV Transformer
- Diversified Cooling Systems

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 strengthendefence against fire and to mitigate failures with common cause, i.e. to improve diversity in safety functions. Major modifications consist of the reactor protection system modernization 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 exchanged to 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 & 4:

- Diesel back up power supply to the spent fuel pool cooling systems installed
- Passive autocatalytic recombiners installed in the containment
- Power up rate project GREAT completed, thermal power increased to 3144 MW (unit 3).
- Upgraded capacity in the heat exchangers to the fuel building cooling systems
- Power operated relief valves at the pressurizer qualified to withstand water blowing
- Fire protection in the relay and cable spreading rooms improved
- Environmental qualification of components in the turbine and auxillary building

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, § 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 regardto 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.

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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).

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.

During the 1980's, 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 were earlier issued by SKI and 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, SKI 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, SKI 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

[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.

- Environmental qualification and impact on other plant systems
- Requirements on the main control room and emergency control panels
- Safety classification
- Event classification
- 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 seven design generations, five for BWR and two for PWR as shown in Table 13. The original designs were made in the late sixties and the seventies. They 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 of the reactors ordered for Ringhals.

BWR		
Unit	**Design generation**	**Main design features**
Oskarshamn 1	BWR 1	External main recirculation loops. No explicit requirements regarding physical separation. Diversification by auxiliary condenser. Fine motion control rods, diversified shut down system with rods. Boron system not fully qualified.
Ringhals 1	BWR 2	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.
Barsebäck 1 and 2 and Oskarshamn 2	BWR 3	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	BWR 4	Four-train redundancy of the safety systems (4x 50 % capacity), but less focus on diversification. Internal main recirculation pumps. Single-failure- and repair criterion. Pipe-whip restraints.
Forsmark 3 and Oskarshamn 3	BWR 5	As Forsmark 1-2 plus complete physical separation of the safety systems. Seismic safety. No external water storage for core cooling and auxiliary feed water.
PWR		
Ringhals 2	PWR 1	Three loop PWR. Diversification by steam driven auxiliary feed water pumps. Partial four-train electrical separation.
Ringhals 3 and 4	PWR 2	As Ringhals 2 plus improvements in physical separation and in fuel design.

Table 13. Swedish nuclear power plant design generations.

The first three generations of BWR comprising five units have external main recirculation loops, while the last 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. In the first two generations diversification was used in the emergency cooling systems, but in the later generations this was replaced by increased reliability in the electrical supply and a higher degree of redundancy.

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 1970's as a modification of 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 until 2006 is given in Appendix 3.

Backgrounds for back fitting measures have been:

- Domestic incidents e.g. the so called strainer event in Barsebäck 2 in 1992, where it was evident that emergency core cooling systems of the BWRs with external main circulation pumps did not function as postulated in the safety analysis reports. This event triggered large modifications of most Swedish reactors and also 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 procedure see section 14.2).
- New Swedish regulations (see sections 7.3 and 18.1).

Backfitting measures are basically taken to strengthen the safety concept of multiple barriers and defence-in-depth, now clearly required in SSM regulations. Important principles in this work have been and are 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 on-going modernization projects including control room upgrading, MTO (human factors) 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 BWRs, the problem of core instability has to be considered and in some of the BWRs power oscillations have occurred. Several measures have been taken to secure stability in the operational region, detect deviations from stable behaviour and suppress induced power oscillations. A redundant Detect- and Suppress- system has been installed which detects local, regional and core wide oscillations and signals alarm, partial scram and full scram respectively, depending on the amplitude of the oscillations.

18.2.5. Measures to improve physical and functional separation

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. This work continues in ongoing modernization projects in which, for instance, improved separation is one of the objectives of the Ringhals 2 project for modernization of the electrical equipment and I&C systems (the TWICE project). Further work to improve separation and diversification in all reactors is planned as a large part of the individual safety programmes to meet the new back-fitting regulations (see section 6.2).

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. Backfitting measures consisted of filtered containment venting to protect against overpressure and (with theexception 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 will probably be avoided. However, steam explosions could occur when the melt falls into the water and the coolability of the core melt in the vessel and in the containment can be questioned. The severe accident research is now targeted to show that the chosen solution can adequately protect the environment.

Since the governmental decision in the 1980's the Swedish utilities and the authority SSM have in collaboration continued to conduct research on severe accidents and to follow international research on this topic. At present the APRI-7 project (Accident Phenomena of Risk Importance) is running for the three year period 2009-2011, with research on core melt sequences at the Royal Institute of Technology (KTH), and research on chemical conditions in the containment at the Chalmers University of Technology (CTH). Experimental resources have been built at KTH with assistance of EU-funds. Sweden also cooperates with the USNRC within CSARP (Cooperative Severe Accident Research Programme) and CAMP (Code Application and Maintenance Programme). This enables Sweden to get a good overview of the current knowledge and have access to the latest analytical computer codes. Projects within OECD and the EU have also contributed to the overview. Currently the BIP-project (Behaviour of Iodine Project) is ongoing within NEA-OECD. In the EU programme PHEBUS, experiments have shown that the composition of fission products is quite different from earlier assumptions. The project SARNET (Severe Accident Research – Network of Excellence) is underway as which is which is a network aiming at integration of the EU research within the area of severe accidents.

SSM will require further back fitting of the reactors to enable cooling of a core melt in the pressure vessel in order to avoid a melt through. This will require a new external water source and other dedicated equipment. This solution is, however, not uncomplicated and the design prerequisites need careful investigation.

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 SKI to ensure that they comply with the regulations. More detailed review of different design solutions has been performed in connection with notifications.

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

- An overview of recent year's operational events is given in section 6.1.
- The number of licensee event reports (category 2 LERs) has varied in the range of 30-50 per year and reactor, over recent years. The trend is increasing slightly since 2001.

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, §§ 1 and 2).

Documented up-to-date operational limits and conditions (OLC) 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, § 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, § 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, § 3 point 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 without delay: 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 documented 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, § 3 point 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, § 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

There is no legally binding requirement in Sweden to minimize radioactive waste apart from the indirect effect of regulatory requirements concerning dose limitation and planning of waste management. There exist, however, direct requirements on waste management programmes to account for the future handling and disposal of the waste, and it is stated that one of the objectives of the regulations is to limit the amounts of waste (SSMFS 2008:22). The regulations of SSM include requirements about:

- An up-to date inventory of all spent fuel and radioactive waste on-site (SSMFS 2008:1 and 2008:22)
- Plans for the management, including disposal, of all waste that exists at the facility, arises at the facility or is brought to the facility in other ways. The plans shall include e.g. amounts of different categories of waste, estimated nuclide specific content and sorting, treatment and interim storage of the waste. The plans shall be reported to the authority before the waste is generated (SSMFS 2008:22).
- Measures for the safe on-site handling, storage or disposal of nuclear waste shall be described in the safety analysis report of the facility. The measures for on-site handling shall consider the requirements on safety posed by the continued handling, transportation and disposal of the waste. (SSMFS 2008:1).

Only packages approved by SSM may be transported to a geological repository for disposal. For this approval, the waste must comply with the conditions stated in the safety analysis report of the repository. For shallow land burial facilities, the waste acceptance criteria are stated in the licence conditions.

Since disposal of spent fuel and nuclear waste is expensive, the licensees have a powerful economic incentive to keep the volumes, as well as the activity, low. Other contributing factors to this result are a decreasing number of serious fuel failures and lowered system radiation levels at Swedish nuclear power plants. Even if the driving forces to achieve these results have been costs and radiation doses, the end result also impacts positively on the volume and activity content of radioactive wastes.

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 start up 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 21.

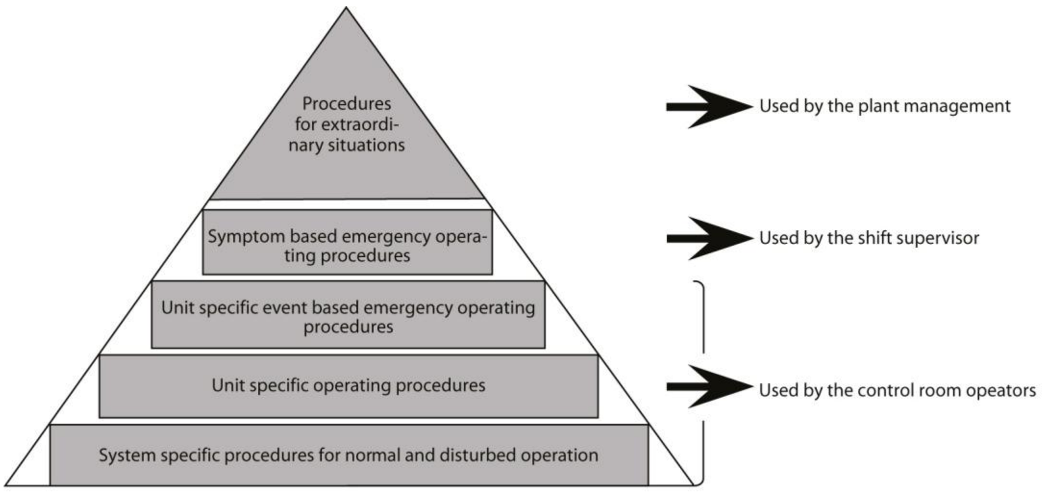

Figure 21. Overview of the main procedures applied during emergency situations. Other documents exist as reference to the main procedures. The level of the detail and the number of procedures decreases with the height of the pyramid.

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 experts to handle all forthcoming matters. In the first national report it was reported that competence might not be fully available within the own organisation at all plants, for instance expertise and resources for:

- core design and calculation,
- accident analysis,
- materials and chemistry assessments,
- radiation shielding and environmental consequence calculations.

Today all licensees claim that these competences are available in their organisation, although in some cases as part of the independent safety review function and thus should not be used for work within the line organisation. This means that even if some specialised consultants still have to be used, the plants have the competence and the capability of evaluating the results of analyses, calculations, etc. performed by such consultants.

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 the International Nuclear Event Scale (INES).

The other type of LER, called category 2, is used for less severe events, typically 30-50 per unit and year. 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.

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 manger 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.

During the period 2000 to 2009, Sweden has reported a total of eight events to IAEA. Of these events there has been one event at a nuclear power plant (Forsmark 1 in 2006) classified as INES level 2 and one transport event (Studsvik nuclear facility in 2002) classified as INES level 3. The other events were rated as INES 1 or under the scale. An overview of INES-events in nuclear facilities classified as INES 1 and above between 2000 and 2009 is given in Figure 22.

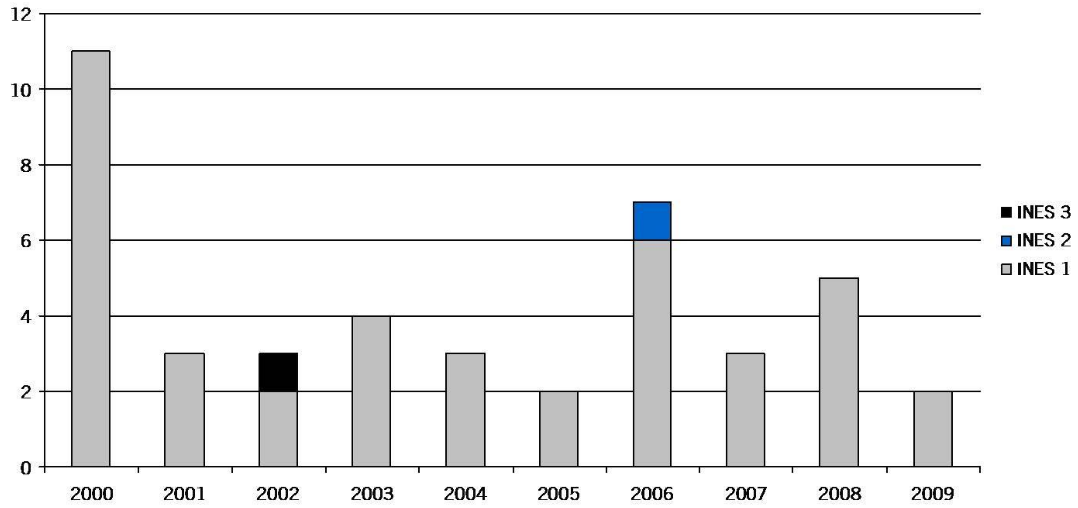

Figure 22. Events in Sweden classified as INES 1 or above during the period 2000-2009.

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 feed-back 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. Root cause analysis, RCA, also called 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 RCA analyses have been made each year at Ringhals, Oskarshamn and Forsmark respectively.

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, see Figure 23. 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.

At OKG, as a support to the common OEF system, there is a reference group where important functions are represented. The task of this group, termed Experience Forum, is to assist in effective management and development of the OEF system. Meetings are held quarterly. There is also an annual self-assessment of the effectiveness of the OEF system.

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. Ca 600 reports per year have been screened for their relevance by the Ringhals organisation.

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 number of MTO-related events at the Swedish nuclear power plants is not considered as alarming from a safety point of view, However, for other reasons such as economics, or public acceptance, the plants have the ambition to reduce the number of events. One should, however, be careful when drawing too firm conclusions from this material, because there are uncertainties in the underlying information and the forms for reporting of events were originally made for technical failures, and are not fully adapted for human factors analysis.

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: PWR Owners Group (PWROG), BWR Owners Group (BWROG), Framatom Owners Group (FROG), Nordic Owners Group (NOG). 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.

The Nordic Owners Group work has led to effective coordination of R&D efforts. Many of the projects initiated by NOG would have been too costly for a single plant to carry out.

19.2.9. New operating experience function at Ringhals

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)
- OPEX
  - Internal
  - External

19.2.10. Corrective Action Programme

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.

Figure 23. CAP process.

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 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.

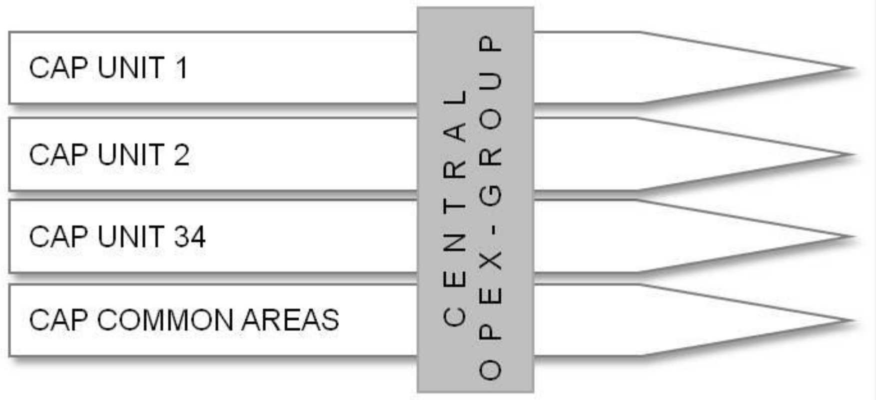

Figure 24. CAP-processes at Ringhals.

19.2.11. 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 (explained later in this document).

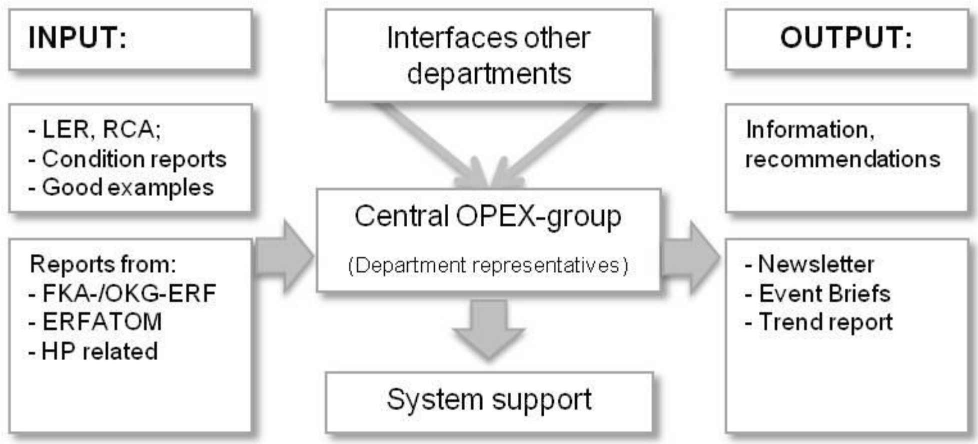

Figure 25. Ringhals central OPEX-group. The section for human performance (RQH) is the secretariat and administers systems support of OPEX. The unit also has the responsibility for the OPEX-process

The Nordic countries have an OPEX-organisation led by Westinghouse Electric (formerly ABB-Atom) on behalf of the Swedish and Finish nuclear owners, called ERFATOM. This covers events from the Swedish/Finish and foreign nuclear power plants.

19.2.12. 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.

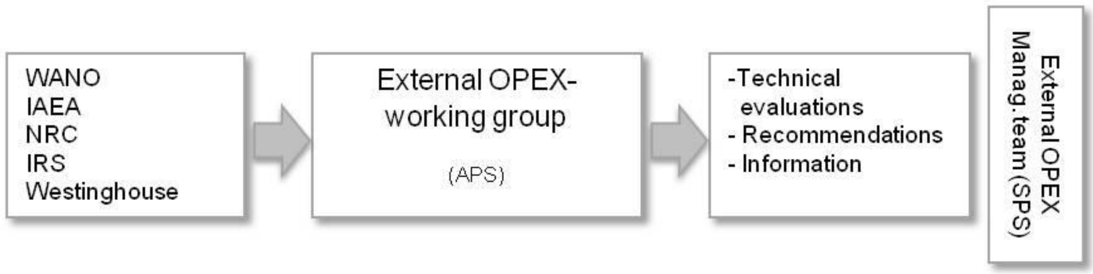

Figure 26. Ringhals external OPEX-group.

19.2.13. New operating experience 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 7 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 a Corrective Action Programme (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.

19.2.14. Operating experience in Oskarshamn

Each department/unit is responsible for OEF its daily work. One specific department is responsible for operation of the central OEF processes for external as well as internal OEF. Another department has responsibility for methodology development and establishing requirements within OEF.

19.2.15. Operating experience for training at KSU

OEF are 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 OEF-modules comprise a library of OEF information for training and are updated on a continuous basis.

KSU also make selections of international OEF suitable for ERFATOM and Ringhals PWR units.

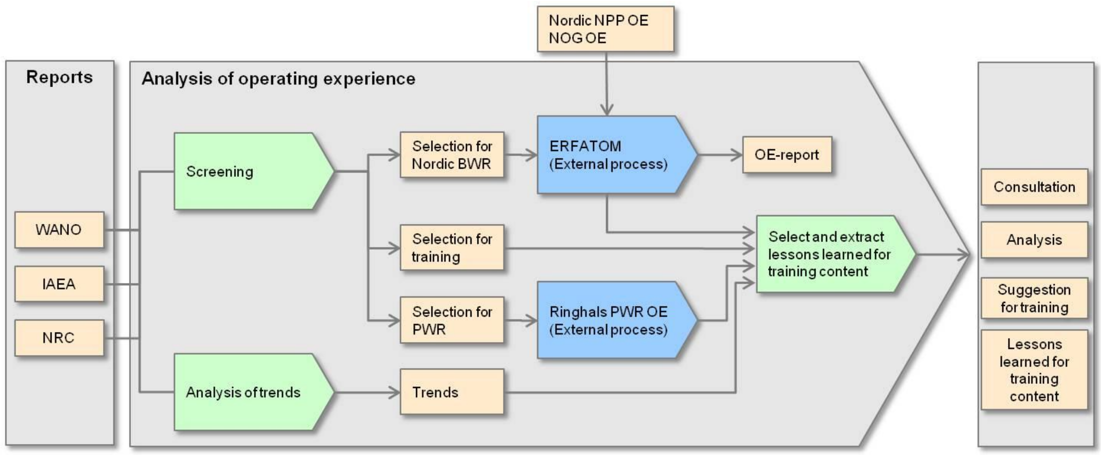

Figure 27. OEF selection process at KSU.

19.2.16. 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 to the Swedish Nuclear Fuel and Waste Management Company (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, owned and operated by SKB) 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

All reports from the licensees are screened every week by a group of 6-8 persons from the reactor safety department with different expert knowledge, making 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 number of licensee event reports (category 2 LERs) varies in the range of 30-50 per year and reactor, over the last years. The long-term trend decreased until 2001 but the number has since increased. In about 5 cases per year, SSM makes a further in-depth investigation and in most of those cases SSM requires further measures to be taken by the licensee, as a result of the investigation.

For more serious incidents, SSM has a procedure for making an early on-site investigation. This procedure has been used in a few cases over the last years. Normally the licensee reporting provides the necessary information, together with SSM verifications on-site, for making the needed regulatory decisions.

19.3.5. Experience feed-back analysis

All LERs and scram reports from the Swedish nuclear units have for many years been registered in a database at SSM (STAGBAS). With this data SSM conducts systematic trend analyses. The results are published in ”Incident catalogues” where the trends for different areas included in STF can be compared for a specific unit with the average for the reactor type. The total number of LERs, the proportion of recurrent failures and the causes stated in the LERs are also presented. This material is used in different ways in the regulatory supervision. The ”Incident catalogues” are also distributed to the licensees, but they are not intended to replace the trend analysis to be conducted by the licensees themselves. SSM does not have the detailed knowledge of the plants which should govern the utility work with trend analysis.

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 safety have been reported in several sections of part B. The following are the main points:

Modernization and safety upgrading of all reactors in line with modern safety standards

These extensive programmes covering different measures for improvement of physical and functional separation, diversification of safety functions, accident management, withstanding local dynamic effects from pipe breaks, withstanding external events, improvement of operations aids and environmental qualification and surveillance will be finalised around 2013. Details are given in section B 6.2.

Improvement of leadership, management system, safety culture and operation experience programme in Ringhals

In July 2009 SSM put Ringhals under special supervision to follow more closely the safety development at the plant. A decision was issued including four special conditions for operation and four separate items that should be reported back to SSM.

Ringhals has put together 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, improved quality of the management system, safety culture programme, and operation experience programme. Ringhals strive 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.

Measures taken after the Forsmark event 25 July 2006

As a result of this the Forsmark event, described in section B 10.4, the licensee FKA has taken a number of technical and administrative measures to prevent recurrence and SSM no longer have Forsmark under special supervision, due to the fact that Forsmark the 21 of July 2009 were judged to have implemented the necessary safety measures to an extent that special supervision no longer was necessary.

Even though a large number of measures have been implemented in Forsmark, the licensee as well as the reactor owner Vattenfall AB has planned further improvements regarding the safety management and safety culture at Forsmark. Details are given in section B 10.4.

SSM has, based on the experience from the Forsmark event 2006, made some changes in the inspection philosophy and also increased its personnel. Additional resources will be available during 2010 and 2011. Details are given in section B 8.7.

Development of SSM's supervision and adaption to changes at the licenses

In April 2010 the Swedish Government gave the SSM a mission to investigate the long-term development of nuclear safety at the Swedish nuclear installations. The objective is to provide the Government with an up-to-date picture of nuclear safety, its long-term development, including the inspection methods used by SSM. The background to this is ageing reactors and their particular safety needs, challenges in connection with safety upgrade work and planned power up rates, the utility owners' efforts to rationalize and optimize operations, and plans for extended operation of the reactors.

In February 2012, on an initiative by the Swedish Government and a request from the Authority, the IAEA will conduct a full-scope IRRS mission in Sweden. The mission scope has been determined, and further planning is underway. Details are given in section 8.5 and 8.8.

Continued economical support of higher nuclear education and research

With regard to higher nuclear education and research, there is now an agreement between the Swedish nuclear industry and SSM to support the Swedish Centre of Nuclear Technology economically for several years. The present agreement is valid 2008-2013 and there are efforts to expand the support by including more members in the Centre. Details are given in section A 4 and B 11.5.

Investigation of needed national competence

The government has in the appropriations directions for SSM in 2010 asked for an investigation of needed national competence for the activities of SSM now and in the future. This investigation will be completed by early 2011.

Further reduction of releases to the environment of radioactive substances

The releases from the nuclear power plants of radioactive substances to the environment, given in Becquerel's and compared internationally, are still relatively high. However, the effort to reduce the releases by administrative and technical means have had effect and the released activity, as well as the resulting doses to the most exposed individuals (< 1 μSv/year and site), have decreased. Further actions to reduce the gaseous and liquid effluents are planned. Details are given in section B 15.3 and 15.5.

Further back fitting of the reactors to enable cooling of a core-melt in the pressure vessel in order to avoid a melt through

SSM will require further back fitting of the reactors to enable cooling of a core-melt in the pressure vessel in order to avoid a melt through. This will require a new external water source and other dedicated equipment. This solution is, however, not uncomplicated and the design prerequisites need careful investigation. This is mentioned in section B 18.2

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 CO2 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.

Nuclear Safety Policy

E.ON Kernkraft GmbH

E.ON Kärnkraft Sverige AB

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 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.ONs 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 programme 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 programmes 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.

Appendix 3

Implemented modifications in Swedish reactors 1995 2006

Below follows a summary of the major modifications done 1995–2006. The most recent modifications are listed in 18.1, and planned future modifications in 6.2.

Oskarshamn 1

The major renovation of Oskarshamn 1 in the early 1990's 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.

In the emergency control building an emergency control room is also located in order to provide backup capability for plant control in case the main control room is unavailable. In the emergency control room, it is possible for the operators to monitor and control the reactor process from full power level down to sub critical, cold and depressurised condition, and to maintain the reactor in that condition. The emergency control room is completely separated and independent from the main control room.

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, where no changes have been made. A safety desk has been installed and has the same function as a Safety Display Panel. The emergency control room also contains a replica of the safety desk and the control functions that are part of the safety concept as indicated above. Upgraded cooling of condensation pool was performed during 2004. Diversified power supply of the programmable reactor protection system introduced.

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 on-going 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 major part of the work will be performed during the 2007, 2009 and 2011 outages.)

Oskarshamn 3

Upgrading of battery-backed electrical distribution system and change-over of power supply to certain main steam valves (The on-going PULS project includes a power up rate, modifications to comply with SSMFS 2008:17 as well as replacement of critical components in order to achieve a 60-year life. The major part of the work was performed during the 2009 outage, see article 18.)

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)

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)
- preparations for the Twice-project, replacement I & C equipment including the main control room (final implementation planned for 2008) (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)

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