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Safety assessment of the Loviisa nuclear power plant

Statement regarding the licence application by Fortum Power and Heat Oy concerning the operation of the Loviisa nuclear power plant

Säteilyturvakeskus
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Radiation and Nuclear Safety Authority

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Executive summary

In this safety assessment the Radiation and Nuclear Safety Authority (STUK) has evaluated the safety of the Loviisa Nuclear Power Plant in connection with application for the operating license renewal. This safety assessment provides a summary of the reviews, inspections and continuous oversight carried out by STUK.

The issues addressed in the assessment and the related evaluation criteria are set forth in the nuclear energy and radiation safety legislation and the regulations issued thereunder. The provisions of the Nuclear Energy Act concerning the safe use of nuclear energy, safety and emergency preparedness arrangements, and waste management are specified in more detail in the Government Decisions and Regulatory Guides issued by STUK.

Based on the assessment, STUK consideres that the Loviisa Nuclear Power Plant meets the set safety requirements with some reservations related to the redundancy and separation of components needed for performing safety functions. These reservations are originating from the design basis laid down during the 1970s. However, substantial modernisations have been carried out at the Loviisa Nuclear Power Plant since its commissioning to improve safety. During the current operating licence period, risk factors have been systematically identified and eliminated using operating experience, research and development and probabilistic risk analysis (PRA). Examples of such plant modifications are given in the assessment. Licensee has many ongoing projects for enhancing safety. This is in line with the principle of continuous improvement of safety provided in Section 27 of the Resolution 395/1991. In addition, section 28 of the Resolution 395/1991 allows considering expediency in evaluating technical solutions at nuclear power plant in operation.

In addition to the implementation of the plant modernisation programme, STUK raised issues of special significance in ensuring safe operation of the plant during the next operating license period. These were related to the management of brittle fracture risk in the reactor pressure vessel, adequacy of ageing management programmes for electrical and I&C systems and components, adequacy of the organisation and monitoring of safety culture and effective utilisation of operating experience feedback.

In conclusion, the prerequisites for safe operation of Loviisa Nuclear Power Plant and the related buildings and storage facilities required for nuclear fuel and waste management have been met. The application submitted by licensee for extending the operating licence to exceed the 30-year service life by 20 years is essentially based on the estimates made in the lifetime management programme. STUK required licensee to carry out two periodic safety reviews during the licence period. The first safety review shall be submitted to STUK for approval by the end of 2015, and the second safety review by the end of 2023.

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(continued)

1 Introduction

Fortum Power and Heat Oy (FPH) has submitted an application to the Government in which the company applies for a licence referred to in section 20 of the Nuclear Energy Act:

1. *to operate the power plant units Loviisa 1 and Loviisa 2 of the Loviisa Nuclear Power Plant, each with nominal thermal power of 1500 MW, for the purpose of producing electrical energy until 31 December 2027 for Loviisa 1, and 31 December 2030 for Loviisa 2; and*
2. *to use the buildings and storage facilities, as well as their necessary extensions, relating to Loviisa 1 and Loviisa 2 and required for nuclear fuel and nuclear waste management until 31 December 2030.*

In preparation for the issuance of the licence, the Finnish Ministry of Trade and Industry (MTI) has sent letter 6/330/2006, dated 6 November 2006 (No. A213/73), to the Finnish Radiation and Nuclear Safety Authority (STUK) requesting a statement regarding the application filed by FPH.

FPH has filed with MTI an operating licence application, as well as the documents to be included in the operating licence application, as required according section 33 of the Nuclear Energy Decree. In addition, a number of other documents, to be submitted directly to STUK, are required for the periodic safety review included in the renewal of operating licence. The requirements concerning them are presented in Guide YVL 1.1.

The periodic safety review is mainly based on the following documents referred to in section 36 of the Nuclear Energy Decree:

1. *the final safety analysis report;*
2. *a probabilistic safety analysis;*
3. *a quality assurance programme for the operation of the nuclear facility;*
4. *the Technical Specifications, which shall at least define limits for the process quantities that affect the safety of the facility in various operating states, provide regulations on operating restrictions that result from component-failures and set forth requirements for the testing of components important to safety;*
5. *a summary programme for periodic inspections;*
6. *a description of the arrangements for physical protection and emergencies;*
7. *a description of how to arrange the safeguards that are necessary to prevent the proliferation of nuclear weapons;*
8. *administrative rules for the nuclear facility; and*
9. *a programme for radiation monitoring in the environment of the nuclear facility.*

According to section 36 of the Nuclear Energy Decree: *"When the application for an operating licence is made for a nuclear facility that has already been in operation, the documents mentioned in subsection 1 need be submitted to STUK only to the extent that they have not been submitted before. In addition, the applicant must submit to STUK any other information considered necessary by the Radiation and Nuclear Safety Authority."*

The documents referred to in section 36 of the Nuclear Energy Decree shall be continuously updated, and the updated versions shall be regularly submitted to STUK. According to Guide YVL 1.1, when applying for renewal of the operating licence, the documents may be submitted to STUK only insofar as they have been amended since the previous updates. The licensee shall also submit a periodic safety review of its own concerning the safety status of the nuclear facility, potential areas of development and maintenance of the safety.

According to Guide YVL 1.1, this assessment shall include:

- *a report on fulfilment of the requirements laid down in Government Decisions 395–397/1991 and in the relevant YVL Guides*
- *a summary of the renewed safety analyses and conclusions drawn from their results*
- *experience of the facility ageing and ageing management*
- *a description of the licensee's safety culture and safety management*
- *a report on the actions required in Section 27 of Government Decision 395/1991 [operating experience and safety research] and on the consequent plant improvements*
- *a report on compliance with any terms of the operating licence*
- *a summary of fulfilment of the requirements laid down in Section 20 of the Nuclear Energy Act.*

The International Atomic Energy Agency (IAEA) has published the safety guide NS-G-2.10, "Periodic Safety Review of Nuclear Power Plants", 2003, concerning periodic safety reviews. The guide lists the following 14 safety factors that are assessed in the safety review:

- plant design
- physical condition of the nuclear power plant
- qualification of equipment and structures
- ageing management
- deterministic safety analyses
- probabilistic safety analyses
- protection against external and internal hazards
- plant operating experience in terms of safety
- operating experience obtained from other plants and safety research findings
- organisation and administration
- plant procedures
- factors contributing to the work performance of people
- emergency planning
- radiological impact on the environment.

According to Guide YVL 1.1, *In making its own periodic safety review, the licensee shall verify that the safety factors proposed in the IAEA's guide [17]* [NS-G-2.10, "Periodic Safety Review of Nuclear Power Plants", 2003] *have been taken into account to a sufficient degree in the safety review and other licence application documents.*

The said documents and reports have been filed with STUK in several batches and updated or otherwise supplemented in the course of the application process in response to the remarks presented by STUK.

This Safety Assessment presents the basis for STUK's statement. This Safety Assessment provides a summary of the reviews concerning the issues and documents relating to the operating licence application, inspection of the safety review presented by the licence applicant and the results of the continuous oversight carried out by STUK.

1.1 Safety-related regulations

Sections 5 to 7 of the Nuclear Energy Act (990/1987) contain the following safety provisions:

Section 5, The use of nuclear energy, taking into account its various effects, shall be in line with the overall good of society;

Section 6, The use of nuclear energy must be safe; it shall not cause injury to people, or damage to the environment or property;

Section 6a, Nuclear waste generated in connection with or as a result of use of nuclear energy in Finland shall be handled, stored and permanently disposed of in Finland […]; and

Section 7, Sufficient physical protection and emergency planning as well as other arrangements for limiting nuclear damage and for protecting nuclear energy against illegal activities shall be a prerequisite for the use of nuclear energy.

This Safety Assessment covers all the aspects of the operation of the Loviisa 1 and 2 nuclear power plant units that fall within STUK's mandate. The issues to be addressed in the Safety Assessment and the related evaluation criteria are set forth in the nuclear energy and radiation safety legislation and the regulations issued thereunder. The provisions of the Nuclear Energy Act concerning the safe use of nuclear energy, safety and emergency preparedness arrangements, and waste management are specified in more detail in the Government Decisions applicable to each field of activity and issued under Section 81 of the Nuclear Energy Act. The resolutions are:

- General Regulations for the Safety of Nuclear Power Plants (395/1991)

- Physical Protection of Nuclear Power Plants (396/1991)
- Emergency Response Arrangements at Nuclear Power Plants (397/1991)
- Safety of a Disposal Facility for Reactor Waste (398/91), and
- Safety of Disposal of Spent Nuclear Fuel (478/1999).

The YVL Guides published by STUK set out even more detailed safety requirements. STUK continually evaluates the currency of the nuclear safety regulations in relation to current international developments, particularly within the framework of the International Atomic Energy Association IAEA and the Western European Nuclear Regulators' Association WENRA. The currency of the YVL Guides is checked regularly at about five-year intervals.

The principle regulations governing the field of nuclear energy – that is, the Nuclear Energy Act, the Nuclear Energy Decree and the Government Decisions on the general regulations for the safety, physical protection and emergency preparedness of nuclear power plants, and for the safety of a disposal facility for reactor waste and disposal of spent nuclear fuel – have, with the exception of the latter of the above, been issued between the late 1980s and early 1990s. Section 80, paragraph 1 of the new Constitution of Finland, which entered into force at the beginning of March 2000, requires that principles governing the rights and obligations of private individuals and the other matters that, under the Constitution, are of a legislative nature shall be governed by Acts.

On the basis of the above, the Ministry of Trade and Industry initiated a project for revising the nuclear energy legislation in cooperation with STUK. The objective and task of the project is to amend the nuclear energy legislation so that it fulfils the requirements laid down in the Constitution. In particular, the regulation level of certain regulations relating to nuclear safety and the authorisation provisions of the Nuclear Energy Act are under consideration. The regulations relating to the export and import of nuclear products and goods and the decommissioning of nuclear facilities will be reviewed and supplemented when required during the course of the project. The legislation will also be technically updated in other relevant respects. A Government proposal to amend the Nuclear Energy Act, as well as the Government decrees on the amendment of the Nuclear Energy Decree and on general regulations for the safety of a nuclear power plant, physical protection concerning the use of nuclear energy, emergency preparedness arrangements at nuclear power plants and the safety of the disposal of nuclear waste will be prepared in connection with the project.

According to preliminary estimates, the changes concerning nuclear energy legislation are planned to enter into force at the beginning of 2008. The assessment concerning the renewal of the operating licence for the Loviisa 1 and 2 nuclear power plant units shall be carried out based on the currently effective legislation. However, the impact of the planned changes on the assessment has been considered in the summary of the safety assessment (Section 14) by assuming that the changes were already in effect.

1.2 Structure of the safety assessment

In this Safety Assessment, matters relating to nuclear safety are discussed in the same order as they are presented in the Government Decision 395/1991. In addition, the discussion also covers matters that are proposed to be transferred from the YVL guides onto the decree level in connection with the amendment of the Nuclear Energy Act and Government Decrees. These additions relate to the qualification and service life management of equipment and structures, handling and storage of nuclear waste and nuclear fuel, and decommissioning of a nuclear power plant. In addition, matters relating to Government Decisions 396/1991, 397/1991, 398/1991 and 478/1999 are also discussed, as well as the compliance with the terms of the current operating licence of the plant. This Safety Assessment also discusses those preconditions laid down in section 20 of the Nuclear Energy Act that have not been separately included in the current Government Decisions but the assessment of which nevertheless falls within the mandate of STUK. Relating to the above, section 20, paragraph 1, point 4 concerns, among other things, the applicant's financial prerequisites to engage in operations; although this point primarily falls within the mandate of other authorities, STUK nevertheless presents its observations concerning the cover for nuclear liability, preparations for nuclear waste management costs and the operations FPH in the current conditions of the open electricity market. In accordance with section 20, paragraph 1, point 4, this Safety Assessment also discusses the fulfilment of Finland's international contractual obligations concerning nuclear material safeguards, nuclear safety and nuclear waste management.

The relevant text from the Government Decision is quoted at the beginning of each section *in italics*. Direct quotations from other regulations are likewise presented in italics. If necessary, a brief description of the practical applications of the requirements in the Government Decisions and the more detailed criteria presented in the YVL Guides is provided. Each section includes an evaluation of how the related requirements are implemented at the Loviisa 1 and 2 nuclear power plant units. Special attention will be paid to the question of whether *"the nuclear facility meets the safety requirements set, that the physical protection and emergency planning are sufficient, that the necessary control to prevent the proliferation of nuclear weapons has been arranged appropriately, and that the licensee of the nuclear facility has, as provided, arranged indemnification regarding liability in case of nuclear damage"* (Nuclear Energy Act, section 20, paragraph 2, point 1). A summary of the results of the review is presented at the end of the Safety Assessment.

2 Premises and definitions (Government Decision 395/1991)

2.1 Section 1: Applicability

In this decision general regulations relating to the safety of nuclear power plants equipped with a light water reactor are given.

In terms of their basic design, the Loviisa 1 and 2 nuclear power plant units are VVER-440 light water reactors.

2.2 Section 2: Definitions

In this decision:

1. ***dose (more precisely, effective dose)*** *shall refer to the weighted sum of the equivalent doses of tissues and organs subjected to radiation, where the equivalent dose denotes the product of the mean energy absorbed per unit mass in the tissue or organ and of the radiation weighting factor;*
1. ***dose commitment*** *shall refer to the time integral of the dose rate reaching to a separately defined period of time;*
2. ***criticality accident*** *shall refer to such an accident during which an uncontrolled chain reaction of fissions caused by neutrons arises;*
3. ***quality assurance*** *shall refer to all planned and systematic actions necessary to provide adequate confidence that a component, plant or activity will satisfy given requirements;*
4. ***anticipated operational transient*** *shall refer to a deviation milder than an accident from normal operational conditions which can be expected to occur once or several times during any period of a hundred operating years;*
5. ***accident*** *shall refer to a deviation from normal operating conditions which is not an anticipated operational transient. Accidents are grouped into two classes:*
6. ***postulated accident*** *means an event which serves as a design basis for the engineered safety systems of a nuclear power plant. The nuclear power plant shall withstand a postulated accident without severe fuel damages and without radioactive releases that would require extensive measures for restricting the exposure of the general public; and*
7. ***severe accident*** *means an event during which a considerable part of the fuel in the reactor is damaged;*
8. ***probabilistic safety analysis*** *shall refer to estimates and calculations based on experience and probabilistic methods which address the reliability of operation of nuclear power plant systems, potential accident sequences, reactor damage, accident propagation and releases of radioactive materials;*
9. ***safety functions*** *shall refer to functions important from the safety point of view the meaning of which is to prevent the emergence or advancement of transient and accident conditions or to mitigate the consequences of accidents; the most important safety functions are reactor shutdown, residual heat removal from the reactor to the ultimate heat sink and the functioning of the containment building; and*
10. ***nuclear power plant*** *shall refer to a nuclear installation equipped with a nuclear reactor which is intended for electricity generation, or, if several such or other nuclear installations have been placed on the same site, the entity of installations formed by them.*

This Safety Assessment makes use of the definitions specified in the Government Decision 395/1991.

3 General Principles (Government Decision 395/1991)

3.1 Section 3: General objective

The general objective is to ensure nuclear power plant safety so that nuclear power plant operation does not cause radiation hazards which could endanger the safety of workers or of the population in the vicinity or could otherwise harm the environment or property.

This objective is defined in section 6 of the Nuclear Energy Act. More detailed requirements for measures required to ensure safety are also included in sections 6a, 7 and 20 of the Nuclear Energy Act (see section 14, Summary), Government Decisions 395/1991, 396/1991, 397/1991, 398/1991 and 478/1999, YVL Guides issued by the Radiation and Nuclear Safety Authority, and radiation safety legislation. The above-mentioned regulations form the basis of this Safety Assessment.

This Safety Assessment gives an evaluation of the attainment of the general objective laid down in section 3.

3.2 Section 4: Safety culture

When designing, constructing and operating a nuclear power plant, an advanced safety culture shall be maintained which is based on the safety-oriented attitude of the topmost management of the organisations in question and on the motivation of the personnel towards responsible work. This presupposes well-organised working conditions and an open working atmosphere, as well as the encouragement of alertness and initiative in order to detect and eliminate factors which endanger safety.

The significance of a safety culture as an important factor affecting safety has been widely acknowledged since the 1990s. The development of a safety culture is a continuous learning process carried out in slightly different ways in different utilities due their different approaches. The safety culture prevailing in organisations does not remain unchanged but is constantly changing due to internal and external reasons. Changes are introduced to procedures and attitudes by, among other things, personnel turnover, changing economic conditions and developments in technology. Because the safety culture is constantly changing, it is essential that FPH and the Loviisa Nuclear Power Plant retain the capacity for assessing, developing and maintaining their safety culture.

In line with an advanced safety culture, the management of FPH and the Loviisa Nuclear Power Plant have documented their commitment to nuclear and radiation safety in the documents serving as operating guidelines. Annual planning is strategy-based, the consequence of which is that safety objectives are being used as criteria for long and short-term planning of operations and resourcing.

In line with an advanced safety culture, the Loviisa Nuclear Power Plant has systematic procedures in place through which the personnel are motivated towards responsible work (e.g. inroduction, training, communications, plant procedures and monitoring of supervisors). However, in its OSART (Operational Safety Review Team) review in 2007 the International Atomic Energy Agency IAEA observed deficiencies in the visibility of safety management and compliance with procedures. STUK will monitor the implementation of the corrective measures taken and development plans prepared on the basis of these observations.

The Loviisa Nuclear Power Plant has procedures in place for selecting, instructing and supervising contractors and subcontractors. The power plant aims at developing long-term co-operation with its suppliers. The objective is to raise the subcontractors' knowledge of the plant and its procedures to ensure it is sufficient. The cooperation between Loviisa Nuclear Power Plant, part of the Fortum Generation business unit, and Fortum Nuclear Services Ltd has been significantly improved during the present operating licence period, and these efforts should be further continued in the future.

With regard to successful preconditions for a safety culture, development needs have been observed in the working conditions at the Loviisa Nuclear Power Plant concerning, for example, housekeeping as well as workspaces and locker facilities. These deficiencies have been adequately addressed by means of a development programme relating to occupational safety and plans relating to workspaces. Different types of reporting practices promote initiative and alertness to raise nuclear and radiation safety issues. The organisation attempts to identify possible nuclear and radiation safety risks.

FPH has at its disposal a variety of tools (e.g. QA activities, atmosphere surveys, appraisal discussions and external reviews) for obtaining information about the current state of the safety culture. However, extensive follow-up targeting the safety culture of the entire operating organisation of the Loviisa Nuclear Power Plant has not been implemented, nor is such follow-up planned for implementation in the reports submitted in connection with the operating licence renewal.

The conclusion to the above is that attempts are being made to maintain an advanced safety culture at FPH and the Loviisa Nuclear Power Plant in line with the basic intention of section 4 of the Government Decision. However, systematic work for promoting safety culture with the help of experts in organisational research has not been conducted at FPH. In future, FPH must pay more attention in the monitoring and further improvement of the state of the safety culture. STUK will monitor the subsequent developments of the safety culture in connection with its regulatory work.

3.3 Section 5: Quality assurance

Advanced quality assurance programmes shall be employed in all activities which affect safety and relate to the design, construction and operation of a nuclear power plant.

The Quality Assurance Programme of the Loviisa Nuclear Power Plant refers to the entity described in the quality assurance manual for operations and in the procedures required for implementing the programme. The quality assurance requirements and procedures to be adhered to when procuring nuclear fuel and planning its use are defined in the nuclear fuel quality assurance manual. All sections of the quality assurance manual for operations have been revised and approved by STUK during 2002–2006, and the sections of the nuclear fuel quality assurance manual during 2002–2004 respectively. The procedures for implementing the quality assurance measures have been submitted to STUK for information.

The organisations of the licensee participating in nuclear operations, the Generation business unit as a whole, and the Loviisa Nuclear Power Plant and Fortum Nuclear Services Ltd (FNS) within it, have a shared quality policy for nuclear operations, while each of the above have separate management systems that interrelate in an appropriate manner. The Generation business unit has an environmental certificate in accordance with SFS-EN ISO-14001:2004, which also comprises the operations of the Loviisa Nuclear Power Plant. FNS has a quality management system certificate in accordance with SFS-EN ISO-9001:2000.

During the present operating licence period the quality management system of the Loviisa Nuclear Power Plant has been developed in several ways according to the experience gained and the general development trend of quality management. Examples include:

- reflecting the impact of changes on the organisation and work duties at the Loviisa Nuclear Power Plant in the administrative and operating procedure system and emphasising the role of management in the procedures
- extensive update to emergency procedures and development of procedures for severe accidents
- development of new occupational health and safety system and its integration with the certified environmental system
- development of information systems and utilising them in document management
- development of laboratory quality system
- establishing a separate inspection organisation at Loviisa Nuclear Power Plant in 2001
- development of investment and refurbishment project procedures as well as modification and design procedures.

A project for developing a process-oriented operating model was initiated at the Loviisa Nuclear

Power Plant in 2005. The description of the quality management system in the form of process diagrams was completed during 2006. The objective is that the development of the quality management system and the improvement of operations over the next few years are to be carried out on the basis of the process diagrams.

STUK has conducted regular inspections on the implementation of the quality system at the Loviisa Nuclear Power Plant. During the current operating licence period, no such deficiencies relating to the fundamentals or structures of quality management that would have essential significance to safety or operations affecting quality have been observed. FPH has appropriately processed and rectified the single deficiencies observed in the implementation of quality management.

The quality management system and its efficiency have also been assessed by organisations other than STUK. IAEA conducted the OSART (Operational Safety Review Team) inspections targeted at the operating activities at the Loviisa Nuclear Power Plant in 1990 and 2007. Other assessments of quality management include, for instance, a number of self-assessments on the basis of various quality standards, the Peer Review inspections by WANO (World Association of Nuclear Operators), certification inspections concerning the management of environmental matters, a number of focused inspections carried out by different organisations, the plant's own annual inspections, and the independent reviews of the Loviisa Nuclear Power Plant ordered by the licensee.

The conclusion to the above is that FPH has exposed its operations to external assessment according to the distinctive features of an advanced quality system, and that such inspection and assessment activities have been comprehensive during the operating licence period. The quality management system of the Loviisa Nuclear Power Plant meets the set requirements and is up to date. The undergoing project for describing operating processes creates improved preconditions for monitoring, assessing and developing operations affecting safety.

The organisation and its operational preconditions, as well as the implementation of the quality system, is also discussed in several other sections of this Safety assessment.

In summary, it can be stated that activities relating to the quality management system of the Loviisa Nuclear Power Plant have been arranged in manner referred to in section 5 of the Government Decision.

3.4 Section 6: Demonstration of compliance with the safety regulations

If compliance with the safety regulations cannot be directly ascertained, fulfilment shall be demonstrated by the necessary experimental and calculational methods.

Nuclear power plant safety and the design of its safety systems shall be substantiated by accident analyses and probabilistic safety analyses. Analyses shall be maintained and revised if necessary, taking into account operating experience, the results of experimental research and the advancement of calculating methods.

The calculating methods employed for demonstrating that the safety regulations are met shall be reliable and well qualified for dealing with the events in question. They shall be applied so that the calculated results are, at a confident estimate, less favourable than the results which are considered best estimates. Furthermore, analyses which picture the likely course of transients and accidents shall be conducted for the purpose of probabilistic safety analyses and for the development of emergency operating procedures.

3.4.1 Accident analyses

Analyses are intended to prove the ability of the plant unit to safely overcome various transients and accidents. According to Guide YVL 2.2, the analyses shall focus on events that, by their nature and severity, cover various types of incidents and accidents as well as possible. The course of transients and accidents shall be analysed as a function of time, starting from the initiating event and ending in a safe and stable state.

FPH has reviewed all analyses of transient and accident conditions presented in section 14 of the Final Safety Analysis Report for Loviisa Nuclear Power Plant and updated them to the extent required by modifications carried out at the plant or amendments to the requirements set by the authorities. After the granting of the valid operating licence, Guides YVL 2.2 and YVL 6.2, for example, have been revised. These guides define the classification of initiating events, provide instructions on how to perform the analyses, and present the acceptance criteria for the analyses. As to plant modifications, the introduction of new emergency procedures, for example, has resulted in needs for renewing the accident analyses.

The calculation methods used for calculating the plant's normal operating condition, transients and postulated accidents are primarily those developed in Finland. The methods have been qualified primarily by performing comparative calculations against the results measured using different methods and test equipment. The extent of the qualification is on a good level from an international perspective. Due to uncertainty relating to the accuracy of calculating methods, it is essential that sufficiently wide safety margins be applied when assessing the fulfilment of the analysis acceptance criteria.

The analyses described in the safety analysis report, as well as the related topical reports, also present and justify the initial values used and the assumptions made affecting the end results of the analyses, as well as the sensitivity analyses carried out. STUK has reviewed the presented analyses and the methods used therein. In addition, STUK has commissioned independent comparative analyses. Sensitivity and comparative analyses are required for assessing and reducing the uncertainties relating to calculating methods and calculating assumptions in general.

The analyses presented in the safety analysis report discuss anticipated operational transients and postulated accidents used as the design basis of the safety systems as well as the so-called severe accidents. Different types of transients and accidents have been further divided into classes. Each class contains a variety of accident sequences, and separate analyses have been presented for each. All safety-critical analyses include sensitivity analyses, often of considerable scope.

Anticipated operational transients are disturbances that can be expected to occur at least once during the service life of the plant. On the basis of the review of the analyses, the following cases of operational transients have been reanalysed:

- stopping of one and three reactor coolant pumps,
- opening of secondary circuit safety relief valve, and
- stopping of main feedwater pump.

The results of the renewed analyses meet the acceptance criteria set for operational transients in all respects.

According to Guide YVL 2.2, postulated accidents are divided into two classes according to the estimated frequency of the initiating event:

- level 1 postulated accidents; frequency 10^{-3}… 10^{-2}/year, and
- level 2 postulated accidents; frequency less than 10^{-3}/year.

FPH has classified the postulated accidents on the basis of the above and reanalysed the following cases resulting from level 1 postulated accidents:

- feedwater pipe break and
- steam generator heat transfer tube rupture (without the loss of off-site power).

The following cases of level 2 postulated accidents have been reanalysed:

- steam generator heat transfer tube rupture (with the loss of off-site power),
- large break primary-to-secondary leak
- small and large break loss of coolant accident, and
- uncontrolled actuation of control rods from zero power with failure of automatic scram.

FPH has also supplemented the overpressure protection analyses and renewed the analysis of boron dilution with regard to small break loss of coolant accident.

The results of the renewed analyses meet the acceptance criteria set for postulated accidents in all respects. The accident analyses assessing the operability of safety systems are discussed in more detail in section 5.3 in terms of reactor core and fuel, and in sections 4.4 and 4.5 in terms of radiation safety.

Transient and accident analyses, and the methods of analysis used therein shall be maintained and developed throughout the service life of the nuclear power plant. On the basis of the results of the analyses, safety-enhancing measures shall be taken as required. Nearly all of the analyses of transient and accident conditions will be updated in connection with the automation renewal that is to be implemented at the Loviisa Nuclear Power Plant over the next few years. In connection with the conceptual design plans for the functional changes to be implemented during the course of the renewal, FPH has already carried out and submitted to STUK a number of analyses to justify these changes. Over the next few years, FPH will also prepare analyses of the so-called extensions of postulated accidents. The primary purpose of these analyses is to ensure that there are no such conditions immediately outside of the actual design basis the plant is incapable of managing safely.

The conclusion to the above is that the transient and accident analyses concerning the Loviisa Nuclear Power Plant have been prepared in a manner referred to in section 6 of the Government Decision.

3.4.2 Probabilistic risk analyses (PRA)

In this connection, probabilistic risk analyses (PRA) refer to the probabilistic safety analyses as prescribed in section 36 of the Nuclear Energy Decree 161/1988 and in section 6 of the Government Decision 395/1991.

PRA is used for systematically analysing the occurrence of transients and the operation of the safety functions required by them, while taking into account the possibilities for faults and errors, as well as their probabilities, in each system. Transients may originate from equipment failures, fires, floods, harsh weather conditions, earthquakes or human errors. Event sequences describing accident propagation resulting in reactor core damage are analysed in the PRA, and the probability for their occurrence is estimated. The PRA can be used for identifying such dependencies between systems that may otherwise remain unnoticed.

The timing and probabilities of accident sequences resulting in reactor core damage are defined on level 1 of the PRA; the quantity, time and probability of the release of radioactive material into the environment is estimated on level 2 of the PRA.

In the PRA, an initiating event is a single event that causes a transient and requires starting the plant safety functions. The initiating event can be an internal or external event. Internal initiating events are transients arising from component failures, loss of off-site power and human errors made by plant personnel. The 'flood' initiating events are floods occurring inside the plant due to ruptures in piping or pressure vessels causing a transient and loss of components important to safety. The 'fire' initiating events are fires occurring inside the plant site causing a transient.

External initiating events are transients caused by weather phenomena and earthquakes as well as disturbances in the environment caused by human activity. The weather phenomena considered in risk analyses include strong wind, lightning, exceptionally high or low outdoor temperature, snowfall, high seawater temperature, high seawater level, and phenomena causing a clogging risk in the seawater systems, such as frazil ice (sudden subcooling of seawater) and excessive growth of algae. In addition, the impacts of offshore oil accidents are also analysed.

Level 1 PRA – Internal initiating events

In terms of core damage frequency, the most important internal initiating events during power operation are leaks from the primary circuit outside containment and the loss of control room I&C facilities cooling. The core damage frequency caused by internal initiating events during power operation has decreased by approximately 50 % from the estimate of 1997, even though new significant risk factors have been identified during the development of the PRA model. The risk has been reduced by a number of plant modifications and changes to plant procedures. The most significant of these changes concern the reductions of risks arising from leaks outside the containment and leaks in the seals of reactor coolant pumps.

During an annual maintenance outage, the most important internal initiating in terms of core damage frequency are dropping heavy loads in the reactor hall and losses of reactivity control. The analysis has been supplemented during the current operating licence period, while new risk factors relating to annual maintenance outages have been identified. A number of plant modifications have been made on the basis of the updated analyses, the most important of which being the changes relating to heavy load lifting routes and instructions, as well as the changes relating to the prevention of boron dilution implemented to ensure reactor sub-criticality.

Level 1 PRA - Flood risks (internal flooding)

The flood risk analysis of Loviisa Nuclear Power Plant has been developed and supplemented by modelling, among other things, the feed water tank level and the plant modifications implemented during the current operating licence period. According to the analysis, the most significant floods are caused by a leak in the emergency cooling system inside the reactor building, leaks in the fire fighting water system inside the control room building, and leaks in the feed water system above the control room.

The risk arising from floods has been reduced during the current operating licence period. The risk arising from leaks occurring in the feedwater system above the control room was reduced by changing the feed water piping material to more erosion-corrosion resistant, by installing jet shields and restraints for the possible occurrence of pipe breaks, and by improving the leaktightness and drainage of the level. Risks arising from leaks in the seawater systems and in the fire fighting water system were reduced by a number of plant procedure changes and plant modifications. The most important of these plant modifications included protecting the service water system pressure measurements against the impacts of flood, enhancing the drainage of and adding flood alarms to the cable room below the control room, and changing the sprinkler systems below the control room to manually actuated.

The planned automation renewal will enhance the reliability of the cooling of reactor coolant pump seals, which will also reduce the risk arising from floods in the control room. The flood risk from the emergency cooling system and the seawater system will not essentially change as a result of the automation renewal.

Level 1 PRA – Fire risks

The fire risk analysis of Loviisa Nuclear Power Plant has been developed and supplemented by modelling, among other things, the control room building and the plant modifications implemented during the current operating licence period. The analysis does not yet cover the modelling of reactivity accidents, pressure vessel brittle fracture and shutdown states.

The majority of the risk caused by fires arises from leaks in the reactor coolant pump seals. The large risk share of reactor coolant pump seal leaks is due to the fact that the operation of the pumps involves a large number of cables and a seal leak can be the result of fires in several rooms. The plant modifications carried out in order to ensure the cooling of seal water have not significantly reduced the risk of seal leak arising from fires.

The risk arising from fires has been reduced during the current operating licence period. The improvement of the model and the several plant modifications carried out have both contributed to the reduction of the risk. Plant modifications for ensuring residual heat removal have been carried out during the operating licence period and, as a result, the operation of systems located in the turbine hall is no longer necessary. The risk significance of fires in the turbine hall has thus been reduced. Fire detector systems have been renewed, and fire extinguishing systems have been improved.

Level 1 PRA – Weather phenomena

FPH has updated the weather risk analysis for power operation of the Loviisa Nuclear Power Plant during the current operating licence period and prepared a weather risk analysis for shutdown states. The weather risk analysis has been supplemented by a separate detailed oil risk analysis.

The core damage frequency estimate arising from weather phenomena has decreased significantly during the current operating licence period. Among other things, this is due to the plant modifications carried out for preventing the complete clogging of the seawater system. The modifications will be continued in 2007, after which seawater intake will be possible from the outlet side as well. Backup of the cooling of reactor coolant pump seal water independent of the seawater system has been implemented at the plant during the current operating licence period, which reduces the risk of seal leak caused by clogging of the seawater intake.

After the plant modifications, the most important external phenomena are clogging of the seawater system during outage caused by an offshore oil accident and high seawater level (+2.5 m above average water level) during power operation. Other risk-relevant external phenomena include strong wind, lightning and clogging of the seawater system caused by algae and frazil ice.

Level 1 PRA - Earthquakes

Apart from slow land uplift, the Finnish bedrock is stable. The occurrence of dangerous earthquakes in Finland is considered extremely unlikely, but very weak earthquakes are observed relatively often.

Loads caused by earthquakes have not been separately accounted for in the design of the Loviisa Nuclear Power Plant. Instead, other load cases were considered to cover them to a sufficient extent. It has since turned out that earthquakes may present a significant risk factor for nuclear power plants in areas of low seismic activity if the horizontal forces caused by earthquakes have not been considered at all in the design of components and their supports, for example. However, no items particularly sensitive to earthquakes have been detected in the Loviisa Nuclear Power Plant.

The earthquake resistance of the Loviisa Nuclear Power Plant was assessed in a seismic risk analysis completed in 1992. The main elements of the analysis are the estimation of the annual frequency of earthquakes of varying magnitude on the basis of seismologic measurement data and historical observations, building vibration analyses and definition of peak accelerations on different floor levels, and estimation of the probability of structural damage in earthquakes of different magnitude.

The seismic resistance of the structures, systems and components of the Loviisa Nuclear Power Plant was generally considered good. The feed water tank supports and certain direct current power systems were considered the seismically most sensitive items. On the basis of the analysis, the core damage frequency resulting from earthquakes is relatively small.

The number of accumulated accurate measurement observations has increased and methods for estimating the frequency of rare earthquakes have been developed globally during the past 15 years. Various investigations carried out in different conjunctions have produced slightly different earthquake frequencies for the Loviisa area. The calculation methods for building vibration analysis have also advanced. Although the above-mentioned factors are not likely to have essential significance for the conclusions concerning the earthquake risks of the Loviisa Nuclear Power Plant, there is a justified reason to update the analysis early on during the next operating licence period.

Level 2 PRA

Level 2 PRA for the Loviisa Nuclear Power Plant has been significantly improved and supplemented with further detail during the current operating licence period. The model for migration of radioactive material has been renewed. Level 2 PRA has been supplemented by flood and weather events during power operation and preliminary estimates on fire and seismic events during power operation. In addition, the risk resulting from internal initiating events during an outage has also been preliminarily assessed.

Initiating events during outage comprise the majority of the frequency of a major release. The PRA is not yet comprehensive in this regard. Major release in this connection refers to a release exceeding the limit for a release arising from a severe accident as defined in section 12 of Government Decision 395/1991. According to a preliminary estimate, the most important outage events in terms of the risk of a major release are dropping heavy loads when lifting heavy loads, reactivity increase, and floating of oil into the plant. During power operation, the most significant causes of release risk are internal initiating events.

FPH has presented plans for plant modifications to be carried out on the basis of the current level 2 PRA results in order to reduce the frequency of a major release. These include, e.g., improving the reliability of break isolation in the control rod cooling piping, reducing the reactivity risk by means of on-line boron analyzers and development of instructions, identifying the opportunities for reducing the risks arising from heavy load lifting by means of crane modifications, as well as numerous instruction development efforts. Other significant renewal projects are also currently underway at the plant (for example, the automation renewal project LARA), the completion of which will further reduce the frequency of a major release. The majority of the modifications will be implemented during 2007–2012.

FPH has also presented a plan for supplementing the level 2 PRA analyses for the missing parts. The long-term objective is to improve plant safety based on the results of the analyses. The outage analysis will be carried out during 2007–2009, and STUK has required that the development of instructions for outage situations based on the results of the analysis is completed by the end of 2014.

Summary

PRA has been used for systematically identifying and eliminating risk factors during the preceding and the current operating licence period.

The Loviisa Nuclear Power Plant meets the target value for core damage frequency set for old plants by the International Atomic Energy Agency (IAEA), but fails to meet the numerical design objectives set for new power plants concerning core damage and major release frequency in Guide YVL 2.8 issued by STUK. STUK has set attaining a safety level as high as reasonably achievable as a target for nuclear power plants in operation.

In the 1998 safety assessment STUK requested that the most significant risks be reduced. Safety has been improved by means of several plant modifications during the current operating licence period. Examples include ensuring the cooling of reactor coolant pump seals as well as improvements to the plant residual heat removal and emergency cooling systems.

The PRA has indicated that it will be necessary to continue the safety improvement measures during the future operating licence period in, e.g., the following areas:

- Improvements aiming at preventing reactor coolant pump seal leaks shall be continued with regard to fire and flood conditions.
- Precautions against oil accidents in the Gulf of Finland shall be further improved by, e.g., developing the emergency preparedness for oil-combating in the neighbouring area and the instructions relating to outage situations.
- In order to decrease the possibility of a reactivity accident, the accidental migration of unborated coolant into the primary circuit shall be more reliably prevented.
- The risks arising for heavy load lifting shall be further reduced by improving the structural reliability of the crane and developing the procedures relating to lifting.

Improvements to the containment systems for managing severe accidents were implemented during the current operating licence period of the Loviisa Nuclear Power Plant. However, the estimated risk of major release has not been significantly reduced because new accident sequences have been identified that are not included in the present severe accident management strategy. Relating to the above, it will therefore be necessary to carry out the following improvements during the future operating licence period:

- The risk arising from leaks from the primary circuit outside the containment shall be reduced. An example of these kinds of containment bypass sequences is a non-isolated leak in the cooling piping of the reactor control rod drive mechanism.
- The impact of external events (storm, lightning, earthquakes) and fires on the frequency of a major release shall be analysed in more detail.

FPH has presented a long-term plan for reducing the accident and release risk, and for supplementing the existing PRA. STUK will monitor and oversee the implementation of the programme.

On the basis of the above, it can be stated that FPH has justified the plant safety and safety engineering solutions in accordance with the requirements concerning probabilistic safety analyses presented in section 6 of Government Decision 395/1991.

4 Regulations concerning radiation exposure and releases of radioactive materials (Government Decision 395/1991)

4.1 Section 7: Limitation of radiation exposure

Radiation exposure arising from the operation of a nuclear power plant shall be kept as low as reasonably achievable. A nuclear power plant and its operation shall also be designed so that the limits presented in this decision are not exceeded.

Consequently, exposure to radiation must be controlled in accordance with the As Low As Reasonably Achievable (ALARA) principle.

The International Commission on Radiation Protection (ICRP) is currently revising its radiation protection policy document. The reforms will not, however, require any substantial changes to the existing national radiation protection regulations. For example, the dose limits prescribed in the Radiation Decree (1512/1991) will remain unchanged.

The radiation safety of the Loviisa Nuclear Power Plant workers and the population in the plant vicinity is discussed in more detain in sections 4.2–4.6 below.

4.2 Section 8: Radiation safety of nuclear power plant workers

A nuclear power plant's design and operation shall be implemented so that radiation exposure to workers can be limited as separately enacted.

The regulations concerning the radiation exposure of employees are the Radiation Act 592/1991, the Radiation Decree 1512/1991, and the ST and YVL Guides issued by STUK. Section 3 of the Radiation Decree stipulates that the effective dose caused to a worker by radiation work shall not exceed an average of 20 millisieverts (mSv) per year reckoned over a period of five years, nor 50 mSv in any single year.

Chemical decontamination of the entire primary circuit was carried out in the Loviisa 2 nuclear power plant unit in 1994. This significantly decreased the radiation dose rates in the steam generator room of the plant unit. Dose rates were successfully stabilised to an equal level of Loviisa 1 nuclear power plant unit, and have remained relatively stable at both plant units since this treatment. The contribution of various radionuclides is examined at the plant units on a regular basis. Cobalt-60 and antimony-124 have been the most significant nuclides contributing to the dose rate during the past few years.

In addition to radiation dose rates, the amount of maintenance work carried out during annual maintenances, including the amount of refurbishment work due to ageing and plant modifications to improve plant safety, has essential impact on the radiation doses of workers. The target value presented in Guide YVL 7.9 for reducing the collective occupational dose of nuclear power plant workers is 2.5 manSv per one GW net electrical power calculated for one reactor unit as an average of two consecutive years. For the Loviisa Nuclear Power Plant, this translates to an average of 1.22 manSv per year for one reactor unit at the current power lever. This reporting limit, stipulated in Guide YVL 7.9, was exceeded at the Loviisa 1 nuclear power plant unit in 2003-2004. FPH has submitted to STUK an extensive report that discusses the factors contributing to the dose development and assesses the methods for reducing the doses. The limited space of the steam generator room affects the radiation protection results at the Loviisa Nuclear Power Plant.

The monitoring of occupational exposure at the Loviisa Nuclear Power Plant and the reporting of measurement data to the Dose Register maintained by STUK has been developed during the operation of the plant in accordance with Guides YVL 7.9 and YVL 7.10. The annually conducted quality control tests targeted at the dosimetric service have indicated that the measurement accuracy has remained in accordance with the requirements set forth in international standards. FPH has submitted to STUK the documents concerning the maintenance and quality of dosimetry systems. FPH thus accounts for the amendment to the Radiation Decree ratified in 2006, according to which the approval of the dosimetric service has changed into a fixed-term approval.

No annual radiation doses exceeding 20 mSv have accumulated in any employee at the Loviisa Nuclear Power Plant since 1996. The highest individual radiation dose in 2006 was 13.6 mSv. The average radiation dose of exposed workers in 2006 was 2.4 mSv.

During the past five years (2002–2006) the highest radiation dose received by a Finnish nuclear power plant worker, 70.4 mSv, was accumulated while working both at Swedish nuclear power plants and at the two nuclear power plants in Finland. The highest radiation dose accumulated during 2002–2006 while working exclusively at the Loviisa Nuclear Power Plant was 55.0 mSv.

The monitoring of dose rates, occupational dosimetry and monitoring of internal doses of workers have been improved at both nuclear power plant units in Loviisa. The stationary radiation measuring systems of the plant have been renewed during 2002–2003.

STUK has required that additional measures be taken in annual maintenances to improve radiation protection concerning, for example, the work carried out in the steam generator room of the plant. STUK has also paid attention to the operation and resource needs of the radiation protection organisation and the training of external contractors participating in annual maintenance. STUK will inspect the procedures relating to the above in connection with the annual maintenances in 2007.

The conclusion to the above is that the radiation protection and occupational dosimetry of workers at the Loviisa Nuclear Power Plant have been implemented in a manner referred to in section 8 of the Government Decision.

4.3 Section 9: Limit for normal operation

The limit for the dose commitment of the individual of the population, arising from normal operation of a nuclear power plant in any period of one year, is 0.1 mSv. Based on this limit, release limits for radioactive materials during the normal operation of a nuclear power plant are to be defined.

The prescription concerning individual protection contained in section 9 of the resolution must be implemented together with the ALARA requirement concerning the limitation of radiation exposure (section 4.1). Detailed requirements concerning the calculation methods used for assessing the radiation exposure of the population are specified in the Guides YVL 7.2 and YVL 7.3.

Release limits for radioactive materials for the Loviisa Nuclear Power Plant are defined in the Technical Specifications concerning the operation of the plant units. Limits have been separately defined for atmospheric noble gas and iodine releases, and, on the other hand, for water releases into the sea. A separate nuclide-specific release limit has been defined for radioactive tritium in water releases. The purpose of the release limits is to retain the individual annual radiation exposure in the surrounding population of the plant units clearly below the threshold value of 0.1 mSv set forth in section 9 of the Government Decision. The licensee shall constantly monitor the releases and radioactive substances present in the environment, reporting any abnormal conditions to STUK without delay.

When calculating the radiation dose of an individual of the population caused by releases of radioactive materials, the analysis is based on the average radiation exposure of the most exposed group. This group represents a hypothetical group of individuals in the population who, based on their residence and life style, are estimated to receive the highest radiation exposure arising from releases according to calculations.

FPH has renewed its calculations methods concerning the radiation exposure of surrounding populations arising from the normal operation of the Loviisa Nuclear Power Plant during the current operating licence period. The renewed methods are in accordance with the requirements specified in the Guides YVL 7.2 and 7.3.

The highest theoretical dose commitment received by an individual of the population most exposed to radiation in the vicinity of the Loviisa Nuclear Power Plant, calculated from the releases of 2006, was, as reported by FPH, 0.00012 mSv (in Finland, the average annual individual dose resulting from natural radiation is above 1 mSv). The comparative calculation performed by STUK resulted in a value lower than that reported by FPH. The calculated radiation dose has remained within this order of magnitude during the past few years since the implementation of the measures for restricting caesium releases into the sea at the Loviisa plant. The radioactive releases from the Loviisa 1 and 2 nuclear power plant units have also been clearly below the release limits set forth in the Technical Specifications.

STUK has requested a report from the Loviisa Nuclear Power Plant on the implementation of the updated YVL 7.1 and YVL 7.6 guides concerning the availability of solutions for further reducing the radioactive releases.

The control of radioactive releases from the Loviisa Nuclear Power Plant and the monitoring of radioactive substances and radiation in the environment are discussed below in section 6.4.

The conclusion to the above is that the operation of the Loviisa Nuclear Power Plant has not resulted in such radioactive releases that the limit of 0.1 mSv set forth in section 9 of the Government Decision would have been exceeded. It can be expected that the calculated dose to an individual in the most exposed group of the population arising from annual normal radioactive releases of the Loviisa Nuclear Power Plant will remain small.

4.4 Section 10: Limit for an anticipated operational transient

The limit for the dose of the individual of the population, arising, as the result of an anticipated operational transient, from external radiation in the period of one year and the simultaneous radioactive materials intake, is 0.1 mSv.

Detailed requirements concerning the analyses of anticipated operating transients are specified in the Guide YVL 2.2. If an operational transient could cause a release of radioactive substances, the radiation doses caused by the releases shall be identified. Detailed requirements concerning the calculation methods used for assessing the radiation exposure of the population are specified in the Guides YVL 7.2 and YVL 7.3.

The descriptions of the analyses concerning anticipated operating transients are presented in the safety analysis report for Loviisa 1 and 2 nuclear power plant units. These analyses are discussed in section 3.4.1 of the Safety Assessment with regard to plant behaviour. Operating transients are not expected to result in a release of radioactive materials because the fuel is not damaged or plant systems are capable of retaining the releases. The radiation doses to an individual in the population arising from anticipated operational transients are therefore not assessed by means of calculations.

No such operating transients have occurred at the Loviisa Nuclear Power Plant in which increases in radioactive releases compared with the normal conditions had occurred.

The conclusion to the above is that the anticipated operating transients of the Loviisa Nuclear Power Plant do not result in a release as a consequence of which the radiation doses of an individual in the population would exceed the limit value of 0.1 mSv set forth in section 10 of the Government Decision.

4.5 Section 11: Limit for a postulated accident

The limit for the dose of the individual of the population, arising, as the result of a postulated accident, from external radiation in the period of one year and the simultaneous radioactive materials intake, is 5 mSv.

The Guides YVL 2.2, YVL 7.2 and YVL 7.3 contain detailed requirements for calculating the accident analyses concerning plant behaviour and the releases and radiation doses relating to them, and for the acceptability of the results.

Accident analyses and their calculation methods are under continuous development throughout the operating life of the nuclear power plant. The descriptions of the accident analyses of the plant units are presented in the safety analysis report for the Loviisa 1 and 2 nuclear power plant units (discussed in more detail in section 3.4.1). The methods of analysis for radiation exposure employed by FPH have been developed over several years and are in accordance with the requirements specified in the Guides YVL 7.2 and 7.3. The methods contain unlikely assumptions that, in reality, result in overestimating the size of radiation doses calculated as a consequential effect.

Safety-enhancing measures are taken as required on the basis of the analyses. In terms of radiation safety, special attention has been paid to an accident in which a large leak of coolant from the primary circuit cooling the reactor into the secondary circuit could occur rapidly due to internal damage to the steam generator. FPH has implemented a number of important modifications at the Loviisa 1 and 2 nuclear power plant units (section 5.6), the purpose of which are to, e.g., prevent damage to the fuel and the resulting major releases of radioactive material if such leaks were to occur. The heads of the steam generator primary collectors have been replaced during the current operating licence period, with the new heads being furnished with leak restrictors and rings restricting the elevation of the heads. New graphite seals have been installed in the heads to replace the original nickel ring seals. The leak restrictor restricts the leak of coolant into the secondary circuit in the event of damage to the head, thus also restricting the release of radioactive materials into the environment. The emergency operating procedures relating to accident management were revised and put into use in 2006.

In the analysis performed in 1997, the maximum value for the dose to an individual in the population arising from a large primary-to-secondary leak was 12 mSv, which remains below the 100 mSv limit set forth in section 28 for a postulated accident concerning a nuclear power plant commissioned prior to entry into force of the Government Decision, but exceeds the 5 mSv dose limit set forth in section 11. According to the results of the accident analyses, revised to a large extent during the current operating period from among the postulated accidents analysed, a primary-to-secondary leak may still result in the highest radiation dose to an individual in the population, but the maximum value for the dose is 3.9 mSv. The reduction of the maximum value is based on the reduction of permissible leak of fuel during operation in the Technical Specifications, and reanalysis of mass flows during an accident while taking into account the changes to the plant's technical systems and procedures as well as on a more realistic modelling of the release and dispersion of radioactive materials inside the plant and in the environment. A spent nuclear fuel handling accident in the containment may cause an individual dose of the same order of magnitude (the maximum value for the calculated dose being 0.82 mSv). The doses arising from other postulated accidents were, according to the analyses, smaller by several orders of magnitude.

The conclusion to the above is that the postulated accidents at the Loviisa Nuclear Power Plant do not result in a release of radioactive material as a consequence of which the radiation doses to an individual in the population would exceed the limit value of 5 mSv set forth in section 11 of the Government Decision.

4.6 Section 12: Limit for a severe accident

The limit for the release of radioactive materials arising from a severe accident is a release which causes neither acute harmful health effects to the population in the vicinity of the nuclear power plant nor any long-term restrictions on the use of extensive areas of land and water. For satisfying the requirement applied to long-term effects, the limit for an atmospheric release of cesium-137 is 100 TBq. The combined fall-out consisting of nuclides other than cesium-isotopes shall not cause, in the long term, starting three months from the accident, a hazard greater than would arise from a cesium release corresponding to the above-mentioned limit. The possibility that, as the result of a severe accident, the above mentioned requirement is not met, shall be extremely small.

The original design basis of the Loviisa 1 and 2 nuclear power plant units did not include provisions for the loads or radiation condition prevailing during a severe accident. FPH has carried extensive research to identify the plant modifications required for making provisions for severe accidents at the Loviisa 1 and 2 nuclear power plant units. The modifications have been practically completed during the current operating licence period. The management of severe accidents at the Loviisa Nuclear Power Plant is discussed in more detail in section 5.5 in this assessment.

The probability of a severe accident and the related releases of radioactive materials have been investigated in the PRA level 2 analyses (section 3.4.2). The radiation doses to the surrounding population have been assessed in the same connection. On the basis of the analyses, the probability for not meeting the requirement concerning the limit value set forth in section 12 of the Government Decision is extremely small, as prescribed in that section. The development plan for reducing the probability of a major release is discussed in section 3.4.2.

The reason why the radiation exposure of individual workers relating to a severe accident is exceptionally high in an early stage of an emergency condition occurring on the plant site of the Loviisa nuclear power plant could be due to the fact that the radiation shielding thickness of the reactor containment roof is not sufficient in this condition. Part of the upwards-directed radiation penetrating the roof would thus reflect back from the air onto the plant site as external radiation. Modification of the reactor containment roof structures afterwards is not possible in practice, considering the adverse safety effects that would result from the modification. The reports prepared by FPH demonstrate that the radiation exposure caused by a severe accident does not exceed the radiation protection design requirements, provided that attention is continuously paid on these conditions in, for example, emergency response planning and implementation as well as in the related exercises. The emergency procedures have been updated during the current operating licence period to take into account the radiation safety of workers during an accident. FPH has developed an information system for radiation experts (SaTu) that can be used for assessing the radiation dose rates caused by different types of accidents, both inside the plant and on the plant site.

The conclusion to the above is that the provisions set forth in section 12 of the Government Decision have been fulfilled at the Loviisa Nuclear Power Plant as well as reasonably possible when taking into account the provisions set forth in sections 27 and 28.

5 Design criteria for nuclear safety (Government Decision 395/1991)

5.1 Section 13: Levels of protection

In the design, construction and operation, proven or otherwise carefully examined high-quality technology shall be employed to prevent operational transients and accidents (preventive measures).

*A nuclear power plant shall encompass systems by means of which operational transients and accidents can be quickly and reliably detected and the aggravation of any event can be prevented. Accidents leading to extensive releases of radioactive materials shall be highly unlikely (**control of transients and accidents**).*

*Effective technical and administrative measures shall be taken for the mitigation of the consequences of an accident. Counter-measures for bringing an accident under control and for preventing radiation hazards shall be planned in advance (**mitigation of consequences**).*

In addition to the structure of the plant, the quality of operation activities has crucial significance in the prevention of transients and accidents. Quality assurance concerning operating instructions, other plant procedures and operating activities is being continuously developed at FPH. The importance of complying with the instructions and the quality assurance programme is highlighted in the training of personnel.

The Loviisa 1 and 2 nuclear power plant units have operated reliably, and the number of safety-significant transients occurred has remained small. The transients that have occurred have been discussed in the quarterly reports published by STUK and in the statements of position concerning the renewal of operating licences for the plant units.

STUK's inspection programme concerning the control of nuclear power plant operation includes inspections of the procedures and methods adhered to in the operating activities. Quality assurance and operating activities are discussed in more detail in sections 3.3 and 6.

Guide YVL 1.0 requires that a nuclear power plant be provided with a protection system. The Loviisa 1 and 2 nuclear power plant units have in place protection systems that include a reactor protection system and a plant protection system. The function of the protection system is to actuate the required safety functions if any of the safety-important parameters substantially deviates from its normal value. The function of the reactor protection system is to initiate reactor shutdown. The most important of the functions actuated by the plant protection system are reactor emergency cooling, residual heat removal and containment isolation functions. The Loviisa 1 and 2 nuclear power plant units have the required safety systems in place for executing these functions (section 5.6).

The reactor protection systems of the Loviisa 1 and 2 nuclear power plant units have been implemented by means of relay technology, and the plant protection systems by means of conventional electronics. The employed technology is proven but becoming outdated. The design and implementation of the reactor protection system is based on solutions on which the plant supplier had gained experience from the previously constructed VVER-440 type plants. The operating reliability of the system has been improved on the basis of operating experience by replacing certain components with more reliable ones and by adding new components that ensure operability in the event of common cause failures affecting redundant components. The testing and user experience of the plant protection system indicate that the solutions employed have thus far been effective. The protection systems meet the fail-safety requirement set forth in Guide YVL 1.0 – that is, each subsystem shifts into a state requiring protection in the event of a failure of any of its components.

The I&C systems of the Loviisa 1 and 2 nuclear power plant units will be renewed in four stages during the future operating licence period. In the second stage of the renewal the old reactor and plant protection systems will be integrated into a single new reactor protection system. An automatic and a manual backup protection system will be implemented for fault conditions in the reactor protection system. The automatic system covers the actuation of safety functions urgently required in cases of accidents, while the manual system covers the remaining functions. These two securing systems will make it possible to bring the plant into hot shutdown even in event of complete loss of the actual reactor protection system. The latter renewal stages involve the renewal of, e.g., main control rooms and operational I&C systems. Backup systems for bringing the plant from hot shutdown to cold shutdown will also be implemented in this connection.

The plant is equipped with appropriate safety systems for the purpose of mitigating the consequences of accidents postulated in the design of the Loviisa Nuclear Power Plant. The plant operators also have at their disposal instructions prepared for abnormal occurrences and accidents, reviewed by STUK. The emergency plan is a document approved by STUK in which the definition of duties and responsibilities required for accident conditions are presented, among other things. Emergency response arrangements are discussed in more detail in section 9.

Major releases of radioactive substances into the environment may occur mainly in severe accidents. The provisions made for severe accidents are discussed in more detail in section 5.5.

The conclusion to the above is that the levels of protection at the Loviisa Nuclear Power Plant meet the requirements set forth in section 13 of the Government Decision. Deficiencies with regard to ensuring containment integrity and ensuring safety functions are discussed in sections 5.5 and 5.6.

5.2 Section 14: Technical barriers for preventing the dispersion of radioactive materials

*Dispersion of radioactive materials from the fuel of the nuclear reactor to the environment shall be prevented by means of successive barriers which are the fuel and its cladding, the cooling circuit (**the primary circuit**) of the nuclear reactor and the containment building.*

Detailed regulations concerning the operability of technical barriers are laid down in section 15, 16 and 17 of the Government Decision.

The first barrier to the dispersal of radioactive materials is the fuel and its cladding. The fuel used at the Loviisa 1 and 2 nuclear power plant units is uranium dioxide enriched in the U-235 isotope to a maximum level of 4%. During normal operating conditions, when the temperature of the uranium dioxide does not rise exceptionally high, the majority of fission products remain within the fuel pellet (inside the matrix).

Uranium dioxide pellets have been packed in cladding tubes with an outside diameter of approximately 9 mm, which, in turn, have been assembled into fuel assemblies consisting of 126 rods. The ends of the cladding tubes have been sealed gas-tight. The properties of the cladding tube material make it very suitable for the conditions prevailing in the reactor. The material also meets the exceptional durability requirements imposed by high temperatures.

The next barrier after the fuel (the uranium dioxide matrix and the surrounding gas-tight cladding) for preventing the dispersion of radioactive materials is the pressure-bearing boundary of the primary circuit. The main components of the primary circuit (the reactor pressure vessel, steam generators, pressurizer, pipings) have been manufactured of stainless steel or carbon steel coated with stainless steel.

The starting point of the design of the reactor primary circuit was that the releases into the environment would remain within the set limits even if the integrity of the cladding of approximately one per cent of the approximately 40,000 fuel rods contained in the core were lost in normal operating conditions. Nowadays the primary circuit activity limit set forth in the Technical Specifications of plant units is lower, equalling approximately 33 leaking fuel rods. The water treatment system of the reactor primary circuit is furnished with filter equipment that enables orderly collection and removal of fission products released into the cooling water, as well as corrosion products activated by neutron radiation that are migrating in the circuit.

The current requirements relating to the basic dimensioning of the primary circuit and the fuel are essentially similar to those that were in force in the building stage of the plants.

The primary circuit is entirely contained within a gas-tight containment building manufactured of steel plates. The steel containment is surrounded by a cylindrical secondary building made of concrete and equipped with a light roof structure supported by steel lattices. The space between the inner and outer containment is held at negative pressure and equipped with filtered ventilation systems in order to reduce potential radioactive releases in the event of accidents.

The containment was not originally dimensioned against severe accidents. Plant modifications implemented in order to make provisions for severe accidents are discussed in more detail in section 5.5, while section 6.2.5 provides further details on containment ageing management.

The conclusion to the above is that the Loviisa Nuclear Power Plant is equipped with technical barriers for preventing the dispersion of radioactive materials referred to in section 14 of the Government Decision.

5.3 Section 15: Ensuring fuel integrity

The probability of significant degradation of fuel cooling or of a fuel failure due to other reasons shall be low during normal operational conditions and anticipated operational transients.

During postulated accidents, the rate of fuel failures shall remain low and fuel coolability shall not be endangered.

The possibility of a criticality accident shall be extremely low.

Detailed requirements relating to section 15 of the Government Decision are set forth in the guides YVL 1.0, YVL 2.2 and YVL 6.2.

The fuel cladding in the Loviisa Nuclear Power Plant is made of zirconium–niobium alloy. The fuel manufacturer has gained considerable experience of its use as fuel rod cladding material since the 1960s. The results of the manufacturer's operating experience and laboratory research have been successfully confirmed by the research on spent fuel carried out at the plant site. The oxide layer on the surface of the cladding caused by corrosion remains very thin, and the ductility of the material remains sufficient throughout the service life of the fuel.

The fuel manufacturer has provided measurement results concerning the quantities of fission gases released from the fuel pellet inside the rod. These have been analysed by computational methods, and supplementary measurement results have also been obtained from the fuel irradiated at the Loviisa Nuclear Power Plant. On the basis of these results and analyses, the release fraction of fission gases can be regarded as being sufficiently low at the current operating mode of the reactor.

The integrity of fuel during power change conditions relating to the normal operation of the reactor is ensured by restrictions concerning power change rates, which are mainly based on investigations carried out on research reactors in Russia as well as operating experience obtained elsewhere.

On the basis of the current operating experience from the Loviisa Nuclear Power Plant, the probability of fuel damage can be regarded as being sufficiently small in normal operating conditions of the plant. The structure of fuel assemblies and rods has been gradually developed on the basis of the operating experience obtained. In the current structure of the top section of fuel assemblies, provisions have been made for the elongation of fuel rods during operation beyond the original dimensioning, the manufacturing method of fuel pellets has been changed, the internal pressure of fuel rods has been increased, and the material used in the spacer grids has been changed to zirconium-niobium alloy. All of these changes have had a beneficial impact on fuel integrity in normal operating conditions, anticipated operating transients and postulated accidents.

The probability of significant degradation of fuel cooling during normal operation – that is, heat transfer crisis – is extremely small at the Loviisa 1 and 2 nuclear power plant units. This is primarily due to the beneficial ratios between the total and linear power of the fuel and between primary and secondary coolant flows, the coolant quantities and the related time constants. This is indicated by the fairly large margin of departure from nucleate boiling during the stationary state. For the above reasons, the probability of a heat transfer crises during anticipated operating transients is also very unlikely.

As for postulated accidents, fuel damages may be expected mainly in loss of primary coolant, ejection of control rods and anticipated transient without scram (ATWS) accidents. The analysis results for a large break loss of coolant accident indicate that the temperatures of the fuel cladding will remain so low that the probability for the occurrence of fuel damages is unlikely. According to the analyses, the number of fuel damages possibly occurring as a result of control rod ejection or an ATWS accident remains small. The coolability of fuel is not endangered in postulated accidents.

One major objective is to prevent transients resulting in inadvertent criticality and/or reactivity increase of the reactor. The probability and significance of malfunctions resulting in the dilution of the boron solution used as reactivity poison for the primary circuit or internal dilution occurring in connection of certain types of accidents has been investigated. On the basis of the investigations, plant modifications to prevent inadvertent boron dilution have been made at the Loviisa 1 and 2 nuclear power plant units. These measures will be further continued during the next operating licence period (section 3.4.2). The prevention of inadvertent criticality has also been taken into account in the fuel storage and handling systems of the Loviisa Nuclear Power Plant.

A number of improvements to the operation of the emergency core cooling systems of the Loviisa 1 and 2 nuclear power plant units have been made during the current operating licence period. The operating parameters of the pressurised emergency make-up water tanks of the low-pressure emergency cooling system have been changed and the pumps have been renewed. These modifications have improved the cooling of fuel in the event of a large break loss of coolant accident. In addition, two of the four high-pressure emergency cooling system pumps have been replaced at the Loviisa 2 nuclear power plant unit. Similar replacement will be carried out at the Loviisa 1 nuclear power plant unit in 2008.

The conclusion to the above is that fuel integrity has been ensured at the Loviisa Nuclear Power Plant in a manner referred to in section 15 of the Government Decision.

5.4 Section 16: Ensuring the integrity of the primary circuit

The primary circuit of a nuclear reactor shall be designed so that the stresses imposed upon it remain, with sufficient confidence, below the values defined for structural materials for preventing a fast growth crack during normal operational conditions, anticipated operational transients and postulated accidents. The possibility of a primary circuit break due to other reasons shall be low, too.

Requirements concerning the strength analyses of a nuclear power plant primary circuit, as well as in-service strength assurance are specified in Guide YVL 3.5, which was implemented at the Loviisa Nuclear Power Plant on 3 October 2006. According to the above-mentioned guide, Safety Class 1 pressure equipment shall be dimensioned according to the ASME (American Society of Mechanical Engineers) Boiler and Pressure Vessel Code, Section III, or by otherwise fulfilling a similar safety level. A brittle fracture analysis shall be carried out for the most stress-imposed parts of pressure vessels made of ferrite steel.

The design of primary components of the Loviisa Nuclear Power Plant is mainly based on standards that were in force in the Soviet Union at that time. The design principles are similar to those in the ASME Boiler and Pressure Vessel Code, but the requirements are deficient with regard to brittle fracture. The design of the primary circuit is based on setting a sufficient safety factor for various types of failure mechanisms, such as general deformation (plastic instability), continuously increasing deformation during load variations, fatigue, brittle fracture and instability (compression stress). The defined design loads comprise normal operation, deviations from normal conditions and postulated accidents. Provisions have been made for a guillotine break of the reactor coolant pipe by constructing emergency restraints and jet shields. Earthquake loads were not included in the design basis.

The reactor pressure vessel is manufactured of low-alloy CrMoV steel and cladded on the inside with austenitic stainless steel. After three years of operating the Loviisa 1 nuclear power plant unit, it was discovered, on the basis of the investigation of the material samples placed inside the reactor pressure vessel, that the material characteristics of the ring weld at the level of the reactor core were deteriorating faster than anticipated. The observation was made prior to the commissioning of the Loviisa 2 nuclear power plant units. Neutron radiation from the reactor core increases the transition temperature, in the vicinity of which the ductility of the material deteriorates rapidly when the temperature decreases. Safety is not endangered in normal operating temperature, but in certain transient and accident conditions cold coolant is fed into the primary circuit and the risk of fast brittle fracture increases if the embrittled area contains a crack. To reduce the risk of brittle fracture, the dose rate of neutrons has been reduced by replacing the 36 fuel elements on the edges of the reactor core with elements made of steel. A number of other modifications have also been made at the plant units to reduce loads and their probability. Primary circuit safety relief valves operating at low-pressure have been added to the plant units to prevent cold pressurisation during an outage. The best available non-destructive testing methods have also been used for detecting potential faults. The endurance of the reactor pressure vessel in the above conditions has been investigated by means of thermohydraulic and fracture-mechanical calculations. The reactor pressure vessels of both plant units have fulfilled the acceptance criteria set for them in the deterministic and probabilistic safety analyses performed by FPH.

Heat treatment was applied to the embrittled weld in the reactor pressure vessel of the Loviisa 1 nuclear power plant unit during the 1996 refuelling outage, which recovered the ductility characteristics of the weld nearly back to the original level. Material samples were placed inside the reactor pressure vessel for determining the re-embrittlement rate. The rate of the re-embrittlement was estimated conservatively and thorough non-destructive examinations were performed on the reactor pressure vessel. In 2003 the estimate of the re-embrittlement rate was further specified by means of a calculation formula containing phosphor concentration, which was derived according to research principles from the results of material samples selected to represent the critical weld as accurately as possible that were irradiated inside the reactor pressure vessel. On the basis of the results of these analyses, the reactor pressure vessel has been approved for operation until the refuelling outage of 2012. Continued operation requires that more detailed analyses are performed in which the conservativeness included in the analyses is reduced or, alternatively, another heat treatment is performed on the reactor pressure vessel. STUK is not aware of any obstacles of a principal nature to the continued operation of the reactor pressure vessel of the Loviisa 1 nuclear power plant unit.

The embrittlement rate of the reactor pressure vessel of the Loviisa 2 nuclear power plant unit is lower than that of Loviisa 1 due to smaller concentrations of impurities in the weld material. On the basis of the safety analyses performed, the reactor pressure vessel of the Loviisa 2 nuclear power plant unit has been approved for operation until the refuelling outage of 2010. Continued operation requires that more detailed analyses are performed in which the conservativeness included in the analyses is reduced or, alternatively, heat treatment is performed on the reactor pressure vessel. STUK is not aware of any obstacles of a principal nature for the continued operation of the reactor pressure vessel of the Loviisa 2 nuclear power plant unit.

Other pressure-bearing components of the primary circuit of the Loviisa nuclear power plant units have been manufactured of austenitic stainless steel or carbon steel cladded with austenitic stainless coating. The safety factor for general deformation is at least 1.5. Thus the magnitude of a fault resulting in fast fracture is so large that it can be detected with high probability as a minor leak or discovered in in-service inspections. Due to choices of materials, general corrosion reducing wall thickness cannot occur in the primary circuit.

The over-pressure protection of the primary circuit has been implemented as redundant pressurizer safety relief valves with staggered opening pressures. The safety relief valves are designed to operate by steam, water and a steam-water mixture. Pressure increase at low temperatures has been prevented by means of an outage safety relief valve that is actuated when the temperature of the primary circuit falls to the level requiring brittle fracture protection.

The conclusion to the above is that the integrity of the primary circuit of the Loviisa Nuclear Power Plant has been demonstrated to meet the requirements set forth in section 16 of the Government Decision, provided, however, that the situation will be re-assessed for the reactor pressure vessels of the Loviisa 1 and 2 nuclear power plant units in 2012 and 2010. STUK is not currently aware of any obstacles of a principal nature for the continued operation of the reactor pressure vessels of the Loviisa 1 and 2 nuclear power plant units after 2012 and 2010. FPH will estimate the need for further heat treatments on the pressure vessels in connection with the preparation of a subsequent application concerning the use of pressure vessels.

5.5 Section 17: Ensuring containment building integrity

The containment shall be designed so that it will withstand reliably pressure and temperature loads, jet forces and impacts of missiles arising from anticipated operational transients and postulated accidents.

Furthermore, the containment shall be designed so that the pressure and temperature created inside the containment as a consequence of a severe accident will not result in its uncontrollable failure.

The possibility of the creation of such a mixture of gases as could burn or explode in a way which endangers containment integrity shall be small in all accidents.

The hazard of a containment building failure due to a core melt shall also be taken into account in other respects in designing the containment building concept.

The function of the containment is to limit the release of radioactive materials during normal operation and accidents. The Loviisa 1 and 2 nuclear power plant units are equipped with a double containment. The inner, steel containment is gas-tight and surrounded by the outer containment made of reinforced concrete. The purpose of the outer containment is to protect the inner containment from external impacts. The double containment structure makes it possible to maintain negative pressure in the annular space between the buildings.

The operability and leaktightness of the containment access openings, penetrations and process line isolation valves is verified by periodic tests carried out at regular intervals. The leaktightness of the steel containment is inspected by means of leak tests carried out at four-year intervals. A periodic testing programme has been defined for testing the auxiliary systems that are essential for the overall functionality of the containment. The containment has been assigned to the highest class in terms of service life in the service life management programme of the Loviisa Nuclear Power Plant.

The inner containment, its penetrations and directly related auxiliary systems have been dimensioned to withstand pressure and temperature loads, jet forces and impacts from missiles arising from postulated accidents in a manner referred to in section 17 of the Government Decision and in the Guide YVL 1.0. The containment is equipped with ice condensers that condense the steam discharged in accident conditions, thereby limiting the pressure increase inside the containment. The containment is also equipped with an internal spay system and systems for the treatment of combustible gases. The crane wall inside the containment protects the steel containment against jet forces and missiles occurring during accidents.

The space between the steel liner and the outer containment is held at negative pressure by means of a safety ventilation system equipped with filters. The negative pressure causes an air flow from the outdoor air into the annulus. The fission products that may leak from the inner containment in accident conditions can be retained in the filters to a large extent, which decreases the releases into the environment arising from containment leaks. The outer containment is made of reinforced concrete.

Loads arising from severe accidents were not included in the original dimensioning basis of the containment systems of the Loviisa 1 and 2 nuclear power plant units. Section 17 of the Government Decision and YVL 1.0 require that the containments of new nuclear power plants have the capability for severe accident management. In this regard, the requirements set forth in sections 27 and 28 are applied to plants that are currently in operation. On the basis of extensive research and development activities, FPH prepared a strategy for severe accident management drawing from the distinctive features of the plant, and the plant modifications required by the strategy have been completed during the current operating licence period. The primary elements of the strategy are pressure reduction in the primary circuit, retention of core melt inside the reactor vessel by cooling the pressure vessel from the outside, removal of residual heat from the containment by means of a spray system outside the containment, and prevention of fast pressurisation of the containment (prevention of hydrogen fires and explosions).

The retention of core melt inside the pressure vessel by cooling the pressure vessel from the outside is a central function in the severe accident management strategy of the Loviisa Nuclear Power Plant. The purpose of the primary circuit pressure reduction is to reduce the load imposed on the pressure vessel in a severe accident, which, in turn, is to ensure the retention of core melt inside the pressure vessel and the required cooling outside the pressure vessel. Two redundant high-capacity pressure reduction lines were installed at both plant units in 1996. Significant modifications have been performed at both plant units to implement the strategy: the neutron and heat shield below the pressure vessel was changed to one supported by a hydraulic cylinder in 2002, which makes it possible to lower it down during an accident. This ensures the access of water to the outer surface of the pressure vessel, thus also ensuring the cooling of core melt. Additional flow channels were installed in the reactor, and filters were installed to remove potential impurities contained in the water.

The overpressurisation of the steel containment in a severe accident is prevented by means of a spray system outside the containment. The plant unit-specific spray system comprises a water storage, two redundant pumps, a heat exchanger and the actual spray circuit. The seawater system cooling the spray system and the system securing the emergency power of the spray system are shared systems within the plant. Spray systems were installed at both plant units in 1992.

Large quantities of combustible gas mixtures may only be generated at the Loviisa Nuclear Power Plant in a severe accident in which a substantial part of the reactor core is damaged. TThe fuel cladding material reacts with water steam, producing hydrogen in the overheated core. A large-scale hydrogen fire or explosion in the containment of the Loviisa Nuclear Power Plant could endanger the integrity of the containment. The hydrogen management at the Loviisa Nuclear Power Plant is based on the controlled dilution of hydrogen concentrations and the removal of water.

The dilution of high hydrogen concentrations to a non-flammable level is carried out by mixing the hydrogen into the containment atmosphere. The doors of the containment ice condenser are forced open to ensure successful mixing. Opening the doors causes a natural circulation flow from the lower into the upper plenum, which mixes the gases effectively and evens out the hydrogen content. Plant modifications to enable the forced opening of ice condenser doors were carried out at both plant units in 2001.

Hydrogen is removed from the containment using a recombiner and ignition plugs designed for the purpose. The recombiners remove the hydrogen by means of a catalytic reaction by oxidising it into water. 154 recombiners have been installed at both plant units, the majority of which are located in the steam generator room and in the upper plenum of the containment. The recombiners are passive equipment that does not require electrical power or operator action to actuate. The ignition plugs burn the hydrogen in accident conditions where hydrogen generation occurs very rapidly. 40 ignition plugs have been located in the steam generator room as close to the possible sources of hydrogen leak as possible. The recombiners and ignition plugs, as well as the instrumentation, automation and power supply needed for their operation, were installed at the Loviisa nuclear power plant units in 2003. The processing is still in progress with regard to the testing criteria for new ignition plugs and recombiners.

During a severe accident, all control and monitoring can be performed from within the so-called SAM (Severe Accident Management) control room, which, at the Loviisa Nuclear Power Plant, is shared between both plant units. The fact that control activities may need to be performed for a long time from within the SAM control room has been considered in the design. The SAM control room was completed in 2000.

FPH has completed all plant modifications required by the severe accident management strategy developed for the Loviisa Nuclear Power Plant during the current operating licence period, with the exception of the processing of the testing criteria for ignition plugs and recombiners, which is still in progress. These measures will ensure the integrity of the containment in most cases where a leak from the primary circuit into the containment occurs. FPH has performed new PRAs during the current operating licence period, which indicate that containment bypass leaks are of greater significance than previously assessed. The current severe accident management strategy is not effective in the management of such accident conditions. STUK's position in this matter is that the prevention of containment bypass conditions and more reliable prevention of their consequences is one of the most important development targets for the next operating licence period.

With regard to severe accidents, the Loviisa 1 and 2 nuclear power plant units may be considered to fulfil the requirements set forth in section 17 of the Government Decision and in the Guide YVL 1.0, while taking into account the provisions of section 28 of the resolution concerning operating plants. The development plan concerning containment bypass conditions is discussed in more detail in section 3.4.2.

5.6 Section 18: Ensuring safety functions

In ensuring safety functions, inherent safety features attainable by design shall be made use of in the first place. In particular, the combined effect of a nuclear reactor's physical feedbacks shall be such that it mitigates the increase of reactor power.

If inherent safety features cannot be made use of in ensuring a safety function, priority shall be given to systems and components which do not require an off-site power supply or which, in consequence of a loss of power supply, will settle in a state preferable from the safety point of view.

Systems which perform the most important safety functions shall be able to carry out their functions even though an individual component in any system would fail to operate and additionally any component affecting the safety function would be out of operation simultaneously due to repairs or maintenance.

A nuclear power plant shall have on-site and off-site electrical power supply systems. The execution of the most important safety functions shall be possible by using either of the two electrical power supply systems.

Safety systems which back up each other as well as parallel parts of safety systems shall be separated from each other so that their failure due to an external common cause failure is unlikely.

In ensuring the most important safety functions, systems based on diverse principles of operation shall be used to the extent possible.

Detailed requirements relating to section 18 of the Government Decision are specified in the Guides YVL 1.0, YVL 2.1 and YVL 2.7. Provisions concerning the application of this section to operating nuclear power plants are set forth in section 28.

The most important safety functions of a nuclear power plant are: 1) reactor shutdown, 2) residual heat removal from the reactor to the ultimate heat sink, and 3) the functioning of the containment building. These functions shall be operable in normal operational conditions, anticipated operational transients and postulated accidents.

Inherent reactor-physical feedbacks are made use of in the design of the reactors in Loviisa 1 and 2 nuclear power plant units and in their loading plans so that each physical feedback separately, and thus their combined effect collectively, mitigates the increase of reactor power in transient and accident conditions. This is demonstrated both analytically and experimentally in the start-up of the plant following refuelling outages.

Both control rods and boron systems are available for the purpose of shutting down the reactor at the Loviisa 1 and 2 nuclear power plant units. Control rods may be used by either driving them by means of electric motors or by dropping them into the reactor by means of gravity in connection with a reactor scram. If the control rods lose their electric diving force, they will fall into the reactor shutting it down. The fuel loading of the Loviisa 1 and 2 nuclear power plant units is designed to enable reactor scram during normal operation, anticipated operational transients and postulated accidents by means of control rods even in the event of a malfunction of the most effective control rod. In addition to the control rods, the reactors can be shut down using the boron systems equipped with emergency diesel power supply.

Modifications concerning the systems and operating mode of the Loviisa Nuclear Power Plant have been performed to provide for the inadvertent dilution of boron concentration of the water used for long-term power control of the reactor. These measures have reduced the risk of inadvertent boron dilution, but attention must be paid to further reduction of the risk (section 3.4.2).

The removal of residual heat from the primary circuit into the secondary circuit is carried out by means of natural circulation of the primary coolant. The heat transferred into the secondary circuit can be further transferred into the sea or the atmosphere using a number of different systems. These systems require active equipment that receive their driving power from power supply sources equipped with emergency diesels. The shared standby emergency feedwater system constructed for the power plant units is equipped with designated diesel-operated pumps that are independent of the electrical systems of the plant. The supply of water into the steam generators carried out by means of the standby emergency feedwater system and the removal of residual heat carried out by means of secondary circuit blowdown are operable in the event of a loss of power supply.

Residual heat removal has been further secured during the current operating licence period by constructing a standby residual heat removal system, which makes it possible to cool the plant units down into cold shutdown if the actual residual heat system is lost, for example in the event of fire in the turbine hall. Amendments have also been made to secure the ultimate heat sink. These include the construction of an alternate cooling water intake from the seawater outlet channel. As a result, the reliability of the plant safety systems has been improved in conditions where, for example, ice, oil or algae endanger the normal cooling water intake.

FPH has presented plans for further securing the residual heat removal. The modifications will improve the reliability of residual heat removal carried out using the feedwater and steam supply to the steam generator in, e.g., various steam and feed water pipe break conditions. The plans have been submitted to STUK and the modifications will be implemented in connection with the automation renewal of the plants.

If residual heat removal through the secondary circuit is not possible, the residual heat can be removed directly from the primary circuit. This is carried out by feeding water through the high-pressure emergency cooling pumps into the primary circuit, where the warmed-up water is released into the containment by opening the pressurizer high-capacity relief valves. Residual heat removal from the containment is carried out by means of recycling through floor drains using the emergency heat transfer chain.

After the possible occurrence of a primary circuit break, water to the primary circuit is first obtained from pressure water tanks that discharge without any external driving force. Subsequently, the residual heat removal is carried by means of the emergency cooling systems. The residual heat is removed through the component intermediate cooling system into the seawater circuit.

The filter structures of the containment floor drains have been so designed that they do not become clogged if the thermal insulation used on the outer surface of the primary circuit is damaged and breaks off in the occurrence of a pipe break. The clogging of the floor drains would mean complete loss of the emergency cooling function. According to the current best available knowledge, the filter structures of the floor drains have been designed to collect the greatest possible amount of loose insulant without causing disturbance to the cooling function due to the loose insulant or other simultaneously released impurities. In addition, the floor drain filters are also equipped with instrumentation and a cleaning system. This makes it possible to monitor the possible emergence of clogging and to clean the filter structures if required, which, in turn, makes long-term operation secure.

In order to mitigate the consequences of leaks occurring from the primary side into the secondary circuit, the structure of steam generator collector heads has been modified so that the largest possible leak size has been reduced to approximately 20% of the original. To ensure the cooling of the reactor during a primary-to-secondary leak, a shared emergency make-up water tank has been constructed for the plant units. The primary circuit pressure control in primary-to-secondary leaks has been changed to be performed using the pressurizer relief valve instead of the previously used spraying from the high-pressure emergency cooling system.

Keeping containment pressure and temperature within the design values does not require the operation of active components in the early stage of any of the design basis accidents. In conditions where a large amount of steam leaks into the containment, the operation of the spray system inside the containment is required after the ice contained in the ice condenser has melted. In a condition of this type, the heat released from the reactor is transferred into the seawater circuit through the reactor emergency cooling system and the component intermediate cooling system that cools it. The operation of these systems is based on active components that require electrical energy as their driving force. Spraying outside the steel containment can also be used for containment residual heat removal. The spraying pumps receive their power supply from the on-site diesel generators that are independent from other electrical systems of the plant. The leaktightness of the containment process penetrations is ensured by isolation valves, of which there are normally two, one outside the containment and one on the inside.

In the original design basis of the systems important to the safety of the Loviisa 1 and 2 nuclear power plant units it was not considered that, in addition to the inoperability of any single component, another component could be simultaneously unavailable due to repair or maintenance. Instead, in accordance with the requirements that were in force at that time, it was set as an objective that all systems important to safety were to be able to perform their function even in the event of a malfunction of any single component of the system. For this reason alone, several modifications to the plant safety systems, as well as replacements of single components to improve the operational reliability of systems and the general reliability of the plant, have been necessary since the commissioning of the plant. A number of fully redundant standby systems have also been constructed, the most important of which being the standby emergency feedwater system.

The off-site electrical power supply at the Loviisa Nuclear Power Plant comprises two 400 kV connections and one 110 kV connection to the Finnish national grid. In addition to the normal emergency power systems, the plant is also equipped with four diesel generators for each plant unit, as well as battery systems, for backup supply of electrical power. The plant's safety systems have been divided into two subsystems, separated from each other, both of which receive power supply from the external network or from two diesel generators. In systems where there are four redundant active components, such as the low and high-pressure emergency cooling pumps, the power supply to each of the components is arranged through busbars connected to a different diesel generator. In addition, a power supply connection of 6 kV has been constructed between the units.

A connection from the Ahvenkoski hydropower plant has also been constructed at the Loviisa Nuclear Power Plant. This connection may simultaneously replace one of the emergency diesel generators at both Loviisa 1 and Loviisa 2 nuclear power plant units.

Gas turbines located on the plant site may also be used for power supply through the 110 kV connection.

A number of modifications to the electrical components have been carried out at the Loviisa 1 and 2 nuclear power plant units in order to secure safety functions. A power supply connection from the SAM diesel generators of the spray system outside the containment was constructed for the battery pack rectifiers of the DC systems of both plant units. The purpose of these modifications is to ensure the operability of safety systems in accident conditions, while taking into account, e.g., the requirements indicated by the revised safety analyses.

The detailed regulations laid down in the Technical Specifications of Loviisa Nuclear Power Plant direct the operation of the plant units towards continuous maintenance of the acceptable safety level and the securing of the necessary safety functions required by it. The requirements in the Technical Specifications for the Loviisa Nuclear Power Plant are quite extensive in terms of their number, as well as strict and very detailed in terms of their content, thereby expressing the need to compensate by strict administrative means the deficiencies in systems technology arising from the design basis.

Because the components required by the safety functions of the Loviisa 1 and 2 nuclear power plant units are not adequately separated in all respects, the same external reason could damage mutually securing redundant components. For this reason, a number of modifications, mostly those relating to fire compartmentalisation requirements, have been required since the commissioning of the plant. The separation and protection of systems has been improved on the basis of the results of a probabilistic risk analysis assessing the magnitude of risks arising from fires and floods.

According to STUK's view, continuous improvements have been made in ensuring safety functions since the commissioning of the plant by means of research and plant modifications performed on the basis of the results of this research, the most important of which are the new standby emergency feedwater and standby residual heat removal systems, as well as the improvements made to the seawater systems.

The conclusion to the above is that the Loviisa Nuclear Power Plant can be considered to fulfil the requirements concerning the measures to ensure safety functions set forth in section 18 of the Government Decision, while taking into account the provisions of section 28 of the resolution concerning operating plants.

5.7 Section 19: Avoiding human errors

Special attention shall be paid to the avoidance, detection and repair of human errors. The possibility of human errors shall be taken into account both in the design of the nuclear power plant and in the planning of its operation so that the plant withstands well errors and deviations from planned operational actions.

It is not possible to completely avoid human errors. However, the possibilities for errors can be reduced by proper design, instructions, procedures, training and effective quality management (see section 3.3, 6.1, 6.2 and 6.3).

FPH has conducted an extensive study of human activities, the purpose of which is to detect the possibilities and consequences of human errors. A variety of tasks routinely carried out at the plant during power operation and annual maintenance have been assessed for the purpose of analysing the errors affecting the sequence of events of a potential transient or accident. Different plant conditions and the related operation and maintenance errors have been systematically assessed in the analysis. It is important that the plant operating experience is systematically studied in order to avoid human errors. The operating experience feedback activities at the Loviisa Nuclear Power Plant are discussed in more detail in section 6.5.2. FPH has developed the utilisation of operating experience and performs root cause analyses of significant events. For annual maintenance, a comprehensive survey has been performed in which the hazards resulting in inoperability or an initiating event are identified.

The method of analysis for human activities and their reliability was originally developed on the basis of methods internationally used in the probabilistic risk analysis (PRA) of power operation, while taking into account the specific features of and the operating experience from the plant. A plant simulator has been employed in the development of analysis methods. FPH has made additions to and further specifications in the analysis method for the reliability of human activities at the Loviisa Nuclear Power Plant for the analysis of shutdown states. Shutdown states are characterised by a large amount of repair and maintenance work, numerous alarms and disabled voice alarms, large number of external workers, increased possibilities for errors in coordination and communication, low number of plant simulator exercises concerning exceptional situations, lack of emergency procedures for transients occurring during an outage, low and changing degree of plant automation, as well as low decay power that enables longer completion times than those allowed during power operation.

FPH has utilised the results obtained from the PRA and operating experience when planning procedure and plant modifications as well as in training. FPH has identified the single errors that are most important in terms of their risk significance, as well as the operating states in which these errors are most likely to occur. In connection with each new PRA entity or update, FPH has assessed and prioritised the risk elimination procedures and recommendations. On the basis of the recommendations, dozens of plant and procedure modifications have been made, as a result of which it has been possible to reduce the risk of human errors by, for example, replacing operator actions with automation, increasing the operator's completion time by means of plant modifications, and improving the opportunities for detection and repair of errors.

The renewal of emergency procedures is currently underway at the Loviisa Nuclear Power Plant (the renewal project is discussed in more detail in section 6.1). The method for assessing operation actions during transients, as well the reliability assessments performed, shall be updated to reflect the new procedures. FPH also aims at developing emergency procedures for outages. The assessment of heavy load lifting, reactivity accidents and recovery functions during outages constitutes an important development target. In addition to the above, the impact of the automation renewal on human operations shall be assessed.

According to STUK's view, FPH has in place systematic measures for detecting the possibility for human errors. FPH has assessed the significance of errors in terms of core damage risk and implemented risk reduction measures.

In summary, it can be stated that the avoidance, detection and repair of human errors at the Loviisa 1 and 2 nuclear power plant units has been implemented in a manner referred to in section 19 of the Government Decision.

5.8 Section 20: Protection against external events and fires

The most important nuclear power plant safety functions shall remain operable in spite of any natural phenomena estimated possible on site or other events external to the plant. In addition, the combined effects of accident conditions induced by internal causes and simultaneous natural phenomena shall be taken into account to the extent estimated possible.

Structures, systems and components important to safety shall be designed and located, as well as protected by means of structural fire barriers and adequate fire fighting systems so that the likelihood of fires and explosions is small and their effect on plant safety insignificant.

Detailed requirements relating to section 20 of the Government Decision are specified in the Guides YVL 1.0, YVL 2.6, YVL 4.1, YVL 4.2 and YVL 4.3, among others.

External events

Loads and conditions arising from natural phenomena have been considered in the design of the Loviisa Nuclear Power Plant in accordance with Finnish building regulations. The most important natural phenomena, as well as their combinations, have also been considered in the functional design of systems. The safety margins used in the original design are not as wide as those currently applied when designing new nuclear power plants. FPH has studied the risks arising from external events in probabilistic risk analyses. The events analysed include, among others, harsh weather conditions, high seawater temperature and level, and phenomena causing a clogging risk in the seawater systems, such as frazil ice, algae and oil accident in the Gulf of Finland. According to the analyses, the most important external events are the introduction of oil into the seawater system during an annual maintenance outage and high seawater level during power operation.

The Loviisa Nuclear Power Plant is relatively well prepared for the complete clogging of seawater systems caused by oil, seaweed and frazil ice (sudden sub-cooling of seawater). The plant has a standby emergency feedwater system independent of the seawater cooling that can be used for cooling the reactor in the event of complete clogging of the seawater systems. However, this system cannot be used in those shutdown states in which the primary circuit is not pressurised.

On the basis of probabilistic risk analyses, no significant risks have been detected resulting from combinations of accidents arising from internal causes and natural phenomena.

The aircraft crashes considered in the plant design are milder than those required for new nuclear power plants.

According to the plant's seismic risk analysis, the risks arising from earthquakes are relatively minor. The safety factors used in the original dimensioning of the plant structures and components are considered to sufficiently cover the loads caused by earthquakes.

A survey of electromagnetic conditions (EMC) has been performed during the current operating licence period. As a result of the EMC survey, case-specific solutions will be implemented pertaining to conditions deviating from those of normal industrial environment. Lightning protection has been improved after damage caused by lightning. The electromagnetic interferences caused by nature and human action have been considered in the design of new I&C buildings in accordance with the current requirements.

The plant and procedure modifications implemented during the current operating licence period reduce the risk imposed on the plant by natural phenomena and other external events. Probabilistic risk analyses are discussed in more detail in section 3.4.2. According to STUK's view, the Loviisa Nuclear Power Plant can be considered to fulfil the requirements concerning protection against external events to a sufficient extent. However, during the next operating licence period, attention shall be paid to oil-combating arrangements in the event of an offshore oil accident because the oil transport volume is estimated to increase in the Gulf of Finland. FPH has reported that, in co-operation with regional rescue authorities, it is planning to arrange practical exercises concerning the efficiency of oil-combating in order to test the reliability of operations and to assess the opportunities for improvement.

Fires

The possibility of fires, as well as the accident risks resulting from them, was not sufficiently considered in the original design of the buildings and systems of the Loviisa Nuclear Power Plant. In many respects, the fire compartmentalisation is not such that the plant safety functions could be maintained in all possible fire conditions. The turbine building has a major significance in terms of safety due to the residual heat removal systems centrally located inside it. Because of the deficiencies in the original design, it has been important to develop fire detection and fire extinguishing systems, as well as operative fire protection in parallel with structural fire protection.

A new residual heat removal system has been constructed at the Loviisa Nuclear Power Plant during the current operating licence period, among other things for the possible loss of all residual heat removal systems located inside the turbine hall as a result of a fire in the turbine hall. The fire fighting water system and fire extinguishing systems have been renewed throughout the plant site. The fire extinguishing systems located in the turbine hall have been renewed, and the diesel generators have been protected by new sprinkler systems. The fire detection system has been renewed and made address-based, as a result of which fires can be detected, located and automatically extinguished faster than previously. A new fire station has been commissioned, and operative fire protection equipment has been renewed.

According to STUK's view, the fire safety of the Loviisa Nuclear Power Plant has improved during the current operating licence period. Due to deficiencies in the compartmentalisation of safety systems and insufficient structural fire resistance, which are due to the basic design of the plant, the fire safety is not capable of fulfilling all of the requirements laid down in the Guide YVL 4.3. The licensee shall further develop fire safety in order to reduce the risks arising from the above-mentioned deficiencies. Some improvements to that effect are in fact being implemented in connection with the LARA automation renewal currently underway.

Summary

The conclusion to the above is that the Loviisa Nuclear Power Plant is presently sufficiently protected against external events and fires in a manner referred to in section 20 of the Government Decision. However, the level of plant protection, as well as oil-combating in offshore areas, shall be further developed in order to amend the deficiencies indicated in the PRA, among others.

5.9 Section 21: Safety classification

The functions important to the safety of the systems, structures and components of a nuclear power plant shall be defined and the systems, structures and components classified according to their safety significance.

The systems, structures and components important to safety shall be designed, manufactured, installed and operated so that their quality level and the inspections and tests required to verify their quality level are adequate considering any item's safety significance.

Detailed requirements relating to section 21 of the Government Decision are set forth in the Guide YVL 2.1, which was revised during the operating licence period (valid as of 1 January 2001). In connection with the renewal, Safety Class 4 was introduced and definition of systems assigned to that category was required in the implementation decision.

The purpose of the safety classification is to ensure that the quality level complied with in the design, manufacture, installation and operation of systems, structures and components important to safety, as well as required inspections and tests, are in correct proportion to the safety significance of the item. The safety class provides a starting point for specifying the requirements to be set for the design, manufacture, installation, inspection, testing, operation and quality assurance of a system, structure or component. STUK uses the safety classification when defining its inspection activities. The direct dependence between the safety classification and the inspection activities is presented in detail in various YVL guides.

The systems, structures and components of the plant units have been classified into four safety classes in the classification document: Safety Classes 1, 2, 3 and 4, as well as Class EYT (non-nuclear). The items with the highest safety significance belong to Safety Class 1.

The safety classification of process-related, I&C and electrical components is presented in the safety classification document of the Loviisa 1 and 2 nuclear power plant units, which consists of classification diagrams and classification lists. This document as a whole has been approved by STUK in June 2007. System-level safety classification is presented in the Final Safety Analysis Report of the Loviisa 1 and 2 nuclear power plant units (LO-FSAR).

As to system modifications, FPH presents the required changes and additions to the safety classification of systems in connection with the pre-inspection documentation submitted to STUK for approval. The revised parts of the safety classification documents are submitted to STUK once a year.

In addition to the requirements arising from the actual safety classification, additional requirements may be imposed on components concerning environmental conditions in accidents or certain electrotechnical requirements. On the basis of these requirements, the classification of some components has been changed and the components have been replaced by those with better endurance in accident conditions. The results of probabilistic risk assessments may also impose a need to present additional requirements for certain systems or components.

The conclusion to the above is that the safety classification of the Loviisa Nuclear Power Plant fulfils the regulations set forth in section 21 of the Government Decision.

5.10 Section 22: Monitoring and control of a nuclear power plant

A nuclear power plant's control rooms shall contain equipment which provide information about the plant's operational state and any deviations from normal operation as well as systems which monitor the state of the plant's safety systems during operation and their functioning during operational transients and accidents.

A nuclear power plant shall contain automatic systems that maintain the plant in a safe state during transients and accidents long enough to provide the operators a sufficient time to consider and implement the correct actions.

There shall be an emergency control post at a nuclear power plant which is independent of the control room and the necessary local control systems by the means of which the nuclear reactor can be shut down and cooled and residual heat from the nuclear reactor and spent fuel stored at the plant can be removed.

Guide YVL 5.5 provides a set of more detailed guidelines concerning monitoring and control.

The Loviisa 1 and 2 nuclear power plant units have separate independent control rooms. The alarms from the spent fuel storages are also printed into the main control room of the Loviisa 2 nuclear power plant unit. The implementation of the main control rooms is based on proven control room technology. In addition to the main control room, reactor shutdown, as well as the control and monitoring measures necessary for safety, can also be conducted from the so-called safety panel located in the main control room of the other plant unit.

In addition to the main control room, both auxiliary buildings have auxiliary control rooms for the monitoring of the operation of important auxiliary processes. Further, the plant has plant unit-specific ventilation control rooms as well as diesel generator-specific local control stations. Alarms from all auxiliary control rooms are collected and sent to the main control rooms.

Monitoring and control systems for severe accidents, independent from the other I&C, have been implemented during the current operating licence period. The monitoring and control stations of these systems are located crosswise in the vicinity of the control rooms of both plant units, in the annular spaces, and in a monitoring station shared by both plant units. The standby emergency feedwater pump building and the containment spray system serving both plant units have separate monitoring stations each.

In the main control room, the process information is presented by gauges, indicator lights, plotters and display devices of the process computer system. Alarms arrive in the main control room from two systems implemented by different technology: from the conventional alarm system and from the process computer system. The signal light fields of the alarm systems are in the control consoles. Process computer alarms are indicated by its display devices. In addition, event and status information, as well as any information about warning and alarm limits being exceeded, are also printed out on the alarm printers. The process computer provides operators with process information in an illustrative form. The process computer carrying out process monitoring, as well as the related technical systems, has been renewed in the course of general development of technology.

The control performed from within the control room targeting different plant systems is implemented through different levels of I&C. The highest level is that of plant control and the lowest that of individual controls. Currently, the principal user interface devices for the controls include the push button control units placed in the consoles and panels of the main control room, key switches, and a set of other selector switches and controls representing conventional technology.

The protection systems of the Loviisa 1 and 2 nuclear power plant units are so designed that the actuation of safety systems in transient or accident conditions does not require rapid action from the operator. The operators' time for consideration before control and other actions, appropriate emergency operating procedures and operator training effectively reduce the possibility of human errors. The process computer is equipped with the so-called HOKE support screens that are used together with the emergency operating procedures presented in the form of flow charts.

The management of the plant equipment and material data, planning and control of maintenance, management of periodic tests, and operating journals have previously been implemented as separate information systems or journals. During the operating period they have been collected under a single information system deployed in 2006, the user interface of which is located in the main control room.

The changes relating to the automation renewal project LARA have been commenced during 2006 as preparations for the first control room changes. The purpose of the project is to gradually renew the protection I&C, operational I&C and control rooms of the plant over several years, as well as to implement a separate emergency control post. The I&C ageing management is discussed in more detail in section 6.2.5.

The automation renewal has been divided into four stages:

- In stage 1, both safety-classified and non-classified items will be renewed; the first stage serves as a kind of pilot stage. The items to be renewed include, among others, fast and slow reactor shutdown and interlocking of control rods, sequence control and position indication of control rods, and the non-classified I&C of the auxiliary building. Stage 1 is planned to be implemented during 2007–2008 at the Loviisa 1 nuclear power plant unit, and in 2008 at the Loviisa 2 nuclear power plant unit.
- In stage 2, reactor protection – that is, the reactor scram function – and the plant protection functions will be renewed. Old reactor and plant protection systems will be integrated into a single new reactor protection system and for fault conditions in that system, an automatic and a manual backup protection system will be implemented. Stage 2 is planned to be implemented in 2008 for the Loviisa 1 nuclear power plant unit, and in 2010 for the Loviisa 2 nuclear power plant unit.
- In stage 3, the I&C for the primary circuit and its auxiliary systems will be renewed. Stage 3 is planned to be implemented in 2010 for the Loviisa 1 nuclear power plant unit, and in 2012 for the Loviisa 2 nuclear power plant unit.
- In stage 4, the I&C for the secondary circuit and its auxiliary systems will be renewed. Stage 4 is planned to be implemented in 2012 for the Loviisa 1 nuclear power plant unit, and in 2014 for the Loviisa 2 nuclear power plant unit.

The new I&C systems are primarily based on programmable technology, which makes it possible to obtain more accurate information on the status of the monitored and controlled processes and I&C systems. The I&C functions will primarily remain unchanged. However, some changes to the plant functions will be made in connection with the automation renewal. These are due to the needs for modifications that have emerged and analysed during operational history. For example, the fans in safety-important rooms will in future be actuated from the reactor protection system, the start-up conditions of the containment spray system will be revised, and the probability for the occurrence of a coolant leak through the reactor coolant pump seals in transient conditions will be reduced. Most of the control functions will become screen-based.

The I&C cabinets of the new system will be located in new buildings that meet the requirements laid down in the YVL guides, providing clear physical separation for the mutually redundant systems. The buildings are in the finishing stage in the summer of 2007.

A simulator unit is being used in the training of control room personnel, the functions, user interface and appearance of which are very similar to those of the main control rooms of the plant units. The control room changes relating to the LARA project will first be implemented with a simulator to provide the control room personnel with an opportunity to practice operating the changed control room before the change is implemented in the actual control room. For the purposes of the LARA project, a separate development simulator has been implemented in the facilities of FNS responsible for the design, and used as a control room design tool. In significant automation changes, the new user interfaces are implemented and tested for the first time in the supplier's testing site.

The approval of the automation renewal by STUK is progressing in stages. STUK has approved the conceptual design plan as the starting point for the automation renewal, as well as the conceptual design plans concerning functional changes. Most of the detailed pre-inspection documents concerning stage 1 of the Loviisa 1 nuclear power plant have already been approved by STUK, as have the quality management and qualification plans concerning the automation platforms intended to be used. The stage 1 automation is currently in a trial run at the manufacturer. The most important plans in terms of safety concerning stage 2 will be processed by STUK during 2007.

The conclusion to the above is that the monitoring and control of the Loviisa Nuclear Power Plant has been implemented in a manner referred to in section 22 of the Government Decision.

5.11 Equipment qualification

According to the IAEA guide NS-G-2.10 "Periodic Safety Review of Nuclear Power Plants", a nuclear power plant shall have systematic procedures for qualifying equipment and structures important to safety and for maintaining the documentation demonstrating qualification. The qualification is to ensure that equipment and structures are capable of performing their functions in design basis operating conditions and accidents with sufficient margin while taking into account the loads and environmental conditions arising during them. Most essential in connection with periodic safety reviews is to review those factors that may have impaired the qualification since the previous safety review or may do so during the subsequent review period.

Mechanical components

The most important mechanical components of the Loviisa Nuclear Power Plant are the Safety Class 1 pressure equipment, the qualification of which is sufficiently implemented by fulfilling the requirements of the applicable standards and YVL guides pertaining to design, manufacture, inspection and testing. The fatigue analyses of these components have been updated in connection with the operating licence application to correspond with the 50-year service life. Requirements concerning accident loads have remained unchanged, and the power increase carried out in connection with the previous operating licence has not increased the loads imposed on the primary circuit. The suitability of other mechanical components such as pumps and valves to the designed environmental conditions is also ensured in connection with their design, procurement and installation by defining for them accident and normal operating conditions under which they must maintain their operability and under which the ageing and wear of components can be managed by means of maintenance. These requirements are presented in the pre-inspection documents and material specifications. The construction inspections include pressure, load and leak tests, in addition to which other tests, type tests and operating experience data for applicable components may also be required. Component-specific supplementary qualification tests have been performed on the emergency cooling system floor drain filters, emergency cooling and emergency make-up water system pumps and impulse pipe flow limiters, among others. The qualification of valve actuators inside the containment in terms of environmental conditions and the suitability of torque ranges was also reassessed during the first years of operation.

Electrical and I&C systems and components

According to the guides YVL 5.2 and YVL 5.5 concerning electrical and I&C systems and components, the systems and equipment at a nuclear facility shall be qualified for their intended use. Qualification verifies the conformity of the systems and their components with the requirements. The licensee shall draw up a special qualification plan to demonstrate the suitability of Safety Class 2 and 3 electrical power and I&C systems and components for their intended use. A system's safety significance and the reliability requirements placed on it shall be considered in the drawing up of the qualification plan. The qualification plan shall be updated if the requirement specification of the system is changed such that this affects the qualification, or if essential new information has been obtained about the system and this information may be considered to affect the qualification plan.

The environmental conditions and stresses of a nuclear facility's safety-classified electrical power and I&C systems and components as well as cables in all planned operational conditions and during storage and transport shall be defined. The systems, components and cables shall be of such design that their operating capability is maintained within set requirements for their entire design service life. The qualification of safety-classified components and cables under design environmental conditions and stresses shall be demonstrated by means of tests and analyses that are in accordance with standards. The tests shall correspond to the combined effects of the most unfavourable operational and environmental conditions possible.

Deficiencies in the accident qualification of the electrical and I&C systems of the Loviisa Nuclear Power Plant were observed during the design and construction phase. For this reason, a systematic qualification assessment of the electrical and I&C components outside containment (qualification to conditions) was performed at the beginning of the 1980s, with the safety significance of each component and the operational and environmental conditions prevailing during accidents serving as the starting point. In connection with the assessment, the components were classified as follows: components to be qualified, components to be replaced by qualified components, and components with no qualification requirements. The required qualification measures and replacements of components and cables were performed as a result of the assessment. On the basis of the analysis of accident conditions, certain structural changes, mostly relating to cables, were also performed.

The power increase of the Loviisa nuclear power plant units has only had limited significance for the qualification of electrical and I&C components. Therefore, the power increases have not resulted in new significant qualification requirements. With regard to electrical systems, the power increases have mainly resulted in modifications concerning secondary side components (generators and main transformers) and structures (generator busbars). The inspection of the reactor emergency heat transfer chain relating to the increase of thermal power, mostly performed during 1997, resulted in modifications, the purpose of which were to ensure the thermal endurance of components and systems relating to the heat transfer chain. Electrotechnical modifications of this type include, e.g., the rewinding of certain pump motors as well as the replacement of supply cables and fan motors.

Temperatures exceeding the design basis of the components (+50°C) were detected in the temperature characterisations carried out inside the containments after the annual maintenances of 1997. It was also discovered that the general temperature of the steam generator rooms had increased significantly. To rectify the matter, FPH took the following measures to restore the temperatures back to an acceptable level:

- lowering the temperature of the cooling water for these rooms
- increasing the cooling capacity for these rooms and directing the cooling more accurately into hot areas
- increasing the number of temperature measurements
- improving the thermal insulation.

As a result of these improvement measures, the general temperatures of the steam generator rooms have presently been successfully lowered by nearly ten degrees. Regardless of the measures taken, some hot spots have been detected in the steam generator rooms, for which FPH has designed cooling on a case-specific basis. In addition, the impact of the highest temperature on component ageing was studied by theoretical methods in the component type-specific report prepared in 1998. Due to bad availability of the original electrical and I&C cable types used inside the containment, new cable types from two manufacturers have been qualified.

The qualification of thermocouple sensors and plugs for the conditions prevailing in loss of coolant accidents and main steam pipe breaks was assessed in connection with the modifications concerning the coolant temperature measurements of the reactor upper section. Certain qualification measures relating to the above are still in progress. Sensors and plugs are part of the instrumentation that penetrates the reactor head, and the compartment in question is not directly connected to the steam generator room.

The qualification requirements pertaining to electrical and I&C components have been updated as a result of the analyses concerning leaks from the main steam pipe in 2002. The components needed in severe accidents have been qualified for the environmental conditions of severe accidents described in the safety analysis report. As part of the project for implementing provisions for severe accidents, temperature sensors and magnetic switches, as well as new ignition plugs qualified for severe accident conditions, were installed in the containment.

The qualification of electrical and I&C components outside containment was reviewed between the late 1980s and early 1990s. The reviews resulted in certain structural improvements relating to cabling and mechanical protection. In 1998 FPH decided to carry out additional reviews relating to the qualification of components outside containment, primarily concerning the management of accidents arising from postulated pipe breaks on the feedwater level of the control room building. Critical objects have been protected against jets caused by pipe breaks by moving them into a protected location or by protecting them. The qualification is intended to be completed in connection with the automation renewal (LARA) by separating the mutually redundant components, functions and measurements required for performing critical functions.

The directive concerning electromagnetic compatibility (EMC) entered into force in 1996. Since the beginning of 1997 STUK has required that the environmental qualification of electrical and I&C components must also include the demonstration of electromagnetic compatibility. A survey of the electromagnetic conditions prevailing at the Loviisa Nuclear Power Plant has been performed during the current operating licence period. As a result of the EMC survey, case-specific solutions will be implemented pertaining to conditions deviating from those of a normal industrial environment. Lightning protection has been improved after damages caused by lightning. The electromagnetic interferences caused by nature and human action have been considered in the design of new I&C buildings in accordance with the current requirements.

The original design of the plant did not include any special earthquake resistance requirements. However, according to the plant's seismic risk analysis, the risks arising from earthquakes are relatively minor. The seismic classification in accordance with the Guide YVL 2.6, demonstrating that the plant's earthquake resistance is not impaired, is to be applied in connection with major modifications being performed at the plant. The structures of new I&C buildings are to be dimensioned in accordance with the earthquake resistance requirements.

Service life management at the Loviisa Nuclear Power Plant is discussed in section 6.2.5 of the safety assessment. In particular, the remaining service life must be known for components qualified to accident conditions. The remaining service life of cables is intended to be ensured by tests performed on samples. As to the replaced components, the remaining qualification life is under control provided that the environmental conditions and functional requirements have remained within the original limits. As to the other components, the validity of the qualification usually cannot be as clearly verified, which requires continuous development of the qualification methods.

Summary

In summary, it can be stated that the review of factors affecting the preservation of the qualification status of systems, structures and components in accordance with the IAEA guide NS-G-2.10 was not presented in the reports submitted to STUK in connection with the submission of the operating licence application. STUK required FPH to develop their qualification procedure to make it more systematic, taking into account the traceability of the qualification of the most safety-important systems, structures and components for the original qualification requirements and the possible changes in loads, as well as operational and environmental conditions occurring during the operation of the plant, updates to the safety analyses, and the changing of qualification requirements due to the advancement of technology. FPH has presented an action plan for improving the maintenance of qualification. The revised qualification programme will utilise the existing practices of the Loviisa Nuclear Power Plant in the areas of maintenance, management of spare parts and plant modifications, monitoring of component status, environmental conditions and malfunctions, operating experience feedback, and quality management. The qualification programme presents written definitions for operating principles and connections between various organisations, and provides more systematic instructions for the qualification activities. The information systems of the plant will be expanded to enable more efficient management of the information needed for maintaining the qualification of systems, structures and components. The qualification programme, revised in accordance with the plan, is to be initiated at the beginning of 2008. STUK considers the presented action plan sufficient.

The qualification of components outside the containment of the Loviisa Nuclear Power Plant has been investigated, and structural improvements relating to cabling and mechanical protection have been performed. Measures required for pipe breaks occurring on the feedwater level are intended to be completed in connection with the automation renewal project.

The conclusion to the above is that the qualification procedures at the Loviisa Nuclear Power Plant, together with the development measures presented, are sufficient for the renewal of the operating licence.

6 Operation of the Nuclear Power Plant (Government Decision 359/1991)

6.1 Section 23: Technical Specifications and plant procedures

Technical and administrative requirements and restrictions for ensuring the safe operation of a nuclear power plant shall be set forth in the plant's Technical Specifications.

Appropriate procedures shall exist for the operation, maintenance, in-service inspections and periodic tests as well as transient and accident conditions of a nuclear power plant.

Taken together, the Technical Specifications and plant procedures define the limits and operating procedures for the safe operation of the nuclear power plant in different operational conditions.

The Technical Specifications for the Loviisa 1 and 2 nuclear power plant units set forth the restrictions and conditions, defined in accordance with the design basis, concerning the operation of the reactor and the plant, the requirements concerning periodic tests, and the essential administrative procedures. The Technical Specifications is a document reviewed and approved by STUK, which is continuously kept up to date. According to STUK's view, the Technical Specifications for the Loviisa 1 and 2 nuclear power plant units are up to date and sufficient. FPH submitted the latest updated revisions of the Technical Specifications for the Loviisa 1 and 2 nuclear power plant units to STUK for approval in November 2005, and STUK approved them according to the requirements set forth in the Guide YVL 1.1 in decisions A273/104, 13 April 2006, and B273/29, 13 April 2006.

FPH has also made continuous efforts to develop and improve the Technical Specifications in order to enhance their unambiguity and usability. In addition, efforts have been made to perform the assessment of modification needs on the basis of the completed modifications and the operating experience gained to the extent regarded as sufficient, and these assessments have been appropriately included in the Technical Specifications. Similar care will also be required in the future because extensive modifications will be made to the Loviisa Nuclear Power Plant in the coming years (the automation renewal project LARA), the particular challenge at that point being the maintenance of Technical Specifications, training relating to the changes, and the correct timing of the deployment.

STUK has required FPH to assess the comprehensiveness and adequate balance of the Technical Specifications by the end of 2008 using probabilistic analysis.

The most important instruction types included in the operation and maintenance manuals of the Loviisa Nuclear Power Plant are:

- the quality assurance manual and the administrative procedures included the administrative rules contained therein
- procedures for controlling the operating and maintenance routines of the plant
- emergency procedures
- operation and maintenance procedures to ensure the appropriate operation and maintenance of systems and components
- procedures for periodic tests and in-service inspections to ensure the operability of systems and components
- procedures for restoring the normal state to ensure the correct state of systems and components
- operating chemistry procedures for supervising chemical parameters and taking appropriate measures.

The Loviisa Nuclear Power Plant currently has in place an advanced and up to date system of plant procedures that is incorporated as part of the quality system of the plant. The requirements pertaining to the comprehensiveness and up-to-dateness of, the responsibilities relating to, and compliance with the plant procedures and instructions are laid down in the quality assurance manual. The annual assessment of the comprehensiveness and effectiveness of the quality assurance programme in accordance with the manual also includes the review of the plant procedure system. This review will highlight, among other things, the requirements, sufficiency and update needs of the plant procedures, as well as the fulfilment of the set requirements.

FPH has significantly developed its plant procedures with regard to, e.g., emergency and troubleshooting procedures, severe accident management procedures, instructions concerning the quality systems of the radiochemistry and operating chemistry laboratories, and the instructions and structure of procedures concerning the inspection organisation Loviisa YVL during the current operating licence period. The project for presenting the emergency procedures in a flow chart format was initiated in 2000. The procedures were put into use after STUK's approval on 1 March 2006. Procedures for severe accident management (SAM) were introduced in 2002. The procedures were updated in 2005, and the revised procedures were introduced in 2006.

According to STUK's view, the plant procedures of the Loviisa Nuclear Power Plant adequately cover the safety-significant work processes and actions, such as the nuclear power plant's operation, maintenance, in-service inspections and periodic tests, and transient and accident conditions. The project for developing new emergency procedures, as well as other instruction development efforts, reflects Loviisa's aim to create as good a set of instructions for the needs of the organisation as possible. The maintenance and development of instructions is determined and controlled, targeting the requirements of the future with a sufficiently long reach. A longer-term development target at the Loviisa Nuclear Power Plant is to prepare comprehensive emergency procedures for shutdown states. A plan for the instruction development has been drawn up, and STUK has required the instructions to be completed by the end of 2014. One of the future challenges will result from the update needs arising from extensive modifications, such as the automation renewal project LARA.

The conclusion to the above is that the Technical Specifications and plant procedures of the Loviisa Nuclear Power Plant have been implemented in a manner referred to in section 23 of the Government Decision.

6.2 Section 24: Operation and maintenance

In all activities affecting the operation of a nuclear power plant and the availability of components, a systematic approach shall be applied for ensuring plant operators' continuous awareness of the state of the plant and its components.

The reliable operation of systems and components shall be ensured by adequate maintenance as well as by regular in-service inspections and periodic tests.

6.2.1 Plant operation

The responsibilities relating to plant operation and safety are defined in the administrative procedures of the Loviisa 1 and 2 nuclear power plant units. The plant may only be operated from within the control room by an operator approved by STUK. All operational measures carried out at the plant relating to safety or operability are performed by operators or field operators and approved by the shift supervisor. The operation and condition monitoring of the plant is carried out in accordance with pre-determined and approved instructions.

The actions carried out when operating the Loviisa Nuclear Power Plant are based on written plant procedures or written regulations. Written regulations are prepared, for example, when changing the operating state or power level of the plant or for actions relating to reactor and nuclear fuel. Compliance with the Technical Specifications is always ensured by the shift supervisor in connection with planned changes to the plant state and work orders concerning components that are important to safety.

The state of the Loviisa Nuclear Power Plant is primarily monitored using the data received from the process computer. The shift personnel monitor the main parameters of the plant, as well as other required process or status information as applicable, on the screen of the process computer. The plant state is also monitored on the basis of the gauges and alarms. The shift team also have procedures at their disposal for the purpose of checking plant systems, components and states, and for reading status information on a regular basis. Any deviations observed by the shift team will be responded to in a manner required by the operating and emergency procedures.

The flow of information concerning the state of the Loviisa Nuclear Power Plant is ensured by means of printed documents, information systems and meeting practices. The shifts maintain journals in which the main parameters describing the plant state, operational measures and all significant faults and observations are recorded. Written procedures have been prepared for change of shift, the purpose of which is to ensure that all relevant information is passed on to the next shift. Plant parameters are recorded in information systems in a manner that enables viewing them as history data and monitoring trend developments.

The plant has a periodic testing programme that defines the regularly performed tests used for ensuring the operability of components important to safety and availability, as well as the related acceptance criteria and testing frequencies. The testing is performed in accordance with the separate testing instructions.

The Loviisa Nuclear Power Plant has in place a work order system that ensures the safe and timely execution of repair, maintenance and preventive maintenance work. The shift supervisor gives permission to start a certain task when inspecting the work plans prepared in accordance with the work order system, taking into account the operability requirements for systems and components laid down in the Technical Specifications.

Components and systems at the Loviisa Nuclear Power Plant are always tested for operability after fault repairs and maintenance work. Tests for ensuring the operability of the plant after maintenance, modifications and repairs are performed before the start-up of the plant after annual maintenance. The supervision and monitoring procedure for annual maintenance tests is instructed in the plant procedures.

The Loviisa Nuclear Power Plant has in place regulated procedures for reporting plant operation activities. These include regular and event-related reports. The plant also has daily meetings for sharing plant condition information to the organisation.

In summary, it can be stated that systematic procedures are adhered to in the operation of the Loviisa Nuclear Power Plant. The reliable operation of systems and components has been ensured by regular in-service inspections and periodic tests. These procedures are used for ensuring that the plant systems and components are in the design basis state and that operators are constantly aware of the state of the plant and its components.

The conclusion to the above is that the operation of the Loviisa Nuclear Power Plant has been implemented in a manner referred to in section 24 of the Government Decision.

6.2.2 Maintenance

The maintenance operations at the Loviisa Nuclear Power Plant comprise preventive and corrective maintenance as well as the planning and implementation of modifications, spare parts maintenance, outage operations, and quality control relating to all of the above-mentioned functions. The requirements concerning maintenance operations are specified in the guides YVL 1.8 and YVL 1.13. Detailed technical requirements and regulatory oversight are also described in several other YVL guides published by STUK.

According to the plant's administrative rules and procedures, the maintenance unit operating under the authority of the plant manager assumes the main responsibility for maintenance operations at the Loviisa Nuclear Power Plant. Other organisation units of the plant have also duties relating to the planning and implementation of maintenance. The planning of annual maintenance, as well as the quality control of maintenance, fall under the responsibility of the technology unit, while the consideration of nuclear and radiation safety aspects in maintenance work planning are included in the duties of the safety unit. The duty of the operating unit is to arrange the process isolations and restorations required by maintenance work as well as the related administrative supervision.

The requirements pertaining to maintenance operations are specified in the quality assurance manual. The documents pertaining to maintenance operations are in accordance with the set requirements and have been kept up to date during the operating licence period. The extensive plant modifications currently underway impose considerable challenges for the update of instructions concerning I&C technology in particular. The incorporation of maintenance instructions for revised systems as part of the plant procedure system is also perceived as a challenge.

A larger share of the maintenance operations at the Loviisa Nuclear Power Plant have been performed by subcontractors during the current operating licence period, in particular those carried out during annual maintenances. Both the licensee and STUK have recently paid particular attention to the technical competence of the external workforce and their familiarity with the plant and its procedures, as well as to the instruction and supervision carried out by the personnel of the licensee. According to the Nuclear Energy Act, the licensee is responsible for the safe use of nuclear energy and, consequently, also for the safety of maintenance work.

Plant modifications to improve safety, operability and reliability have been carried out throughout the operating history of the Loviisa Nuclear Power Plant. Examples of significant modifications carried out during the current operating licence period include:

- power increase by 11% at the beginning of operating licence period in 1998 (licensed in connection with the previous operating licence renewal)
- modifications relating to provisions made for severe accidents, the so-called SAM project (discussed in more detail in section 5.5 above)
- initiation of the plant automation renewal project LARA in 2004 (sections 5.1 and 5.10)
- renewal of the measurement system supporting the load monitoring of primary circuit structures (section 6.2.5)
- renewal of the condition monitoring system measuring the vibration levels of reactor coolant pumps and turbines (section 6.2.5)
- enhancing the endurance of safety-classified cables located in the steam generator room against environmental conditions (section 6.2.5)
- reducing the reactivity risk during refuelling outages by removing unnecessary clean water lines (section 5.3 and 5.6)
- ensuring power supply by securing the power supply of the batteries of the 220 V and 24 V direct current systems (section 5.6)
- renewal of the fire alarm system, modifications to the fire fighting water system and fire extinguishing system, and the construction of a new fire station (section 5.8)
- securing the cooling of reactor coolant pump seals
- renewal of stationary radiation measuring system and personal contamination monitors (section 4.2)
- renewal of maintenance and laboratory information systems
- modification of the protective sleeve of temperature sensors in the protective tubes of control rods
- ensuring the cold shutdown of the plant by securing the emergency residual heat removal system and the seawater systems serving as the ultimate heat sink (section 5.6)
- construction of a liquid waste solidification facility (section 10.1).

In addition to conventional condition monitoring measures, the preventive maintenance programme of the Loviisa Nuclear Power Plant comprises continuous-monitoring methods such as the vibration measurements of the reactor pressure vessel control rod drive mechanisms, reactor coolant pumps and the turbo-generator, monitoring of the primary circuit loads, and monitoring of leaks, water chemistry and loose parts. The operability of systems and components is ensured by tests performed at regular intervals. The tested systems and components, as well as the testing schedule, are specified in the Technical Specifications. Periodic tests of at least similar scope are required after modifications and repairs, and after maintenance operations that required disassembly. The prior approval of STUK is required for the functional test programme executed after considerable modifications. Inspections concerning the operability and condition of components are also carried out as required on the basis of the accumulated operating experience and advancement of technological knowledge. The operators of VVER type plants have served as an important source of operating experience in this regard.

The maintenance data of the Loviisa Nuclear Power Plant is assigned to operating locations and components according to work numbers, from which they are entered into the maintenance information system through work order and work assignment routines. The maintenance history feedback data obtained from the maintenance information system is generated for the purpose of serving the plant operating organisation. The collection, recording and reporting of the maintenance and fault history is guided by procedures. The analysis and reporting of maintenance history has been recently developed on the basis of the accumulated experience.

The experience accumulated from maintenance operations is made use of when estimating the remaining service life of the components of the Loviisa Nuclear Power Plant. The applicable policies and procedures have been described in the procedure concerning the ageing management of components and structures. The history database is updated and the reporting is developed on the basis of the decisions made by the annually held ageing management and planning meeting. According to STUK's view, the maintenance history currently serves effectively both the operation and maintenance activities and the PRAs concerning the reliability of technology.

In addition to day to day regulatory oversight, the effectiveness of the maintenance operations of the Loviisa Nuclear Power Plant has been monitored during the current operating licence period using the indicator system developed by STUK. Failure detection and anticipation have been continuously improved in maintenance operations at the Loviisa Nuclear Power Plant, and components have been replaced. As a result of these measures, the indicator concerning maintenance or the underlying fault data do not show negative effects potentially associated with the ageing of the plant, which indicates effective service life management and successful maintenance of components.

The total number of the annual maintenance work at the Loviisa Nuclear Power Plant concerning components subject to Technical Specifications, including both fault repairs and preventive maintenance, has been increasing towards the end of the current operating licence period. This is partly due to the new information system commissioned in 2006. In connection with the commissioning of the new system, the follow-up was also targeted at those components subject to Technical Specifications that do not have any associated limiting conditions for operation. Despite the changes to the work recording procedure, there was no marked change in the ratio of the number of preventive maintenance works to the number of fault repairs. Since the increase in the number of components covered by the indicator has not affected the ratio of the number of preventive maintenance works to the number of fault repairs, maintenance operations can be considered to be in balance and consistently implemented on all plant components subject to Technical Specifications.

The average repair times of faults causing inoperability of components subject to Technical Specifications have remained relatively stable at the Loviisa Nuclear Power Plant for several years, varying from one day (24 h) to over two days (more that 48 h). Production losses due to failures have been small at the Loviisa Nuclear Power Plant, as is also indicated by the high load factors of the plant units.

Maintenance operations are also discussed in sections 5.7 (avoiding human errors), 5.9 (safety classification), 5.10 (qualification of equipment and structures), 6.1 (Technical Specifications and plant procedures), 6.2.1 (plant operation), 6.2.3 (in-service inspections), 6.2.5 (plant ageing management), and 6.3 (personnel).

The conclusion to the above is that the maintenance operations of the Loviisa Nuclear Power Plant fulfil the set requirements.

6.2.3 In-service inspections

The condition of the pressure-bearing components of the Loviisa 1 and 2 nuclear power plant units is ensured by means of in-service inspections. Primary circuit components are subjected to in-service inspections performed during outages at regular intervals using non-destructive testing methods in accordance with the Guide YVL 3.8. The results of the in-service inspections are compared with the results of earlier inspections and pre-service inspections performed prior to the commissioning.

The in-service inspection programmes are submitted to STUK for approval prior to each round of inspections. The programmes and the related inspection procedures are modified when necessary, taking into account the development of industry requirements and standards, the development of inspection techniques, inspection experience, and operating experience from nuclear power plants in Finland and elsewhere.

Attempts have been made to focus the inspections on areas where faults are most likely to emerge. These include, for example, items susceptible to fatigue due to temperature variations. The selection of inspection items is under continuous development. A risk-informed in-service inspection programme is being developed to that end.

The frequency of the non-destructive examinations performed at regular intervals is usually ten years. The inspection programmes have been supplemented with additional inspections for reactor pressure vessel and primary circuit pipelines, and their frequency has been shortened to eight years. The inspection frequency for items susceptible to thermal fatigue is three years.

The Guide YVL 3.8 and the latest edition of the ASME Code, Section XI are used as the acceptance criteria for in-service inspection programmes and procedures. A qualification system complying with European practice has been developed for in-service inspections. STUK monitors the implementation of qualifications.

In addition to the aforementioned inspections, physical inspections that concern the condition and reliability of pressure vessels are performed at regular intervals in accordance with the Finnish pressure equipment legislation. These inspections are the full inspection, internal inspection and operational inspection, and they include non-destructive testing as well as pressure and leak tests. Inspections concerning pipelines have been defined in the system-specific condition monitoring programmes. These in-service inspections are discussed in the Guides YVL 3.0, YVL 3.3, YVL 5.3, YVL 5.4 and YVL 5.7. The in-service inspection programmes fulfil the requirements specified in the YVL guides with regard to the number of inspections and inspection technique.

The reliability of the non-destructive examination methods for primary circuit pipelines and components has been essentially improved since the commissioning of the plant. The implementation of the qualification system for in-service inspections and the introduction of the risk-informed in-service inspection programme are significant development targets for operations.

The in-service inspection of electrical and I&C components, as well as the related procedures, are specified in the Loviisa Nuclear Power Plant procedures. The in-service inspection of safety-important items, as well as the frequency of these inspections, is defined in the Technical Specifications. The scope of the in-service inspections is based on the required extent of condition monitoring, which is assessed in connection with the assessment of systems and their modifications. Requirements concerning the definition of testing scope are specified in the Guides YVL 5.2 and YVL 5.5.

The tasks to be performed on each item and the applicable procedures, acceptance criteria, measuring equipment, safety aspects and protocols are defined in more detail in the maintenance instructions of the Loviisa Nuclear Power Plant. The instructions are updated every four years or whenever required. The equipment classification that has been under preparation at the Loviisa Nuclear Power Plant is intended to be used in the further improvement of the preventive maintenance and in-service inspection programmes.

The power increase implemented at the end of 1990s did not directly affect the scope of the in-service inspections of electrical and I&C components. However, plant modifications, both those relating to the power increase and those performed later, such as the implementation of the severe accident management system and the renewal of radiation measuring systems, have changed the inspection items for the in-service inspection of electrical and I&C systems. New platforms equipped with self-diagnostic and testing features will be introduced in connection with the automation renewal project (LARA). The I&C in-service inspection programmes will be so defined that the monitoring and in-service inspections performed by the systems themselves provide sufficient coverage.

A considerable part of the in-service inspections of the Loviisa Nuclear Power Plant is performed in connection with annual maintenance outages, at which point STUK oversees the tests by inspecting the testing protocols, the comprehensiveness of the tests and the appropriateness of the testing procedures. The state of the testing procedures is also assessed in connection with the operational in-service inspection programme. The remarks concerning the comprehensiveness and correctness of the I&C in-service inspections have been accounted for in the procedure development, although there remains room for improvement with regard to comprehensiveness.

The conclusion to the above is that the in-service inspections of the Loviisa Nuclear Power Plant have been implemented in a manner referred to in section 24 of the Government Decision.

6.2.4 Currency of plant documentation

A large number of modifications are carried out at the Loviisa Nuclear Power Plant each year. This requires clear procedures being defined for the maintenance and assessment of plant documentation in order to ensure that the plant documentation corresponds with the actual plant and its current design basis after the modifications. The updated plant documentation of the Loviisa Nuclear Power Plant includes:

- the Final Safety Analysis Report (FSAR)
- Technical Specifications
- the safety classification document
- emergency procedures
- operation and maintenance manuals
- flow diagrams, figures
- computer applications and files, the most important of which is the plant information system LOMAX containing, e.g., information about the storage facilities and modifications, fault repairs, maintenance activities and in-service inspections performed at the plant
- in-service inspection and periodic testing procedures
- system line-up procedures
- operating chemistry procedures.

The procedures for modifications at the Loviisa Nuclear Power Plant have been completely revised during 2002–2005 and now contain sufficient and comprehensive maintenance routines for plant modification documentation. The procedures concerning modifications and the maintenance of plant modification documentation are part of the plant quality assurance system that is updated at regular intervals and assessed annually.

STUK supervises the currency of the plant documentation in connection with document revisions and inspections of the periodic inspection programme, as well as during annual maintenances. As a significant share of the modifications are carried out during annual maintenance, one criteria for the start-up permit granted by STUK after the annual maintenance is that all safety-significant modifications have been incorporated in those plant documents that may be needed when the plant is in power operation.

According to STUK's view, the present procedures for ensuring the currency of the documentation are sufficient and comprehensive. Currently, the plant documentation corresponds with the actual plant and its design basis. The present procedures, established at the end of the 1980s, have contributed to the elimination of potential discrepancies between the plant and its documentations arising from the various modifications. Further, no apparent problems have been observed in the operation and maintenance of the plant that had resulted from deficiencies or outdatedness of the plant documentation.

More timely incorporation of the modifications into the documentation presents a target for future development. Future challenges are provided by the incorporation of the numerous modifications resulting from the Loviisa automation renewal (LARA) into the documentation and the concurrent future development of the emergency procedures.

The conclusion to the above is that the documentation of the Loviisa Nuclear Power Plant is sufficiently up to date for the renewal of the operating licence.

6.2.5 Plant ageing management

According to the Guide YVL 1.1, a nuclear power plant shall have a comprehensive ageing management programme comprising the design and qualification of components and structures, their operation and operating experience, in-service inspections and periodic tests, and maintenance. The programme shall identify all significant ageing and wear mechanisms, and potential degradation owing to ageing. The periodic safety review shall assess the experience of the facility ageing and ageing management.

Service life management programme

Service life management and the related technological and financial planning have been implemented at the Loviisa Nuclear Power Plant in the form of a proceduralised service life management process known as LOPLIM. The Power Plant Technology group is responsible for its coordination and supervision, and the system managers nominated within the group take care of the implementation of the service life management of those systems, structures and components important to safety and operability that fall under their responsibility, consulting the experts of Fortum Nuclear Service as applicable. For the purpose of proper definition of the content and extent of the measures taken, the systems, structures and components have been assigned to four classes: A) those limiting the service life of the plant, B) those critical in terms of their availability/financial impact, C) those important in terms of their availability/financial impact, D) others. Class A systems, structures and components are further divided into subclasses, and the service life of 50 years is attempted to be ensured for each. The procedure applicable to Class B is similar, but the estimate of remaining service life based on the ageing mechanisms of each subclass is only made when required. For Class C, the ageing management is based on operating experience, while for Class D the normal maintenance and operating activities are considered sufficient.

For the purpose of attaining the service life targets, the persons responsible for systems direct the activities of the organisation with several procedures relating to operation, maintenance, modifications and refurbishments, inspections, and R&D. Among other things, they prepare modification and project proposals, review the plant procedures and draw up amendment proposals, participate in planning, implementation and annual reviews, and maintain a long-term plan. These planning and directing efforts make use of the knowledge of the condition of the plant and plant trends accumulated through plant operation activities, maintenance and inspection programmes, research and development programmes, operating experience from sister plants, and memberships of WANO (World Association of Nuclear Operators) and NUMEX (Nuclear Maintenance Experience Exchange). The persons responsible for systems enter the information concerning the operability and the remaining service life of, as well as actions required for, the systems falling under their responsibility into the plant information system. Other information relevant to service life management is also collected in the information system, such as the details of inspections, vibrations, maintenance history, and the like. System-specific overall assessments are also maintained for service life management, and separate summary reports on the ageing of electrical, I&C and mechanical components are annually prepared and submitted to STUK. Follow-up and review meetings, with representatives from operation and maintenance and experts in ageing research as participants, are arranged on a regular basis for directing and developing the service life management. STUK has received more detailed information about the implementation of service life management in the periodic inspections conducted annually at the plant site.

According to STUK's view, this organisational implementation meets the requirements specified in the Guide YVL 1.1. The LOPLIM process also sufficiently reflects the basic idea expressed in the IAEA guides of having service life management serve as the umbrella programme directing operation and maintenance, while the link to long-term planning creates preconditions for proactive operations that detect the investment needs in a timely manner. On the basis of the implemented refurbishments and modernisations, it can also be stated that the expertise and R&D activities relating to ageing management are on a good level at FPH: new technology solutions (e.g. the recovery heat treatment of the reactor pressure vessel, extensions of steam generator tube inspections and plugging of the tubes, primary head of the steam generator collector, secondary circuit water chemistry, and change of materials in the secondary circuit) have been deployed, and the electrical and I&C systems that are becoming technologically outdated are being extensively replaced with new ones.

Class A components and structures

The systems, structures and components assigned to Class A include the reactor pressure vessel (RPV), reactor coolant pump, steam generator, pressurizer, containment and reactor building.

On the basis of the decisions issued by STUK, the operation of the RPV may be continued until 2012 at the Loviisa 1 nuclear power plant and until 2010 at the Loviisa 2 nuclear power plant unit. The reason for this restriction is the embrittlement of the weld in the core area caused by neutron radiation. In FPH's view, the embrittlement of the RPV in both plant units can be managed with the currently available means until the end of the 50-year service life. Radiation embrittlement is discussed in more detail in section 5.4. The leaks in the corrosion protection sleeves of the RPV head nozzles detected over the past few years, and the bulging obstructing the operation of control rods that potentially arises from them, have been addressed by developing an ultrasonic inspection method and repair methods with which these damages are estimated to be kept successfully under control during the entire planned service life. The condition of the coating on the RPV head seal is also under special supervision. The cumulative fatigue factors for 50 operating years calculated in connection with the operating licence application for items subjected to the highest fatigue loads by extrapolating from the 1994–2004 transient statistics are low and do not impose limits on the service life. However, according to STUK's understanding, this assessment is based on the assumption of having the plant undergo the most undisturbed operating years during its entire life cycle, which requires careful monitoring of loads and further specification of fatigue analysis if any load increases are detected during the next operating licence period.

During the current operating licence period, the operating experience of reactor coolant pumps has been dominated by mechanical and acoustical vibrations in the primary circuit manifesting themselves in shutdown and start-up conditions at a high frequency of 65 Hz, which is independent of the operation of the pump. These vibrations caused damage to the suction structures serving as mounting platform for stator blades in several pumps, but the problem was rectified by structural changes to the stator blade seal ring and by repair grinding of the worn sections in the seal groove at the housing end. Vibration monitoring has also been more effective during the current operating licence period. Through these experiences, the importance of also maintaining the know-how relating to the original design basis is now better understood at the Loviisa Nuclear Power Plant. The 50-year cumulative fatigue factors calculated in connection with the operating licence application for sections of the reactor coolant pump subjected to the highest fatigue loads are low with the exception of the labyrinth seal, which is being monitored by inspections, as are the stress corrosion risks caused by seal leaks and concentrated boron acid. In light of the investigations carried out, the thermal embrittlement of the reactor coolant pump housing, manufactured of austenitic steel, and the 90-degree pipe curve connected to it on the pressure side, is not thought to impose limits on the service life. The reactor coolant pump motors have operated reliably over the past few years, and no ageing phenomena limiting their service life have been detected.

Corrosion phenomena occurring in the heat transfer tubes and collector structures have been considered factors potentially limiting the service life of the steam generators. Since it is not possible to reliably anticipate these phenomena, it is important to control them by means of in-service inspections, monitoring of feedwater impurities and removal of precipitation. Faulty heat transfer tubes can be isolated from the cooling water circuit by plugging. By 2007 this solution had been used 55 times at the Loviisa 1 nuclear power plant unit, and 28 times at the Loviisa 2 nuclear power plant unit. The figures are small in international comparison. The increased number of fault indications is partly due to the development of the inspection programme. In the inspections of 2006 the indications were observed in the area of accumulated precipitation. The stress corrosion resistance of the collector screw joints has been improved, and provisions have been made for a leak arising from the failure of the collector cover by refurbishment of the secondary circuit. The feedwater distribution pipes inside the steam generator have been replaced as a result of the erosion corrosion damage occurring. On the basis of the fatigue analyses updated in connection with the operating licence application to correspond with the 50-year service life, the fatigue will not limit the service life of the steam generator.

The pressurizer, operating at a higher temperature, functions as a pressure and volume controller for the primary circuit, which causes temperature transients in its pipe nozzles during start-up and shutdown. The fatigue analyses, updated in connection with the operating licence application to correspond with the 50-year service life, indicate that the cumulative fatigue factors allowed by the applicable standard are exceeded in a restricted area of the bottom nozzle, which will require intensified in-service inspections of these areas. These impacts have been monitored at the Loviisa 1 nuclear power plant unit by an on-line load monitoring system that was expanded during the current operating licence period.

The condition and leaktightness of the containments is monitored annually by visual inspections, as well as by leak tests carried out, on average, every four years. A separate corrosion monitoring system has been set up for the containment steel liner anchor bolts, and the replacement of these bolts is possible. The condition of the containment liner plates is monitored by random-check-type inspections from accessible locations and through inspection holes drilled into the concrete structure. The introduction of water into these structures is avoided in order to prevent corrosion damage. The reactor building is not estimated to impose limits on operation during the planned 50-year service life.

Other mechanical components and structures

The fatigue loads on the reactor coolant pipes are minor, which is corroborated by the fatigue analyses updated for 50 operating years. However, phenomena of mixing and sedimentation of waters in different temperatures imposing stress on materials occur in the pipes of the reactor auxiliary system branching off from the reactor coolant pipes, in particular in the connection pipe leading to the pressurizer, and the fatigue arising from these phenomena is monitored by the load monitoring system. The objects being monitored in the secondary circuit in this system include the feed water nozzle stressed by thermal loads and the steam generator blowdown pipes. STUK has been provided with a report on the erosion corrosion of the secondary circuit in connection with the operating licence application, according to which no significant thinning of walls has been observed in the inspected items due to the relatively extensive renovation of the pipes. The thinning of the wall may be very local in single-phase flow conditions, which is taken into account when selecting the inspection object and technique. The thinning trends and the impact of the power increase implemented in 1997–1998 could not be determined on the basis of the thickness measurement results. The clarification of the current vibration level of the reactor coolant pipes and the main steam pipes located in the steam generator room requested in connection with the operating licence application is still under preparation but expected to be completed in connection with the next annual maintenance outage.

Electrical and I&C systems and components

Detailed requirements concerning ageing monitoring of electrical and I&C systems and components are specified in the Guides YVL 1.0, 2.0, 5.2 and 5.5. The Loviisa Nuclear Power Plant instructions concerning operating procedures, technology and maintenance cover the service life management processes for electrical and I&C systems and components as well as external and internal reporting.

The ageing of electrical and I&C components inside and outside the containment of the Loviisa Nuclear Power Plant, as well as their cables and installations, will be monitored in connection with the regular inspections carried out during annual maintenance. The condition of components and installations located in the electrical and electronics rooms is also inspected at regular intervals. The ageing of electronic boards is monitored by component type.

Ageing phenomena have been observed in the reactor protection system components, in particular in connection with the embrittlement of the plastic parts of the original relays, the resulting breakdowns having caused malfunctions. The capacitors of the electronics also dry up in a manner proportional to the temperature. A replacement spare part has been approved for protection system relays, of which approximately 10 items are needed each year. The protection system relays and the electronics have required repairs. The plant protection system is mainly implemented with the technology of the 1970s and 1980s. However, the need for spare part replacements is currently reasonable and not growing.

The plant automation systems at the Loviisa Nuclear Power Plant can be considered to include the I&C systems, control systems, and turbine control and protection systems. The plant I&C systems have been implemented using technology that dates back to the beginning of the 1970s. On the other hand, the single control, interlocking, automation and binary measurement cabinet boards included in the plant process control systems represent technology that dates back to the late 1960s (boards for stand-alone components). The fault frequency of plant automation components has remained within reasonable limits and has not increased, even though emerging embrittlement has been detected in the plastic parts of the board frames.

The thermal ageing of cables occurring in the high-temperature compartments inside the containment is discussed in section 5.11 above. This may be regarded as the most important ageing phenomena concerning electrical and I&C systems.

According to the safety analysis report, the original service life of the Loviisa Nuclear Power Plant was 30 years. A significant number of components required in postulated accidents were replaced or re-qualified in the 1980s, targeting a 40-year service life. In connection with the renewal of the protection systems, the intention is to replace the pressure and pressure differential transmitters of these systems by the end of the decade, targeting a 50-year service life. As to other I&C field components, ageing monitoring by inspection measures has been presented, targeting a 50-year overall service life. STUK has noted (section 5.11) that the qualification procedure shall be made more systematic. In particular, the remaining service life must be known for components qualified for accident conditions, which is difficult to verify using the existing procedures.

Summary

The application submitted by FPH for extending the operating licence to exceed the 30-year service life that served as the original design basis by 20 years is essentially based on the estimates made in the service life management programme. With regard to mechanical components and structures imposing limits for the plant service life, the ageing phenomena identified through operating experience, as well as the analysis of their future development based on the international research results, have served as the starting point. The phenomena that have not yet occurred but can be expected to occur on the basis of the operating conditions have also been taken into account. The currently valid brittle fracture analyses indicate that the reactor pressure vessel can be safely operated until 2012 in the Loviisa 1 nuclear power plant unit and until 2010 in the Loviisa 2 nuclear power plant unit. STUK is not currently aware of any obstacles of a principal nature for the continued operation of the reactor pressure vessels of Loviisa 1 and 2 nuclear power plant units after 2012 and 2010. However, the continued operating life is subject to renewal of the analyses and possibly also the heat treatment of reactor pressure vessels. FPH will estimate the need for further heat treatments on the pressure vessels in connection with the preparation of a subsequent application concerning the use of pressure vessels. For fatigue analyses, updates comprising the entire licence period being applied for and acceptable with regard to their essential parts have been submitted in connection with the application. However, for corrosion phenomena, in particular those concerning the exposure of heat transfer tubes, it has not been possible to present a reliable estimate for this long a time span. The containment is not estimated to impose limits on operation during the planned 50-year service life.

A key element in the compensation of these uncertainty factors is the ability of the operating organisation and its technical support to resolve the potentially emerging problems, proof of which may be considered to have accumulated during the operating history to date. The determination of reactor pressure vessel fracture toughness has been an object of intense research at the Technical Research Centre of Finland (VTT) for more than two decades. The internationally recognised master curve approach created on the basis of this research has reduced the uncertainty of results by enabling the determination of fracture toughness directly from the irradiated material samples. A recovery heat treatment was performed on the reactor pressure vessel of the Loviisa 1 nuclear power plant unit in 1996, as a result of which the material characteristics of the critical weld were successfully recovered nearly back to the level before irradiation. The mixing and sedimentation loads in the primary circuit, which were not included in the original design basis, have also been controlled using measurement systems developed and implemented for this purpose by FPH. The service life management programme and the related know-how have been actively and systematically developed at the plant since the early 1990s, which has served as the basis for the modernisations and the power increase carried out during 1997–1998.

In summary, it can be stated that the components installed in the plant's protection and I&C systems are old, mostly representing technology dating back to the 1960s and 1970s. Fault frequencies and the spare part situation have remained under control, but old relays in the reactor protection system, for example, have required repairs.

The implementation of the automation renewal by the mid-2010s, starting from the protection I&C systems, is necessary. For I&C field components, the spare part situations seems to be under control in view of the 50-year service life.

STUK has required that the ageing management programmes for electrical and I&C systems and components be assessed on a regular basis and the annual reporting be improved. The programmes shall be comprehensive and effective, fulfilling the requirements specified in the Guides YVL 5.2 and YVL 5.5. The assessment of the remaining service life of I&C field components is expected to become easier when the procedures relating to qualifications are made more systematic. STUK will monitor the subsequent developments in connection with its oversight process.

6.3 Section 25: Personnel

Nuclear power plant personnel shall be well suited for its duties, competent and well trained. Initial, complementary and refresher training programmes shall be established for the personnel.

For ensuring safety in all situations, competent personnel shall be available in a sufficient number.

The number of permanent personnel at the Loviisa Nuclear Power Plant decreased by approximately 20 people between the end of 1995 and the end of 2005 due to outsourcing of certain operations. The outsourcing concerns support functions such as personnel catering and maintenance of outdoor areas. However, the number of employees working in positions important in terms of power plant operation has in fact increased, and FPH is not planning to transfer these functions to service providers outside the plant organisation. Employee turnover has increased due to the retirement of the people of nearly the same age who were hired in the 1970s. As to licensed operators, all of the original control room operators will be replaced within the next four years.

Both the anticipated changes in the long term and the requirements of the near future are considered in the human resource planning of the Loviisa Nuclear Power Plant. The readiness to react to changing resource needs exists even though the initiation or completion of some recruitment campaigns has been delayed.

On the basis of the interviews carried out by FPH, it can be concluded that there is a strong and widely established view amongst the personnel that resources are insufficient in respect of the amount of work involved. The periodic inspection targeting personnel resources performed by STUK in November 2006 found the personnel resources were insufficient with regard to quality assurance, radiation monitoring, and work supervision of annual maintenances. The Loviisa Nuclear Power Plant paid adequate attention to the strengthening of these functions during the spring of 2007.

The organisation of the Loviisa Nuclear Power Plant has in place the functions important to nuclear power plant safety in accordance with the Guide YVL 1.7 (Functions important to nuclear power plant safety, and training and qualification of personnel). The authority, responsibilities and lines of communication relating to functions important to safety have been clearly defined. An exception to the above is personnel development, for which the coordination responsibility is shared between several parties (training office, operating technology group and personnel administration). Expertise and resources for training and development of the operations of the organisation have been available at the Loviisa Nuclear Power Plant during the current operating licence period.

The organisational structure, job descriptions, qualification requirements, authority and responsibilities of the personnel and the lines of management are described in the administrative rules and organisation manual of the plant. The person serving as the responsible manager of the plant is the Plant Manager, who meets the requirements set for a responsible manager and in such position has sufficient authority and factual opportunity to effectively perform his duties.

Initial, refresher and complementary training programmes have been established for the personnel of the Loviisa Nuclear Power Plant. The competence requirements for duties important to safety have been described at the plant, and FPH has in place procedures for identifying training needs. Attention has also been paid to the assessment of the effectiveness of training. However, there are deficiencies with regard to the sufficient availability of office and training facilities at the Loviisa Nuclear Power Plant.

The conclusion to the above is that the training and competence of the personnel of the Loviisa Nuclear Power Plant fulfils the regulations set forth in section 25 of the Government Decision. The personnel of the Loviisa Nuclear Power Plant are well suited to their duties, as well as competent and trained. Initial, complementary and refresher training programmes have been established for the personnel. Procedures exist for ensuring the sufficient number of available plant personnel, the effectiveness of which shall be paid attention during the next operating licence period.

6.4 Section 26: Monitoring releases of radioactive materials

Releases of radioactive materials from a nuclear power plant and their concentrations in the environment shall be effectively monitored.

Detailed requirements relating to section 26 of the Government Decision are set forth in the guides YVL 7.6 and YVL 7.7.

The Loviisa Nuclear Power Plant has in place technical systems for collecting and storing the majority of radioactive materials released into and residing in the plant's process systems. Only a minor part of the radioactive materials are released into the environment.

The radioactive releases occur in gaseous or particulate form through the vent stack into the atmosphere, as well as in the form of particles dissolved or mixed in water entering the seawater tunnel and further into the sea environment. The airborne and aquatic radioactive releases from the Loviisa Nuclear Power Plant are monitored in all significant release pathways by on-line radiation monitors as well as by sampling and nuclide-specific radioactivity measurements carried out at the laboratory. Other potential release pathways are monitored by sampling and other methods. The on-line radiation monitors located in the release pathways and the sampling equipment have been replaced during the current operating licence period.

An extensive environmental radiation monitoring programme, approved by STUK, is being implemented in the vicinity of the Loviisa Nuclear Power Plant. According to this programme, the potential migration of radioactive materials is being continuously monitored by analysing the radionuclide concentrations in foodstuffs produced in the area surrounding the plant and in other samples indicating the migration of releases. The results obtained from the monitoring of the environment corroborate the monitoring of radioactive releases carried out at the Loviisa Nuclear Power Plant. The monitoring programme has been revised during the current operating licence period.

The monitoring programme comprises approximately 335 samples per year. Types of samples include milk, meat, fish, crops and vegetables, as well as water and airborne aerosols. Samples are also taken from such indicator organisms that very effectively accumulate radioactive materials from their living environment. The nuclides that are most important in terms of human radiation exposure are analysed when studying the samples: gamma emitters such as ^{60}Co, ^{131}I and ^{137}Cs, beta emitters ^{3}H and ^{90}Sr, and alpha emitters such as ^{238}Pu, ^{239}Pu and ^{240}Pu.

During the past few years the dose effects of the releases from the Loviisa Nuclear Power Plant have remained below 1/1000 of the annual release limits. For airborne releases, the predominant releases, expressed in terms of activity, are those of noble gases, and for aquatic releases, those of tritium. The released nuclides observed in the environment have been activated corrosion products (e.g. ^{60}Co) as well as certain other activation products and tritium. Observations in ground environment samples have been rare, mostly those detected from high-capacity air collectors and fallout during annual maintenance. Regular observations have been made of small amounts of radioactive materials originating from the Loviisa Nuclear Power Plant in the indicator samples taken from the water environment. These are insignificant in terms of the surrounding population or nature. Radioactive materials originating from the Chernobyl accident have also been predominant in the environmental samples of the Loviisa Nuclear Power Plant.

The results of the environmental monitoring indicate that the releases from Loviisa Nuclear Power Plant have been minor and insignificant in terms of their impact on the environment and people. Although the radioactivity concentrations in the environmental samples are small, the measurement results for the air and fallout collectors and the Co-60 concentrations in kelp show a decreasing trend, which is also apparent in the release measurements. The impact of the minor fallout condition in Finland caused by the Chernobyl accident on the external radiation dose measured at the dosimeter station and on the Cs-137 concentration in milk is also clearly apparent in the results.

On the basis of the above, it can be stated that the methods employed are sufficiently sensitive for the purpose of environmental monitoring during normal operation and the changes in measurement result caused by abnormal conditions can also be clearly observed from them.

An automatic measuring system for the external radiation in the environment is located in the area surrounding the Loviisa Nuclear Power Plant, the purpose of which is to rapidly provide information about the possible changes in the environment occurring in a potential abnormal condition. A conceptual design plan concerning the renewal and complementation of the instrumentation of the weather measurement system located near the plant and used for assessing the spread of a radioactive release in the atmosphere is currently being processed by STUK.

The conclusion on the above is that the releases of radioactive materials and their concentrations in the environment are effectively monitored at the Loviisa Nuclear Power Plant in a manner referred to in section 26 of the Government Decision.

6.5 Section 27: Operating experience and safety research

Operating experience from nuclear power plants as well as results of safety research shall be systematically followed and assessed.

For further safety enhancement, actions shall be taken which can be regarded as justified considering operating experience and the results of safety research as well as the advancement of science and technology.

6.5.1 Operating experience from the previous operating licence period

The severity of operational events at nuclear facilities is described using the INES scale. The INES scale is a seven-level scale jointly developed by the International Atomic Energy Agency (IAEA) and the Nuclear Energy Agency of the Organisation for Economic Co-operation and Development (OECD/NEA) used internationally to depict the severity of events at nuclear facilities. Events in classes 1–3 are incidents increasingly significant in terms of safety, and events in classes 4–7 are accidents. In addition to the above, class 0 is used for indicating that the event has no safety significance. No events exceeding the severity class 2 have occurred at the Loviisa Nuclear Power Plant during its service life. Four events have been classified as INES 2 events during the service life of the plant, the latest of which occurred in 1993. The number of events warranting a special report during the current operating licence period was 32, of which 5 were classified as INES 1 events and 26 as INES 0 events. One of the events remained below the INES classification limit. The number and severity of specially reported events is lower than previously, and the total number of operational events has slightly decreased. The number of reactor scrams has also been low.

Due to an exceptionally high seawater level at the Gulf of Finland, the emergency organisation of the Loviisa Nuclear Power Plant convened and emergency standby was declared at the plant on 9 January 2005. The event did not endanger plant safety.

Frequently occurring events during the current operating licence period include problems with adjusting the boron acid concentration in the primary circuit during shutdown and start-up of the plant units. The situation has been improved on the basis of the root cause analysis performed in 2002 to address the problem. One form of frequently occurring events has also been the so-called cross failures. These refer to mutual dependencies between different components and systems, the joint effect of which must be identified to prevent inoperabilities violating the Technical Specification from occurring due to, for example, periodic maintenances. Since it has not been possible to eliminate the cross failures, they are regarded as issues requiring constant monitoring.

The status of several factors affecting safety, operability and quality of operations are monitored at the Loviisa Nuclear Power Plant using indicators. The load factors of the plant units have been good in international comparison. From 1998 to 2005 the load factor was 84.8-95.4 % for the Loviisa 1 nuclear power plant unit and 82.2-95.7 % for the Loviisa 2 nuclear power plant unit. Reactor scrams have occurred rarely, the latest, in 2001, performed manually, and, in 2004, due to component failure, both at the Loviisa 1 nuclear power plant unit.

On the basis of the indicators describing the inoperability of safety systems, the operation of the Loviisa Nuclear Power Plant has been controlled and safe. Safety systems have not been inoperable to any significant extent due to faults, maintenance or other similar reasons. The indicators also provide follow-up data on occupational safety, fires and common cause failures, among other things.

In summary, it can be stated that none of the operational events at the Loviisa Nuclear Power Plant has essentially impaired plant safety or caused significant radioactive releases to the environment. The development has been positive during the current operating licence period, both in terms of the number of events and in terms of their safety significance.

6.5.2 Operating experience feedback

The monitoring of operational events at the Loviisa Nuclear Power Plant is part of the plant's normal operation and maintenance activities. The depth of operational event analysis depends on the nature of the event and the severity of the consequences. A so-called root cause analysis is prepared for events that are considered significant, in which the root causes of the event are investigated in addition to the actual causes. These usually relate to human activity and are thus principally of organisational origin.

The operating experience feedback activities are described in the plant procedures. The safety unit assumes the main responsibility for these activities. A responsible safety engineer has been appointed for the operating experience feedback activities. The operating experience feedback activities have been appropriately organised and instructed. The assessment of operating experience feedback activities is carried out on a regular basis by quality control and plant management. The operating experience feedback activities are reported to STUK annually.

A special operating experience feedback team has been assigned for the purpose of analysing operating experience from other nuclear power plants, with participants representing expertise from different fields of technology. The essential sources of information for the operating experience feedback team are the WANO (World Association of Nuclear Operators), IAEA (International Atomic Energy Agency) and OECD/NEA (Nuclear Energy Agency). The operating experience data processing team reviews the reports received and investigates whether any of the events requires measures to be taken at the plant or in its procedures and instructions. The team provides recommendations for further processing and decisions to be made on possible further action. FPH annually reports the activities of the operating experience feedback team to STUK.

The success of the operating experience feedback activities can be assessed on the basis of the results attained. No significant frequently occurring events are evident in the plant's operational events, and the number and severity of them are steadily decreasing. The operating experience feedback is a continuing process for which sufficient resources and opportunities to pursue the related activities must be continuously ensured. In particular, the identification of root causes of events and the timely execution of the respective corrective actions are of special importance. According to STUK's view, needs for improvement in this area remain.

In summary, it can be stated that operating experience feedback activities of the Loviisa Nuclear Power Plant have been arranged in manner referred to in section 27 of the Government Decision.

6.5.3 Safety research

Due to the development history of the Loviisa Nuclear Power Plant, the Fortum Generation unit has considerable know-how on VVER type plants in particular. For this reason, the follow-up of and participation in nuclear technology research is active. Nuclear power plant research has been organised into five research and development programmes within the Fortum Generation unit: material research, nuclear waste research, operation and maintenance, fuel and reactor physics research, and thermal nuclear safety.

Within these programmes, Fortum Generation carries out its own research, coordinates research commissioned from other parties, and follows up and participates in international research programmes. The main focus of the research conducted by Fortum Generation or commissioned from elsewhere is in resolving the detected needs that directly concern the Loviisa Nuclear Power Plant. The company receives more extensive information on the topical issues and recent results of research and development through national and international research programmes.

In summary, it can be stated that the follow-up of and participation in nuclear technology research by the Fortum Generation unit has been arranged in a manner referred to in section 27 of the Government Decision.

7 Miscellaneous provisions (Government Decision 395/1991)

7.1 Section 28: Nuclear power plants in operation

For the part of such a nuclear power plant for which an operating licence was issued before the entry into force of this decision (an operating nuclear power plant) the limit for the dose referred to in Section 11 is 100 mSv, unless the application of the provisions contained in Section 11, as such, is justified, considering the provisions of Section 27, second paragraph.

The provisions of Sections 12, 17 and 18 of this decision are applied to an operating nuclear power plant to the extent justified based on the provisions of Section 27, second paragraph, and taking into account the technical solutions of the nuclear power plant in question.

Section 28 of the Government Decision provides certain exceptions to the provisions of sections 11, 12, 17 and 18 of the resolution. The fulfilment of these provisions is assessed in sections 4.5, 4.6, 5.5 and 5.6 above.

7.2 Section 29: Detailed regulations

Detailed regulations relating to the safety of a nuclear power plant are issued by the Finnish Centre for Radiation and Nuclear Safety.

STUK prepares and issues detailed regulations concerning the safe use of nuclear energy by virtue of section 55, paragraph 2, point 3 of the Nuclear Energy Act (990/1987) and section 29 of the Government Decision 395/1991 quoted above. STUK has chosen the issuance of YVL guides as its operating practice. These guides shall be complied with by the licensee or any other organisation concerned unless STUK has been presented with some other acceptable procedure or solution by which the safety level set forth in the YVL Guides is achieved. STUK has not wanted to make the YVL guides mandatory regulations because it would have had to confine to merely recording the attained level of technology and, further, reflecting in the guides the restrictions that the already implemented solutions impose on further modifications. One purpose of the YVL guides is to provide the users of nuclear energy with good design bases and operating procedures STUK considers acceptable.

STUK assesses the currency of the YVL guides on a regular basis and, when updating the guides, takes into account the advancement of nuclear and radiation safety technology and research as well as operating experience from Finland and abroad in a manner referred to in section 27 of the Government Decision 395/1991. The structural reform of the YVL guide system was initiated on the basis of the prepared project plant in 2006. The views of the expert group assembled in 2005 with representatives from STUK and Finnish nuclear power companies were taken into account when preparing the plan. The central objectives of the structural reform are the elimination of the observed overlaps and deficiencies, clarification of the set requirement level by removing the descriptive interpretation instructions, and reducing the number of detailed requirements. In connection with the reforms, the intention is to also introduce a system for marking individual requirements and a reference apparatus that utilises modern information technology. The number of instructions will be reduced to half of the present amount, and maintaining and using the guides will become easier. The objective is to have the new set of STUK-YVL guides completed by the end of 2011.

When preparing the YVL guides, one starting point is to attempt to continuously raise the level of safety. Consequently, when setting the safety targets specified in the guides, the highest level internationally achieved is considered the model to be followed. In some regards, the targeted level is that which is considered achievable, at least in new nuclear power plants. For this reason, it is not possible, or even feasible, to consider the new YVL guides binding on nuclear power plants in operation in all respects.

For the purpose of clarifying the scope of applicability, a decision concerning nuclear facilities in operation or under construction is prepared for each new or revised YVL guide, defining the applicability of the guide with regard to nuclear facilities in operation or under construction. The measures to be taken by, for example, a utility company due to the guide are specified in implementation decisions. The guide does not change the decisions issued by STUK prior to the guide entering into force unless it is separately announced by STUK. On the other hand, STUK requires that the need and opportunities for increasing the safety level are re-assessed in light of new YVL guides. Measures to increase safety may be required on the basis of the assessment when deemed justified. The systematic preparation of implementation decisions for YVL guides was started in 2000.

The design bases concerning structures, systems and components of the Loviisa Nuclear Power Plant have been mostly laid down during the 1970s. Although the plant has been considerably renovated since the commissioning and extensive modifications have been implemented in several systems to improve safety, the plant does not quite meet the requirements of the currently valid YVL guides in all respects. The deviations from the YVL guides are discussed under the respective sections of Government Decisions concerning the subject matter in question.

8 Physical protection (Government Decision 396/1991)

Regulations and the requirements issued by virtue of it
The regulations for physical protection are defined in the Nuclear Energy Act, Nuclear Energy Decree, and the Government Decision 396/1991. Detailed application instructions for the requirements and the control procedures of STUK are described in the classified YVL Guides 6.11, “Physical protection at nuclear power plants”, and YVL 6.21, “Physical protection of nuclear fuel transports”. Moreover, some YVL Guides, for example YVL 1.0, YVL 2.0, YVL 5.5 and YVL 5.6, contain requirements where the need to consider unlawful actions against the nuclear power plant shall be taken into account.

Relating to potential new plant projects and significant modification projects concerning the existing plants, it has been observed that requirements concerning physical protection should be further specified in certain respects. These specifications have been presented to licensees in STUK’s classified decisions in 2002. The events of 11 September 2001 were taken into account in the preparation of these decisions. New requirements concerning the specification decisions are mainly related to the so-called external threats. In this context, external threats refer to such intentional or negligent external actions against a nuclear power plant, which, without provisions against such actions, could endanger nuclear power plant safety. The requirements aim to take into account the long operating life of the plant units as well as the difficulties related to forecasting the future as regards, for example, various disorders and crises in society. However, actual military operations have not been taken into account in the design basis. International agreements concerning military operations prohibit attacks on targets containing large amounts of energy, such as power plants.

Responsibility and control
According to the law, the licensee is unambiguously responsible for the safety of the nuclear power plant. However, the licensee’s means and authorisations are not adequate as such in, for example, a situation caused by terrorism. Even then it must be possible to dimension the applicable countermeasures, both as regards the extent and timing of the verified threat. In addition to the licensee, the police and other authorities providing executive assistance to the licensee also have legal obligations to secure safety in the event of various unlawful circumstances. Therefore, the significance of cooperation between the safety authorities and the various parties should be emphasised in cases relating to threat situations and the provisions made for them at nuclear power plants. There have not been any actions aiming to damage nuclear power plants in Finland.

STUK also acts as the regulatory authority for physical protection in cases relating to the use of nuclear energy. STUK has summoned a separate expert team to provide safety precautions against unlawful action, whose task is to regularly follow and assess threat scenarios and any changes to them, to develop operational preparedness and the flow of information, and to widen its members’ expertise. In addition to STUK and experts from the power companies, the team includes representatives from the main Finnish police and safety authorities. The member organisations of the team have an extensive international cooperation network, through which information and opinions concerning international developments are forwarded to the team.

Physical protection arranged by the licensee and its control

The procedures for preventing unlawful action against the Loviisa 1 and 2 nuclear power plant units are described in the physical protection plan of the Loviisa Nuclear Power Plant. The plan covers the structural and technical protection of the plant as well as administrative procedures. The said plan and certain other documents concerning physical protection are handled as secret documents. This is due to the fact that their coming into the possession of those planning unlawful actions could compromise the achievement of the objective of the security arrangements (Act on the Openness of Government Activities 621/1999, section 24, paragraph 7).

The physical protection plan has been regularly updated, and the latest version was approved by STUK in 2003. Detailed operating instructions for the physical protection organisation are specified in, among others, the guarding procedures that have been regularly submitted to STUK for information.

STUK has assessed the currency and sufficiency of the physical protection of the Loviisa Nuclear Power Plant on the basis of the requirements laid down in the Government Decision 396/1991 and Guides YVL 6.11 and YVL 6.21, as well as on the basis of the specification decision concerning the said guides, focusing on the changes in the national and international security situation during the past 10 years and the impact of these factors on physical protection at nuclear power plants. In connection with the operating licence application, FPH submitted a report that, among other things, provides a statement of position regarding the implementation of the design bases presented in the above-mentioned specification decision at the Loviisa Nuclear Power Plant. A large number of improvement measures have been carried out during the past few years. The improvement measures are still partly in progress but the majority of them will be completed by the end of 2007.

Concerning the licensee's description of the arrangements for physical protection, a statement from the Police Department of the Ministry of the Interior, as well as a supplementary statement complementing it, has been requested and obtained in accordance with section 37 of the Nuclear Energy Decree. According to the statement and the supplementary statement, the Police Department has not found anything objectionable in the description of the arrangements for physical protection relating to the operating licence application.

According to STUK's view, the arrangements for physical protection of the Loviisa Nuclear Power Plant have been planned and implemented in a manner that makes it possible to prevent unlawful actions against the plant. On the basis of STUK's assessment, there are no obstacles with regard to physical protection for the continuation of the operating licence.

9 Emergency response arrangements (Government Decision 397/1991)

Planning of emergency response arrangements and the emergency organisation

FPH has analysed accident and safety-impairing events as the basis for the planning of emergency response arrangements at the Loviisa Nuclear Power Plant (see section 3.4.1 above). Emergencies have been classified and described in the plant's emergency plan and procedures. The notifications and alarms to plant personnel and authorities required by different classes of emergencies, as well as the scope of operations of the emergency organisation pertaining to the type of emergency, are described in the procedures.

FPH has analysed the radiation exposure of employees in different accidents during the current operating licence period, as well as the accessibility of items in terms of repairs and maintenance both inside the plant and on the plant site. The assessment is still partly in progress. In preparation for potential emergencies, FPH has developed an information system for radiation experts (SaTu), which is an auxiliary system primarily used in severe accidents. The system can be used for assessing the releases from the plant into the environment and the radiation condition of the plant site during an accident.

The emergency response arrangements of the Loviisa Nuclear Power Plant have been coordinated with the management of operation and the arrangements for physical protection. The emergency procedures contain the required references to operation procedures, and the changes required by the emergency and severe accident management procedures introduced in connection with the renewal of plant procedures have been updated into them. The changes resulting from the regional restructuring of rescue operations and the initiation of emergency response centre operations have been updated into the emergency response plan and procedures.

A person responsible for emergency response arrangements and his deputy have been appointed for the Loviisa Nuclear Power Plant. The emergency organisation has been described in the emergency procedures, updated with regard to personnel changes and contact information approximately once a year. The narrower staffing of the emergency organisation required for emergency standby state is defined in the emergency procedures. The assignment and training of the users of the information system for radiation experts is continuing for the Loviisa Nuclear Power Plant.

Operational preparedness

Provisions have been made at the Loviisa Nuclear Power Plant for performing the measures required in an emergency and for analysing its effects and assessing its development. The operation of the emergency organisation is guided by written procedures (see Appendix 2, Chapter 8 of the statement). The premises of the emergency organisation at the Loviisa Nuclear Power have the emergency procedures and a large amount of status information readily available on the process computer, part of which is sent to the Fortum Nuclear Services (FNS) support at Keilaniemi and to STUK's emergency response centre.

Preparations have been made at the Loviisa Nuclear Power Plant for assessing the radiation condition and dispersion of radioactive materials in accidents. The equipment at the plant site has been developed by replacing two external radiation dose rate meters in 2004 and the weather mast measuring system in 2002. The LENA calculating model can be used for assessing the dispersion of the release in the emergency planning zone. The users of the calculating model, originating from

Sweden, are continuing their cooperation and exchange of information.

Premises have been allocated for the emergency organization of the Loviisa Nuclear Power Plant in the air raid shelter and for the FNS support in Keilaniemi. The premises contain the equipment and software required for analysing the plant and radiation condition and for maintaining an overall picture of the accident, as well as the required written procedures and background material. The power plant has the required protective equipment readily available for emergencies.

The communications and alarm systems of the plant have been developed during the past three operating licence periods by replacing the dedicated DigiPower dial connection with other redundant and secured phone connections and, at FPH, by deploying the ForHelp calling service for alerting the emergency organisation. This is also used for testing the availability of the emergency organisation at regular intervals. In connection with the Loviisa Nuclear Power Plant automation renewal project (LARA), it has been required that the impacts of the project on, e.g., data communications connection, be assessed.

Written procedures have been planned and drawn up for informing the media and the public. These are performed in accordance with the crisis communications principles of the Fortum Group and regularly tested in emergency exercises.

Maintenance of preparedness

Emergency preparedness training and exercises are annually arranged for the emergency organisation of the Loviisa Nuclear Power Plant. FPH has submitted the annual plans for emergency preparedness training to STUK, as well as reports on their implementation. Further, STUK has also been provided with a longer-term plan for emergency preparedness training and exercises. The emergency preparedness training has comprised classroom and action group-specific practical training. In addition to severe accidents, the emergencies covered by the emergency preparedness exercises have varied to also include conditions classified as emergency standby. A combined fire and emergency exercise was organised in 2002 to test the operating procedures. The content and extent of the exercises are assessed in the periodic inspections conducted by STUK. The generation change currently underway at the Loviisa Nuclear Power Plant requires, in addition to recruitment, a substantial training investment concerning both the actual work duties and duties relating to the emergency organisation of the newly recruited experts.

In addition to the emergency organisation training, attention has also been paid to the emergency preparedness training of others working at the plant site. In addition to annual maintenances, different kinds of construction projects are underway at the Loviisa Nuclear Power Plant, and the induction training for which an access permit is required includes instructions for emergencies.

The responsibilities for maintaining the facilities and equipment reserved for emergencies, as well as the related inspection intervals, have been described in the emergency instructions. Sections 13.3 and 13.4 of the Final Safety Analysis Report describing the emergency plan are updated when required, while the emergency instructions are updated at least once a year.

Operation during emergencies

The control rooms of the Loviisa Nuclear Power Plant are in constant readiness to initiate emergency operations. The shift supervisor serves as the emergency manager until the emergency manager appointed from within the emergency organisation assumes the responsibility for managing the situation. The emergency plan contains a description of the emergency organisation in the initial stage of its operation, as well as of the actual emergency organisation along with the related job descriptions. The procedures concerning notifications and alarms to the authorities have been updated with regard to emergency response centre operations. Means of communicating the overall picture on the situation have been developed during the past few years by introducing computer aided emergency record keeping and by providing instructions for forwarding the emergency records and release data to STUK during the emergency situation.

The plant emergency manager's command responsibilities in an emergency situation have been revised due to amendments implemented in rescue legislation, and the related updates have been made in the emergency plan and instructions. During the past few years attention has also been paid to the termination of emergency situations and debriefing measures. This has been instructed in the emergency manager's emergency instructions, and the activities concerning it have been tested in emergency exercises. The emergency situation has been terminated in the concluding stage of the exercise when the plant has been successfully brought into a safe state and the further measures required by the situation have been briefly assessed.

Measures relating to rescue operations

FPH has ensured the cooperation with the Eastern Uusimaa Fire and Rescue Services in cases of emergencies by means of joint meetings and in connection with the updates to the rescue plan for a severe radiation accident at the Loviisa Nuclear Power plant prepared by the regional fire and rescue services. The parties participating in the planning of the rescue operations exercise arranged in the autumn of 2006 included FPH and the relevant authorities, and the appropriateness of the operations and instructions in terms of all parties concerned was assessed with regard to new rescue region arrangements. The exercise tested the functionality of the instructions and the cooperation between the utility and the authorities in practice.

Emergency operating instructions have been distributed to the population of the emergency planning zone, while iodine tablets were distributed to the population of the protective zone in 2002.

Summary

According to STUK's view, FPH has ensured the emergency response arrangements of the Loviisa Nuclear Power Plant in accordance with the Government Decision 397/1991 and has further developed the preparedness for emergencies. In connection with the processing of the operating licence, the Ministry of the Interior has provided STUK with a statement stating that the arrangements are tested by means of emergency exercises at regular intervals and no significant defects have been observed in them. In its statement, the Ministry draws attention to the changes that have occurred in the rescue services and to the importance of continued close cooperation with the regional rescue services when preparing and updating the emergency and rescue plans.

10 Nuclear fuel management

The general design bases for nuclear fuel have been defined in the Guides YVL 1.0 and YVL 6.2. The design objective is that the probability of fuel failure is low during normal operational conditions and anticipated operational transients, and that during a postulated accident the rate of fuel failures remains low and the fuel remains in a coolable state. The measures for ensuring fuel integrity during the operation of the Loviisa Nuclear Power Plant are discussed in more detail in section 5.3.

Detailed requirements for the design, quality management and control, handling, storage and transport of fuel are specified in the Guides YVL 6.2, YVL 6.3, YVL 6.4, YVL 6.5, YVL 6.7 and YVL 6.8. The Russian company TVEL and the British company BNFL (Westinghouse) have served as the fuel manufacturers for the Loviisa Nuclear Power Plant. At the end of 2006 FPH decided to order fuel for both plant units exclusively from TVEL until the end of their service lives.

The stationary fuel assembly and the control rod fuel extension consist of an assembly formed by control rods that are surrounded by a hexagonal tube and equipped with tie plates in the ends. Each fuel assembly contains 126 fuel rods. The rod assembly rests on the lower support plate and is held together by spacers. The fuel rod consists of uranium oxide pellets located inside the cladding. End plugs have been welded gas-tight into the ends of the cladding. The degree of enrichment with regard to Uranium-235 has varied between 3.2 and 4.0 per cent. The control rod is a combination of absorber rod and fuel extension. The neutron-absorbing structure of the absorber section consists of a stack of hexagonal boron-steel sleeves standing freely inside the tube.

FPH, and the consultants possibly hired by FPH, control the fuel manufactured in the fuel factory. The purpose of STUK's regulatory control is to ensure that the activities of the licensee are adequate. A receiving inspection is performed on each fuel batch arriving at the Loviisa Nuclear Power Plant in which the dimensions of the fuel assemblies and absorber sections are inspected and the quality of the surfaces is visually checked. The quality assurance operations concerning the procurement of nuclear fuel are also described in section 3.3.

The fresh fuel storage of the Loviisa Nuclear Power Plant is shared by both plant units. The storage is dimensioned to provide room for the reload batches of three refuelling periods of the Loviisa 1 and 2 nuclear power plant units. Provisions for ensuring subcriticality have been made in the structural design of the storage and in the geometrical design of the fresh fuel storage and handling racks.

In summary, it can be stated that nuclear fuel management has been appropriately arranged at the Loviisa Nuclear Power Plant.

11 Nuclear waste management

According to Section 20, paragraph 1, point 2 of the Nuclear Energy Act, one prerequisite for granting a construction permit for a nuclear facility is that *the methods available to the applicant for arranging nuclear waste management, including the final disposal of nuclear waste and the decommissioning of the facility, are sufficient and appropriate.*

11.1 Handling, storage and disposal of reactor waste (Government Decisions 395/1991 and 398/1991)

The starting point of the management of reactor waste by FPH is that the waste is taken care of at the Loviisa plant site, including its final disposal. No significant safety-related problems have emerged in the management of intermediate and low level waste generated during the operation of the Loviisa Nuclear Power Plant during the current operating licence period.

A new practice based on the LaMDA system for accounting for the reactor waste of the Loviisa Nuclear Power Plant was introduced in 2006. It contains both computational and measured waste inventories concerning stored waste and disposed waste packages. The new system fulfils the requirements for the accounting of nuclear waste specified in the YVL guides.

At the end of 2006 the volume of intermediate and low level waste amounted to approximately 2990 m^3; the average annual accumulation thus amounting to 110 m^3. The total activity, excluding the so-called activated metal waste, was approximately 18 TBq. The accumulated waste volumes and activities were below average on international comparison. The total accumulation of reactor waste by the end of the operating licence period being applied for is estimated to be approximately 11,500 m^3. The accumulation is calculated on the basis of the outer volume of disposed waste packages, assuming that liquid waste is solidified into a concrete matrix.

It is proposed in the licence application that the maximum waste volume of 3,000 m^3 solid waste and 2,400 m^3 liquid waste be recorded in the licence conditions. These are the same as those in the current licence conditions and correspond with the existing storage capacity.

The most significant project relating to the management of intermediate and low level waste during the current operating licence period of the Loviisa Nuclear Power Plant has been the construction of a liquid waste solidification facility and a repository for solidified waste. The commissioning of the facilities, as well as the related safety assessments and document approvals, is planned to take place in 2007. The intention is to initially only solidify and dispose of evaporator bottoms, while the handling of ion-exchange resins is only to be started after sufficient experience of the operation of the solidification facility has been obtained.

The management of the solid waste of the Loviisa Nuclear Power Plant is intended to be developed by employing centralised facilities for the handling, activity monitoring and temporary storage of maintenance waste. The plan concerning the above has been completed and the project was initially scheduled to be implemented by 2009, but, according to the present schedule, will be completed in 2010.

Maintenance waste has been disposed of since 1998, and the second disposal tunnel in the repository was approved for use in 2006. The disposal facility, comprising the repositories for both maintenance waste and solidified waste, has been provided with an operating licence until 2055. According to the operating licence conditions, an extensive intermediate safety assessment of the final disposal shall be made by the end of 2013.

Following the initiation of the disposal of solidified waste, long-term disposal at the Loviisa Nuclear Power Plant is needed for shield elements removed from inside the reactor pressure vessel, core instruments, samples and vacuum cleaning residues, and highly radiating seal water filters, as well as some 200 m^3 of non-combustible waste in the basement storage. Their disposal is intended to be taken care of in connection with the decommissioning of the Loviisa Nuclear Power Plant at the latest.

According to STUK's view, the methods for managing reactor waste employed by FPH are, considering the plans for their future improvement, appropriate and sufficient for managing the waste in a safe manner.

11.2 Handling, storage and disposal of spent nuclear fuel (Government Decisions 395/1991 and 478/1999)

The starting point of the management of spent nuclear fuel by FPH is that the interim storage of spent fuel is provided at the Loviisa Nuclear Power Plant site until it can be disposed of in the disposal facility constructed by Posiva Oy. No significant safety-related problems have emerged in the storage of spent fuel during the current operating licence period.

At the end of 2006 there were 403 tU of spent nuclear fuel in the storage of Loviisa Nuclear Power Plant. In addition, 330 tU of spent nuclear fuel were exported to the Mayak plant in Russia, as agreed at that time. By the end of the operating licence period being applied for the estimated accumulation of spent fuel will amount to approximately 1,100 tU. If the disposal operations are initiated in 2020 as planned, the intermediate storage will contain a maximum of 760 tU of spent nuclear fuel.

The storage capacity for spent nuclear fuel will be increased at the Loviisa Nuclear Power Plant so that it is sufficient until the initiation of disposal by employing more compact racks in the existing storage pools. The first two compact racks have already been installed and additional compact racks will be commissioned two at a time every 2 to 3 years. STUK has approved the pre-inspection documents concerning the commissioning of compact racks. The changes to the licence conditions concerning the increase of storage capacity are intended to be taken care of in connection with the renewal of the operating licence for the Loviisa Nuclear Power Plant in 2007.

It is proposed in the operating licence application that the interim storage maximum capacity of 1100 tU be recorded in the licence conditions. According to STUK's understanding, the storage of the said volume of spent fuel in the existing storage facilities is possible both technically and in terms of safety. The cooling capacity of fuel pools needs to be increased, but this has been technically prepared for when designing the plant.

The spent nuclear fuel disposal plan for the Loviisa Nuclear Power Plant is based on the disposal project of Posiva Oy, for which the related Government decision-in-principle was ratified by Parliament in 2001. STUK performed a preliminary safety assessment of the disposal project in 2000 based on Government Decision 478/1999. According to the present schedule, a construction licence is to be obtained for the encapsulation and disposal facility in 2012 and an operating licence in 2018. The disposal of spent nuclear fuel could thus be commenced in 2020.

STUK oversees the spent nuclear fuel disposal project prepared by Posiva Oy in accordance with the Nuclear Energy Act. The construction oversight of the underground research facility to be constructed in Olkiluoto is based on the principles laid down in STUK's letter Y819/22, 26 October 2001. By virtue of the decision issued by the Ministry of Trade and Industry in 2002, Posiva Oy published an extensive report on the status of the disposal project and the related research, development and design work at the end of 2006. STUK has performed an expert review of the report, which was also be submitted to the Ministry of Trade and Industry for information at the end of June 2007.

According to STUK's view, the methods for managing spent nuclear fuel employed by FPH, as well as the plans for their future improvement, are appropriate and sufficient for managing spent nuclear fuel in a safe manner.

11.3 Decommissioning of plant units

According to the decision issued by the Ministry of Trade and Industry in 1991, the plan concerning the decommissioning of a nuclear power plant must be updated every five years. The decommissioning plan for the Loviisa Nuclear Power Plant was last updated in 2003, and STUK reviewed the plan and provided a statement concerning it to the Ministry of Trade and Industry in 2004 (dno A841/12, 12 October 2004). On the basis of the statement, the Ministry of Trade and Industry stated that in respect of its implementation principles and level of detail, the plan meets the requirements imposed on it at this point. The decommissioning plan will next be updated in 2008.

The starting point of the decommissioning plan for the Loviisa Nuclear Power Plant is the decommissioning of most of the plant approximately 14 years after the termination of the plant operation. According to the plan, all structures and components exceeding the limits for the removal of regulatory control will be disassembled from the plant and packed for disposal. The waste packages and certain large components will be disposed of in facilities constructed in the close vicinity of the disposal facility. The interim storage for spent fuel would only be disassembled when the disposal of spent fuel is implemented.

According to STUK's view, the plans prepared by FPH for the decommissioning of the Loviisa Nuclear Power Plant are appropriate and at this point sufficient.

12 Handling of nuclear materials

As regards the Loviisa Nuclear Power Plant, FPH is obliged to comply with the nuclear material accounting and control manual approved by STUK and the applicable EU regulations. The nuclear safeguards are based on the Non-Proliferation Treaty (NPT) and the subsequent Safeguards Agreement signed by the IAEA, the EU Commission and the non-nuclear weapon states of the EU (INFCIRC/193), in addition to the national Nuclear Energy Act and Decree. The EU Commission also has its own safeguards system that is based on the European Atomic Energy Community (Euratom) Treaty. As regards safeguards arrangements, the relevant changes during the current operating licence period include the EU regulation concerning the control of dual-use items (Council Regulation EC No 1334/2000), the new Commission Regulation on the application of safeguards (302/2005), and the additional protocol (INFCIRC/193a8) relating to the Safeguards Agreement signed by the non-nuclear weapon states of the EU, the Euratom and the IAEA. The reports relating to the Loviisa Nuclear Power Plant required by the additional protocol have been submitted to the IAEA and partly to the EU Commission within the time limits specified in the agreement.

The practical safeguards procedures and arrangements of the Loviisa Nuclear Power Plant are presented in the plant's nuclear material accounting and control manual. The manual was last revised in 2006 on the basis of the experience gained, modifications performed at the plant and changes to international treaties. The most important changes in the plant's nuclear material safeguards relate to changes in international treaties and regulations (Commission Regulation No 302/2005) or entry into force of new treaties and regulation (the Model Protocol Additional). STUK approved the manual on 31 January 2007. Another manual relevant for nuclear safeguards is the Loviisa Nuclear Power Plant manual for international transfer, which was approved by STUK on 11 August 2005.

STUK has overseen the operations of FPH at the Loviisa Nuclear Power Plant concerning nuclear materials, and no deficiencies have been observed in the inspections. No deficiencies have been observed in the inspections performed by the International Atomic Energy Agency (IAEA) and the Commission (Euratom).

In summary, it can be stated that the necessary controls to prevent the proliferation of nuclear weapons have been appropriately arranged at the Loviisa Nuclear Power Plant.

13 Other requirements

In addition to the safety requirements specified in the Government Decisions, a few other requirements relating to the safety of a nuclear facility are laid down in the Nuclear Energy Act. This chapter discusses the applicant's financial and other prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations (section 20, paragraph 1, point 4 of the Nuclear Energy Act) to the extent falling within STUK's mandate. In addition, the compliance with the terms of the current operating licence of the Loviisa 1 and 2 nuclear power plant units is also assessed.

13.1 The applicant's financial prerequisites to engage in operations

The licence to operate a nuclear facility may be granted if *the applicant is otherwise considered to have the financial and other prerequisites to engage in operations safely…* (section 20, paragraph 1, point 4 of the Nuclear Energy Act).

The financial preconditions are primarily assessed by authorities other than STUK (mainly the Ministry of Trade and Industry). The licensee has financial obligations to, e.g., make provisions for the costs of nuclear waste management (for the related technical aspects, see section 11 above) and to cover the nuclear liability (see section 13.2 below). The financial position and business environment of the licensee also affects the safety of the plants, and STUK is therefore keeping track of the trends in investments made in Finnish nuclear power plants to improve safety, as well as organisational reforms and the number and competence of the personnel.

As the Finnish electricity market was deregulated some 10 years ago, there is relatively long practical experience of the operations of nuclear power companies in the deregulated market in Finland. FPH has adhered to a policy whereby the financial performance of operations is ensured by maintaining a high utilisation rate at the plant, meaning that even minor disturbances are to be avoided, which, in turn, requires that the plant units be kept in good condition. This requires investments that, for their part, contribute to the improvement of safety; proactive prevention of disturbances is always the primary goal in safety planning as well.

In the reports submitted to STUK in connection with the operating licence application, FPH undertakes to continuously improve the safety of the Loviisa Nuclear Power Plant in the future.

13.2 International treaties

The international concerning nuclear material safeguards and matters pertaining to nuclear liability, nuclear safety and nuclear waste fall within STUK's mandate. In addition, Finland is bound by the Treaty establishing the European Atomic Energy Community (Euratom) as well as by the obligations of the regulations and directives issued by virtue of it. These treaties have been incorporated into the national legislation.

Nuclear liability – that is, the liabilities and obligations arising from nuclear damage – is prescribed by the Nuclear Liability Act (484/1972). The Nuclear Liability Act takes into account the international treaties concerning Finland, which mainly set the minimum limits on the liabilities for nuclear damage. Raised liabilities can be enacted nationally, as is done in some countries.

The Nuclear Liability Act was last amended by an Act (493/2005) in which the amendments concerning, e.g., the amount of liability of the operator of a nuclear facility, provided in section 18, required by the Protocol amending the Paris Convention and the Protocol supplementing the Brussels Supplementary Convention were incorporated into the Nuclear Liability Act. In the amendment, the licensee's amount of liability to be covered by insurance is substantially increased to EUR 700 million (the present requirement is EUR 175 million Special Drawing Rights, which translates to approximately EUR 200 million). In addition, the revised agreements provide EUR 500 million from the host country and EUR 300 million from the States participating in an international Convention to be used for compensation, which amounts to EUR 1,500 million being available for compensating the consequences of an accident in the new contractual arrangement. Finland's amended Nuclear Liability Act also imposes unlimited liability on the licensee to compensate for damage arising from an accident occurring in Finland.

The Nuclear Liability Act amended by Act 493/2005 will enter into force by virtue of a Government Decree to be issued later. The entry into force of the new Nuclear Liability Act and the ratification of international conventions is intended to be executed simultaneously in all Member States.

The liability insurances taken out by FPH cover the separate plant units located on the plant site – that is, the Loviisa 1 and 2 nuclear power plant units and the reactor waste repository. The amounts insured currently fulfil the requirements laid down in section 18 of the Nuclear Liability Act. The Insurance Supervision Authority has assessed the liability insurances taken out by FPH and stated, by virtue of decision 23/499/2003, 15 January 2004, that they are acceptable. According to section 20, paragraph 2 of the Nuclear Energy Act, the operation of a nuclear facility is subject to the licensee of the nuclear facility having arranged indemnification regarding liability in the case of nuclear damage as prescribed.

STUK assesses the liability insurances relating transports in connection with each transport. The insurances have been appropriately arranged. In the case of FPH, the insurance cover has been provided by FPH taking out the required insurances with the Nordic Nuclear Insurance Pool.

The International Nuclear Safety Convention, SopS 74/1996 (INFCIRC/449), a collection of top-level nuclear safety principles legally binding the States that have joined the convention, was signed in 1994. Finland joined the convention right from the beginning, and it has been effective as of 1996.

Conversely, the International Nuclear Waste Convention, SopS 36/2001 (INFCIRC/546), a collection of top-level nuclear waste management principles legally binding the States that have joined the convention, was signed in 1997. Finland joined the convention right from the beginning, and it has been effective as of 2001.

The matters regulated by the International Nuclear Safety Convention and the International Nuclear Waste Convention are covered by the Finnish legislation, Government Decisions and regulations. The implementation of the conventions is reviewed at the meetings organised by the International Atomic Energy Agency (IAEA) every three years, for the purpose of which each member country must submit a report on its actions. The previous international review meeting in which the implementation of the International Nuclear Safety Convention was assessed was held in April 2005.

International treaties relating to nuclear material safeguards were discussed in section 12 above.

13.3 Compliance with the conditions of the current operating licence of the plant

The Government granted Imatran Voima Oy an operating licence concerning a nuclear installation by virtue of resolution 1/812/97 on 2 April 1998. The operating licence for the Loviisa 1 and 2 nuclear power plant units and related buildings required for nuclear fuel and nuclear waste management is valid until 31 December 2007. The trade name of Imatran Voima Oy registered with the Trade Register was changed to Fortum Power and Heat Oy on 1 March 1999. The following licence conditions are presented in the operating licence.

By virtue of the licence issued with this decision, the licensee is allowed to possess, fabricate, handle, use and store nuclear waste and nuclear material as well as other nuclear substances at the plant site as follows:

- *spent nuclear fuel produced in connection with the operation of the Loviisa Nuclear Power Plant in plant unit Loviisa 1 and Loviisa 2 and in the spent fuel storages a total of 610 tons of uranium,*

- *fresh nuclear fuel needed for the operation of the Loviisa Nuclear Power Plant and nuclear material already existing at the plant site, as well as other substances, components and equipment in the import of which the regulations provided by the Nuclear Energy Act and Nuclear Energy Decree have been complied with,*
- *3000 m^3 of solid reactor waste produced in connection with the operation of the Loviisa Nuclear Power Plant in the storage and on the plant site, as well as 2400 m^3 of liquid reactor waste in the liquid waste storage and in the solidification plant.*

The Radiation and Nuclear Safety Authority shall approve the extension of the spent fuel storage and the continuation plans for the liquid reactor waste solidification facility, as well as their construction and commissioning.

Only the spent fuel produced in connection with the operation of the plant itself is being possessed, handled, used and stored at the Loviisa Nuclear Power Plant. All spent fuel produced at the plant during the operating licence period is possessed at the Loviisa 1 and 2 nuclear power plant units or stored in spent fuel storage facilities. The amount of spent fuel at the plant site has remained below 610 tonnes of uranium throughout the entire operating licence period: on 31 December 2005 the amount was 379 tonnes, and upon termination of the operating licence period on 31 December 2007 the amount is estimated to be 428 tonnes.

Only the fresh fuel needed for the operation of the plant itself is possessed, handled, used and stored at the Loviisa Nuclear Power Plant. The regulations laid down in the Nuclear Energy Act and Decree have been complied with in the import of all nuclear materials, components and equipment present on the plant site.

Similarly, only the solid and liquid reactor waste produced in connection with the operation of the plant itself is possessed, handled, used and stored at the Loviisa Nuclear Power Plant. The amount of solid reactor waste in the storage facilities and on the plant site has remained below 3,000 m^3 throughout the entire operating licence period: on 31 December 2005 the amount was 332 m^3, and at the end of the operating licence period on 31 December 2007 the amount is estimated to be 729 m^3. Part of the solid waste produced at the plant is disposed of in the reactor waste repository, at which point it falls within the operating licence conditions of the repository. The operating licence for the repository is valid until 31 December 2055.

The liquid waste has been stored in the liquid waste storage on the plant site. Since the commissioning of the solidification facility in 2007, only small amounts of liquid reactor waste are being stored pending solidification. Small amounts of solidified waste are stored at the solidification facility before the waste containers are transported into the reactor waste repository. The amount of liquid reactor waste has remained below 2,400 m^3 throughout the entire operating licence period: on 31 December 2005 the amount was 1,160 m^3, and at the end of the operating licence period on 31 December 2007 the amount is estimated to be 1,240 m^3.

The spent fuel storage of the Loviisa Nuclear Power Plant was expanded during the current operating licence period by constructing four additional pools. STUK approved the plan for expanding the storage, supervised the construction during 1997–2000 and approved the commissioning in May 2000 according to the respective operating licence condition. FPH has initiated a new project for increasing the capacity of the storage by procuring more compact fuel storage racks for the existing storage. The first compact storage racks were procured in 2007. STUK approved the plans relating to the project in 2006 and will oversee the commissioning of the new racks.

A solidification facility for liquid reactor waste has been constructed at the Loviisa Nuclear Power Plant during the current operating licence period. STUK approved the plans for the solidification facility, supervised the construction during 2004–2006, and is expecting to approve its commissioning in 2007 according to the respective operating licence condition.

In summary, it can be stated that the Loviisa Nuclear Power Plant has fulfilled the licence conditions defined in the current operating licence.

14 Summary

Sections 5 to 7 of the Nuclear Energy Act (990/1987) contain the following provisions on the safe use of nuclear energy:

Section 5, The use of nuclear energy, taking into account its various effects, shall be in line with the overall good of society;

Section 6, The use of nuclear energy must be safe; it shall not cause injury to people, or damage to the environment or property;

Section 6a, Nuclear waste generated in connection with or as a result of use of nuclear energy in Finland shall be handled, stored and permanently disposed of in Finland […]; and

Section 7, Sufficient physical protection and emergency planning as well as other arrangements for limiting nuclear damage and for protecting nuclear energy against illegal activities shall be a prerequisite for the use of nuclear energy.

A licence is required for the use of nuclear energy (section 8 of the Nuclear Energy Act). According to section 20 of the Nuclear Energy Act, the licence to operate a nuclear facility may be granted if:

1. *the operation of the nuclear facility has been arranged so that the protection of workers, the population's safety and environmental protection have been taken into account appropriately (sections 4 and 4.6 of the safety assessment);*
2. *the methods available to the applicant for arranging nuclear waste management, including the final disposal of nuclear waste and the decommissioning of the facility, are sufficient and appropriate (section 10);*
3. *the applicant has sufficient expertise available and, in particular, the competence of the operating staff and the operating organisation of the nuclear facility are appropriate (section 6.3.2);*
4. *the applicant is otherwise considered to have the financial and other prerequisites to engage in operations safely and in accordance with Finland's international contractual obligations (sections 12 and 13); and*
5. *the nuclear facility and its operation otherwise fulfil the principles laid down in sections 5–7.*

Operation of the nuclear facility shall not be started on the basis of a licence granted:

1. *until the Radiation and Nuclear Safety Authority (STUK) has ascertained that the nuclear facility meets the safety requirements set, that the physical protection and emergency planning are sufficient, that the necessary control to prevent the proliferation of nuclear weapons has been arranged appropriately, and that the licensee of the nuclear facility has, as provided, arranged indemnification regarding liability in case of nuclear damage (sections 3–13); and*
2. *until the Ministry of Trade and Industry has ascertained that provision for the cost of nuclear waste management has been arranged in accordance with the provisions of chapter 7.*

In this safety assessment, STUK has evaluated the realisation of those points that fall within its mandate.

With regard to section 20, paragraph 1, points 1–3 of the Nuclear Energy Act, the arrangements for the Loviisa 1 and 2 nuclear power plant units, and the related buildings and storage facilities required for nuclear fuel and nuclear waste management are sufficient and adequate in respect of safety for granting the operating licence.

With regard to section 20 of the Nuclear Energy Act, STUK states that the Finnish electricity market has already been open to competition for 10 years with no adverse effects in respect of the investments relating to the safety of the Loviisa Nuclear Power Plant having been observed. The Finnish legislation and the practices of the licensee concerning it are, to the extent falling within STUK's mandate, in accordance with international treaties.

No such factors on the basis of which the Loviisa Nuclear Power Plant could be deemed not to comply with the principles laid down in sections 5 to 7 of the Nuclear Energy Act have arisen in the course of supervisory activities carried out by STUK.

Relating to section 20, paragraph 2, point 1 of the Nuclear Energy Act, STUK states that the Loviisa Nuclear Power Plant meets the set safety requirements, with the reservations presented below. Further, STUK has ascertained that the physical protection and emergency planning at the Loviisa Nuclear Power Plant are sufficient, that the necessary control to prevent the proliferation of nuclear weapons has been appropriately arranged, and that the licensee of the nuclear facility has, as provided, arranged indemnification regarding liability in case of nuclear damage.

The design bases concerning the Loviisa Nuclear Power Plant were mostly laid down during the 1970s. The objective during the operation of the plant has been to continuously improve plant safety. Substantial modernisations have been carried out at the Loviisa Nuclear Power Plant since its commissioning, and extensive modifications have been implemented in several systems in order to improve safety.

Risk factors have been systematically identified and eliminated using probabilistic risk analysis (PRA) during the current operating licence period. Examples of such plant modifications include ensuring the cooling of reactor coolant pump seals as well as improvements to the plant residual heat removal and emergency cooling systems. Improvements to the containment systems for managing severe accidents were also implemented during the current operating licence period. However, the estimated risk of major release (the frequency of a release exceeding the severe accident limit set forth in section 12 of the Government Decision 395/1991) has not been significantly reduced because new accident sequences have been identified that are not included in the present severe accident management strategy. According to the latest updated analyses, the Loviisa Nuclear Power Plant meets the target value for core damage frequency set for old plants by the International Atomic Energy Agency (IAEA) but fails to meet the numerical design objectives set for new power plants by STUK in Guide YVL 2.8.

For nuclear power plants in operation, STUK has set a target to attain a safety level as high as reasonably achievable. It will be necessary to further continue the safety improvement measures during the future operating licence period. FPH has presented a long-term plan for reducing the accident and release risk, and for supplementing the existing PRA. STUK will monitor and supervise the implementation of the programme.

The application submitted by FPH for extending the operating licence to exceed the 30-year service life that served as the original design basis by 20 years is essentially based on the estimates made in the service life management programme. The service life management programme and the related know-how have been actively and systematically developed at the Loviisa Nuclear Power Plant since the beginning of the 1990s. With regard to mechanical components and structures imposing limits on the plant service life, the ageing phenomena identified through operating experience and research, as well as the analysis of their future development based on the international research results, have served as the starting point. The fatigue analysis of primary circuit components has been updated to correspond with the 50-year service life.

A number of improvements have been made at both nuclear power plant units to reduce the risk of brittle fracture in the reactor pressure vessel. The recovery heat treatment carried out at the Loviisa 1 nuclear power plant unit in 1996 recovered the fracture toughness characteristics of the most embrittled weld nearly back to the original level. According to the justification presented by FPH, the risk of brittle fracture can be sufficiently controlled until the end of the 50-year service life. On the basis of the currently valid safety analyses, the reactor pressure vessel has been approved for operation in the Loviisa 1 nuclear power plant unit until 2012 and in Loviisa 2 nuclear power plant unit until 2010. STUK is not currently aware of any obstacles of a principal nature for the continued operation of the reactor pressure vessels after 2012 and 2010. However, the continued operation life is subject to renewal of the analyses. FPH will estimate the need for further recovery heat treatments on the pressure vessels in connection with the preparation of a subsequent application concerning the use of pressure vessels. STUK will issue a decision on the further use after processing the applications received from FPH.

The ageing of electrical and I&C components inside and outside the containment of the Loviisa Nuclear Power Plant, as well as their cables and installations, will be monitored in connection with the regular inspections carried out during annual maintenances. STUK has required that the ageing management programmes for electrical and I&C systems and components be assessed on a regular basis and the annual reporting be improved in order to meet the requirements prescribed in the YVL guides. STUK will monitor the subsequent developments in connection with its oversight process.

The components installed in the protection and I&C systems of the Loviisa Nuclear Power Plant are old, mostly representing technology dating back to the 1960s and 1970s. The changes relating to the automation renewal project LARA have been commenced during 2006 as preparations for the first control room changes. The purpose of the project is to gradually renew the protection I&C systems, operational I&C systems and control room of the plant by the end of 2014. The new I&C systems are primarily based on programmable technology, which makes it possible to obtain more accurate information on the status of the monitored and controlled processes and I&C systems. The I&C functions will primarily remain unchanged. Most of the control functions will become screen-based. Old reactor and plant protection systems will be integrated into a single new reactor protection system. Two independent backup protection systems will be implemented for fault conditions in the reactor protection system: an automatic programmed and a manual hard-wired protection system. The automatic system covers the actuation of safety functions urgently required in cases of accidents, while the manual system covers the remaining functions. These two securing systems will make it possible to bring the plant into hot shutdown even in the event of complete loss of the actual reactor protection system. The approval of the automation renewal by STUK is progressing in stages. STUK has approved the conceptual design plan as the starting point for the automation renewal, as well as the conceptual design plans concerning functional changes.

The significance of a safety culture as an important factor affecting safety was widely acknowledged at nuclear power plants in the 1990s. The development of a safety culture is a continuous learning process. According to STUK's view, FPH aims at maintaining an advanced safety culture in accordance with requirements. However, the safety culture could be advanced in a more systematic manner with the help of experts in organisational research. In future, FPH must pay more attention in the monitoring and further improvement of the state of safety culture. STUK will monitor the subsequent developments of safety culture in connection with its oversight process.

The personnel of the Loviisa Nuclear Power Plant are well suited to their duties, as well as competent and trained. Both the anticipated changes in the long term and the requirements of the near future are considered in the human resource planning of the power plant. The readiness to react to changing resource needs exists even though the initiation or completion of some recruitment campaigns has been delayed. Special attention shall be paid to ensuring a sufficient number of available plant personnel during the future operating licence period.

The operating experience feedback at nuclear power plants is a continuing process for which sufficient resources and opportunities to pursue the related activities must be ensured. In particular, the identification of root causes of events and the timely execution of the respective corrective actions are of special importance. According to STUK's view, there remain needs for improvement in this area for FPH.

In the spring of 2006 the Ministry of Trade and Industry initiated a project for revising the nuclear energy legislation in cooperation with STUK. In connection with the project, a Government proposal to amend the Nuclear Energy Act, as well as the Government decrees on the amendment of the Nuclear Energy Decree and on general regulations for the safety of a nuclear power plant, physical protection concerning the use of nuclear energy, emergency preparedness arrangements at nuclear power plants and the safety of the disposal of nuclear waste, will be prepared. According to preliminary estimates, the changes concerning nuclear energy legislation are planned to enter into force at the beginning of 2008. The assessment concerning the renewal of the operating licence for the Loviisa 1 and 2 nuclear power plant units shall be carried out based on the currently effective legislation. However, the impact of the planned changes on the assessment has been considered below by assuming that the changes were already in effect.

The main emphasis in the changes planned to the Act is on transferring the basic requirements of Government Decisions and the Nuclear Energy Decree to the level of the Act, as well as those identified from the content of decree drafts issued as Government Decrees according to the new constitution. Since the majority of the basic requirements to be transferred are included in the Government Decisions and the Nuclear Energy Act currently in force, the planned changes to the legislation do not, according to the view of the Radiation and Nuclear Safety Authority, affect the assessment concerning the renewal of the operating licence for the Loviisa 1 and 2 nuclear power plant units.

The planned amendments to the Nuclear Energy Decree concern the transfer of regulation-level requirements to the Nuclear Energy Act with no changes to their content in accordance with the new constitution, as well as the revision of export and import regulations. Thus the planned amendments to the Nuclear Energy Decree would not change the assessment of the renewal of the operating licence for the Loviisa Nuclear Power Plant.

The objective of the renewal efforts targeted at the Government Decision level is to update the 10- to 16-year-old regulations so that the Government Decrees to be issued are up to date with regard to nuclear safety. The most important amendments to Government Decision 395/1991 currently in force would relate to severe accidents and handling of aircraft crashes, as well as organisational and safety culture issues in respect of which both technology and the level of requirements have advanced. Planned amendments to Government Decision 396/1991 on the Physical Protection of Nuclear Power Plants relate directly to the regulations that are to be included in the Nuclear Energy Act. Government Decision 397/1991 on the Emergency Preparedness of Nuclear Power Plants will be updated to reflect the amendments to the rescue legislation and operations concerning, in particular, the regional renewal of rescue operations and the initiation of emergency response centre operations. In addition, a few principal requirements from the guide level are also proposed to be transferred to the decree.

The planned amendments to the general regulations will revise the general requirements concerning nuclear safety in such a way that the currently operating nuclear power plants in Loviisa and Olkiluoto will no longer fulfil the requirements in all respects when the decrees enter into force. Therefore, a provision concerning tolerances with regard to the application of certain regulations to nuclear power plants in operation will be included in the Government Decree on the General Regulations on the Safety of Nuclear Power Plants. Similar provisions concerning tolerances with regard to nuclear power plants in operation are included in the current Government Decisions. It should be noted in this connection that a tolerance provision concerning the limit for the dose to an individual in the population arising as the result of postulated accidents is not intended to be included in the revised Government Decree on the Safety of Nuclear Power Plants. The current Government Decision 395/1991 does contain such tolerance provision. In connection with submitting the operating licence application, FPH has also submitted a clarification to STUK in which it is demonstrated that the 5 mSv dose limit for postulated accidents prescribed in section 11 of Government Decision 395/1991 is not exceeded. The status of all nuclear power plants either currently in operation or under construction in respect of the amended decree-level requirements will be assessed as a whole in connection with the preparation of the decrees in order to estimate the need for tolerance prescriptions, as well as at a later stage when the decrees have entered into force. For the plant units in operation at Olkiluoto, this will take place in connection with the periodic safety review to be carried out by the end of 2008, and for the plant units at Loviisa in connection with the separate review required to be carried by FPH by the end of 2008. For the Olkiluoto 3 nuclear power plant unit, the assessment will be carried out in connection with the processing of the operating licence application.

FPH has applied for an operating licence for the Loviisa 1 nuclear power plant unit until 31 December 2027, and for the Loviisa 2 nuclear power plant unit, as well as the related buildings and storage facilities required for nuclear fuel and nuclear waste management, until 31 December 2030. According to section 24 of the Nuclear Energy Act, the operating licence shall be granted fixed-term, and particular attention shall be paid to ensuring safety and to the estimated duration of operations. The nuclear energy legislation provides STUK with means to intervene in the use of nuclear energy if safety so requires. In this statement, STUK considers the operation referred to by the licence applicant to be safe and meets the requirements prescribed by legislation. The validity periods of the licences presented in the application by the applicant are the same as the estimated duration of operations. The operating licence periods applied for in respect of the plant units are in line with the decommissioning plan concerning the plant.

The spent fuel storage, liquid waste storage and solidification facility located in the area of the Loviisa Nuclear Power Plant are all dependent on the Loviisa 1 and 2 nuclear power plant units in terms of both administration and process technology. When the operation of the plant units is terminated, this will require that the operation of these facilities is made independent. The stage when the facilities are made independent will involve a need for a quite extensive safety review.

In conclusion, STUK's overall evaluation is that, with regard to matters falling within it's mandate, the prerequisites of sections 5 to 7 and section 20, paragraph 1, of the Nuclear Energy Act for granting an operating licence for the Loviisa 1 and 2 nuclear power plant units and the related buildings and storage facilities required for nuclear fuel and nuclear waste management have been met. In connection with the preparation of this statement, STUK has noted that the matters and arrangements referred to in section 20, paragraph 2, of the Nuclear Energy Act are in order.

If the operating licence is granted for the period indicated in the application, STUK proposes that the licensee be required to carry out two periodic safety reviews for the Loviisa Nuclear Power Plant during the licence period as referred to in Guide YVL 1.1; the first safety review shall be submitted to STUK for approval by the end of 2015, and the second safety review by the end of 2023. STUK considers it important that the first overall safety assessment be conducted soon after the completion of the extensive plant modifications and safety improvement measures to be carried out at the beginning of the upcoming licence period. Further, for the purposes of effective operation of STUK, it would be beneficial if the extensive safety assessments of the Loviisa and Olkiluoto nuclear power plants were not processed simultaneously. The operating licence for the Olkiluoto Nuclear Power Plant is valid until 31 December 2018. The continuation of the operation of the reactor pressure vessels will be assessed in connection with the periodic safety reviews. The execution of periodic safety reviews should be included as one of the licence conditions.