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2009 assessment of radiation safety in the Swedish nuclear power plants

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Contents

Summary

The Swedish Radiation Safety Authority has through its supervision ensured a comprehensive basis for this overall assessment of radiation safety.

The overall conclusion is that the radiation safety, nuclear safety, the physical protection including nuclear safeguards and radiation protection, in the Swedish nuclear power plants has been maintained at an acceptable level. The barriers comply with the requirements, and improvements have been implemented to the defence in depth. Further, large investment programmes are being carried out to comply with the requirements imposed by the authority regarding modernisation. Management systems and internal audits have developed in a positive direction.

2008 has been an eventful year in many respects. The nuclear industry is in a very intensive period. Modernisations are under way, aimed at improving safety, and measures are being taken to strengthen the physical protection in order to make forced entry to the plants more difficult. In addition, preparations are in progress to increase the thermal power in most of the reactors.

Operational events in 2008

Four events have occurred in 2008 that required SSM's permission to restart the plant (Category 1, SSMFS 2008:1). One event occurred in each of Oskarshamn 1 and 3, Forsmark 3 and Ringhals 2. The events in Oskarshamn 3 and Forsmark 3 were the result of broken control rod shafts. In Oskarshamn 1 a perturbation was caused by lightening, and in Ringhals 2 the event was due to deficiencies in the auxiliary feedwater capacity.

Five events have been classified and reported as level 1 on the International Nuclear Events Scale (INES). Level 1 is the first step above 0 of the 7-level scale.

In all 14 scrams have occurred. They have been reported from Oskarshamn 1 and 2 and Forsmark 2 and 3. This is a higher frequency than the reactors have set as their goal. There have been no scrams at the other reactors.

During the year SSM has carried out five incident-related (RASK) inspections in order to collect information relating to how the licensees have responded to the events and which measures have been taken to prevent a recurrence.

None of the events have led to threats to the safety of the surroundings. However several events have been classified at a higher level than has been normal in recent years.

Major alterations to the plants

Modernisation is being carried out in the form of large projects lasting for several years. The work is either carried out during extended refuelling outages or longer planned stops. Measures and component replacement to

enable increases in thermal power are organised in a similar manner. Further large efforts have been implemented during the year to improve the physical protection of the plants. This has resulted in extensive and complex alterations to the plants.

During 2008 the installations planned in Ringhals 1, Ringhals 2 and Oskarshamn 3 were moved to 2009. Because of the size of these projects, SSM must grant permission prior to installation. Even though extensive resources have been deployed to prepare the safety documentation supplemental documentation is necessary before the alterations can be started, which has resulted in changes to the time schedules planned for implementing the measures. Other reasons for the delays have been problems in the delivery of components. There is a large demand for components for nuclear power plants around the world which manufacturers have not been able to meet. One problem that has been noted is that some sub-contactors are not able to meet the quality requirements. This causes problems for the licensees.

Condition of the barriers and safety systems

Fuel and fuel cladding
During 2008 eight fuel failures were reported. They occurred in Oskarshamn 3 and Forsmark 3. The damaged fuel assemblies have been replaced. Previously Forsmark 1 has also had a number of failures. SSM considers that it should be possible to reduce the failure rate further. The other reactors have a relatively low failure rate. SSM considers that these failure levels are acceptable.

Primary system
Damage to the primary system has only been found in one plant, Ringhals 4. 3.05 % of the tubes in the three steam generators have been plugged as a result of various sorts of degradation. Replacement of the steam generators is planned for 2011.

Reactor containment
No degradation or other serious deficiencies have been found in the reactor containments of the plants. The minor leak in Ringhals 2 which was found earlier has been followed up. There are no signs of propagation or other changes to the defects which have caused the small leaks.

Management, quality assurance and organisation, and competence and resource assurance

There are signs of high work loads at all the plants. The personnel situation for the operational organisation at some of the units is still strained. SSM is going to follow this so that the extensive project activities do not remove the focus from the daily activities, and that there are sufficient resources to investigate operational disturbances should this be necessary. One question that SSM is following is how the licensee ensures its role as a purchaser in consideration of the supplier situation which exists, and which puts increased requirements on control.

The management systems are in general functional and readily accessible. Internal revision activities have been developed in a positive manner.

Waste management
Nuclear power plants have been required to implement a programme of measures to complement their safety reports with regard to the management of spent fuel and nuclear waste.

Since Clab 2 was taken into operation considerable amounts of spent fuel and reactor vessel internals have been transferred to the extension. Thus the transport of fuel to Clab will be able to follow existing plans.

Low level waste is deposited, according to plan, locally in shallow land fills or is sent to Studsvik for treatment.

Physical protection, nuclear safeguards and emergency preparedness

Physical protection
Strengthening of the physical protection is under way at all the plants. The extensive work is considerably behind time. As result of this SSM has granted exemptions to the requirements. In the exemptions SSM has defined conditions in order to ensure that the level of protection is maintained at an acceptable level during the period of implementation.

A relatively large number of Category 2 deficiencies have been reported which can have been caused by the extensive measures which have been carried out during the year. Some of these events have indications of a defective attitude towards physical protection. This has been followed up by the authority.

Nuclear Safeguards
SSM considers that the nuclear power plants comply with national and international requirements concerning nuclear safeguards and have good orderliness concerning their safeguards.

Radiation protection
SSM notes that the release of radioactive nuclides from the nuclear power plants in 2008 has resulted in a calculated dose which with good margins is under the environmental quality goal. SSM considers that the radiation doses to personnel, who have worked at the nuclear power plants during 2008, are at a reasonable level taking into account the existing radiation environment and the work performed.

1 Premises and evaluation criteria

The Act (1984:3) on Nuclear Activities stipulates that the holder of a license to conduct nuclear activities has the full and undivided responsibility to adopt the necessary measures to maintain safety. The Act also stipulates that safety shall be maintained by adopting the measures required to prevent

– equipment defects or malfunction
– human error
– other events that could result in a radiological accident.

In a corresponding manner, the Act (1998:220) on Radiation Protection stipulates that any person who conducts activities involving radiation shall, according to the nature of the activities and the conditions under which they are conducted, take the measures and precautions necessary to prevent or counteract injury to people, animals and damage to the environment.

The Swedish Radiation Safety Authority (SSM) shall in its regulatory activities clarify the implications of the licensees' responsibility and ensure that they comply with the requirements and rules for these activities and also achieve a high degree of quality in their safety and radiation protection work.

Basic principles for nuclear safety and radiation protection

Safety at Swedish nuclear power plants must protect humans and the environment from the harmful effects of nuclear operations. Safety work shall be based on the so-called principle of defence in depth - see Figure 1 - which has been ratified in the International Convention on Nuclear Safety and in SSM's regulations, as well as in many other national nuclear safety regulations.

Defence in depth

Defence in depth assumes that there are a number of specially adapted physical barriers between the radioactive material and the plant staff and the environment. In the case of operating nuclear power reactors the barriers comprise the fuel itself (fuel pellet), the fuel cladding, the pressure-bearing primary system of the reactor and the reactor containment.

In addition the defence in depth principle assumes that there is good safety management, control, organisation and safety culture at the plant, as well as sufficient financial and human resources. Personnel shall also have the necessary expertise and the right conditions for their work.

Defence in depth also assumes that a number of different types of engineered systems, operational measures and administrative procedures exist to protect the barriers and maintain their effectiveness. This is necessary both during normal operations and under anticipated operational deviations and accidents. If this fails, measures should be in place to limit and mitigate the consequences of a severe accident.

Necessary Conditions

- Several physical barriers successively placed between the radioactive material and the plant personnel and environment.
- Good safety management, control, organization and safety culture.
- Adequate financial and human resources as well as personnel with the necessary expertise and who are provided with the right conditions for work.

Level	Purpose	Main means
1	Prevention of abnormal operating occurrences and failures.	Robust design and high construction, operation and maintenance quality.
2	Control of abnormal operating occurrences and detection of failures.	High quality of the supervision and regulatory control of the facility through technical systems and administrative measures.
3	Control over conditions that can arise in connection with design basis accidents.	Efficient safety systems and emergency operating procedures.
4	Control over and limit of conditions that can arise in connection with severe accidents.	Technical measures prepared in advance and an efficient accident preparedness at the facility.
5	Mitigation of consequences in connection with the release of radioactive substances.	Measures prepared in advance for effective information to and protection of the population in the vicinity of the facility.

Figure 1. The necessary conditions for a defence in depth system and the different levels of the system

Analyses are performed to identify which barriers must function and which parts of the different levels of the defence in depth system must function during different operational conditions. When a plant is in full operation, all barriers and parts of the defence in depth system must be functional. When the plant is shut down for maintenance, or when a barrier or part of the defence in depth system has to be taken out of operation for other reasons, this must be compensated by other measures of a technical, operational or administrative nature.

If one level fails, the next level will take over. Failure of equipment or a manoeuvre at one level, or combinations of failures occurring at different levels at the same time, must not be able to jeopardise the performance of subsequent levels. Independence between the different barriers of the defence in depth system is essential in order to achieve this.

Radiation protection

Radiation protection is also organised according to internationally accepted principles. These are based on the balance between usefulness and risk, and are:

- the use of radiation must be necessary, that is to say, no unnecessary applications are permissible
- the use of radiation must be optimised, that is to say, radiation doses must be as low as reasonably possible

– doses to all individuals shall be below the dose levels stipulated by SSM.

The requirements that SSM imposes on the different levels of the defence in depth system are described in its regulations and the associated general recommendations. These legal documents comprise the essential premises and criteria for the evaluation presented by SSM in this report.

2 Events of significance for safety

Four events have occurred in 2008 in the Swedish nuclear power plants that have been classified as Category 1 events in accordance with SSMFS 2008:1, Appendix 1:

1) Oskarshamn 1 as a result of a rapid temperature transient in the primary circuit;

2-3) Oskarshamn 3 and Forsmark 3 as a result of broken control rod shafts;

4) Ringhals 2 as a result of deficiencies in the auxiliary feedwater capacity.

In 2008 five events have been classified and reported as level 1 on the International Nuclear Events Scale (INES). None of the events have led to threats to the safety of the surroundings. The events occurred in Forsmark 2, Forsmark 3, Oskarshamn 3, Ringhals 2 and Ringhals 3 and are described in the following text for the plants concerned.

Broken control rod shafts
A serious problem identified in 2008 was the broken control rod shafts which were found in both Oskarshamn 3 and Forsmark 3. The cracks were formed by fatigue due to thermal fluctuations caused by mixing of cold and hot reactor water. The thermal fluctuations were generated in the unique design of the control rod mechanism and control rod guide tubes in Forsmark 3 and Oskarshamn 3.

The root cause has not been remedied and Forsmarks Kraftgrupp AB (FKA) and OKG Aktiebolag (OKG) applied to SSM for permission to resume operations until their refuelling outages in 2009 using an interim solution. This was based on only using control rod shafts which were either new or had been found to be free from cracks when inspected. In addition, all the control rods were withdrawn to at the most 86 % which means that the mixing region for hot and cold water is moved to solid regions of the control rods.

Forsmark

Forsmark 1

There were no scrams in Forsmark 1 in 2008.

Leakage in the turbine containment
In January one turbine was shut down because of a leak in the turbine containment. The leak was repaired and during the refuelling outage in 2008 FKA expanded inspection of the areas concerned.

RASK inspection clarified the measures taken
A RASK inspection was carried out in February aimed at clarifying how FKA had responded to an event in which two of the stand-by diesels were declared “not ready for operation” at the same time, but for different reasons. The investigation also assessed the organisation’s capability to cope with unclear situations whilst maintaining safety.

SSM considers that the event was dealt with in a manner that did not threaten reactor safety and complied with SKIFS 2004:1 2 ch. 3 §, even if there was room for improvement. FKA responded to the problem of the diesels not being ready for operation in an acceptable manner between 6 February and 13 February. On the other hand SSM considers that there are a number of circumstances in connection with the event that Forsmark must improve. For example the planned repair did not follow previous decisions by Forsmark's safety committee. Other needs of improvement concern for example the capability to carry out a root cause analysis and assessment of readiness for operation, as well as working with the operations log book and the capability to document meetings. SSM has also identified that communication and expectations between operators and maintenance need to be improved.

Forsmark 2

There were four scrams in Forsmark 2 during 2008.

- Manual shutdown after a power oscillations because 8 main circulation pumps stopped triggered by a grid disturbance (2008-08-17)
- Scram associated with adjustment of the neutron flux measurement during power reduction prior to the annual refuelling outage (2008-08-17
- Scram due to a disturbance in the measurement of the neutron flux during refuelling (2008-08-17)
- Scram due to high reactor pressure in association with a hot scram test (2008-09-16)

Grid disturbance transmitted into the plant
A disturbance in the grid occurred on Friday 13 June in the 400 kV line Hagby – Tuna as a result of lightning. Forsmark 2 was affected in an unexpected manner: the grid disturbance was transmitted into the plant and resulted in the energy bearing not receiving a signal to shut down. All the main circulation pumps were running at full power when the energy bearings were exhausted, which resulted in rapid roll out of the pumps. After about three minutes an operator initiated a manual scram since there were such large thermal power oscillations. According to Forsmark 2 there have been historic problems with the reliability of the energy bearing, but previously the problems have been associated with vibrations and large maintenance demands.

Following the grid disturbance Forsmark started the refuelling outage earlier than planned. 84 fuel assemblies which had fallen below the limit for dryout margins were replaced. Most of the fuel assemblies which were replaced had only been in the reactor for one fuel cycle. A plan has been developed to verify that most of the assemblies are ready for operation.

Following the event on June 13, 2008, the energy bearings are no longer credited by Forsmark 2. This has the consequence that the maximum thermal power of the reactor has been limited somewhat.

Erroneously shut safety valves
On August 18, 2008, Forsmark 2 discovered during a test of the manoeuvrability of a check valve that there was not a free flow path in one train in the emergency core cooling system. This was because a service valve had been shut erroneously. The service valve had been in this position since

the previous refuelling outage in August 2007. During the start up after the refuelling outage in 2007 a RSP-test (reactor protection system) had been carried out when the manoeuvrability of the safety valve was tested it triggered due to torque the outer safety valve in sub D of the emergency core cooling system. After this a tightness test was carried out on the safety valve without problem, and the associated service valve was reset into the "correct" open position.

It is normal practice to carry out a tightness test when work is carried out on a safety valve. After this someone has manoeuvred the service valve in error to the shut position. The event resulted in FKA's safety department initiating a quick investigation of the incident, and later also a more comprehensive investigation to ascertain the root cause. The event has been classified as level 1 on the international INES scale.

On August 19 SSM decided to carry out a RASK inspection on site at Forsmark in order to obtain its own impression of the event. The goal was also to control how FKA had responded to the event and to assess the capability of the organisation to maintain safety. SSM considers that the incident has been dealt with in an acceptable manner and that SSMFS 2008:1 2 ch. 3 § has been complied with, even if there is some need for improvement. FKA has not been able to show any documentation of the measures and the independent safety review, nor identify which documentation was used during the operations meeting and as the basis for the decision to restart.

SSM has identified several deficiencies in how FKA with their own safety reviews. SSM considers that FKA have broken two administrative barriers according to FKA's own safety directive. The most important is that FKA has not applied approved routines. Therefore SSM considers that there is room for improvement to ensure that personnel follow approved routines.

Damage to the cooling system
On August 21, 2008, Forsmark informed SSM that they had found damage to the residual heat removal system when controlling the reactor containment after the refuelling outage. The damage was to a small bypass from the main pipe to a sprinkler system for the reactor vessel flange. Forsmark 2 reported the event as a category 2 event in accordance with SKIFS 2004:1 and repaired the damage before the reactor was taken back into operation.

High pressure in the reactor pressure vessel
In connection with a hot scram test on September 16 an automatic scram occurred because of high pressure in the reactor pressure vessel. This was caused because the operator regulated the pressure in the vessel manually during the test and did not manage to adjust it in time. It is acceptable according to the specific operating instructions, but requires that the operator is observant to the pressure variations.

Forsmark 3

Three scrams have occurred in Forsmark 3 in 2008:

- A scram because of a tube rupture in the turbine condenser, 2008-06-03
- Manual scram in connection with a faulty feedwater pump minimum flow valve, 2008-07-13
- A scram in connection with a hot scram test, 2008-08-13.

Indication of fuel failure
An indication of leaking fuel was obtained on July 30, 2007, and remained at a stable low level throughout 2008.

Leak in the nitrogen pressure system
On Sunday June 1 a leak occurred in the nitrogen pressure system. This means that the valves in the residual heat removal system in the reactor containment were not ready for operation.

In order to remedy the leak it was necessary to take the reactor first to warm standby and then to cold standby – the latter since FKA also decided to remedy the fuel leak that had existed during the fuel cycle. Core leak testing revealed two leaking fuel assemblies. During the power reduction to hot standby high conductivity levels were obtained which resulted in a scram. This led to an inspection and repair of the condenser when a condenser tube was plugged. On June 8 the reactor was restarted and phased on to the grid after the short shutdown.

Further fuel failures
On September 15 a new fuel failure was found, only one month after the refuelling outage.

Failed and cracked control rods
In connection with manoeuvring of the control rods on September 28 one of them, control rod I55, could not be inserted. The control rod mechanism was triggered on high moment in the 99 % position. The control rod was left in this position and declared as "not ready for operation". In this situation it must be verified by calculation that the reactor can be made under critical safely with the specific control rod configuration and the most effective scram group non-functional. The power was reduced to 65 % and the control rod sequence was changed to comply with the requirements regarding sufficient margins for shut down. It was later found during the stop on October 21 that control rod I55 had a rupture in its shaft.

On Tuesday October 21 Oskarshamn 3 informed SSM that a control rod with a ruptured shaft and others containing cracks had been found, and that the plant had been shut down for inspection of control rod shafts. SSM considers that FKA took the necessary measures to comply with the regulations that the reactor should without unnecessary delay be brought into a safe state.

Inspection of the control rods was started during the weekend 25 – 26 October once the reactor pressure vessel had been made ready for transport of fuel and control rods. During the inspection control rod shafts which had failed were found in both Forsmark 3 and Oskarshamn 3. FKA reported the event as a category 1 in accordance with SKIFS 2004:1. The incident was classified as level 1 on the international INES scale. FKA has subsequently inspected all the control rods, and control rods with cracks have been removed from the core. After a safety review SSM decided on December 30 to approve Forsmark's application to restart the reactor and to operate it until July 31, 2009. The restarting process of Forsmark 3 was initiated after SSM's decision and the generator was phased onto the grid on January 1, 2009.

Physical protection

During the year a relatively large number of category 2 deficiencies in the physical protection have been reported to SSM. SSM has not investigated these, but the probable cause of the large number can be that extensive measures have been undertaken during the year to strengthen the physical protection.

Oskarshamn

Oskarshamn 1

Oskarshamn 1 has a higher frequency of scrams than the other Swedish plants. In 2008 five scrams have been reported in accordance with SSMFS 2008:1. Oskarshamn 1 should take measures to reduce this number. The reported scrams are:

1. scram triggered by TSxD[1] (2008-01-22)
2. scram triggered by TSxD[1] (2008-03-04)
3. scram caused by steam blockage (2008-05-24)
4. scram caused by a disturbance on the grid (2008-06-16)
5. scram triggered by relay protection on the main generator (2008-07-22)

Scrams 1 and 2
Scrams 1 and 2 were initiated by the same fault. A short circuit in a manoeuvre coil resulted in a steam safety valve shutting.

Scram 4
Scram number 4 occurred in connection with lightening hitting a 130 kV cable close to Simpevarp which caused all the main circulation pumps to stop. The restart was unsuccessful because of erroneous blocking. During the hours spent finding the fault the temperature in the main recirculation system sank. OKG then decided to cool down the reactor pressure vessel with all the main circulation pumps stopped, in order to obtain a smaller temperature difference between the reactor pressure vessel and the main circulation system.

When the temperature in the other systems had reached 230°C a temperature gradient of about 60°C was registered over 2 minutes. According to the plant operational technical specifications (STF), this is the maximum permissible level (HTG), and therefore the incident was classified as a category 1 in accordance with SSMFS 2008:1, Appendix 1. This requires the permission of SSM to restart the reactor. The reactor was therefore cooled down to cold shut down.

On July 16 OKG submitted its application to take Oskarshamn 1 back into operation. After a safety review SSM decided on July 18 to approve the application to restart. The safety review however indicated that OKG needed to carry out a number of complementary measures and studies. OKG were required amongst other things to:

– increase possibilities to measure the temperature, and install a so-called HTG alarm

[1] TSxD: turbine stop when dump to the condenser is prohibited

- describe the revision of the instructions to deal with potential HTG-events
- describe the steering/strategy for the choice of which pump should be restarted first after loss of power
- revise routines for dealing with the need for updating instructions and training as a result of experience and changes in the plant

SSM considers that OKG took the necessary measures to comply with the regulations that the reactor should without unnecessary delay be brought into a safe state. SSM bases this judgement on the fact that personnel had taken precautionary measures to avoid worsening the suspected temperature gradient. SSM considers that OKG took a reasonable length of time to try and identify the fault and analyse the situation. It took about four hours for OKG to take the decision to cool the reactor which SSM considers is reasonable.

Scram 5
The refuelling outage was started on June 22. When restarting after the outage, in connection with a speed test of the turbine, a scram occurred when a relay guard was not blocked. The plant was phased onto the grid on July 25.

Oskarshamn 2

In 2008 two scrams have been reported in accordance with SSMFS 2008:1. The reported scrams are:
- scram in connection with a logic test (2008-03-12)
- scram caused by a pressure transient (2008-03-25)

Scram number 2 occurred in connection with a quarterly test of the reactor's level and pressure measurements.

All the subsequent functions worked as expected in connection with the scram. SSM carried out a RASK inspection and found that the disturbance had been dealt with in a manner that inspires confidence for the routines and response in Oskarshamn 2. The following needs for improvement were identified however:
- communication between the test leader and the operator in the control room can be improved so that important alarms or events in the process which are not part of the test are not missed
- the new control system for the turbine equipment does not indicate a deviating position as clearly as the old system did when the feedwater pump stopped
- in projecting OKG needs to take into account the capabilities and capacity of personnel in connection with the approval of the prerequisites for a new installation
- when testing a new system OKG needs to thoroughly investigate all unexpected events.

Oskarshamn 3

No scrams in accordance with SSMFS 2008:1 have been reported in 2008.

Contaminated core
At the end of October 2007 a fuel failure was identified and at the end of January 2008 Oskarshamn 3 found indications that it has developed to a so-called secondary failure with uranium released to the primary system. According to its internal policy Oskarshamn 3 has a limit of 2 g released uranium before the reactor should be shut down without delay. There was therefore a short shutdown in February in order to replace the damaged fuel. In addition 26 new fuel bundles were loaded in order to extend the operational season since the refuelling outage had been postponed.

After restart with the core free from damaged fuel, Oskarshamn 3 still had a relatively high level of contamination. At the end of June another primary fuel failure was observed, which developed to a secondary failure in August. This means that the problem must be dealt with in the coming project to increase the thermal power, when the coolant flow rate across the core will be increased.

Erroneous adjustment of the intermediate heat exchanger valves
In the middle of August a shut down occurred in connection with an error in the adjustment of the intermediate heat exchanger valves. OKG planned to carry out work on the control valves during the refuelling outage and continued operating with reduced power until then.

Broken control rod shaft
During the refuelling outage a broken control rod shaft was found in the control rod mechanism that had triggered by a torque guard prior to the refuelling outage in 2007. After this the control rod was completely inserted. During the outage in 2007 the control rod mechanism was test manoeuvred on several occasions without problem and therefore no remedial actions were taken prior to restarting. During the cold scram test prior to restart the rod could not be withdrawn more than 50 %. The control rod mechanism/rod was therefore left completely inserted and declared to be ready for operation in accordance with STF 3.3B.

The broken control rod shaft was initially classified as a category 2 event, and a failure group was formed to determine the root cause in accordance with normal routines at OKG. On October 19 SSM received information about the broken control rod shaft. During the following days OKG inspected more shafts, and several of them were cracked. SSM was informed continually.

On October 24 OKG reclassified the event as a category 1 and a week later OKG submitted a preliminary report to SSM in accordance with SSMFS 2008:1 7 ch. 1 §. Category 1 means that the plant may not leave a safe condition without the permission of SSM. SSM considers that the time taken for classification and reporting was reasonable, and that the measures taken after the reclassification were carried out in accordance with SSMFS 2008:1 2 ch. 4-5 §§. The event has been classified as level 1 on the international INES scale.

In the mid-December 2008 OKG submitted an application to restart Oskarshamn 3 and on December 30 after performing a safety review SSM granted permission for the plant to be operated until March 1, 2009.

Physical protection

In May 2008 it came to SKI's attention that OKG did not perform safety checks of individuals during some parts of the day. SKI carried out a RASK inspection in order to obtain an independent opinion of what had happened. During the inspection it was found that some requirements in earlier decisions concerning exemptions were not being complied with such that the safety control posts were left unmanned under some periods of time on the day that was the subject of the inspection. SKI therefore considered that OKG had at those times not complied with the requirements concerning:

- safety checks of individuals
- controlled access to guarded areas
- detection of forbidden removal of radioactive substances and nuclear waste.

In addition to imposing requirements that OKG take certain remedial measures, on September 16 SSM informed the public prosecutor in Kalmar of the situation. On November 25, 2008, the public prosecutor decided to initiate a prejudicial inquiry, which is not yet complete.

In October 2008 it came to SSM's attention that OKG employed personnel not trained for guard duties to replace faulty alarm detectors in parts of the site protection system. After an investigation SSM found that:

- OKG's decision to use personnel without training for guard duties had been going on for a longer period of time, and was not in compliance with their internal instructions
- Documentation of decisions was misleading
- OKG's written report of the incident contained a number of erroneous facts
- OKG's instruction "Routines for assessing the status of the physical protection" had not been subjected to a safety review

In connection with the investigation of both of these incidents information was found that can indicate that there are deficiencies in the safety culture with regard to attitudes concerning the physical protection at OKG.

Ringhals

Ringhals 1

No scrams occurred in Ringhals 1 during 2008.

Pressure variations in the emergency cooling system
Repeated problems with pressure variations in the emergency cooling system for the reactor resulted in a pressure tank being installed on the suction side of the pump in both circuits. This problem led to a 14 week extension of the refuelling outage.

Two valves set wrongly
During start-up after the refuelling outage Ringhals 1 discovered on December 17, 2008, in connection with a hot scram tests, that two scram groups were not pushed in. On looking for the cause of the problem it was noted that two valves had been erroneously set to the shut position. This error

meant that the nitrogen tanks had a lower pressure than the water tanks. SSM carried out a RASK inspection and came to the conclusion that the measures taken by RAB were sufficient to remedy the situation. The authority's overall assessment is that Ringhals dealt with the event in an acceptable manner and that SSM did not need to take any further measures.

Ringhals 2

No scrams occurred in Ringhals 2 during 2008.

Risk for leakage through a check valve
Ringhals 2 decided on January 31 to shut the plant down since there was a risk for leakage though a check valve to an accumulator tank which could result in a rapid degradation of its pressure bearing function. During the repair it was noted that the damage had not affected the inner cover which determines the valves integrity. On February 7 Ringhals was back in full power operation.

Deficiencies in the feedwater capacity
During tests after the 2008 refuelling outage in Ringhals 2 it was discovered that the electrically powered auxiliary feedwater pump did not deliver the flow rate as specified in the safety analysis report. RAB completed the tests and looked for the cause of the problem when they found that there were also deficiencies in verification of operational readiness. The deficiencies were classified as a category 1 event in accordance with 2 ch. 3 § SKIFS 2004:1. RAB therefore carried out investigations and analyses and took measures in order to restart the reactor and operate it in a safe manner. Amongst other things the highest permissible thermal effect was reduced from 100 to 90 % until new feedwater pumps became available which complied with the capacity requirements. The event was classified as a level 1 on the international INES scale.

The deficiencies discovered in the verification of operational readiness of the auxiliary feedwater system resulted in RAB checking and documenting the operational readiness of all of the cooling systems.

SSM required that Ringhals report by December 31, 2008, at the latest report a systematic review that all of the verification of operational readiness tests of safety systems and safety functions are carried out in such a manner that the acceptance criteria are met. Ringhals had to carry out studies which clarified:

- Why test procedures which does completely verify the functionality correctly had been used for a long period of time
- Why the company, when testing the auxiliary feedwater system, have not observed that the resulted are lower that the acceptance criteria in the safety analysis report.

The report of the review and studies has been submitted to SSM.

Ringhals 3

No scrams occurred in Ringhals 3 during 2008.

Deviations in fuel supplies
During the restart after the refuelling outage it was found that the readings from the core instrumentation were not as expected. A review of the documentation for the fuel delivery showed deviations in the positioning of the burnable absorber rods, gadolinium, compared with the order Ringhals had placed. The supplier had made a mistake during manufacture. The incident showed that there is a need for improving the control of fuel deliveries both at the manufacturer and Ringhals. The event was classified as level in the INES scale.

Leaking generator rotor
At the end of August 2008 a leak was found in the generator rotor. The leak occurred in the rotor itself so that it had to be returned to the manufacturer for dismantling and repair. In order to transport the rotor away from the plant the reactor had to be shut down. A reserve rotor was installed and the reactor could be restarted on September 1.

Ringhals 4

Ringhals 4 had for the most part problem free operations without any disturbances during 2008.

Physical protection

A relatively large number of category 2 deficiencies in the physical protection have been reported to SSM. SSM has not investigated them, but a probable cause of this large number could be the extensive measures which were being undertaken during the year to strengthen the physical protection.

3 Major alterations to the plants

The Swedish nuclear industry is in an intensive period of activities – the most intensive since the construction period during the 1970:s. This is due primarily to three things:

- Extensive modernisation with respect to safety improvements as a result of more stringent regulations
- Operation is planned for a longer time than was originally covered by the analyses of the plants
- Preparations are under way for increasing the thermal power of most of the reactors.

Safety related modernisation

The regulations concerning the design and construction of nuclear power plants, SSMFS 2008:17, came into effect on January 1, 2005. Transitional decisions have given the licensees time to plan and carry out the necessary measures to comply with the regulations. The transitional plans run to 2013 when the regulations must be complied with in full.

The major safety improvements and modernisations will for the most part be regulated by SSMFS 2008:1 (previously SKIFS 2004:2). But for the nuclear industry there are also other reasons for implementing the measures, for example operational measures with economic implications where older equipment requires increased maintenance and inspection. Other examples are that the technical equipment needs to be replaced because of its age and the difficulties associated with the supply of reserve parts or competence for its maintenance. The electronics and equipment in the control rooms is one example of the latter in which older equipment will be replaced with more modern equipment.

Modernisation projects

For the older reactors, Oskarshamn 1 and 2 and Ringhals 1 and 2, the modernisations are being carried out for the main part in large projects which will last for several years. For the other plants the modernisations will be carried out either during the normal extended refuelling outages or in connection with thermal power increases.

A status of the modernisation of the plants is given shortly below:

Forsmark

- Forsmark 1: in 2008 Forsmark 1 had an extended refuelling outage and strengthened amongst other things the cooling system building, carried out physical separation of the residual heat cooling system and modernised that part of the reactivity control system which screws in the control rods, the so-called V-chain.
- Forsmark 2 will carry out an extended refuelling outage in 2009 when they plan major modernisation. The most important from the safety aspect are the reconstruction of the V-chain, replacement of the steam

safety valves, and diversification of reactivity control (automatic boron pumping).
– Forsmark 3 plans in 2009, as does Oskarshamn 3, to install diversified core cooling from an external water source.

Oskarshamn

– Oskarshamn 1 was the first Swedish nuclear power plant to undergo very extensive modernisation. The work was completed in 2002 and involved amongst other things a new design of the safety systems, new instrumentation and control equipment, as well as a new control room.
– Oskarshamn 2 is planning to rebuild the safety systems, instrumentation and control equipment, as well as the control room. Most of the modernisation will be carried out in 2011. According to the plans, the modernisation of Oskarshamn 2 to comply with SSMFS 2008:17 will be completed in 2012.
– Oskarshamn 3 is planning to increase the thermal power in 2009. As a prerequisite there are requirements for diversified reactivity control (automatic boron pumping), which will be installed in 2009. In addition OKG is planning to install diversified core cooling from an external source of water during the outage prior to the increase in thermal power in 2009.

Ringhals

– Ringhals 1: major reconstruction work is under way to install a new reactor protection system and new cooling chains. They were intended to be installed for the main part in the autumn of 2008, but were postponed until the spring of 2009. In order to delay the installation it was necessary for SSM to take a new decision concerning the times in the transitional decision.
– Ringhals 2: there are also major alterations under way in Ringhals 2 to modernise the reactor protection system, which requires a completely new control room. The project has suffered major delays because of problems with the introduction of modern electronics, and the installation is now expected to be carried out in 2009.
– Ringhals 3 and 4: the times for the modernisation measures lie under the later part of the transitional period. During the earlier part of the period analyses will be performed to illuminate to what extent the plants need to be rebuilt.

The entire control room of Ringhals 2 is going to be rebuilt as part of the project TWICE and Ringhals 2 has since the beginning of 2008 a full scale simulator on site. The delays in the project have been used for more training and work associated with the interaction between man – technique – and the organisation. A number of tests are being carried out in order to be sure that the control room in its new configuration will work at least as well as the old one.

Permission for and safety review of the conditions for increasing the thermal power

SSM's review of power increase applications is performed in several stages. Initially SSM carries out a broad safety review which forms the basis of the comments submitted to the government. When the license is granted SSM carries out a safety review of the specific plant to ensure that they comply with the conditions of the license and that the safety requirements are fulfilled. The safety review of a thermal power increase is very extensive and takes several years.

Forsmark

In 2005 FKA submitted an application for permission to increase the thermal power rating for Forsmark 1, Forsmark 2, and for Forsmark 3. Comments have been submitted to the government stating that the technical premises exist for thermal power increases but that the authority will not start its safety review of the preliminary safety analysis report until FKA has remedied the deficiencies in the management and steering of the company which were pointed out as a result of the Forsmark incident in 2006.

Oskarshamn

On June 8, 2006, the government granted permission for OKG to increase the thermal power in Oskarshamn 3 from 3,300 MW to 3,900 MW. In April 2007 OKG submitted an application to SKI for the approval of the preliminary safety analysis report which forms the basis for plant modifications prior to trial operation at a thermal power of 3,900 MW. The safety review was very extensive. Additional material and explanations were requested on several occasions. An updated preliminary safety analysis report was required. The safety review has now been completed and the report approved. Alterations to the plant are under way, and SSM plans to assess the question of trial operation in June or July of 2009.

On September 26, 2007, OKG also applied for permission to increase the thermal power of Oskarshamn 2 from 1800 MW to 2300 MW. Due to a lack of resources the authority's safety review of the application was postponed until the autumn of 2008.

Ringhals

The government has earlier granted permission for Ringhals 1 to increase its thermal power and SSM approved trial operation. This has been in effect since 2008 and is expected to continue into 2009. After an evaluation of the results of the trial operation SSM will assess the question of routine operation at the higher power level.

The government has also granted permission for RAB to increase the thermal power of Ringhals 3 from 2,873 MW to 3,160 MW. This is intended to be carried out in two steps, first to 3,000 MW and later up to 3,160 MW. In September 2007 RAB submitted an application for approval of the preliminary safety analysis report for Ringhals 3 which will form the basis for the plant modifications prior to trial operations of the reactor at a thermal power of 3,160 MW. The safety review was completed in June 2008. Based on the safety review the authority considered that the analyses, studies and updates had for the most part been carried out in a satisfactory manner. However SSM considered that there was a need for further improvement to various degrees and of varying safety significance that needed to be implemented within the framework of the renewed safety analysis report which will be submitted with the application for trial operation at 3,160 MW.

RAB has subsequently worked to remedy these deficiencies. In December 2008 RAB submitted an application for approval of the new safety analysis report and trial operation. The safety review is currently in the final stages and a decision approving trial operation is expected at the beginning of May 2009. This will however be limited to operation at 3,144 MW.

On December 17, 2007, RAB also applied for permission to increase the thermal power of Ringhals 4. This power increase requires very extensive alterations to the plant. Amongst other things the damaged steam generators need to be replaced, which will require a hole being made in the reactor containment. SSM's safety review of this application will be completed in January 2009 together with comments to the government supporting the application.

Strengthening the physical protection

Work is underway at the plants to strengthen the physical protection to the level required by SSMFS 2008:12 (previously SKIFS 2005:1). The projects which are very extensive have been considerably delayed at all the plants which has had the consequence that all the nuclear power plants have requested exemption from the implementation times required in the regulations. In order to assess the prerequisites for a time limited exemption SSM carried out inspections in the autumn of 2008. The inspections assessed partly whether the projects had the prerequisites to comply with the regulations and also which temporary measures were required for the physical protection during the period of implementation.

On January 22, 2008, SSM decided to approve a time limited exemption for all the nuclear power plants to implement the planned measures. The exemption is associated with requirements to ensure a sufficient safety level during the implementation.

4. Condition of the barriers and safety systems

Barriers and inspection requirements

Defence in depth assumes that there are a number of specially adapted physical barriers between the radioactive material and the plant staff and the environment. In the case of operating nuclear power reactors in operation the barriers comprise the fuel itself (fuel pellet), the fuel cladding, the pressure-bearing primary system of the reactor and the reactor containment.

Comprehensive analyses and assessments as well as detailed quality control of the barriers are necessary before they become operational for the first time. The purpose of this is to ensure that sufficient safety margins exist to the loading conditions which can occur during normal operations, and under anticipated operational deviations and accidents. The corresponding analyses, assessments and quality control are also necessary when alterations are made to the plant or the operational conditions, for example modernisations or thermal power increases.

Once the barriers have become operational continuous maintenance, following up and in-service inspection are necessary in order to catch damage resulting from unexpected conditions or degradation mechanisms that were not included in the design basis.

In order to ensure that the barriers do not degrade over time the authority imposes requirements both regarding maintenance and inspection programmes and for coordinated programmes for managing ageing related degradation. The purpose of these programmes "Ageing Management Programmes" is to enable better time margins in the work to prevent damage.

Degradation mechanisms and the overall development of damage

Extensive replacement of components that have been found to be susceptible to degradation has been carried out by the Swedish nuclear power plants. Many of these replacements have been performed preventatively as more knowledge has been acquired about the causes of damage and the degradation mechanisms. In other cases the components have been replaced when damaged. In 2008 relatively few new cases of degradation and defects have been reported. Previously identified problem areas have been followed up and analysed.

SKI continuously follows the development of degradation in the mechanical components that form part of the barriers and defence in depth of the plants. This work includes both evaluation of the development of the damage overall and for the individual plants. The work also covers efforts to follow up under which conditions the various degradation mechanisms occur.

An overall evaluation which covers all the cases of damage in mechanical components since the first plant was commissioned confirms that the preventative and mitigation measures taken have had the intended effect. This conclusion is valid even after the damage that has occurred up to the end of 2008 is included. There is no sign of an increase in the number of defects as the plants become older. The overall evaluation also shows that most of the damage to date has been found through periodic in-service inspection before safety has been affected. Only a small proportion of the defects have led to leakage or more serious conditions as a result of the cracks or other types of degradation remaining undetected.

Fuel and fuel cladding
Tight fuel cladding is basic for safety to prevent the release of radioactive substances in and from the plant. During the 1980:s and into the 1990:s a number of stress corrosion cracking failures were reported in which the fuel cladding did not comply with the requirements concerning resistance to the environment.

The failures that occur nowadays are primarily caused by metal turnings or threads that enter the fuel bundles via the coolant and then wear holes in the cladding. To reduce the number of this sort of failure, fuel assemblies are fitted with filters to prevent the debris from entering the bundles, and cyclone filters are installed in the plants to clean up the coolant. It is however most important that there is a greater awareness of the importance of keeping the coolant free from debris that can wear holes in the fuel cladding. The plants have programmes in place to reduce the risk for damaging debris getting into the systems.

Primary and safety systems
Different corrosion mechanisms are the main cause of the defects that have occurred in the mechanical components of the primary and safety systems, and have accounted for approximately 60 % of the cases, with intergranular stress corrosion cracking as the most frequent degradation mechanism followed by flow accelerated corrosion.

Stress corrosion cracking is a degradation mechanism that in nuclear systems occurs for the most part in austenitic stainless steels and nickel base alloys when these are exposed to tensile stresses and corrosive environments. Despite the fact that considerable knowledge of the factors which affect this form of degradation has been built up over the past few decades, it is not sufficient to completely avoid problems.

Whilst stress corrosion cracking has most often occurred in the primary piping and safety systems, flow accelerated corrosion is more common in secondary systems such as steam and turbine components. Thermal fatigue, which is the third most prevalent cause of damage accounting for about 10 % of the events, has largely occurred in primary piping and safety systems.

The positive development, in which the number of cases of damage in mechanical components is not increasing as the plants become older, requires a continued high level of ambition with regard to the preventative maintenance and replacement efforts. SSM will therefore continue to pressure the licensees to maintain this high level of ambition and the preparedness to evaluate and assess damage when it is detected.

Reactor containment
Further studies and development work is still necessary in order to achieve adequate monitoring of the ageing related damage that can decrease the safety of the reactor containment and other building structures. The damage and deterioration which have occurred to date have for the most part been caused by deficiencies in connection with the erection of the structures or their subsequent modifications. This type of damage has been observed in, for example, Barsebäck 2, Forsmark 1, Oskarshamn 1, Ringhals 1 and Ringhals 2.

The damage has primarily been the result of corrosion of the metallic parts of the reactor containment, but degradation of the sealing material has also occurred. Similar experience has been reported from other countries. Considering the difficulties associated with the reliable control of the reactor containment and other important building structures, SSM considers it important that the licensees continue to study possible ageing and degradation mechanisms that can affect the integrity and safety of these structures.

SSM is continuing with its own studies and research concerning the damage and other degradation mechanisms that can affect the reactor containment. The results indicate that the risk is generally small for damage or other degradation caused by the environment. On the other hand the damage which has occurred shows that deviations from the construction drawings have led to damage at a later stage. Therefore the risk for the occurrence of different damage mechanisms cannot be assessed entirely on the basis of operational conditions and the nominal design, but must also be based on the reported damage.

Status of the barriers

Fuel and fuel cladding
In 2008 eight fuel failures were reported, from Forsmark 3 (three failures) and Oskarshamn 3 (five failures). The damaged fuel rods have been replaced.

Over the last five years between three and eight failures due to wear have been reported to SSM each year. A few of the reactors (Oskarshamn 3, Forsmark 1 and Forsmark 3) have had most of the failures which indicates that it should be possible to further reduce the failure frequency. For the other reactors the failure frequency has stabilised at a relatively low level.

Primary system
In 2008 only one plant has reported damage to the primary system: Ringhals 4. This plant has steam generators with tubes manufactured in a material, Alloy 600, which is susceptible to degradation. As in previous years extensive testing has been carried out on the tubular parts of the steam generators' tube sheet, support plate intersections, preheated parts and the U-bends. Several more tubes were found to contain indications of stress corrosion cracks in the region of the tube support plate as well as some growth of previously detected cracks. No new defects were found in the U-bend region of the tubes from the inspections and tests performed during the year.

Tubes with such limited damage that there are safe margins to rupture and flaking have been kept in operation in Ringhals 4, in accordance with specific permission from the authority. Damaged tubes with insufficient margins were removed from service. In the three steam generators somewhat more than

2,000 tubes have been damaged in some way or another. The total number of steam generator tubes which have been taken out of service in Ringhals 4 now corresponds to 3.05 % of all the tubes.

In 2011 Ringhals is planning to replace the steam generators in Ringhals 4 with a new design which amongst other things has more damage-resistant tube material.

Reactor containment
No damage or other serous deficiencies has been found in the reactor containments.

During the year a small leak which remains in Ringhals 2 has been followed up after repair of the toroid liner in the lower section of the containment. The leak was the result of a manufacturing defect and needs to be followed up so that it does not begin increase because of corrosion. Further inspection has also been performed of the liner plate in the containment of Ringhals 1. Small leaks had been observed earlier because of pores in the welds joining the plates. Some unexpected variations in the leak rate have been noted but are not considered to be an indication of propagation or other changes.

5. Management, quality assurance and organisation, and competence and resource assurance

Forsmark
In 2008 Forsmark carried out a comprehensive programme of measures aimed at improving operations. Improvements of the safety culture have been given priority and for the most part FKA deals with safety matters which arise according to their relevance for safety.

Internal audits and safety review
During the year internal auditing has been developed and now has a permanent staff. Independent safety reviewing also has a more stable personnel situation and submits clearer and better documented reviews to the authority. Forsmark has also improved its routines for assessing contractors and suppliers.

Staff
The working organisation, maintenance and working routines are areas which need to be improved and focus on safety work. There are still signs of high work loads for the staff in Forsmark. The staffing situation for the operational organisation of Forsmark 1 and 2 continues to be strained and the staff level of the central guard office has been inadequate.

The activities regarding plant alterations have had a continued high work load. There are however the prerequisites for improvement with regard to experience feedback after the alterations now that routines have been established and the group for experience feedback (FTQ) has been formed. FKA has hired two behavioural scientists to the group FTQ.

Ambiguities concerning decision making
SSM noted in June 2008 that there were still ambiguities associated with decision making in matters of safety and classification of events. Forsmark is going to introduce classification in the next retraining for shift personnel, a measure which can remove the uncertainties which still remain concerning the classification of serious events.

Oskarshamn

OKG has a homogeneous management system with a clear structure and distribution of work. There is a need to complete and improve the system, but the past year has shown that the steering and management of their activities functions well for the most part – exceptions are activities for dealing with waste and physical protection. OKG needs to amend both the safety analysis reports and management system with regard to activities regarding spent fuel and radioactive waste. It can also be noted that the steering and management of physical protection does not seem to be integrated with other measures to maintain safety.

Safety programme complies with the regulations
OKG complies with the regulations concerning the safety programme, but needs to clarify utilisation of the programme so that it can obtain the intended dignity. SSM also considers that the safety programme needs to contain more comprehensive and strategic measures.

SSM notes that OKG has a programme for safety culture which has been developed over the years. The authority has also observed that OKG has evaluated its own work in this area critically.

Internal audits and quality assurance system
During the year OKG's work with internal audits has developed in a positive manner, but small improvements are still needed regarding experience feedback and the competence of the auditors. OKG has during recent years spent considerable efforts to develop its quality assurance system. Based on a summarial review the authority considers that responsibility and authority have been clarified at the general level. Authority which follows with a specific responsibility needs to be clarified in the quality assurance system since the authority is not clearly defined for all managerial levels.

Project for dealing with deviations
OKG has a project for dealing with deviations and is looking amongst other things at the CAP-system. A need of investigating and learning more than just category 2 events has been identified.

OKG has also seen a need to further develop routines to evaluate if measures taken have had the intended effect.

New unit for MTO
OKG has established a new unit for MTO activities. One part of their work is to improve taking hand of the root cause analyses concerning the interaction between man, technique and organisations. Improvements are needed however amongst other things in describing the evaluation activities as well as classification and trending of events. One question in this respect has been the organisational position of the unit.

Safety reviews
Safety reviews by OKG have during the year shown variations in the quality of the different parts of the process. Reviews are documented as review memorandum only when there are comments or issues are identified. It is therefore more difficult to assess the primary safety reviews that have been performed. OKG is revising its routines regarding primary safety review, control of how regulations are followed and the system for primary and independent safety review.

Control of suppliers
OKG has increased its control of suppliers and also their routines for assessing them. The amount of information in a project prior to the work can however make it difficult for the individual supplier to appreciate what is important.

Theoretical training in accidents
There is no theoretical education for shift personnel and the operational leadership in how accidents develop. Training during accident exercises is

not sufficient to ensure that personnel have the knowledge needed to be able to deal with possible accidents.

Ensuring staff competence
OKG has a functioning system to ensure that personnel have the necessary competence and during the year have continued to improve and apply it even for ensuring the competence of extra staff – even if they have not been entirely successful in implementing the methodology described in the routines for ensuring staff competence. There still remain improvements to be made regarding the documentation of experience at an individual level. OKG has a concrete plan to remedy the deficiencies.

Projects lead to higher work loads
Numerous and large projects mean an increased work load for the entire organisation. Delays have affected the daily activities and also the possibility to remedy identified deficiencies or to evolve operations.

Ringhals

SSM considers that Ringhals has a clear organisation and managerial structure. During the year there has been a reorganisation to make R3 and R4 one department. Separate operational groups have been kept for R3 and R4 whilst the groups for operational support and technique are shared. A new group for human performance has been formed, RQH, as part of the RQ staff. This is intended to deal with a number of different areas such as man-technique- organisation (MTO), safety culture, experience feedback, process development and human reliability analysis (HRA) in a more collected manner. A larger focus is being put on reporting risk observations and they are also working to include near happenings in the reporting system. Ringhals is also revising its system for dealing with deviations/experience feedback.

Management system
Ringhals' management system is functional and easily accessible. Work is under way to ensure that the management system has a long life and can be adapted to reality. Rationalisation of the management system is under way also aimed at reducing the number of documents. Ringhals is also working to complete both the safety analysis report and the management system with regard to spent fuel and radioactive waste.

Ringhals has had stable operations with only a few disturbances in 2008 without large variations in the attitude to rules and routines. Ringhals now analyses what can lie behind the earlier variations in appraisals and decision making in questions of safety during operations.

Safety management
Ringhals has high ambitions regarding its safety management, something which gives good prerequisites for operations. The top management of Ringhals has also noted that there is a maintenance debt to the plants in Ringhals and the managing director has pointed out that safe and stable operations are to have the highest priority. Ringhals has directed its focus on further developing safety management and lifting its status at the plants.

Ringhals works on a daily basis with methods that encourage positive safety work. Amongst other things they are revising the process for safety reviews and the management system. The structure for the early morning meetings has for example been changed so that the head of the shift reports the safety situation to operational level 3 for an assessment of the operational readiness of the unit.

High work loads
The work load for many at Ringhals continues to be high, something that will continue for a long time. One indication of this is the delays relative to the time plans affecting the large projects. The submissions to the authority associated with these projects have not always been of good quality. Ringhals must ensure that the function for safety reviewing has sufficient time to carry out an acceptable review. Changes in the time plans must not mean that the quality of the safety reviews is affected negatively.

SSM is worried that the extensive project activities will have the result that Ringhals cannot retain sufficient focus on the daily activities, and that there are insufficient resources to carry out investigations of operational disturbances if the need should arise.

6. Waste management

Treatment, interim storage and disposal of nuclear waste

Different forms of treatment of radioactive operational waste are conducted at the nuclear power plants so that the waste can be disposed of, or placed in interim storage pending disposal. Low level waste is deposited in shallow landfills on site at Studsvik, Forsmark, Oskarshamn and Ringhals, or is sent to Studsvik for treatment. More radioactive waste is deposited in the repository for operational waste, SFR-1, which is located near the Forsmark nuclear power plant. From 2009 SKB intends to run the operations of SFR-1 themselves. Very low level waste can be exempted (free-classed) from the regulations of the Radiation Protection Act and the Act on Nuclear Activities and can then be used without restriction, incinerated or deposited in municipal dumps. Waste containing long-lived radioactivity is placed in interim storage at the nuclear power plants or in Clab, Central interim storage facility.

Regarding the treatment of waste in 2008 the following can be noted:

– During 2008 the restrictions imposed by SSI on May 29, 2007, for deposition of waste in SFR-1 were partially lifted. The background to the restrictions was amongst other things that SKB had not clearly demonstrated that they complied with a number of regulations regarding radiation protection at the plant, such as the requirement that the best available technique (BAT) be used and optimisation. SSI had therefore required that SKB should clarify that decisions made during normal operations of SFR-1 are well based and motivated with regard to the safety analysis report for SFR-1, as well as describe the criteria used to steer waste to the different storage areas in the depository. Based on its review SSI considered that SKB had submitted documentation such that operations of the depository could be resumed, with the exception of the waste which has the dominant contribution of Carbon-14 to SFR-1. SSI also imposed requirements for additional measurements and analyses of the most important radionuclides from the point view of the safety analyses. SKB’s application for changes to the inventory levels was rejected with the motive that the application did not contain sufficient information on which to base a decision concerning the changes and also that as assessment of resumption of full deposition can be made first when the revised safety analysis report clearly shows compliance with the required safety regulations. This was submitted to SSM in 2008 and is currently being reviewed.
– An inspection of spent fuel and radioactive waste treatment at the Forsmark plant was carried out in May 2008. As a result FKA has amongst other things been required to submit a programme of measures to revise and improve parts of the quality assurance system and the safety analysis report. The question of establishing an interim storage for low and medium active scrap metal at Forsmark has been raised, as well as a temporary storage for fresh fuel and a transport container for spent fuel, was examined in 2008. In October 2007 SSI granted renewed permission for shallow landfill deposition in accordance with the Act on Nuclear Activities and the Act on Radiation Protection. This was also assessed in 2008 by the environmental court and limited permission was granted in accordance

with the environmental code. The first deposition in the storage extension is planned for 2009.

- An inspection of waste treatment of radioactive waste and spent fuel at Oskarshamn was carried out by SKI in April 2008. As a result OKG has been required amongst other things to submit a programme of measures concerning parts of the treatment of low and medium radioactive waste, revisions to the quality assurance system for waste treatment and some additions to the safety analysis report regarding waste treatment.
- An inspection of waste treatment of radioactive waste and spent fuel was also carried out at Ringhals in May 2008. As a result of this SKI required that Ringhals submit a programme of measures regarding parts of the waste treatment, quality assurance system and the safety analysis report. In 2008 Ringhals made a third deposition in its shallow landfill. In connection with the deposition, work was also carried out to strengthen the existing depository. SSI carried out a plant monitoring visit and noted that there were a number of deficiencies with the work. Ringhals has, in its final report for the work, addressed these questions as requested.

Spent nuclear fuel

Spent fuel and remains of the reactor pressure vessel internals that are classified long-lived radioactive waste, are placed in interim storage in Clab which is located close to the Oskarshamn nuclear power plant. During the year 1,123 fuel elements have transported to Clab, where in all 24,997 elements are stored. After permission to take Clab 2 into operation, a considerable amount of spent fuel and vessel internals have been transferred to the extension.

7. Nuclear safeguards and emergency preparedness

Nuclear safeguards

In 2008, SKI, IAEA and the EU-commission have conducted inspections of how nuclear safeguards are handled at the facilities. 63 such inspections have been carried out at the nuclear power plants. The criteria used by IAEA and the Commission require that the inspection interval for facilities with irradiated nuclear fuel does not exceed three months. Furthermore, each facility must perform a physical inventory once a year. For nuclear power plants this is carried out in connection with the annual refuelling outage. The results of this inventory are verified by SKI/SSM, IAEA and the Commission. Nothing has emerged during the inspections in 2008 to indicate deficiencies in nuclear safeguard work at the nuclear power plants. There have however been some deficiencies in the preparations prior to the inspections, for example objects have prevented access to material for verification.

In 2008, the updates of the facility descriptions submitted to SKI by the plants for the supplementary protocol to the safeguard agreement with IAEA, have been forwarded to IAEA in advance of the stipulated date of May 15. The supplementary protocol requires that the signatory must provide IAEA with more information than previously concerning nuclear activities and activities concerned with the nuclear fuel cycle. The supplementary protocol also gives IAEA extended rights of inspection. IAEA did not exercise this right in 2008.

Emergency preparedness

SSM's supervision is dimensioned on the premises that the licensees have the entire responsibility that their activities are carried out in manner that ensures safety.

In 2008 SSM's emergency preparedness activities with regard to the Swedish nuclear power plants been directed to verify to what extent they comply with SSIFS 2005:2, concerning emergency preparedness at certain nuclear facilities. SSM has also performed a detailed review of the exercise and training activities at the plants. SSM has in addition participated in a number of the emergency preparedness exercises organised by the nuclear power plants.

SSM's overall assessment after inspections regarding the compliance with SSIFS 2005:2 was that OKG AB and RAB comply with the regulations and that FKA complies for the most part. SSM considers however that FKA lacked some instructions regarding the assembly point and the relocation of their control centre. SSM was also under the impression that there are indications that insufficient resources are reserved for emergency preparedness. A follow up inspection has been carried out during the spring of 2009 and evaluation is under way.

SSM's assessment after its review of the exercise and training plans for the plants is that they comply with the regulations in SSIFS 2005:2, § 19. There are requirements concerning the competence and plans for training and exercises. Participation in training and exercises is documented. SSM emphasises however that the value of exercises together with other emergency services, county administrative boards, and other authorities and emphasises the requirement according to 20 § SSIFS 2005:2, that personnel who can be needed for post-accident efforts, should be given priority to exercises.

In summary SSM considers that the Swedish nuclear power plants have emergency preparedness organisations and plans which have the prerequisites to control and limit the conditions which can arise during an accident. Developments are under way to improve the source term assessment (specification of meteorological data) and to define the dimensioning scenarios associated with rapidly developing events.

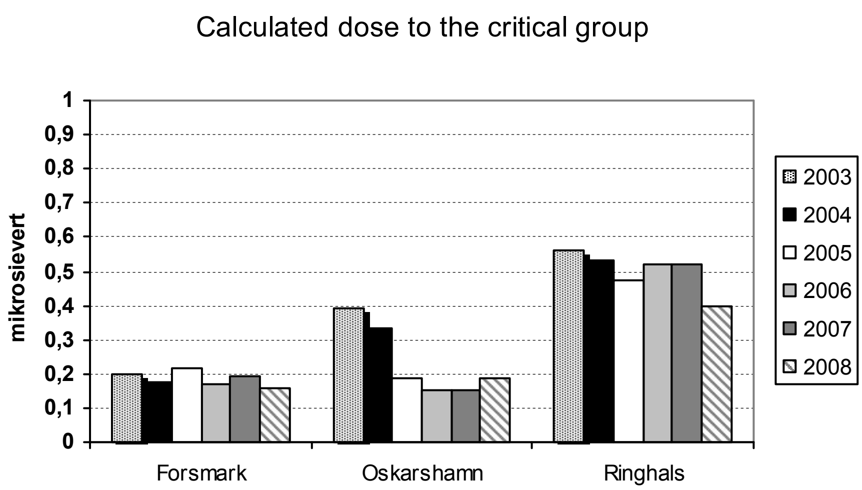
8. Radiation protection

The radiation protection consequences that arise in connection with the operation of the Swedish nuclear power plants are partly the release of radioactive substances to the environment and partly the exposure of personnel who work at the plants.

Release of radioactive substances
Nuclear power plants release radioactive substances in a controlled manner to both the atmosphere and water. These releases are measured continuously. The radiation dose to the public from these releases is calculated using models which are plant specific, and which take into account, amongst other things, meteorological conditions and the local land and water environments. The measurement and reporting of these releases are to be conducted in accordance with the regulations issued by the Swedish Radiation Safety Authority.

Diagram 1 shows the radiation doses calculated from the release of radioactive substances from nuclear power plants for the period 2003 – 2008. The radiation doses (quoted in μSv) are for people living close to a nuclear power plant and who are expected to receive the highest doses: the critical group. SSM notes the release of radioactive substances from the nuclear power plants in 2008 has resulted in a calculated dose to the most exposed person in the critical group which by large margins is lower than the environmental quality goal of 10 microsievert.

Diagram 1: Release of radioactive substances to the atmosphere and water from nuclear power plants.



Radiation doses to personnel
SSM considers that the radiation doses to personnel at the nuclear power plants in 2008 are reasonable, taking into account the existing radiation environment and the work performed. The total collective dose for all the plants during the year was 7.7 manSv. SSM notes that no individual has received a dose in excess of the established dose limits and that no-one has

received a internal dose in excess of the reportable level (0.25 mSv). A summary of the doses received in 2008 is shown in Table 1. Diagram 2 shows the dose trend over the period 1996 – 2008 for personnel at the nuclear power plants.

No incidents or accidents have occurred which have resulted in any doses worthy of mention. There are however events that could be of interest from the point of view of radiation protection. One example occurred before the refuelling outage in Oskarshamn 3 when 740 MBq Xe-133 gaseous product was delivered to the plant. Transportation, marking and the address on the packet were correct, but the recipient personnel in a store on the site wrongly delivered the package to an office which lies outside the controlled area. This did not result in doses to personnel worthy of note. Oskarshamn took the correct measures, primarily information about the relevant instructions and experience feedback. Oskarshamn is also planning to take the event up with the external supplier to prevent a repercussion.

SSM has not considered that further measures are needed in this particular case. No obvious deficiencies have been identified in Oskarshamn's instructions, response or the measures taken,

At both Oskarshamn and Ringhals there have been some smaller incidents involving radiography, however without anyone being subjected to doses worth mentioning. The incidents show the importance of coordination in connection with radiography work at the plants.

During the spring of 2008 SSM carried out an inspection at Ringhals to review how mishaps concerning radiation protection are handled by the organisation. The authority considered that Ringhals has good ability to respond in the event of incidents related to radiation protection, and also to initiate the necessary measures to prevent a repercussion.

The radiation levels in the nuclear power plants are measured during the refuelling outages. The levels have remained at a relatively stable level in 2008 with some exceptions. One example is Ringhals 3 where there has been an increase of 15 – 20 % around the heat exchanger in the chemistry and volume control system (334) and the residual heat removal system (321). One reason could be that prior to the outage in 2008 the operational cleansing time, aimed at reducing the levels of radioactivity in the system, was decreased from 12 to 6 hours.

Ringhals increased the thermal power of two of their reactors, Ringhals 1 and Ringhals 3. No unexpected consequences to the radiation protection situation have been noted as a result of this.

Ringhals has had a relatively large number of contaminated overalls and shoes during 2008. Ringhals has not yet produced a systematic documentation of these events, which has meant that it is difficult to follow up and remedy the cause of the contamination. A new control function is planned. This can be compared with Forsmark where the radiation protection organisation carries out controls and follows up all contamination of personnel detected in the plant. All the information is entered into a radiation protection database for systematic statistical analysis and on-line control of the trends. In this manner a potential spread of radioactive substances from a work place can be limited quickly, extra protection measures can be taken and further training carried out as necessary.

Prior to work in the controlled area which can result in larger doses to personnel it is important to plan the work in a relevant manner from the point of view of radiation protection. SSM notes that there have been some deficiencies in this respect at both Oskarshamn and Forsmark in recent years. Oskarshamn have had difficulties to make accurate dose prognoses in both 2007 and 2008, which has been traced to incomplete, insufficient or late information from subcontractors and hired personnel. Forsmark 1 and 2 have difficulty to obtain sufficient information in time to assess the need for dose saving measures before a refuelling outage. These questions should be followed up by SSM prior to future outage planning in Forsmark and Oskarshamn.

Diagram 2. Annual collective dose (manSv) to personnel at the Swedish nuclear power plants

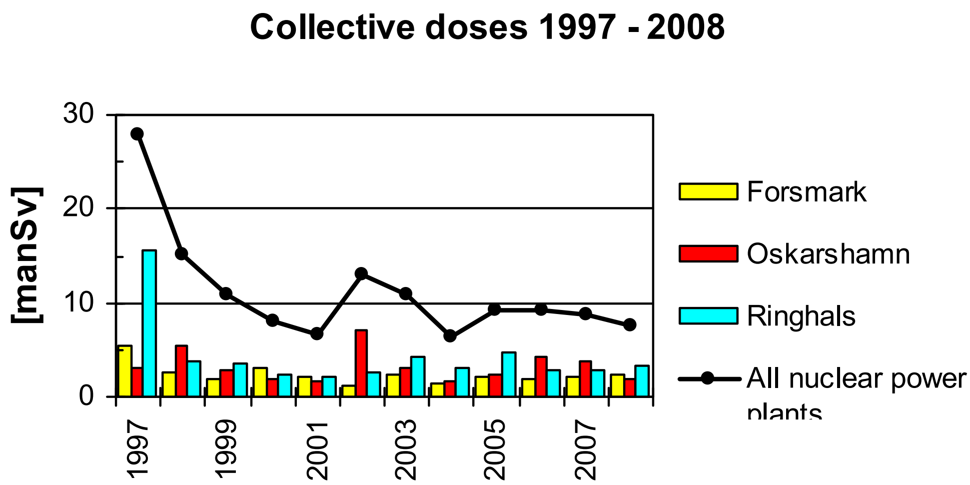


Table 1: Summary of doses to personnel at the Swedish nuclear power plants in 2008

Plant	**Total annual dose** (manSv)	**Average dose** (mSv)	**Largest individual dose** (mSv)	**No. with registered dose >0,1 mSv**
OKG	1,88	1,40	18,0	1348
Forsmark	2,34	1,78	13,0	1309
Ringhals	3,38	1,74	17,7	1950
All	*7,67*	*1,79*	*18,6*	*4290*

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