Ds 2007:30

SWEDEN'S FOURTH 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 and the third in August 2004. All reports are available on the CNS website as well as on the website of the Swedish Nuclear Power Inspectorate (www.ski.se). The reports were well received at the review meetings held 1999, 2002 and 2005 respectively.

A summary of highlights and issues raised about Sweden during the third review meeting 11–22 April 2005 can be found in section A 6. This section also includes an overview of those issues Sweden was asked to report about in its fourth national report (the present report).

As was the case with the three earlier national reports, a four persons working group with one representative each of the regulatory bodies: the Swedish Nuclear Power Inspectorate and the Swedish Radiation Protection Authority and of the reactor owners: Vattenfall AB and E.ON Sweden AB has produced the present report on behalf of the Government. The Nuclear Power Inspectorate was assigned the task to co-ordinate the work. The SKI Board and the Advisory Committee on Reactor Safety have been informed about the report.

The present report is structured as the three earlier 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. Every chapter under part B corresponds to one Article of the Convention. Chapters 9–19 have a similar structure where information is provided about the regulatory requirements related to the respective Article. In addition, information is provided about measures taken by the licence holders to comply with the regulatory requirements as well as own safety initiatives. Finally, information is provided about the means used by the regulatory bodies to supervise the measures taken by the licence holders. Taken together this will provide evidence for meeting the obligations of the Convention.

Recommendations on the report structure issued by the President of the third review meeting and the IAEA secretariat 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
CCF	Common Cause Failure
CTH	Chalmers Tekniska Högskola (Chalmers University of Technology)
DBA	Design Basis Accident
ENISS	European Nuclear Installations Safety Standards
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 Thechnology)
LBB	Leak Before Break
LER	Licensee Event Report
LOCA	Loss of Coolant Accident
MTO	Interaction between Man-Technology and Organization
NDT	Non Destructive Testing
NEA	Nuclear Energy Agency within OECD
NPP	Nuclear Power Plant (including all nuclear power units at one site)
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
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 Regulations)
SSI	Statens strålskyddsinstitut (Swedish Radiation Protection Authority)
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 Organization
USNRC	US Nuclear Regulatory Commission
VTT	Finnish Technical Research Centre
WANO	World Association of Nuclear Operators
WENRA	Western European Nuclear Regulators' Association

EXECUTIVE SUMMARY: GENERAL CONCLUSIONS

The national reports 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 existing nuclear power programme is currently under strong development since a few years. Large amounts are being invested in the 10 remaining operating reactors to prepare for long term operation.

The licensees as well as the regulatory bodies have also been challenged over the last years by events, especially the Forsmark event in July 2006, demonstrating the importance of having strong safety management in place and maintaining of a vital safety culture. 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. The need for this attention is reinforced by the major programmes going on during a limited time period to upgrade and uprate the plants. These programmes will require a full effort of the operating organisations as well as of the regulatory bodies.

An additional challenge is, during the same time period, to manage the transfer of knowledge to a new generation of engineers and specialists. A large number of key staff is due to retire within the next 10 years.

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

- The Swedish legal framework is well developed and the responsibility for safety is very well defined. The nuclear law also provides for public insight into the activities of the licensees.

- The regulatory bodies have maintained and increased their resources and are further developing their regulatory practices. There is an open and constructive dialogue between the regulatory bodies 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.

- Arrangements are in place to support higher nuclear- and radiation protection research and education.

- The average occupational radiation doses are rather low at the nuclear power plants.

- The designs of the nuclear power plants have developed over the years as a response to domestic and international events, insights from safety analyses, R&D-projects and development of regulations and safety standards. Currently large programmes are 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:

- The resources of the regulatory body need to be strengthened in order to reinforce the supervision of the nuclear power plants and to cope with the expected work load during the next years. SKI estimates that 24 additional employees will be needed in the long term and additionally 7 during the period up to 2013. The Government has so far announced that they intend to reinforce the supervision of the nuclear power plants.

- The announced merger of SKI and SSI will pose challenges with regard to integrating the organisations and the regulatory practices.

- The licensees need to implement a stronger assessment of their safety management and safety culture, especially to improve monitoring and follow up of how the management systems function in the daily work at the plants.

- The licensees need to further develop and monitor their efforts to transfer competence from experienced staff soon being retired to younger generations of engineers and other specialists.
- The releases to the environment of radioactive substances, given in becquerels and compared internationally, are still relatively high. Further actions to reduce the gaseous and liquid effluents are planned.

Sweden looks forward to reporting on the development of these issues in its 2011 national report to the Convention.

A. INTRODUCTION

1. Current role of Nuclear Power in Swedish Power Production

The electrical power consumption in Sweden was about 146 TWh 2006 as compared with 148 TWh 2005 and 145 TWh in 2003[1] . The total electrical power production was 139,8 TWh 2006 and 154,7 TWh 2005, which meant that Sweden had to shift from power exports 2005 to power imports 2006. The 2006 nuclear power production was 64,7 TWh, down from 69,5 TWh 2005 depending on forced outages of Forsmark 1 and other units. The 2006 hydropower production was 61,2 TWh down from 72 TWh 2005 depending on a very hot summer and low water levels in the reservoirs until the last quarter of the year. Fossil- and bio fuel power production amounted to about 13 TWh. Wind power production was 0,99 TWh a steady increase over the last years. 2005 Sweden had 770 major wind power plants in operation and several new wind power parks under planning. In a normal year, hydropower and nuclear power deliver over 90% of the total electrical 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.

Since 1996 the electrical power market has been deregulated and competitive in principle for both the production and sale of electricity. The national high voltage grid is managed by a state company: 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 electricity trade. Spot market prises have fluctuated considerably during the operational period of Nord Pool. The first years after deregulation prices fell to very low levels but the last years average prices have been higher, depending to a large extent on the availability of hydropower.

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 to 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 permanently shut down the two research reactors (R2 and R2–0) at the Studsvik site. They were closed in June 2005. The decision was taken on economical grounds, the licences had recently been extended until 2014, subject to certain conditions. The reactors were mainly used for commercial materials testing purposes, isotope production, neutron source for research purposes, medical applications and higher education. They are currently under decommissioning.

3. Political development of the Nuclear Power Issue

As described in detail in the first national report to the Convention, nuclear power has been a very prominent issue in the political debate in Sweden since the 1970's. In 1997, the Act (1997:1320) on the Phasing-Out of Nuclear Power was adopted by Parliament. This Act authorises the Government to shut down a nuclear power reactor as a consequence of conversion of the energy system. The location, age, design and importance for the energy system of a particular reactor shall be considered when taking such a decision. The Act also includes provisions for reimbursement of the reactor owner, in the case a shut down decision is taken according to the Act.

Pursuant to the new Act, Barsebäck 1 was shut down on 30 November 1999 and Barsebäck 2 on 31 May 2005. The reactor owner Sydkraft AB was fully compensated by shares in the state owned utility Vattenfall.

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

The Government decided 2006 to allow power uprates of Ringhals 1, Ringhals 3 and Oskarshamn 3. Except of this, no firm decisions have been taken about the future of the nuclear power programme in Sweden. The earlier time limit 2010 for decommissioning of the remaining units was revoked already in 1997 as a result of an energy policy agreement between the political parties. The present Government declared in their election programme 2006 that no more units will be considered for shut down and no decisions will be taken on new nuclear power during the election period ending 2010.

4. Nuclear Power Installations in Sweden

At present, in May 2007, 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[2]	Electrical gross output MW	Type	Operator	Construction start	Commercial operation
Power reactors						
Ågesta	105	12	PHWR	AB Atomenergi Vattenfall	1957	1964–1974[3]
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	1014 1014 1190	BWR BWR BWR	Forsmarks Kraftgrupp AB	1971 1975 1978	1980 1981 1985
Oskarshamn 1 Oskarshamn 2 Oskarshamn 3	1375 1800 3300	487 623 1197	BWR BWR BWR	OKG Aktiebolag	1966 1969 1980	1972 1975 1985
Ringhals 1 Ringhals 2 Ringhals 3 Ringhals 4	2540 2660 3000 2783	880 870 1010 915	BWR PWR PWR PWR	Ringhals AB	1968 1969 1972 1973	1976 1975 1981 1983

Table 1. Nuclear power installations in Sweden. Main data.

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

Eight of the power reactors (including Barsebäck 1 and 2) were uprated during the period 1982–1989 between 6–10% from the original licensed power levels. The Government has recently approved further uprating of Ringhals 1, Ringhals 3, Oskarshamn 3. Uprating is planned for more reactors. An overview of all plans is given in section B 6.3. In total this programme, including measures on the conventional side, will add 1275 MWe to the current generating capacity.

Ownership, organisation and staffing

The restructuring of the European nuclear power industry, caused by the deregulation and widening of the electrical power markets, has brought about an internationalisation of the, for many years, two dominant Swedish utilities: Vattenfall AB and Sydkraft AB. Vattenfall AB has acquired large power production assets in Poland and Germany, including co-ownership of four German nuclear power plants, and has established itself as a major actor on the European level. The major German utility, E.ON, has acquired a majority of the shares in Sydkraft AB. As a result Sydkraft AB has changed name to E.ON Sverige AB. The Norwegian utility Statkraft has acquired the remaining part of Sydkraft. The Finnish utility Fortum, owner of the Loviisa nuclear power plant, has established itself as a big owner on the Swedish market, with a large share of OKG. The result is a large extent of cross ownership of the Swedish nuclear power plants as shown in figure 1 below.

2 According to SKI documentation.

3 Slightly 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.

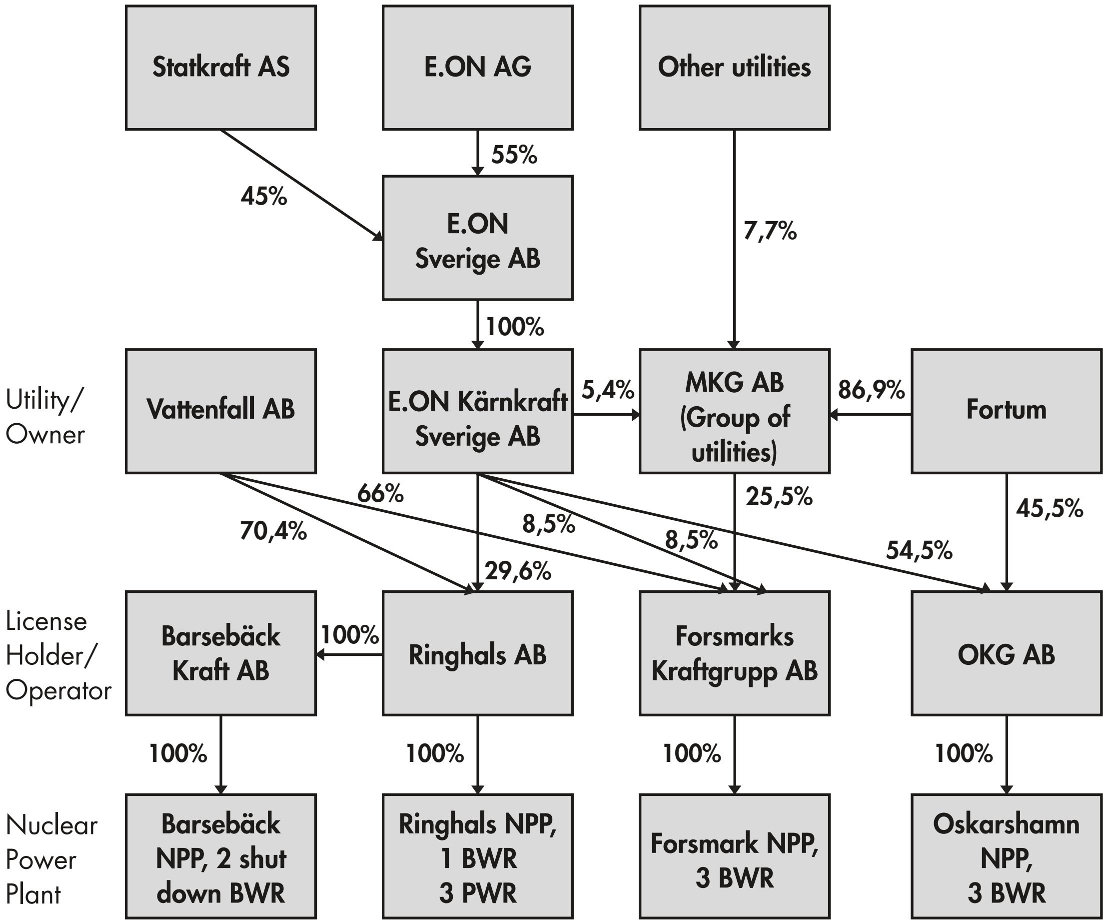

Figure 1. Utility structure and owner relations.

The staff figures for the different sites are:

Nuclear power plant	Staff 2007	Staff 2003	Staff 1998
Barsebäck	40	344	430
Forsmark	860	794	850
Oskarshamn	850	837	1050
Ringhals	1430	1162	1200

Table 2. Staffing of the Swedish NPPs 2007 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 now increases 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 also grows, although 70 people have been transferred to SKB following their take-over of operations of the spent fuel storage Clab. Section B 11.3 provides more details about the current staffing situation.

Own support organisations

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

- KSU AB (Nuclear Safety and Training): provides operational training, including simulator training, on a contracting basis for all 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. KSU also represents Sweden in WANO.

- SQC (Swedish Qualification Centre): a company for independent qualification of NDT systems to be used by NDT-companies in Swedish nuclear power plants.
- ERFATOM: a cooperation between the Swedish and Finnish BWRs operators and Westinghouse Electric AB (former ABB Atom) to carry out experience feedback analysis of events at Swedish BWRs.
- SKB: 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 over the last 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.

According to Swedish law, a license holder needs a permit from the Government or SKI for contracting out a major part of the nuclear activity. For minor parts it is sufficient under certain conditions to notify SKI that a contract is given (see further section B 7.1). SKI requires the licensees to make the necessary check of quality and competence of a contractor and 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 and for companies dealing with 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 of course 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 new build in Finland.

Studsvik Nuclear AB is still an important contractor for materials testing and nuclear fuel investigations. The materials testing reactors have been shut down but there is a co-operation with the Halden reactor in Norway. Also, a hot cell laboratory is maintained. Studsvik is also expanding its business in the decommissioning- and waste treatment field.

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 19 000 m^3 spent fuel, 60 000 m^3 low and intermediate level waste (LILW), and 160 000 m^3 decommissioning waste (based on 40-year operation of each reactor). The typical total annual production of LILW at the nuclear facilities is 1 000–1 500 m^3.

Existing waste management practices are the repository for radioactive operational waste, SFR-1, shallow land burials, Clab, the transportation system and clearance.

SFR-1 is a repository for LILW resulting from the operation of Swedish nuclear reactors. In addition small amounts of radioactive waste from hospitals, research institutions and industry are disposed of in SFR-1. SFR-1 consists of four rock caverns and a silo. The facility is situated at 50 m depth, in the bedrock 5 m under the Baltic 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 2006 a total volume of 31 250 m^3 had been used. 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 (< 300 kBq/kg). Each of these burials is licensed for a total activity of 100–200 GBq (the highest allowed level according to the legislation is 10 TBq, of which a maximum of 10 GBq may consist of alpha-active substances).

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 25 m depth in the bedrock. Construction started in 1980 and it was taken into operation in 1985. The current total storage capacity is 5 000 tonnes of spent fuel. 4 775 tonnes were being stored at the end of 2006. Clab is currently being expanded with a second rock cavern and water pool. The capacity after the expansion will be sufficient for storing all spent fuel from the nuclear power reactors, approximately 8 000 tonnes. The commissioning of the extended part of the storage facility is delayed but is planned within the near future.

All transportation of spent nuclear fuel and nuclear waste is by sea, since all the nuclear facilities are situated at 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 an important component in the waste management system. Material may be cleared for unrestricted use or for disposal as conventional non-radioactive waste. For example, in 2004 approximately 600 tonnes were cleared for disposal at municipal landfills. In addition 500 tonnes of scrap metal (< 500 Bq/kg) were cleared for recycling.

Four major facilities remain to be designed, sited, constructed and licensed. Namely 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 a repository for waste from decommissioning and dismantling the nuclear power plants. An application for the encapsulation plant was received by SKI 2006.

The development work for the final repository of spent fuel has continued according to plan and the process for selecting suitable sites is underway. Östhammar, close to Forsmark, and Oskarshamn are presently being investigated as possible locations for the final repository. These investigations are planned to be completed in 2008.

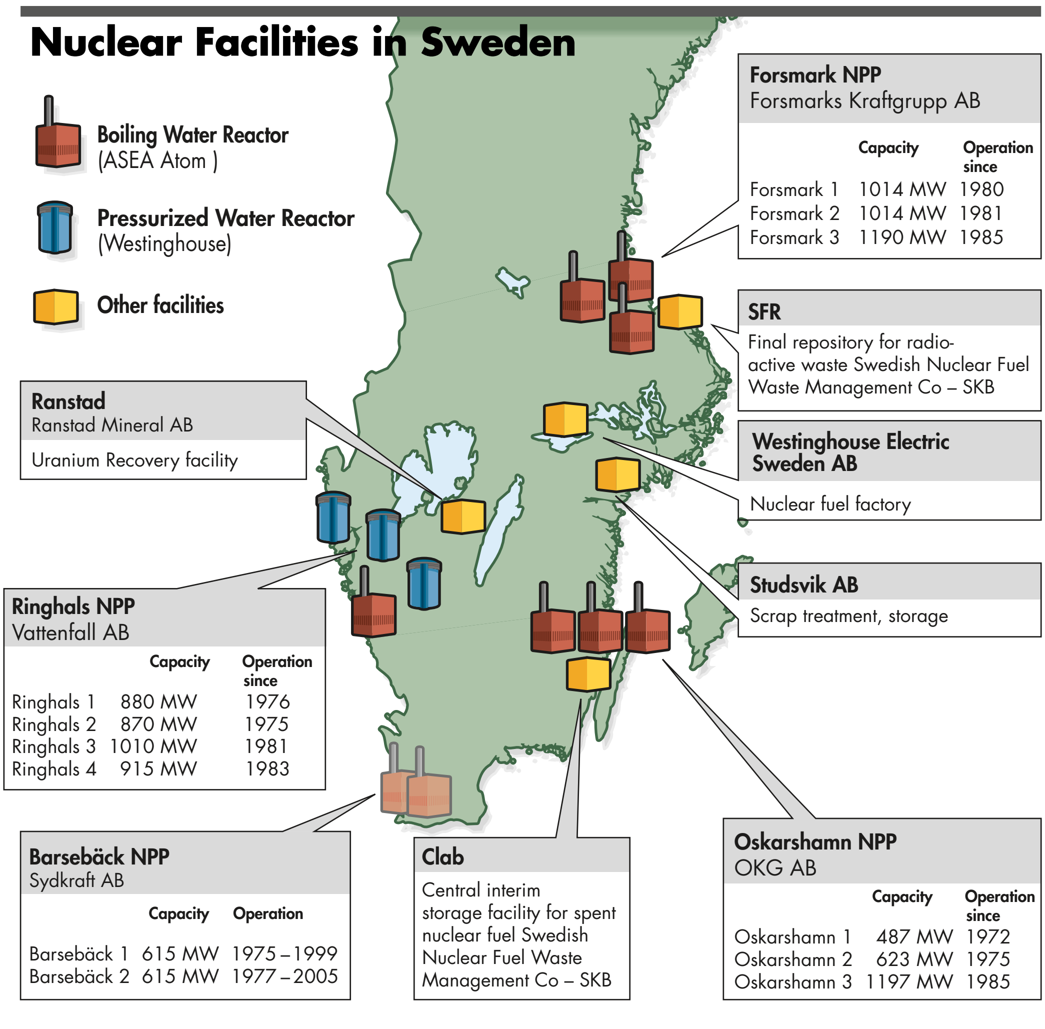

Figure 2. Location of the nuclear facilities in Sweden.

Nuclear education, research and development

As mentioned in the third 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 (CTH) and Uppsala University (UU). At KTH the Swedish Centre of Nuclear Technology has existed since 1992. From having been mainly oriented towards KTH and support to doctoral students, the Centre has now as its aim also to support professor- and lecturer posts and post-graduate education in the nuclear field at the three universities mentioned above. Ten professorships (of which two are vacant currently) with a specific nuclear technology or human factors profile and ten lectureships exist in Sweden for higher nuclear education and research. Somewhat over 200 students per year have attended the nuclear courses at the mentioned universities over the last years.

As also mentioned in the third report, Sweden has taken a systematic approach to maintain basic academic resources for higher nuclear education and research. This is done by an agreement between the Swedish nuclear industry and SKI to support the Swedish Centre of Nuclear Technology economically during several years. A new assessment of the needs was made in 2006 and the present financiers have decided to continue the support after 2007, when the present agreement ends. (see further section B 11.5).

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

Regulatory bodies

The international nuclear safety cooperation has a large and increasing volume. SKI is involved in about 80 international groups at different levels. Most of the reactor safety cooperation takes place within the frameworks of IAEA, OECD/NEA and EU, but also in connection with the international conventions ratified by Sweden and within associations (NGOs) as the Western European Nuclear Regulators' Association (WENRA) and the International Nuclear Regulators' Association (INRA). In addition to these multilateral contexts, SKI has bilateral agreements with nine countries to exchange information and to cooperate on technical issues as agreed. These countries are Denmark, Norway, Finland, Iceland, USA, Russia, Japan, Germany and Lithuania. Sweden has a relatively high profile in the international technical groups. SKI and SSI both consider the active international involvement to be important for the quality of the national safety and radiation protection work. It is also an important obligation to contribute to the development of international safety standards and the common knowledge base. However, since the regulatory bodies have limited resources, and national safety work has to be prioritised, it is increasingly necessary to limit the international activities to those that are mandatory or judged as very useful for the national safety work.

The Director General of SKI has held the chair of both WENRA and INRA and is a member of the IAEA Board of Governors and the NEA Steering Committee. SKI has put a lot of effort into WENRA's benchmarking project where 17 countries have made a systematic comparison of national reactor safety requirements and their implementation against jointly agreed reference levels on 18 major safety issues[4]. On the basis of this benchmarking all the participating countries have made national action plans for incorporating the reference levels in the national legislation by 2010 (see further chapter 7). SKI has also, since the Swedish Presidency 2001, been actively involved in the European Council's expert group on nuclear safety WPNS. In the end of 2006 WPNS completed a stocktaking of the international nuclear safety work that EU Member States are involved in, and on that basis made recommendations to the Council on additional measures to take on the EU level, in order to contribute more effectively to achieving a high nuclear safety within the Union[5].

The SSI Director General is currently chair of the International Commission on Radiological Protection (ICRP). SSI is further represented in several committees and working groups of NEA, IAEA and the EU. International agreements exist with authorities and technical support bodies in Europe and Asia as well as in the US in areas such as emergency preparedness, occupational exposure, environmental radiological protection and radioactive waste management.

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4 See Harmonisation of Reactor Safety in WENRA Countries. Report by the WENRA Reactor Harmonisation Working Group, January 2006 and WENRA Reactor Safety Reference Levels, January 2007. Both documents are available on www.wenra.org.

5 See Working Party on Nuclear Safety (WPNS) Final Report, December 2006. Council document 16737/06.

Besides the regulatory issues, SKI and SSI are engaged in research projects, mostly within the co-operation of the EU research programme, NEA and the IAEA. Staff of both regulatory bodies has also been involved in a number of international expert missions.

International support programmes

Sweden has continued its technical support and co-operation programme, which is now mainly directed at the Russian Federation and Ukraine. This programme, which includes reactor safety, waste management, radiation protection and emergency preparedness as well as nuclear non-proliferation is administered by SKI's Department for International Co-operation Programme (ICP) and SSI's Department for International Development Co-operation (SIUS). The technical support commenced in 1991 and over the years' projects has been implemented in several countries. The largest recipient has been Lithuania, but this bilateral support was gradually phased out when Lithuania became a member of the European Union. The annual appropriation is approximately 50 MSEK. Besides the bilateral co-operation both ICP and SIUS have been active in the EU Phare and Tacis-programmes.

Utilities

The utilities in Sweden have traditionally also been active in international co-operation to enhance nuclear safety by sharing experience, contributing to work with international regulations and guidelines and participating in safety assessments and peer reviews. This is today primarily accomplished through membership in WANO, in owners group associations of the major European and US vendors, and by participation in 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 co-operated in international projects and research organisations. 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. These projects have all been adapted to today's needs and conditions and are 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 has been an active part since early 2005 when the European nuclear industry formed, under the Foratom organisation, the European Nuclear Installations Safety Standards, ENISS. Today ENISS has representation from all of the 17 countries participating in the regulators association WENRA.

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

The following were defined as the main tasks of ENISS:

- To create an information platform for the different national and international activities with respect to new regulation.
- To establish a common industry position with respect to the "WENRA Reference Levels".
- To discuss with WENRA, as a major stakeholder, the WENRA "Reference Levels" after publication in early 2006.
- To support an exchange of information about the interaction of operators with their national regulators, in order to achieve a harmonized implementation of new regulations.

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, at the end, at a set of common 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, as there are currently no plans for new nuclear power construction in Sweden, has been to obtain a basis for further development of 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 one to power generation plants. The document has been benchmarked vs. other sets of safety requirements; EPRI-URD, US regulatory requirements, and IAEA requirements & 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 (Finland), Iberdrola (Spain), Nuclear Research & consultancy Group (Netherlands), Rosenergoatom (Russia), Società gestione impiante nucleari (Italy), Tractebel (Belgium), Teollisuuden Voima Oy (Finland), Swissnuclear (Switzerland), Vattenfall (Sweden) and VGB Powertech (Germany). Two more utilities are about to join; EnergoAtom (Ukraine) and the CEZ (Czech Republic). ENEL (Italy) and Endesa (Spain) plan to re-enter the organisation.

The EUR organisation analysed the earlier mentioned WENRA reference levels with regard to the last published issue of the EUR safety requirements, the revision C of volumes 1 and 2, and the results were presented to WENRA.

6. Highlights and issues in the discussion about Sweden at the third review meeting 2005

During the period before the third review meeting Sweden received in total 85 questions from 15 countries. The questions touched several articles of the Convention and were mostly requests for clarifications, additional information and reports on experiences with specific practices. The questions could be grouped under the following headlines: regulations, licensing issues, openness and transparency, regulatory practices, specific technical issues, human factors issues, radiation protection issues and resources of the regulatory body. All questions were answered on the CNS website and commented at the review meeting.

During the discussion in the country group it was noted that the political uncertainty of future nuclear power operations in Sweden remains, but conditions had become more stable after the decision to close Barsebäck 2 in May 2005. Closure of more units would depend on supply of replacement power by renewable means. Government had indicated that this could be a long process.

It was noted that the outsourcing and downsizing in NPP organisations, following the deregulation of the electricity market, had stopped and organisations had consolidated. There was again long term planning in place to modernise and uprate the reactors. These plans created some concerns with regard to the workload for both utilities and regulators during the coming years.

Events over the last years had indicated that the licensees needed to pay more attention to safety management especially international operational experience feedback, ageing management and conservative decision making. It was noted that the Swedish regulations did not explicitly mention safety culture, but compliance with the extensive regulations on safety management will create the conditions needed for building and maintaining a good safety culture.

Regular top meetings were held in Sweden between the licensee corporate management and the regulatory management to discuss overall safety issues and future planning on both sides. It was noted that this could help to avoid corporate complacency.

A systematic approach was in place in Sweden to support higher nuclear education and research.
Development of regulatory practices was noted including revision of SKI regulations, pilot use of regulatory indicators and full implementation of the regulatory management system.

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

- A strong industry ambition to upgrade NPPs despite uncertainty of the future of the nuclear programme
- A systematic approach to ensure national nuclear competence
- Strong legal emphasis on the licensees' responsibility for safety
- Comprehensive requirements on safety management
- Stringent requirements on the licensees' assessment of organisational change
- Integration of human factors competence in regulatory safety reviews and inspections
- Licensee programmes in place for assessment of safety culture
- Regulatory management system in place
- Use of risk-informed decision making within defined limits
- Transparency and an active public information strategy, local civilian safety committees enhance the understanding of local authorities on nuclear issues

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

- Consolidation of the licensing procedures according to the nuclear law and the environmental code
  This report is found in section B 7.1.

- Supply of radiation protection specialists and continued measures to maintaining national nuclear competence
  This report is found in section B 11.5.

- Programmes to meet new regulations on ageing management
  This report is found in section B 14.3.

- Uprating plans submitted by some plants and planning in progress
  This report is found in section B 6.3.

- Reactor specific upgrading plans to be submitted by the end of 2005
  This report is found in section B 6.2.

- Knowledge transfer industry programmes in place and to continue
  This report is found in section B 11.3.

- Coordination of outages, upgrading and uprating required along with consolidation of service companies
  This report is found in section B 11.3 for industry and sections B 8.2, 8.9 and 8.10 for the regulatory side

- Continued development of regulatory indicators
  This report is found in section B 10.5.

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 fourth 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 occurred at the nuclear power plants during the last three years as well as conclusions drawn from these events. Furthermore, information is provided about planned safety upgrading measures and plans for uprating of the reactors. Basic information about the design of the reactors and already implemented safety upgrading measures is given in chapter 18.

Summary of developments since the last national report

- 2004 and 2005 were good nuclear power production years in Sweden with few events. On 25 July 2006 a complicated electrical event occurred at Forsmark 1 resulting in loss of power supply to two out of four redundant safety trains during 22 minutes. This event triggered a large debate on nuclear power safety in Sweden and was also highly noticed internationally. Other events in Forsmark 2006 indicated deficiencies in safety management and safety culture and SKI required a firm improvement programme.
- Barsebäck unit 2 was closed down for political reasons in May 2005. Unit 1 was closed 1999.
- SKI has decided on reactor specific safety upgrading programmes as a result of the new regulations SKIFS 2004:2 on design and construction of nuclear power reactors.
- The licensees have applied for major power uprating of seven reactors and a minor uprating of one reactor. The whole program will add 1275 MWe to the current nuclear power production capacity in Sweden.

6.1 Overview of major events since the last national report

In their annual reports to the Government for the years 2004 and 2005, 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 four events were classified as level 1 on the International Nuclear Event Scale (INES) during 2004 and 2005. During 2006 five events were classified as level 1 and one event as level 2. Handling of events during 2006 and early 2007 was to a large extent dominated by the so called Forsmark 1-event, level 2 on the INES-scale, as well as other incidents and signs of a declining safety culture at the Forsmark NPP. The following is an overview of the most significant events 2004–May 2007.

Electrical and I&C events

During outage 2004 Oskarshamn 1 had a false alarm in the control room for low water level in the reactor pressure vessel. It showed that wrong material had been used to make the connecting cables to the level indicators. In the hot and moist environment where the cables are, the marking emitted chlorine gas which caused corrosion on the level indicators. The licensee OKG inspected all of the level indicators and found similar defects. The investigation also revealed deficiencies in the installation inspection. If the procedures had functioned as intended, the faulty material would have been detected. In the light of this, OKG and SKI rated the event as 1 on the INES-scale and SKI decided to report it to the IRS, (Incident Reporting System).

The heavy "Gudrun" storm in January 2005 affected the operation of the reactors at Ringhals and Barsebäck. At Ringhals, the switchyards were affected by salt deposits that could not be removed by the spray systems and, at Barsebäck, the 400kV grid was subjected to interruptions. Ringhals 1, 2 and 3 were disconnected from the grid. At Ringhals 4 power was decreased to about 25% for a few hours. The interruptions in the 400kV grid led to partial scram of Barsebäck 2. The facility changed over to island mode operation at 54% reactor power. Automatic switchover to the 130 kV grid occurred. Early in the morning of the following day, the reactor returned to normal operation and was reconnected to the 400 kV grid.

On 25 July 2006 Forsmark 1 scrammed as a result of a short circuit in the offsite 400 kV switchyard in connection with maintenance work done by Svenska Kraftnät (the national grid company). The voltage and frequency variations that followed, together with additional component failures, especially of the rectifiers and inverters belonging to the uninterruptible power system (UPS) of the battery backed-up 220 V AC grid, resulted in failure of the emergency diesel generators of train A and B, resulting in loss during 22 minutes of two out of four redundant subdivisions in several safety systems. The transient caused no disturbance in train C and D. After 22 minutes the operators could manually reconnect the train A and B diesel secured bus bars to the ordinary 6 kV grid, that remained operational during the entire event through connection to the 70 kV off-site grid, and after 45 minutes the operators could verify that the reactor was in a stable shutdown mode. Reactor shutdown, core cooling and residual heat removal were ensured, during the whole event, by the automatic functions. No release of radioactivity occurred.

In the control room the event resulted in a large information flow and in a complicated signal flow that was difficult to interpret. The loss of power supply in UPS backed-up 220 V AC train A and B led to the loss of important computer based and conventional I&C generated information for the handling of the event. Among such information were lost indication for "control rods fully inserted" for the rods belonging to train A and sub B, lost indications from the neutron monitoring system, and for level and pressure in the reactor pressure vessel. The loss of UPS in train A and B also resulted in the unavailability of the operator workstations. In addition some of the mimics panels for the electrical systems indicated faulty status for the subdivisions still having power supply.

The event indicated that the unit did not, in all aspects, respond to the disturbance as analysed in the unit's Safety Analysis Report. The event was classified as a level 2 on the INES-scale, due to the CCF characteristic, and as a category 1 event according to Swedish regulations, the most serious category (see chapter 19). The Swedish Nuclear Power Inspectorate (SKI) has to give its formal approval before the licensee can restart the unit after a category 1 event.

In November 2006 an explosive fire started in one of the two unit transformers at Ringhals 3 due to a flashover. It took about two hours to extinguish the fire. The rector scrammed and all safety functions worked as expected. The fire was well contained within the concrete transformer box. The licensee made extensive checks to find out whether any other equipment had been damaged during the transient. Two auxiliary electrical pump motors were found to be damaged. The transformer was replaced and the unit restarted about one month after the fire. The event was classified as a level 1 on the INES-scale. As a result of this event, as well as the Forsmark 1 event, SKI will require a better surveillance and registration of fast (milliseconds) electrical transients.

Events affecting the containment integrity and PS-function

In connection with quarterly testing of isolation valves in Forsmark 2 in 2004, one of the external containment isolation valves in the residual heat removal system failed to close. The same fault occurred during retesting. The faulty valve, one of two in series, was repaired. As a result of the degraded containment function, the event was classified as a level 1 on the INES-scale.

In connection with a temporary shutdown 2004 of Barsebäck 2, it was found that one of the blow down pipes installed 2003 had been placed at an incorrect height and was positioned above, instead of below, the condensation pool water surface. The discovery led the licensee BKAB to launch an inspection of mechanical modifications conducted over the past two years in order to ensure that the installations were correct.

During 2003 and 2004 leakages were detected in the containment steel liners of both Ringhals 1 and 2. Both reactors have concrete containments with double steel liners. At Ringhals 1 it was determined that the defect most probably only concerned the inner steel liner. SKI decided that operations could continue until the refuelling outage in August 2003. During the outage, the defect was repaired. Also at Ringhals 2, SKI was informed that a leak had been detected in the inner of the two steel plates. SKI decided that the reactor could be operated until the 2005 refuelling outage with certain stipulations, but could not be restarted after the outage without SKI's permission. However, the unit was shut down already in February 2005 for repair since measurements showed a higher leakage flow than assumed in the basis for SKI's earlier decision. Initial investigations showed extensive corrosion damage on the toroid plates in the bottom of the containment. The reactor was shut down for about two months for repairs.

In 2005, an inner containment isolation valve in the system for drainage water was found not to be properly leaktight at Forsmark 2. The valve had an internal leak. The root cause was assessed to be debris entering into the valve from the reactor containment sump. The outer isolation valve installed in series was leaktight. The event was classified as a level 1 on the INES-scale.

During the 2006 outage of Forsmark 2 the upper toroid (steel liner) in the containment was modified. The welds were inspected by an accredited inspection body. At restart after the outage, a leakage was detected in the modified part of the toroid. The defects causing the leakage had not been detected at the inspection. Upon the request of SKI, FKA could not find the documentation from the inspection. Hence, FKA conducted a new inspection of the welds. This inspection revealed some additional minor defects. A deviation report from the inspection body submitted by FKA to SKI stated that the earlier inspection was made accurately but was not correctly documented. The reason was explained as time pressure. As a result, SKI decided that before Forsmark 2 was allowed to resume operation, FKA had to review all documentation of modifications and exchange of mechanical equipment in the quality classes 1 and 2 during 2005 and 2006. The review had to make sure that the equipment has been adequately tested and inspected according to SKI regulations. The review had to be documented and submitted to SKI. Corresponding decisions were made for Forsmark 1 and 3, however these units were allowed to remain in operation during the investigation.

At a routine follow up of work orders in the fall of 2006, it was detected at Forsmark 1 that a test piece taken from a rubber seal in the beam structure between dry well and wet well of the containment, had not been analysed according to the preventive maintenance programme. A test piece had been taken already 2003 but remained at the plant unanalysed. The work order had been wrongly signed off, consequently the fact was not detected at the normal follow-ups. New test pieces were taken 2006. When the test results were available 31 January 2007, the rubber seal showed to have degraded beyond the acceptance limits. The deficiency was classified as a category 1 according to SKI regulations. As a result FKA decided to shut down Forsmark 1 and 2 for further investigations. Tests of the rubber seal in Forsmark 2 showed that for this reactor the acceptance criteria were met. However, SKI decided that Forsmark 2 may not be taken in operation before FKA has reviewed all documentation of tests and investigations of equipment of importance for safety and included in the preventive maintenance programme of the reactor. The review had to focus on tests and investigations only controlled by work orders. The results had to be documented, safety reviewed and submitted to SKI. A corresponding decision was made for Forsmark 3, however this unit was allowed to remain in operation during the investigation. Forsmark 2 was allowed to restart in February and Forsmark 1 was finally allowed to restart in mid March 2007 after review by SKI of submitted investigations and exchange of the rubber seal.

Final shut down

As a result of a governmental decision, Barsebäck 2 was closed down on 31 May 2005. On June 10, all of the fuel had been removed from the core and placed in the fuel pools. A year later all fuel was removed from the site and transported to Clab, the intermediate storage for spent fuel located in Oskarshamn.

SKI's special supervision of Barsebäck 2 continued until the closure of the reactor 31 May 2005. This supervision entails a more frequent presence of inspectors than normal and more stringent reporting requirements. In SKI's opinion, the licensee BKAB handled the long closure process adequately. Directly after the closure a new organisation of Barsebäck 2 was introduced. The main difference, compared with the previous organisation, is the reduction of staff. The principles for safety management are basically unchanged. Operational measures taken since the final shutdown include surveillance testing in accordance with the OLCs and certain tests on systems which are not governed by requirements but for which the licensee would like to maintain a good status.

Other notable events

At the end of 2005 Ringhals 2 reported that, in connection with work the previous day, errors were made which resulted in unavailability of two auxiliary feed water pumps. The pumps had been covered with plastic to protect from dust during work and the plastic was not removed after the work was finished. However, a third pump was available with a double capacity compared with the two other pumps. This capacity is enough to feed two of three steam generators. This would thereby make it possible to handle the residual heat in connection with a possible operating event. In connection with such an event, the covered pumps would also have functioned as intended for a short period of time. The event was classified as a level 1 on INES-scale.

The handling of the Forsmark 1 event 25 July 2006

This complicated event is described under "Electrical and I&C events" above. SKI's immediate investigation showed that the operators in the control room acted methodically throughout the whole event sequence according to simulator-practiced routines and emergency operating procedures. The licensee Forsmarks Kraftgrupp AB (FKA) informed SKI rapidly after the reactor scram. A matter of discussion later was that the reactor was kept in hot standby for 24 hours before FKA brought it to cold shut down and the event was classified as category 1 according to SKI regulations. However, FKA assessed early that the causes behind parts of the event chain could be generic, and informed early other licensees in Sweden and Finland. SKI notified timely the International Atomic Energy Agency (IAEA) about the event.

Three days after the event, SKI requested all Swedish licensees to provide information confirming that their nuclear power plants do not have similar weaknesses in the emergency power systems as Forsmark 1. OKG informed SKI on 2 August that Oskarshamn 1 and 2 had been shut down during the day since it could not be guranteed that these two units would not experience similar malfunctions in the emergency power systems as Forsmark 1.

SKI performed extensive follow-ups and assessments of the event as well as of analyses and corrective actions made by FKA, and by the other Swedish licensees.

SKI's decisions

In a decision issued on 14 September, SKI ordered FKA to take the following measures for Forsmark 1 and 2

- modify the electrical system in such a way that the function of the DC/AC-inverter in the battery secured net is maintained also during voltage disturbances up to 130% of the nominal voltage level,
- start of emergency diesel generators and connection to the diesel secured bus bar shall be independent of the own underlying AC bus bars,
- verify the entire function for safe power supply to Forsmark's nuclear installations,
- make sure that the control room display of electrical systems provides an adequate picture that does not mislead the operators at loss of power,
- make sure that the control room panel for the 6 kV grid provides an adequate picture at loss of power,
- update the instructions regarding the electrical systems in accordance with SKI's Regulations (SKIFS 2004:1) and General Recommendations.

FKA had to account for the above measures as soon as they were implemented. SKI had to approve the measures before a decision is taken on restart of the units.

Further issues

SKI judged that some issues needed further analyses:

- Root causes behind the fact that the UPS system was not dimensioned for electrical transients as the experienced one
- Enhanced selectivity between the ordinary grid and the battery/diesel generator backed-up grid in order to prevent disturbances to propagate down to the unit's safety systems
- Sufficiency of current arrangements for experience feed-back
- Sufficiency of the plant modification process when new technology is fitted on to older plants
- Sufficiency of the regulatory supervision and regulations

- Further measures for diversification and robustness of the emergency power supply

SKI performed a separate review of the generic issues as basis for other long-term corrective measures. As for Forsmark 1, SKI had to give its approval before Forsmark 2, and Oskarshamn 1 could restart. Those two reactors showed to have similar design deficiencies in the power supply systems as Forsmark 1.

On 28 September, after review and approval of the necessary technical modifications, SKI permitted restart of Forsmark 1 and 2 subject to certain conditions. FKA had to daily submit the minutes from operational meetings and to submit all internal decisions to restart after planned or unplanned shut down. Furthermore, SKI ordered FKA

A. To submit before 15 December an action plan covering measures to
- strengthen the staff's ability to assess and take necessary safety measures when a reactor behaves in an unexpected manner,
- improve maintenance and periodic inspection of installed components and systems,
- improve routines and processes for plant modifications,
- investigate assess and strengthen the safety culture of the management of the plant and other personnel taking part in the operations of the units.

B. To supplement before 15 December the safety reports of all three units with the design basis requirements for withstanding of electrical power disturbances.

C. To submit before 20 October those directives on safety priorities over production given by the Vattenfall Board to the CEO of FKA.

The Forsmark units remained under special supervision. In January 2007 SKI also handed over to the general prosecutor the suspicion that FKA had violated SKI regulations and the Act on Nuclear Activities while not bringing the reactor to a safe state (normally cold shut down) without delay after the event 25 July 2006.

Oskarshamn 1 was permitted to restart in January 2007 after several modifications of the UPS units and installation of redundant and diversified power supply of important safety functions. According to SKI's assessment the modified unit will fulfil the reliability requirements and withstand reasonable disturbances and failures.

SKI's review

The required documentation according to the decision of 28 September was submitted to SKI within the deadlines. In a review report issued 2 March 2007, SKI concludes that FKA fulfils the requirements with regard to the directives on safety priorities over production. Furthermore, the submitted action plan was assessed to contain relevant and reasonable measures for correction of the identified deficiencies. However, SKI requested some modifications to the plan and asked for submission of the revised plan:

- The proposed training programme in safety management and conservative decision making, outlined for the operations management, engineers on duty and managers of the department on safety and quality, should also include the shift supervisors. The training programme will consist of seminars and a supplementary course at the Vattenfall Nordic Safety Management Institute (NSMI, se also Article 10.2).
- The course at the Vattenfall Nordic Safety Management Institute should be completed earlier than end of 2008 as proposed by FKA.
- FKA has to use additional methods to those proposed to investigate the safety culture. Proposed methods are safety culture questionnaires and WANO peer review. FKA should supplement this by a combination of interviews, questionnaires, observations and document review.
- FKA has to state more clearly how to evaluate the actions taken to improve the safety culture.

SKI expected that necessary resources will be allocated for follow up of actions and decisions. In addition SKI expected that FKA will apply a broad perspective in the improvement of maintenance and testing/ inspection in order to ensure that systems and components fulfil specified requirements. This should also include experiences from investigations of the damaged toroid in Forsmark 2 as well as the handling of the rubber seals in the containments of Forsmark 1 and 2 (see descriptions above). Measures taken need to be evaluated and improvements fed back into the process descriptions for maintenance and testing.

SKI intends to follow up on all measures in the framework of the special supervision. A more detailed overview of FKA's action plan can be found in chapter 10. SKI's internal review and conclusions from the event is described in section 8.7.

SKI has also taken initiatives to inform about the Forsmark event and to bring up the generic issue of the robustness of safety related power supply in international contexts. A seminar for this purpose is planned to be held in Stockholm in September 2007 in cooperation with NEA and IAEA.

Conclusions

It is clear that most of the reported events have implications for safety management and safety culture. Especially the Forsmark 1 event of 25 July 2006 revealed several deficiencies in the management of plant modifications and maintenance, including inspection and testing of installed equipment and operability verification. The other two Forsmark events 2006 with the defect toroid welds and the rubber seal degradation add to this impression. The Forsmark event in July started a large public debate in Sweden about the safety of the Swedish NPPs. This debate was reinforced by a critical internal report on safety culture deficiencies at Forsmark that was leaked to the media. This report was written, on request by the plant manager, by three staff members of a section belonging to the maintenance department. The chair of the FKA Board, the SKI Director General and the Minister of Environment all had to appear in media to explain their positions. A debate on nuclear safety was also held in Parliament. SKI was challenged with regard to why inspections did not detect the reported deficiencies and whether the authority was independent enough. After all, Sweden is a small nuclear country. However, SKI could make the case that the measures taken as reported above showed that the authority had reacted firmly and timely according to the legal framework for the supervision of safety. The Government indicated that they will consider an increase of SKI's resources.

The impression is that the Forsmark events have been an eyeopener for the licensees as well as for SKI. The licensees have requested IAEA OSART missions to all plants in order to restore the public confidence, knowing that the results of the OSART-missions will be public. The last OSART-mission to Sweden was conducted in 1991. Since the early 1990's, WANO Peer Reviews have been chosen as the main tool for peer reviews of the Swedish plants. The SKI Director General has asked the national audit office for a review of the independency and integrity of the authority. As well as the licensees, SKI will assess its internal procedures to make sure that the authority has efficient instruments to early detect declining safety performance at the NPPs.

As can be seen in other parts of this report, the Swedish reactors are in a process of modernisation, safety upgrading and uprating in order to be fit for operation for 40 years and beyond. These programmes are ambitious and quite concentrated in time. This puts heavy challenges on safety management, since the operating organisation may become overloaded and lose its focus on operational safety. The Forsmark case has shown that such shifts of focus can backlash in terms of forced extended outages with associated generation losses and high costs.

Generally, it is also a challenge for operating organisations to maintain a proactive safety work and a questioning attitude to safety after good production years with few events.

The largest challenge for the Swedish licensees during the near future seems to be safety management in the broad sense and maintaining of a vital safety culture. It is important that these challenges are met with the use of good tools and methodologies. Firm evaluations as well as domestic and international experience feedback are central for development of these tools. In its supervision, SKI will pay much attention to the safety management issues during the next years (see further chapter 10).

6.2 Ongoing/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 (see section 18.2). In connection with deciding on licensing conditions for this upgrading, and the fact that the industry document had been delayed, SKI decided to issue guidelines for modernisation and safety upgrading of the Swedish reactors for the rest of their operating time. As this work proceeded, and a series of meetings were held with the licensees to discuss interpretations and consequences, SKI 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 SKIFS 2004:2 and general recommendations on their interpretations came into force 1 January 2005 with transitional provisions (see further section 7.2).

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 industry standards that were applied in the construction of the facilities. However, the new regulations are not covering all aspects of a design standard but those issues 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, a consequence assessment was made for each reactor. This assessment included whether further analyses and backfitting were needed in relation to each paragraph of the regulations. A cost estimate was made for each measure and summarised for the specific reactor. The licensees were given time until 31 December 2005 to submit more detailed programmes and time schedules for implementation of measures for each reactor based on the consequence assessment. During 2006, SKI has 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 mentioned 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.

Improvement of physical and functional separation

- Separation of operation and safety systems within the 110 and 220 V systems (F1: 2005, F2: 2006)
- 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 (F1–2 & R3–4: 2006, including measures if necessary (F1: 2011 F2: 2012, R3–4: 2009)
- Modernisation of reactor protection system to strengthen the separation of operation and safety systems (O2: 2012)
- Improvement of fire detection and fire extinguishing systems (R3–4: 2009)
- Analysis of dependencies between the hydraulic scram system and the pressure relief system (O1: 2007, O2–3: 2008), 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 new water supply (R2: 2011)

- Functional separation of the residual heat removal systems (F1: 2008, F2: 2009)
- 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 (R2: 2008), including measures if necessary (R2: 2011)
- Separation within component cooling system (R2: 2012)
- Physical separation to reduce the consequences of steam at a pipe break (R2: 2011)

Diversification of safety functions

- Re-construction of V-chain (electrical rod drive shut down) to safety function (F1: 2008, F2: 2009)
- 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 (F1–3: 2006, R2: 2009, R3–4: 2008, O1–3: 2008), 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 (F1–3: 2005) including measures if necessary (F1: 2008, F2: 2009, F3: 2010)
- Installation of diversified measurement of the reactor pressure vessel level (R1: 2008)
- Installation of a new residual heat removal system for diversified core cooling (R1: 2008)
- Installation of an external water supply for emergency core cooling (F3: 2007, O3: 2010)
- Installation of new digital reactor protection system and control room modernisation (R1: 2008, R2: 2009, O2: 2012)
- Analysis of the requirement for diversified reactivity control, core cooling and protection of RCPB (R3–4: 2008)
- Installation of two phase flow relief valves (O2: 2012)
- Installation of new logic for the pressure relief system (O3: 2010)

Accident management measures

- Additional assessment of the containment integrity in case of a severe accident (all reactors: 2007), 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)
- Installation if passive hydrogen recombiners (R2–4: 2008)
- Analysis of the emergency control post (F3: 2009, O3: 2007, R3–4: 2009), including measures if necessary (F3: 2009, O3: 2012, R3–4: 2012)
- Installation of a new emergency control post (F1: 2011, F2: 2012, O2: 2012)
- Improvement of the emergency control post to enable initiation of scram (R1: 2008, R2: 2009)

Withstanding of local dynamic effects from pipe breaks

- Analysis of local loads (F1–3 2010, O1–3 2010, R1–4 2008), including measures if necessary (F1–3 2011, O1 2012, O2 2007–2012, O3 2010, R1 2010, R2–4 2011)
- Request to apply LBB (R1 2008, R2 2007)
- Supports of several containment isolation valves (R2 2011, R3–4 2007)

Withstanding of external events

- Analysis of natural phenomena (R1: 2009, R3–4: 2008), including measures if necessary (O1–2: 2012, O3: 2010, R3–4: 2013)
- Analysis of earthquake (R1: 2011, R2: 2008), including measures if necessary (R1–2: 2013)
- Measures in the I&C system due to earthquake (O2: 2012)
- Reinforcement of the control room ceiling due to earthquake (O1–2: 2012)
- Fire hazards analysis (F1–3: 2007, O3: 2010, R2: 2008), including measures if necessary (R2: 2013)
- Improvement of the fire protection (F1: 2010, F2: 2011, O2: 2012, R2: 2008)
- Analysis of strong wind, including measures if necessary (O2: 2012)
- Measures due to consequences of strong wind (F1: 2009, F2: 2010)
- Reinforcement of the reactor building due to flooding (O2: 2012)
- Update of the PSA of flooding caused by pipe break in the salt water system (R2: 2007), including measures if necessary (R2: 2012)
- Measures due to risk for turbine missiles (O2: 2012)

Operations aids

- Improvement of the back panels in the control room (R1: 2011)
- Detection of, and automatic protective measures against local core instability (F1: 2008, F2: 2009, F3: 2010, O2: 2007, R1: 2009)

Environmental qualification and surveillance

- Update of the environmental qualification (F1–2: 2009, F3: 2010, R1–2: 2009, R3–4: 2008), including measures if necessary (R1: 2009, R3–4: 2009)
- Update of the environmental qualification inside the containment (O1–3: 2007)
- Exchange of I&C and cabling inside the containment (R2: 2009)
- Update of the environmental qualification outside the containment (R3–4: 2007, O1: 2012, O2: 2007, O3: 2010), including measures if necessary (R3–4: 2009, O1: 2012, O3: 2010)

The total cost for the upgrading programme has been estimated at about 5 billion SEK (550 million Euros). The heaviest costs are associated with measures to improve the physical and functional separation, diversification measures and upgrading of 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 uprates are also planned at several reactors (see next section). Altogether, this work as well as normal maintenance activities will entail major challenges for the licensees and their suppliers over the next years. SKI has already noticed that the workload of the operating organisations is heavy and, as a result, time schedule delays happen as well as a certain backlog of documentation work.

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

In addition to the plant modifications listed above, the licensees need to implement a number of measures to comply with SKI's new regulations on physical protection (SKIFS 2005:1) in force from 1 January 2007. These measures are not accounted for in this report.

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

6.3 Uprating programme of the nuclear power reactors

Nine of the power reactors (including Barsebäck 1 and 2) were uprated during the period 1982–1989 between 6–10% from the original licensed thermal power levels. This was possible due to better use of existing margins, better methods of analysis and improved fuel design. Major plant modifications were not necessary. Current plans for uprating include major uprates of seven reactors and a minor uprating of one reactor. In addition to the six applications already submitted to SKI, two applications are expected during 2007. The current power levels and the uprating plans are shown in the table below. The whole programme, including measures on the conventional side, will add 1275 MWe to the current nuclear power production capacity as shown in table 3.

The operating licence, issued by the Government, stipulates the highest allowed thermal power level. The licence only applies up to this power level. To further increase the power level, the licensee has to apply to the Government for a new licence in accordance with the Act (1984:3) on Nuclear Activities.

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 mainly occurs from the fact that the core will contain more reactivity. The inventory of radioactive substances in the fuel will increase. The neutron radiation 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 have an increased capacity. Since the total energy generation from the reactor will increase, the consumption 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 uprate %
	Thermal	Electrical	Thermal	Electrical	Thermal	Electrical	
F 1	2711	900	2928	1014	3253	1134	20.0
F 2	2711	900	2928	1014	3253	1134	20.0
F 3	3020	1100	3300	1190	3775	1360	25.0
O 1	1375	460	1375	487	1375	487	
O 2	1700	580	1800	623	2300	840	35.3
O 3	3020	1100	3300	1197	3900	1450	29.1
R 1	2270	750	2540	880	2540	880	11.9
R 2	2440	785	2660	870	2660	920	9.0
R 3	2783	915	3000	1010	3160	1110	13.5
R 4	2783	915	2783	915	3300	1160	18.6
Total	24813	8440	26357	9240	29516	10465	

Table 3. Power levels of the Swedish operating reactors.

A power uprating case comprises several steps as illustrated in the figure below. To begin with, SKI 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 licencee's application to uprate is granted by the Government, subsequent stages are handled by SKI and SKI is authorized to issue the necessary permits. A permit is also needed according to the Environmental Code (see section 7.1). SKI's detailed process for handling power increase cases is described in the report, "Regulatory Review and Other Supervision of the Thermal Power in Nuclear Reactors"[6].

Step 0	**Step 1**	**Step 2**	**Step 3**	**Step 4**
INFORMATION	PRINCIPAL REVIEW AND DECISION	PSAR PLANT MODIFICATION	SAR TEST OPERATION	SAR ROUTINE OPERATION
Information exchange	Licensee's Preparation of - Principal safety review - Environmental impact statement - Application to Government	Licensee's Preparation of - PSAR - Application to SKI	Licensee's Preparation of - SAR and test operation program - Application to SKI	Analysis of operational experience. "Clean table" SAR amendments Application to SKI
Planning	SKI review SKI statement to Government	SKI review	SKI review	SKI 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

Figure 3. The power uprating process.

6 Regulatory Review and Other Supervision of Thermal Power Uprating of Nuclear Power Reactors. SKI-PM 04:11. Swedish Nuclear Power Inspectorate, November 1, 2004.

The following cases are currently being handled:

In September 2005 FKA applied for a permit to uprate the thermal power level of Forsmark 1 and 2 from 2928 MW to 3253 MW and from 3300 MW to 3775 MW at Forsmark 3. After review of the application and its technical basis, SKI in April 2006 recommended the Government to approve the applications. In September 2006 the Government asked SKI to supplement the earlier recommendation in the light of the event 25 July 2006 at Forsmark 1 (see section 6.1), and the conditions imposed by SKI as a result of the event. In November 2006 SKI informed the Government that the earlier assessment still stands that Forsmark 1, 2 and 3 can be safety uprated and SKI also had the opinion that FKA could correct the deficiencies in the safety management and safety culture manifested in the 25 July event. However, SKI also declared that, in case of a positive governmental decision on the uprates, the authority will not review the submitted PSARs and allow testing operation as long as the Forsmark plant remains under special supervision. FKA plans to apply for testing operation at the higher power levels 2009–2011.

The Government decided in October 2005 that Ringhals AB was allowed to uprate the thermal power level of Ringhals 1 from 2500 MW to 2540 MW. In May 2006 Ringhals AB applied at SKI for testing operation at the higher power level. The application was substantiated with a number of new safety analyses. After review of these, SKI approved start of testing operation in April 2007.

Also in October 2005 the Government decided to allow uprate of Ringhals 3 from 2783 MWth to 3160 MWth. Ringhals AB plans to perform this uprate in two steps. In December 2005, a PSAR for operations at the higher power level and an application for testing operation at 3000 MWth were submitted to SKI. SKI reviewed the PSAR with additional safety analyses and asked for further measures before testing operation could begin. Ringhals AB has thereafter developed a renewed SAR and also reset the reactor control- and protection system for operations at higher power level. After some additional measures and analyses, SKI approved in January 2007 the use of the renewed SAR and testing operation at 3000 MWth. The second step is planned to follow later 2007. Ringhals 4 is planned to apply for testing operation at the higher power level in 2011.

In June 2006, the Government decided that OKG was allowed to uprate Oskarshamn 3 from 3300 MWth to 3900 MWth. OKG plans to submit a PSAR for operations at higher power level to SKI during spring 2007 and to apply for testing operations at 3900 MWth in 2008. Oskarshamn 2 is planned to apply for testing operation at the higher power level in 2011.

Uprating is not done for safety reasons but review of an uprating case is, as mentioned, an important safety issue. In the regulatory review of an uprating case, SKI checks that the licensee complies with all applicable safety requirements. Older issues are followed up and SKI's position is that there shall be a "clean table". An application for uprating is in this sense an opportunity to revisit and verify the whole safety case.

6.4 Conclusion

The Swedish nuclear power plants have been analysed, maintained and improved as a continuous process since the start of the nuclear programme. Events and new insights have been used to make important modifications when needed. Two nuclear power reactors have been shut down for political reasons. Despite political uncertainties about the future use of nuclear power, the Swedish licensees have recently decided to make major safety investments in their plants to make them fit for 40 years of operation and beyond.

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 basic nuclear legislation, the Act on Nuclear Activities, was amended 2006 with regard to use of contractors for nuclear activities. The new provisions limit the number of sub-contractors that can be used for one particular activity.
- SKI has issued new regulations on physical protection (SKIFS 2005:1) and on exemption from the requirement on approval of contractors (SKIFS 2006:1). Older regulations on mechanical equipment in nuclear facilities have been amended (SKIFS 2005:2).
- SSI has issued new regulations on emergency preparedness (SSI FS 2005:2).
- Several reactors have been licensed according to the Environmental Code.
- The WENRA reactor harmonisation main study has been finalised and will lead to minor changes in Swedish regulations.

7.1 Nuclear safety legislation and regulatory framework

The basic nuclear legislation

The following five Acts[7] constitute the basic nuclear legislation of Sweden:

- The Act (1984:3) on Nuclear Activities
- The Radiation Protection Act (1988:220)
- The Environmental Code (1998:808)
- The Act (1992:1537) on the Financing of Future Charges for Spent Nuclear Fuel[8]
- The Nuclear Liability Act (1968:45)

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

Operation of a nuclear facility can only be conducted in accordance with a licence issued under the Act on Nuclear Activities and a licence issued under the Environmental Code. Thus, operation of a nuclear facility requires two separate licences.

The Act on Nuclear Activities is mainly concerned with issues of safety and security, while the Environmental Code is focusing on the general environmental aspects and impacts of "environmentally hazardous activities", as to which Nuclear Activities are defined.

The Act on Radiation Protection aims to protect people, animals and the environment from the harmful effects of radiation. The Act is of particular importance as regards protection of employees involved in radiological operations.

7 All Swedish Acts and Ordinances are published in the Swedish Statute-book, indicated as "SFS", and given a individual number within brackets.
8 Replaced 1 January 2008 by the Act (2006:647) on Financing of Management of Residual Products from Nuclear Activities.

The Act on the Financing of Future Charges for Spent Nuclear Fuel contain 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 (2000:1064) and the Act (2000:140) on Inspections according to International Agreements on Non-proliferation of Nuclear weapons. Emergency preparedness matters are regulated by a separate Act (2003:778) and Ordinance (2003:789) on protection against accidents with serious potential consequences for human health and the environment.

In December 1997, the Parliament adopted the Act (1997:1320) on the Phasing-Out of Nuclear Power, which entered into force on 1 January 1998. This Act formed part of the 1995 inter-party agreement on guidelines for energy policy in order to create conditions for the efficient use of energy and for a cost-effective supply of energy, thereby facilitating the creation of an "ecologically sustainable society". Based upon provisions in this Act, the Government decided upon the shut-down of the two boiling water reactors in Barsebäck in 1999 and 2005 respectively.

A more extensive overview on the legal system is given in the first national report. In the following, focus will be given to some of the recent amendments in the core legislation as well as to certain questions related to the dual-licence system.

The Act on Nuclear activities

The Act on Nuclear Activities applies to all nuclear activities. Nuclear activities are defined as:
- the construction, possession and operation of a nuclear installation,
- acquisition, possession, transfer, handling, processing, transport or other dealings with nuclear substances and nuclear waste,
- import of nuclear substances and nuclear waste,
- export of nuclear waste.

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

The Act also contains a wide set of means for efficient supervision by the regulatory authority. Among these are administrative and criminal sanctions for non-compliance (see further section 7.5).
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 SKI with reference to the Act can be appealed to the Government. However, if urgent measures are required according to the decision, they have to be taken while the appeal is handled by the Government.

Licences for Operation of Nuclear Installations

With a few exceptions, licences for nuclear installations are decided upon and issued by the Government upon a written recommendation prepared by SKI. An application for a permit to construct, possess or operate a nuclear installation shall – along with the particular documents concerning construction and nuclear safety – contain an Environmental Impact Assessment (EIA).

Procedures regarding the EIA are laid down in the Environmental Code. These provisions are also applicable in the licensing procedures according to the Act on Nuclear Activities. The EIA aims to facilitate an

overall assessment of the planned operation's effects on the environment, health and management of natural resources, thus providing a better basis for the decision.
SKI is given the mandate to decide upon licence conditions for nuclear safety. Previously this mandate was given by the Government in every particular licence, but according to a legal amendment on 1 July 2006, SKI now has a continuous and general mandate to decide such conditions for all sorts of licences issued under the Act on Nuclear Activities.

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

New rules on the use of Contractors in Nuclear Operations

On 1 July 2006, more strict requirements on the use of contractors in nuclear activities entered into force in the Swedish nuclear legislation. Since many years there has been a legal requirement that all contractors the licence holders want to use in the operation, need to be approved – upon application – by SKI. The new provisions limit the number of sub-contractors that can be used for one particular activity. According to the amended wording of the Nuclear Activities Act (1984:3) § 5, there can be at most two contractors involved in a specific task. This means that it is no longer possible to run a system where one general entrepreneur keeps several subcontractors.

It is important to stress that the strict provisions regarding approval of contractors only applies to contracts that according to the Swedish nuclear legislation is classified as Nuclear Activities. This means that a range of contracts, although of vital importance for the operators, are not subject to the requirements and the approval procedure. For instance, manufacturing of components that are to be installed in a nuclear power plant is not considered nuclear activities – however, installation is.

In a simultaneous amendment of the Ordinance (1984:14) on Nuclear Activities, SKI was authorized to issue regulations on certain exemptions from the requirement that all contractors need to be approved before engaging in a contract involving nuclear activities. If only one contractor is to be used for a specific activity, the application-approval process can be replaced by a notification to SKI. In December 2006, SKI issued such regulations[9]. According to these regulations 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 have been conducted. As mentioned, the exemption is only due in cases where the number of contractors is limited to one (1).

The following illustration gives an overview of the new requirements:

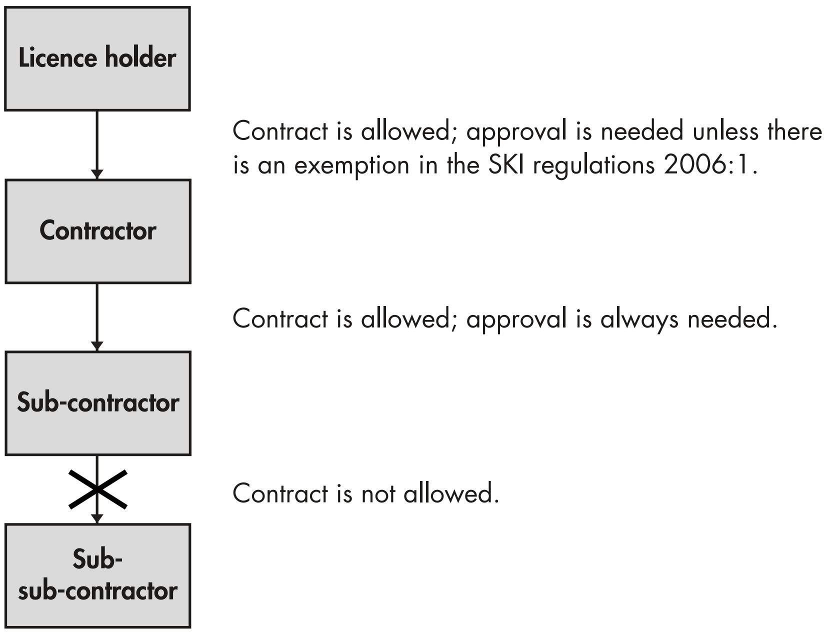

Figure 4. Legal requirements on use of contractors.

9 The Swedish Nuclear Power Inspectorate's Regulations (SKIFS 2006:1) on exemption from the requirement on approval of contractors.

The Act on Nuclear Activities and the Environmental Code

In 1998 the Act on Nuclear Activities was amended to incorporate references to the Environmental Code. The amendments entered into force on 1 January 1999. Since then, the General Rules of Consideration and the requirements on Environmental Quality Standards (fundamental principals according to the Environmental Code) shall apply also when considering matters under the Act on Nuclear Activities. Simultaneously, the previously mentioned requirement on the submitting of an EIA, was also coming to effect.

The General Rules of Consideration, as laid down in the Environmental Code, indicates that operations must be conducted and measures taken so that harm to human health and to the environment is avoided. The General Rules of Consideration comprise the following fundamental principles:

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

The Environmental Quality Standards (EQS) specify the levels of pollution or disturbance as concerns land, water, air or the environment in general, that humans may be exposed to without any significant risk. Permits, approvals or exemptions may not be issued for a new operation that would contradict an Environmental Quality Norm, unless precautionary measures to alleviate the negative effects are taken. So far, no EQS has been decided with regard to radiation.

The Environmental Code is a framework law, which means that its rules do not generally specify limit values for various operations and the Code does not go into detail when it comes to striking a balance between various interests. Many operations that fall within the scope of the Code are also subject to other acts, which apply in parallel with the Code. As for Nuclear Operations, such acts are of course the Act on Nuclear Activities and the Radiation Protection Act.

Since the entry into force of the Environmental Code it is no longer sufficient to obtain a permit solely under the nuclear legislation, a permit according to the Code is required as well. All operations and measures, which may be detrimental to human health or to the environment are now covered by the Code and must therefore pursue its objectives. Nuclear activities must comply with the common rules of consideration laid down in Chapter 2 of the Code. Licences according to the Code are tried by a special Court of law, namely the Environmental Court.

Procedures according to the Act on Nuclear Activities

An application for nuclear activities is handed in to the Swedish Nuclear Power Inspectorate, SKI.
SKI is required to assess whether the following provisions in the Nuclear Activities Act and the Environmental Code have been satisfactorily complied with:

- the safety regulations according to the Act on Nuclear Activities,
- the general rules of consideration in Chapter 2 of the Code and the measures proposed by the applicant to avoid any environmental hazards,
- possible environmental quality standards in Chapter 5 of the Code,
- the Environmental Impact Assessment (EIA) and Statement (EIS), i.e. its contents as well as the extent of the consultations with concerned parties.

SKI will, as part of its preparation of the matter, obtain the necessary opinions and statements from concerned parties, such as the Swedish Radiation Protection Authority (SSI) and local authorities. Other parties affected by the operation will also be given the opportunity to express their opinions at local hearings organised by SKI and SSI jointly.

Before handing over the matter to the Government for decision, SKI includes in its expert opinion any special conditions that it deems necessary to be part of a future permit, such as precautionary measures to minimize the hazards involved. Also such conditions concerning radiation protection considered by SSI will be included.

Procedures according to the Environmental Code

An application including EIA/EIS, similar to those submitted to SKI, 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 satisfactorily complied with and thereby all kinds of emissions and disturbances, i.e. also those caused by radioactive substances and ionizing radiation.

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

The Government's consideration of permissibility

Since normally the Environmental Court refer the question of permissibility to the Government, the Government has a fundamental role in both procedures. Naturally the Government takes the expert opinions, submitted by SKI, SSI and the Environmental Court, under consideration before making its decision. Once the applications have been referred to the Government, they soon go separate ways again. After the Government has decided on permissibility, the case according to the Environmental Code is returned to the Environmental Court for final handling, i.e. the question of different conditions. In the case according the Act on Nuclear Activities, the Government itself takes the final decision, normally referring the questions on different conditions regarding nuclear safety to SKI.

Considerations made by other parties concerned

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

The two-track licensing procedure

To a certain extent the two-track licensing procedure means that the same issues are tried twice, by two different authorities. Although this has been foreseen and desired by the legislator, it is of great importance that a reasonable balance can be upheld between the scopes and focuses of the two systems. For instance, there is a theoretical possibility, and would be unfortunate from the legal and safety point of view if the licensing conditions are contradictory. As mentioned in the third national report, it has been proposed by SKI to the Government to change the Environmental Code in such a way that licensing conditions, regulations or orders issued according to the Act on Nuclear Activities or Radiation Protection Act, shall apply also in relation to the Environmental Code. This is, however, not the opinion of the Environmental Courts. The Environmental Court of Appeal declared in a verdict in December 2006, on an appeal by Ringhals AB, that the courts could and should pose own safety requirements and not only refer to SKI. For instance, it is important for the courts to clarify how far the requirement on BAT (Best Available Technology) can be driven. Furthermore, when safety issues are decided by the courts, also stakeholders such as neighbors and environmental groups have the right to appeal. This is not the case with the nuclear legislation. The Government has not announced any action to change the Environmental Code in line with the SKI proposal.

The Environmental Code replaced several different Environmental Acts at its entry into force on the first of January 1999. According to the transitional regulations, licences that had been granted according to the previous legislation would still be valid according to the Code. The previous relevant environmental legislation – namely the Environmental Protection Act (1969:387) – had been in force since 1969, but explicitly didn't cover activities with radiation. Due to this exemption, most of the nuclear power reactors in Sweden had not obtained a licence according to the Environmental Protection Act.

The three Nuclear Power Reactors at Forsmark did have a licence according to the previous Act. Although not required in order to maintain operation at the present power level, Forsmark has decided to apply for a new licence according to the Environmental Code. The reason for this is Forsmarks intention to uprate. Oskarshamn reactor 3 also had a valid licence according to the previous legislation. In order to uprate, a new licence was required according to the Code. Such permit was obtained from the Environmental Court in August 2006.
The Environmental Courts have decided upon licences for Ringhals 1–4 and Oskarshamn 1–3. The Case of Forsmark is still pending.

In the case of Ringhals, the Environmental Court at the Municipal Court of Vänersborg in its decision 22 March 2006, decided upon certain licensing conditions. One of these was that Ringhals AB within five years shall investigate the technical and economical possibilities to, while exercising the principle of BAT (Best Available Technology), obtain safety levels equivalent to a new power plant. Ringhals AB appealed this decision, but the appeal was rejected by the Environmental Court of Appeal.

In the Case of Oskarshamn, the Environmental Court at the Municipal Court of Växjö in its decision 16 August 2006, decided upon other licensing conditions. One of these was that the reactors O1 and O2 within five years shall install and make use of a "deep water intake"….for cooling water. Another condition was that the company, in order to enhance the physical protection, shall erect a fence across large parts of the peninsula of Simpevarp. OKG appealed parts of the conditions and on the 27 April 2007 the Environmental Court of Appeal rejected the condition regarding the fence, arguing that the SKI regulations on physical protection (SKIFS 2005:1) sufficiently covered all aspects of physical protection. The Court of Appeal stressed, in this matter, that such a fence advocated by the first instance in practice would be meaningless.

7.2 National safety regulations

SKI safety regulations

With reference to its legal mandate, SKI has to date issued seven legally binding safety regulations for nuclear facilities in the SKIFS series. In addition, general recommendations have been issued on the interpretation of most of the regulations. The general recommendations are not legally binding per se, but they can not be ignored by the licensee without risking a sanction by the regulatory body. Measures should be taken according to the recommendations or other measures which are justified to be equal from the safety point of view.

Generally in preparing SKI's regulations, regulations of other Swedish authorities are considered, as well as current IAEA safety standards and applicable industrial standards and norms. SKI regulations also take into account relevant EU legislation and other international obligations. SKI regulations are issued according to an established management procedure stipulating several technical and legal reviews of the draft, and in accordance with governmental rules, review of the final draft by a large number of stakeholders, including other authorities, the licensees, industrial- and environmental organisations.

Regulations concerning the competence of operations personnel at reactor facilities (SKIFS 2000:1)

These regulations, in force since 2001, include requirements on competence analysis, competence assessment, authorisation by the licensee, recruitment and training for a position, and retraining of operations personnel belonging to the categories operations management, control room personnel and field operator. If an individual satisfies all requirements regarding competence and suitability, the licensee may issue an authorisation 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 also contain requirements on simulators used for operational training. Attached to the regulations are general recommendations for their application.

Regulations on safety at final storage of nuclear materials and nuclear waste (SKIFS 2002:1)

These regulations, in force since 2002, contain specific requirements on design, construction, safety analysis and safety report for final repositories, in view of the period after closure of the facility. For the period before closure, the general safety regulations SKIFS 2004:1 apply.

Regulations concerning safety in nuclear facilities (SKIFS 2004:1)

These regulations, in force since 1 January 2005, are an updated version of the first general safety regulations, SKIFS 1998:1, issued by SKI. SKIFS 2004:1 is written for nuclear power reactors but is applicable in a graded way on all licensed nuclear facilities, no matter size or type of facility. The regulations aim at specifying measures needed for preventing and mitigating radiological accidents, preventing illegal handling of nuclear material and nuclear waste and for conducting an efficient supervision:

- Application of multiple barriers and defence-in-depth
- Handling of detected deficiencies in barriers and the defence-in-depth
- Organisation, management and control of safety significant activities
- Actions and resources for maintaining and development of safety
- Physical protection and emergency preparedness

- Basic design principles
- Assessment, review and reporting of safety
- Operations of the facility
- On-site management of nuclear materials and waste
- Reporting to SKI of deficiencies, incidents and accidents
- Documentation and archiving of safety documentation
- Final closure and decommissioning

General recommendations on the interpretation of the requirements are issued for most of the requirements.

Regulations on design and construction of nuclear power reactors (SKIFS 2004:2)

These regulations, in force since 1 January 2005, contain more specific requirements for nuclear power reactors on design principles for the defence in-depth, withstanding of failures and other internal and external events, withstanding of environmental conditions, requirements on main- and emergency control room, safety classification, event classification, requirements on the design and operation of the reactor core.

Transitional rules to the regulations stipulate that measures to comply with certain paragraphs shall be implemented at the latest at time points decided by SKI. The reason for this is that the licensees must be given time to investigate in depth, specify, procure, install, test and safety review those backfitting measures needed to comply with the regulations. The licensees were initially given time until 31 December 2005 to develop the initial reactor specific plans. SKI has now reviewed and decided on these plans (see section 6.2).

Regulations on physical protection of nuclear facilities (SKIFS 2005:1)

These non-classified regulations, in force from 1 January 2007, contain requirements on 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 secret attachment to the SAR of the facility. These regulations replace older requirements from 1975.

Regulations concerning mechanical components in certain nuclear facilities (SKIFS 2005:2)

These regulations, in force since 1 January 2006 (some parts 1 July 2006), are an update of older regulations on mechanical components in nuclear installations (SKIFS 1994:1 and 2000:2). They contain requirements for use of mechanical equipment, limits and conditions, damage control, accreditation of control organisations and laboratories, requirements on in-service inspection and control, requirements in connection with repair, exchange and modification of structures and components, requirements on compliance control and annual reporting to SKI. Over the different versions of the regulations, more precise requirements have been introduced for design specifications and assessments of such specifications when plants are to be modified. More stringent requirements have also been introduced for assessing the safety impact of continued operation with components that are degraded to a certain level. Also more focus has been given in the guidance on important aspects to be considered when applying different qualitative and quantitative risk oriented approaches (see further section 14.1).

Regulations on exemption from the requirement on approval of contractors (SKIFS 2006:1)

These regulations, in force from 1 February 2007, are a result of a recent change in the Act on Nuclear Activities regarding the use of contractors (see section 7.1). The basic provision is that a licensee can not without a permit by the Government or the regulatory body contract out an activity that is included in the licence. Now, a possibility has opened to exempt certain activities from the permit requirement. If the activity is suitable and the licensee controls and follows up on the contractor's work, the permit can be replaced by a notification to the regulatory body. SKI has been authorized by the Government to specify the prerequisites for these exemptions.

The regulations contain a list of activities that can be contracted out without a permit. This list includes building and construction work, decommissioning work, maintenance and inspection work, training, qualified expert tasks that can not reasonably be done with own staff and archiving of safety documentation. It is pointed out that the exempted activities shall only be parts of what has to be done under the licence and not all or major parts. Furthermore, exempted activities can not include security measures and activities for storage and disposal of nuclear material or waste.

In addition, the regulations specify that exempted activities must be conducted under management and control by the licensee. In cases where SKI after a notification finds that a contract includes activities of principal importance, SKI can decide that the contract can not be awarded without a permit by the Government or SKI.

SKI has also issued separate general recommendations (SKIFS 2006:2), in force from 1 February 2007, on interpretations of 5 § the Act on Nuclear Activities regarding the use of contractors. Contractors are defined as every physical or legal person to whom the licensee hands over an activity. This means that other companies belonging to the same corporation are regarded as contractors as well as staff renting companies. If a contract is approved and a permit issued, the contractor has the right to take all measures defined by the contract and included in the nuclear licence. SKI can decide on safety conditions for the contract. It is further clear that a contractor for a licensee can not without a new permit use a subcontractor (third person) for certain activities within the contract. In no case is it allowed for a subcontractor to use a sub-subcontractor (fourth person).

SSI regulations on radiation protection

SSI regulations comply with the radiation protection legislation of the European Community and agree with recommendations of the IAEA and ICRP. At the end of 2006 the SSI FS series contained 44 regulations (some with guidelines), six separate general guidelines and four regulations with changes in existing regulations covering all areas of radiation protection. Eleven of these, listed below, are directly applicable to occupational exposure issues, emergency preparedness and control of releases of radioactive substances from nuclear facilities[10].

Regulations on Emergency Preparedness at Certain Nuclear Facilities (SSI FS 2005:2)

These regulations entered in to force 2006. They apply to the planning of emergency preparedness and radiation protection measures in case of an emergency or a threat of an emergency in nuclear facilities of threat category I, II or III according to the IAEA Safety Requirements GS-R-2: Preparedness and Response for a Nuclear or Radiological Emergency Safety Requirements.

Regulations on Planning Before and During Decommissioning of Nuclear Facilities (SSI FS 2002:4)

These regulations entered into force in 2004. They contain provisions concerning the planning of decommissioning of nuclear facilities in matters of importance from a radiation protection point of view. Requirements are put on decommissioning planning and other administrative measures such as documentation before and during decommissioning and reporting to SSI at different stages of a facility's life cycle.

Regulations on Protection of Human Health and the Environment from Discharges of Radioactive Substances from certain Nuclear Facilities (SSI FS 2000:12)

These regulations are applicable to all releases of radioactive substances from nuclear facilities that are directly related to the normal operation at each facility. The effective dose to an individual in the critical group of 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).

Regulations on Radiation Protection Manager at Nuclear Plants (SSI FS 2000:11)

According to these regulations a license holder shall appoint a radiation protection manager at the facility in order to implement and look after radiation protection conditions issued by the authorities.

Regulations on Radiation Protection of Workers Exposed to Ionising Radiation at Nuclear Facilities (SSI FS 2000:10)

These regulations apply to the radiation protection of workers at nuclear facilities and regulate several different areas as optimisation, education, demands on local procedures, controlled areas, personal radiation surveillance, procedures connected to fuel elements, reporting and documentation.

Regulations on Medical Examinations for Radiological Activities (SSI FS 1998:6)

These regulations are general and apply to all kind of radiological workers of category A with ionising radiation.

10 SSI regulations concerning high, medium and low level radioactive waste management are addressed in Sweden's National Reports under the Joint Convention on the safety of spent fuel management and on the safety of radioactive waste management.

Regulations on Monitoring and Reporting of Individual Radiation Doses (SSI FS 1998:5)
These regulations apply to measurements of individual radiation doses to workers of category A working with ionising radiation and reporting of doses received to the National Dose Database. Some procedural changes for accreditation of laboratories for individual dose monitoring were introduced in the regulations SSI FS 2003:2 (Amendments to the Regulations (SSI FS 1998:5)).

Regulations on Dose Limits at Work with Ionising Radiation (SSI FS 1998:4)
These regulations apply to the limitation of radiation doses to workers and the general public resulting from applications using ionising radiation. The regulations also apply to the protection of pregnant women who otherwise might be exposed to ionising radiation by their work.

Regulations on Categorisation of Workplaces and Workers at Work with Ionising Radiation (SSI FS 1998:3)
These regulations apply to applications using ionising radiation where humans may receive radiation doses.

Regulations on Filing at Nuclear Plants (SSI FS 1997:1)
These regulations apply to the filing of documentation that is drawn up or received in connection with the operation of nuclear plants. If the practice ceases, the archives shall be transferred to the National Archive of Sweden.

Regulations on Outside Workers at Work with Ionising Radiation (SSI FS 1996:3)
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.

Amendments under way

Both SKI and SSI have internal procedures to regularly review and assess the adequacy of the issued regulations. This assessment is done against regulatory experiences and the international development of safety standards and legal instruments such as the EU-legislation.

SKI plans to issue during 2007 an amendment to chapter 4, 2 § SKIFS 2004:1 with regard to the contents and structure of the safety report. The amendment clarifies the safety documentation to be submitted in connection with major plant modifications and includes extended general recommendations on the structure and contents of the SAR.

SSI plans to issue amendments to the Regulations on Outside Workers at Work with Ionising Radiation (SSI FS 1996:3) during 2007. Furthermore, work is under way in order to update and merge the regulations on Radiation Protection of Workers Exposed to Ionising Radiation at Nuclear Facilities (SSI FS 2000:10) and Radiation Protection Manager at Nuclear Plants (SSI FS 2000:11) into one regulation with the introduction of a new section with organisational requirements.

7.3 The WENRA reactor harmonisation project

SKI has taken a very active part in WENRA's reactor harmonisation project since its start with a pilot study year 2000. In this work the national requirements and implementation on the nuclear power plants have been systematically assessed against jointly agreed reference levels, mainly based on the most recent IAEA safety standards. In the main study starting 2003, 291 reference levels were defined for 18 major safety issues within 5 safety areas. Self-assessments were made about the compliance with the reference levels on the legal side and the implementations side. These assessments were documented in a standardised format and challenged by a panel of other countries. All 16 EU countries with nuclear power programmes and Switzerland have participated in the project. The main study report was published on the WENRA homepage (www.wenra.org) in January 2006[11]. After that, consultations on the reference levels have been conducted with stakeholders and a number of reference levels have been slightly modified for clarity. The current list of reference levels dated January 2007 is also published on the WENRA homepage.

11 Harmonisation of Reactor Safety in WENRA Countries. Report by the WENRA Reactor Harmonisation Group. January, 2006.

As a result of the benchmarking, WENRA members agreed to develop and make public national action plans on measures needed to amend the national legislation to include the reference levels and to implement the levels on the nuclear power plants. It was agreed to align the legal systems with the reference levels by 2010.

For Sweden no major gaps were identified between the reference levels and national regulations, due to the work over the last 10 years to develop modern regulations in the SKIFS series (see previous section). Measures already taken or planned by the licensees to implement these regulations also cover the implementation of most of the reference levels.

However, the SKI's regulations need to be amended with some details of the reference levels. This will mostly be done in the general recommendations to the regulations. On a few points the legally binding parts will be supplemented. On the implementation side further investigations need to be done by SKI and the licensees on a few points before adequate measures can be defined. This has mainly to do with the scope of the deterministic and probabilistic safety analysis.

Regarding protection against internal fires, SKI's regulations require passive means, i.e. physical separation so that redundant parts of safety systems can not at the same time be disabled by a fire. SKI has no specific requirements on active means such as detectors, alarm and sprinkler systems. This has earlier been required by other authorities. As a result of WENRA's harmonisation study, SKI will investigate whether regulations issued by other authorities on fire protection systems are sufficient, or if SKI will have to issue such regulations specifically for nuclear facilities.

SKI sees the action plan as a living document that can be changed during the work process. The plan itself has no legal or formal status. The identified measures are fed into SKI's ordinary processes to revise regulations and to supervise plant safety and will undergo the same treatment as measures identified in other ways. The plan will also not prevent that further measures will be taken if needed. Nevertheless, SKI regards the WENRA reactor harmonisation project as a very useful exercise that has brought back a lot of new insights and has established a valuable network of experts from the European nuclear safety authorities.

7.4 Licensing system

The Act on Nuclear Activities (1984:3) includes the basic legal requirements on licensing, and the legal sanctions to be imposed on anyone who conducts nuclear activities without a licence. For major installations and activities, the licence is granted by the Government on the recommendation by the regulatory bodies. For all the existing Swedish nuclear power plants, the licences are valid without time limit, although licensing conditions can be limited in time and function as control stations. If the licensee complies with all legally binding safety requirements, a prolongation of the licence cannot be denied in principle. A licence can be permanently revoked if licence conditions are not complied with, or for other serious safety reasons. Revoking a licence for other reasons than safety, as in the Barsebäck 1 and 2 cases, requires a special law. As mentioned in section 14.1, there is a legally binding requirement to conduct a periodic safety review of every reactor unit every 10 years of operation. One purpose with this review and its regulatory assessment is to determine whether the units still comply with all regulations and licensing conditions, and that safety is developing as required. SKI regards the periodic safety reviews as time limited licensing conditions.

Hence, the concept of "Life time extension" has no formal meaning in Sweden. The expression "40 years technical life time" is used in a non-formal way, mostly by the licensees in their long term planning. The plants will be made fit for 40 years operation and beyond. The background of this expression is that on-going and planned modernisations are assumed to increase the technical lifetime of the plants. Originally, when designing the plants, 40 years was an assumed technical lifetime, "guaranteed" with large margins for the major passive structures and components. Today, based on international operational experience, technical lifetime for similar rector designs is expected to be 50 to 60 years. The investment analyses for the planned modernisations are also based on lifetimes of 50 or 60 years, although investments will be profitable even with lifetimes of 40 years.

The first Swedish reactor Oskarshamn 1 has been in operation for 40 years 2012, although with several years of shut down due to reconstruction. SKI has todate not made any plans how to assess a reactor for operation beyond 40 years. It can be expected that the PSR instrument (see chapter 14) will be used with reinforced emphasis on analyses of maintenance, material, inspection and testing issues with special consideration of degradation due to ageing.

7.5 Regulatory inspection and assessment

See section 8.3.

7.6 Enforcement

SKI and SSI have extensive legal powers to enforce their decisions. According to 17 § the Act on Nuclear Activities, a licensee has to provide SKI with all information, documentation and access to facilities that are needed for the regulatory supervision. According to 18 § the Act on Nuclear Activities, SKI is authorized to decide on measures that are needed and issue those orders and prohibitions that are needed in individual cases in order to enforce the Act or regulations, licensing conditions or decisions issued according to the Act. If a licensee fails to take the required action, SKI is authorized to take action on the licensee's expense. According to 22 § the Act on Nuclear Activities SKI can also decide on fines in cases of non-compliance with licensing conditions or regulations. According to 22 § the Act on Nuclear Activities, it is also a criminal offence to violate the Act as well as conditions or regulations issued according to the Act. This means that SKI also has to hand over suspected cases of criminal violations to a public prosecutor. This has been done in a few cases where it was evident, in the opinion of SKI, that the licensee had violated a legally binding requirement. Normally, however, SKI uses a scale of administrative sanctions in cases the licensees deviate from SKIFS. The different steps are:

- issuing of a remark to be corrected by the licensee,
- ordering of an action plan to be developed and actions taken within a certain time period,
- ordering of specified actions to be taken within a certain time period and results submitted to SKI for review and approval,
- ordering of stop of operations until the deficiencies are corrected, and measures reviewed and approved by SKI.

The SKI management system provides guidance on type of sanction to use in a specific case. The legal service is also always consulted.

If SSI discovers non-compliance with rules or regulations at a license holder, SSI can use injunctions or prohibitions with or without a penalty in the form of a fine as means to enforce compliance. SSI has established, in a special policy document, the procedure for selecting enforcement tools and appropriate means for communication to concerned parties and the public in connection with enforcement activities.

7.7 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 organization concerned with the promotion or utilization of nuclear energy.*

Summary of developments since the last national report

- The organisations of SKI and SSI were slightly modified 2006.
- The Government announced in April 2007 that they intend to merge SKI and SSI by 1 April 2008. A new integrated regulatory body will be established at that date.
- The staffs of SKI and SSI for nuclear supervision have slightly increased.
- SKI has worked to make inspection practices more systematic.
- SSI has reviewed its inspection policy.
- SKI has started internal audits of the management system.
- SKI will improve regulatory practices as a result of the Forsmark event.
- SKI estimates that 24 additional employees will be needed in the long term and additionally 7 during the period up to 2013 in order to reinforce the supervision of the nuclear power plants and to cope with the expected work load during the next years. The Government has so far announced that they intend to reinforce the supervision of the nuclear power plants.

8.1 Regulatory bodies and their mandates

General

There are two nuclear regulatory bodies in Sweden; the Swedish Nuclear Power Inspectorate (SKI) and the Radiation Protection Authority (SSI). The missions and tasks of the two authorities are defined in Ordinances with instructions for the respective authority, and the annual government letter of appropriation which contains more detailed objectives and reporting obligations. In addition to SKI and SSI there are also a few other administrative authorities with responsibility to supervise specific activities of the NPPs, such as the Rescue Services Agency, the Swedish Work Environment Authority and the Electrical Inspectorate.

SKI and SSI are central administrative authorities 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 can not 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.

SKI and SSI are each headed by a director general appointed by the Government, normally for a period of six years. The period can be extended. Both authorities are "supervised" by boards chaired by the respective director general. The SKI Board consists of nine persons, among those are members of Parliament, senior officials from other "safety agencies" and independent experts. The Director General of SSI is also a member of the SKI Board and vice versa. The board members are appointed by the Government for a specified time period on proposal by the Director General. The tasks of the Boards are mainly to advise the Director General, but on a few issues such as to recommend the fees to the Nuclear Waste Fund, to decide on issuing of regulations, to decide on the annual activity report, the Board makes the decisions.

Requirements are very high on SKI and SSI on openness and provision of information services to politicians, media and the public. Official documents in Sweden are public unless a decision is made to classify them according to the Secrecy Act. Reasons for secrecy could be national security, international relations, commercial relations of a company or privacy of individuals. Nobody needs to justify a wish to see a public document or to reveal his identity to get access to the document. Since 11 September 2001, more safety systems documentation related to the nuclear power plants has been classified and SKI has established more stringent security practices.

As other authorities, SKI and SSI are required to issue annual activity reports to the Government summarizing major results, effects and costs of their activities. In addition, SKI and SSI are required to submit an annual report to the Government on the safety and radiation protection at the Swedish nuclear power plants. The SKI parts of this report summarize major findings and conclusions from operational experience, regulatory inspections and reviews with regard to the technical safety status as well as organisation, safety culture, physical protection and safeguards. SSI parts of the report account for the radiation protection activities of the nuclear power plants, the occupational doses and the environmental impact. Both regulatory bodies contribute to reports on waste management and emergency preparedness.

Furthermore, SKI and SSI issue periodical reports to inform stakeholders. Some examples from SKI are

- Kärnsäkert, a tertail news letter to inform about major events and activities related to the nuclear programme,
- NUCLEUS, a periodic publication reporting on research projects and long term safety issues,
- The SKI Report series, where R&D reports and more important regulatory assessments are published.

All reports issued by SKI and SSI can be ordered by the media and the public. Most are available for download on the respective websites. The websites are also used extensively to inform about current events and decisions within the respective area of responsibility.

Both SKI and SSI maintain a decision maker on duty round the clock to respond to incidents and other urgent matters. In cases of more severe events both authorities have emergency staff that will be mobilised on notification.

The Government has recently announced its intention to merge SKI and SSI by 1 April 2008 (see section 8.6 below).

The Swedish Nuclear Power Inspectorate (SKI)

The SKI missions and tasks are defined in the Ordinance (2006:520) with instruction for the Nuclear Power Inspectorate and in the annual letters of appropriation where the Government issues directives for the authorities including the use of appropriations. The Ordinance states that SKI is the central administrative authority for nuclear safety including physical protection, final disposal of nuclear material and nuclear waste, nuclear non-proliferation and decommissioning of nuclear facilities. SKI shall deal with any civil service matter within its area of responsibility, issue regulations, regulate the nuclear activities and supervise and exercise control over final repositories. SKI shall also handle certain financial issues with regard to nuclear waste and provide technical advice to authorities responsible for protection of the public in cases of a nuclear accident within or outside the country. In addition, the following more detailed tasks are mentioned:

1. follow the development within the nuclear energy area,
2. take the initiative to research that is needed for the nuclear supervision and for promoting national competence,
3. actively contribute to information of the public about national nuclear safety and waste safety work,
4. handle tasks following from Sweden's international obligations within SKI's areas of responsibility,
5. take part in international cooperation aiming at development of nuclear safety, transport safety, spent fuel and nuclear waste safety and decommissioning,
6. assist the Government with investigations, statements and expert knowledge when needed.

The SKI missions are conducted within four main sectors: reactor- and nuclear materials safety, nuclear non-proliferation, nuclear waste safety and, since 2007, nuclear waste economy. In addition SKI is involved in international development co-operation within the areas of reactor safety, nuclear waste safety and non-proliferation. The development cooperation is administered through a separate unit, the International Cooperation Programme, reporting directly to the Director General.

Within reactor and nuclear materials safety, SKI has the following tasks as specified in the 2007 letter of appropriation:
1. Maintain effective safety requirements
2. Supervise licensee's responsibility for safety

3. Push safety work forward nationally and internationally when motivated by experience, research and technical development
4. Develop and maintain national competence with regard to nuclear safety
5. Maintain preparedness for advising other authorities in cases of nuclear emergencies
6. Maintain an active information, reporting and transparency towards the public

Achievements in all these tasks have to be assessed and reported back to the Government annually.

For consultations before more complicated decisions are taken, SKI has three permanent advisory committees: one for reactor safety matters, one for nuclear fuel cycle matters and one for research and development matters. Each committee consist of a chair and six other members. The chairs are appointed by the Government and other members by the SKI Board for a limited time period.

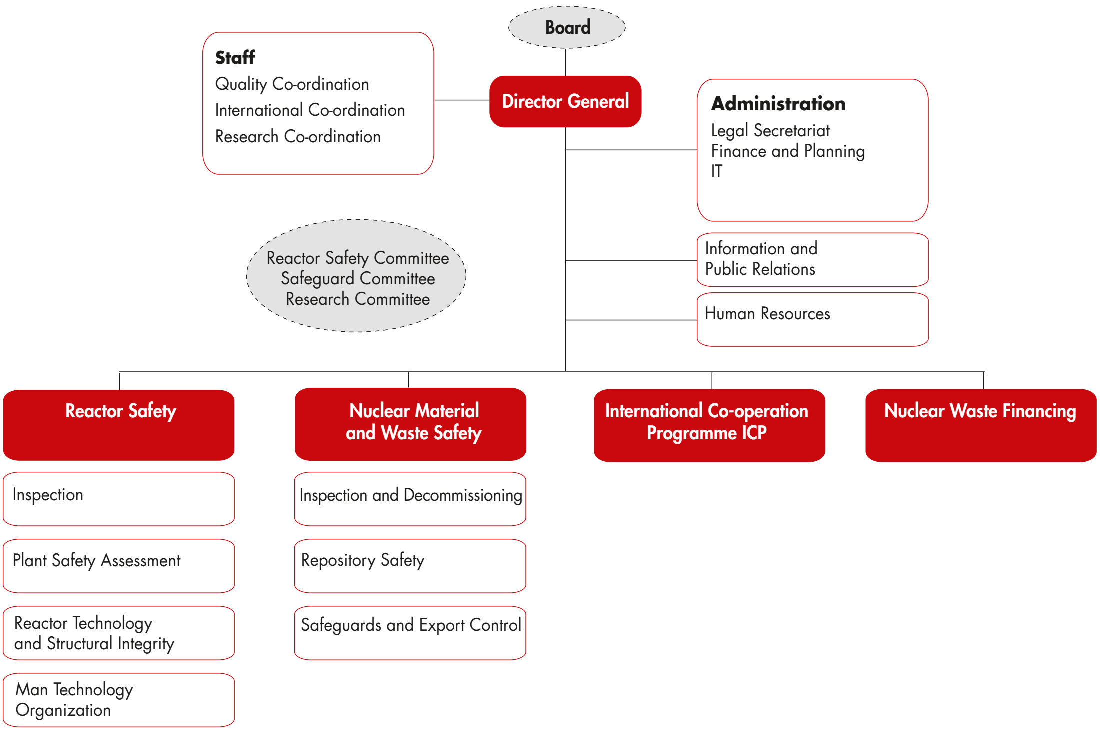

Figure 5. The SKI organisation.

The organisation was changed 1 January 2006. The earlier departments for nuclear waste safety and nuclear non-proliferation were merged. The new department is divided in three sections and a management group has been created. An administrative department was also created with a total responsibility for coordination of planning and follow up of all activities including the SKI research. This department is divided in two sections and a legal secretariat. A staff unit was also created for the Director General consisting of three coordinators one for the management system, one for international relations and one for research strategy issues. The organisation for supervision of the nuclear power plants is not directly affected by this change. The main reason for the change was to create better opportunities for meeting the upcoming regulatory challenges regarding the nuclear waste programme, decommissioning and safeguards.

From May 2007 a new section is established directly under the Director General dealing with financial issues related to decommissioning and handling of spent fuel and nuclear waste.

The Swedish Radiation Protection Authority (SSI)

SSI's mission is to promote effective radiation protection for people and the environment. For this purpose, SSI issues regulations and provides information, education, issuing advice and recommendations, and funding and evaluating research.

In the letter of appropriation for SSI three activity goals are listed under the main objective: Nuclear Energy Supervision and Emergency Preparedness:

1. National emergency preparedness. It is pointed out that the Swedish national emergency preparedness of high class shall be maintained, developed and co-ordinated with Sweden's international responsibilities. SSI shall also co-ordinate the national competence regarding measurement techniques relevant for emergency preparedness issues.

2. Safe handling of radioactive waste, as well as limitation of emission of radioactive nuclides. Spent nuclear fuel and radioactive waste have to be managed and transported, from a radiation protection point-of-view, in safe way. The amount of radioactive waste and the emissions of radioactive substances shall be limited as far as reasonably achievable. Assessment, dialogue and information in connection with the on-going siting- and licensing process for a future repository for long-lived and high-level activity radioactive waste should be carried out in such a way that a good basis for decisions is achieved.

3. Protection of workers and public. A safe radiation environment for workers and the public has be upheld. Acute radiation effects should not occur and doses to workers and the public should be kept as low as reasonably achievable. SSI shall report how the work of the authority has contributed to good administrative control of radiation sources and has counteracted the risk for orphan sources.

SSI is also tasked with reporting the effect on radiation protection of its research and development projects.

SSI was reorganised in 2006. The central authority work is performed within three main departments:

- Waste Management and Environment Protection
- Emergency Preparedness and Environmental Assessment
- Occupational and Medical Exposures

The National Metrology Institute for Ionising Radiation with its staff is organisationally placed within the Department of Occupational and Medical Exposure with separate financing and its quality management system follows the ISO-standard 17025: 2005.

Two offices report directly to the Director General:
- Office of Communication;
- Office of Administration (Finance, Human Resources, IT, Legal Issues).

In addition to these offices there is a special programme for international radiation protection and emergency preparedness and response: the International Development Co-operation (SIUS). The programme is operationally independent from SSI but reports directly to the Director General. The unit administers Swedish radiation protection assistance and co-operates with mainly Central- and East European countries.

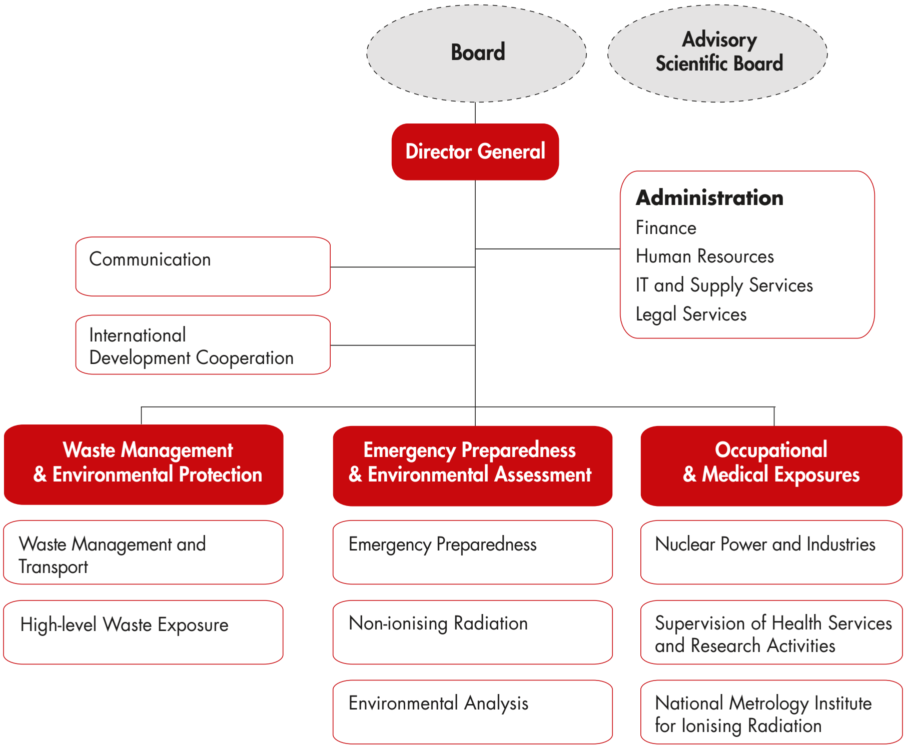

Figure 6. SSI organisation.

8.2 Human and financial resources for regulatory activities

Staffing

SKI presently has a staff of 128 (end of 2006). This is an increase with 9 persons from 2005. Before that the staff number was quite constant over several years 118 (2003) and 115 (1999). 53 persons (an increase from 47 over the last years) belong to the Department of Reactor Safety, thus dealing with supervision of the 10 operating nuclear power reactors and the fuel factory. The average employment time at SKI is 10 years. 48% of the regulatory staff is older than 50 years, 22% is younger than 40 years. The average age is 48.5 years. 16% of the regulatory staff will reach 65 years of age, the official retirement age, within the next 5 years. The staff turnover rate excluding retirement was 5% during 2006, which is about normal.

SSI presently has a staff of 118 persons (end of 2006). This is an increase in the total number of employees from the earlier reporting period (106 in 2003). Of the total staff approximately 30 persons are occupied with matters in direct connection to the supervision of nuclear facilities. Some of these are scientists in the area of physics and radiation physics but there are also radio ecological physicians and biologists. The average employment time is 15 years, and approximately 50% of the staff had been employed more than 10 years. Staff turnover in 2006 was 4%.

In the staff of both regulatory bodies there are also lawyers, IT-experts, information- and administrative personnel. At both authorities one inspector per site is designated as site-responsible, serving as the main contact point between the facility and the authority. At both authorities there is also a decision maker on duty 24 hours a day.

SKI has made an extensive planning and developed a strategy for the future recruitment of qualified staff. The needed types of competence have been defined and competence profiles have been developed for all functions. In order to manage retirements and knowledge transfer to a younger generation, some recruitments have been made earlier to allow a younger professional to work in parallel with a much experienced colleague. Decisions have been taken to extend this programme. For some years, ending mid 2007, there have been special funds available to governmental authorities for facilitating such generation change. Retirement age is now flexible between 61–67 years. This, together with possibilities for staff in these ages to reduce working time, has increased the possibilities to keep older staff and has extended the available time for the generation change.

In Sweden there is also since several years a special programme in place called "Young Generation". This programme aims at building a network between persons younger than 35 in the nuclear sector and to transfer knowledge from older colleagues. The programme includes the industry and vendors as well as the regulatory bodies. Typically three persons from SKI participate every year. Activities are extensive and include seminars, project work and study visits in Sweden and abroad.

The distribution of educational background in 2006 was as follows for SKI and SSI:

Education	Percentage of staff	
	SKI	SSI
Post graduate degree	19	29
Bachelor/master	57	51
Secondary high school	22	17
Other	2	3
Total	100	100

Table 4. Educational background of the staff at SKI and SSI.

Compared with most other agencies, the staffs of SKI and SSI have a rather high educational level. This has to do with the many specialist areas, which have to be covered by the regulatory bodies, and to some extent with the fact that there is no regular TSO in Sweden to support the regulatory bodies with specialist knowledge.

Internationally the numbers of regulatory staff in Sweden are quite small for the size of the nuclear programme. Each professional staff member is typically involved in several tasks, for instance 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 staff members per reactor, but also to consider the types of legal obligations put on the licensees and the different oversight practices.

Long term planning and need for additional resources

Currently SKI experiences a high workload depending on the safety modernisations of the Swedish reactors (see section 6.2), upgrading of the physical protection of the plants, as well as applications to uprate the power levels of several reactors (see section 6.3). This makes it important to implement a very good long term planning and to develop the necessary assessment and administrative tools to deal with the tasks without overloading the staff. Such planning has been done. For instance, a special procedure has been developed for review of the power uprating applications. SKI was also during 2006 given extended legal possibilities, through a change in the Ordinance (1991:739) on fees to the Nuclear Power Inspectorate, to invoice the licensees for handling of applications and safety reviews of licensing conditions. This has made it possible to employ a few additional staff for review of the applications for power uprates.

However, in the budget preparations for 2008, SKI notified the Government that there is a need for additional reinforcement of SKI's regulatory activities and SKI will came back to the Government on this issue (see section 8.8).

Internal staff training

SKI has a relatively large volume of internal staff training, organised by the Human Resource section. 30 training sessions were performed during 2006, in total 965 training days which is about 8 days per person. 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 profiles for each position. The newly hired technical staff varies a lot in knowledge and experience, between having a solid knowledge about NPP design and operation and coming directly from the university. Annual dialogues are held between the respective manager and the staff to assess the training needs. Courses are typically given on internal processes of the management system, the legal framework for regulatory activities, IT and security routines, project management, inspection methodology, various technical courses such as nuclear technology, NPP plant- and systems courses, and media training. For the technical training SKI also to some extent uses the licensee training programmes for operations staff including simulator training. Newly employed SKI staff has also been given the opportunity to follow the work in a control room on site for several weeks. Several SKI inspectors have also practiced for a period at USNRC.

SKI plans in the next years to make the internal training programme more consistent for the technical staff.

Economical resources

As mentioned in the earlier national reports, the regulatory activities of SKI and SSI are financed over the state budget. However, they have a neutral impact on the budget since the costs are recovered by the Government from the licensees, as regulatory and research fees. These fees are proposed every year by the respective Director General. The budgets[12] for 2006 are shown in the table below as compared to 2003 and 2000. Administration includes salaries and operational expenses.

Appropriation	SKI			SSI, all radiation protection applications and emergency emergency preparedness		
	2006	2003	2000	2006	2003	2000
Administration	98 392	95 485	82 648	135 900	111 300	73 800
Research	73 019	72 015	65 969	8 800	13 300	14 400
Total	171 411	167 500	148 617	144 700	124 600	88 200

Table 5. Budgets of SKI and SSI in KSEK. 1 SEK is about 0.1 Euro.

As can be seen in the table the total economical resources of the regulatory bodies have been maintained and increased in real terms over the last years. The 2007 budget for SKI has been further slightly increased. SSI's research budget for the year 2006 was somewhat lower than customary, but for the year 2007 and onwards the resources will increase to about 20 000 KSEK. The increase of the research budget is connected with a decision of the Government in order to cover newly identified critical research areas and also to counteract a depletion of national competence in radiation protection research.

8.3 Regulatory inspection and assessment

Regular inspections and safety assessments are carried out by SKI and SSI as authorised by their respective laws and ordinances and tasks given by the Government.

SKI practices

Over the last years SKI has developed its inspection practices to become more systematic. 15 areas have been defined where requirements exist in regulations, licensing conditions or regulatory decisions. The ambition is to successively cover these areas in a basic inspection programme and to document the findings. Moreover, the same 15 areas are used in the annual assessments of the licensees (SKI-Forum, see below) as well as in the periodic safety reviews every 10 years. In this way, SKI is able to maintain a systematic picture of the safety situation and monitor the development. When new assessments need to be done, already existing and documented assessments of the areas can be consulted and the picture 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 of the 15 areas. The areas are:

1. Design and construction, including plant 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 SKI
9. Investigation of events, experience feedback and external reporting

12 According to Government's letter of appropriation. Added to these figures are some reservations from earlier years which need a special permission to be used.

10. Physical protection
11. Safety analyses and safety report
12. Safety programme
13. Handling of plant documentation
14. Management of nuclear material and nuclear waste
15. Nuclear non-proliferation, exports control and transport safety

As a result of assessments within the 15 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 (as described in SKIFS 2004:1).

More development work is needed before this structure is fully functional. It is also clear that SKI needs to evaluate how regulatory time on-site is used and allocated between major and minor inspections as described below. Some further issues have been identified as a result of the Forsmark event (see section 8.8). For instance it was clear that established routines, positively assessed by SKI, were not followed at the plant. SKI inspection practices are good at evaluating the formal system of the licensees but could be reinforced with regard to assessing the actual working practices at the plants, without taking over inspection issues already under third party control.

Safety inspections

Over the last three years SKI has carried out 19 major inspections focused on the following themes:

- Competence and training of operational staff
- Licensee's safety program
- Quality assurance of organisational changes
- Management of safety reviews
- Management and assessment of incidents
- Inspection of specific technical conditions in connection with incidents.

The major inspections are carried out by teams composed of the site inspector(s) and experts on the subject matter of the inspection. Normally they spend several days on-site and cover all sites. An exit meeting is held where preliminary results are communicated to the licensee. The inspections always result in extensive reports covering 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 further regulatory action. In most of the inspections above it was concluded that the licensees complied with the requirements. In a few cases SKI issued an order to improve activities.

In addition to major inspections, SKI makes a number of minor inspections to get informed on the power production, safety problems and the overall activities of the plants. Normally the minor inspections include 3–4 meetings every year with each reactor operations management, two meetings every year with the safety department, one inspection of the annual outage and annual meetings to review the safety programme and the internal audit programme. Special inspections are made in connection with events, to follow up organisational change and other current issues and findings from earlier inspections. In many cases the inspections have focused on soft issues such as safety management and safety culture.

Preparation and documentation of a minor inspection is much simplified in comparison with major inspections, but results are documented in a systematic way and announced at the SKI management meetings. Each inspection typically takes one or two days on-site for one or two inspectors. Often a specialist on the subject matter for the visit accompanies the inspector.

The following numbers of minor inspections have been done over the last years:

Year	Barsebäck	Forsmark	Oskarshamn	Ringhals	Total
2004	12	15	27	16	70
2005	21	27	30	27	105
2006	4	32	27	26	89

Table 6. Number of minor inspections done by SKI 2004–06.

SKI also has an instrument called "special supervision". The use of this supervision is decided by the Director General and applied in cases where SKI is not satisfied with the safety performance of a licensee. It can also be applied for other special safety reasons, e.g. during testing operation after a large plant modification. The special supervision regime means that more inspections are done and special progress reporting is required. Special supervision has been applied in a few cases, an ongoing case is Forsmark where SKI more closely wants to follow developments after the Forsmark 1 event (see section 6.1). This is also reflected in the increased number of inspections 2006 in the table above. Special supervision is formally terminated when SKI is satisfied with the improvements made or the special safety reason is no longer valid.

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

SKI-Forum

SKI-Forum is a regular annual and integrated safety assessment of each major facility under SKIs supervision. Based on all inspections and safety assessments a general conclusion is made about the safety- and non-proliferation control status of the facility in relation to relevant requirements. A document, covering the status in the 15 areas mentioned above is circulated by the inspection department before each Forum. Under the chairmanship of the respective department director and the site inspector, the preliminary conclusions are scrutinised and amended, by a group of experts representing all relevant areas. Notes are taken and the minutes are approved by the SKI regulatory department directors. The minutes are an important tool in prioritising further regulatory activities. They are also discussed with the respective plant management shortly after each Forum. SKI-Forum is now an established practice at SKI and found to be most valuable for maintaining an updated picture within SKI of the safety issues of the plants and, as a result, for prioritising and planning of other regulatory activities. It has also shown to be a strong information basis for top management discussions between SKI and the licensees. However, experiences over the last years have shown that there is room for some improvement of the procedure. The work will be made more continuous over the year and four assessment meetings held instead of one. This is to spread out the work efforts and have a faster handling of the results. This is to some extent a learning from the Forsmark event, where the safety culture problems could have been detected earlier with a modified procedure in place.

SSI practices

Since the third national report, SSI has reviewed its inspection policy. The quality management system contains policy documents and routines for supervision of all areas and activities under SSI oversight.

The general supervision policy document points out inspection as the main supervision method. During inspections, SSI controls the compliance with the radiation protection law, SSI regulations, and issued terms of licences. The methods for gathering inspection information are interviews, dialogues, direct observations, document control, and sampling of filters/materials.

SSI inspection policy outlines three types of inspections:

System inspections

During system inspections the license holder's organisation, administrative routines, co-ordination within the organisation, division of responsibilities and competence are in focus. The aim of a system inspection is to obtain good knowledge of the management system of the license holder.

Detailed inspections

A detailed inspection is concentrating on one specific issue. A detailed inspection could e.g. be triggered by an unexpected radiological event. A detailed inspection could also be performed as a follow-up of an earlier inspection.

Theme inspections

A theme inspection is co-ordinated and performed towards several license holders, on a specific theme (e.g. air monitoring programme at the nuclear facilities).

SSI inspection policy also describes the requirements on an SSI inspector and details his/hers powers and duties. Furthermore, the inspection process is outlined in the document: the selection of inspection object, the preparations prior to the inspection, the effectuation of the inspection and the supplementary work of documentation and follow-up actions.

In September 2006, SSI performed a different sort of inspection during the annual outage of the nuclear power plant Ringhals 1. Ten SSI inspectors followed the management of outage activities at different management levels, the work of the health physics staff, and the co-operation between the plant personnel and contractors during four days of the outage. SSI presently evaluates this new inspection form, taking into account the effectiveness of the inspection and the increase in required planning and execution resources.

Year	Barsebäck	Forsmark	Oskarshamn	Ringhals	Total
2004	7	12	9	10	38
2005	6	12	7	9	34
2006	7	7	7	8	29

Table 7. Number of inspections by SSI, excluding waste management supervision, at the plants during 2004–2006.

Table 7 displays the number of performed SSI inspections, excluding waste management supervision, at the nuclear power plants during 2004–2006. SSI performed extra inspections of decommissioning planning during 2004–2005. During 2006, a substantial fraction of the inspection resources was allocated to a detailed inspection of the outage activities at the power plant Ringhals 1.

8.4 Regulatory research

SKI

SKI's research is based on the research strategy from 2002[13], where it is stated that the overall goals of SKI's nuclear safety research are that they should contribute to:

- keeping SKI up to date with the knowledge, facts, analytical methods and supervisory tools that are needed to pursue effective regulatory and supervisory activities, promote the safety and non-proliferation work, and be able to carry out SKI's advisory tasks in accident situations or threats thereof,
- giving SKI continuous access to the competence and the resources that are needed to assess the safety situation and the non-proliferation work with a sufficient degree of independence and integrity,
- ensuring that national competence and research capacity of importance for nuclear safety and non-proliferation work are available.

To achieve these goals, SKI applies a strategy with both short-range and long-range research. The research activities shall be based on a well-balanced programme of long-range research whose point of departure is the supervisory challenges and whose aims are:

- to gradually build up knowledge in matters that are of importance for the safety or non-proliferation work, and for which there is a more long-term need,
- to gradually build up or maintain competence and research resources within subject areas that are of importance for the safety or non-proliferation work, and which SKI needs access to,
- to systematically clarify whether concerns aroused in the supervisory work are or may become a safety problem.

This programme shall be kept up-to-date and modified to suit the changing supervisory challenges, be based on a holistic perspective on safety and non-proliferation issues, and take into account the interdisciplinary nature of the issues.

An external, limited evaluation of the research was performed in May 2004. The evaluation focused on the research process and the coupling to the supervisory needs. In this investigation a number of recommendations were given concerning how the SKI research should be implemented in the supervisory process and in the management documents describing the supervisory work. In the report it is also discussed how to

13 SKI Rapport 02:45, also available in English.

maintain a proper balance between the diversified needs of SKI. Many of the recommendations have now been implemented.

Research is a prerequisite for SKI to be able to conduct its regulatory activities. Research to support supervision is focused on a number of strategic areas such as safety assessment, safety analysis, reactor technology, material and fuel questions, human factors, emergency preparedness and non-proliferation. SKI:s analysis shows that this focus should be maintained for the time being. However, the Government has asked SKI to submit a report on the future research strategy by 31 December 2007 and changes on SKI's present focus may change due to the conclusions from this report.

To fulfil the research needs, SKI contracts universities and consulting companies and a dominating share goes to research organisations in Sweden. However, since national resources are limited, SKI has, for a long time, actively participated in international research. There has been a clear trend for many years that international co-operation is increasing, also for safety research. SKI is prioritising co-operation on research conducted in the OECD/NEA and is participating in a large number of projects organised in this framework. An example is the Halden Project in Norway, which 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. SKI is itself actively participating and supporting Swedish organisations 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).

SSI

SSI research budget consists of two parts of approximately equal size. SSI uses one part directly to support its supervising activities. Approximately 75% of this budget is used for research related to nuclear energy production, such as radioecology, radiation protection of power plant workers, emergency preparedness, nuclear waste matters, and questions related to risk perception and acceptance of waste disposal. The remaining 25% of the budget is used for non-nuclear research, i.e. mainly medical and technical applications and uses of radiation, and for non-ionising radiation (UV, electromagnetic fields).

The purpose of the other part of the research budget, which is new from 2007, is to finance basic and applied research in the whole field of radiation protection. The new research funds will be used to finance advanced research positions in radiation biology, radiation dosimetry, and radioecology at universities. The primary focus is to maintain competence in radiation protection. Part of the new funds will also be used to give research grants after application (see also section 11.5)

8.5 Quality management of regulatory activities

SKI

SKI has continued to improve its management system SKIQ. During the last years the efforts have been focusing on three areas. The first has been to complete the management system to include all main activities of SKI. The second has been to implement audits as a basis for the improvement of the processes, and finally an evaluation of the complete SKIQ has been made as an input to more general ideas of improvements.

The addition of processes and parts of the system were made to include all activities within the jurisdiction of SKI. Additions have dealt with the process used during safety investigations, processes used in the areas of nuclear non-proliferation, physical protection and transport safety and the process used in the International Cooperation Programme. The final major addition to the SKIQ, is the procedures used by SKI during various emergency preparedness situations. Below is an updated the list of the content of SKIQ.

Policies and sub-processes;
- SKI – The role of SKI
- SKIQ – The Management system,
- Supervision principles
- Activity planning – follow up and reporting
- Competence assurance
- Working environment

- Document control and registration
- Organization
- General internal administration

Main processes;

- Issuing of regulations
- Review of licensees documents – safety investigations
- Inspections
- Nuclear non-proliferation, physical protection and transport safety
- Analysis of licensees event reports
- International work
- Research
- Integrated safety assessment
- International cooperation projects
- Information
- Emergency preparedness

By using a web-based software tool, SKIQ is accessible for all staff via the intranet at SKI.

Implementation of internal audits

The first step in the implementation of internal audits, was to appoint and train internal auditors. An audit program is now in place and the role and responsibilities are defined and implemented in the system. The role of the audits is, to verify that processes are implemented and to collect information for the improvement of the processes and their descriptions.

Evaluation of the SKIQ system and the organisation of the work

In the light of continues improvement, the system was evaluated by external experts, during 2006. The main recommendation from the evaluation was to increase the management involvement in the processes and their improvement.

A plan to implement a new organisation for the continued development of the management system has been decided and is now being implemented. Managers have been assigned also the positions as process owners. The quality manager, and the internal auditors roles are changed towards more of a controller function.

SSI

During 2006 the environmental work of SSI was certified according to ISO 14001. SSI activity plan for 2007 includes instructions for the measures needed to achieve certification of SSI's quality management and work environment management systems according to relevant ISO-standards. Work with updating and completing existing SSI policy and routines has presently started. See also section 8.3.

8.6 Merger of SKI and SSI

Different from the situation in many nuclear countries, Sweden has two separate regulatory bodies, SKI for nuclear safety and SSI for radiation protection. Their missions and tasks have been basically the same since the beginning of the nuclear programme. According to the Ordinance on Nuclear Activities, SKI and SSI have to cooperate in certain licensing decisions and other forms of cooperation have been developed over the years, such as common reporting to the Government and cooperation in some inspections and safety reviews. The Director Generals are members of the respective Board and SSI is represented in the SKI Advisory Committee on Reactor Safety.

On several occasions organisational changes have been discussed but not decided. It has been seen as an advantage that two independent authorities, each from its own viewpoints, review and supervise the nuclear industry. At the same time there has been some overlap in regulations and from time to time some friction between the two authorities. After a review 2002–2003 by a special investigator, it was again concluded that a full or partly merger is not justified.

However, the Government has recently announced (April 2007) that they intend to merge SKI and SSI by 1 April 2008. A new authority will be created at that date with the same tasks as the two earlier authorities. Several motives are presented for this move:

- a general ambition by the Government to reduce the number of authorities and make civil service more efficient
- a more efficient use of common resources for supervision of nuclear facilities
- an integrated competence within nuclear safety and radiation protection will lead to a reinforced supervision of both nuclear and non-nuclear activities
- inspections will benefit from an integrated perspective
- it will be easier for the licensees and other stakeholders to deal with only one regulatory body, the risk for contradictory rules and decisions will be eliminated
- Sweden will be more clearly represented in international contexts of nuclear safety and radiation protection

The date for the merger has been chosen so that the new authority will be organised and in place well before the licensing of the final repository for spent fuel. An application is expected during 2009.

A special investigator will be appointed to propose the new organisation, legal changes and other necessary measures. The investigator will be expected to head the new authority that will be located to the Stockholm area. Since present regulatory activities of SKI and SSI will be preserved, the merger is not expected to generate any large economical savings.

The merger proposal has been sent (May 2007) for review and comments to a large number of organisations before any more concrete steps are taken. Some preparations have already started within SKI and SSI, mainly dealing with the administrative functions. The staffs of SKI and SSI are generally positive to the merger. However, it will be a challenge to integrate the organisations and the different regulatory practices.

8.7 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 SKI and SSI concentrate solely on nuclear safety and radiation protection. Both regulatory bodies report to the Ministry of Environment, which has nothing to do with the promotion or utilisation of nuclear energy. Such matters are handled by the Ministry of Enterprise, Energy and Communications. An individual minister cannot interfere with the decision making of a governmental agency according to Swedish Constitution. This is a matter for the Government, in plenum.

8.8 Actions initiated at SKI after the Forsmark event

The Forsmark event (see section 6.1) was a major regulatory and information effort for SKI. In order to benefit from this experience and to improve, the Director General decided on the following measures in April 2007:

Principal design issues of robustness of safety related power supply

SKI shall assess the international experiences of safety related power supply robustness as well as analyses initiated by the industry, to decide whether additional investigations are needed and whether regulations need to be made more stringent. The head of the reactor safety department is given a special investigation task to be reported in October 2007, after the NEA and IAEA seminar in Stockholm.

Methods to catch indications on deteriorated safety management/safety culture

SKI shall analyse whether there have been earlier indications of a declining safety focus at Forsmark. In that case, what are those indications and can they be used as general indications of declining safety focus (declining safety culture). The instrument "integrated safety assessment" (SKI-Forum) should be developed further during the year, e.g. by use of dedicated indicators.

Increased supervision of the first level of the defence-in-depth

Forsmark did not follow own routines for maintenance and testing of existing and new equipment. SKI shall establish a strategy and a plan for improvement of assessments of how licensees follow established routines. To this effect, the effectiveness of the SKI inspection process will be reviewed. The head of the reactor safety department is given a special investigation task.

Supervision to strengthen conservative decision making by the licensees

If a plant behaves in a non-predicted way and the causes or safety significance can not be determined, the plant shall be brought to a safe state without delay according to regulations. All licensees have routines and procedures for this. In some actual cases, SKI has noticed that the licensees did not sufficiently apply this conservative decision making. SKI shall continue to push on this point and prioritize inspections and investigation when there is a suspicion of non-conservative decision making. SKI will also at meetings on several levels with the licensees, clarify the intention with these regulations.

Direction of the supervision as a result of extensive technical modifications and changes of administrative routines at the plants

Measures following from SKI regulations SKIFS 2004:2, licensees own modifications to improve reliability and modifications due to uprating put increased demands on SKI's supervision. The number of notifications to be reviewed will increase, the modification work will need to be followed up on sites and the processes used by the licensees to manage the changes will need to be inspected. Tools used to identify weaknesses in the designs, e.g. PSA, will be developed further. SKI shall assess the need for additional competence and increased capacity. The work to make the supervision more effective and to develop a strategy for SKI's supervision should take into account the planned plant modifications. What changes of priorities can be done temporarily or permanently to accommodate these needs? The head of the reactor safety department is given a special investigation task..

Expectations on information from SKI

Expectations from society on information from SKI have been very high over several months. Expectations have also existed internally as well as from the Board and the Advisory Committee on Reactor Safety. It seems that SKI has been the single most important source of information, meaning that copies of many documents have been asked for or documents to read on the spot. Requested documents have to be security cleared. It is important that SKI can transmit information on safety issues and make documents available as efficiently as possible. SKI shall investigate expectations on information and how this can be supplied in the best way for SKI. The head of the information department is given a special investigation task.

Organisation, coordination and the civil service role

Over several months SKI's administrative processes and decision making have been tested during relatively tough conditions. SKI shall evaluate how the event has been handled by the own organisation. Strengths should be identified and weaknesses where routines need to be improved. Has enough room been given in the organisation during the Forsmark event to continue the supervision of other facilities? The head of the administrative department is given a special investigation task. Internal discussions earlier started on the values and roles as civil servants and on priorities in cases of events, will be amended with experiences from how SKI acted during the Forsmark event.

Response

In his response to the investigation tasks, the head of the reactor safety department proposes to develop a regulatory strategy for review and assessment of the safety culture of the plants, to extend review and follow up of the implementation of the licensees management systems including internal audits, to conduct more rapid investigations of events (RASK) also in cases where the licensees have done adequate investigations, to increase the number of inspections and minor inspections at all plants in order to cover the 15 areas (see section 8.3), to reinforce the operations experience feedback process, to evaluate the review and supervision of plant modernisations and to extend the review and analysis of the uprating applications.

Implementation of the above proposals would require a substantial addition of staff. Most of these will be needed to reinforce the basic inspection programme and the reviews of expected additional notifications of plant modifications. The SKI management will further assess the proposals and submit a request to the Government.

8.9 Estimation of additional resource needs for the supervision of reactor safety

In June 2007, SKI submitted an assessment to the Government of the additional resources needed to reinforce the regulatory supervision of the nuclear power plants as well as to cope with the increased work load over the next years to review a large number plant modifications and uprate cases. This estimation is made for the regulatory supervision within SKI's jurisdiction and is not affected by the planned merger with SSI. To reinforce the inspection programme and increase on-site time, SKI estimates that 19 additional staff will be needed, distributed over the inspection areas operations, maintenance and physical protection. This reinforcement should be done successively over the next years with 5–7 persons per year.

The number of plant modifications per plant and year are estimated to increase from about 200 to 300 over the next eight years depending on the safety modernisations, upgrading of the physical protection and optimisation of operations. These modifications will be notified to SKI and SKI has to assess all notifications according to the established procedure (see section 14.3), and in an increased number of cases make a further review to make sure that designs, components or material are used that will not affect safety negatively. One experience from the Forsmark event is that a deficient design, installed in the mid 1990's, was not detected until more than 10 years later in connection with an event. SKI estimates that 11 additional staff will be needed for this reinforced safety reviews. Six staff will be needed up to 2013 and five as a permanent reinforcement. Without this reinforcement, and with the same ambition as today, regulatory reviews will take much longer and the safety upgrading programmes of the licensees will be delayed.

Finally SKI estimates that one additional staff is needed during a five year period for the review of power uprates. This resource can be directly invoiced by SKI.

8.10 Conclusion

With the reinforcements earlier provided, the staffing and competence situation has been satisfactory for the regulatory bodies in relation to supervision programmes and practices so far. However, as mentioned above SKI has estimated that additional resources are needed in order to handle the expected workload of the next years. Without additional resources, the modernisation programmes of the reactors risk to be delayed due to limited regulatory review resources. In addition, SKI will need to make heavy priorities in order to increase inspection time on site. The Government has announced in the budget bill that they intend to reinforce the supervision of the nuclear power plants and provide additional resources for this. No details have been given yet on the additional resources to be allocated.

Sweden complies with the obligations of Article 8, but it will be necessary to follow up on the resource situation for the regulatory body during the next years in order to maintain a high quality supervision of the nuclear power plants.

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

- A minor amendment has been made in the Act on Nuclear Activities concerning the responsibilities of the licensee.
- The safety policies of the owner companies have been updated.
- The licensees have asked the Government to request three IAEA OSART missions during 2008–2011.

9.1 Regulatory requirements

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

10 §: The holder of a licence 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) ensuring the safe handling of the final disposal of nuclear waste arising in the activities or nuclear material arising therein and not reused, and
(3) the safe decommissioning and dismantling of plants in which nuclear activities are no longer to be conducted.

This paragraph was amended 2006 with the following:

The licensee shall, in connection with accidents, threats or other similar circumstances, without delay give the responsible authority such information that is important for the assessment of safety.

In the pre-work to the 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.

It is stated in the annual government letter of appropriation that SKI requirements have to be clear with regard to the design of the plants and the obligations of the licensees regarding activities of importance to safety as well as the organisation and competence of staff. Regulations shall be outlined in such a way that the responsibility of the licensees are not negatively affected or is taken over by the state.

SKI's 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 SKI regulations (SKIFS 2004:1) 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 develops according to valid objectives and strategies. The meaning of this is that a continuous preventive safety work is legally required, including safety reassessments, analysis of events in the own and other facilities, analysis of relevant new safety standards and practices and research results. Any reasonable measure useful for safety shall be taken as a result of this proactive and continuous safety work and be documented in a safety programme that shall be updated annually (Chapter 2, § 10).

SKI regulations contain three basic control principles, making the roles clear between licensee and regulator:

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

The basic safety documentation (SAR including OLCs, plans for emergency response and physical protection) has to be approved by SKI. Plant and organisational modifications and changes in the safety documentation have to be notified and SKI can if needed impose additional conditions and requirements. All other issues are handled under the self inspection of the licensee. SKI inspects how this responsibility is taken.

9.2 Measures taken by the licence holders

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

Safety policies

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

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

A translation of Vattenfall's policy can be found in appendix 1. E.ON.'s policy is under editing. The earlier policy of Sydkraft AB is being modified to fit the new company.

Implementation of the safety policies is further described in chapter 10.2.

Continuous upgrading of the plants

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

International peer reviews

International peer reviews are performed at the initiative of the licensees. Recent years WANO peer reviews have been performed in Ringhals 2005, Oskarshamn 2005 and Forsmark 2004. These reviews are highly regarded as benchmarks since they are performed by active colleagues from other power plants. The results are not public, and this tends to make the reviews tougher.

As a result of the Forsmark 1 event (see section 6.1) the licensees have 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 will be public.

Several Swedish NPP staff members, participate each year in WANO as well as OSART peer reviews outside of Sweden. 59 Swedish experts participated in OSART-missions between 1983 and 2005 which is among the six most contributing countries. Participation as an expert is considered of great value to the individuals as well as their plant organisations.

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

- Corporate audits have started of the licensee's management systems.
- Vattenfall has created a Safety Management Institute.
- The licensees are developing their safety culture programmes.
- Vattenfall takes firm measures after the Forsmark event.

10.1 Regulatory requirements

Policies that give due priority to safety can be understood as ordinary 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 as a result 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 very basic requirement in SKIFS 2004:1 (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 recommendation to 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 required safety policy to be implemented by an appropriate operating organisation with an effective management system:

- safety takes priority over commercial operations,
- sufficient economical resources are available for implementation of safety measures,
- sufficient number of 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 timely identified and corrected,
- the operating organisation have in place a strong program to learn from own and others' mistakes so that safety deficiencies do not recur,
- quality management is applied in all activities,
- possibilities to improve safety are continuously evaluated and appropriately implemented,
- the organisation as a whole is characterized by a good safety culture.

These key points are further included in SKI regulations on safety in nuclear facilities, SKIFS 2004:1 chapter 2, 7–9 §§, as legally binding requirements on safety management aiming at giving safety the right priority:

- The operating organisation shall have the necessary economical and personal 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 co-operation 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 review.
- 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 continuously assessed 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.

SKIFS 2004:1 chapter 2, 10 § requires that the licensee has a living safety programme: After taken into operation, the safety of a facility shall be continuously analysed and assessed in a systematic way. Necessary technical and organisational measures to be taken as a result of this analysis and assessment shall be included in an established safety program. This program shall be evaluated and updated annually and show priorities and time schedules for measures to be taken.

The continued analysis and assessment should include technical and organisational experience from 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 change, evaluation of work conditions and self assessments of the working climate and safety culture.

10.2 Measures taken by the licence holders

Safety policies

The earlier mentioned safety policies (chapter 9) 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 of each nuclear power plant management. The safety policies of the owner companies are reviewed periodically by the Safety Councils and the policies of the plant managements are reviewed by external and internal safety audits.

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 is shown in appendix 2. Furthermore, local safety review committees are established on the plant site levels to advice 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 assigned. 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 of policies, the safety management system and company directives for nuclear safety, as well as sanctioning deviations from those.
  - Safety oversight level 2 is represented by the production unit manager, and responsible for long-term safety issues, manuals and procedures. Level 2 is also responsible for the unit related safety review. 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 to Level 1. Level 2 shall also sanction routines for and 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 department of Safety & Compliance. Furthermore, when the plant manager takes decision on important safety issues, or principal matters such as restart of the reactors after outage, plant modifications in safety equipment etc, the principle is that he 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 SKI regulations SKIFS 2004:1. The programmes are part of the management systems 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. RAB and FKA use safety indices. The FKA Safety Index is shown in figure 7 below. OKG uses the performance indicator index developed by WANO.

- The quality assurance systems (see chapter 13) have for all plants been developed 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.

- Vattenfall business unit "Generation" performs internal audits on the functioning of the respective management systems within its nuclear and hydropower divisions. The audit teams are headed by corporate staff, but peers from the other divisions normally also participate. These audits deal with nuclear and dam safety as well as other important business risks, and they aim at:
  - Assessing the general **efficiency** and status of the management systems
  - Ensuring that the companies make use of and correctly interpret corporate policies and guidelines
  - Generally improving the exchange of good practices
  - Qualitatively assessing attitudes to and fulfilment of regulatory requirements, and relations to regulators and other authorities

  In recent years, audits have covered thematic issues such as: The common Vattenfall system for Safety Management and Safety Review; Effects of the new regulations on Security; The Environmental management systems; and the Investment process. Generally the audited companies have responded positively to the recommendations from the reviews, and there is a very open attitude during the interviews. The reports are treated as internal Vattenfall documents.

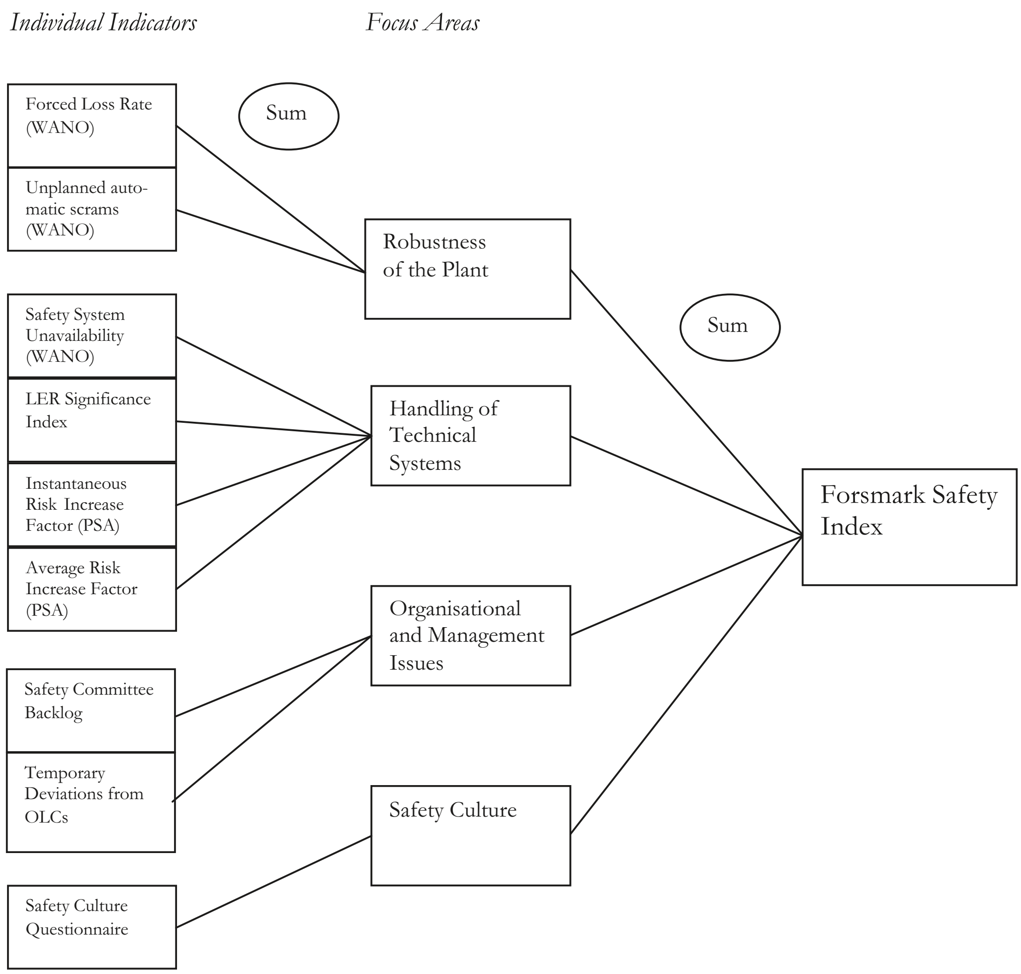

Figure 7. The Safety Index used in Forsmark (FSI).

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, and further courses will be provided. 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.

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.

The OKG safety culture programme

OKG has been working with an intense action plan for safety culture since 2004. It is carried out on one and a half full-time basis by a co-ordinator and a number of part-time Safety Culture-Ambassadors. An annual follow up is carried out of the action plan and of the work methodology.

The Safety Culture-Ambassadors always participate in the general activities existing in connexion with the action plan. They implement cross-sectional seminars with all employees, partner companies and contractors (for a longer period then three months). The co-ordinator harmonizes the safety culture activities, conducts the compilation of results, analyzes, reports and is team leader of the Safety Culture-Ambassadors. A Safety Culture manager is responsible for the strategy and development of the program. The manager also makes analyses. A Safety Culture governing body assists and supports the Safety culture manager and also anchor the safety culture work in the organisation. External partners are available to support the action plan on a long-term basis.

The aim of the **general efforts** is to enhance the understanding of every individual's possibility to influence safety and, to put safety on the personal agenda of everybody. 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 the like.

- A **quantitative survey** is carried out every second year. The result of the whole 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 the 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 every second year resulting in a report. The report and its result as well as the planning of the specific efforts are communicated to the whole organization through the cross-group seminars.
- A **meta-analysis** is carried out every third year in order to give a more modulated 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. The ambition with the analysis is to create a comprehensive picture of the OKG safety culture. The result of the meta-analysis is communicated at workshops with the senior management, seminars with middle management as well as during cross-sectional seminars. On the basis of the meta-analysis measures to improve the safety culture are taken.

The Ringhals safety culture program

For RAB, the safety culture work is described in a 4-year programme that is updated once a year. This programme contains planned activities for different levels of the organisations. A specific report is issued each year, which contains a summary of projects. Some examples of specific activities from the years 2005 and 2006 are given bellow.

Ringhals has especially recognized the importance of the feedback received from the WANO peer review as an important method for creating enhanced awareness about safety culture issues. Hence, during the last two years many safety culture projects were associated with the WANO peer review (Ringhals units 3 and 4). Examples of more specific projects are; focus on communication where management informed and discussed challenges associated with coming large projects; projects focused on pre-job briefing strategies; projects focused on stress management; and projects focused on values and safety.

Upper level management personnel have participated in the first pilot course held by the Nordic Safety Management Institute.

Ringhals has supported various kinds or research activities focused on safety culture. For example, research about safety culture associated with managing large projects (in collaboration with the technical university LTH in Lund) Research collaboration also includes the LearnSafe Project and specific projects for updating a safety culture questionnaire.

Forsmark safety culture initiatives

New initiatives regarding safety culture enhancement are currently in progress. For example, enhanced training will be conducted regarding safety culture issues for leading personnel. Since several years Forsmark have had a practice of running safety culture seminars, often with invited speakers. This practice continues, for example issues of decision-making has been explored in the context of recent events. A specific project aimed at developing strategies for safety culture enhancement is in progress (May 2007). A specific focus will be on Meta analysis, which brings together information from more specific processes such as; audits, event investigations, peer-review, safety culture assessments etc. Forsmark will also benefit from the initiatives taken in the Nordic Safety Management Institute.

10.3 Vattenfall AB and FKA actions to cope with issues revealed by the Forsmark event

The incident on 25 July 2006 in Forsmark unit 1 (see section 6.1) revealed a number of technical and administrative weaknesses at the plant. 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 more long-term program of 72 issues that were ranked into four groups. The following are examples on issues of priority 1, to be analysed/completed at the latest by mid 2007:

- Analysis of capacity problems concerning computerised event registrations during disturbances
- Analysis of the need to further improve the power supply to the diesel generators
- Improved routines for testing following plant changes
- Selected protective devices should be designed for testing during operation
- Changes to the preventive maintenance program for UPS units
- Emergency procedures to be improved.
- Correct inaccuracies in the Safety Analysis Report (SAR) and procedures.

Forsmark has also initiated safety culture seminars to make all personnel:
- Understand the reactor safety policy including the meaning of "Safety First"
- Ensure that quality work shall be prioritised so that procedures are updated and observed
- Understand that strictly observing routines and procedures is mandatory
- Understand and apply routines for plant modifications.

Vattenfall AB initiated a number of measures in early 2007, including:
- Postponement of major projects (i.e. power uprates) in order to relieve the organisation and make possible a focus on reconstitution of operations in the near-term
- Nomination of a new CEO with extensive nuclear experience. He immediately initiated a program to evaluate the management structure of FKA
- Organizational changes to put more focus on operational and reactor safety

The Board of Vattenfall AB, has strengthened its involvement in nuclear safety issues through:
- Nomination of several of it's members to the Board of Forsmarks Kraftgrupp AB (FKA) to form closer ties

- Installation of a new sub-committee on nuclear safety, to receive improved reporting on nuclear safety issues, including direct and frequent reporting from the Forsmark safety manager
- Appointing an independent, internationally renowned, external expert to analyse the safety management systems including organisation and reporting functions

10.4 Regulatory control

SKI 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 8.3 are targeted to assess how safety is prioritized. Examples are inspections of the licensee safety programmes, management of organisational change, management of safety review, management and assessment of incidents (conservative decision making).

- Investigations in connections with events (SKI has a special methodology RASK for fast investigations) and assessments of event reports (see chapter 19). Licensees decision making regarding the operational status of the reactor in connection with events and detected deficiencies have received increased attention during the last years.

- The practice of SKI-Forum (see section 8.3). SKI-Forum provides an updated comprehensive regulatory assessment of the safety of the facility. A management meeting follows each SKI-Forum.

- Regular top management meetings with the licensees. The Director General of SKI 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 meetings with the corporate executives of the utilities every year.

- SKI follows the work on site of the licensees on safety culture issues mainly through minor inspections. The role of SKI in this context is to make sure that the licensees have a proactive safety management. By this SKI expects that the licensees create and maintain a strong safety culture. One important factor of great interest for SKI, is that the licensees act timely on 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.

10.5 Measures taken at SKI to prioritise safety

One basic idea behind the management system (SKIQ) is that SKI shall devote its supervision resources to the most important safety issues. The annual activity planning system takes as its starting point the current regulatory challenges, which are documented, as well as input from SKI-Forum and other regulatory processes, e.g. inspection, international work and research, indicating that SKI needs to devote regulatory resources to certain facilities and safety issues. Furthermore, the general safety regulations (SKIFS 2004:1) allow SKI a flexible approach with regard to review of modifications to the plants as well as review of modifications of the SAR and OLCs. As described in the second national report, the licensees have to notify SKI of such modifications. SKI has a procedure in place with specific criteria to assess the notifications and decide which are interesting enough from a safety point of view. This system allows SKI to concentrate review resources on the most important safety issues and retain full insight and control over the measures taken by the licensees.

Regulatory indicators

In order to further develop instruments to prioritise safety, SKI runs a pilot project on indicators since some years. The aim is to provide additional insights to various inspection activities and to support the annual integrated safety assessments done by SKI of each major facility (SKI-Forum). The set of indicators has been modified as experience has been obtained but has not been much changed over the last three years. An overview is given in the figure below.

The present set of pilot indicators has a hierarchy formed after data collection possibilities and in the future to facilitate aggregation of groups of indicators. For the time being the licensees provide data for the higher-level indicators and maintain a database on maintenance records. For the lower level, SKI derives the indicators based on licensee event reports. Unavailability is calculated for the mentioned systems. There are no threshold values linked to a certain SKI response. This might be considered later. Colour codes are only used for the large set of system unavailability with the purpose to alert SKI inspectors.

The high-level indicators were chosen because they are available. The lower level indicators were chosen to provide more detailed insights into various safety concerns. A grouping into barriers and levels of the defence-in-depth was chosen to match the broad picture used in the integrated safety assessments and Swedish regulations, and thus to evaluate how well the utility operates and maintains equipment important to safety. The MTO-indicators can be sees as indicators on the prerequisites for maintaining a good defence-in-depth system.

For the future, some indicators might be modified and additional indicators will be tested. Documentation will cover some years for trending purposes. When sufficient experience has been obtained, an evaluation will be done and a decision taken on the continued use of indicators for regulatory purposes.

10.6 Conclusion

Sweden complies with the obligations of Article 10.

WANO indicators	Availability Unplanned production loss Collective dose Fuel index Unplanned scram
MTO-related indicators Based on MTO LERs	Number of LERs Management and organisation Work organisation Supervisory methods Change management Communication Instruction Work practices Training/competence Ergonomics/design Work schedule Work environment
System unavailability Calculated from LERs Follows the defence-in-depth concept	Control & protection systems (8 systems) Safety systems (6 systems) Separation barriers (7 barriers) Surveillance & monitoring systems (8 systems) Consequence mitigation systems (2 systems)
Work order system Pilot study (one unit)	Quota: corrective maintenance/preventive maintenance
Emergency preparedness Under development	Drill participation Training in emergency response
Physical protection Under discussion	
Fire protection Under discussion	

Figure 8. Overview of indicators used by SKI.

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 Euros) will be invested in the Swedish NPPs over the next five years.
- The relocation of full scale simulators from Studsvik to the plant sites has been nearly completed.
- New simulators are being constructed on sites for Ringhals 2, Oskarshamn 2 and Oskarshamn 3.
- SKI has determined that the required systematic approaches are in place at all nuclear power plants to assure long term staffing and competence of operations staff.
- An agreement has been reached between SKI and the industry to continue the economical support of the Swedish Centre of Nuclear Technology after 2007.
- SSI is given 10 MSEK additional annual funds from 2007 to support radiation protection research, SSI has decided to support research positions in radiation biology, radioecology, and dosimetry for a first three year period.

11.1 Regulatory requirements

In order to obtain a licence in Sweden, large economical resources must be committed in order to manage the far- reaching safety obligations required in the Act on Nuclear Activities and SKI 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 on an operating time of 40 years. In the event of a longer operating time, fees for the handling of additional spent fuel will have to be paid, but all the fixed costs are included in the cost estimate for 40 operating years. In the event of an earlier shut down, the licence holders must provide financial security to the Nuclear Waste Fund[14]. Licensees also have to pay regulatory and research fees on invoices by the regulatory bodies. These fees are determined in Ordinances and are paid to the Government (see chapter 8).

Regarding human resources, the SKI general safety regulations (SKIFS 2004:1) are clear about the staffing, competence and training of staff 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. A systematic approach should be used for the definition of competence requirements, planning and evaluation of all safety related training. Annual competence assessments should be done. These general requirements apply also in applicable extent 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 the ordering, managing and evaluation of the results of contracted work, should always exist within the licencee's organisation. For operations personnel at the nuclear power plants there are more specific regulations (SKIFS 2000:1, see section 7.2). These regulations also include operations managers and plant managers to the extent the latter involve in the operational decision-making. Operations staff has to be formally authorised by the licensee for the specific position. The authorisation is valid for three years under certain conditions.

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14 The average fee for 2007 is 0.013 SEK/kWh. Required financial securities amount to 10 billion SEK. A special fee, at present 0.03 SEK/kWh, must also be paid for the handling of old nuclear waste at the Studsvik site, Ranstad mine and Ågesta reactor.

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 producers in Sweden. Besides the nuclear power plants both have substantial assets in hydropower, thermal power and wind power. Both groups are financially stable and have good financial records. Some key figures from 2006 are given in table 8 below.

Utility Group	Earnings MSEK[15]	Total assets MSEK	Electricity sales TWh	Equity/Assets Ratio %	Investments MSEK
Vattenfall	25 525	323 166	164.5	33	17 220
E.ON AG	47 503	1 150 228	400.4	38	47 799

Table 8. Financial records of the utility groups in Sweden.

All safety investments in the NPPs have so far been financed by corporate funds, as decided by the utility boards, on commercial conditions for the licensees. This means that realistic plans for write-offs 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 essential for the total business concept. Extensive investments are now being done in all the Swedish nuclear power plants. In total about 30 billion SEK will be invested during the next five years. The priorities are enhancing safety and otherwise modernize the plants to provide for longer-term operation (50–60 year life times). Power uprates are also planned for most of the reactors. In total, an additional 1275 MWe will be installed until 2011 (see section 6.3).

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

Staffing situation

The Swedish operating organisations 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 for by the use of a number of consultants and contractors, among these the original main vendors.

After deregulation of the electricity market, the traditional large use of consultants has been reduced, particularly those on long-term contracts. However, consultants are still being used when it comes to specific competence and during certain periods of time when the workload is too high on-site. This number of consultants today typically amounts to 20–50 per plant and year. A complicating factor in the continued use of consultants is that several with a genuine 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 the last 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 available expertise, the need for development and training of employees and for recruiting has been assessed.

The need to "rejuvenate" the nuclear power plant organisation is obvious when regarding the age distribution figures shown from Forsmark. 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 over 45 years. About 230 persons are due to retire within the next 10 years. The situation is similar for the other NPPs. About 220 persons are due to retire within the next ten years from OKG and about 360 from Ringhals.

All licensees have planning in place to transfer competence from experiended staff, soon to retire, to new generations. The planning builds on mapping of strategic competence needs and individual plans to replace key persons. Other approaches used are trainee programmes and to involve young engineers together with

15 Before taxes and minority share.

highly experienced staff in modernisation and development projects as well as in international R&D-projects. Current planning at the different sites is reflected within the frames 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 is however very stable with about 80% men.

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,
- 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 out of 900 will leave OKG, most due to retirement. About 50 (mostly in maintenance and engineering) of the 220 are chosen to participate in a program "Transferring of competence". The main objective is to maintain OKG's strategic competences. Other objectives are to reduce the dependency on consultants, avoid vulnerability because of too few individuals and to prevent lack of competence among the 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. 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 in transferring of competence consists of different steps:

1. map the need of transferring competence, in order to achieve an updated program
2. engage resources, e.g. recruitment or other personnel, identify nestors and adepts
3. produce individual plans
4. carry out the plans
5. evaluate/follow up the plans

Transferring of competence at Ringhals

In seven years, 25% of the Ringhals employees are due to retire. Strategies to transfer the important competencies are based on a annual competence and resource plan, where future needs, mixes of competence, and a balance between Ringhals employees and contractors/consultants are set, and the need for competence transfer is assessed on an individual level. The current plan shows a need for transfer of competence for nearly 100 people until 2012. A "need for transfer of competence" is defined as an activity lasting for at least six months and involving parallel service, participation in specific projects, or other forms of transferring.

Related actions include:

- Cooperation with the university "Högskolan i Väst" to develop a methodology for parallel service, that will be tested during 2007 on recently recruited maintenance technicians and engineers.
- Cooperation with Vattenfall and the technical university KTH aiming to develop a structured model to transfer tacit knowledge, a previously developed concept.

Transferring of competence at Forsmark

Within the next ten years more than 220 employees are due to retire from FKA. The goal for transferring of 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 of 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 task analysis are used to complement available work methods for competence transferring and documentation, e. g. instructions, material for training, work rotation, supervising/guidance, pre-job briefing, in daily working practise. Depending of the level of knowledge and experience receivers/adepts suitable methods 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 receiver/adept and supervisor/guidance. Fore 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.

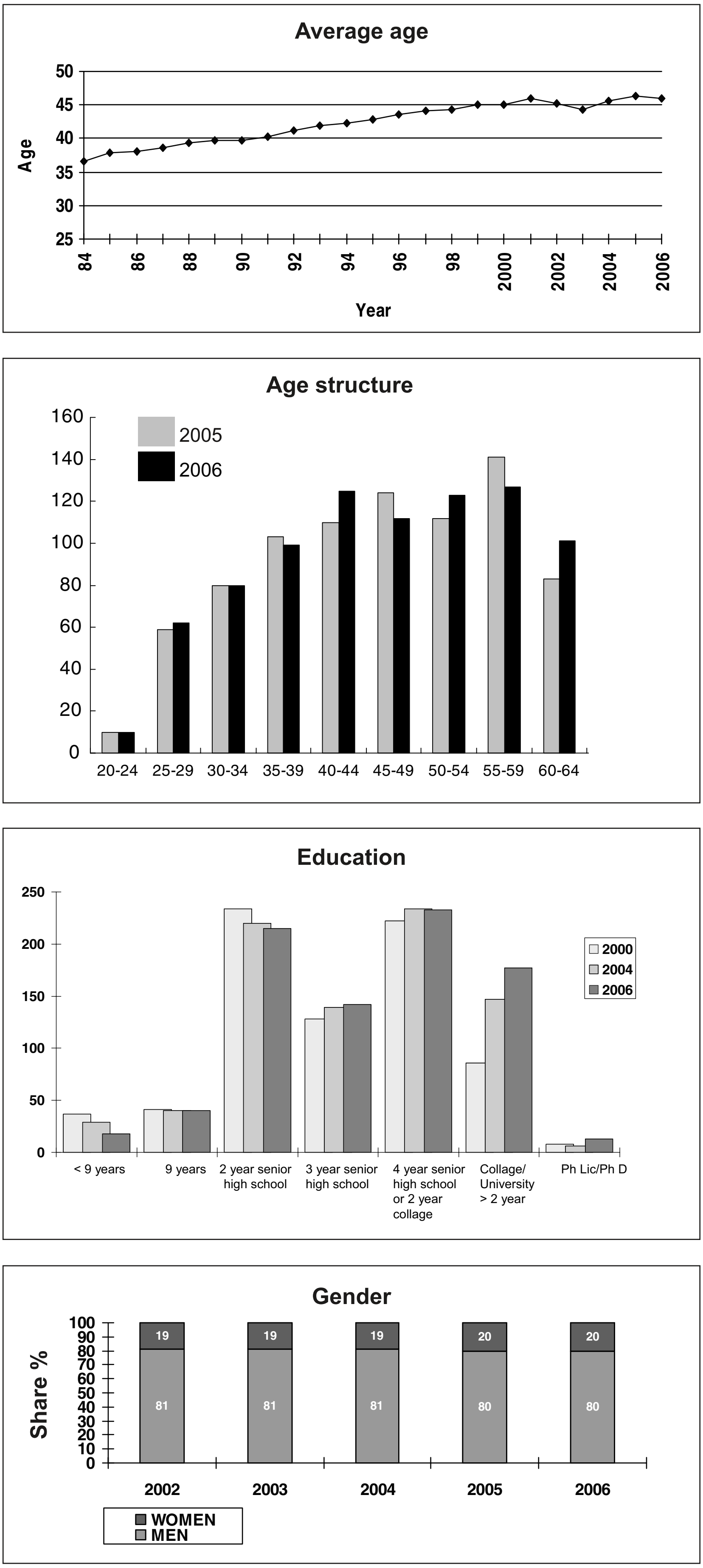


Figure 9. Staffing data from Forsmark NPP.

Training of nuclear power plant staff

All licensees have a systematic approach in place for the training of operations staff. Training programmes are developed based on task analysis and definitions of required competence. A systematic method is used as well to define the annual retraining that is required. The training programmes include theoretical courses, parallel practice with experienced colleagues and 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 about 7 years, if a straight schedule is applied.

The mandatory training programmes typically include basic courses in nuclear technology and safety, plant knowledge including systems, processes and dynamics, operational limits and conditions (STF), radiation protection, plant organisation and work routines. Operations 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 of annual retraining, partly on simulator, divided in two periods, one focused on normal operation start up and shut down procedures and one on transients and accidents. All simulator sessions are systematically evaluated.

Competence assessments are done 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 for issuing of the authorization 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 organisations are responsible for the training of their staff and for providing the necessary resources. KSU (the Swedish Nuclear Training and Safety Center) has taken over most of the operations training and annual retraining on contracts with the licensees. 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. 2006 the company had 195 employees of whom 70 were located to local centres. About 12 000 pupil-days of training were provided. KSU also has an extensive instructor training programme for its own staff with several qualification levels.

During the period 2000–2006, most training of operators has been moved from the KSU central facility in Studsvik to the power plants. Full scale simulators for all operating reactors, except Forsmark 3/Oskarshamn 3 (FO3) simulator, are now located at the plant sites. The new Oskarshamn 2 simulator will be taken into operation during 2007 and a new simulator for Ringhals 2 is under construction. From 2008 Oskarshamn 3 will have a new full scale simulator on site while the old FO3 simulator will remain at Studsvik for the time being and be solely used for the Forsmark 3 training. The old Barsebäck simulator is used for special projects and will remain in Studsvik. Table 9 provides a current overview of the simulator situation.

Going from a total centralised system to a more locally fitted system a lot of benefits have been achieved. Not only have the nearness of the simulators made it more convenient for trainees but it also gives opportunities to test certain systems and lay outs at simulators before installing them on the power plant.

KSU is now investigating the possibility to take a national responsibility for training of maintenance personal. Discussion about using the closed Barsebäck reactors for that purpose is one part of that investigation.

Present full scale simulators and plans for next years

Simulator	Target unit	Taken into operation
B1	Barsebäck 1 and 2, Oskarshamn 2	1975 (will remain in Studsvik)
F1	Forsmark 1 and 2	1990 (relocated 2001)
FO3	Forsmark 3 and Oskarshamn 3	1984 (still at Studsvik)
R1	Ringhals 1	1991 (relocated 2002)
R2	Ringhals 2	1995 (new planned for 2007)
R3	Ringhals 3 and 4	1978 (relocated 2001)
O1	Oskarshamn 1	1993 (relocated and modernised 2002)
O2	Oskarshamn 2	2007 (new)
O3	Oskarshamn 3	2008 (new)

Table 9. Swedish full-scale simulators.

11.4 Regulatory control

The compliance with the SKI requirements on competence assurance was inspected a few years ago at all nuclear power plants. SKI continued to follow up on these inspections and has now concluded that the required systematic approaches are in place at all nuclear power plants to assure long term staffing and competence of operations staff. Issues concerning other staff categories and competence assurance of consultants, will be followed up in 2007.

SKI has also made special inspections of competence assurance of the staff of the independent safety review functions at the plants (see chapter 14). A few gaps were found in the existing professional staff profiles but it was also noted in those cases that recruitments were in progress. All licensees have extended their groups of independent safety reviewers over the last years. According to SKI regulations, these have to cover all forthcoming technical areas as well as human factors issues.

Regarding transfer of competence from the older generation to the younger, a recently financed study by SKI (not issued yet) shows that all the three nuclear sites address this problem, but only one site so far has a formal programme. The other two addresses the issue in a more informal way. SKI will carefully follow up on this issue. Further efforts by the licencees will most probably be needed.

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

In the first national report, concerns were expressed over the future supply of nuclear experts against the background of the uncertainty of future nuclear power in Sweden. The second report painted a more optimistic picture since there were agreements in place to support the university infrastructure for six years, with basic resources for education and research in key nuclear disciplines. It was also mentioned that there were no difficulties experienced so far to recruit the necessary technical staff to the nuclear power plants.

In 2002 the Government appointed a special investigator to analyse the conditions for safety and radiation protection at the Swedish nuclear power plants. The investigator was expected to study the situation for the licensees and the regulatory bodies, especially with regard to resources and competence.

A specific task for the investigator was to review the supply and demand for nuclear expertise, taking into account the start of decommissioning and the fact that the market for vendors and service companies had narrowed. The investigator found that the nuclear industry did not foresee any problem to recruit the necessary qualified staff.

For the regulatory bodies SKI and SSI the situation was similar. They did not foresee any real problems to recruit qualified staff even if SSI had experienced problems in finding some specialists.

The investigator judged that agreements in place between SKI and the industry to support the Swedish Centre of Nuclear Technology and the technical universities (see section A4) will be sufficient for the next ten years to cover the national demands for key nuclear competence. In the longer perspective as more reactors are decommissioned and more approaching their technical end of life, there are reasons to closely monitor the situation.

The investigator showed more concerns about the situation in radiation protection, where higher education and research had decreased over the last years. An increased number of adequately qualified radiation protection specialists will be needed as the nuclear power plants enter their decommissioning phase. It was suggested that the Government orders SSI to investigate the long term needs for strategic national radiation protection competence and suggest measures in order to safeguard the necessary supply of specialists.

At the end of 2004, the Government tasked SSI with investigating the long-term needs of strategic competence in radiation protection and suggesting measures for securing the necessary future supply of specialists. SSI reported the results of the investigation in December 2005.

The investigation represents SSI's assessment of the needed competence during the next 15-year period. Additional resources should be allocated to higher education, especially in the threatened topics radiation biology and radioecology. This should include both means for advanced courses as well as for postgraduate research students. Already accounting for an announced strengthening of research funds of ten million SEK (1.1 million Euros), SSI proposed that additional funds should be allocated for three lectureships and five positions for post-graduate research and/or junior research fellowships, especially in radiation biology and radioecology.

The Government announced in its autumn budget 2005 that there is a need for strengthening radiation protection research in order to secure the national competence. It was suggested that SSI should receive an additional ten million SEK for financing basic and applied research in radiation protection. The new Government that took office 2006, also allocated, with the start in 2007, ten million SEK (about 1.1 million Euros) of annual extra research funds to SSI for radiation protection research.

SSI will use about six million SEK of the new research funds to finance advanced research positions in radiation protection and the remaining almost four million SEK to fund radiation protection research, the primary focus being on basic research and on maintaining competence. The six million SEK will be divided between three research positions, in radiation biology, radioecology, and dosimetry, each attached with either an additional postgraduate research position or a post-doctorate research fellowship and basic resources for the research activities. Each research position will be for three years with a foreseen extension of an additional three years.

With regard to higher nuclear education and research, there is now an agreement between the Swedish nuclear industry and SKI to continue the support of the Swedish Centre of Nuclear Technology economically after 2007, when the present agreement ends (see further section A 4).

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

- Human factors (MTO) competence has been established at all Swedish nuclear power plants.
- The safety culture questionnaires used at the plants have been more closely analysed.
- The project LearnSafe has been completed with several spin-offs for the nuclear power plants as well as the idea to create the Vattenfall Nordic Safety Management Institute.
- The SKI MTO-section has increased from 5 to 8 staff.
- SKI has taken initiative to develop knowledge about conflicts between safety versus economic pressure/ production.
- SKI has taken initiative to further develop safety evaluations of organisations and organisational changes.

12.1 Regulatory requirements

As a result of the 1979 Three Mile Island accident, a human factors programme started at SKI to build competence and to introduce these issues in the regulation of the nuclear power plants. It was later referred to as MTO (interaction between Man-Technology-Organisation). Most of the initiatives regarding control room design and evaluation, staff working conditions, safety management and organisational issues, earlier discussed with the utilities, are now included as requirements in the safety regulations (SKIFS 2004:1 and SKIFS 2004:2.). In general SKI regards the MTO-issues as equally important for safety as the technical issues.

SKIFS 2004:1 includes 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 feed back,
- monitoring and follow up of safety,
- design adapted to human capabilities and limitations, such as allowing time for consideration, adequate information- and announciator systems in the control rooms and good ergonomic design supporting co-operation and communication within the team, design solutions have to be evaluated in a realistic environment.

SKIFS 2004:2 includes 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,
- design requirements to detect and control core instability.

SKI requires the licensees to have adequate human factors competent staff to make independent safety reviews (see chapter 14) of such issues. There is no requirement to have staff with a behavioural science competence in the line organisation of the operators, but SKI recommends this in order to early integrate the MTO perspective 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 organisational structures, which differ between the plants and the different subject areas. All licensees today have MTO specialists in their independent safety review functions (see chapter 14). Line managers and technical specialists in the operating organisations have received MTO training. OKG plans to establish a MTO-department in the operating organisation. More emphasis has been focused gradually upon management, safety culture and organisational issues as important areas for application of the MTO-concept.

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

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

The Swedish licensees use a specific method for the analysis of human factors events called MTO-analysis. The method is based on HPES (Human Performance Enhancement System), which originally was developed by NASA and later modified by INPO. KSU has adjusted the methodology for application in Sweden, and a lot of experience has been gained in using it at 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, HRA, 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 organisational modifications.

Current projects

Organisational change

All licensees have introduced formal procedures for assessment and review of organisational changes. These procedures ensure that relevant safety aspects are considered when such changes are reviewed and notified to SKI in the same manner as technical changes. To further increase knowledge and further develop these procedures, a university graduate project is currently in progress at Mälardalens Högskola.

Safety culture

An overview of the current safety culture programmes at the plants is given in section 10.2. Safety culture questionnaires are used regularly at all plants, and are seen as an important tool for development of the safety culture. Since the previous national report, the safety culture questionnaires has been reviewed and updated in light of recent advances in the knowledge of safety culture. Factor analysis have been performed on data from the plants and revealed a stable data structure – regardless of the specific power plant.

In cooperation with researchers in Finland (VTT) research has recently been conducted exploring maintenance culture in Sweden and Finland (VTT publication 627).

Design

Research on the design of alarm systems is going on at the Chalmers University of Technology in Göteborg.

LearnSafe

The main objective of the EC-sponsored, now finalised, LearnSafe project was to create methods and tools for supporting processes of organisational learning at the nuclear power plants. Organisational learning has become increasingly important for the nuclear industry in its adaptation to changes in the political and economic environment, changing regulatory requirements, a changing work force, changing technology in the plants, and the changing organisation of nuclear power plants and power utilities. The danger during a rapid process of change is that minor problems may trigger a chain of events leading to actual degrading of safety and/or diminishing political and public trust in the safety standards of the particular nuclear power plant, utility or corporation. The focus of the project has been on senior managers at nuclear power plants and power utilities who are responsible for strategic choice and resource allocation. This focus was selected with the understanding that their decisions, approaches and attitudes have an important influence both on safety and economy of the nuclear power plants. The LearnSafe project has developed methods and tools that can be used in the management of change and in ensuring efficient organisational learning. The LearnSafe results also include descriptions of methods and tools that can be used by the nuclear power plants themselves in assessing and improving their performance. Furthermore, LearnSafe has also collected and documented good practices for safety management.

More information is available on the web-site http://www.vtt.fi/virtual/learnsafe/.

One result of the LearnSafe project was the creation of the Vattenfall Nordic Safety Management Institute described in section 10.2.

12.3 Regulatory control

The MTO-section of SKI participates in inspections, safety reviews and other regulatory activities completely integrated with the technical sections. Eight professionals (an increase by three over the last years) with a behavioural science background work at the MTO-section.

Current issues for the department are inspection and review of

- Management systems
- Economy and safety
- Organisational change
- Safety culture
- Safety management
- Competence, training, staffing, fitness for duty
- Working conditions for safety
- Plant modernisations, MTO perspective at plant modifications
- Investigation of events
- Maintenance
- Decommissioning
- Human reliability analysis (currently under development at SKI)

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

- Safety culture assessment – safety leadership in practice, a literature study.
- Event reporting systems – "near misses", lessons learned from other industries such as aviation, methods to measure, register, identify and report near misses.
- Knowledge management – a review of the methods used by the Swedish licensees to transfer knowledge from one generation to the next .
- The decision-making process in operation – a study of how the Swedish NPPs assure through the management systems and in practice that the station remains safe at all times (including the handling of any conflict between safety and economic pressure/production).
- How to measure safety through a safety index – a study of the licensees "safety indices" and their importance for the improvement of safety.

Except these R&D-projects, SKI also supports one professorship in Man-Technology-Organisation at the Stockholm University (currently vacant) and several post graduate studies. SKI also supports the human factors programme of Halden Reactor Project since many years.

12.4 Methods to assess organisational change, update

According to the safety regulations SKIFS 2004:1, the licensees are obliged to notify SKI about organisational changes of importance for safety, before the changes are implemented. SKI can then put additional conditions and requirements on the proposed change. The third national report described the approach used by SKI in its review of such notifications.

Inspections during 2005 and 2006 have shown that the licensees have learned from their experience of the major organisational changes that took place in the early 2000. They have improved their processes and procedures of the management systems with regard to management of organisational change. A review of a few examples of practice also showed that the licensees are following the steps of their processes. However, some opportunities for improvement of the processes/procedures were identified in the inspections, such as a more complete description in the procedures of the factor "assessment of strengths and weaknesses" (baseline assessment) and description of the step in the process to collect experience of similar changes at an early stage within and from outside of the organisation.

One further important step or factor of the process is to assure that periodic safety audits will be performed of the management of organisational change. SKI has found in the inspections that audits are performed according to the plans and the results are used for i mprovements.

SKI has identified a need for improvement of methods of safety evaluations of organisations and organisational changes. Research initiatives in research have been taken to develop such methods in Sweden (Mälardalens Högskola) and Finland (VTT) and SKI will asses this knowledge gained as a basis for regulatory activities.

12.5 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

- All licensees are working continuously to improve their management systems.
- Major changes have been done in the management systems of Ringhals AB and OKG
- Vattenfall AB has required Ringhals AB, FKA and SKB to systematically assess their management systems against the new IAEA Safety Requirements on Management systems GS-R-3.

13.1 Regulatory requirements

The SKI general safety regulations SKIFS 2004:1 chaper 2, 8 § require that nuclear activities: design and construction, operation and decommissioning, shall be managed, controlled, assessed and developed through a management system so designed that requirements on safety will are met. The management system including the needed routines and procedures shall be kept up to date and be documented. This view on quality and safety to be integrated with other business concerns into a total management system, is in line with the recently issued IAEA Safety Requirements on Management Systems, GS-R-3.

It is further required in SKIFS 2004:1 that the application of the management system, its efficiency and effectiveness, shall be systematically and periodically audited 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 recommendations 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 to audit contractors and vendors, and how to keep results form these audits up to date.

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

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

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

13.2 Measures taken by the licence holders

Current development of the management systems

All licensees have integrated management systems in place and are working continuously to improve their systems.

It was mentioned in the third national report that, as a consequence of the formation of the Ringhals group, Ringhals and Barsebäck had modified their existing systems towards a common management system. Now, for the reason of decommissioning of Barsebäck 1 and 2, the Ringhals Group has worked to develop a management system for the Barsebäck plant tailored to the current situation of service operation without fuel on site. As a consequence, Barsebäck and Ringhals again have separate management systems.

Ringhals continues to develop the structure and contents of its management system. Documents are divided in 5 different groups:

- Class 1 documents are related to highest-level management. The documents include directives to all departments and staff units. The plant manager owns the class 1 documents.

- Class 2 documents include those related to plant configuration such as requirements, realisation, inspection, testing, operation and maintenance. The respective production manager owns the class 2 documents
- Class 3 documents include such that govern the processes, i.e. process handbooks, instructions, reports, letters etc. The respective process owner owns the class 3 documents.
- Class 4 documents include such related to individual department internal activities, i.e department handbooks, procedures, reports, protocols, letter of assignments etc. The respective department manager owns the class 4 documents.
- Class 5 documents include those related to project activities such as administrative documents which are created and belongs to the projects, i.e. reports, protocols, time schedules etc. The respective process owner owns the class 5 documents.

Current development work includes full implementation of a new system for management of deviations, issues and experiences. The next step is to add management of event reports.

FKA has not made any major changes of its management system.

In the business plan for 2006–2007 Vattenfall has required Ringhals, Forsmark and SKB to make a comparative study of their management systems against the new requirements and guides issued by IAEA. This comparison shall be reported to Vattenfall's corporate function, and relevant conclusions and recommendations are to be implemented.

Over the last two years OKG has made a major revision of its integrated management system. This development 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 more clear way. Figure 10 is an illustration of the current system.

1. OKG AB - Business
The purpose of this document is to give a brief overview of the company and contains information on OKG:s business strategy and vision, owners, customer and other interested parties. This document also contains the company policies and values.

2. The president's directive on governance, management, assessment and development
The president's directive on governance, management, assessment and development is the overall requirements for the activities of OKG:s business. This document contains the main principles for the management and control of the business, for example giving the requirements for the structure and content of the integrated management system.

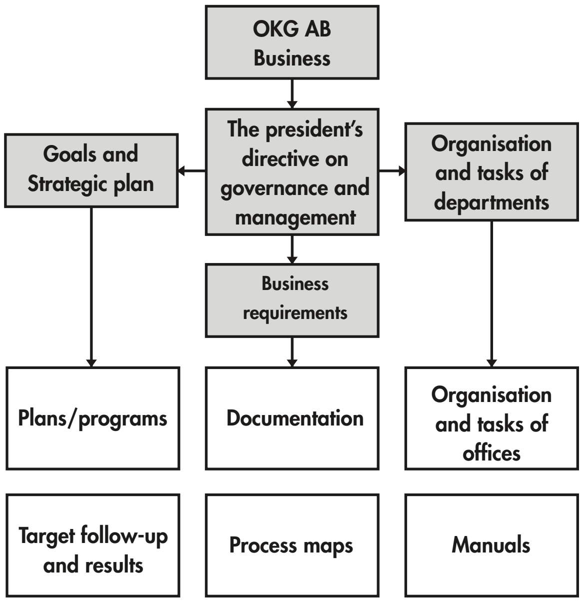
3. Goals and strategic plan
This box contains the targets and the strategic plan for OKG.

4. Organization and tasks of departments
The documents in this box consist of the departmental descriptions of each department's organization, responsibilities and main tasks.

5. Business requirements
This box contains the requirements (legal, regulatory or corporate), the governing rules and guidance for each of OKG:s main tasks.

6. Plans / Programs
In this box you will find OKG:s different plans, such as the business plan for each department and specific programs.

7. Target follow-up and results
In this box the latest information on the follow-up of the targets and indicators at OKG will be made available.



8. Documentation
In this box the administrative and technical documentation at OKG will be found.

9. Process maps
This box contains the process maps of OKG:s entire business.

10. Organization and tasks of offices
The documents in this box consist of each unit and group's descriptions of their organization, responsibilities and main tasks.

11. Manuals
In this box each department will have their business manual containing all applicable procedures for each organizational unit.

Figure 10. Portal to the Integrated Management System at OKG.

OKG has also implemented a new process for handling of new or changed legal, regulatory or corporate requirements.

Furthermore, OKG has established a new Quality department with the responsibility to maintain and develop the integrated management system and also to develop the methods for continuously improvement of the processes within the whole company.

Audit programmes

All NPP licensees have a process to conduct audits and an audit programme, which is utilised to monitor how well the quality system is implemented and applied in the organisation on different levels, 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 during a four-year period. Audit teams consisting of 3–4 individuals, experienced in the reviewed area, and an audit team leader, normally perform the audits. At OKG the programme has been changed to reflect the recent development of process maps.

As mentioned in section 10.2, the Vattenfall business unit "Generation" performs internal audits on the functioning of the respective management systems within its nuclear and hydropower divisions.

Audits of suppliers

Audits of suppliers have for a long time been done in cooperation between the Swedish nuclear power plants and there is a common group for the management and supervision of supplier audits. There is also a common procedure for executing a supplier audit, which is maintained and developed in cooperation between the nuclear power plants.

13.3 Measures taken at SKI and SSI

See section 8.5.

13.4 Regulatory control

SKI has reviewed the management systems of all plants and is of the opinion that they comply with the regulatory requirements. Every year SKI follows up on the work of the licensees to improve the systems. In addition SKI meets annually with every licensee to review the sample of internal audits that has been conducted over the year and the results of these audits. The assessment of SKI is that all internal audits are managed and conducted in a satisfactory manner at all plants.

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

- SKI plans to issue additional general recommendations on the structure and contents of plant safety reports (SAR).
- The licensees are finalising their work to update the safety reports in order to comply with the new more strict regulations in SKIFS 2004:1.
- Reactor specific modernisation plans as a result of SKIFS 2004:2 include revisiting of some earlier deterministic safety analyses of external events and beyond design basis events.
- The WENRA benchmarking project may lead to revisiting of analyses of combinations of independent events.
- SKI has ordered the licensees to amend their newly submitted ageing management programmes.
- SKI has approved the use of risk-informed in-service inspection programmes under certain conditions.

14.1 Regulatory requirements

Safety assessment

Requirements on safety assessment, safety review and reporting are collected in a separate chapter (chapter 4) of the general safety regulations SKIFS 2004:1. The legally binding requirements are summarized in the following points:

- A comprehensive deterministic safety analysis shall be done 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 report shall be prepared before a facility may be constructed. The safety report shall be renewed before testing operation and completed before the facility may be taken into routine operation. The safety reports shall contain information as specified in the regulations. All stages of the safety report shall be reviewed by the licensee as required (twofold safety review), and reviewed and approved by SKI. Thereafter the safety report shall be kept up-to-date.

The safety report (SAR) shall reflect the plant as built, analysed and verified and show how the valid safety requirements are met. All 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 found to be of importance for the safety of the faciltiy, shall be documented and inserted into the SAR as soon as corresponding modifications or other plant measures have been taken.

- After being taken into operation, the safety of a facility shall be continuously analysed and assessed in a systematic manner. Any need for safety improvement measures, engineering as well as organisational, 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 SKI.

The purpose with this periodic safety review shall be to check how the facility complies with the valid safety requirements and assess whether it can be safely operated until the next periodic safety review, taking into account the development in science and technology.

General recommendations are issued on the interpretation and application of the legally binding requirements. In these recommendations the safety analysis conditions are specified. As to the 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.

In Sweden probabilistic assessments have not been used in the licensing of the reactors. The deterministic requirements are still the basis for the licence. However, these requirements should be verified and developed by probabilistic safety analysis in order to achieve a more certain basis for the design. In the general recommendations 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 recommendations on periodic safety review, 15 safety areas (see also section 8.3) are pointed out where the plant shall be assessed with regard to valid regulations, licensing conditions and applied safety standards, as well as against applicable new safety standards and practices. Deviations from valid requirements have to be corrected without delay. Deviations from newer applicable requirements, standards and practices should be assessed with deterministic or probabilistic methods or engineering judgement and reasonable practicable measures defined and included in the safety programme of the plant. The applied review methodology has to be specified in the report.

Verification of the physical condition and operation

Sweden has since the beginning of the 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.

SKIFS 2004:1, chapter 5 on operations include 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 done periodically as well as before structures, systems and components are taken in operation after maintenance or other interventions. Programmes for testing of active components should reflect consequences for malfunction and probability of this occuring. The functional testing has to be done with the frequency and scope that provide confidence that the equipment will function as credited in the safety analyses. Integral tests should be done of the whole safety function. If it is not possible to fully verify the safety function by tests, it has to be justified that the function is sufficiently verified despite limitations of the testing.

As mentioned in section 7.2, specific regulations (SKIFS 2005:2) exist on mechanical components. They contain requirements for use of mechanical equipment, limits and conditions, damage control, accreditation of control organisations and laboratories, requirements on in-service inspection and control, requirements at repair, exchange and modification of structures and components, requirements on compliance control and annual reporting to SKI.

In SKIFS 2005:2 the following new features have been included as a result of operating experience and new insights:

- the scope of application has been extended to include thermal liners, internal sleeves and other devices for protection of pressure and load bearing equipment from adverse loads,

- requirements on in-service inspection and control have been extended to include the metallic parts of the containments[16],
- requirements on investigation, reporting and analysis of damages in mechanical equipment have been made more clear and stringent,
- requirements at modifications of the plant and operational conditions have been made more clear and stringent,
- more guidance is given on application of qualitative risk models for optimisation of control programmes,
- application of the EU directives on load bearing equipment at exchange and modification of Swedish NPPs have been clarified.

Verification of safety decisions

SKIFS 2004:1 chapter 4, 5 § stipulates that technical or organisational modifications to a facility which can affect the conditions specified in the safety report, as well as essential modifications to the report shall be subjected to a twofold safety review. Before the modifications may be implemented, SKI shall be notified of the modifications.

Chapter 4, 3 §, specifies the requirements on 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 done within those parts of the licensee 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 (twofold review). 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 way 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 met,
- whether proposed measures will lead to a maintained or increased safety level.

SKIFS 2004:1 also includes requirements on use of the twofold safety review in other cases than those to be notified to SKI. One example is review of emergency operating procedures and beyond design basis accident management guidelines.

SKIFS 2004:1 also stipulates (Chapter 2, 9 § point 4) that decisions on safety issues shall be preceded by sufficient preparation and advise so that all aspects of the issues are considered. Except of the twofold safety review, a safety committee should be established to provide advice on principal safety issues.

14.2 Measures taken by the licence holders

Safety assessment

Safety reports

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

16 SKI's investigations and research show that the risk for environmentally induced damage or other degradation of the Swedish NPP's concrete containment parts is low, but identified damages over the last years have shown that deviations from construction specifications have resulted in damages at a later stage. Therefore SKI plans to extend the regulations also to include the concrete parts of the containments. This is planned for 2008.

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 shut down of the five oldest BWR reactors in 1992 and 1993, to improve the emergency core cooling systems, the utilities initiated major reassessments of the final safety analysis reports for the older reactors. The reassessments started with pilot projects in 1993/94 and were scheduled for completion before 2000. The objectives have been

- to develop complete modern safety 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 organisations,
- 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 was finalised in 2005.

As a result of more stringent regulations in SKIFS 2004:1 the work has continued to supplement the SARs with additional information. Some additions that recently have been made or are in process are the following:

- how the requirements on design and construction in SKIFS 2004:2 are being met,
- extending of the systems descriptions beyond the safety systems to include other SSCs of importance for the defence-in-depth,
- extending descriptions of organisational principles and safety management provisions.

Ringhals AB and OKG expect to have completed this updating during 2007. FKA has done most of the work. By this the all NPPs will have up to date safety reports complying with Swedish regulations.

Still the SARs will need to be continuously updated over the next years with the plant modifications following from the ongoing modernisation and uprating programmes (see sections 6.2 and 6.3). SKI requires that for major plant modification project, such as the modernisation and uprating projects, a PSAR is developed which is then renewed before testing operation and completed before routine operation. This structure prepares well for updating of the SAR documents. SKI would like the SAR to be updated within three months after implementation the respective plant modification.

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

- periodically checking up on the release of new codes and standards,
- assessment of applicability of new requirements,
- decision on specific application for the plant,
- revision of the requirements in the SAR.

As an example, OKG has a norm committee of nine members holding monthly meetings. If it is concluded that the SARs should be changed , the matter is handed over to the department of technology and reactor safety. In the future a co-operation in the evaluation of new codes and standards is foreseen between all Swedish licensees.

Deterministic safety assessments

The safety analyses of the Swedish plants were from the beginning essentially structured according to the US rules. The events to be analysed were divided into different classes depending on expected frequency and severeness of the event. The highest class contains the design basis accidents (DBA), typically a large loss of coolant accident: double ended guilliotine 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, a large part of the fission products was postulated to be released to the containment. It was then proven 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 18.1) were satisfied.

As a result of the new regulations SKIFS 2004:2, the need for updating and extension of certain analyses have been identified and included in the reactor specific implementation plans (see section 6.2). This has mainly to do with a few external events and some beyond design basis events.

Probabilistic safety assessments

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) was required to be included in the first cycle of PSR. In the second cycle of PSR a more comprehensive PSA was required.

Extensive development of the methods and tools for PSA has been undertaken over the years. As a result, up-to-date software and considerable expertise exists both within the Swedish utilities, authorities and consultants/vendors. One item of particular importance is the reliability data base accumulated from operational experience since 1977. This data base is systemized in the so-called reliability handbook (the T-book), which provides specific reliability data of high quality for a large number of components.

According to the safety regulations SKIFS 2004:1, all Swedish reactors shall be analysed with probabilistic methods to supplement the basic deterministic safety studies. All power reactors are required to have 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 level 1 and level 2 studies. The level 1 studies have been updated continuously with regard to plant modifications. Work has been going on to fill some gaps in the level 1 studies and to finalise studies for low effect, area events and external hazards. The current situation is summarised in the simplified table below where the latest basic version of the studies are indicated.

Unit	Level 1	Level 2	Fire, Flooding	Low power, Refuelling	Start up- and shut down	External events
Forsmark 1 and 2	2006	2006	2006	2006	2006	2006
Forsmark 3	2006	2006	2006	2006	2006	2006
Oskarshamn 1	2005	2005	2005	2005	2005	2005
Oskarshamn 2	2004	2002 2007	2003	2007	2007	2004
Oskarshamn 3	2004	2006	2003	2004	2003	2005
Ringhals 1	2006	2006	2006	2006	2006	2006
Ringhals 2	2004	2004	2004	2001	2004	2004
Ringhals 3 and 4	2004	2004 2007	2004 2007	2004 2007	2004	2004 2007

Table 10. Latest PSA versions reported to SKI. Italics= planned updates and completion of limited studies.

The basic PSA studies are now undergoing a regular updating every year taking into account the past year plant modifications which have impacted the PSA-models. In principle most licensees are moving towards Living PSA. PSAs results are also routinely used 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.

Many safety improvements have been done over the years based on PSA. Generally, they cover measures to protect against common cause failures, improvement of fire protection, improvement of operator support and improvements in maintenance and testing. PSA results have been a very important input for the completed modernisation of Oskarshamn 1 and currently for the planning of measures to comply with the new regulations SKIFS 2004:2. Other current applications of principle interest are a proposal by Ringhals AB to use a risk-informed in-service inspection programme for the piping of Ringhals 2 (the RIVAL-project) and a common project for all Ringhals units “Streamlined Reliability Centred Maintenance”, (SRCM), a system to be combined with traditional maintenance methods. The RIVAL project is based on a procedure developed by the Westinghouse owners Group (WOG).

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

Periodic safety reviews

The NPP 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 valid 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 SKI.

New from 2005 is that the PSR should include 15 defined safety areas as well as an integrated assessment. The areas are the same as used in the SKI inspection programme (see section 8.3).

Periodic safety reviews started in Sweden in the early 1980’s as a result of the Three Mile Island accident. The requirements on the reviews have developed over the years and are now quite similar to what is recommended in the IAEA safety standards. The first and second cycle of periodic safety reviews are completed for all reactors. Three SKI reports are pending. The current status of the programme is shown in table 11 below.

Reactor unit	Licensee report completed	SKI review report completed
Oskarshamn 1	2004 (third)	2004
Barsebäck 2	1995 (second)	1996
Ringhals 2	2004 (third), rev 2005	2005
Oskarshamn 3	2006 (second)	–
Forsmark 3	2005 (second)	–
Ringhals 1	2006 (third)	–
Oskarshamn 2	1999 (second)	2004
Forsmark 1 and 2[17]	2001 (second)	2003
Ringhals 3 and 4	2002 (second)	2004

Table 11. Latest versions of periodic safety reviews.

The periodic safety reviews are submitted to SKI, which makes a comprehensive review and assessment of the submitted report and its references. This regulatory assessment is submitted to the Government.

The licensee is required to take the initiative to begin a PSR and to inform SKI that the planning starts. A meeting is held with SKI to discuss the proposed scope, contents and methodology of the review. Typically a project is formed to conduct the review, involving 15–20 staff of the operating organisation. An objective is to involve a few young engineers in every project in order to transfer knowledge. The total work effort is calculated to the order of 8–10 man years.

Since all NPPs 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 organisational learning has taken place. Probabilistic safety analysis is now a safety activity of its own and is not any longer done as part of the periodic safety reviews.

Safety programmes

All licensees have safety programmes in place as required by SKI regulations SKIFS 2004:1. The programmes are part of the management systems documentation. They contain priorities and time schedules for technical,

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

organisational and administrative measures to be implemented as a result of safety analyses, audits, safety culture surveys and other evaluations done at the plant.

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. Recent developments have been to adapt the programmes to new SKI regulations. 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 procedures and all test results are reviewed and documented.

Verification of the operability of safety systems when going from shut-down to a power operating mode has been paid specific attention after some earlier incidents, and is today ensured by use of a great number of parameters, computerised tools and new procedures. This is further commented in chapter 19.

In-service inspection

In order to document the industry's interpretation of the new regulations SKIFS 2005:2, the Swedish NPPs 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 an aid for the development of plant specific documents in these areas.

Organisations required for the qualification of NDT-systems and techniques as well as for carrying out and evaluating such inspections have been established already according to earlier regulations.

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 to be 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, damage which has been found in Swedish or foreign installations, or new research information with relevance to the safety of mechanical equipment in the NPPs. The volume of inspections is high, between 1000 and 5000 inspections and tests are done every year per site.

Extensive exchanges have been done at all reactors of piping that has shown to be sensitive to damage. Many of these changes have been done for preventive reasons as knowledge has been gained on damage causes and mechanisms. In other cases changes have been made when damage has occurred. During 2006 relatively few damages and deficiencies have been detected. Earlier identified problem areas have been followed up and analysed.

Preventive maintenance

Maintenance in systems important for reactor safety, and for other systems and structures as well, is optimised with regard to the relation between corrective and preventive maintenance. The preventive maintenance implemented at the Swedish NPPs 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 is 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 SKIFS 2004:1 make it generally possible to perform preventive maintenance during operation, if this is specified in the OLCs and within the conditions analysed and described in the basic safety report (SAR).

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

Modification activities are carried out also 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 NPPs. They are part of the long-term plans and strategies included in the safety programmes.

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 NPPs. 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 SKI and issues to be notified to SKI as well as other important safety issues are reviewed a second time by the safety department within the plant organization, but which is 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 functions 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 points of view clearly marked. 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 safety review committees and councils at different levels of the utility organisations. They exist in some cases at the unit level, normally on the site, and also at the utility level (see section 10.2). They are manned by individuals representing different disciplines in order to achieve a broad view of the discussed subjects. 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 character, such as event and scram-reports, operational experience from other plants, and safety issues linked to OLC and to modifications. Committees working on the site or on the utility level focus on principal issues such as safety policy and strategy, the plants' adherence to the authorities' regulations, and general reviews of the safety and quality activities.

International peer reviews

See sections 9.2 and 10.2

14.3 Regulatory control

Safety analyses and safety reports

SKI is in the process of reviewing updated safety reports as a result of notifications related to the modernisation programmes to comply with SKIFS 2004:2 and the PSARs required in the application for power uprates. This review process will continue over the next years. SKI's review aims at checking that the updated SARs comply with the requirements on structure and contents stipulated in SKIFS 2004:1. SKI has already noticed substantial improvements of the submitted safety documentation, but is in some cases SKI is not satisfied with parts of it and has required further efforts. In order to make the expectations more clear, SKI plans to issue additional general recommendations to the requirements in SKIFS 2004:1 on the structure and contents of the SAR. These recommendations are planned to be issued by the end of 2007.

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

The periodic safety reviews are submitted to SKI, 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, SKI uses all the material available from inspections and assessments of the reactor during 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 bodies have typically issued a number of recommendations. However, to date no periodic safety review has resulted in a questioning of the operating licence of the reactor.

Inspection and testing

SKI has inspected the management of in-service-inspection at the plants in connection with broad inspections of safety management at all plants. Also in connection with events, such as the deficent torioid welds in Forsmark 2006 (see section 6.1) SKI has made a special review. The principle used for the regulatory control of mechanical equipment is that detailed review of design specifications, design calculations, welding procedures, manufacturing procedures and also observation of these activities, is done 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 SKI regulations SKIFS 2005:2. An overview of the control system is given in the frame below.

Over the last years SKI has noticed a larger interest by the licensees to use quantitative risk-informed models to optimise the inspection programmes. I these models probabilistic break mechanical models are combined with probabilistic safety analyses of the plant. The primary motive for use of these models is to reduce costs for inspection and testing. Therefore it is necessary for SKI to make sure that the changes can be implemented without increased risks for core damage and releases to the environment. SKI has, as well as safety authorities in other countries, posed strict requirements on indata to the models and validation of the models.

During 2006 SKI completed a new regulatory review of an application by Ringhals AB to use the risk-informed in-service inspection programme (RIVAL) for the piping of Ringhals 2. SKI concluded that the use of the RIVAL-procedure has given a good overview over the risks from the passive mechanical components of the reactor. However, SKI also had some remarks about how the WOG-procedure had been applied and decided on a number of conditions for the further use and development of RIVAL-applications at Ringhals 2. SKI also concluded that more research is needed on risk-informed inspection programmes. RIVAL-applications are expected to be extended to Ringhals 3 and 4 (also PWRs) during 2007.

Regulatory control of inspection and testing of plant structures, systems and components
In SKIFS 2005:2, SKI requires certain inspections and inspection intervals of specified components, such as reactor pressure vessel nozzles. Except of those required inspections, the licensees have to divide the mechanical components of the plant into inspection groups quality classes and. The inspection groups determine the extent of the in-service inspections. The principles for making this division have to be approved by SKI. The inspection programme resulting from the use of the principles shall be approved by an accredited inspection body certifying that the programme follows SKI's decision.

Three inspection groups A, B and C are used where A includes components with the highest relative risk and C 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 damages that can affect the component. Such qualification is assessed and approved an independent qualification body that is approved by SKI.

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

Hence, the Swedish system builds on decisions by SKI on principles, methods and modes for inspections and testing. Accredited inspection bodies are reviewing the inspection programmes in detail and issue certificates on compliance with SKI decisions. A qualification body approves the non-destructive testing systems used and certifies 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) decides about accreditation of laboratories and inspection bodies. SKI decides about approval of qualification bodies. SWEDAC makes annual inspections and follow ups of the accredited inspection bodies. SKI, as the competent authority for nuclear matters, supports SWEDAC in this supervision of the inspection bodies.

Ageing management

As mentioned in section 14.1, SKIFS 2004:1 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. Since this was a new requirement in SKIFS 2004:1 licensees were given time until 31 December 2005 to submit ageing management programmes to SKI.

During 2006, SKI has reviewed the submitted programmes and found that amendments and improvements are needed to a varied extent. Some programmes were limited to passive components of long life. For active components references were made to ordinary inspection, testing and maintenance programmes. This means that the integrated programmes need to be supplemented and extended as well as to make clear how the existing programmes on surveillance, in-service inspection and testing shall be included in the integrated management of ageing at the plants. Therefore, SKI has ordered all licensees to submit by the end of 2008 extended ageing management programmes as well as amended management systems in order to assure an effective and comprehensive ageing management.

Review of notifications

As mentioned, the licensees have to notify SKI before implementation of all plant and organisational 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 shall be added to the notification. A standing group of experts, from different SKI departments, has been established 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, or
- the notification should be further reviewed in specified aspects,
- the proposed modification should not be allowed until SKI 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 SKI has in the self-inspection of the licensee. For instance, if a notification has to do with new or complex technology, is of high safety significance or confidence is low, there is a high probability that this notification will be reviewed further. The department head makes the final decision whether to review further or not.

SKI now have several years of experience with this model. After some initial problems, it can be concluded that the notification routines are running smoothly and meet the expectations of SKI. It is also clear that SKI has the necessary regulatory control of the modifications, without having to review everything in detail and issue approvals. In that way resources can be released for other important safety tasks.

In year 2004, a total of 169 technical, organisational and documentation change notifications were submitted to SKI from the operating NPP licensees. 32 of the notifications resulted in a review by SKI. Corresponding figures for 2005 are 231 notifications of which 48 were reviewed further and the number of notifications 2006 was 261 of which 48 were further reviewed. In some cases SKI imposed further conditions on the modifications, and in a few cases SKI halted the implementation of the modification until further investigations could be made. The more detailed statistics of last years can be seen in the table below. The table also illustrates the increased review burden of SKI in connection with the modernisation projects and uprating of the plants. This will further increase over the next years.

Year	Licensee	Number of notifications	Further review
2004	BKAB	20	5
	FKA	31	4
	OKG	69	11
	RAB	44	12
2005	FKA	55	10
	OKG	82	16
	RAB	94	22
2006	FKA	54	18
	OKG	101	20
	RAB	106	40

Table 12. Number of notifications to SKI from the operating NPP licensees 2004–2006.

As mentioned in section 11.4 SKI has recently inspected the staffing and competence of the independent safety review functions at the plants and noticed that all licensees have extended these functions. Remaining gaps in the competence profiles are being filled.

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

- SSI is in the process of updating some of the regulation on radiation protection
- After the closure of Barsebäck 2 in 2005, the radiation protection organisations at Barsebäck and Ringhals have separated.
- The planned and partly implemented power uprates have been studied with regard to the effect on radiation doses to the personnel, and the releases of radioactive substances have been studied. SSI has tasked an international consortium to make an inquiry into the radiological consequences of power uprates at light water rectors worldwide. The study will be finished during 2007.
- Action programmes for the reduction of effluents from nuclear power plants are prepared and introduced.

15.1 Regulatory requirements

Occupational radiation protection

The Swedish occupational radiation protection requirements aimed at the nuclear power plants are similar to those of other EU Member States. The most important requirements are the following:

General requirements and dose limits

Anyone who conducts a practice with ionising radiation shall ensure that

- the practice is justified by which is meant that the use of radiation gives a benefit that exceeds the estimated health detriment caused by the radiation,
- the radiation protection measures are optimised by which is meant that human exposures are as low as reasonably achievable social and economic factors taken into account, and
- no radiation dose limit is exceeded.

Limits for workers regarding effective dose and equivalent dose per calendar year are as follows (SSI FS 1998:4):

Effective dose	50 mSv
Equivalent dose to the lens of the eye	150 mSv
Equivalent dose to skin, hands and feet	500 mSv

In addition, during five (5) consecutive years, the total effective dose shall not exceed 100 mSv.

The regulations also stipulate special rights for breast-feeding or pregnant woman to be transferred to work that does not imply risk of internal contamination with radioactive substances or exposure to ionising radiation. If a pregnant woman remains at her ordinary work, the work shall be planned in such a way that the equivalent dose to the foetus becomes as small as reasonably achievable and that it is unlikely that it exceeds one (1) mSv during the remaining period of pregnancy.

Medical examination

A medical examination for radiological activities is required at least every third year. The employee must each year submit a new certificate as proof of that he/she is fit for service. The medical doctor issues this certificate based on a specified medical examination or, which is allowed in the intervening years, on a health declaration filled out and signed by the employee.

Supervised and controlled areas

The surveillance of workplaces shall be made using suitable methods with respect to present kinds of radiation, energies, and the physical and chemical properties of radioactive substances. The results shall be recorded and, if necessary, provide possibilities to calculate individual radiation doses.

Workplaces and premises where persons might receive an effective radiation dose, resulting from the radiological activities; exceeding one (1) mSv shall be classified as supervised area. The supervised areas must be marked and instructions for work in such areas are required.

If there is a risk for spread of radioactive contamination or the annual effective dose can exceed six (6) mSv, taking into account the risk of mistakes and accidents, the workplace/premises shall be classified as a controlled area. The access to controlled area is restricted and special education is required. Persons working in a controlled area shall wear a personal dosimeter. It shall be forbidden to smoke or consume food in controlled areas.

Anyone who runs a practice shall for each controlled area lay down local instructions, in written, about how the work should be performed and what protective measures should be taken by those who work in the area. The instructions shall be adjusted according to the kind of work and the radiation sources and shall be available at the workplace.

If radioactive substances may contaminate surrounding areas, the operator shall introduce the necessary measures to prevent the spread of contamination outside of the controlled area. When exiting the controlled area, all persons shall be monitored for external radioactive contamination.

Within a controlled area, premises and places shall be specially marked and admittance restricted, if the risk of receiving a yearly effective dose exceeding 50 mSv in these places is not negligible.

Information and education

All personnel, permanent staff and contractors, shall be informed about radiation protection prior to work within a controlled area. Repetitive information shall be given at least every third year. The regulations uses a graded approach; i.e. for personnel working with radiation protection issues, personnel working with operation and maintenance and contractors in charge of work management, extra radiation protection education are required. The training shall be adjusted to the scope and type of the performed work and to the existing radiological working environment.

Personal dose monitoring

All personnel including contractors, on entering a controlled area, shall carry a personal dosimeter that fulfils certain requirements. Before leaving the controlled area, they shall be monitored for external radioactive contamination. All persons for which there is suspicion or confirmation of internal contamination with radioactive substances shall be measured in a whole-body counting system so that the committed effective dose can be estimated.

Optimisation

The work shall be performed in such a way that human exposures are limited as far as reasonably achievable, economical and social factors being taken into account. For this purpose, the licence-holder shall ensure that documented goals and actions for the optimisation work are established and that necessary resources are available in order to perform the actions and work towards the established goals.

Site-specific instructions concerning radiation protection

The licence-holder shall ensure that site-specific instructions for radiation protection are established.

Visitors

Visitors from the public are allowed in a controlled area if guided by designated persons and a prearranged visit plan is followed. Visitors to controlled areas must be at least 14 years old.

Instruments and equipment

All instruments used for radiation protection and the control of radiation doses shall be calibrated and undergo regular functional checks. The dose rates in the calibration set-up shall at least every second year be checked towards an instrument that is calibrated at a test-house that is accredited for ionising radiation. Alternatively, the instrument may be calibrated directly at an accredited test-house.

Transport within the facility

All transport of radioactive substances within the industrial area shall with regard to the requirements on dose rate, surface contamination or the transportation package, as far as is practical, follow the international regulations regarding the transport of hazardous goods on roads.

Work with irradiated fuel elements

Work with dismantling of irradiated fuel elements in the reactor pool, when individual fuel rods are handled, must not take place earlier than five days after the reactor is put into the cold shut down mode. During work with fuel rods only persons directly involved may be present in the area. The air shall continuously be monitored for air-borne and gaseous radionuclides during this type of fuel dismantling work. Documented instructions for alarms and evacuation of the premises shall be developed. The content of these instructions shall be well known by all persons working on the premises.

Policy in the event of fuel damage

A documented policy for the event of fuel damage shall be established at all facilities where nuclear reactors are involved. The policy shall include a description of the facility's strategy for avoiding fuel damage as far as reasonably possible. In addition, there shall be a strategy for how to handle a situation if fuel damage occurs.

Reporting to SSI

An annual written report shall be sent to SSI that contains a compilation of the radiation doses to personnel as well as the results of the radiation surveillance outside the controlled area.

Any work for which the total collective dose is expected to exceed 100 mmanSv shall be reported in writing to SSI in advance. No later than 3 months after the work for which the total collective dose has exceeded 100 mmanSv is finished, a written report shall be sent to SSI that includes the experience obtained concerning radiation protection matters.

Any internal contamination occurring, in one single event, which is estimated to result in a committed effective dose exceeding five (5) mSv shall be promptly reported after discovery to SSI. The report shall include the type of intake, the estimated committed effective dose and the basis for the calculations, as well as the cause and circumstances of the internal contamination.

If there has been an event that led to, or could have led to, exeeding any given dose limit (SSI FS 1998:4) a report shall promptly be sent to SSI.

Documentation and filing of measurement data

Primary data on the evaluation of individual radiation doses due to external as well as internal exposure shall be kept at least one year after the calendar year in which the measurements were made. From the results of these evaluations, it shall be possible to correlate a measured dose to the person that received that dose. The final dose results shall be available in a central national dose register that is approved by SSI. The dose records shall be kept until a person have reached 75 years, however at least until 30 years after work with ionising radiation has stopped.

Radiation protection manager

The licensee shall appoint a radiation protection manger. This person shall be approved by SSI and have sufficient competence in matters related to radiation protection.

SSI has commenced the work to update some of the existing radiation protection regulations. Areas that are reviewed and where changes in the existing requirements are planned are the radiation protection organisation, radiation management programmes, including internal reviews, and the radiation protection education. SSI plans to issue the new regulations during 2007.

Both SSI and the nuclear industry have studied the effects on radiation protection of the planned, and already partly implemented, power uprates at some Swedish nuclear power plants. SSI has tasked an international consortium to make an inquiry into the radiological consequences of power uprates at light water rectors worldwide. The study started during 2006 and it will be finished during 2007.

Environmental radiation protection

The regulations (SSI FS 2000:12) on protection of human health and the environment from discharges of radioactive substances from certain nuclear facilities entered into force on 1 January 2002. These regulations apply on nuclear power reactors, research reactors, fuel fabrication facilities, storages for spent fuel and waste disposal facilities during their operational phase (shallow land burial sites are excluded). The most important provisions are described in the following subsections.

Dose constraints and critical group

The dose limit for members of the public is one (1) mSv per year from all contributing practices involving ionising radiation (SSI FS 1998:4). Taking into consideration that an individual may be exposed from more than one source of radiation, a dose constraint for the discharges from a particular site is set to 0.1 mSv per year in the regulations SSI FS 2000:12. The licensee has to show that the doses from discharges are below 0.1 mSv per year to the most exposed individual (critical group).

Some of the radionuclides will be present in the environment for a long time and the dose constraint of 0.1 mSv is compared with the effective dose calculated as the sum of doses from direct exposure (external exposure) and dose commitments (internal exposure) resulting from a yearly discharge. SSI has decided that an integration time of 50 years shall be used when calculating dose commitments. When the calculated dose is 0.01 mSv or more per calendar year, realistic calculations of radiation doses shall be made for the most affected area. These latter calculations should use the measured dispersion data and the knowledge about the most affected area.

Discharge limits

SSI has formally not defined any nuclide-specific discharge limits. Limitation is done through the restriction of the radiation dose to the critical group. Thus, for each nuclear facility and for each radionuclide discharged, site-specific discharge-to-dose values have been established. These values have been pre-calculated for persons in hypothetical local "critical groups", considering meteorological dispersion conditions, assumed eating habits and the contribution of locally produced foodstuff to the food intake.

Use of Best Available Technology

The Best Available Technology (BAT) shall be used for reducing the discharges at nuclear facilities. For this purpose, for nuclear power reactors, the concepts of reference and target values are used.

A reference value is a value that for the release of individual radionuclides or groups of radionuclides signifies the optimal operation of the reactor in terms of performance and management of systems of importance for the generation, elimination, or delay of discharges into the environment. The selection of relevant radionuclide(s) should be based on their, e.g., impact or indicative function of the system performance. The operator shall draw up and formulate reference values for a specified period and these are subsequently reviewed by SSI.

A target value defines the operator's ambition in terms of discharge limitation, taking into account, inter alia, the use of the BAT concept. The operator shall define target values and the periods within which to reach the targets.

The discharge of radioactive substances to the environment shall be measured. In particular, discharges to the atmosphere via the main stacks of nuclear power reactors shall be controlled through continuous nuclide-specific measurements of volatile radioactive substances such as noble gases, continuously collected samples of iodine and particle-bound radioactive substances, as well as measurements of C-14 and tritium.

Releases of radionuclides to water shall be controlled through the 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.

Environmental monitoring

Environmental monitoring shall be conducted in the surrounding areas of nuclear facilities in accordance with monitoring programmes formulated by SSI. The environmental monitoring programme specifies type of sampling, sample treatment, radionuclides considered, reporting, etc.

The site-specific monitoring programmes are divided into one terrestrial and one aquatic part. The environmental samples consist of local flora and fauna e.g. algae, fish, shellfish, mosses, game and sediment as well as local food products (grain, milk etc.). The selection of environmental samples (biota and sediments) has been done in order to be highly representative of the area around the facility and to, preferably, be similar (or have a similar function in the ecosystem) for all facilities. In addition, some of the species have been selected because they are part of the human food chain.

Every year a basic monitoring programme involving spring and autumn sampling is carried out. Furthermore, certain samples are taken on a monthly and quarterly basis. In addition to the basic programme, extended sampling is also conducted every fourth year. The extended programme focuses exclusively on samples taken in the marine environment.

Sampling at and outside the facilities is generally performed by the Swedish Board of Fisheries. The samples are analysed by the facilities themselves or by external laboratories, which must have an adequate system for quality assurance. To verify that the facilities comply with their programme, SSI performs inspections and takes random sub-samples for measurements at SSI or at independent laboratories.

According to the regulations, quality assurance and documentation of environmental monitoring shall be provided in accordance with the principles of the ISO 9000.

Reporting

The nuclear power reactor licensees shall annually report to SSI adopted or planned measures to limit radioactive releases with the aim of achieving the 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 semi-annually to SSI. The report concerning the second half of the year shall simultaneously be the annual report.

Events that lead to an increase in releases of radioactive substances from a nuclear facility shall as soon as possible be reported to SSI, including a description of the actions taken to reduce the releases.

15.2 Measures taken by the licence holders

The three 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.

The organisation of radiation protection at the nuclear power plants

The radiation protection (RP) resources are centralised at all Swedish nuclear power sites but normally though, some individuals are still allocated to specific units. Particularly during the refuelling outages, the plant operators frequently hire external RP personnel. The fraction of the hired RP personnel is typically as high as 70–80% of the total demand during the outage.

Since the closure of the last reactor unit at the Barsebäck site in May 2005, the Ringhals and Barsebäck organisations have again been divided into two separate organisations. RP personnel from Ringhals perform some services at the Barsebäck site on a contractual basis.

Internal procedures for radiation protection

No fundamental changes have taken place within this area, but procedures are updated continuously due to organisational changes, changes in SSI regulations or other internal and external factors. A trend has been, partly due to the centralization of the RP resources but also as a goal in itself, to harmonise the procedures at a site and only have unit specific procedures when necessary. E.g. at the Forsmark site there is since some years now harmonized procedures regarding RP areas, including for example radioactive waste handling and release monitoring, with only a minimum number of unit specific procedures necessary.

System radioactivity measurements

As a complement to periodic measurements of activity build-up and dose rates in various reactor systems, three of the ten operating Swedish reactor units, Ringhals 1, Oskarshamn 1, and Oskarshamn 2 have on-line activity measurement systems installed in order to measure the activity build-up on system surfaces.
The measurements are nuclide-specific and allow the operators to follow the response and the transients in the reactor water when injecting, for instance, hydrogen and/or zinc, which are used for keeping the oxygen content in the reactor water at a low level and reducing the dose rates respectively. On-line dose rate measuring at several places, primarily in reactor water-cooling and clean-up systems, is applied at more reactor units in order to follow the dose rate situation continuously.

At Forsmark, all units perform on-line nuclide-specific gamma measurement, mainly aimed as a tool for early detection of fuel damage. There is no zinc injection in the Forsmark reactors. The on-line measurement system for the off-gas system will be modernized during 2007 for all units.

Dose reduction and ALARA programmes

The following list exemplifies introduced measures for reducing the dose rates and the radiation doses at the nuclear power plants.

- The zinc injection method was in Sweden first used at Barsebäck 2. In 2003, zinc injection started at the reactor units Oskarshamn 1 and 2. The operator OKG AB continuously follows the effect of the zinc injection on the radiation levels. At unit 1, the outcome is somewhat better than expected but at unit 2, the outcome is much better than expected. For example, dose rates on decontaminated pipes at unit 2 were during 2006 only 20% of the dose rates before decontamination and zinc injection.
- Forsmark 3 has performed a partial decontamination in the residual heat removal and core spray systems in connection with piping replacements in 2001. In year 2006, the recontamination was still only approximately 30% of the original value.
- The operators at Oskarshamn have regularly performed system decontaminations ahead of major work in the primary systems of their reactor units. As an example, during the first stage of the Oskarshamn 2 modernisation, project PRIM, it was estimated that a collective dose of approximately 2.5 manSv was saved due to reduced radiation levels.
- Replacement of valves to such without the cobalt-containing alloy Stellite is done at the plants in parallel with that other work is performed on the valves.
- The OKG and FKA programmes "Clean systems" (Foreign material exclusion programmes) aim at preventing foreign material intrusion, an important factor to reduce radiation doses since it decreases the risk for fuel damage and improves the radiological working environment around the lower plenum. At Forsmark, mandatory information/education on the content and demands of the programme is given to all persons working in the controlled area. This training is realised using an interactive data program on a web site.
- All plant operators have a policy for the management of fuel damage that gives guidance on when to stop the reactor for fuel replacement. This has resulted in decreasing levels of uranium contamination on the reactor cores, which subsequently has lowered the radiation levels in the stations as well as reduced radionuclide discharges to the environment.
- Forsmark has established an ALARA group that meets 3–4 times per year to evaluate and develop the ALARA programme. Focus has also turned from mainly collective doses to concentrate more on individuals with yearly doses of more than 10 mSv. For total collective dose the goal has been lowered to 0.8 manSv/GW(e), with the aim of reaching 0.6 manSv/GW(e) of year 2011. A formal goal is now also that nobody should receive a radiation dose exceeding 0.3 mSv from internal contamination.
- Ringhals is currently developing new methods for cleaning water-borne activity and conventional chemicals from different sources
- Ringhals continues the work with optimisation of chemistry conditions in PWR reactors to minimise the production of activation radionuclides and their deposition on system surfaces.

Environmental radiological surveillance

After new stricter requirements from SSI concerning the measurement of tritium and C-14 in the release paths through the ventilation, the Swedish nuclear power plants in 2002 installed advanced specific equipment for such measurements.

Renewed plans and action programmes for the reduction of effluents are prepared and introduced for those nuclear power plants, which implement power uprates.

15.3 Environmental impact of the Swedish nuclear power plants

Worker protection

Occupational doses have decreased, following the international trend, and the radiological environment in the reactors has improved. Figure 11 displays the development of the collective radiation doses at Swedish nuclear power plants during 1995–2006. As seen from the figure, the total collective dose has decreased from about 20 manSv in the mid 90's to about 10 manSv over the last eight years. The average individual dose has decreased from 3–4 mSv/year in the beginning of the 90's to an average value of 2.3 ± 0.2 mSv in the last five-year period.

The increase in radiation levels (apart from re-contamination of decontaminated surface layers) has generally stopped and in some plants lower radiation levels are realized due to the continued efforts to reduce the production and distribution of Cobalt 60 in the reactor systems. The number of reported intakes of radionuclides is also a reflection of low contamination levels and improved working procedures. The average number of reported intakes during the last five years (a committed effective dose larger than 0.25 mSv) was 1.4 ± 0.4 per year. During the year 2006, no intakes were detected at the power plants.

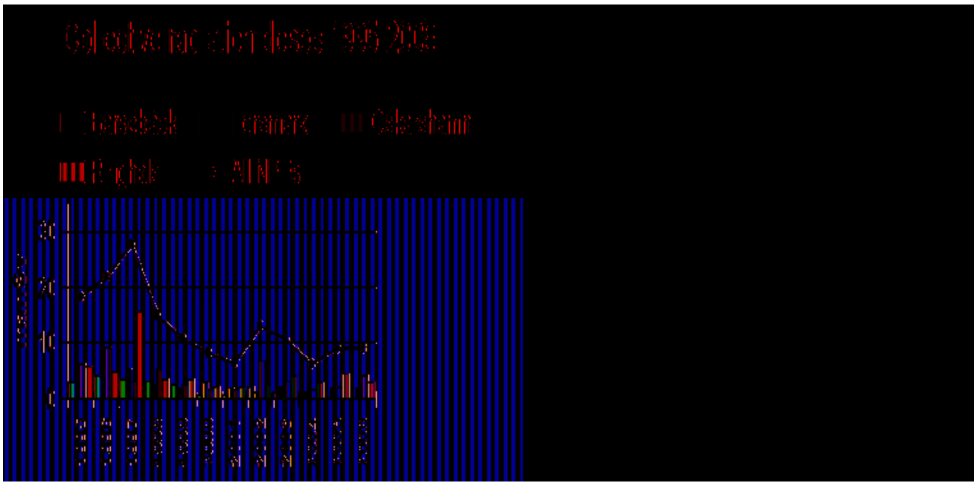


Figure 11. Collective radiation doses at Swedish nuclear sites during 1995–2006. At the units Ringhals 1and Oskarshamn 1, major modernisation projects were carried out in 1997 and 2002, respectively. The radiation levels at the nuclear power plants have, as a general trend, decreased.

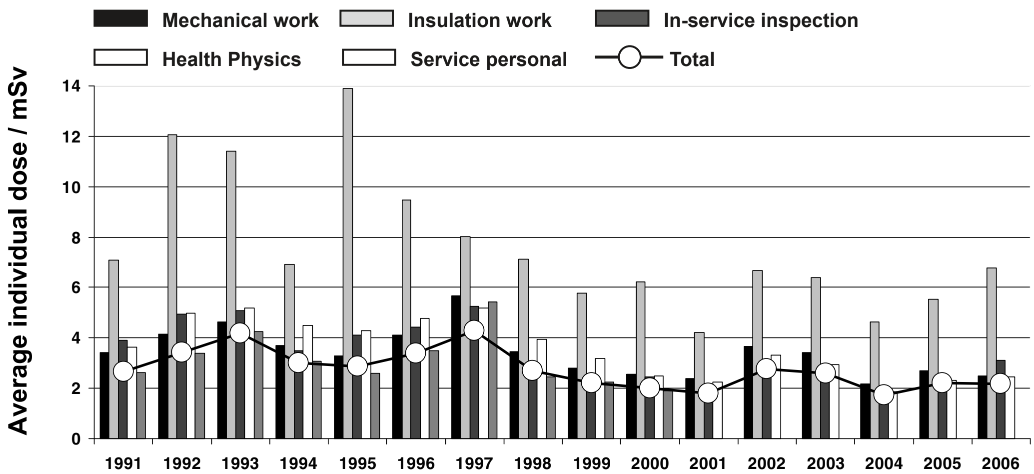


Figure 12. Average individual dose to some selected worker categories. Note that only workers with a registered radiation dose above 0.1 mSv in the calendar year are used when calculating the average values.

Year	Total dose (manSv)	Average dose (mSv)	Number of persons which received a radiation dose above 20 mSv
2002	13.0	2.9	12
2003	10.9	2.7	8
2004	6.4	1.7	0
2005	9.2	2.2	3
2006	9.3	2.2	2

Table 13. Radiation dose statistics for nuclear power workers over the last years.

Releases to the environment

SSI regulations on the limitation of releases of radioactive substances from nuclear installations limit the calculated effective dose to representative individuals in the critical group. There are no formal limitations of releases of particular radionuclides. However, all liquid and atmospheric releases of radionuclides 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 13 displays the estimated radiation doses resulting from the discharge of radionuclides during the period 2003–2006 at the Swedish nuclear power plant sites.The concepts reference values and target values are used for nuclear power reactors as a measure of the application of Best Available Technique (BAT) for reducing releases of radionuclides. These values are defined by the licensees.

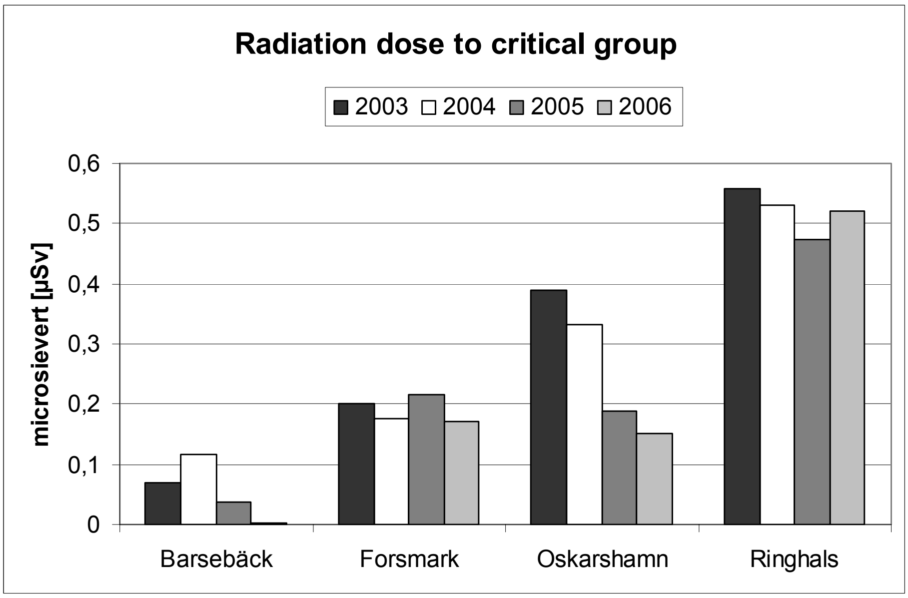


Figure 13. Estimated radiation doses in mikrosievert (µSv) to the representative individuals of the critical group from releases of radionuclides for the period 2003–2006.

The reactor licensees decided that the first set of target values should be reached in 2006. Therefore, in January 2007 all reactor licensees reported to SSI whether or not the target values have been achieved. SSI is presently evaluating the reports from the licensees about accomplishing the overall objective set by the target values. This evaluation is not yet ready(May 2007) but a preliminary conclusion is that the target values have not been realised for all radionuclides. Nevertheless, SSI finds the overall process successful 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.

The licensees have also suggested new reference and target values for the period 2007–2011. SSI will examine these suggestions making sure that the licensees are implementing the BAT concept in the on-going power uprate projects. The power uprates must not lead to any increase of the discharges to the environment.

15.4 Regulatory control

SSI inspection activities are described in chapter 8.3.

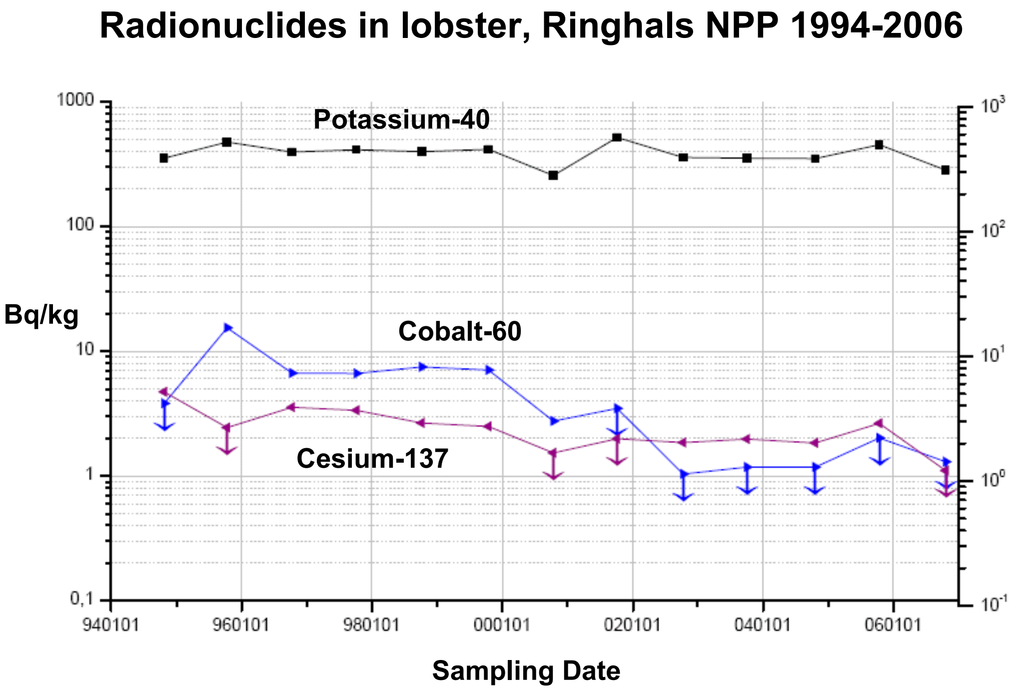


Figure 14. Examples of the results of the environmental monitoring programmes. Radionuclides measured in lobster collected outside Ringhals nuclear power plant. A decrease in the specific activity of Co-60 and Cs-137 in lobster is observed during the sampling period. The lobster specific activity of K-40 is shown as reference.

15.5 Conclusion

Since the last national report the overall collective radiation dose has stabilized on a value of around 10 manSv (9.7 ± 1.1 manSv over the last five years). This gives an average of less than 1 manSv per rector year which internationally is a good result. Also the average individual dose has been maintained at a low value; 2.3 ± 0.2 mSv.

These results have largely been achieved due to the improved radiological environment in the reactors since the amount of work (man-hours) performed in the stations has been high and is not foreseen to decrease, in view of the on-going and planned work with power uprates and reactor safety upgrades. The work to further improve the radiological environment at the reactors is performed within the scope of the existing ALARA programmes.

The releases to the environment of radioactive substances, given in becquerels 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.

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

- SSI's regulations on emergency planning and preparedness are in force since January 1, 2006.
- A web-based information system between all responsible parties involved in a nuclear accident has been further developed and improved.
- The on-line monitoring systems at the sites of the nuclear power plants have been upgraded and the relevant meteorological data is now transferred to SSI.
- Finland and Sweden have agreed to dispatch liaison officers to each other's countries should a nuclear emergency occur.
- SKI has initiated a research project on NPP technical alarm criteria.
- As a result of the Barsebäck NPP closure the Skåne County has applied to maintain a qualified off-site emergency preparedness organisation in order to assist the other NPP counties should the need occur.

16.1 Regulatory requirements

Requirements on on-site emergency activities and plans for the nuclear facilities are included in several legally binding documents:

- The Act (SFS 2003:778) regarding protection against accidents with serious potential consequences for human health and the environment
- The Ordinance (SFS 2003:789) regarding protection against accidents with serious potential consequences for human health and the environment
- SKI regulations (SKIFS 2004:1) concerning safety in nuclear facilities
- SSI regulations (SSI FS 2005:2) concering emergency preparedness at certain nuclear facilities

The Act on protection against accidents 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, among those radiological accidents.

The Ordinance is more specific about reporting obligations, information of the public, and the responsibility of the county authority for planning and implementation of 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 SKI-regulations SKIFS 2004:1 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,
- returning the facility to a safe and stable state,

- inform the responsible authorities.

The actions shall be documented in an emergency preparedness plan to be safety reviewed by the licensee and approved by SKI. The plan shall be kept up to date and validated through regular exercises. SKI 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.

SSI's regulations on emergency planning and preparedness, in force since January 1, 2006, 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 SSI
- Radiation monitoring
- Emergency ventilation
- Collection of meteorological data

Depending on which category a facility belongs to (categories I, II or III depending on its radiological hazards potential), the requirements regarding radiation monitoring, emergency ventilation, and collection of meteorological data differ.

The SKI and SSI regulations are harmonised.

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. An overview of the national organisation and the responsibilities is given in figure 15.

In 2002, a new authority was formed in Sweden, the Swedish Emergency Management Agency. The tasks of the new authority are to co-ordinate national work with preparedness for severe emergencies and strengthen Sweden's preparedness through coordinated funding for exercises, education, and investments. SKI and SSI are taking part in the planning process. Some actual results of these efforts are a new national emergency response centre and a newly established countrywide measurement and sampling organisation for radiological and nuclear accidents and events.

Two national alarm levels exist for nuclear power plants emergencies: 1) increased preparedness and 2) emergency alarm. Implementation of one more, lower level, in order be able to mobilise the off-site emergency preparedness organisation, is still discussed but no decisions have been taken.

Two of the nuclear power sites have installed "rapid-reach" computerised systems for alarming the on-site organisations. These systems automatically dial predetermined numbers. Additionally, SKI and SSI are currently implementing the same system for alarming their own internal emergency organisations.

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.

The Swedish Government and the Ministries

The Swedish Emergency Management Agency

- Co-ordinates emergency preparedness funding
- Co-ordinates national emergency preparedness work

CENTRAL LEVEL

Examples of central authorities which co-operate and advice within their area of competence:

- Swedish Meteorological and Hydrological Institute
  - o National contact point, relaying international alarms
  - o Performs weather forecasts, dispersion calculations
- Swedish Radiation Protection Authority
  - o Advises on radiation protection, supports the information work and coordinates the national measurement organisation
  - o Co-ordinates the advice of other central authorities (Swedish emergency response centre)
- Swedish Nuclear Power Inspectorate
  - o Advises on technology and supports the information work
  - o Estimates source terms and evaluates technical causes
- Swedish Board of Agriculture
- Swedish National Food Administration
- The National Board on Health and Welfare
- The Swedish Police Service
- The Swedish Coast Guard

The Rescue Services Agency

- Oversees the planning of the regional County Administrative Boards.
- Draws up and holds training and education courses

REGIONAL LEVEL

Co-operating bodies are e. g.:

- County councils
- Rescue services
- Police forces
- Hospitals
- The nuclear power plants/operators
  - o Plans the emergency activities at its own site
  - o Reports any malfunction or unplanned releases to the County Administration, the SKI, and the SSI
  - o Resources for measurement and sampling
- National contract laboratories, Universities

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

LOCAL LEVEL

Co-operating bodies

- Health centres
- Companies
- Local police and rescue units

The Municipalities

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

Figure 15. A schematic layout of the Swedish national emergency preparedness organisation.

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

The on-line monitoring systems at the sites of the nuclear power plants have been upgraded and the relevant meteorological data is now transferred to SSI, enabling improved dispersion calculations to be performed on the national level.

To improve the tools for external information between all responsible parties involved in a nuclear accident, a web-based information system has been introduced. The system aims at exchanging information and decisions taken in the event of an emergency. The system has been used in exercises and improvements occur after evaluations. Currently, applications to improve system security have been implemented. In addition, an interface between this information system and the national crisis information management system is being developed.

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

16.3 National monitoring

Sweden presently has 32 permanent gamma monitoring stations, spread around the country, to provide warning and rapid information on radiation levels. A gamma station continually records the radiation level and if the integrated 24-h radiation dose differs from the previous 24-h period value with more than 300 nanosievert (alarm level can be set), the SSI radiation protection officer on duty will be alerted. There also exist five sensitive permanent air filter stations which can reveal the type of plant from which radioactive releases originate. The air filter stations are 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 or equivalent bodies of the local authorities at permanent measurement points in the municipalities. The results of the measurements after deposition can be compared with reference measurements which have been registered every seven months at the 2 – 4 measurement points in each municipality. These data are collected by the county administrative board which compiles and transmits the readings to a national database. The Swedish municipal measurement system offers good opportunities for detecting even small increases in radiation level at the reference points.

The Geological Survey of Sweden and the Armed Forces are contracted concerning 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 for grazing. SSI has agreements with laboratories around Sweden, under the terms of which they maintain a state of preparedness for taking measurements. SSI 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
- in hospitals or at medical health centres.

At the major national hospitals, like Karolinska sjukhuset 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 Swedish National Board of Health (SoS) and SSI are activated along with the jointly appointed Nuclear Medical Expert Group (N-MEG). Medical doctors from the medical areas haematology, oncology, radiology, and catastrophe medicine are represented within

N-MEG. The group has an on-call operation and is available for giving advice, also in connection with minor incidents, by contact through the national alarm telephone number (112). In case of a large accident; the group is summoned to the national emergency centre at SSI and is provided with information on radiation levels, meteorological conditions, etc. With the information available N-MEG performs a medical risk judgement and leaves the information and suggestions for measures primarily directed to the medical doctor in charge at the county administrative board's rescue work management group. N-MEG advices 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 institutet in Stockholm. Among the tasks of this centre are 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 is established with SSI and various other national and international bodies.

16.5 Exercises

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

Every second year a "total" exercise is performed at one of the three NPP sites to check the plans and the capability of the on-site and off-site organisations. The full-scale exercises are designed to enable evaluation of command at the regional level, inter-agency co-operation, and public information. During the last years, exercise scenarios have included physical protection events such as sabotage, armed intrusion, taking of hostages in order to exercise co-ordination between the special police forces and other actors.

The respective county authority plans these exercises and the Rescue Services Agency is responsible for the evaluation and follow-up analysis. SKI and SSI participate in the planning as well as in the evaluation. Usually between 15 and 30 organisations participate in these exercises including the regulatory bodies.

In addition, a number of more limited on-site functional exercises are conducted at all the Swedish nuclear power 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, emergency maintenance etc. One or more off-site organisations normally participate in these exercises. SKI and SSI frequently participate in such exercises since it is a good opportunity to exercise the authorities' emergency staffs.

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). 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 countries should a nuclear emergency occur. The concept with a liaison officer was tested, with positive results, during the Swedish "Falken" exercise in October 2006 and, to some extent, during the exercise at Loviisa NPP in November 2006.

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 24h 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 on authority level also exists with Lithuania. Sweden uses the ECURIE information system for information exchange within the European Union and the ENAC/Emercon system between the IAEA member states.

The Nordic authorities involved in the field of radiological emergency planning have agreed to exchange data on a routine basis from the automatic gamma monitoring stations in the respective countries.

16.7 Nuclear accidents abroad

As demonstrated by the Chernobyl accident 1986, several regions in 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, mushrooming, 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 SKI, SSI, SoS and others to distribute information is strengthened in this situation. The local county administrative board still has the responsibility to inform and take any protective action in its region according to the earlier mentioned legislation.

The Swedish Meteorological and Hydrological Institute, SMHI, performs regularly transport and deposition simulations using the program MATCH (a 3-dimensional "off-line" Eulerian atmospheric transport code) and the actual recorded 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 6th hour using existing weather. The transport, spread, and concentration of the simulated, released radionuclides are displayed.

Furthermore, the MATCH-trajectory simulations are also available for tracing the source regions for recorded measurements at specific measurements 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

SKI has initiated a research project on NPP technical alarm criteria. Alarm criteria provide a basis for declaration of alarm levels, which in their turn are used for decision of initial actions from off-site organisations, should an accident occur. The project formally started in March 2007 and will review a set of categories of initiating events and evaluate the reliability of the correlation between initiating events and the symptoms through which they would manifest themselves. The project will also evaluate the possibility for further harmonisation between the nuclear power plants of the site-specific alarm criteria.

The second and last reactor at the Barsebäck NPP was permanently shut down on 31 May 2005. On the 1 December 2006, all spent fuel had been shipped off-site to the interim storage Clab at the site of the Oskarshamn NPP. SKI and SSI participated in a working group discussing how the change of operational status of Barsebäck NPP will affect the requirements for an off-site emergency preparedness organisation, at the regional level in the Skåne County. The working group report is not yet formally adopted; however, one of its conclusions is that it is not any longer justified to require Skåne County to maintain a special preparedness organisation regarding nuclear emergencies on the same high level as for counties with operating NPPs. The general requirements of the Act (SFS 2003:778) regarding counties with no nuclear power stations would be sufficient also for the Skåne County. However, the Skåne County has applied to the Government to be given the status of "Assisting County" and to maintain a qualified organisation, which can assist other counties in case of nuclear emergencies.

16.9 Regulatory control

During 2005, SKI carried out inspections to verify the compliance with the obligations on emergency planning and information exchange as stipulated in the SKI regulations SKI 2004:1 (see above). The SKI judgement was that the licensees complied with the requirements of the regulations. At all sites, however, aspects for further improvements were identified and SKI followed up on these findings during 2006. SKI has planned further follow-up actions during 2007.

During 2005, SSI visited all nuclear power plants in order to follow-up on the implementation of the new SSI regulations regarding emergency preparedness as mentioned above. During a transition and implementation period, SSI agreed to temporary exclusion of some requirements during 2006. During 2007, SSI will inspect the facilities in order to control the compliance with the new regulations.

In 2004 SKI and SSI completed an assessment of Swedish practices against the IAEA Safety Requirements: Preparedness and Response for a Nuclear or Radiological Emergency, issued in 2002. On the mentioned points below, it was found that Swedish measures differ somewhat, with regard to the detailed solutions, in comparison with the IAEA recommendations:

- One national co-ordinating authority
- Classification of nuclear and radiological threats
- Analysis of threat scenarios
- Emergency zones and pre-planned activities
- National alarm levels
- Prompt initiating of alarms

Work has started to evaluate the implication of the differences and the potential need for additional actions. Among actions already taken, is the mentioned project to review the Swedish alarm criteria.

16.10 Conclusion

Sweden complies with the obligations of Article 16.

17. Article 17: SITING

Each Contracting Party shall take the appropriate steps to ensure that appropriate procedures are established and implemented:

(i) for evaluating all relevant site-related factors likely to affect the safety of a nuclear installation for its projected lifetime;

(ii) for evaluating the likely safety impact of a proposed nuclear installation on individuals, society and the environment;

(iii) for re-evaluating as necessary all relevant factors referred to in sub-paragraphs (i) and (ii) so as to ensure the continued safety acceptability of the nuclear installation;

(iv) for consulting Contracting Parties in the vicinity of a proposed nuclear installation, insofar as they are likely to be affected by that installation and, upon request providing the necessary information to such Contracting Parties in order to enable them to evaluate and make their own assessment of the likely safety impact on their own territory of the nuclear installation.

Summary of developments since the last national report

- Some of the licensees will need to revisit the site impact analyses of their designs and all will update the dimensioning values as a result of the new regulations SKIFS 2004:2.
- All licensees have completed plant specific PSAs including relevant external events except seismic events.
- SKI will require justifications for not analysing seismic events with PSA.

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 Act on Nuclear Activities § 5 a, it is not allowed 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 SKIFS 2004:1, in connection with requirements on design and safety analysis. Also in connection with new activities in the neigbourhood of a NPP, analyses have to be made to show the possible impact on the NPP 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 report of the facility.

The regulations SKIFS 2004:2 on 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, and with a 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 determined for those situations where the dimensioning values for the design risk to be exceeded.

In the general recommendations 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 of Contracting Parties in the vicinity of a proposed nuclear installation, the Swedish government concluded agreements 1976 with the governments of Denmark, Norway and Finland to notify 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 SKI

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. During the years, some backfitting 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 the clogging of cooling water inlets by sea weed and jellyfish and spray systems to clean the switch yards from salt deposits during storms from the sea.

In the modernisation of the oldest reactor Oskarshamn 1 external events have been fully considered and the safety functions have been qualified for seismic events, fire and flooding. As mentioned in chapter 14, the need for updating and 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 SKIFS 2004:2. 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 size (sports plane) and the risk of larger crashes has been analyzed and found to be tolerably low based on available air traffic statistics.

As a result of the events in USA 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 SKI homepage, www.ski.se. SKI concludes that consequences of a deliberate airplane crash are difficult to assess, depending on many factors.

A crash of a commercial airplane belonging to normal types 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. Especially the consequences of consequential fires are difficult to assess. Also in these cases however, the passive filtered venting systems will provide a good protection. SKI has chosen to publish an open version of this report, without giving any details, in order to serve the public interest in this issue.

In 2003 SKI presented a report – "Guidance for External Events Analysis" – that aims at creating 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 Swedish and Finnish plants as well as SKI. It will make it possible for the utilities to perform these analyses in a cost-efficient way, while still assuring the quality of the analyses. The plants have further developed the basic methodology described.

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

Plant specific PSAs taking into account relevant external events, except seismic events, have now been completed for all plants (see also section 14.2). According to WENRA 's reference levels for PSA, seismic events shall be addressed. Addressing is interpreted to mean that seismic events shall be included in the PSA, except if a justification is provided for not including them, showing that its omission from PSA does not weaken the overall risk assessment of the plant. Such a justification will be required by SKI.

Regarding further regulatory actions in relation to safety assessments and safety 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 2004–2006:

Forsmark 1:

- conversion of 6 kV switchboards
- alteration of the reactor's auxiliary cooling circuits, separation of power supplies and increase in capacity

Forsmark 2:

- replacement of electrical control boards in the main control room
- replacement of 6 kV switchboards
- modification of the reactor pressure vessel head sprinkler
- modernisation of the power measurement system
- modification of the cooling chain for increased capacity and separation of power supply connections

Forsmark 3:

- new automatic stop of reactor building ventilation in case of loss of heating system for the building

Oskarshamn 1:

- upgraded cooling of condensation pool
- modifications of the programmable control equipment

Oskarshamn 2:

- upgrading of feed water control system
- separation of safety and non-safety related equipment

Oskarshamn 3:

- upgrading of battery-backed electrical distribution system and change-over of power supply to certain main steam valves

Ringhals 1:

- a new main fire water ring installed for the site of units1 and 2

Ringhals 2:

- pressurizer relief valves replaced/modified
- replacement of toroid plates
- modernisation of 110 V DC systems with new switchboards
- a fourth level measurement channel installed in the steam generators
- preperations for the Twice-project, replacement I & C equipment including the main control room (final implementation planned for 2008)

Ringhals 3 & 4:

- reactor pressure vessel heads replaced
- pressurizer relief valves replaced/modified
- new emergency core cooling strainers fitted in the bottom of the containments

18.1 Regulatory requirements

The general safety regulations SKIFS 2004:1 contain the basic requirements on 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. Five levels of defence are applied in Sweden in accordance with the INSAG 10 report.[19]

More specified requirements on design and construction, in order to achieve what is required in the fundamental paragraph, are given in chapter 3 of SKIFS 2004:1. These can be summarised 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 reference to safety. Design solutions shall be adapted to the ability of the personnel to manage the facility in a safe manner as well as to manage abnormal events, incidents and accidents. Functionally based safety classification is also required. In the general recommendations to these legally binding requirements, guidance is given on their interpretation and application. Radiological release criteria for normal operation are established in SSI regulations SSI FS 2000:12 (see section 15.1).

SKIFS 2004:1 stipulates that guidelines shall be developed to manage beyond design basis events but the regulations do not include any specific design requirements to deal with severe accidents. Requirements on release mitigation in the event of severe accidents were given in a governmental decision in February 1986[20], as a condition for operation after 31 December 1988. This decision states that, in the event of an accident involving severe core damage, including core melt, releases should be limited to a maximum of 0.1% of the core content of cesium 134 and cesium 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 extremely low probability, such as 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 in 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.

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).

21 Release-Limiting Measures for Severe Accidents. Swedish Nuclear Power Inspectorate - Swedish Radiation Protection Institute Report to Government, December, 1985 (in Swedish).

In December 2006, SKI and SSI completed an investigation titled "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 analysis 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 and severe accidents are as mentioned already legally established. Based on this study, SKI and SSI will during 2007 decide on analysis assumptions and reference values to be used by the licensees in the deterministic safety analyses. These decisions will apply until regulations are updated.

Requirements concerning protection from intentional damage such as sabotage are posed in separate regulations SKIFS 2005:1 on physical protection of nuclear facilities (see section 7.2). These regulations are in force from 1 January 2007.

More specific design requirements are posed in separate regulations on design and construction of nuclear power reactors, SKIFS 2004:2. SKI has recently decided on reactor specific plans for complying with the regulations. According to these plans, backfitting will continue over the next years and be finalised around 2013. An overview of the backfitting programmes is given in section 6.2.

There were no immediate safety reasons behind SKI´s decision to issue these supplementary regulations. As mentioned in section 6.2, SKI several years ago planned to issue guidelines for modernisation and safety upgrading of the Swedish reactors for the rest of their operating time. SKI also had to issue licensing conditions for the extensive upgrading 1995–2002 of Oskarshamn 1. When modernisation programmes were 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 updated 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 will be possible to communicate as a whole to different stakeholders.

The requirements are grouped under the following headlines

- General design principles for the defence in depth
- Withstanding of failures and other internal and external events
- Environmental qualification and impact on other plant systems
- Requirements on the main control room and emergency control posts
- Safety classification
- Event classification
- Requirements on the design and operation of the reactor core

There are requirements on

- The basic safety functions up to and including 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 not to challenge systems with safety function
  - withstanding of single failures and common cause failures
  - degree of physical- and functional separation of redundant part of safety systems
  - withstanding of 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

22 In Swedish only.

- 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 probability of occurrence: normal operation, anticipated events, not anticipated 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 as well as 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 common cause failures should be applied in the design of the safety functions for events up to and including not anticipated 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 backfitting plans submitted by the licensees and, as mentioned, now decided by SKI (see section 6.2).

18.2 Measures taken by the licence holders

Original design concepts

The Swedish power reactors represent seven design generations, five for BWR and two for PWR as shown in the table below. 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 O1 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 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 Oskarshamn 3	BWR 5	As F 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 R2 plus improvements in physical separation and in fuel design.

Table 14. Swedish NPP design generations.

The first three generations 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, which involves risk for radioactive release, have to be automated. This rule is implemented in the BWRs, and with some justified 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.

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 backfitting measures have been introduced in all reactors over the years. The latest implemented modifications are listed in the introduction to this chapter. An overview of the modifications implemented 1995–2003 is given in appendix 3.

Backgrounds for backfitting measures have been:

- Domestic incidents e.g. the so called strainer event in Barsebäck 2 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 reports. This event triggered large modifications of most Swedish reactors and also major projects to revise and update the safety reports.
- International accidents/incidents e.g. TMI-2 in 1979, which triggered the so far most comprehensive backfitting 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 soft issues, such as safety management and safety culture.
- Insights from PSA and other safety analyses, e.g. the importance of Common Cause Failures 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 7.2 and 18.1).

Backfitting measures are basically taken to strengthen the safety concept of multiple barriers and defence-in-depth, required in SKI regulations. Important principles in this work have been and are the following:

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 had to be performed when the original tests had 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, ABB 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 according to this programme, but 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 within 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 NPPs and SKI and in close contact to what is going on abroad.

In the modernisation 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 for following up the environmental impact on the safety systems during the operating life time of the reactor. In the modernisation work, the specification of all new instalments is carefully checked with respect to environmental requirements.

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 modernisation projects including control room upgrading, MTO (human factors) and the man-machine interface have been given 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 of various extent for modernisation 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 modernisation 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. Further measures to improve detection and installation of automatic protective measures against local core instability are foreseen for five reactors during the next years (see section 6.2).

Measures to improve physical and functional separation

The separation of systems, physically and functionally, is an important area in which a number of backfitting measures have been implemented over many years as previously reported. In many cases, the need for improved separation was identified through PSA analyses. This work continues in ongoing modernisation projects in which, for instance, improved separation is one of the objectives of the Ringhals 2 project for modernisation 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 backfitting regulations (see section 6.2).

Design extension for mitigation of severe accidents

After the TMI-accident 1979, a reactor safety commission appointed by the Government proposed that the Swedish reactor containments should be backfitted 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 backfitting were decided by the Government in 1980 for Barsebäck NPP and in 1986 for the other NPPs. Backfitting measures consisted of filtered containment venting to protect against overpressure and (except 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 pressure vessel bottom is assumed and the damaged core/core melt has to be handled in the containment without major environmental consequences.

This Swedish strategy for handling of 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 remaining uncertainties connected with the Swedish strategy. A major initiating concrete and core melt will probably be avoided. However, steam explosions could not be precluded when the melt falls into the water and the coolability of the core melt in the vessel and in the containment could be questioned.

The severe accident research is now targeted to show that the chosen solution adequately can protect the environment.

Since the governmental decision in the 1980's the Swedish utilities and SKI have in collaboration continued to conduct research on severe accidents and to follow international research on this topic. At present the APRI-6 project (Accident Phenomena of Risk Importance) is running for the three year period 2006–2008, 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 CARP (Cooperative Severe Accident Research Program) 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. Also projects within OECD and the EU has contributed to the overview. In the EU programme PHEBUS, experiments have shown that the composition of fission products are quite different from earlier assumptions. At present the project SARNET (Severe Accident Research – Network of Excellence) is going on which is a network aiming at integration of the EU research within the area of severe accidents.

SKI is investigating at present whether to require further backfitting of the reactors to enable cooling of a core melt in the pressure vessel in order to avoid a melt through. This would require a new external water source and other dedicated equipment. This solution is, however, not uncomplicated and the design prerequisites need a careful investigation.

18.3 Regulatory control

Regulatory review of design solutions is mostly done in connection with notifications to SKI 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 SKI can assess that they comply with the regulations. SKI occasionally makes its own analyses to verify the submitted calculations by the licensees. The independent safety review required of the licensee also has to be submitted in the notification. SKI checks that this independent review holds sufficient quality. If SKI is not satisfied with a notification, the licensee has to supplement it, or SKI can pose further requirements or conditions on the proposed solution before it may be implemented. If more investigation time is needed, SKI can halt the implementation until the case is further investigated. Notifications dealing with new or complex technology are most often reviewed further by SKI, 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 testing operation, the PSAR will be supplemented and then finalised in the updated SAR taking into account the results of the testing operation.

The reactor specific backfitting programmes as a result of SKIFS 2004:2 have been reviewed by SKI to ensure that they comply with the regulations. More detailed review of different design solutions will be done in connection with notifications. SKI expects that a relatively large number of these notifications will need to be reviewed further. SKI is planning to use also external resources from the technical universities KTH and CTH to handle this workload.

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 authorisation 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 organisations 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

- The new MERITS OLC concept (according to NUREG-1431) to be used at Ringhals 2–4 has been approved by SKI after additional conditions were met.
- An overview of last years operational events is given in section 6.1.
- The number of licensee event reports (category 2 LERs) is varying in the range of 20–40 per year and rector, over the last years. The trend is slightly increasing from 2001.

19.1 Regulatory requirements

The general safety regulations SKIFS 2004:1 contain legally binding requirements relevant to all obligations of Article 19. These requirements are summarised below:

Initial authorisation

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 preliminary safety report is required before construction. The safety report has to be renewed before commissioning tests and be finalised, taking into account the results from testing operation, before the plant may be taken into routine operation. (Chapter 4, §§ 1 and 2).

Operational limits and conditions

Documented up-to-date operational limits and conditions (OLCs) are required containing the necessary limits and conditions, as further specified in a separate annex to the regulations. The OLCs shall together with the operational procedures ensure that the conditions which are postulated in the safety report are maintained during the operation of the facility (Chapter 5, § 1). The OLCs shall be subjected to a twofold safety review by the licensee and submitted to SKI for approval. SKI shall be notified about any changes after a twofold safety review by the licensee.

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 in order 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 suitable extent for verification of operational procedures. Procedures for maintenance which is 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 SKIFS 2005:2).

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 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.

Reporting of incidents in a timely manner

SKIFS 2004:1 contains a whole 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 scram, and requirements on a comprehensive annual report summarising 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 recommendations.

In one of the basic paragraphs of SKIFS 2004:1, 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 first assessment and classification, adjustment of the operational state, implementation of necessary measures, performing of safety review and reporting to SKI. 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:

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).

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).

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 SKI. After a category 1 event, SKI 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 SKI. 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 shows to function in an unexpected way or in cases where it is difficult to determine how serious an identified deficiency is.

Programmes to collect and analyse operating experience

The licensee shall ensure that experience of importance for safety from the facility's own and from similar activities in other relevant facilities is continuously analysed, used 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 SKI (see above) SKI ensures event reporting to the proper international organisations and other regulatory bodies. SSI is responsible for most international notifications in emergencies.

Generation of radioactive waste, conditioning and disposal

There is no legally binding requirement in Sweden to minimise 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. The regulations of SKI and SSI include requirements about:

- An up-to date inventory of all spent fuel and radioactive waste on-site (SKIFS 2004:1, SSI FS 2001:1).

- Measures for the safe on-site handling, storage or disposal of nuclear waste shall be analysed and included in the safety report of the facility. The measures for on-site handling shall consider the requirements on safety posed by the continued handling, transport and final disposal of the waste. The safety report shall also include measures, which need to be taken on-site for the safe transport, storage or final disposal in a nuclear waste facility (SKI FS 2004:1).

- Established plans for the handling and disposal of all waste that exists at the facility, arises at the facility or in other ways is brought to the facility. 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 authorities before the waste is generated (SSI FS 2001:1).

Only packages approved by SKI and SSI may be transported to a final repository. For this approval, the waste must comply with the conditions stated in the safety report of the repository.

Since disposal of spent fuel and nuclear waste is expensive, the licensees have a powerful economical 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 receive these results have been costs, radiation doses and decreased releases of radioactive substances to the environment, the end result also positively impacts the volume and activity content of radioactive wastes.

19.2 Measures taken by the licence holders

Initial authorisation

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 bothe the function of the different individual systems and their joint function. Permission to start up the units was given in steps by SKI after completion of the different operational tests, and reporting of the results of the start up stages. Permission for commercial operation was given when the operational tests were satisfactory completed and reported, and FSAR and technical specifications were accepted.

Operational limits and conditions

The operational limits and conditions of the reactor units are included in an operational document called STF in Sweden (Säkerhetstekniska driftförutsättningar). This document is considered one of the cornerstones in the governing and regulation of the operations of the Swedish NPPs. As required by SKI, all control room operators and operations managers as well as engineers on duty at the plants are given extensive training on the intent and content of this document as well as annual retraining. Every STF is unit-specific and is in its basic version approved by SKI. STF 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 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 the 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 undergoing a twofold safety review (see section 14.2) and are notified to SKI. Today the STF are integrated into the plants 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 chapter 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 going on to describe all the SAR conditions upon which STF are based. SKI has increased its requirements on the scopes of STF, for instance also to 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 according to 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 STF have been approved by SKI and are in use.

Operability verification

Before equipment is being 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 operability verification.

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 the completion and facilitate verification. Temporary modifications and special conditions are controlled by operation notices (DM, driftmeddelanden) limited in time. 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 of the systems is the responsibility to develop, review and revise their operating procedures.

The development of procedures follows specified directives, which include the reviewing of 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 and validating a new or revised operations procedure.

Response to anticipated operational occurrences and accidents

Emergency procedures have been developed in order to deal with anticipated operational occurrences and accident conditions. Event based emergency operating procedures for individual systems are supplemented with symptom based emergency procedures for all units (Övergripande störningsinstruktioner, ÖSI). The ÖSI are handled by the shift supervisor and represent a link to the safety parameter display system (SPDS) which exist in different layouts at all Swedish units as part of the accident management system. The symptom based emergency operating procedures cover events up to and including onset of core melt and use of the mitigating systems. They are also the link to the emergency planning and its criteria for issuing of alarm. The common structure of procedures is shown in figure 16.

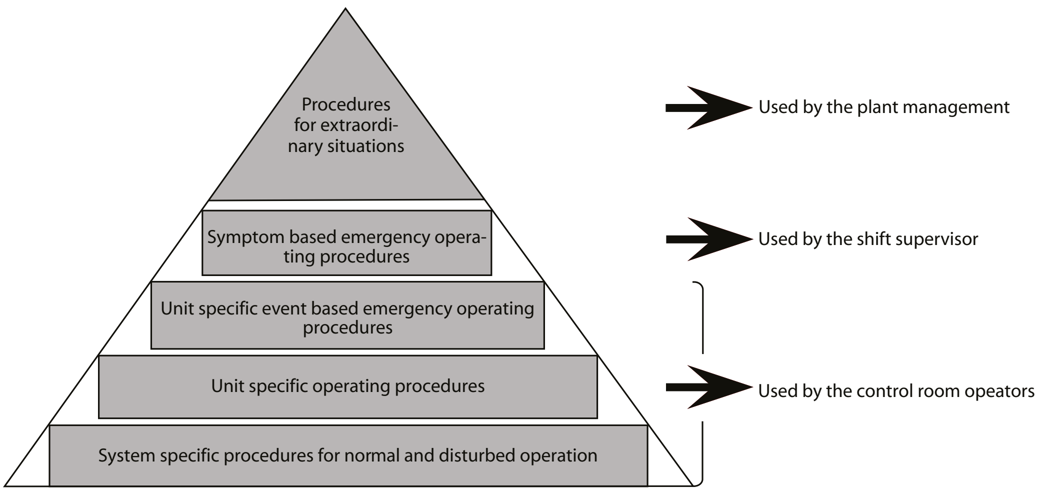


Figure 16. Overview of the main procedures applied during emergency siuations. Other documents exist as reference to the main procedures. The level of th detail and the number of procedures decreases with the height of the pyramid.

Procedures for extraordinary situations, at the top of the pyramid, include procedures for the engineer-on-duty, the operative emergency response plan, and knowledge based guidelines, technical handbooks, for severe accident management in cases the ÖSI are not successful to recover the plant to a safe state.

Engineering and technical support

The NPPs 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 organization 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 also these competences are available in their organisation, although is some cases in the independent safety review function that 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.

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 SKI, SKIFS 2004:1. Two types of licensee event reports (LER) exist. The more severe one, called category 1, requires that the plant inform SKI within an hour, and in some cases also SSI. An extensive report shall be submitted within seven days from the time of the event and the analysis of the event and appropriate measures to prevent recurrence shall be approved by SKI 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 20–40 per unit and year. This type of event is mentioned in the daily report, which is sent to the regulatory bodies, 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 relevant safety review committee before the re-start of the unit. The reports are reviewed at different levels within the operating organization and approved by the operations or production manger before submittal. As well as a wide distribution within the own organization and to the regulatory bodies, the reports are sent to the other Swedish NPPs.

The front side of the standardized report form describes the event in general: identification number, title, reference to STF, 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 a description of the event is given. The following titles are used:
- 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 comprehensive, additional pages are added to the form. Modifications are being discussed in the reporting forms and projects are going on to find a better classification of different events.

Reports are also required in accordance with STF when exceeding the permitted levels of activity release from the plant or in the event of unusually high radiation exposure to individuals at the plant. These types of non-routine reporting are primarily directed towards SSI.

In the period 1991 (when the INES system was introduced) until 2006, Sweden has reported in total 50 events to IAEA. In the nuclear power plants, there have been six events at INES-2. In the Studsvik nuclear activities, there has been one event classified as INES-2 and one as an INES-3. An overview of reported events up to 2004 is given in figure 17.

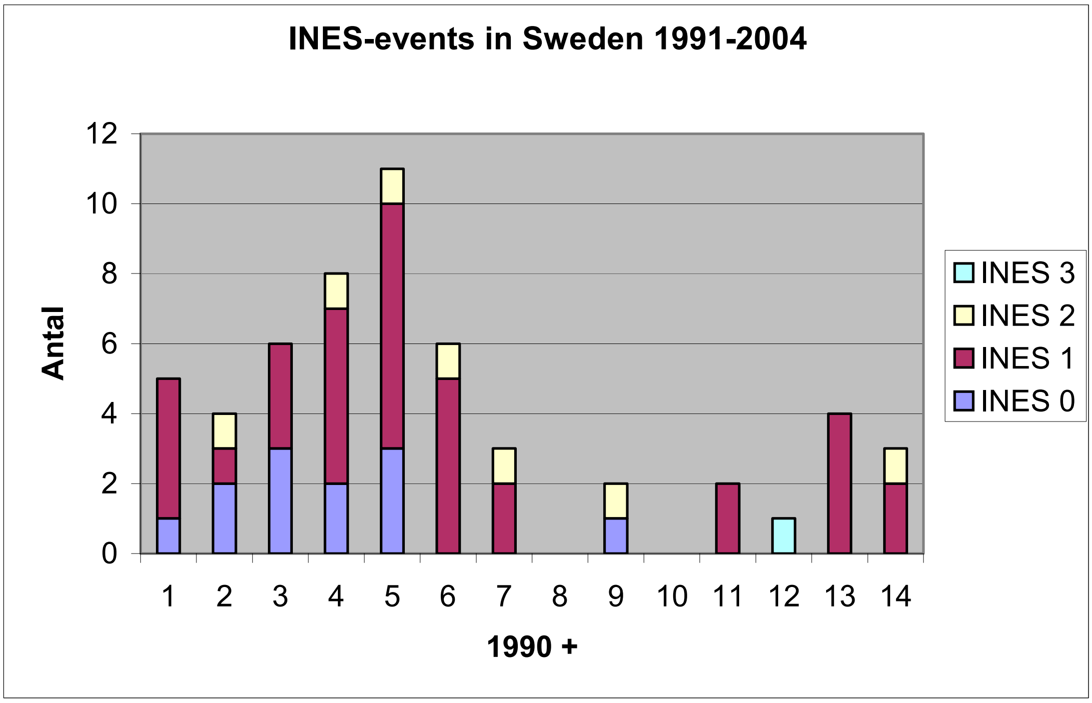


Figure 17. INES events reported by Sweden 1991–2004.

Operating experience analysis and feedback

The objective of the operating experience analysis and feedback program is to learn from own and others experience 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 not meeting the event criteria, or so called near-misses.

SKI has strict requirements on systematic investigations and analyses of events. The event sequence has to be fully clarified including circumstances that could have prevented or stopped the sequence, causes and root causes identified, consequences clarified and measures defined to prevent recurrence. MTO-analysis is used, when and analysis in-depth is deemed necessary or desirable. MTO-analysis is an established methodology (see section 12.2) executed by a team of trained investigators available at all plants. Every year, over the last years, 6–8 such analyses have been made at Ringhals, 3–4 at Oskarshamn and 2–3 at Forsmark.

For the **BWR** operating experience feedback, Sweden is part of a Nordic system where a common organisation ERFATOM 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.

ERFATOM is formed by the Swedish and Finnish BWR-operators and Westinghouse Electric Sweden AB. The analysis work is performed by representatives of these organisations and the result of the work is reported to the plants in weekly and monthly reports 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 working principles of the Nordic OEF system to collect, evaluate, document, and follow-up experiences are illustrated in figure 18.

- KSU is responsible for collecting and assessing foreign events. 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
- The OEF database is an Oracle application to register and manage issues and measures taken.
- All ERFATOM Category A events, WANO SOERs, and ERFATOM recommendations are further followed up in the Nordic system.

To support to the common OEF system, there is a reference group at OKG. The task of this group, termed Experience Forum, is to assist in an effective management and development of the OEF system. Meetings are held three times per year. Annually, there is also a self-assessment of the effectiveness of the OEF system.

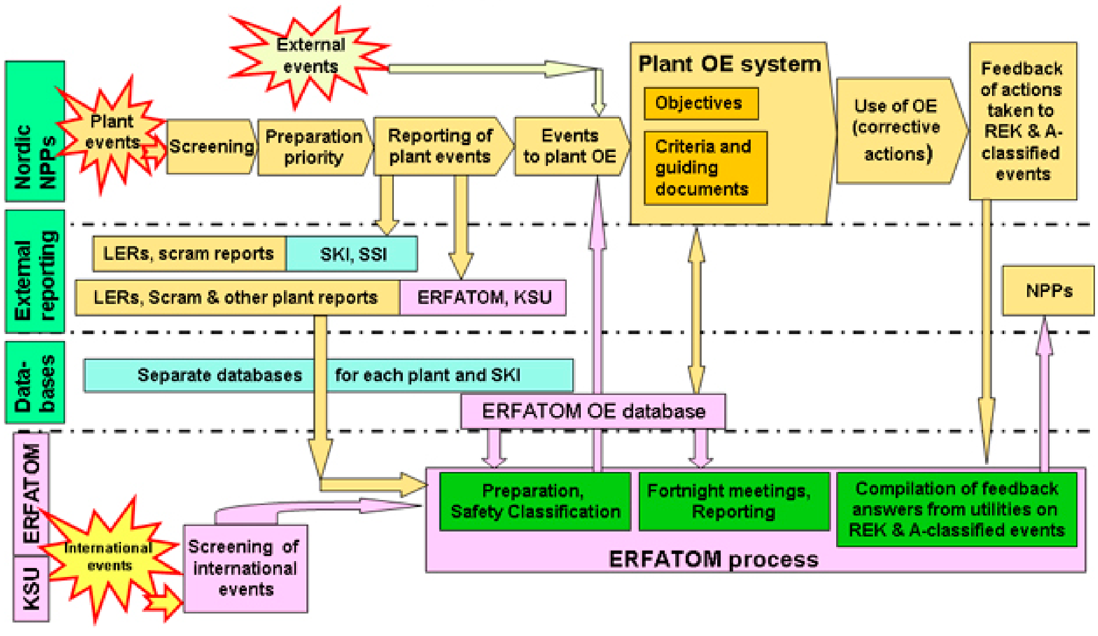


Figure 18. The Nordic OEF-system.

For the **PWR**s, a process was established in Ringhals after the TMI-2 accident to systematically collect and analyse safety issues relevant for the Swedish units. Sources of information have been various NRC, INPO and WANO documents as well as information from Westinghouse and Framatome Owners Groups. Later the same process has also been used to evaluate information from international sources, relevant for the Ringhals 1 BWR. In recent years about 600 reports per year have been screened for its relevance by the Ringhals organization.

All Swedish event reports are also registered in a database operated by KSU. The database is intended for the use by the operators, who have direct access and use it for specific purposes, and for KSU, which uses it for statistics and different types of trend analysis. Reports from KSU showed that 50% of all scrams are MTO-related, i.e. a failed interaction between man, technology and organization is the direct cause in these events.

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 economical, 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.

Operating experience distributed by organizations like WANO, INPO, IAEA, OECD-NEA and NucNet is collected, reviewed, screened and sorted by KSU before distribution to the nuclear power plants. The information is analysed and distributed as monthly reports, but also as special reports, when appropriate. KSU also produces an annual report summarising the performance of the Swedish nuclear power plants, unit by unit, but also containing special articles about interesting events. The annual report is issued not only in Swedish but also in English in order to make the information available for foreign operators.

KSU is also the link for reporting events from the Swedish nuclear power plants to the WANO Event Reporting Program. Based on the Swedish LERs KSU chooses the events that meet the WANO criteria and together with representatives of the affected NPP, KSU produces the WANO event report for worldwide distribution.

As mentioned, the Swedish utilities also participate in various owners groups: PWR Owners Group (PWROG), BWR Owners Group (BWROG), Framatome 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). 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 an effective coordination of R&D efforts. Many of the projects initiated by NOG would have been too costly to run for a single plant.

Handling of spent nuclear fuel and radioactive waste

The general objectives of the waste management at the locations of the nuclear power plants are to:
- minimize the amount of waste (although not formally required),
- ensure that all nuclear waste is handled and conditioned for the final deposition according to current laws and authority 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, when consideration is taken to radiation doses and costs. Minimization of the amount of waste is, for example, achieved by reducing the amount of different kind of materiel that is brought into radiological controlled areas, and by separation of waste at source. Radioactive waste generated at the nuclear power plants is of different kinds, and consequently treated and stored differently, as described briefly below.

Spent fuel

Spent fuel is stored in the fuel pools at the nuclear power plants, usually on the average for two years while awaiting transportation by m/s Sigyn to the central interim storage facility (Clab) at Oskarshamn. Transportation is routine operation.

Intermediate-level waste

This type of waste is dominated by filter and ion exchange resins, which are mixed with cement or bitumen in concrete, or steel containers, or steel drums, of different sizes. The cement or bitumen immobilises the waste, while the containers and drums contain the waste, and in the case of concrete containers provide some radiation shielding. Some intermediate-level filter resins with lower activity contents are placed in concrete tanks and dehydrated.

Metal scrap, and different types of garbage above a certain level of activity, also belong to this category and are placed in concrete containers, compacted, if possible, and filled with concrete.

Low-level waste

After a separation process, 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. At three of the sites some waste with very low activity level is disposed of in special shallow land burial sites at the nuclear power plants. These deposits are covered with soil and the drainage water is checked regularly.

Some low-level filter and ion-exchange resins are stored in concrete tanks and dewatered. Some combustible low-level waste is shipped to Studsvik, where it is incinerated at a special facility. The ashes are collected in steel containers.

The intermediate and low-level waste at the nuclear power plants is stored temporarily in rock caverns or storage buildings awaiting transportation to the final repository (SFR) located near the Forsmark nuclear power plant. In order to fit into the SFR-program, both during transportation and disposal, containers and drums have to be approved by the authorities.

For all waste management at the sites strict 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 a distance of 1 m
- Position in the intermediate storage facility

The production and storage of radioactive waste at the plants is reported quarterly and annually to SKI , SSI and to the Swedish Nuclear Fuel and Waste Management Company (SKB). The objective is to keep the generation of radioactive waste to the minimum level practicable.

19.3 Regulatory control

Operational limits and conditions

Notifications about changes in STF and on exemptions from STF are reviewed as described in section 14.3. SKI is of the opinion that the STFs are updated regularly at all plants. The new MERITS STF used by Ringhals 2–4 has been fully reviewed and approved by SKI after additional conditions were met.

Procedures

Operational, emergency and maintenance procedures are normally not reviewed by SKI. Only in connection with event investigations or specific inspections would SKI ask for a procedure to be submitted for review.

Engineering and technical support

Except for the independent safety review functions and involvement in the national competence situation as reported in chapter 11, SKI has not so far specifically reviewed the engineering and technical support available at the NPPs. In connection with other inspections and reviews, the specialist staffing situation has occasionally been commented upon.

Incident reporting

All reports from the licensees are screened as a routine 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 SKI are decided.

The number of licensee event reports (category 2 LERs) is varying in the range of 20–40 per year and rector, over the last years. The long-term trend was until 2001 decreasing, from 2001 it is slightly increasing in numbers. In about 10 cases per year, SKI makes a further in depth investigation and in about five cases SKI requires further measures to be taken by the licensee, as a result of the investigation.

In cases of more serious incidents, SKI has a procedure (RASK) for making an early investigation on-site. This procedure has been used in a few cases over the last years, latest in the Forsmark 1 case of loss of power to two safety trains (see section 6.1). Normally the licensee reporting provides the necessary information, together with SKI verifications on-site, for making the needed regulatory decisions.

Experience feed-back analysis

All LERs and scram reports from the Swedish NPP units have for several years been registered in a database at SKI (STAGBAS). With this data SKI 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.

Radioactive waste

Inspection of the on-site technical handling of spent fuel and nuclear waste is occasionally carried out by the SKI site inspectors reinforced with specialists from the department of nuclear material- and waste safety. Sometimes inspectors from SSI participate in these inspections. In addition SSI also inspects the radiation protection apects of the waste handling. A major effort by the specialists at SKI has been to review and approve the type packages produced at the NPPs for final disposal in SFR, or regarding spent fuel in the intermediate storage Clab. This review is also made in cooperation with SSI.

19.4 Conclusion

Sweden complies with the obligations of Article 19.

C. PLANNED ACTIVITIES TO IMPROVE SAFETY

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

Modernisation 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 of local dynamic effects from pipe breaks, withstanding of external events, improvement of operations aids and environmental qualification and surveillance will be finalised around 2013. Details are given in section B 6.2.

Measures taken after the Forsmark event 25 July 2006

As a result of this event at Forsmark 1, described in section 6.1, the licensee FKA has taken a number of technical and administrative measures to prevent recurrence. The licensee as well as the reactor owner Vattenfall AB has planned further improvements of safety management and safety culture at Forsmark to be implemented during 2007 and 2008. Details are given in sections B 6.1 and 10.3.

The licensees have asked the Government to request OSART missions to Forsmark in 2008, to OKG in 2009 and to Ringhals in 2010. The result of these peer-reviews will be public. IAEA has accepted to conduct these missions.

As a result of the Forsmark event the SKI Director General initiated internal investigations of the regulatory practices in order to learn from this experience and to improve. Several means for improvement and reinforcement of the regulatory practices were identified and justified. The implementation of these means would require more resources. In June 2007 SKI submitted an assessment to the Government of additional resources needed to reinforce the regulatory supervision as well as to cope with the expected increased work load over the next years to review a large number of plant modifications and uprate cases. 24 additional employees would be needed in the long term and additionally 7 during the period up to 2013. The Government has so far announced that they intend to reinforce the supervision of the nuclear power plants. Details are given in sections B 8.8 and 8.9.

Amendment to the SKI regulations (SKIFS 2004:1) on safety in nuclear facilities

SKI plans to issue during 2007 an amendment to chapter 4, 2 § SKIFS 2004:1 with regard to the contents and structure of the safety report. The amendment clarifies the safety documentation to be submitted in connection with major plant modifications and includes extended general recommendations on the structure and contents of the SAR. See further sections B 7.2 and 14.3.

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 SKI to continue the support of the Swedish Centre of Nuclear Technology economically after 2007, when the present agreement ends. Details are given in sections A 4 and B 11.5.

Further reduction of releases to the environment of radioactive substances

The releases from the nuclear power plants to the environment of radioactive substances, given in becquerels 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 sections B 15.3 and 15.5.

Appendix 1

VATTENFALL'S NUCLEAR SAFETY POLICY

The Vattenfall policy on nuclear safety sets up the guiding principles for the safety work. The emphasis of the policy is put on the following:

SAFETY FIRST: In all plant activities, sufficient margins should be maintained with regard to reactor safety and radiological safety. The aim is a safety level as high as reasonably achievable.

A SOUND SAFETY CULTURE: High competence, motivation and commitment should be maintained at all levels of the organisation. These are the basic elements of a sound safety culture.

CONTINUOUS IMPROVEMENTS: We should actively search for weaknesses and strive for continuous improvements. We should have the initiative in this by participation in, and by taking part of results from development efforts.

OPENNESS: We should be open to learn from other operators and willing to share our own experiences. Competition should not affect the exchange of safety relevant information. Openness to the public and to media is of special importance to strengthen the confidence for Vattenfall as a competent nuclear power utility.

The policy and the main structure of the safety work are described in the Management Handbook of the business area. Plant managers have committed to work according to the outlined principles.

GUIDING PRINCIPLES

Responsibility and leadership

Responsibility includes providing the requisites for employees and contractors to perform their tasks safely.

Delegation of accountabilities and responsibilities should be clearly documented.

The leadership should be characterised by knowledge and commitment on the safety issues of nuclear power, and insights on consequences of decision-making. In particular, all technical, procedural as well as organisational changes should be assessed considering their impact on safety in the long and short term.

The ALARA principle should be well known and accepted.

There should be a system for follow-up of safety.

All managers should promote a common view on safety throughout the organisation.

Safety first

Safety should always have priority before availability and economy. At decision-making, with potential conflicts between nuclear safety and other goals, conservative decisions with respect to safety should be made.

Competence and motivation

Great importance should be put on securing competence and developing motivation and safety consciousness of all personnel. Rules should be respected and each individual should contribute to a high level of safety.

Continuous development

Initiatives should be taken in order to be continuously updated on developments in reactor and radiological safety, and to implement measures for increased safety. The safety work should be characterised by continuous improvements.

Internal and external operational experience, as well as knowledge from research and development work, should be systematically reviewed and appropriately implemented. Nuclear safety should be addressed within the organisation as an area for development.

In all planning of plant activities, radiological aspects should be considered in order to limit negative effects on human life and the environment. Releases of radioactivity and doses to individuals and groups shall be minimised. The ALARA principle (As Low As Reasonably Achievable) should be applied concerning protection of plant personnel and the environment. When selecting and prioritising of important radiological protection measures cost-benefit analysis should be applied. As guidance, for a collective dose of 1 manSv a monetary value of 4 million SEK (as of the year 1994) could be used. Expected higher doses, high dose rates or other factors could motivate spending more on dose limiting measures. Reasonable costs are then considered on a case-by-case basis.

For planning of measures to improve safety the following should be considered:

Highest priority should be given when requirements according to the Safety Analysis Report (SAR) are found not to be fulfilled, or to measures that are based on regulatory requirements.

Safety programs for such improvements should be based on broad technical reviews that include deterministic criteria, probabilistic methods and MTO (Man, Technology and Organisational interaction). The safety programs should consider results and experience from the safety work, and include prioritisation, level of ambition and time for implementation.

Probabilistic, plant specific safety analysis (PSA), based on realistic assumptions, should be used as a tool for control of uniformity of contributions from various events sequences on the results. The following have been set as numerical goals for the Vattenfall nuclear units:

- Core damage frequency (CDF): < 1E-5/reactor, year
- Probability for releases of more than 0.1% of the core inventory of radioactive substances contributing to land contamination: < 1E-7/reactor, year

Deviations from these goals should initiate the planning of corrective measures, and such measures should be included in the safety programs.

The risk for events/accidents that may have a negative effect on humans and the environment should be eliminated as far as reasonable. Emergency preparedness should be maintained at a high level by effective planning to mitigate such events and to limit their consequences.

Openness

Confidence in our safety work is a necessary prerequisite for continued and future operation of nuclear power, and thus the safety work should be characterised by openness. The plants should be operated and maintained in such a way that the public, authorities, employees and owners feel high confidence in the safety of nuclear operations.

Openness, transparency and respect should characterise our contacts with authorities.

We should exchange information on safety related issues.

Appendix 2

E.ON's Nuclear Safety Council

The overall aim is to improve safety and set a common standard within the E.ON Group for nuclear safety.

The goal is to review the operation of nuclear power plants by using for instance different safety data, safety indicators, safety program and trends in the area of safety culture.

The Safety Council will promote safety development by, for instance, exchange of experience, good practice and evaluation of research. On a general level, the objectives are the following:

1. To follow up and assess the safety based of the E.ON Nuclear Safety Policy and to propose changes or modifications in order to promote safety

2. To follow up and assess safety as reflected by the use of safety indicators and periodic reviews, and to identify trends. In particular, the Council shall promote internal safety audit programs at the plants and monitor and assess the outcome of such planning

3. To follow up how nuclear safety issues are managed and prioritized in the long-term planning

4. To follow up and assess operational experiences and research

5. To follow up the developments of new requirements and guidelines

6. To promote a positive development of the safety culture will take place

7. To promote a common view/standard 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 organisations including representatives from the power plants.

Appendix 3

Implemented modifications in Swedish reactors 1995–2003

Below follows a summary of the major modifications done 1995−2003. 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 modernise 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 modernised 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 modernisation 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 busbars 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 subcritical, 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 modernised 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.

Oskarshamn 2

The modernisation 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

(The on-going PLEX project includes modifications to comply with SKIFS 2004:2 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

(The on-going PULS project includes a power uprate, modifications to comply with SKIFS 2004:2 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 2008 outage.)

Forsmark 1–3

The first comprehensive modernisation programme for the Forsmark plant, Program 2000, started in 1995, and was completed in 2000. Another strategy and modernisation plan was then adopted, Program P40+, that contained modernisation 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

Ringhals 1–4

The renewal programme for the Ringhals plant was initiated in 1997, and the following major measueres 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)
- modernisation of the radiation monitoring system (R2, R3, R4)
- modernisation of the safety injection pumps including vibration monitoring (R3, R4)
- upgrading with redundant cooling of the charging pumps at shut-down (R3, R4)
- modernisation 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 modernisations (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)

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