An assessment by the Radiation and Nuclear Safety Authority on the periodic safety review of Loviisa NPP

Table of Contents

1 Introduction

The Government has, in its decision 6/330/2006 (26 July 2007), granted to Fortum Power and Heat Oy's Loviisa Nuclear Power Plant a licence, as referred to in Section 20 of the Nuclear Energy Act (YEL, 990/1987), to operate and use the nuclear power plant units Loviisa 1 and Loviisa 2 as well as the buildings and storages necessary for the management of nuclear fuel and nuclear waste.

One condition for the operating licence is that the licensee must prepare a comprehensive safety assessments for the Radiation and Nuclear Safety Authority (hereinafter “STUK”) by the end of 2015 and 2023, including interim assessments of the power plant's safety and emergency plan.

Section 7 e of the Nuclear Energy Act states that *The overall safety of the facility shall be assessed at regular intervals*.

The more specific regulations concerning the content of the assessments are included in the STUK Guide YVL A.1 Regulatory oversight of safety in the use of nuclear energy.

If a licence has been granted for a significantly longer term than ten years, STUK requires, pursuant to para. 352 of Guide YVL A.1, that the licensee carry out a periodic safety review of the facility and request its approval from STUK within approximately ten years of receiving the operating licence or of conducting the previous periodic safety review.

According to Section 4.8 of Guide YVL A.1, STUK will make an approval decision on the separate periodic safety review required of the licensee and attach to it its own safety assessment. The safety assessment is a summary of STUK’s inspections and reviews of various issues and documents, as well as the results of continuous oversight.

In accordance with para. 353 of Guide YVL A.1, STUK requires that safety reports and descriptions corresponding to those submitted in the context of applying for operating licence renewal be delivered to STUK for the periodic safety review. These are listed separately in the Guide's Annex A, Section A.4:

- A37. The documents referred to in section 36 of the Nuclear Energy Decree.
- A38. Description demonstrating compliance with the requirements specified in Government Decrees 734/2008, 736/2008, 716/2013, 717/2013 and applicable YVL Guides.
- A39. Description of the reassessment of the design bases of the facility site
- A40. Summary of the previous periodic safety review – the action plan prepared in connection with it and the implementation status of the actions
- A41. Description of the facility's ageing and ageing management with regard to the remaining operating licence period
- A42. Description of the environmental qualification equipment with regard to the remaining operating licence period
- A43. Summary of renewed safety analyses
- A44. Summary of the plant’s safety indicators
- A45. Description of the licensee’s safety culture and safety management
- A46. Summary of plant procedures

A47. Summary of the plant's radiation protection arrangements
A48. Summary of the waste management procedures and decommissioning of the facility
A49. Summary of the plant's operating experience feedback and research activities and plant improvements
A50. Summary of fulfilment of the requirements laid down in section 20 of the Nuclear Energy Act and compliance with the conditions of the operating licence
A51. Summary of the period safety review and action plan for plant safety improvements carried out pursuant to Section 7 a of the Nuclear Energy Act, complete with timetables

The periodic safety review is mainly based on the following documents referred to in Section 36 of the Nuclear Energy Decree (161/1988):

1) a final safety analysis report;
2) a probabilistic risk assessment;
3) a classification document, which shows the classification of structures, systems and components important to the safety of the nuclear facility, on the basis of their significance with respect to safety;
4) a quality management programme for the operation of the nuclear facility;
5) 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;
6) a summary programme for period inspections;
7) plans for the arrangements for security and emergencies;
8) a description of how to arrange the safeguards that are necessary to prevent the proliferation of nuclear weapons;
9) administrative rules for the nuclear facility;
10) a description of the baseline environmental radiation conditions and an environmental radiation monitoring programme for the vicinity of the nuclear facility;(31 October 2013/755)
11) a description of how safety requirements are met(17 December 2015/1532)*;*
12) a programme for the management of ageing; and(17 December 2015/1532)
13) a plan for the decommission of the nuclear facility(17 December 2015/1532)

The documents shall be kept up-to-date at all times, and the updated versions shall be submitted to STUK on a regular basis. Upon renewal of the operating licence or in connection with a periodic safety review, the documents may be submitted to STUK only insofar as they have been amended since the previous updates. Furthermore, the licensee shall provide a summary of the most significant changes to the documents since the previous operating licence was granted and a description of the up-to-dateness of the documents. The documents are addressed in Appendix 2.

Instructions for carrying out the periodic safety review are provided in the IAEA Safety Standards Series, Specific Safety Guide No SSG-25, Periodic Safety Review of Nuclear Power Plants.

1.1 Documents delivered by Fortum

Fortum Power and Heat Oy (hereinafter "Fortum") submitted the documentation related to the periodic safety review to the Radiation and Nuclear Safety Authority (hereinafter "STUK") as separate document packages in four phases:

1. As an enclosure to letter LO1-A4-17628, 27 February 2014, the project plan and some of the clarifications related to Guide YVL A.1, Annex A4, Sections A37, A40, A41, A43, A45, A46 and A50 for information. (STUK document number 1/A42213/2014)
2. As an enclosure to letter LO1-A4-17995, 16 September 2014, the updated project plan and some of the clarifications related to Guide YVL A.1, Annex A4, Sections A37, A39, A40, A41, A42, A44, A45, A46, A47, A49, A50 (3/A42213/2014) for information
3. As an enclosure to letter LO1-A4-18117, 22 December 2014, the updated project plan and some of the clarifications related to Guide YVL A.1, Annex A4, Sections A37, A38, A41, A42, A43, A45, A46, A48, A49, A50 (4/A42213/2014) for information
4. As an enclosure to letter LO1-A4-18360, 15 April 2015, the updated project plan for information and, for approval, the clarifications related to Guide YVL A.1, Annex A4, Section A51 concerning the summary for the periodic safety review and the action plan to improve plant safety by 2023. (2/A42213/2015).

STUK issued a separate request for clarification 1/A42213/2014 (16 June 2014) for document package 1, based on which the licensee updated the documents in packages 2 and 3.

After this, STUK inspected packages 2 and 3 and prepared joint request for clarification 3/A42213/2014, 4/A42213/2014 (10 June 2015), which demanded the following additions to the documents:

1. Fortum shall provide a clarification of the number of necessary changes that should have already been incorporated into the FSAR and the chapters to which these apply.
2. Fortum shall present the design bases for the emergency control room and provide grounds for how the requirements laid down in Government Decree 717/2013 and Guide YVL B.1 are met.
3. Fortum shall provide a clarification that describes the follow-up measures to be implemented to rectify the issues that remained open after KLUPA [previous renewal of the operating licence]. Furthermore, Fortum shall justify why some of the measures in the follow-up list will not be implemented.
4. Fortum shall indicate how the safety-improving plant changes that were promised in conjunction with the LARA project and the previous KLUPA licence renewal will be implemented.
5. Fortum shall submit a clarification detailing the grounds and means for its measures to ensure the availability of spare parts for the ageing TB, TK and SUZ frequency converters, and the maintained operability of the converters until the next periodic safety review and the end of the plant units' planned service life.
6. Fortum shall present a clarification of the possible technical means and/or changes to operating methods that will achieve a substantial improvement in the level of safety to reduce the brittle fracture risk of the reactor pressure vessel. Simply preparing safety analyses is not enough.

7. The PSR2015 documentation shall be supplemented with an account indicating that the safety-critical devices have been qualified to perform their designed tasks at least until the next periodic safety review. Where the requirement is not be met, the qualified time shall be provided and the acceptability of the deviations shall be justified.
8. Fortum shall submit a summary report on the results of the electrical grid transient analyses conducted during the operating permit period and the effects on the operability of the plant units' electrical systems and devices. Furthermore, the report shall present the voltage and frequency requirements for the facility's internal consumption grid. The report shall also list the electrical systems and devices for which the anti-transient qualification process is incomplete as well as the additional qualifications plans and schedules concerning the systems and devices in question.
9. Fortum shall supplement the instructions intended for the management of severe accidents with measures to prevent the excessively rapid feeding of water onto the melt pool. The instructions shall also be amended with the measures by which the process of feeding water onto the melt pool can be initiated carefully.
10. Fortum shall submit to STUK for information an up-to-date containment fragility curve, indicating the probability of containment damage as a function of pressure.

The updates necessitated by requirements 1-5, 7-8 and 10 were to be provided for information by 15 November 2015, the update based on requirement 6 by 31 December 2016, and the update compliant with requirement 9 by 15 September 2017.

Fortum delivered the following document packages on the basis of requirements 1-5, 7-8 and 10:

5. Document package 5 as an enclosure to letter LO1-A4-18800, 13 November 2015 (7/A42213/2015):
    5.1. Description of the necessary changes to the FSAR
    5.2. Protection of the LO1 emergency control post against unlawful activities
    5.3. A38: Description detailing the fulfilment of the requirements laid down in Government Decree 717/2013 and Guide YVL B.1 – Description of the emergency control posts and their functions, version 1.2
    5.4. Summary of the previous periodic safety review, version 1.2
    5.5. Description of ensuring the availability of spare parts for and the operability of the TB, TK and SUZ frequency converters
    5.6. Description of the qualification of the I&C equipment, version 2.0
    5.7. Summary of the transient analyses
6. Document package 6 as an enclosure to letter LO1-A4-19007, 22 February 2016 (2/A42213/2016):
    6.1. Containment overpressure capacity for severe accident loads, version 2.0
    6.2. Hydrogen management strategy, level 2 in PRA.

As an enclosure to letter LO1-A4-19729, 28 December 2016 (4/A42213/2016), Fortum submitted to STUK a description pursuant to requirement 6 of the planned measures to increase the brittle fracture margins of the reactor pressure vessels.

The licensee provided STUK with a separate description of how the requirements of the Government Decree on Security in the Use of Nuclear Energy (VNA 734/2008) are met at the Loviisa 1 and 2 nuclear power plant units. Based on its review, STUK requested additional clarifications, which Fortum delivered by 31 December 2015. By the end of 2016, Fortum also provided a description on the utilisation of PRA in the analysis of the security arrangements.

In addition to the above, STUK has, based on its review, issued decision 3/A42213/2016 (9 November 2016), which requires Fortum to submit to STUK a description detailing how the operability of the transfer machine in the interim storage for spent fuel will be ensured when the storage exceeds its designed service life, and the measures employed to prepare spent fuel for transport to the final disposal site.

STUK has also requested the Ministry of the Interior to provide statements on the sufficiency of the Loviisa NPP's safety and emergency arrangements in accordance with Section 37 of the Nuclear Energy Decree. The statements have been taken into account in Chapters 7 and 8 of the safety assessment in Appendix 1 and the items 8 and 9 in the Appendix 2 review of the documents prescribed in Section 36 of the Nuclear Energy Decree.

1.2 Provisions concerning safety

1.1.1 Nuclear Energy Act and STUK's general safety regulations

The following is stipulated in the Nuclear Energy Act with regard to safety:

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 nuclear energy must be safe, it, shall not cause injury to people, or damage to the environment or property.*

Section 6 a *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.*

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 aspects within STUK's sphere of operations that are related to the operation of the Loviisa 1 and 2 nuclear power plant units. The matters addressed in the document and their assessment criteria are presented in the nuclear energy and radiation safety legislation and the regulations issued based thereon.

In conjunction with its revision in 2008, the Nuclear Energy Act was supplemented with more detailed safety-related requirements in Sections 7 a–p. Thereafter, specifications and additions have been made to many parts of the Act with regard to security arrangements and related authorisations, and the Act has been refocused to provide better coverage for final disposal activities.

The requirements laid down in the Nuclear Energy Act with regard to the safety of the use of nuclear energy, security and emergency arrangements, and waste management have been specified in Government Decrees (VNA) issued by virtue of Section 7 q of the Nuclear Energy Act. The Government Decrees concern the following:

- Safety of nuclear power plants (Government Decree 717/2013)

- Security in the use of nuclear energy (Government Decree 734/2008)
- Emergency arrangements of a nuclear power plant (Government Decree 716/2013)
- Safety of disposal of nuclear waste (Government Decree 736/2008).

The amendments to the Nuclear Energy Act that came into force in early 2016 targeted this subsection and (by the authority bestowed in Section 55) added the issuing of general safety regulations to STUK's range of duties. In practice, this means that, at the same time as the amendments to the Nuclear Energy Act, new STUK regulations were implemented on

- the safety of a nuclear power plant (STUK Y/1/2016),
- the emergency arrangements of a nuclear power plant (STUK Y/2/2016),
- security in the use of nuclear energy (STUK Y/3/2016), and
- the safety of disposal of nuclear waste (STUK Y/4/2016),

which replace the aforementioned Government Decrees.

Some of the regulations in the Government Decrees, such as the dose limits, were moved into the Nuclear Energy Decree (161/1988).

Fortum has not complied with the effective provisions in delivering the periodic safety review as it has taken into account the YVL Guides published in November 2013 and implemented in the autumn of 2015 but not the new STUK regulations that came into force on 1 January 2016.

STUK has evaluated the fulfilment of the new regulations in connection with their implementation, based on the clarifications provided by the licence holder and by comparing the differences between the STUK regulations and the Government Decrees effective in 2015. The differences between the STUK regulations and Government decrees were not found to be significant from the perspective of periodic safety review.

1.1.2 STUK's detailed safety requirements

Pursuant to Section 55(2)(3), STUK lays down more detailed safety requirements concerning the implementation of the level of safety required by the Nuclear Energy Act and publish them in the collection of STUK regulations (YVL Guides). According to Section 7 r of the Nuclear Energy Act, *the safety requirements of the Radiation and Nuclear Safety Authority (STUK) are binding on the licensee, while preserving the licensee's right to propose an alternative procedure or solution to that provided for in the regulations. If the licensee can convincingly demonstrate that the proposed procedure or solution will implement safety standards in accordance with this Act, the Radiation and Nuclear Safety Authority (STUK) may approve the procedure or solution by which the safety level set forth is achieved.*

STUK is continuously assessing the currency of the nuclear safety provisions and their consistency with the international regulatory developments, especially within the framework of the International Atomic Energy Agency (IAEA) and the Western European Nuclear Regulators Association (WENRA). In updating its guides, STUK takes into account the developments in the technology and research in the field of nuclear and radiation safety, as well as foreign and domestic operating experiences.

The purpose of preparing the YVL Guides is to ensure the continuous improvement of safety. The provisions are developed to match the level that can be reached at least at new nuclear power plants. For this reason, it is not possible or even purposeful to consider the new YVL Guides binding to all operating facilities.

The design bases concerning the structures, systems and components of the Loviisa 1 and 2 nuclear power plant units were primarily issued in the 1970s. Although the safety of the plant units has been improved with numerous modifications, it is impossible to bring the old plant units in line with all the requirements imposed on new nuclear power plant units.

In order to specify the area of application, a decision determining the area for operating or incomplete nuclear power plants is prepared based on each new or updated YVL Guide. The implementing decision presents in detail the measures that the licensee, for example, must take as a result of the Guide. The Guide does not alter STUK's decisions made before its entry into force unless otherwise stated by STUK. On the other hand, STUK requires that the need and opportunities for increasing the level of safety be assessed based on the new YVL Guides. The assessment can be used as a basis for demanding more measures to improve safety, when said measures are deemed to be warranted.

Extensive efforts have been carried out at the same time as this periodic safety assessment, involving the implementation of the majority of the new YVL Guides at the Loviisa 1 and 2 nuclear power plant units in the autumn of 2015. The implementation work at STUK has been conducted separately from the periodic safety assessment of Fortum's operating licence.

As a result of the implementation, the development measures under which the YVL Guides will be implemented as a basis for requirements have been defined in the statements issued by the licensee. Therefore, most of the significant matters related to safety requirements have already been covered in conjunction with the implementation of the YVL Guides. The measures have been taken into consideration in this safety assessment, and they will be consolidated with the measures of the periodic safety review in order to ensure their consistency and management.

1.3 Structure of the safety assessment

This safety assessment covers matters related to nuclear safety in the order in which they are presented in the Radiation and Nuclear Safety Authority regulation STUK Y/1/2016. Matters concerning nuclear waste management have been compiled under a separate chapter. Furthermore, the assessment will cover matters related to the Radiation and Nuclear Safety Authority’s regulations STUK Y/3/2016 (security in the use of nuclear energy) and STUK Y/2/2016 (emergency arrangements), handling of nuclear materials and implementation of the conditions connected to the facility's current operating licence. The safety assessment also addresses any prerequisites laid down in Section 20 of the Nuclear Energy Act that have not yet been incorporated in the current STUK Regulations but whose assessment falls within STUK's authority.

The text of the relevant STUK Regulation is presented in italics at the beginning of each section. Direct quotes from other provisions are also italicised. The practical interpretations of the requirements in the STUK Regulations will be described briefly where necessary, along with any essential specifications presented in the YVL Guides. Each section evaluates how the requirements related to it have been implemented at the Loviisa 1 and 2 nuclear power plant units. The evaluation specifically focuses on whether or not "... 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(2)(1)).

A summary of the inspection results is presented at the end of the safety assessment.

2 General safety (STUK Y/1/2016 – Chapter 2)

2.1 Demonstration of compliance with safety requirements (Section 3)

The safety of a nuclear power plant shall be assessed when applying for a construction license and operating license, in connection with plant modifications, and at Periodic Safety Reviews during the operation of the plant. It shall be demonstrated in connection with the safety assessment that the nuclear power plant has been designed and implemented in a manner that meets the safety requirements. The safety assessment shall cover the operational states and accidents of the plant. The safety of a nuclear power plant shall also be assessed after accidents and, whenever necessary, on the basis of the safety research results.

Nuclear power plant safety and the technical solutions of its safety systems shall be assessed and substantiated analytically and, if necessary, experimentally.

The analyses shall be maintained and revised as necessary, taking into account operating experience from the plant itself and from other nuclear power plants, the results of safety research, plant modifications, and the advancement of calculation methods.

The analytical methods employed to demonstrate compliance with the safety requirements shall be reliable, verified and qualified for the purpose. The analyses shall demonstrate the conformity with the safety requirements with high certainty. Any uncertainty in the results shall be considered when assessing the meeting of the safety requirements.

2.1.1 Operational occurrence and accident analyses

The requirements that specify the transient and accident analyses in Section 3 of Regulation STUK Y/1/2016 are set forth in Guide YVL B.3.

The purpose of the analyses is to demonstrate the facility's capability to withstand various transients and accidents safely. In accordance with Guide YVL B.3, the analyses must cover transients and accidents that are of different types in terms of their nature and severity. The progress of the transients and accidents must be analysed starting from the initiating event and ending in a safe state.

Fortum has reviewed all operational transient and accident analyses included in Chapter 14 of the FSAR and revised them where the changes made at the facility have required it.

Shortly after the periodic safety review, the facility will go through an extensive I&C update and other changes, which will also necessitate updates to these analyses. In this context, Fortum has, therefore, not found it necessary to rework any such analyses that must eventually be updated due to the aforementioned modifications. Guides YVL B.3 and YVL B.4, which entered into force during the current operating licence period, separate the initiating events into different categories and present the assumptions used for preparing the analyses and the approval criteria for the results.

In the context of the periodic safety review, Fortum redid the analyses, which were either very old or not dependent on the current I&C update. Among the changes that have taken place at the facility, the commissioning of a new type of fuel, among other things, has brought about the need to update the accident analyses. In addition to this, Fortum has updated outage analyses as the coverage of the current analysis tools has been expanded to also cover outage conditions.

Calculation tools that have primarily been developed in Finland have been used to analyse the normal operation, transient and postulated accidents. The qualifications have been conducted to an extent that corresponds to the internationally accepted level, mainly by conducting reference calculations against results calculated with various methods and test equipment. Due to the uncertainty related to the accuracy of the calculation methods, it is essential that sufficient safety margins are used when assessing the fulfilment of the analyses' approval criteria.

The analyses described in the FSAR and the related topical reports indicate and justify the initial values and assumptions used that affect the end results, as well as the sensitivity studies performed. The sensitivity studies are necessary to assess and reduce the uncertainties usually related to the calculation methods and assumptions. STUK has reviewed the new analyses submitted to it and the calculation methods employed, and commissioned verification analyses of certain cases.

The analyses in the FSAR cover anticipated operational occurrences, the postulated accidents used as design bases for the safety systems, and severe reactor accidents. As a new chapter, the safety assessment now includes analyses of design extension conditions.

The accident analyses that assess the operability of the safety systems are also covered in Chapter 4.3 with regard to the reactor core and fuel and in Chapters 3.3 and 3.4 with regard to radiation safety.

The implementing decision of Guide YVL B.3 (13/0010/2015, 25 September 2015) requires that the design extension conditions (DEC A and B i.e. common cause failures and combinations of failures) be submitted by the end of 2018. The implementing decision of Guide YVL B.1 (11/0010/2015, 25 September 2015) lays down requirements for identifying design extension conditions (DEC A, B and C; rare external events in addition to the previous conditions) and preparing for them (DEC C).

The conclusion is that the transient and accident analyses concerning the Loviisa NPP have been conducted in compliance with Section 3 of Regulation STUK Y/1/2016 by taking into account the implementing decision of Guide YVL B.3 for the Loviisa NPP.

2.1.2 Probabilistic risk assessments

In this context, the term probabilistic risk assessment (PRA) refers to the quantitative analyses of threats affecting the safety of a nuclear power plant, accident sequences and adverse consequences (emission amounts of radioactive substances and the resulting radiation doses), as specified in Section 1 of the Nuclear Energy Decree (161/1988) and Section 2 of Regulation STUK Y/1/2016.

The detailed requirements related to the PRA are presented in Guide YVL A.7.

The PRA of a nuclear power plant and the qualitative and quantitative studies that complement it form the foundation for nuclear safety-related risk management. In the risk management relating to the safety of nuclear power plants, PRA supports decision-making. Nuclear power plant risk management covers the design, construction, commissioning, operating and decommissioning phases.

PRA is used to systematically assess the occurrence of transient and the implementation of the required safety functions, with due consideration to the failure and error possibilities of each system and their probabilities. Transients and accidents may result from equipment failures, fires, internal and external floods, extreme weather conditions, earthquakes and human error, for example. PRA can be used to identify dependencies between systems that might otherwise go unnoticed. Level 1 is the first part of PRA. It determines the accident sequences leading to core damage and estimates their probability (core damage frequency, CDF). Level 2 is the second part of the PSA. It analyses the amount, probability and timing of a release of radioactive substances from the nuclear power plant to the environment (large release frequency, LRF). The quantitative criteria for level 1 and 2 results, i.e. core damage frequency and large release frequency, are laid down in Guide YVL A.7. A large release is a release that exceeds the severe accident limit value stipulated in Section 22 b of the Nuclear Energy Decree (161/1988).

The nuclear power plant's PRA analyses events that can be initiated in any of the plant's normal operating states (power operation, low power and shutdown states and the transition sequences in between). The licensee must keep the PRA continuously up-to-date and specify it based on operating experience, plant modifications, new research results and developments in calculation methods in order to ensure that the results depict the prevalent situation at the facility. In this context, safety has been assessed based on the risk analyses presented in conjunction with the period risk assessment, which correspond to the facility's condition and situation at the end of 2014.

In the analysis of the PRA, the initiating event is an individual event that causes an operational transient and requires the safety functions of the facility to be initiated. The initiating event can be an internal or external event of the facility. The PRA does not address acts of sabotage as initiating events.

Internal initiating events include operational occurrences initiated by equipment failures, falling of heavy loads, loss of off-site power supply or human error. Flooding events include internal flooding caused by pipe or vessel breakage resulting in an operational occurrence and losses of equipment important to safety. Fire events include fires in the plant area and switchyard that cause and operational occurrence. According to the risk analyses presented in connection with the periodic safety review, internal hazards at the

Loviisa NPP contribute to approximately two-thirds in total of the core damage frequency and large release frequency. The results of the internal hazard PRA are described in further detail in Chapter 4.7 Protection against internal hazards, which covers Section 15 of Regulation STUK Y/1/2016.

External hazards are operational occurrences caused by weather phenomena and earthquakes as well as disturbances in the environment due to human action. The weather phenomena examined in the PRA include extreme temperatures of the atmosphere and sea water, variations in sea level, wind speed, snow and rain fall, lighting and electromagnetic disturbances. Phenomena that cause a blockage hazard in the sea water system, such as frazil ice (sudden freezing of supercooled sea water), clams, jellyfish and dense algae growth are also covered by the PRA of external hazard. In addition to this, the Loviisa PRA analyses the impacts of an offshore oil spill in the water intake of the sea water system. External fires or explosions have not been estimated cause a substantial hazard to the facility as there are no storages of flammable or explosive substances or related transport routes in the vicinity. In addition to individual phenomena, the effects of essential combined phenomena, such as strong winds and heavy snowfall, have been analysed. According to the risk analyses presented in connection with the periodic safety review, external hazards contribute to approximately one-third in total of the core damage frequency and large release frequency. The results of the internal hazard PRA are described in further detail in Chapter 4.6 Protection against external hazards, which covers Section 14 of Regulation STUK Y/1/2016. Furthermore, off-site conditions are covered to a limited degree Chapter 4.1, which covers Section 8, i.e. the safety of the location.

The first version of the Loviisa NPP's PRA was prepared in the 1980s. Since then, the risks caused by internal and external hazards have been identified and mitigated through numerous plant modifications and guide updates. The total result values of the risk assessments have also decreased in conjunction with the specification of the analyses. The PRA has been kept continuously up-to-date, and it has been expanded to cover new initiating events and operational states. Currently, the Loviisa 1 unit's level 1 PRA encompasses the various areas of internal and external hazard while the level 2 PRA covers the areas of external hazards, with the exception of seismic events. The latest expansions during the current operating licence period were the fire analysis in the level 2 PRA and the risk assessment of the reactor hall loading pool. In addition to the above, the first PRA that describes the Loviisa 2 unit specifically was drawn up partially based on data concerning the Loviisa 1 unit. The PRAs of the plant units differ from each other in terms of fires, loss of instrument space cooling and the falling of heavy loads. There are only minor differences between the units with regard to the effects of external hazards. Plant modifications and specified analyses related to internal and external hazards are covered in more detail in connection with Chapters 4.6 and 4.7, which address the threats in question.

A national safety analysis of external threats and extensive EU stress tests were initiated rapidly after the Fukushima Dai-ichi incident, which took place in March 2011. The analyses did not identify new external threats or the need to take immediate action, but a decision was made to improve the plant against the loss of the ultimate heat sink and sea water flooding, and to increase the plant's self-sufficiency in the event that power supply is lost. Furthermore, the analysis necessitated a more detailed assessment of the risks related to the loss of fuel pool cooling. The assessment of the reactor hall fuel pool (loading) has now been included in the plant unit PRA, but the PRA for the interim storage of spent fuel is yet to be prepared. In conjunction with the implementation of Guide YVL A.7 (8/0010/2015, 25 September 2015), STUK required that the risk assessment on the interim storage for spent fuel must be drawn up and submitted to STUK by the end of 2018. Although the actual risk assessment does not need to be delivered until later, the facility has already improved the capabilities of securing the cooling of spent fuel in extraordinary situations.

Fortum is involved in the safety research in the field by engaging in cooperation with the VTT Technical Research Centre of Finland and the Finnish Meteorological Institute, for example. The occurrence of extreme weather phenomena and the effects of climate change have been explored in research programmes since the beginning of the 1990s, and as of 2007, related research has also been conducted under the national research programmes on nuclear power plant safety (SAFIR programmes). Fortum has also been analysing earthquake risks since the beginning of 1990s and addressed them in the SAFIR programmes since 2011.

Fortum updates the PRA's reliability data on an annual basis based on its own operating experiences and, if necessary, supplements this data with applicable international statistics. Furthermore, Fortum has implemented numerous PRA applications that support risk-informed decision-making and resource allocation, such as the risk-informed in-service inspection programme for piping (RI-ISI, Risk Informed In-Service Inspection).

The current practices oblige Fortum to provide STUK with an updated PRA report and computer model at the end of each year. These take into account any plant modifications during the year, failure data updates based on operating experience and the changes necessary to develop the model. STUK then inspects the documentation and, where necessary, presents Fortum with its observations and requirements for further developing the model and improving the facility's safety.

Fortum has kept the Loviisa PRA up-to-date and developed the related analyses. The PRA covers all of the facility's operational states and essential events that may threaten safety. The risk assessments have considered both the facility's own operating experiences as well as those of external parties. In addition to these, the Loviisa NPP has conducted safety improvements and developed the guidelines and instructions The prediction presented by Fortum in 2006 in conjunction with the renewal of the operating licence, which anticipated a decrease in core damage frequency and large release frequency, has been realised thanks to the plant modifications conducted during the licence period and the specification of the models. All the most significant plant modifications presented in connection with the renewal have not been implemented, but the risk has decreased as a result of the other improvements. The updates and plant improvements will be continued, and STUK will monitor their implementation and the PRA updates. STUK pays special attention to the realisation of the safety improvements and the justifications for the changes in the improvement plans.

The Loviisa NPP meets the core damage frequency target set by the IAEA for old facilities but not the numeric design targets laid down in Guide YVL A.7 for new nuclear power plants with regard to core damage frequency and large release frequency. STUK's goal for operating nuclear power plants is to reach a safety level that is as high as practically possible.

Fortum states that fire risks are at an acceptable level. In STUK's view, the fire risk analyses are acceptable overall, but the significance of the steel-coated fire-resistant cables on the galvanised shelves to plant safety has been under prolonged scrutiny. This issue requires the assessment process to be concluded and a specification to be made in the fire PRA, in addition to determining any possible measures based on the results. The issue will be incorporated into STUK's monitoring of the period safety review analyses.

The conclusion is that Fortum has justified safety and the related technical solutions at the facility in compliance with Section 3 of Regulation STUK Y/1/2016. Going forward, Fortum must continue the measures to reduce risks at the facility and develop the probabilistic risk analysis of the Loviisa 2 unit in a manner that gives due consideration to the plant unit-specific initial data. STUK has already required the preparation of a risk assessment for the spent fuel interim storage in conjunction with the implementation of the new YVL Guides.

2.2 Safety classification (Section 4)

The safety functions of a nuclear power plant shall be defined and the related systems, structures and components classified on the basis of their safety significance.

The actions taken on systems, structures and components that implement safety functions or are related to them in order to ascertain the requirements set for them and their compliance must be commensurate with the safety class of the location.

The detailed requirements related to Section 4 of Regulation STUK Y/1/2016 are presented in Guide YVL B.2.

The safety classification of the Loviisa NPP's systems and equipment has been presented in a continuously updated classification document. The classification document is covered in more detail in Chapter 4 of Appendix 2 (assessment of the documents prescribed in Section 36 of the Nuclear Energy Decree).

The safety classification of buildings, as necessitated in Guide YVL B.2, was not conducted at the Loviisa NPP in conjunction with the original planning and a classification performed afterwards has not been found to have had a significant impact on improving safety. STUK has consented to not requiring a comprehensive safety classification of the buildings, but the new buildings to be constructed in the plant area as well as any modifications to the old buildings must be designed and implemented in a manner necessitated by their safety significance.

Guide YVL B.2, which came into force in connection with the overall YVL Guide reform, slightly changed the requirement level regarding the safety classification in comparison to the previous YVL Guides on classification, 2.1, 2.6 and 3.3.

In connection with the implementing decision of Guide YVL B.2 (12/0010/2015, 25 September 2015), STUK stated that the safety classification of the Loviisa NPP meets the requirements of the provisions to a sufficient degree. In the implementing decision, STUK deemed that it is not purposeful to change the safety classification of the old facility to fully correspond to the YVL B.2 classification, but still required that the classification document has henceforth include a compliant classification alongside the classification used at the facility. This enables easy identification of any differences from the requirements, which is helpful when assessing the effects and safety significance of future changes.

The most substantial individual change is the abolishment of safety class 4. In the implementation decision of Guide YVL B.2, STUK required Fortum to prepare a description that presents the new classification of the systems in the abolished safety class 4, including justifications, as well as the systems to be incorporated into class EYT/STUK. Fortum will submit the updated classification document to STUK by 31 January 2017. Any possible changes to be made based on the later DEC analyses will be taken into account once the analyses are complete.

Other matters that are significant with regard to the classification are the specifying the safety significance of structures and buildings, which was brought up in the context of implementing Guide YVL B.2, and the application of seismic classification at the Loviisa NPP. By defining the safety significance, STUK has sought to ensure that the structures and buildings are systematically taken into account in any modification work conducted at the facility.

In the implementation decision 12/0010/2015, STUK further required that Fortum must, in the future, specify the equipment and structures required for safe ramp down in the event of earthquake, as well as any equipment and structures which, when damaged, may cause substantial propagation of radioactive substances inside or outside the facility. The description concerning the seismic classification and the durability of the equipment and structures must be submitted to STUK for approval by the end of 2017. Furthermore, Fortum must, by 31 January 2018, submit to STUK for information a description of any modifications of other equipment or structures – determined based on tours or analyses of the facility – that may in the event of an earthquake compromise equipment deemed important for the purpose of managing the situation.

In its plan, Fortum presents measures to develop the classification document in order to improve plant safety. The conclusion is that the safety classification has been sufficiently implemented in compliance with Section 4 of Regulation STUK Y/1/2016, taking into account the implementing decision of Guide YVL B.2 for the Loviisa NPP.

2.3 Ageing management (Section 5)

The design, construction, operation, condition monitoring and maintenance of a nuclear power plant shall provide for the ageing of systems, structures and components important to safety in order to ensure that they meet the design-basis requirements with necessary safety margins throughout the service life of the facility.

Systematic procedures shall be in place for preventing the ageing of systems, structures and components which may deteriorate their availability, and for the early detection of the need for their repair, modification and replacement. Safety requirements and applicability of new technology shall be periodically assessed in order to ensure that the technology ap-

plied is up to date, and the availability of the spare parts and the system support shall be monitored.

The periodic safety review must cover experiences of the plant's ageing and its management. Pursuant to Guide YVL A.8, the nuclear power plant must have an ageing management programme comprising the functions, duties and responsibilities for assuring the operability and technological conformance of systems, structures and components (SSC) throughout their service life. The programme must identify the significant ageing mechanisms and the condition monitoring and maintenance programmes through which the SSCs' design-based operability can be confirmed. The ageing management must cover mechanical, electrical, I&C and civil SSCs belonging to safety class 1, 2 or 3 or class EYT/STUK.

In the ageing management arrangement of the Loviisa NPP, the SSCs are divided into three categories (A, B and C), which guides the utilisation of the resources allocated to various elements. In maintenance, the categorisation includes four criticality classes, which affects the selection of each SSC. Ageing management is considered to particularly involve ensuring the operability of such SSCs that are estimated to determine the service life of the entire plant unit (class A). In addition to this, replaceable SSCs that are significant to availability (class B) are considered to be covered by actual ageing management. The condition monitoring and maintenance of other SSCs (class C) is regarded as conventional maintenance, although by broader definition these efforts, too, are part of ageing management.

The ageing mechanisms of class A SSCs have been identified and the risks caused these mechanisms have been assessed. The following have been identified as the most significant ageing mechanisms: stress corrosion of steam generator heat delivery pipes, radiation embrittlement of the reactor pressure vessels' critical weld and the core-area internals, fatigue of the corrosion protection sleeves of the pressuriser's lower nozzles, wear of the threaded holes in the main coolant pump housings, possible corrosion of the containment anchoring structures and steel lining, and the condition of the buildings and foundations. These SSCs must be inspected at regular intervals to detect any faults that may compromise their operability at an early stage. In the organisation, ageing management has been placed under the power plant engineering group, which is responsible for coordinating and steering the ageing management efforts. System managers appointed from the group ensure the implementation of ageing management in classes A and B. A system manager's tasks include monitoring operability, preparing condition reports and improvement measures, and organising and monitoring implementation. The system managers also compile summary reports from their areas of responsibility, which assess the operability of the SSC and development needs of ageing management in the long-term.

The development strategy for a specific SSC is based on aspects related to production and safety, official requirements, operating and maintenance experiences, as well as the derived criticality classification, which was mentioned above. Criticality class 1 includes SSCs important to nuclear safety the failure of which will lead to substantial production losses. The maintenance strategy can be based on condition (pre-emptive), which means that the maintenance need is estimated based on the data generated by periodic or continuous condition monitoring. When condition monitoring is always conducted at specific intervals, possibly eliminating the need for maintenance, the strategy is pre-emptive and the goal is to reduce the probability of failure. At the other extreme are criticality class 4 devices, which are not considered to have safety requirements and whose maintenance is not financially justified (corrective maintenance strategy). The group managers of maintenance are responsible for the planning, development and implementation of maintenance, and the preparation and updating of the maintenance instructions. Their duties also include analysing the historical maintenance data and making decisions regarding corrective measures. Information on work conducted under work orders is saved in the plant information system (symptom and failure data, necessary resources, descriptions of device condition, photos, etc.). The information collected about maintenance work is used to calculate the indicators describing the safety, efficiency and reliability of the organisation and SSCs.

The new Guide YVL A.8 on the ageing management of nuclear facilities entered into force at the Loviisa NPP at the beginning of October 2015. According to the Guide's implementing decision (9/0010/2015, 25 September 2015), Fortum must update the current ageing management programme by the end of 2016 and deliver the first ageing follow-up report specified in the new Guide within the first third of 2017. The follow-up report consolidates and replaces Fortum's previous annual ageing management reports from various areas of engineering.

Mechanical technology

Systems, structures and components belonging to class A are the reactor pressure vessel, main coolant pump, steam generator, pressuriser and reactor containment. The phenomenon that has been identified as the most significant in terms of ageing is the radiation embrittlement of the reactor pressure vessel’s core-area weld, which is covered in more detail in Chapter 4.3.2.

The ageing management of the reactor pressure vessel internals examines the radiation embrittlement of the material. The critical elements are the core-area support cage and moderator tank. The ageing management of the reactor pressure vessel internals is based on in-service inspections that seek to ascertain any possible changes caused by radiation embrittlement and the integrity of the internals.

The original design life was 30 years for the primary circuit components and 40 years for the reactor pressure vessel. Specified fatigue analyses have been performed on safety-critical and heavily loaded components. In the update to the fatigue analyses, the number of loading cycles was changed to match the 50-year service period of the facility. By virtue of developing the analysis methods and reducing uncertainties, it has been possible to specify the component durability estimates to ensure safety even if the original service life is exceeded.

In terms of fatigue, the critical points in the reactor pressure vessel are the attachment welds of the head nozzles’ corrosion protection sleeves (control rods, normal makeup water system and leak collection) and the threaded holes and bolts of the main flange. The corrosion protection sleeves can be replaced, the main flange bolts have been replaced and a qualified method exists for repairing the threaded holes, in addition to which these items are covered by the periodic inspections. The ageing management of these items can be regarded as sufficient. The ageing management of the reactor pressure vessel is also covered in Chapter 4.3.2.

Based on the fatigue analyses conducted, the fatigue and corrosion fatigue do not limit the service life of the steam generators. Pit corrosion and stress corrosion of the heat delivery pipes and collector structures have been identified as factors that may limit service life. During further operation, the ageing management of the steam generators is based on monitoring loads and hydrochemistry parameters, utilising operating experiences from other facilities, in-service inspections and, if necessary, possible further examinations of ageing phenomena that have been identified as possible. A change in hydrochemistry (pH) is being planned, which may partially reduce magnetite formation. The operability of the steam generators can be considered to be sufficient, if the periodic inspections and magnetite removal are conducted on time.

Pressuriser ageing has been examined as regards fatigue, corrosion (stress, crevice and pit corrosion) and embrittlement. Fatigue is an essential factor in the ageing management of pressurisers. The corrosion protection sleeves of the pressurisers' lower nozzles are under particularly high stress. Based on the fatigue analyses conducted, the calculated fatigue values in the lower nozzle area of the corrosion protection sleeves exceed the allowed limit. The spray nozzles, safety valve nozzle and electrical resistor penetrations are structurally similar to the lower nozzles. The pressuriser resistors' protection pipes, on which a fatigue analysis has not been conducted, have also been identified as fatigue critical. The corrosion protection sleeves of the pressuriser nozzles, the upper part of the spray nozzle and the leg attachment weld are covered by the periodic inspections whereas the pressuriser's heating resistors (cladding) are not. The ageing management of the pressurisers is based on monitoring cyclical loading, operating experiences from other facilities and in-service inspections. In Fortum's view, with the measures listed above, the detrimental phenomena related to the ageing of the pressuriser and possible damage can be repaired sufficiently early on. The ageing management of these items can be regarded as sufficient.

In terms of ageing management, the most critical and essential part of the main coolant pumps is the casing, as it cannot be replaced like other pump components. Based on the fatigue analyses, the positions that suffer the highest fatigue loads are the position of the shaft opening's labyrinth seal, the corner above the seal of the cover's interior surface, the threads of the casing and the cover stud bolts. Numerous faults have been observed in the main coolant pumps' hydraulic components (impeller and guide vanes), which are suspected to be caused by fatigue, cavitation or erosion. The ageing management of the pumps is based on in-service monitoring, regular inspections, monitoring and management of leaks, and preventing installation errors. The cover's shaft hole shoulder, the threaded joint of the main flange and the pumps hydraulic parts are covered by the periodic inspections. The pump service life management can be considered to be acceptable since the ageing and vibrations of the pumps mainly affect the operability of the pumps instead of nuclear safety.

The pressure and temperature transients caused by the fatigue of the main components have been analysed and reported each year. In the mechanical technology inspection of 2015, STUK noticed that measured elongations are no longer reported, whereas temperature measurements are presented in detail. It remained unclear how the estimates presented in the annual reports on thermally fatiguing effects and service life had been derived. The 50-year fatigue accumulations that were calculated by extrapolating transient statistics are most likely from the most occurrence-free years of plant operation. In decision 39/A45551/2015 (14 December 2015), STUK required Fortum to submit to it for information a description of the possibilities of developing a load monitoring system for the purpose of better estimating the thermal fatigue occurring in the measurement points and the remaining service life. Fortum delivered the clarification via letter LO1-A4-19053, 26 February 2016, which stated that the current Fati system used to monitor and assess thermal loads and thermal stratification will be developed in conjunction with its update. The remodelling is currently in the pre-planning phase. STUK will follow-up on the development work in connection with its inspections. If load increases are observed during the remaining operating licence period, the analyses must be updated to correspond to the remaining service life of the devices.

It is STUK's view that the ageing management of Fortum's mechanical engineering components has been implemented in compliance with Section 5 of Regulation STUK Y/1/2016, taking into account the measures presented by Fortum in its plan to improve safety.

Electrical and I&C technology

In addition to Guide YVL A.8, STUK's detailed ageing monitoring and reporting requirements for electrical and I&C systems and devices are presented in Guide YVL E.7.

Ageing management programmes have been issued for safety class 2, 3 and EYT/STUK electrical and I&C equipment at the Loviisa power plant units. The ageing management programmes must be updated in accordance with the implementing decision of Guide YVL A.8 by the end of 2016. The ageing management programmes for electrical and I&C equipment present the most essential methods employed by Fortum to manage the effects of ageing in the electrical and I&C equipment and related cables of its nuclear power plants. The electrical and I&C systems of the Loviisa NPP belong to the ageing management classes B, C and D.

The ageing management of the electrical and I&C equipment and related cables is based on the monitoring of their condition and assessment of repair or replacement needs. The condition monitoring efforts ensure that the electrical and automation equipment and cables are in the required condition and capable of functioning in the designed operating and accident conditions for the entire planned service life.

The most important electrical and I&C systems are situated outside the containment and process spaces in separate electrical or I&C rooms, which do not impose significant requirements with regard to environmental conditions. The accident detection or management equipment in the containment has been qualified to withstand operating and accident conditions. Their condition is monitored on a regular basis. The ageing of the cables inside the containment is monitored by means of cable samples taken every four years. Fortum submits a condition monitoring report on the cable sample surveys to STUK for information.

The monitoring of feedback information on equipment maintenance, repair and modification work, among other data, is utilised in the monitoring and management of ageing.

The actual condition of the electrical and I&C systems, equipment and cables and their operation according to the design bases are also observed by means periodic tests, condition monitoring and the periodic inspections included in the preventive maintenance programme.

In recent years, many modernisation projects have been conducted on the Loviisa power plant's electrical and I&C systems. The intention is to continue the modernisation efforts in the coming years. The modernisation projects have stemmed from reasons such as the end of the original planned service life, technological obsolescence, end of technical support and lack of spare parts. In order to management spare parts situation, Fortum has initiated measures to secure the availability of essential spare parts.

Future projects concerning electrical systems include updating the rotating converters (ER), updating the TJ motors, replacing the main transformers, replacing generator switches and updating rectifiers.

The power plant’s I&C updates were initiated within the scope of the LARA project by updating the following:

- The parts of the preventive protection I&C that control reactor protection and control rod position indication, and auxiliary control room functions included in protection I&C – in 2008 for Loviisa 1 and in 2009 for Loviisa 2
- The processing system for reactor core temperature and neutron flux measurement signals with the exception of boiling margin measurements – in 2009 for Loviisa 1 and in 2010 for Loviisa 2.

The original purpose of the project was to update the facility’s protection I&C, operating I&C and control rooms in phases by the end of 2014. However, Fortum decided to switch to another supplier in 2014, at which point the LARA project was discontinued before the phase 2 installations to be conducted during the 2014 annual maintenance. The updating efforts have been continued through the slightly less extensive ELSA project, which involves updating the remainder of the preventive safety function I&C at both plant units and installing a new process monitoring system (implemented during the annual maintenance of 2016). Furthermore:

- a prioritising system for redundant safety functions will be installed in 2017
- the 2018 updates will target the reactor protection system, reactor-external neutron flux measurement system, power limitation system and power adjustment system, in addition to which manual and automatic functions that ensure the operation of the protection functions.

In conjunction with processing the periodic safety review, STUK required Fortum to provide a report on the spare parts situation and maintained operability of the chemical supply system's (TB), normal make-up water system's (TK) and reactor protection system’s (SUZ) frequency converters. In its response, Fortum has stated that

- the TB frequency converters will be updated between 2016 and 2018
- The need to update the TK frequency converters will be assessed when operating experiences are gained regarding the new TB frequency converters.

The aim is to update the Loviisa 2 SUZ frequency converters during the annual maintenance of 2019, at which point the decommissioned converters would ensure the availability of spare parts for Loviisa 1.

The operating experiences so far have indicated that the ageing phenomena of the Loviisa 1 and 2 power plant units' electrical and I&C systems and cables have been sufficiently managed through enhanced maintenance and modernisation of the problem areas. According to the analyses of Fortum's electrical and I&C experts, the facility's electrical and I&C systems, devices and cables are currently in working order thanks to correctly-timed and targeted ageing management measures. Fortum has stated that it will continue to pay special attention to managing the service life of electrical and I&C equipment during the upcoming review period (2016–2023).

STUK continuously monitors the appropriateness of Fortum's management programme for electrical and I&C equipment/cables by following operational occurrences, reviewing ageing reports and assessing ageing management in conjunction with inspections included in the Periodic Inspection Programme, for example. Taking into account the measures presented by Fortum in its safety improvement plan regarding the I&C update and the development of the service life management of electrical and I&C equipment, ageing management in this area has been implemented in accordance with Section 5 of STUK Y/1/2016.

Construction technology

In addition to the requirements on ageing management presented in Guide YVL A.8, detailed requirements concerning concrete and steel structures, including periodic inspections, repairs and modifications, are listed in Guide YVL E.6. STUK controls these activities upon inspecting Fortum's corresponding design activities, the implementation of repairs and modifications, and the operation of the facility.

Fortum monitors the condition of the buildings of the Loviisa 1 and 2 plant units by means of structural periodic tests, which cover the buildings, structures and surface materials important to the facility's general operations, in accordance with the instructions observed at the facility. Fortum has prepared separate preventive maintenance programmes for specific structural parts, such as the steel containment and sea water channels.

As regards the steel containment, the condition of the attachment screws in the steel cladding airlocks, penetrations and load-bearing steel components must be monitored under ageing management. The conditions of structures that are sensitive to corrosion are monitored by means of temperature and moisture measurements. The condition of the reactor building and the penetrations and intermediate-level liner is monitored by means of leakage tests. The pool structures are also observed to detect leaks. Targeted inspections have been conducted and structures have been opened to determine the condition of the fastenings of the reactor building's sheet metal cladding and the foundations of the cooling water pipes.

Significant modifications performed in the buildings of the Loviisa 1 and 2 power plant units' buildings due to ageing have included replacing the cooling water intake opening's screen structure between 2006 and 2011, and repairing the concrete damage in the cooling damage intake structures that was observed in previous condition surveys. Separate steel gates were installed in conjunction with this work to enable the tunnel to be closed, alongside electrical corrosion protections for the structures.

In STUK's view, the Fortum's ageing management measures for concrete and steel structures have been implemented in accordance with Section 5 of Regulations STUK Y/1/2016.

Summary

According to STUK's assessment, ageing management at the Loviisa 1 and 2 power plant units has been organised in an appropriate manner. SSCs are monitored by means of inspections, tests, analyses and other equivalent methods that yield information and predictions regarding their operability. The goal that has been set for the monitoring of operability, the selected maintenance strategies and basic improvement work is to keep the integrity and operability of SSCs in line with the design bases until the decommissioning of the plant units.

In recent years, some plant events have come to light resulting from the weakening of a structural or functional property of a SSC due to physical ageing. Technological ageing of SSCs has also been observed particularly as a result of a lack of spare parts. However, the conclusion is that ageing management at the Loviisa NPP has been implemented as intended in Section 5 of Regulation STUK Y/1/2016. STUK will observe the results of the ageing management efforts at the plant units until the end of the operating periods, alongside its other regulatory control work.

The particular aim of ageing management is to pre-emptively identify ageing phenomena that affect the condition of the facility. However, information on the actual state of the facility is gained by means such as measurements and testing, the results of which STUK may use as grounds to require the necessary measures to ensure plant safety.

2.4 Management of human factors relating to safety at a nuclear facility (Section 6)

Attention shall be paid to the avoidance, detection and correction of human errors and the limiting of their effects throughout the service life of the nuclear power plant. The possibility of human error shall be taken into account in the design of the nuclear power plant and in the planning of its operations and maintenance, so that human error and deviations from normal plant operations due to human error do not endanger plant safety or lead to common cause failures.

When assessing the work efforts of shifts, Fortum has considered matters related to the staffing and sufficiency of shifts in a variety of ways from the perspective of human factors. The shift arrangements have taken into account the management of fatigue caused by shift work and sought to ensure the conveyance of situational awareness between shifts by means of practices related to shift changes. Shift work practices have been developed to better manage human factors. These include kickoff and wrap-up meeting practices, multidirectional communication, working in pairs and using mobile devices to identify device positions. A development programme for managing human factors was initiated in 2014, and in 2015, the entire staff of the power plant was trained to apply the aforementioned work practices.

Procedures have been provided for control room operators' basic and refresher training, and a process description on the training has been issued. In addition to this, factors that promote the management of human factors include the continuous development of procedures, methods to maintain alertness, and the availability and presence of competent staff at all times.

Ensuring competence is a key part of the management of human factors. The power plant's administrative rules define competence requirements for personnel who are important to safety and work in operation, maintenance and technical support services. Fortum ensures the proficiency of its staff by means of a systematic training programme, including initial training and other orientation, basic training, refresher training and supplementary training. A simulator is available, with which control room operators can train to handle emergency situations and transients.

The conclusion is that the management of human factors in the Loviisa NPP's operating practices has been implemented as intended in Section 6 of Regulation STUK Y/1/2016.

3 Limitation of radiation exposure and releases of radioactive substances (Section 7)

Pursuant to Section 3 of the Radiation Act (592/1991), Section 2 and Chapter 9 of the Act also apply to the radiation exposure of the employees and the population in the vicinity of a nuclear power plant. The maximum values for workers' exposure to radiation are stipulated in Chapter 2 of the Radiation Decree (1512/1991).

The maximum values for radiation exposure caused to the population in the vicinity of a nuclear power plant due to its operation, anticipated operational occurrences or accidents are enacted in the Nuclear Energy Decree (161/1988).

3.1 Radiation safety of nuclear power plant workers

As regards radiation exposure, the ALARA principle (As Low As Reasonably Achievable) must be observed. The International Commission on Radiation Protection (ICRP) has revised its basic policies on radiation protection (for example, ICRP 103 in 2007). However, the updates have not necessitated significant changes to the current national radiation protection provisions.

The statutes addressing radiation exposure are the Radiation Act 592/1991, Radiation Decree 1512/1991, and the ST and YVL Guides published by STUK. According to Section 3 of the Radiation Decree, *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 one year. The annual equivalent dose in the lens of the eye shall not exceed 150 mSv, nor shall the annual equivalent dose at any point on the hands, feet or skin exceed 500 mSv.*

A chemical decontamination of the entire primary circuit was conducted at the Loviisa 2 plant unit in 1994. This measure succeeded in significantly reducing radiation dose rates in the plant unit's steam generator space. The dose rates were successfully stabilised at the level of the Loviisa 1 unit. Following this measure, the rates have remained quite stable at both plant units. The proportions of various radioactive nuclides are examined at plant units on a regular basis. During the past years, certain activation products (^{60}Co,

^{124}Sb and ^{122}Sb) generated as a result of neutron radiation have emerged as significant nuclides to cause dose rates in primary circuit components. Fortum identified the Burgman seals of the main coolant pumps as the source of antimony (Sb) and decided to replace these seals with antimony-free seals. Based on this measure, dose rates can be expected to decrease at both plant units in coming years.

In addition to dose rates, occupational doses are affected by amounts of maintenance work conducted during annual maintenance, including the amount of repair work resulting from equipment ageing and the implementation of modifications to improve plant safety.

In recent years, a decreasing trend has been observed in occupational doses. Since 1996, annual doses in excess of 20 mSv have not been accumulated by any employees at the Loviisa power plant. The highest personal dose in 2014 was 9.2 mSv, and the average for radiation worker doses was 0.6 mSv. In 2015, the highest personal dose was 7.1 mSv. Between 2010 and 2014, the highest five-year dose accumulated exclusively through working at the Loviisa power plant was 47.2 mSv.

Figure 1 below presents the development of the annual collective radiation of the Loviisa plant units' employees over the years. The collective radiation doses of the Loviisa plant units have been in the same range as corresponding foreign plants. The improvements implemented in recent years have succeeded in reducing the dose rates at the plant units. This is particularly evident in the radiation doses of even years, since all more extensive inspections and modifications are conducted during the annual maintenance in these years.

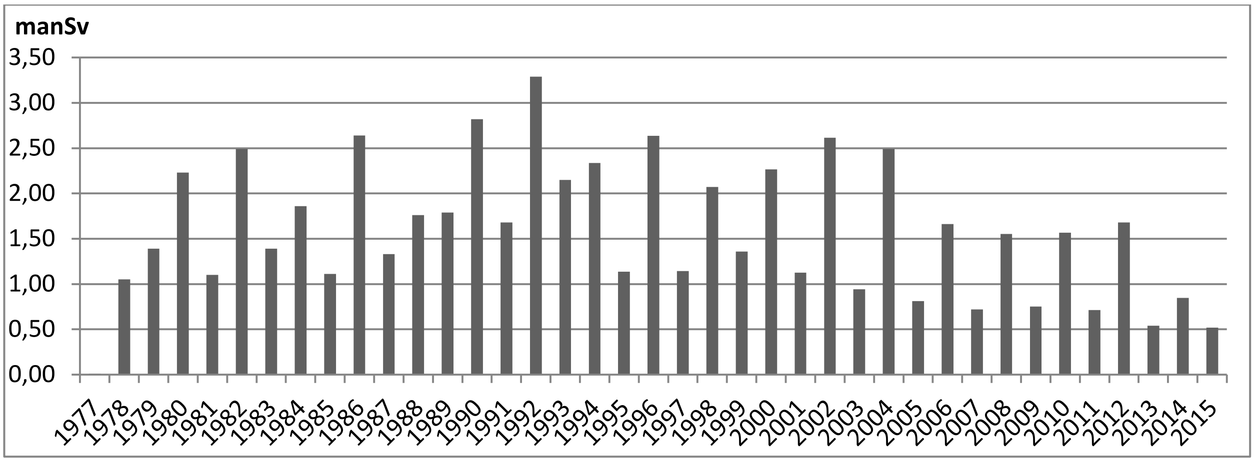

Figure 1. *Collective occupational radiation doses at the Loviisa plant units since the beginning of operation.*

The annual quality control tests on the dosimetric service have indicated that the accuracy of the service's measurement methods have remained compliant with the requirements laid down in international standards. Fortum has regularly updated the documentation required for the approval of the dosimetric service in accordance with the Radiation Decree.

The conclusion is that the radiation protection and dose monitoring of the employees of the Loviisa NPP have been implemented as intended in Section 7 of Regulation STUK Y/1/2016.

3.2 Radiation exposure of the population in the vicinity

Keeping the radiation exposure caused by the operation of the nuclear power plant to the population in the vicinity as low as practically possible means observing a principle of optimisation in radiation protection. Such applicable principles include the International Commission on Radiation Protection's (ICRP) ALARA principle and the EU's IPPC Directive BAT principle (Best Available Techniques).

Limiting the radiation exposure of the population in the vicinity according to both the ALARA and BAT principles is examined in the FSAR of the Loviisa NPP. In conjunction with the implementing decisions of the YVL Guides, Fortum assessed the fulfilment of the BAT principle at the Loviisa NPP. In its decision in 2011 (1/A41301/2011, 10.6.2011), STUK stated that the Loviisa NPP meets the requirement presented in the YVL Guides with regard to limiting the releases of radioactive substances and environmental radiation levels in accordance with the BAT principle. In connection with the implementing decision of Guide YVL C.3 (21/0010/2015, 25 September 2015), STUK did not find any shortcomings in the fulfilment of this principle.

The conclusion is that the radiation safety of the population in the vicinity of the Loviisa NPP has been implemented as intended in Section 7 of Regulation STUK Y/1/2016.

The shortfall of the maximum values set for the radiation exposure caused to the population in the vicinity by the operation, operational occurrences and accidents of the Loviisa NPP are covered in Chapters 3.3-3.5.

3.3 Limiting value for normal operation (Nuclear Energy Decree 161/1988, Section 22 b(1))

The limit for the annual dose of an individual in the population, arising from the normal operation of a nuclear power plant or another type of nuclear facility equipped with a nuclear reactor, is 0.1 millisievert.

In the Nuclear Energy Decree (161/1988), the stipulation concerning the protection of individuals must be implemented alongside the ALARA requirement concerning the limitation of radiation exposure (Chapter 3.1). Guide C.4 presents detailed requirements for calculation methods by which to estimate the radiation exposure of the population.

The Loviisa NPP's release limits for radioactive substances have been determined in the Technical Specifications concerning the use of the plant units. Limits have been set separately for radioactive noble gas and iodine releases into the atmosphere and releases into the sea. A separate release limit for releases of radioactive tritium into the sea has been defined, while the total activity limit is applied for other radioactive substances. The purpose of the release limits is to keep the annual radiation exposure caused to the population in the vicinity by the operation of the plant units well below the limit value of 0.1 mSv set in the Nuclear Energy Decree. The licensee must monitor the releases and radioactive substances occurring in the vicinity of the plant continuously and report any abnormal situations to STUK without delay.

When calculating the radiation dose caused by radioactive releases to a member of the population, the average radiation exposure in the group with the highest exposure is examined. The group represents a hypothetical collection of individuals for whom the highest estimated radiation exposure is calculated based on their place of residence and lifestyle.

Fortum utilises methods that calculate the radiation exposure of the population in the vicinity as caused by the normal operation of the Loviisa NPP in accordance with the requirements of Guide YVL C.4.

In the scope of the 2014 releases, the calculated dose commitment of an individual residing in the vicinity of the Loviisa NPP was 0.00023 mSv, as reported by Fortum. For comparison, the average dose caused to an individual in Finland by natural radiation is over 1 mSv. The reference calculation conducted at STUK yielded a lower value than the one reported by Fortum. In recent years, the calculated dose has been in this range following the measures conducted some 20 years ago at the Loviisa NPP to limit caesium releases into the sea. The radioactive releases of the Loviisa 1 and 2 power plant units have also been clearly below the release limits set in the Technical Specifications.

The monitoring of the radioactive releases at the Loviisa NPP and the radioactive substances and radiation in the environment are covered in Chapter 5.5.

The conclusion is that the operation of the Loviisa NPP has not caused radioactive releases as a result of which the annual limit value of 0.1 mSv, as laid down in the Nuclear Energy Decree, would have been exceeded. Furthermore, the calculated dose of the member of the population with the highest exposure from the annual normal radioactive releases of the Loviisa NPP can be expected to remain very low.

3.4 Limiting value for an anticipated operational occurrence (Nuclear Energy Decree 161/1988, Section 22 b(2))

The limit for the annual dose of an individual in the population, arising as the result of an anticipated operational occurrence, shall be 0.1 millisievert.

Detailed requirements for the analyses of anticipated operational occurrences are presented in Guide YVL B.3. If an operational occurrence can cause a release of radioactive substances, the radiation doses resulting from it must be determined. Guide YVL C.4 presents detailed requirements for calculation methods by which to estimate the radiation exposure of the population.

The FSAR for the Loviisa 1 and 2 nuclear power plant units present descriptions of the analyses of anticipated operational occurrences. These analyses are covered in Chapter 2.1.1 of the safety assessment with regard to plant behaviour. The operational occurrences are not expected to lead to releases of radioactive substances as the fuel is not damaged or the plant systems can retain the releases. Therefore, radiation doses caused to members of the population by anticipated operational occurrences are not estimated by means of calculations.

There have been no operational occurrences at the Loviisa NPP where an increase in radioactive releases would have been observed in comparison to the normal situation.

The conclusion is that the anticipated operational occurrences of the Loviisa NPP do not cause releases that would result in the annual radiation doses caused to a member of the population to exceed the limiting value 0.1 mSv.

3.5 Limiting values for accidents (Nuclear Energy Decree 161/1988, Section 22 b(3–6))

The limit for the annual dose of an individual in the population shall be 1 millisievert for class 1 postulated accidents, 5 millisievert for class 2 postulated accidents, and 20 millisievert for a design extension condition.

The release of radioactive substances caused by a severe reactor accident or a severe accident at a nuclear power plant may not result in the need for large-scale population protection measures or prolonged restrictions on the use of large areas of land and water.

To limit long-term effects, the limit for an atmospheric release of caesium-137 shall be 100 terabecquerel. The probability of exceeding this limit shall be extremely small.

The probability of a release in the early stages of an accident requiring measures to protect the population shall be extremely low.

Guides YVL B.3 and YVL C.4 contain detailed requirements on the calculation of accident analyses concerning plant behaviour, the calculation of related releases and radiation doses, and the acceptability of the results.

The analyses and their calculation methods are under constant development during the entire service life of the nuclear power plant. The FSAR for the Loviisa 1 and 2 nuclear power plant units presents descriptions on the units' accident analyses (covered in more detail in Chapter 2.1.1 of the FSAR). The Fortum analysis methods concerning radiation exposure have been developed over the years, and they comply with the requirements of Guides YVL B.3 and YVL C.4. The methods include improbable assumptions, which, in reality, signify an overestimation of the radiation dose amounts calculated as consequent effects. After the previous periodic safety review, Fortum has renewed the release and dose analyses for control rod ejection and prepared release and dose analyses for a design extension condition where a break occurs simultaneously in a steam pipe and steam generator heat exchanger pipe.

As regards class 1 postulated accidents, the analysis indicates that the in-transit falling of a fuel assembly that has been cooled for 24 hours will cause a dose of 0.82 mSv to an individual in the population, which is lower than the dose limit of 1 mSv laid down in the Nuclear Energy Decree (161/1988). According to the analysis, the doses caused by other class 1 postulated accidents are lower.

As regards class 2 postulated accidents, the maximum dose of an individual in the population as a result of a major primary-secondary leak has been estimated to be 3.9 mSv, which is lower than the dose limit of 5 mSv set in the Nuclear Energy Decree. According to the analysis, the doses caused by other class 2 postulated accidents are lower.

The conclusion is that class 1 and 2 postulated accidents at the Loviisa NPP do not cause radioactive releases that would result in the annual radiation doses caused to a member of the population to exceed the limiting values of 1 and 5 mSv, as set forth in the Nuclear Energy Decree.

The original design bases of the Loviisa 1 and 2 nuclear power plant units do not include preparations for design extension conditions but, during the current operating licence period, Fortum has analysed multiple of these types of accident situations. The maximum dose of an individual in the population as caused by a simultaneous break in a steam pipe and steam generator heat exchanger pipe has been analysed to be 2.0 mSv, which is lower than the dose limit of 20 mSv set in the Nuclear Energy Decree. Radiation doses caused by other design extension conditions have not been analysed so far. Fortum intends to analyse them later as the I&C update of the facility progresses. The implementing decision of Guide YVL B.3 requires that the design extension conditions (DEC A and B) be submitted by the end of 2018. The implementing decision of Guide YVL B.1 lays down requirements for identifying design extension conditions (DEC A, B and C) and preparing for them (DEC C).

The conclusion is that the limiting value of 20 mSv set for radiation doses caused to individuals in the population by design extension conditions is met at the Loviisa NPP as well as practically possible, with due consideration to the requirements in Section 21 of the applicable STUK Regulation and the transition provision in Section 27.

The original design bases of the Loviisa 1 and 2 nuclear power plant units do not include preparations for loads or radiation situations during a severe reactor accident. Fortum has carried out extensive studies and analyses to determine the plant modifications required to prepare for severe reactor accidents at the Loviisa 1 and 2 plant units. The modifications were implemented during the previous operating licence period. In this assessment, the management of severe accidents is covered in more detail in Chapter 4.3.3.

The PRA's level 2 analyses have been used to determine the probability of a severe reactor accident and releases of radioactive substances (Chapter 2.1.3). The doses that the releases cause to the population in the vicinity have also been assessed in the same context. Based on the analyses, the probability of the requirement on the limiting value for ^{137}Cs releases not being met is extremely low, as stipulated in the applicable provision. In addition to this, the probability of a release during an early phase of an accident requiring population protective measures is extremely low. Development measures to reduce the probability of a large release are covered in Chapters 2.1.2, 4.6 and 4.7.

Guides YVL A.7, B.1 and C.3 lay down more detailed requirements than the Nuclear Energy Decree on the scope of population protection measures as a result of a severe accident, the probability of exceeding the limiting value for ^{137}Cs releases, and the probability of a release requiring measures to protect the population in early stages of an accident. The implementing decisions of Guides YVL A.7 (8/0010/2015, 25 September

2015), B.1 and C.3 address the fulfilment of these requirements and present requirements on new analyses.

In the early stages of a severe reactor accident, the radiation exposure of an individual worker could be exceptionally high due to the fact that the radiation protection of the reactor containment's roof is not sufficient for such situations and some of the upward radiation penetrating the roof would be reflected from the air back into the plant area as external radiation. Retroactive modification of the reactor containment's roof structures is not practically possible considering the detriments to safety that would be caused by the modifications. Fortum's analyses and reports have indicated that the radiation exposure caused by a severe accident does not exceed the design requirements for radiation protection when constant attention is paid to the conditions in the planning, implementation and practising of emergency preparedness measures, for example. The emergency procedures have been updated in the previous operating licence period, taking into account the radiation safety of workers during an accident. Fortum has developed an information system for qualified radiation experts (SaTu), which can be used to estimate the radiation dose rates caused by various accidents inside the facility and in the plant area.

The conclusion is that the Loviisa NPP fulfils the regulations laid down in the Nuclear Energy Decree as well as practically possible, with due consideration to the requirements of Section 21 of STUK Y/1/2016 and the transition provision in Section 27.

4 Nuclear safety (STUK Y/1/2016 – Chapter 3)

4.1 Site safety (Section 8)

The impact of local conditions on safety and on the implementation of the security and emergency arrangements shall be considered when selecting the site of a nuclear power plant. The site shall be such that the impediments and threats posed by the plant to its vicinity remain extremely minor and heat removal from the plant to the environment can be reliably implemented.

The detailed requirements related to Section 8 of Regulation STUK Y/1/2016 are presented in Guides YVL A.2 and C.5. Furthermore, the Nuclear Energy Act states the following with regard to the site of the nuclear facility: *The site of the nuclear facility must be appropriate with respect to the safety of the planned operations, and environmental protection must be taken into account appropriately when planning operations* (Nuclear Energy Act, Section 19(2)).

The releases of radioactive substances in relation to the normal operation of the nuclear power plant or anticipated operational occurrences do not impose limitations on land use outside the plant area. This subject is covered in more detail in Chapter 5.5. In the environment surrounding the nuclear power plant, however, precautions in the form of land use and public protection plans must be taken with a view to the possibility of a severe accident. Nuclear power plants are among the sites, as listed in Section 48 of the Act on Rescue Services (379/2011), that pose a particular hazard due to which the rescue department and the licensee must prepare an external emergency plan for them. The vicinity of the nuclear power plant must not include any facilities or population centre where it is impossible to implement the protective measures required in an emergency situation, such as taking shelter indoors or evacuation. In the plant's vicinity, no activities may be carried out that could pose an external threat at the nuclear power plant.

The nuclear power plant's emergency response arrangements and cooperation with the rescue authorities are also covered in Chapter 8.

The general principle in the siting of nuclear power plants is to have the facilities in a sparsely populated area and far away from large population centres. This means that emergency planning will be directed at a smaller population group, thus being easier to implement. The Loviisa NPP is located on the Hästholmen island in the municipality of Loviisa, some 12 kilometres from the centre of Loviisa. This population centre is outside the nuclear power plant's precautionary action zone, which is why it is not considered to be part of the plant's vicinity. Approximately 50 people live permanently within the precautionary action zone of the Loviisa NPP. In addition to the Loviisa 1 and 2 nuclear power plant units, Hästholmen holds several buildings and facilities related to the production of nuclear energy, such as an interim storage for spent fuel (KPA storage), interim storage for power plant waste, final disposal facility for power plant waste (VLJ facility) and a diesel emergency power plant. The site also contains facilities for the pumping, storage, purification and demineralisation of raw fresh water required by the processes. The raw water is extracted through pipeline from Lake Lappominjärvi, located approximately five kilometres away. The Loviisa power plant area, which encompasses the island of Hästholmen, has been zoned as an energy management area in the effective local detailed plan. The area does not feature permanent housing or holiday homes, and no traffic routes run through it.

Hästholmen is an island approximately 1.5 kilometres in length and 0.5 kilometres in width, and it is connected to the mainland by a short bridge. A visitor centre and accommodation village are situated in the mainland in the immediate proximity to Hästholmen. Fortum owns the island, water areas and small islands in its vicinity, and the mainland area that holds the gate building and accommodation village. There are no industrial or storage facilities, land transportation routes or gas pipes in the vicinity of Hästholmen where accidents could pose a hazard to the nuclear power plant.

Almost 40 years of experience has been accumulated with regard to the operation of the Loviisa 1 and 2 nuclear power plant units. The conditions and suitability of the location have been examined for the design of existing nuclear facilities and projects concerning new plant units – last in 2009. The location has not been found to have any particularly negative features as regards the siting of nuclear facilities.

The geological and seismic properties of the site have been surveyed in connection with the design of the operating nuclear power plant units and the nuclear waste disposal facilities. Hästholmen lies in a seismically stable area. The plant site's design basis earthquake was determined in conjunction with the project for the fifth Finnish nuclear power plant unit. An assessment of the need to update the earthquake surveys is currently under way at Fortum.

Extreme weather conditions and sea water level limits have been studied in connection with the risk analyses of the plant units in cooperation with the Finnish Meteorological Institute, for example. In relation to normal Finnish conditions, the sea level variations are fairly high on the coast of the eastern Gulf of Finland. In the current operating licence period, Fortum has improved the facility's protection against the rising sea level. There are no exceptional special features in the ice conditions of the area. The occurrence of extreme weather phenomena and the effects of climate changes have also been studied through SAFIR research programmes since 2007.

The main route of the Gulf of Finland, which is used to transport a significant portion of the Russian oil exports, runs slightly over 30 kilometres from the Loviisa power plant. In the event of a major offshore oil spill, it is possible that oil would also spread to the water intake area of the Loviisa power plant. If oil were to enter a sea water cooling system, it could decrease the efficiency of sea water cooling or, in the worst case, clog cooling systems. In order to prepare for this possibility, Fortum has agreed upon notification procedures regarding oil hazards with the Finnish Environment Institute, which coordinates oil spill prevention and response efforts, along with making preparations for oil spill prevention in cooperation with the Eastern-Uusimaa Emergency Services Department. In 2015, the Loviisa power plan implemented a system, which can be used to discharge the residual heat produced by a shutdown reactor into the atmosphere and maintain the facility in a prolonged safe state even in situation where heat transfer to the sea is prevented. This improvement eliminates the reactor damage risk caused by the loss of sea water cooling almost entirely.

According to STUK's assessment, the Loviisa NPP's emergency response arrangements are up-to-date and sufficient. In addition to the aforementioned factors that affect securing the residents of the surrounding area, the site location has an impact on how emergency situations are handled in the power plant area. Accessibility is crucial in terms of emergency response efforts at the site. The persons dispatched to handle the emergency situation must be able to access the location, in addition to which it must be possible to remove unnecessary persons from the plant area regardless of the rescue operations performed outside the plant area. In an emergency situation, it may be necessary to transport equipment and consumables required for operation to the facility. It may even be necessary to continue bringing in new personnel and consumables for a long period of time. In addition to its own fire brigade, the facility may need equipment from rescue services, and it must be possible to transport this equipment to the location. Being able to transport people and materials to the site is particularly important in emergency situations resulting from external hazards, as accessing the facility may be difficult due to trees that have fallen on the road, for example. Fortum has met the stricter requirements by increasing the inventory amounts of consumables, such as fuel, at the Hästholmen site.

Only one road leads to the facility on Hästholmen. The area a few kilometres away can be accessed via numerous routes. Fortum and the rescue department have plans for restoring traffic links in extraordinary situations. It can be stated with good confidence that the quantity of necessary consumables stored in the plant area will last until access has been restored. The plant area features a pier, which provides the possibility to transport personnel and materials by sea, if necessary. The traffic links leading to the plant site and the plans related to restoring them are sufficient for handling emergency situations. Fortum is developing preparedness arrangements for emergency situations.

The plant's environmental effects during normal operation are described in Chapter 5.5 while the effects of operational occurrences and accidents are described in Chapters 3.3 and 3.4. The effects of weather phenomena on the safety of the Loviisa NPP and the reliable availability of cooling water are covered in Chapters 2.1.3 and 4.6. Security arrangements are described in Chapter 7.

The conclusion is that the location of the Loviisa NPP meets the requirement of Section 8 of Regulation STUK Y/1/2016.

4.2 Defence-in-depth (Section 9)

In order to prevent anticipated operational occurrences and accidents, and to mitigate the consequences thereof, the functional defence-in-depth principle shall be implemented in the design, construction and operation of a nuclear power plant.

In accordance with the functional defence-in-depth safety principle, the design must include the following levels of defence:

1) *prevention to ensure that the operation of the plant is reliable and deviations from normal operating conditions are rare;*

2) *control of deviations from the plant's normal operating conditions so that the plant is equipped with systems which are able to limit the development of operational occurrences into accidents and if required can bring the plant into a controlled state;*

3) *control of accident situations so that the nuclear plant is equipped with systems that function automatically and reliably to prevent severe fuel damage in postulated accidents and in design extension conditions; manually actuated systems can also be used to manage accident situations if it can be justified from a safety perspective;*

4) *confinement of a release of radioactive substances in severe reactor accidents by equipping the nuclear power plant with systems which ensure the sufficient leak-tightness of the containment in severe reactor accidents so that the limits for releases in severe reactor accidents are not exceeded;*

5) *mitigation of the consequences by means of emergency arrangements to limit the public's exposure to radiation in situations where radioactive substances are released from the plant into the environment.*

The levels of defence required under the defence-in-depth principle shall be as independent of one another as is reasonably achievable.

High quality proven technology is to be used for the different levels of the defence-in-depth.

The necessary measures to bring a situation under control or to prevent harmful effects of radiation must be planned in advance. When organising licensee's operations, it must be ensured that operational occurrences and accidents are reliably prevented. There shall be effective technical and administrative provisions to ensure staff's ability to operate in these situations.

The requirements that specify the principle of defence-in-depth in Section 9 of Regulation STUK Y/1/2016 are set forth in Guide YVL B.1.

The operation of the Loviisa NPP has been reliable and there have been very few deviations from normal operating conditions over the course of the entire operating history. Achieving this level in the future will require that the facility's operating measures, maintenance and modifications are performed in a planned and guided manner, and that these measures are targeted and timed correctly. The clarity of the instructions and the training of the personnel are crucially important in preventing disturbances caused by human error.

The Loviisa NPP features adjustment and limitation functions that are activated automatically when the plant parameters deviate from the normal operating conditions and that seek to limit changes in these parameters so that the functions reserved for postulated accidents do not need to be activated. Deviating situations can also be addressed by the plant operators in accordance with the operating procedures prepared in case of such events. If necessary, the facility can be brought to a controlled state. In conjunction with the I&C update, Fortum divided the functions more clearly than before into preventive functions designed for operational occurrences and functions designed for postulated accidents.

The Loviisa NPP has functions designed for postulated accidents, whose main purpose is to secure reactor shutdown and fuel cooling, thereby preventing fuel damage. These functions are activated automatically when certain parameters pass preset limits. With these automatically activated functions, the facility can be brought to a controlled state in all situations – in certain situations, operator action is also required. The facility is brought from the controlled state to a safe state in accordance with the prepared procedure by means of functions manually activated by the operator.

The original design of the Loviisa power plant did not include the design extension conditions presented in the current provisions. Modifications have been implemented during the use of the facility to improve its safety in these situations. The latest change was the residual heat removal system described in Chapter 4.1, which is a precaution for situations where heat cannot be discharged into the sea.

The Loviisa power plant features functions for controlling severe accidents. These functions were not included in the original design of the facility. Instead, they were retrofitted primarily in the 1990s. The functions ensure containment integrity in such a way that, in the event of severe reactor damage, the radioactive releases from the containment are kept so low that there is no need for extensive population protection measures in the vicinity of the plant.

The Loviisa power plant also has emergency response arrangements, the sufficiency of which is assessed in Chapter 8.

The original design of the Loviisa power plant did not include ensuring the independence of functions on the aforementioned defence-in-depth levels, nor is full independence required from new facilities. The independence of functions has been improved by means of in-service modifications, and functions to improve the safety of the facility in case of fire, for example, have been added.

The conclusion is that the Loviisa NPP meets the requirements of Section 9 of Regulation STUK Y/1/2016.

4.3 Engineered barriers for preventing the dispersion of radioactive materials (Section 10),

In order to prevent the dispersion of radioactive substances, the structural defence-in-depth safety principle shall be implemented.

Structural defence-in-depth design shall prevent dispersion of radioactive substances into the environment by means of successive barriers which are the fuel and its cladding, the reactor cooling circuit (primary circuit) and the containment.

The fuel, reactor, primary circuit of the reactor, and the cooling circuit (secondary circuit) of a pressurised water reactor removing heat from the primary circuit, water chemistry of the primary and secondary circuit, containment and safety functions shall be designed so as to meet the safety objectives laid down below.

The fulfilment of these requirements is assessed in the following chapters.

4.3.1 In order to assure the integrity of fuel

In order to ensure the fuel integrity:

1) the probability of fuel failure shall be low during normal operational conditions and anticipated operational occurrences;

2) in postulated accidents, the amount of fuel failures shall be kept small and fuel coolability must not be endangered; and

3) the possibility of a criticality accident shall be extremely small.

Detailed requirements are laid down in Guides YVL B.3 and YVL B.4.

The Loviisa NPP's fuel cladding is made of a zirconium-niobium alloy. The fuel manufacturer has a significant amount of experience in its use as a fuel rod cladding material since the 1960s. The manufacturer's operating experiences and the results of the laboratory studies have been successfully verified through studies and analyses of the fuel at the plant site. The corrosion-induced oxide layer on the cladding remains very thin and the ductility properties of the material remain sufficient for the entire service life of the fuel.

The uranium oxide is in the fuel rods in the form of small pellets. The manufacturer has provided measurement results on the amounts of fission gases released from a fuel pellet into the rod. These amounts have been analysed by means of calculations, and supplementing measurement results have been obtained from fuel irradiated at the Loviisa NPP. Based on these results and analyses, the release fraction of fission gases with the reactor's current operating method can be considered to be sufficiently low to ensure that released gas does not increase the internal pressure of the fuel rods too much to compromise their integrity.

The continued integrity of the fuel in power change situations related to the normal use of the reactor is ensured with limitations regarding power change rates, which are based primarily on tests performed with test reactors and operating experiences from Russian and other locations.

On the basis of the current operating experiences of the Loviisa NPP, the probability of fuel damage can be considered to be sufficiently low in the plant's normal operating situations. The structure of the fuel assemblies and rods has been developed gradually based on the experiences gained. In 2009, a "second generation fuel type" was introduced, where gadolinium in oxide form had been added in the fuel pellets to serve as a burning neutron poison. In the same context, other changes were made to the fuel structure: a method was added to detach enclosures and fuel rods to facilitate inspections.

The probability of a substantial decrease in fuel cooling, i.e. a heat transfer crisis, during normal operating situations is very low at the Loviisa 1 and 2 nuclear power plant units. This is primarily due to the favourable ratios of total and linear power, primary and secondary coolant flows and coolant amounts. This is indicated by a fairly large margin to heat transfer crisis in a steady state, for example. For the above reasons, a heat transfer crisis is highly unlikely in the event of anticipated operational occurrences.

In conjunction with the periodic safety review, Fortum updated the operational occurrence and accident analyses of the Loviisa 1 and 2 power plant units, taking into account the plant modifications implemented, changes to fuel design, developments in provisions, and advancements in calculation software.

Among the postulated accidents, fuel damage is only possible mainly in the context of primarily coolant loss accidents, fuel rod ejection, and ATWS (Anticipated Transient Without Scram), which is one of the design extension conditions. According to the results of a major LOCA analysis, the temperatures of the fuel cladding will remain low enough for fuel damage to be unlikely, provided that the emergency cooling systems function as designed. The analyses performed show that the degree of the possible fuel damage resulting from fuel rod ejection or ATWS would remain minor. The postulated accidents do not compromise fuel cooling.

One essential goal is to prevent transients that lead to inadvertent reactor criticality or reactivity increase. Boron, in the form of water-soluble boric acid, is used in the primary coolant to control reactivity. The possibility and significance of internal dilution occurring in connection with malfunctions or certain accident types has been analysed. Based on the analyses, the Loviisa 1 and 2 power plant units have already implemented plant modifications and procedural changes to the prevent inadvertent dilution of the boron solution. The prevention of inadvertent criticality has also been taken into account in the spent fuel storage and handling systems of the Loviisa power plant.

Since the Fukushima incident, the Loviisa power plant has improved the process of ensuring fuel integrity by implementing new cooling units, which enable the residual heat generated in the reactor to be discharged into the atmosphere if discharge into the sea is not possible. In addition to this, improvements have been planned – and partially implemented – to the possibilities of feeding water into the fuel storage pools in extraordinary situations.

The conclusion is that fuel integrity at the Loviisa NPP has been ensured as intended in Section 10 of Regulation STUK Y/1/2016.

4.3.2 Ensuring primary and secondary circuit integrity

In order to ensure primary and secondary circuit integrity:

1) the primary circuit of a nuclear power plant shall be designed and manufactured in compliance with high quality standards so that the probability of hazardous faults in structures and that of mechanisms threatening their integrity remains extremely low and any faults which occur can be detected reliably through inspections;

2) the primary circuit of a nuclear power plant shall, with sufficient margins, withstand the stresses arising in normal operational conditions, anticipated operational occurrences, postulated accidents and design extension conditions;

3) the primary circuit of a nuclear power plant and systems immediately connected to it, and components important to the safety of the secondary circuit of a pressurised water reactor, shall be reliably protected during anticipated operational occurrences and all accident scenarios, in order to prevent damage caused by over-pressurisation;

4) the hydrochemical conditions in the primary circuit of a nuclear power plant and the secondary circuit of a pressurised water reactor shall not result in mechanisms that threaten their integrity; and

5) the facility shall be equipped with sufficient leak monitoring systems.

The general goals for ensuring primary and secondary circuit integrity are presented above at the beginning of Chapter 4.3. The detailed goals are presented in Guide YVL B.5.

The primary circuit's overpressure protection has been implemented with parallel pressuriser safety valves, the opening pressures of which have been staggered. The safety valves have been designed to function with steam, water, and a mixture of steam and water. Pressure increase at low temperatures has been prevented with a shutdown safety valve, which is used at the level requiring cold crack protection when the primary circuit temperature has dropped. The valve's opening pressure is considerably lower than the primary circuit' design pressure. Correspondingly, the secondary circuit is equipped with two parallel steam generator-specific safety valves that open at different pressures. The safety valves that open at a lower pressure were replaced during the annual maintenance in 2014 at the Loviisa 2 unit and in 2016 at the Loviisa 1. Since then, the valves have functioned with steam and steam-water mixture, in addition to steam. The safety valves of the primary and secondary circuits are tested at regular intervals.

The Technical Specifications (TS) of the Loviisa 1 and 2 nuclear power plant units define the required and permitted operating and maintenance measures. The TS is based on "safety limits", which are the allowed extreme values for reactor power, primary circuit pressure and temperature. These limits have been determined to ensure the integrity of the fuel and the reactor's primary circuit, and they serve as the basis for a large part of the terms and conditions set for operating maintenance activities, as listed in the TS. This contributes to ensuring that the primary circuit's design pressure (137 bar) is not exceeded and the circuit's cold pressurisation is prevented. The TS and compliance with it is covered in more detail in Chapter 5.4.1.

The condition of the pressure-bearing devices of the Loviisa 1 and 2 power plant units is ensured through periodic inspections as well as non-destructive tests performed on the primary circuit devices in accordance with Guide YVL E.5 during outages. The primary circuits of both plant units also feature monitoring arrangements for vibration and loose debris, which are capable of detecting metal fragments carried with the flow. The maintenance operations and periodic inspections are covered in more detail in Chapters 5.4.1 and 5.4.2.

The reactor pressure vessel's integrity in various transients and accident situations has been determined by means of calculations focusing on thermal behaviour, flow and fracture mechanics. Comprehensive instructions on identifying and managing operational occurrences and accident situations have been prepared in accordance with YVL A.6. Operational activities are covered in more detail in Chapter 5.1.

Reactor pressure vessel

The increase in steel transition temperature as a result of radiation embrittlement has been identified as the most important ageing phenomenon in terms of reactor pressure vessel integrity. In 1996, the reactor pressure vessel area most susceptible to radiation embrittlement was annealed at the Loviisa 1 unit to restore the fracture toughness. A similar measure has not been performed on the Loviisa 2 unit's reactor pressure vessel. Thanks to long-term efforts, it has been possible to form a fairly clear picture of radiation embrittlement. On the grounds of the assessment presented by Fortum, the embrittlement of the reactor pressure vessels of both plant units can be managed until the end of the 50-year service life with the currently available methods. The ageing management of the reactor pressure vessels during the planned service life is based on understanding the phenomena related to radiation embrittlement and emergency cooling, utilising the operating experiences of other facilities, and performing extensive inspections during operation. In its assessment, Fortum emphasises that it will continue to assess the embrittlement rate in order to identify previously unknown phenomena affecting embrittlement speed.

STUK has granted an operating licence to the Loviisa reactor pressure vessels until the end of 2027 and 2030. However, the periodic safety review must include an updated estimate of the reactor pressure vessels' remaining service life. The core area of the reactor pressure vessel is one of the most important targets in the brittle fracture analyses of nuclear power plants. The current brittle fracture analyses that correspond to the 50-year service life of the reactor pressure vessel have been using assumptions of the changes brought about by the Loviisa I&C update protect LARA. Since the LARA project was halted in 2014 and replaced with the less extensive equivalent ELSA, the assumptions utilised in the analyses are no longer fully valid. Fortum has stated that it will update the probabilistic reactor pressure vessel analyses by the end of 2018 and the deterministic analyses by the end of 2023. In STUK's view, these time frames are sufficient from the perspective of assessing the continued use of the reactor pressure vessels. Furthermore, at the end of 2016, Fortum submitted the description required by STUK on the technical means by which the Loviisa 2 reactor pressure vessel's brittle fracture risk will be managed during the final years of the operating licence period. This especially applies to cases where the reactor pressure vessel cools from the outside due to the erroneous activation of the reactor hall spray system, for example. According to the description, Fortum intends to implement a change in 2019 to enable increasing the spray water temperature and, thereby, the brittle fracture margin. Fortum will also continue to examine the possibilities of improving the situation by adding thermal insulation on the exterior of the reactor pressure vessel's core area weld. STUK will monitor Fortum's measures as part of its continuous monitoring and assess the total arrangements in the context of the brittle fracture analyses.

Primary and secondary circuit hydrochemistry

The detailed requirements are presented in Guide YVL B.5.

The hydrochemistry parameters for each operational state that are to be monitored at the Loviisa 1 and 2 nuclear power plant units are defined in the Technical Specifications and chemistry procedure, along with the related requirements. The Loviisa plan monitors chemistry parameters by means of both continuous measurements and laboratory analyses. On the primary side the plants continuously operating analysers monitor the following: boric acid, ammonia, conductivity, pH, hydrogen and oxygen. The chemistry laboratory has access to a data system into which the analysis results are recorded and which can be used to monitor compliance with the set limit values and examine the long-term developments of the chemistry parameters.

The hydrochemistry monitoring parameters are variables that have been proven to have a direct effect on the safety of the reactor unit through fuel and primary circuit material corrosion. Guideline values and action levels have been set for the monitoring parameters. The guideline values indicate that the hydrochemistry of the primary circuit is in order if the parameters remain within the value range. The purpose of the action levels is to prompt the operator to restore the monitoring parameters to levels that meet the set guideline values. The monitoring parameters, in turn, illustrate the efficiency of the hydrochemistry and provide additional information on the hydrochemistry to be maintained. The monitoring parameters can also be used to identify any possible problems in the hydrochemistry that may, in time, cause corrosion in the fuel or primary circuit component materials and ultimately affect the development of radiation levels at the facility.

During the current operating licence period, the hydrochemistry of the Loviisa 1 and 2 nuclear power plant units has remained at an acceptable level. There have been some transients during which deviations from the target values have occurred, but due to their short duration, they have not been significant in terms of safety. There are no future needs for changes to the primary side but, as regards the hydrochemistry of the secondary circuit, it may be necessary to prepare for the eventuality that changes to the EU chemicals legislation may prevent the use of hydrazine to manage hydrochemistry. In the coming years, the Loviisa NPP intends to increase the pH of the secondary circuit water with the aim of reducing the iron in the system and, by extension, the accumulation of magnetite in the steam generators. According to the plans, the last copper parts of the secondary side will be removed in the annual maintenance of 2017, after which the pH can be increased.

The chemistry index describing the efficiency of maintaining the hydrochemical conditions has been at a good level for both plant units during the current operating licence period. Loviisa 2's index for 2014 was lower than in the previous year. This is due to the improved start-up procedure introduced in the 2013 revision and stricter adherence to the measures aimed at optimising the relevant chemistry parameters. The Loviisa plant index takes into account corrosive elements and corrosion product concentrations in steam generator blowdown and feedwater. The calculation of steam generator blowdown includes the chloride, sulphate and sodium concentration, and acid conductivity. For feedwater, the calculations cover iron, copper and oxygen content. The concentrations of impurities and corrosion products in the primary and secondary coolants have been at an acceptable level at both plant units. The chloride concentrations of blowdown water and the iron concentrations of the secondary circuit feed water have also been normal.

The ^{60}Co maximum activity levels related to shutdowns have been measured from shutdowns to annual maintenance outages. The concentrations have been at the same good level, which is another indication of successful adherence to the ALARA principle.

During the current operating licence period, the Loviisa 1 unit has removed one leaking fuel assembly from the reactor where as the Loviisa 2 has removed two leaking assemblies. The last removal of a leaking fuel assembly from the reactor took place during the 2009 annual maintenance at the Loviisa 1 unit and during the 2013 annual maintenance at the Loviisa 2 unit. Overall, the fuel integrity and leak-tightness of the Loviisa plant units have been good.

During the current operating licence period, the hydrochemistry of the Loviisa 1 and 2 nuclear power plant units' reactor circuits and the integrity and leak-tightness of the primary circuits have been acceptable.

The conclusion is that the hydrochemistry of the primary and secondary circuits of the Loviisa 1 and 2 plant units has been implemented as intended in Section 10 of Regulation STUK Y/1/2016, with due consideration to the implementing decision of Guide YVL B.5 (15/0010/2015, 25 September 2015).

4.3.3 Ensuring containment integrity

In order to ensure the containment integrity:

1) the containment shall be designed to maintain its integrity during anticipated operational occurrences and, with a high degree of certainty, during all accident conditions;

2) pressure, radiation and temperature loads, radiation levels inside the plant, combustible gases, impacts of missiles and short-term high-energy phenomena resulting from an accident shall be considered in the design of the containment; and

3) the possibility of failure of the reactor pressure vessel in a severe accident so that the leak-tightness of the containment would be endangered shall be extremely small.

A nuclear power plant shall be equipped with systems to ensure the stabilisation and cooling of molten core material generated during a severe accident. Direct interaction of molten core material with the load bearing containment structure shall be reliably prevented.

The general goals for ensuring containment integrity are presented above at the beginning of Chapter 4.3. The detailed goals are listed in Guide YVL B.6.

The purpose of the containment is to limit the releases of radioactive substances during normal operation and in accident situations. The Loviisa 1 and 2 nuclear power plant units feature a double containment. The inner steel containment has gas-tight. The outer shell is formed by a reinforced concrete cylinder and a steel roof. The maximum allowed leakage rate of the containment under design pressure is 0.2%/day. The purpose of the outer containment is to protect the inner containment from external effects.

The double structure also enables using the ventilation system to depressurise the space between the buildings. The negative pressure makes outside air flow into the intermediate space. In accident situations where radioactive substances leak into the intermediate space, the ventilation system flow is diverted to the filters to reduce releases into the environment due to containment leaks.

Normally, the containment pressure is negative to ensure that the radioactive substances released into the air are not dispersed uncontrollably from the containment and can be, instead, routed to the ventilation stack by means of the ventilation systems. In case of accidents, the containment features ice condensers and a containment spray system, which can be used to manage containment pressure.

The operability and tightness of the isolation valves of the containment's access openings, penetrations and process lines are inspected by means of periodic tests. The tightness of the steel containment is checked through leakage tests performed every four years. The leakage tests performed have shown that the containment meets the set criteria.

The original design bases of the Loviisa 1 and 2 plant units' containment systems did not cover severe reactor accidents. The key elements of the severe reactor accident management strategy are depressurising the primary circuit, retaining molten core in the reactor vessel through exterior cooling of the pressure vessel, discharging heat from the containment, preventing overpressurisation by means of a containment-external spray system, and preventing rapid containment pressurisation (hydrogen fires and explosions). In addition to this, the leak-tightness of the containment has been ensured by replacing the necessary seals with materials that can withstand the conditions of severe accidents.

The conclusion is that the containment integrity at the Loviisa 1 and 2 plant units has been implemented as intended in Section 10 of Regulation STUK Y/1/2016, with due consideration to the implementing decision of Guide YVL B.6 (16/0010/2015, 25 September 2015).

4.4 Safety functions and provisions for ensuring them (Section 11)

In ensuring safety functions, inherent safety features attainable by design shall be primarily utilised. In particular, the combined effect of a nuclear reactor's physical feedback characteristics shall be such that it mitigates the increase in reactor power.

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

In order to prevent accidents and mitigate the consequences thereof, a nuclear power plant shall be provided with systems for shutting down the reactor and maintaining it in a subcritical state, for removing decay heat generated in the reactor, and for retaining radioactive materials within the plant. Design of such systems shall apply redundancy, separation and diversity principles that ensure implementation of a safety function even in the event of malfunctions.

The most important safety functions necessary to bring the plant to a controlled state and to maintain it must be ensured even if any individual component of a system providing the safety function is inoperable and even if any other component of a system providing the same safety function or of a supporting or auxiliary system necessary for its operation is simultaneously inoperable due to the necessity for its repair or maintenance.

Common cause failures shall only have minor impacts on plant safety.

A nuclear power plant shall have off-site and on-site electrical power supply systems to cope with anticipated operational occurrences and accidents. It shall be possible to supply the electrical power needed for safety functions using either of the two electrical power supply systems.

A nuclear power plant shall have the necessary components and procedures for securing the removal of residual heat from the fuel in the reactor and the spent fuel inside the storage pools for a period of three days independently of the off-site supply of electricity and water in a situation caused by a rare external event or a disruption in the on-site electrical distribution system.

The management of severe reactor accidents and the monitoring of the plant's status during severe accidents shall be implemented by means of systems that are independent of the systems designed for normal operation, anticipated operational occurrences and postulated accidents. The leak-tightness of the containment during a severe reactor accident shall be reliably ensured.

The plant shall be designed so that it can be brought into a safe state after a severe accident.

The requirements for safety functions and ensuring them that specify Section 11 of Regulation STUK Y/1/2016 are set forth in Guide YVL B.1.

The basic safety functions of a nuclear power plant are as follows: reactor shutdown, removal of residual heat from the reactor into the ultimate heat sink and retaining radioactive substances in the containment. These functions must be ensured in normal operating situations, anticipated operational occurrences and accidents.

The design of the Loviisa NPP utilises inherent safety features in the planning of reactor loading and the systems that implement safety functions. The reactor is stopped during transients with control rods that are dropped into the reactor core by gravity. Residual heat is discharged into the secondary circuit by means of the primary circuit's natural circulation due to differences in water density. As the primary circuit pressure is decreasing in an accident situation, the water volume is secured by the water tanks, which are pressurised with hydrogen, being discharged into the primary circuit. Containment pressure management during accidents is based on ice melting in the ice condensers.

In addition to the aforementioned functions that take place without external actuating power, the Loviisa power plan has in place many active systems that execute safety functions. These systems require electricity to function and primarily comprise four parallel devices.

During the current operating licence period, air cooling units described in Chapter 4.1 were installed to secure the ultimate heat sink. These units can discharge residual heat into the atmosphere if sea water cooling is unavailable due to ice, algae or oil, for example.

The design basis for the systems of the Loviisa power plant that are important to safety does not assume the simultaneous maintenance- or repair-related inoperability of another device during the inoperability of any individual device. Instead, the aim has been to ensure that all system important to safety can perform their tasks regardless of the inoperability any of other individual system device. However, the TTKE limits the repairs and inoperability periods of devices and systems. After the commissioning of the facility, numerous modifications have been made to the plant units' safety systems and many individual devices have been replaced to ensure the operational and overall reliability of the systems. Entirely new parallel systems have also been set up.

The devices required by the Loviisa power plant's safety functions are not physically separated across the board, which means that the same external reason may damage other redundant parallel devices. For this reason, numerous changes have been necessary after the plant's commission particularly as a result of separation requirements. The physical separation of the systems has been further improved based on the results of the probabilistic safety analysis assessing the extent of the risk caused by fires and floods.

The original design of the Loviisa power plant did not ensure the 72-hour residual heat removal from reactor fuel and spent nuclear fuel in the refuelling pool and storage pools in situations caused by a rare external event or a disturbance in the facility's internal power distribution network. When the primary circuit is leak-tight, the fuel in the reactor can be cooled for 72 hours through the steam generators by feeding in water using the emergency feedwater system driven by diesel engines. Currently, the removal of residual heat from the refuelling pool and during outages in situations where the primary circuit is not leak-tight requires the restoration of external sources of water and electricity before the 72 hours is up. For the aforementioned situation, the Loviisa power plant has initiated a project that ensures residual heat removal from the refuelling pool and open reactor using water circulation inside the containment or movable water sources and systems designed for managing severe accidents. If normal cooling is prevented, residual heat is removed from the fuel storage pools by evaporating the water and feeding makeup water into the pool from an external source. The project to ensure the removal of residual heat is intended to be completed by the end of 2018.

The systems designed for the management of severe accidents are independent of the systems designed for normal use and postulated accidents. The systems have primarily been designed to be tolerant of single failure. The facility can be brought to a safe state after a severe accident.

The conclusion is that the safety functions at the Loviisa power plant have been ensured as intended in Section 11 of Regulation STUK Y/1/2016, with due consideration to the transitional provision of Section 27 and the implementing decision of Guide YVL B.1 for the Loviisa NPP. The Loviisa power plant does not fully meet the requirements of Section 11 as the operability of the safety systems during the inoperability of an individual device and the simultaneous repair or maintenance of another device has not been fully ensured, and all parallel parts of the security systems have not been fully separated from each other in accordance with the current provisions. However, STUK has deemed that, pursuant to the aforementioned transition provision and that which is stipulated in Section 7 a of the Nuclear Energy Act, modifying the old facility would not be practically possible and feasible. That being said, the Loviisa power plant will need to implement long-term safety improvements and focus them in areas where they are found to have the most substantial effect on safety.

4.5 Safety of fuel handling and storage (Section 12)

According to Section 114 of the Nuclear Energy Decree (161/1988), *The Radiation and Nuclear Safety Authority (STUK) shall see to it that nuclear fuel is designed, fabricated, stored, handled and used pursuant to the relevant instructions and regulations. Nuclear fuel cannot be placed in the reactor until STUK has accepted the fuel for use.*

Fortum's nuclear fuel procurement is steered by the Loviisa nuclear fuel quality manual, whose higher-level quality management instructions (PK) concern fuel procurement procedures, including use, handling and storage. The procedural instructions (PM) under the higher-level quality management instructions correspondingly describe the work procedures concerning procurement practices.

The nuclear fuel for the Loviisa NPP is manufactured by the Russian company JSC TVEL. At the end of 2006, Fortum made a decision to order fuel for both plant units exclusively from TVEL until the end of the service life. Second generation VVER-440 fuel is currently being used, which was initially delivered to Fortum at the end of 2008 and commissioned during the annual maintenance of 2009.

Section 12 of Regulation STUK Y/1/2016 stipulates the following:

Adequate fuel cooling and radiation protection shall be ensured when handling and storing nuclear fuel.

Nuclear fuel storage conditions shall be maintained such that the leak-tightness or mechanical endurance of a fuel assembly is not substantially degraded during the planned storage period.

Damage to the cladding of the fuel assemblies during handling and storage must be prevented with a high degree of confidence.

The possibility of a criticality accident shall be extremely small.

The probability of a severe accident shall be extremely low.

Guides E.2, A.3, B.4 and D.3 form the basis for the requirements in Section 114 of the Nuclear Energy Decree and Section 12 of Regulation STUK Y/1/2016.

The fuel pools of both the reactor building and spent fuel storage are cooled with separate cooling systems, and preparations have been made for the failure of these systems. The Loviisa NPP's efforts initiated after the Fukushima Dai-ichi incident are continuing for the purpose of ensuring fuel pool cooling and improving the condition monitoring instrumentation (see Chapter 4.4).

The radiation shielding of the fuel pools is primarily based on keeping the fuel assemblies sufficiently deep underwater.

The procedural instructions related to the safe transport, handling and storage of nuclear fuel are provided in the Loviisa NPP's quality assurance manual in order to detect any possible unexpected phenomena and prevent fuel damage. The nuclear fuel's operation condition and performance are monitored and controlled during operation and by means of post-irradiation inspections and examinations in accordance with the operation control programme necessitated by Guide YVL E.2.

The criticality safety of spent nuclear fuel placed in storage racks is primarily based on the distance between fuel assemblies – with new tightly-packed fuel racks, another basis is fixed absorption structures. Criticality safety is ensured with criticality safety analyses conducted in conjunction with fuel licensing, which indicate that all fuel racks used at the plant site meet the criticality safety requirement of Guide YVL B.4, taking into account the uncertainties of the calculation system, storage conditions and fuel irradiation history. The approval criterion for the analyses is that the safety requirement must be met even if the entire rack is filled with the most reactive possible fuel and there is no boric acid in the fuel pool water. Criticality safety during fuel replacement is ensured with the sufficient boric acid content of the reactor coolant, in addition to which criticality is monitored by means of neutron flux measurement.

The conclusion is that fuel management at the Loviisa NPP has been arranged as intended in Section 12 of Regulation STUK Y/1/2016 and Section 114 of the Nuclear Energy Decree. The assessment has taken the ongoing measures to improve the arrangements for ensuring fuel pool cooling into account.

4.6 Protection against external hazards affecting safety (Section 14)

The design of a nuclear power plant shall take account of external hazards that may endanger safety functions. Systems, structures and components shall be designed, located and protected so that the impacts of external hazards deemed possible have only a minor impact on plant safety. The operability of systems, structures and components shall be demonstrated in their design basis external environmental conditions.

External hazards shall include exceptional weather conditions, seismic events, impact of accidents taking place in the plant's vicinity and other factors resulting from the environment or human activity. The design shall also consider unlawful actions with the aim of damaging the plant and a large commercial aircraft crash.

The detailed requirements related to Section 14 of Regulation STUK Y/1/2016 are presented in Guide YVL A.11, B.1, B.2, B.7 and E.6.

Loads and conditions caused by natural phenomena have been taken into account in the structural design of the Loviisa 1 and 2 nuclear power plant units in accordance with current Finnish building regulations. The original design did not include precautions for external hazards as severe as those required to be considered in the design of new nuclear power plants.

The effects of external hazards on the safety of the Loviisa NPP have been studied and analysed since the 1990s in connection with the probabilistic risk analysis, and the resulting risks have been reduced through numerous plant modifications. Risk analyses are kept up-to-date by means such as utilising new measurement data and following research in the field related to matters like the possible effects of climate change on extreme weather phenomena. The external hazards examined in the Loviisa NPP's risk analysis include the following: earthquakes, extreme conditions related to weather (e.g. outdoor and sea water temperature, variation in sea level, wind speed, snow- and windfall, lightning and electromagnetic disturbances), phenomena causing a blockage hazard in the seawater systems (e.g. frazil ice, clams, algae or oil entering the sea water intake due to an oil tanker accident), and external fires or explosions. In addition to individual phenomena, the effects of essential common phenomena, such as strong winds and heavy snowfall, have been analysed. There are only minor differences between the plant units with regard to the effects of external hazards. Unlawful actions to damage the plant are not included in the probabilistic risk analysis. Instead, they are covered by the plant's security arrangements, which are addressed in more detail in Chapter 7.

According to the risk analyses presented in conjunction with the periodic safety review, slightly over one-third of the core damage frequency is attributable to external hazards. The contribution of external hazards to the large release frequency is slightly higher. The following have been estimated to be the most important external hazards:

- blockage hazard of sea water systems during cold shutdown states when cooling is exclusively dependent on sea water;
- sea water level in excess of 3 m, in which case water floods into the yard and, through it, into the plant premises;
- extremely strong wind (over 45 m/s), which topple the turbine hall walls and destroy electronics important to safety; and

- combined effect of abundant algae growth and strong wind, in which case the wind can cause loss of off-site power supply while the algae block the sea water cooling systems, causing a loss of the emergency diesel generators.

The Fukushima Dai-ichi incident in 2011 resulted in the rapid commencement of domestic safety analyses regarding external threats as well as extensive stress tests in the EU countries. The analyses did not identify new external threats or the need to take immediate action, but a decision was made to improve the plant against the loss of the ultimate heat sink and sea water flooding, and to increase the plant's self-sufficiency in the event that power supply is lost. As a result of the Fukushima Dai-ichi incident, a decision was made to revise the estimates related to uncertainties in terms of sea levels in extreme conditions and the possible effects of climate change, using the latest expertise on the subject as a basis. In the updates provided by the Finnish Meteorological Institute, the frequency estimates for high sea level increased substantially. According to the studies, the 100-year statistics, which were used as a basis for Fortum's prior sea level estimates, do not represent the current conditions due to climate change.

As a result, the most significant plant improvements against external threats have been related to implementing protection against high sea levels, reducing the blockage risk of the sea water systems, and ensuring the independence and fuel availability of the emergency power equipment. If necessary to provide protection against sea water flooding, the plant personnel can protect the emergency feedwater pumping facility, which can be used to secure heat removal and keep the power plant in a controlled state in the early phases of an accident. In order to reach the final safe state, the power plant has planned to use the additional residual heat removal system, which is meant to be protected against flooding in the same way as the emergency feedwater pumping facility. In addition to this, the additional residual heat removal system requires redundant power supply to function. The intention is to conduct the work during 2017. The floodgate, which closes the sea water discharge channel and is constructed from elements laid on top of each other, was made higher. This improved protection of the facility against high sea levels during the annual maintenance work. The replacement of the floodgates with gates that reach all the way to the yard level further improves the protection. This modification work has been partially implemented and will be completed for all discharge channels during the 2018 annual maintenance. In 2015, a system that can discharge the residual heat produced by a shutdown reactor into the atmosphere was commissioned at the Loviisa NPP. Thanks to this improvement, the facility can be maintained in a safe state for a long period of time. This solution almost fully eliminates any future risks caused by the loss sea water cooling. In case of accident situations that last longer than three days, the fuel-related self-sufficiency and availability of the emergency diesel generators is bolstered with plant improvements implemented in 2016. In addition to this, the plant site features an air-cooled diesel emergency power plant.

Fortum has presented preliminary results of the risk analysis describing the situation at the end of 2015, which take into account the aforementioned changes made to improve protection in relation to high sea levels and the blockage of sea water systems. The modifications have led to a reduction in risk (core damage frequency) and changes in the mutual significance of the events that cause this risk.

The original design of the Loviisa NPP did not separately consider earthquakes, and the facility cannot be fully brought in line with all new requirements. According to the effective transitional provision (STUK Y/1/2016, Section 27), Section 14 is to be applied to a nuclear power plant unit for which an operating licence was issued prior to the entry into force of the regulation to the extent required under the principle laid down in Section 7 a of the Nuclear Energy Act. In the design of significant plant modifications, earthquakes have been taken into account since 2001. The seismic resistance of the facility has been assessed in connection with the risk analysis, initially in 1992 as part of the risk analysis for external threats. In conjunction with the operating licence application in 2006, Fortum assessed the state of the seismic risk analysis and the significance of the seismic risks during the annual maintenance. The latest seismic risk analysis is from the year 2010. Based on the analysis, the Loviisa NPP is located in a seismically stable are and the plant's risk of core damage due to earthquakes is very low. However, in the context of the latest seismic risk analysis, STUK required Fortum to estimate the need to update seismic risk scenarios and explore the possibilities of improving the supports of the most seismically sensitive equipment.

The significance of extreme temperatures or rain- and snowfall as individual phenomena has been assessed to be low in the external hazard risk analysis. As a combined phenomenon, however, strong wind and snowfall could cause a loss of off-site power supply due the wind, while the snow would simultaneously block the air intake of the emergency diesel generators. Another combined phenomenon that has been identified is heavy algal growth simultaneously with strong wind, which would prevent heat discharge into the sea. High sea level and strong wind, which could topple the turbine hall walls and destroy electronics important to safety, have been identified as individual phenomena important to the safety of the facility. Improvement measures against high seal level have been presented above.

Lighting has caused problems at the Loviisa plant, and relevant improvements were made in the 1990s. After the improvements, the external lighting protection of the buildings that are important to safety has been estimated to be sufficient, as regards the sections that are above ground. Solar storms have caused problems in electricity networks all over the world. According to an analysis conducted in 2016, however, no problems are foreseen for the Finnish national network. Since solar storms constitute an extremely large scale phenomenon (they affect only very long cables and oil pipelines), they do not directly affect nuclear power plants.

Oil, clams, algae, jellyfish, debris or frazil ice entering the sea water systems might weaken them or, in the worst case scenario, block some of them. Preparations have been made for the blockage of sea water intake in the design and operation of the facility. If normal sea water intake is blocked, the sea water required for residual heat removal can be alternatively extracted from the discharge side. Climate change may increase the influx of biomass into the facility, but this possibility has been recognised and the relevant preparations have been made. Fortum has agreed upon notification procedures regarding oil hazards with the Finnish Environment Institute, which coordinates oil spill prevention and response efforts, along with making preparations for oil spill prevention in cooperation with the Eastern-Uusimaa Emergency Services Department. Furthermore, the cooling method, which discharges heat into the atmosphere and was implemented at the Loviisa plant in 2015, eliminates almost all risks resulting from the loss of sea water cooling.

Forest fires have not been estimated to cause a risk to the facility. Efforts are made to prevent the loss of off-site power due to forest fire through the periodic trimming of the trees under the power lines. Aircraft collision with the power lines has been estimated to be unlikely. There are no operations in the vicinity of the facility that could cause a threat of toxic or explosive gasses. Furthermore, no other industrial facilities that would compromise safety are present.

The design of the Loviisa NPP does not include preparations for the collision of a large commercial airliner. It is not possible to bring old nuclear power plants to fully in line all new requirements. For this reason, transitional provisions have been issued for them. The effective transitional provision has been presented in Section 27 of STUK Y/1/2016. It states that Section 14 is to be applied to a nuclear power plant unit for which an operating licence was issued prior to the entry into force of the regulation to the extent required under the principle laid down in Section 7 a of the Nuclear Energy Act.

According to STUK's assessment, the Loviisa NPP's protection arrangements against external threats are up-to-date and sufficient, considering the plant's original technical solutions, the resulting limitations and the improvements current being prepared. The plant modifications implemented have reduced the risk caused by external hazards. Fortum continues to develop its preparations against external hazards and follow developments and research in the field.

The conclusion is that the Loviisa NPP's protection against external hazards meets the requirement in Section 14 of Regulation STUK Y/1/2016 to the extent that is justified by virtue of the principle laid down in Section 27 of Regulation STUK Y/1/2016 and Section 7 a of the Nuclear Energy Act, considering the plant's technical solutions and the resulting limitations. The most significant deviations in conformity are related to the consideration of seismic phenomena in the original design of the facility. The collision of a large aircraft has not been one of the design bases for old facilities, and this type of incident does not need to be taken into account at the Loviisa facilities in accordance with the exception granted in the implementing decision of Guide YVL B.2 on the grounds of the transitional provision in Section 27 of Regulation STUK Y/1/2016. Fortum will continue to assess the need to update the seismic hazard, examine the possibilities to improve the supports of the most seismically sensitive equipment, and develop the probabilistic risk analysis of external hazards.

4.7 Protection against internal hazards affecting safety (Section 15)

The design of a nuclear power plant shall take account of any internal hazards that may endanger safety functions. Systems, structures and components shall be designed, located and protected so that the probability of internal hazards remains low and impacts on plant safety minor. The operability of systems, structures and components shall be demonstrated in the room specific environmental conditions used as their design bases.

Internal hazards to be considered include at least fire, flood, explosion, electromagnetic radiation, pipe breaks, container breakages, drop of heavy objects, missiles due to explosions or component failures, and other possible internal hazards.

The detailed requirements related to Section 15 of Regulation STUK Y/1/2016 are presented in Guides YVL B.1, B.2, B.7 and E.6.

The separation of plant functions, the multiple redundancies of functions, the implementation of safety functions by means of multiple systems utilising different principles (diversity), the placement of the systems that execute the safety systems (layout), and the design of structures to protect against fires and internal threats are addressed in Chapter 4.4.

At the Loviisa power plant, the separation and protection of devices and systems have been implemented in compliance with the requirements effective at each respective time of construction. The solutions have been retroactively improved in many areas, and the Loviisa plant meets the general requirements presented in Section 15 of Regulation STUK Y/1/2016 with regard to the placement, separation and protection of systems and devices. However, the facility does not fully meet the requirements imposed on new nuclear power plants in the current YVL Guides.

Internal hazards are taken into account in the design of nuclear power plants through the physical separation and protection of rooms and mutually redundant safety systems and devices, for example. The design process must also consider the safety systems' support systems, such as the supply of electricity and other power, measurements and controls as well as related cabling. The operability of the systems, structures and devices in the required environmental conditions is covered in more detail in Section 4.7.1 from the perspective of qualification.

Plant-internal missiles were not included in the original design bases. However, later analyses have not led to the identification of any possible missiles that would threaten the safety of the facility. Improvement measures have also been implemented at the plant to reduce the effects of external pipe breaks.

The impacts of internal hazards on the safety of the Loviisa NPP and any possible improvements have been analysed and explored since the 1980s in terms of deterministic requirements and the probabilistic risk analysis. The risks caused by internal hazards have been reduced through numerous plant modifications. In the Loviisa NPP's risk analysis, the following have been examined as internal hazards: fire, internal flood, falling of heavy loads, loss of room cooling, pipe break, safety system failure, etc. Some differences have been identified between the plant units in terms of risks caused by fire and loss instrument space cooling.

According to the risk analyses presented in conjunction with the periodic safety review, fires cause slightly over one-fourth of the core damage frequency, of which two-thirds are attributable to control room building fires. The majority of the core damage risk caused by fire is caused by main coolant pump seal leaks resulting from fire. The Loviisa 2 unit's fire risk analysis is based on the Loviisa 1 unit's model. The higher fire risk of Loviisa 2 is due to, among other things, the fact that the fire separation of the units is not fully identical and that the risk caused by turbine hall fire is higher for the Loviisa 2 unit than for Loviisa 1.Turbine hall fires cause core damage risk primarily as a result of complete loss of feedwater and through equipment failures.

Other events that the risk analyses have found significant in terms of core damage include the falling of heavy loads, on which numerous structural analyses (including mitigating the estimated consequences) have been conducted in recent years, leaks and watering needs caused by human error (when natural circulation is prevent due to air entering the primary circuit) in cold shutdown states, and the loss of instrument space ventilation at the Loviisa 2 unit. The analyses indicate that it would also be possible to cool the instrument spaces by opening the doors, but more specific instructions on the necessary measures must be provided.

Based on the analyses, internal floods cause only a few percent of the core damage frequency.

The 2011 Fukushima Dai-ichi incident resulted in the need to, among other things, assess the risks related to the loss of reactor hall fuel pool cooling more specifically. The risk assessment prepared by Fortum is still partially preliminary, but it states that slightly less than one-sixth of the core damage frequency is attributable to the loading pool. The most significant risk factor for the loading pool is a heavy load falling into the pool. The structures of the plant units are not identical due to which the consequences of a fuel transfer cask are more for the Loviisa 2 unit in the risk assessment.

According to the analyses presented in connection to the period safety review, the loading pool risks cause approximately one-third of the large release frequency. Other internal hazards cause approximately one-fourth of the release risk. The fairly small proportion of fires in the large release frequency (approx. five per cent) compared to their relatively high proportion of the core damage frequency (more than one-fourth) is likely caused by fires not causing significant containment bypass chains which do not cause a significant threat to the severe accident management systems.

As is the case with most other pressurised water facilities, it is characteristic of the Loviisa NPP that, when prolonged, the transients leading to loss of residual heat removal may cause leaks through the main coolant pumps' shaft seals if water supply to the shaft seal is lost simultaneously. In order to ensure the integrity of the shaft seal, numerous analyses and improvements have been conducted and implemented during the facility's service life. In recent years, has commissioned tests from VTT on the durability of the main coolant pump seals in elevated temperatures. The results show that the loss of seal cooling does not cause primary circuit leakage through the shaft seals if the main coolant pumps are successfully stopped in time. Seal leaks have represented a fairly large portion of the total risk at the Loviisa facility but, based on the tests conducted by VTT, their risk significance is lower than previously estimated. In particular, this has reduced the significance of situations where sea water cooling is lost.

In addition to using control rods, the reactivity and power of the Loviisa NPP's reactor are controlled by adding boron to the reactor cooling water. A rapid local drop in boron content ("slug of boron-free water") due to inadvertent supply of boron-free water, for example, may cause an excessive power increase in one section of the reactor core. Based on the updated analyses, the reactor can withstand larger slugs of boron-free water particularly in situations where all control rods are in the reactor core. The results of the updated analyses indicate that the estimate of risks related to slugs of boron-free water has decreased significantly compared to the previous operating licence period.

Fortum continues to develop its preparations against internal hazards and follow developments and research in the field. According to STUK's assessment, the Loviisa NPP's protection arrangements against internal hazards are up-to-date and sufficient, considering the plant's original technical solutions and the resulting limitations.

The conclusion is that the Loviisa NPP's protection against internal hazards meets the requirement in Section 15 of Regulation STUK Y/1/2016 to the extent that is justified considering the plant's technical solutions and the resulting limitations. The most significant deviation from conformance is related to the realisation of the separation principle since, at the time of constructing the facility, the pertinent requirements were not as strict as the current ones.

4.7.1 Qualification of structures, systems and equipment

According to Section 3.9 of Guide YVL B.1 systems, structure and components (SSC) important to safety must be qualified for their intended use. The qualification process must demonstrate that the SSCs are suitable for their intended use and satisfy the safety requirements. Pursuant to Guide YVL A.8, the required operability of a SSC must reliable retain the required operability despite the effects of ageing, even under the most unfavourable design basis operating conditions. The uncertainty factors related to operability must be examined and reduced to an extent that takes into account the safety significance of each SSC.

According to the IAEA guide SSG-25 "Periodic Safety Review for Nuclear Power Plants", one purpose of the periodic safety review is to assess that the qualification of SSCs important to safety can be maintained in continuous effect through the necessary additional measures. Therefore, the SSCs must be able to perform their safety objective in design basis operating conditions and accidents, taking into account the loads and environmental conditions during these events at least until the next periodic safety review.

Mechanical components

No essential changes have occurred in the qualification of mechanical components in the past operating licence period. The qualification requirements of safety class 1 pressure equipment belonging to the primary circuit is achieved to a sufficient degree when the requirements of the appropriate standards and YVL Guides on design, manufacture, inspections and testing are met. The suitability of other mechanical devices, such as pumps and valves, for the planned environmental conditions is ensured in conjunction with design, procurement and installation by determining for them accident conditions and normal operation conditions in which they must retain their operability and in which it must be possible to manage their wear and ageing by means of maintenance. These requirements are presented in the preliminary inspection documentation and material specification. The structural inspections include pressure, load and leakage tests, in addition to which other tests, type tests and appropriate operating experience information may be required.

Electrical and I&C system and equipment

Guide YVL E.7 lists the more specific procedure for electrical and I&C systems and equipment for qualifying these systems, devices and cables for their purpose of use. The suitability of the equipment and cables must be assessed in accordance with the YVL Guides, STUK regulations and applicable standards. Since it must be possible for the equipment to fulfil its purpose in every phase of its entire planned service life, the monitoring of equipment ageing can be viewed as part of the continuous qualification process.

The environmental conditions and stresses of a nuclear facility's safety-classified electrical 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, for their entire design service life, their operating capability is maintained within set requirements. 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.

The accident condition qualification procedures of the Loviisa NPP's electrical and automation systems and equipment exhibited deficiencies as early as in the design and construction phases. For this reason, a systematic qualification assessment (condition qualification) was conducted at the facility in the early 1980s, using the each device's safety significance and operating and environmental conditions during accident situations as the starting point. In the context of the assessment work, the equipment was classified as follows: equipment to be qualified, equipment to be replaced with qualified equipment, and equipment with no qualification requirements. The required qualification measures and equipment and cable replacements were carried out as a result of the assessment efforts. Based on the accident condition examinations, structural changes primarily related to cabling were also conducted.

The power increases of the Loviisa nuclear power plant units have only had limited significance with regard to the qualification of the I&C equipment, due to which the increases have not resulted in new substantial qualification requirements. As regards the electrical systems, the power increases have primary led to modifications of the secondary-side equipment (generators and main transformers) and structures (generator busbars). The inspection of the emergency heat transfer chain in relation to the increase in heating power, which primarily took place in 1997, caused changes that ensured the temperature resistance of the equipment and systems included in the heat transfer chain. The electrotechnical modifications related to the emergency heat transfer chain have included, for example, recoiling some certain pump motors and replacing feed cables and fan motors.

The temperature surveys conducted inside the containments after the 1997 annual maintenance, temperatures exceeding the equipment's design bases (+50 °C) were found. The general temperatures of the steam generator spaces were also discovered to have increased dramatically. To address the matter, Fortum, among other measures, increased the cooling power in the spaces, added temperature measurements and improved the thermal insulation of the process piping. Thanks to these improvements, the general temperatures of the steam generator spaces are currently almost ten degrees lower. Despite the measures, some hot spots were still found in the steam generator spaces, for which Fortum designed cooling arrangements on a case-by-case basis.

The equipment type-specific analysis prepared in 1998, employed theoretical measures to examine the effects of higher temperatures on equipment ageing. Due to the decreased availability of the original electrical and I&C cable types inside the cladding, new cable types from two different manufacturers were qualified.

The qualification requirements for electrical and I&C equipment were updated to the FSAR due to analyses performed in 2002 on live steam pipe leaks. The equipment required in severe accidents has been qualified for the environmental conditions during severe accident, as described in the FSAR. As part of the project on preparations for severe accidents, temperature sensors and magnet switches were installed in the containment, alongside new glow plug devices, which were qualified for severe accident conditions. As regards the primary circuit, the type of the temperature sensors related to the management of severe accidents was improved later in 2009.

Towards the end of the current operating licence period, some of the reactor core's outlet temperature measurements were changed to monitor the temperature under the cover, as this information is required in some accident situations (Loss-of-Coolant Accident LOCA, Main Steam Line Break MSLB) for monitoring the possible steam bubble that may be formed. The modified equipment was qualified by using the conditions of an MSLB accident as the qualification criteria for field equipment.

The qualification of electrical and I&C equipment outside the containments was examined at the turn of the 1980s and 1990s. The efforts led to some structural improvements related to cabling and mechanical protection. In 1998, Fortum decided to conduct additional analyses related to the qualification of containment-external equipment, primarily with regard to the management of accidents caused by postulated pipe breaks at the control room building's feedwater level. Critical points have been protected against jets caused by pipe damage by moving them to a sheltered location or protecting them. The qualification is intended to be supplemented in conjunction with the more extensive I&C update programme (LARP), which entails the ELSA project and initiatives related to the service-life management of I&C and electrical equipment, by separating the equipment, functions and measurements related to the handling of critical functions.

The YP pressure management project carried out during the current decade, new LOCA-resistant valves were qualified and cables that carry their position data and are qualified for accident conditions were installed.

Spare parts were no longer available for the hydrogen content measurement equipment in the containment air space. The system was updated during the annual maintenance of 2015 at Loviisa 1, and the intention is to update the same system for Loviisa 2 in 2017. The sensors and the connected containment-internal intermediate casings and cables must withstand LOCA, MSLB and Post-LOCA conditions.

Since the beginning of 1997, STUK has required the environmental qualification of the electrical and I&C equipment to also indicate electromagnetic compatibility. After this, an EMC survey was conducted on the electromagnetic conditions of the Loviisa nuclear power plant. As a result, case-specific solutions were implemented in relation to conditions deviating from normal industrial environments. Lighting protection arrangements have been improved in the wake of damage caused by lightning. Electromagnetic disturbances caused by nature and people were taken into account in the design of the new I&C buildings commissioned at the beginning of the current operating licence period, in accordance with the current requirements.

The original design of the plant did not include special requirements for earthquake resistance. However, according to the facility's seismic analysis, the risks caused by earthquakes are minor. Seismic classification as per Guide YVL B.7 is used in connection with larger modification work at the facility, and the goal is to indicate that the facility's earthquake resistance will not be decreased. The structures of the I&C buildings have been dimensioned with consideration to the earthquake resistance requirements.

Fortum updated the description concerning the qualification of the I&C equipment with regard to the validity of the qualification of equipment required in various accident situations. According to the description, the validity of the qualification of system TC10/50, TH10/50, YA11-16, TL11, TL15 and YD11-16 temperature sensors will end 30 years of the installation in 2019. The same applies to the level controller type mentioned in the description, which is used to monitor leaks in accident situations. According to the description, this equipment's qualification for accident conditions will be reassessed before 2019. STUK will monitor the implementation of the qualification in its inspections.

It is particularly important to know the service life of equipment qualified for accident situations. The management of the service life and validity of qualification of other equipment is covered in Chapter 2.3 of the safety assessment.

Fortum has also assessed the possibility of occurrences similar to the voltage transients observed in off-site electrical networks between 2006 and 2013 in Sweden (Forsmark) and their possible effects on the electrical systems and equipment of the Loviisa NPP. Based on the analysis and tests performed, Fortum has implemented or decided to implement certain plant improvements to secure the facility against voltage transients. These measures include improving the voltage monitoring of overvoltage protection and updating the rectifiers.

<u>Summary</u>

In summary, STUK notes that the descriptions provided to it in conjunction with the periodic safety review present sufficient information on factors affecting the maintained qualification of systems, structures and equipment, considering the improvement measures presented.

In conjunction with the operating licence renewal in 2007, STUK required Fortum to develop its qualification procedure to be more systematic with regard to the traceability of the qualification of the most important systems, structures and equipment to the original qualification requirements, any possible changes in loads and operating and environmental conditions during the plant's operation, safety analysis updates, and any changes in the qualification requirements with the development of the related technology. As a response to the requirement, Fortum presented in action plan for the development of maintained qualification procedures. The purpose of the qualification programme is to utilise existing practices of the Loviisa NPP in the areas of maintenance, the management of spare parts and plant changes, equipment status, monitoring of environmental conditions and failures, operating experiences and quality management. The facility's maintenance information system is planned to be expanded to provide improved management capabilities for the information required for the maintenance of systems, structures and equipment. This development work is intended to be completed by virtue of the changes necessitated in the power plant's procedures and information systems by the implementation of Guide YVL A.8.

The qualification of the Loviisa NPP's containment-external equipment has been examined, and structural improvement measures have been conducted in relation to the cabling and mechanical protection. The measures required for pipe breaks at the feedwater level are intended to be completed in conjunction with the I&C update programme.

4.8 Safety of monitoring and control (Section 16)

The control room of a nuclear power plant shall contain equipment that provides information on the operational state of the nuclear power plant and any deviations from normal operation.

A nuclear power plant shall be equipped with automatic systems that actuate safety functions as required, and that control and supervise their functioning during operational occurrences to prevent accidents and during accidents to mitigate their consequences.

These automatic systems shall be capable of maintaining the plant in a controlled state long enough to provide the operators with sufficient time to consider and implement the correct actions.

The nuclear power plant shall have a supplementary control room independent of the main control room, and the necessary local control systems for shutting down and cooling the nuclear reactor, and for removing decay heat from the fuel in the nuclear reactor and the spent fuel stored at the plant.

Guide YVL B.1, and specifically its Section 5.2 “Instrumentation and control systems” and 5.3 “Control rooms” present more specific requirements for the systems used in the monitoring and control of a nuclear power plant.

The Loviisa 1 and 2 nuclear power plant units have their own independent main control rooms. They provide access to the necessary process information and the capabilities to control the plant unit during normal use and bring it to a controlled state during anticipated operational occurrences and accidents.

In addition to this alarms from the spent fuel storage facilities are routed to the Loviisa 2 unit's main control room. Both units also feature an “emergency control room board”, which enables stopping the reactor and performing the control and monitoring measures necessary to ensure safety.

The auxiliary buildings of both plant units feature auxiliary control rooms for the monitoring of important auxiliary processes. Furthermore, the facility includes plant unit-specific ventilation control rooms as well as diesel generator-specific local control positions. Alarms from all auxiliary control rooms are sent to the main control rooms in compiled form.

During the previous operating licence period, monitoring and control systems separate from other I&C systems were installed at the facility for the purposes of severe accidents. The monitoring and control solutions for these systems have been situated in a crosswise fashion in connection to the control rooms of both facilities, in the annuluses, and in a joint monitoring location for both plant units. The auxiliary emergency feedwater pumping facilities supplying both plant units, the system that secures the primary circuits cooling during shutdown states (auxiliary RR) and the containment's external spray system have their own monitoring locations.

In the main control room, process information is presented with meters, indicator lights, plotters, and the indicating devices of the process automation and computer systems. The alarm information in the main control room is presented through display panels controlled by conventional alarm systems and indicating devices of process automation and computer systems. In addition to this, the event and status information as well as any breaches of the warning and alarm limits are relayed to the alarm printers.

The process computer system that performs process monitoring tasks and the various monitoring and process automation systems related to it have been updated and expanded in connection with plant modification.

Plant system control functions carried out from the control room are implemented through automation functions at various levels. The highest level is for plant controls and the lowest for individual controls.

Currently, the control interface consists of button control systems, key switches, dials and controllers situated in the main control room consoles and panels, as well as the preventive protection system's on-screen control solutions. In order to avoid mistakes, the “two-hand principle” is observed, meaning that controls can only be engaged if a release function is activated at the same time using a separate button.

The main control room also features user interfaces for the most essential information systems: management of the facility's equipment and material information, maintenance planning and control, management of periodic tests, and operation logs.

The threats affecting the control room and their prevention have been covered in the context of the sections of the safety assessment that address external and internal threats.

The actuators of the facility are divided into operational groups of various levels, whose control in relation to normal operation and failure states are executed through separate I&C functions. Controls important to safety are activated by I&C systems responsible for safety functions, and these controls bypass other controls, with the exception of certain equipment protections.

During the LARA project conducted during the past operating cycle, some of the preventive automatic safety functions and the automation of the in-core measurements and waste water processing were replaced with programmable I&C systems In the on-going ELSA project, the automation of the remaining preventive functions and reactor protection functions as well as process monitoring will be correspondingly replaced programmable I&C systems, along with installing a new I&C system for redundant safety functions.

The plant units' protection systems have been designed in such a way that the activation of safety systems in the event of a transient or accident situation does not require quick action by the operators. The time afforded to the operators to consider the situation before engaging control and other measures, the appropriate transient and emergency procedures, and the training provide serve to efficiently reduce the possibility of human error. The process computer is equipped with support displays that are used in conjunction with transient and emergency procedures that are provided as flow charts.

In addition to the main control rooms, the plant units feature the emergency control rooms described above (SAM control room and separate plant unit-specific emergency control panels), auxiliary and ventilation control rooms, and separate local control positions. Together with the local controls and auxiliary control rooms, the emergency control panel can be used to execute plant unit reactor shut-down, primary circuit cooling and residual heat removal from spent fuel pools, if main control room operations are prevented.

In the context of the operating licence renewal, the emergency control location (auxiliary control room) of the main control rooms was moved to the periodic safety review for final resolution, as the pertaining requirement was not included in the applicable regulations until the 2008 Government Decrees. In connection with the automation update project (LARA), Fortum planned to implement the auxiliary control room by 2014, but the LARA project was suspended before this point was reached.

The intention is to continue the I&C updates at both plant units through the ELSA project, which is slightly smaller in scale than the original plan and does not include the auxiliary control room solution presented in 2006. Instead, the plans aim for modernising the current plant unit-specific emergency control panels.

In conjunction with the safety assessment and as requested by STUK, Fortum provided a separate description of the auxiliary control room's design bases and how it meets the requirements presented in Government Decree 717/2013 (current regulation STUK Y/1/2016) and Guide YVL B.1.

STUK has assessed the matter based on Fortum's description and can state that it has no comments regarding the positioning (separation and internal threats, e.g. fire and flood) of the emergency control panels to be modernised in conjunction with the Loviisa ELSA project.

The conclusion is that the monitoring and control safety of the Loviisa power plant are at the level required by Section 16 of Regulation STUK Y/1/2016. The control and monitoring scope of the emergency control panels is small, but the situation can be deemed to be acceptable on the grounds of the transition provision in Section 27 of Regulation STUK Y/1/2016. STUK will assess the control and monitoring scope of the emergency control panels and issue a separate decision in connection with processing the further reports and descriptions prepared by Fortum.

5 Safety of the operation of a nuclear power plant (STUK Y/1/2016 – Chapter 5)

5.1 Safety of operation (Section 20)

The organisation operating a nuclear power plant shall be responsible for the plant's safe operation.

The control room of the nuclear power plant shall be constantly manned by a sufficient number of operators aware of the status of the plant, systems and components. The control and supervision of a nuclear power plant shall utilise written procedures that correspond to the existing structure and the operational state of the plant. Written orders and related procedures shall be provided for the maintenance and repair of components.

For operational occurrences and accidents, appropriate procedures for the identification and control of incidents shall be available.

Operational measures concerning the nuclear power plant, as well as events having an impact on safety, shall be documented so that they can be analysed afterwards.

The Loviisa power plant has determined the minimum control room staffing in the Technical Specifications (TS) in accordance with requirement 739 and Guide YVL A.6 and the requirement 2 of the STUK-issued implementing decision regarding the guide in question (7/0010/2015, 25 September 2015). The operator tasks are specified in the power plant's instructions and procedures. The shift manager is responsible for compliance with the TTKE document and the procedures. As regards the competences of the nuclear power plant operators, the requirements of Guide YVL A.4, Annex E are observed. STUK takes part in the oral examination of the operators arranged in accordance with the Guide.

As required in Chapters 5 and 6 of Guide YVL A.6 and requirement 1 of the relevant implementing decision, shift teams monitor the state of the nuclear power plant regularly by observing control room displays and measurements, testing the operability of the equipment, and performing inspections and monitoring tours of the plant facilities. The control and monitoring of the plant adhere to the Technical Specifications, operating orders and operating procedures in accordance with the requirements in Chapter 7 of Guide YVL A.6. The updating practices and responsibilities for updating the procedures have been defined.

Comprehensive transient and emergency instructions for identifying and managing operational occurrences and accident situations have been prepared in accordance with Chapter 7.2 of Guide YVL A.6.

Among other measures, the operational logs and work management systems referred to in Guide YVL A.6 as well as the daily report necessitated by Guide YVL A.9 are used to document operating measures. In addition to the practices required by Guide YVL A.6, the event documentation takes into account the requirements of Guide YVL A.10. Each person working at the power plant is obliged to report any events, faults and deficiencies observed. Observation notifications or observation reports are used to log findings. The observations are processed regularly and decisions on their further processing and reporting are made based on safety significance.

STUK's local inspector monitors operational activities at the plant site. Furthermore, STUK inspects operational activities through inspections prescribed in the Periodic Inspection Programme and in conjunction with document reviews, for example. Fortum issues reports to STUK on operational activities by means of the regular and event-specific reports referred to in Guides YVL A.9 and YVL A.10. Any procedures that are significant in terms of nuclear and radiation safety, as well as updates to them, are also submitted to STUK either for information or approval, in accordance with Guide YVL A.6.

The conclusion is that the operational activities of the Loviisa 1 and 2 nuclear power plant units have been implemented as intended in Section 20 of Regulation STUK Y/1/2016.

5.2 Taking operating experience and safety research into consideration in order to improve safety (Section 21)

Safety-significant operational events shall be investigated for the purpose of identifying the root causes as well as defining and implementing the corrective measures.

For further safety enhancement, operating experience from the plant and from other nuclear power plants, the results of safety research and technical developments must be regularly monitored and assessed.

Opportunities for improvements in technical and organisational safety, identified from operating experience, safety research and technical developments shall be assessed and implemented to the extent regarded as justified on the basis of the principles laid down in Section 7 a of the Nuclear Energy Act.

5.2.1 Operating experiences during the current operating licence period

In accordance with Guide A.10 on operating experience feedback, the licensee must notify STUK and report to it any events affecting the nuclear facility's nuclear and radiation safety as well as events that may arouse public interest.

The Loviisa power plant has documented procedures on identifying, notifying and analysing operational events as well as determining and implementing corrective actions. STUK has checked the functionalities of these procedures in conjunction with document reviews and inspections prescribed by the Periodic Inspection Programme.

Between 2007 and 2015, 42 events requiring special reporting took place at the Loviisa 1 and 2 power plant units No significant events affecting safety occurred during the operating licence period (INES at least 2), nine events were classified as INES 1 (anomaly) and 26 events were classified as INES 0 (no safety significance).

STUK has monitored the numbers of operational events to be reported according to YVL A.10 and any changes thereto on an annual basis. Based on STUK's indicator, the Loviisa power plant reported an average of nine events a year over the course of the review period. A significant increase in specially reported events took place in 2012, as a result of which Fortum established a working group to resolve the matter. The working group identified improvement possibilities in the processing of operational events, for example, and the Loviisa power plant prepared an action plan to develop is operations. The goal of the development work concerning operational events was to, among other things, improve the utilisation of lessons learned from events and prevent the recurrence of the events. A core solution was to implement the measures required by Guide YVL A.10 in practice. STUK has monitored the progress of the development work through document reviews and within the scope of the Periodic Inspection Programme, for example.

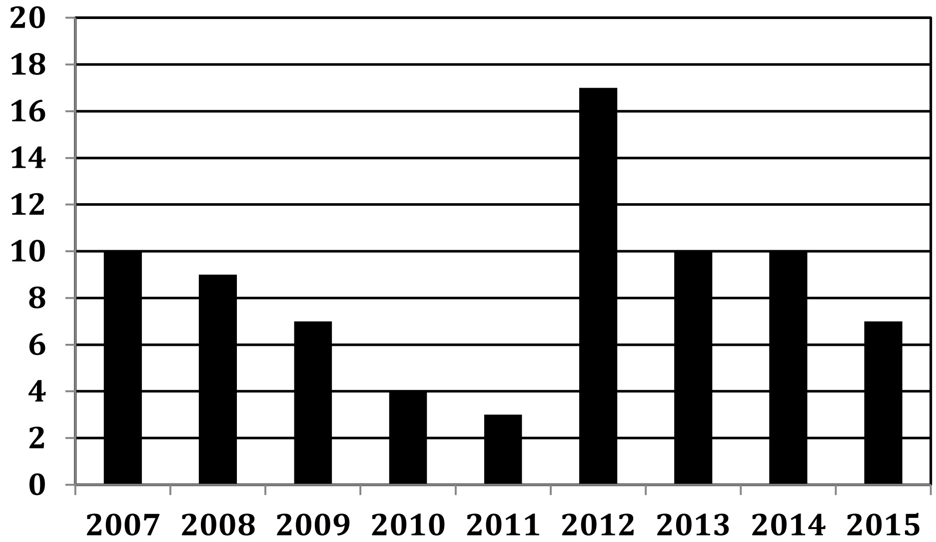

Figure 2: *STUK's indicator A.II.1 Number of operational events*

In summary, the operational events at the Loviisa power plant have not substantially decreased the safety of the plant or caused any radioactive releases into the environment that would deviate from normal operation levels.

5.2.2 Operating experience feedback

Guide YVL A.10 presents the requirements regarding operating experience feedback arrangements and the utilisation of operating experiences that Fortum has taken into account in areas such as the procedural instructions related to the processing of internal and external operational events at the Loviisa NPP.

STUK ensures the fulfilment of the applicable requirements in inspections concerning operations and operating experience feedback, in accordance with the Periodic Inspection Programme. In addition to this, STUK assesses operating experience feedback in conjunction with reviewing reports prepared on events. In its inspections, STUK has required Fortum to pay attention to the follow-up of corrective actions and the assessment of their efficacy, for example. The sufficiency of resources related to the operating experience feedback arrangements must also be ensured so that the reports and actions can be implemented in a timely manner and at a high level of quality.

The general goal of operating licence feedback is to create and maintain practices through which lessons can be learned from experiences gained and corrective actions aimed at improving safety can be implemented. Fortum's operating licence feedback activities cover following the experiences of its own plants and other plants, and taking these experiences systematically into account in its own operations. Fortum has an operating experience and safety culture group, which is tasked with screening the event- and observation-related information from various sources and assess their significance in terms of various areas of technology. Screening meeting, which are attended by a operating experience specialist, operating experience handler and environment expert, are held on a regular basis.

External operational events and the operating experiences of other plants are processed by Fortum's division-level Nuclear Safety Assurance business area. The head of international operations at the Loviisa power plant is responsible for the content of the procedural instructions. The operating experience processing group (KKR), which comprises experts from the Loviisa power plant and Keilaniemi, convenes regularly, at least five times a year. The KKR is responsible for the event reports and documents admitted for processing, their analysis, possible additional clarifications, recommendations for corrective actions, other utilisation, documentation, archiving and reporting. The most important sources of information are operating experiences from IAEA and WANO databases, instructions, recommendations and reports from other nuclear power plants. Further information is received by participating in international organisations' (WANO; IAEA; OECD; NUMEX) operational programmes (Peer Review, OSART, monitoring of performance indicators, etc.) or direct information exchange, collaboration events and visits to other facilities.

Event-related measures are recorded into a separate monitoring system. The progress of corrective actions is followed up by units and the operating experience and safety culture group. The timely implementation of the corrective actions based on the events has been identified as a development target.

The conclusion is that operating experience feedback at the Loviisa nuclear power plant units has been arranged as intended in Section 21 of Regulation STUK Y/1/2016. In the future, STUK will specifically keep an eye on how Fortum will develop its operations in order to determine root causes and implement the resulting corrective actions in a timely fashion.

5.2.3 Safety research

Due to the development history of the nuclear power plant, Fortum has fairly extensive experience specifically with regard to VVER-type facilities. For this reason, the company has been active in following research in the nuclear energy field and participating in it. Fortum organises its nuclear safety research until 2014 into six programmes: APROS software development, nuclear waste research, operation and maintenance, fuel and reactor physics, materials research and thermal nuclear safety. Over the course of 2015, Fortum changed the structure of its research programmes to include three more extensive programmes instead of six separate ones: Safe & efficient operations, Nuclear business growth and Future nuclear technologies. Within these programmes, Fortum conducts its own research, coordinates research commissioned from external parties, and follows and participates in national and international research programmes. In Fortum's own or commissioned research, the main focus is resolving the needs identified directly at the Loviisa NPP. Through national and international research programmes, the company gains more extensive information on the current topics and results of research and development.

In summary, Fortum arrangements to follow the nuclear energy field and participate in related developments are as intended in Section 21 of Regulation STUK Y/1/2016.

5.3 Technical Specifications (Section 22)

The Technical Specifications of a nuclear power plant shall include the technical and administrative requirements for ensuring the plant's operation in compliance with design bases and safety analyses. The requirements for ensuring the availability of systems, structures and components important to safety, as well as the limitations that are to be complied with when equipment is unavailable, shall also be included in the Technical Specifications.

The plant shall be operated in compliance with the requirements and restrictions set in the Technical Specifications, and compliance with them shall be monitored and any deviations reported.

The Technical Specifications (TS) are an operating licence document as specified in Section 36 of the Nuclear Energy Decree. The TS and other instructions of the power plant together define the limits and operating methods by which the nuclear power plant can be operated safety in various situations. The Technical Specifications of the Loviisa power plant are plant unit-specific (LO1 TS, LO2 TS). The contents of LO1 TS and LO2 TS adhere to Section 22 of Regulation STUK Y/1/2016, Chapter 7.5 of Guide YVL A.6, and the implementing decision issued by STUK on said Guide.

After the operating licence renewal, Fortum has made numerous updates to the various sections and chapters of the Technical Specifications. In conjunction with the periodic safety review, Fortum went through the TS in its entirety and prepare a new version based on the review. The goal of the project was to harmonise the terminology of the Technical Specifications and go through all references to the Final Safety Analysis Report (FSAR). STUK approved these changes and the new TS version by decision 32/A42273/2015 (5 April 2016).

Individual changes to the Technical Specifications are caused by modifications conducted at the power plant, for example. Fortum has the document maintenance procedures required in Chapter 7.6 of Guide YVL A.6, which ensure that the TS stays up-to-date. Among other things, the number of TS amendment proposals annually submitted to STUK for approvals, are a testament of the efforts to ensure the currency of the Technical Specifications : 17 in 2014, 11 in 2013 and 10 in 2012. In 2013, the Loviisa power plant observed some discrepancies in the currency of the TS; all needs to change the TS were not identified on time and the TS updates were delayed. These observations indicate a need to develop the TS maintenance procedures. Also in 2013, STUK imposed a requirement on the Loviisa power plant to prepare an action plan to check the currency of the effective TS and develop the TS maintenance procedures. STUK monitored the implementation of the measures through its inspections. All measures were not implemented or documented in accordance with the action plan and the power plant's instructions, so STUK necessitated new measures to complete the improvement project in 2014. The required measures were concluded in the summer of 2016.

In some cases, it may be necessary to deviate from the Technical Specifications. Such cases include ensuring occupational safety and performing modifications that improve safety. Fortum has in place documented procedures compliant with the requirements in Chapter 7.6. of Guide YVL A.6 for determining the acceptability of a TS deviation and applying for permission. Based on the annual statistics in Figure 2, needs to deviate from the TS occur six times a year, on average (based on a ten-year average between 2005 and 2014).

Despite the documented procedures and employee training, there have been some deviations unauthorised deviations from the Technical Specifications over the years. The power plant has in place the documented procedures required in Chapter 7.6 of Guide YVL A.6 and Chapter 3 of Guide YVL A.10 to identify these unauthorised TS deviations, determine their safety significance and reasons, along with specifying the corrective actions to prevent such events during future operation of the facility. STUK's indicator shows that unauthorised TS deviations of this nature occur three times a year on average (based on a ten-year average between 2005 and 2014). The trend has become increasing since 2012 (Figure 3). The increase may have been caused by developments in event observation and reporting methods or a deterioration in operational practices, for example. At the beginning of 2013, Fortum established a working group to examine the increase in operational events, including the TS deviations. Towards the end of 2013, the Loviisa power plant prepared an action plan to develop the operations based on the research conducted by the Fortum working group. The measures were timed to be completed by the end of 2015. Fortum has supervised the implementation of the work, in addition to which STUK has monitored the progress of the development efforts in its inspections.

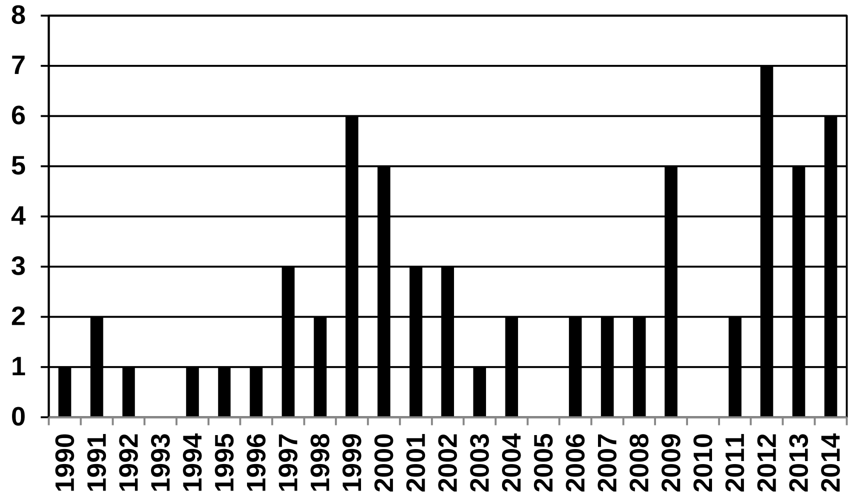

Figure 3. *STUK indicator A.I.2 "Deviations from the TTKE – in violation of the TS",*

The conclusion is that the Technical Specifications of the Loviisa 1 and 2 nuclear power plant units have been implemented as intended in Section 22 of Regulation STUK Y/1/2016. In recent years, more deviations than before have been observed in compliance with the TS, which have resulted in analyses and the initiation of improvement measures. STUK has monitored the implementation of the measures through its inspection efforts. Based on STUK's assessment, TS is at an acceptable level in terms of safety.

5.4 Condition monitoring and maintenance to ensure the safety of the facility (Section 23)

Systems, structures and components important to the safety of a nuclear power plant shall be available as detailed in the design basis requirements.

Operability and the effects of the operating environment shall be monitored by means of inspections, tests, measurements and analyses. Operability shall be checked in advance by regular maintenance, and provisions shall be made for maintenance and repairs in the event of any deterioration in operability. Condition monitoring and maintenance shall be planned, supervised and implemented so that the integrity and operability of systems, structures and components are reliably preserved throughout their service life.

5.4.1 Maintenance operations

The maintenance operations of the Loviisa 1 and 2 nuclear power plant units cover pre-emptive, preventive, corrective and improving maintenance as well as related design, implementation, spare part management and quality control. Pre-emptive maintenance is based on information produced by condition monitoring on operability, and assessing repair needs and timing maintenance work based on this information. According to the strategy of preventive maintenance, the specified maintenance work is conducted at certain specific intervals to reduce the risk of losing operability during operation. In corrective maintenance, a SSC is not covered by the previous schemes and is not repaired or replaced until it has already failed. The maintenance strategy of an individual SSC is selected from production and nuclear safety perspectives and by proportioning the maintenance tasks and their intervals based on operating experiences. According to Guide YVL A.8, corrective maintenance is not permitted as a strategy for safety-classified SSCs. Improving maintenance is a more general principle, which involves utilising operating and maintenance experiences in searching for development targets independently among SSCs and maintenance practices.

Guide YVL A.8 and the E series YVL Guides present the requirements for maintenance and modification work that Fortum has incorporated into its own corresponding instructions. In addition to the instructions, Fortum has a plant information system, which is used to manage and control maintenance operations. The Technical Specifications determine the conditions and limitations concerning the SSCs that are important to safety, as well as the periodic tests and their intervals.

Alongside the measures determined in the maintenance and condition monitoring programmes, Fortum monitors SSCs in conjunction with normal operation and daily monitoring tours. In-service condition monitoring is primarily the responsibility of the operating group, the activities of which include the morning, day and night shift each performing the facility tour prescribed in the weekly list on a daily basis. The primary and secondary circuit have their own weekly lists. The weekly list specifies approximately 10 inspection areas per shift and refers to the procedure to be observed in the inspections. If deviations are identified, the operating personnel submit a work order or record a deviation in the plant log for monitoring. Cameras are used to monitor locations that cannot be accessed during operation due to high levels of radiation – leaks in steam generator space drains, for example. At regular intervals, the operating group performs tests on the emergency system pumps, which compare the measured operating point with the acceptable characteristic curve. In the pump tests, the condition monitoring group measures vibrations with a portable device. The results are stored in the condition monitoring system's database for trend observation. Continuous vibration monitoring is in place for main coolant pumps, main sea water pumps and the turbine generator. The primary circuits of both plant units feature vibration and loose debris monitoring, which is capable of detecting metal fragments carried with the flow. The sensors are installed at the bottom of the reactor, on the nuts of the reactor cover's stud bolts and on the steam generators.

During the annual maintenance, the primary circuit components are subjected to qualified inspections, with inspection areas and intervals based on the ASME XI standard. The inspection areas of pipes are selected in a risk-informed manner (RI-ISI). The inspections listed above look for fracture-type failures. In order to detect possible thinning caused by erosion corrosion, a special pipe conditioning monitoring programme is in place, which measures wall thicknesses at critical points. Safety-classified and registered pressure vessels are subjected to an internal inspection every four years and pressure test every eight years. Inspection plans are prepared for all the inspections listed above, which are submitted to STUK in advance. STUK assesses the inspection results immediately at the facility and in reports delivered at a later time.

In order to ensure the operability of SSCs, inspections and tests are also conducted based on operating experiences from other sources and developments in technical knowledge. The most significant sources of experience-related information have been other VVER facilities and international information distribution systems.

A criticality classification is employed in selecting the maintenance strategies for the SSCs and planning the maintenance programmes. The Loviisa plant instruction documents divide individual SSCs to four criticality classes based on their failure significance as follows:

- *No functional failures are permitted for a class 1 device during the operating period. The device must be kept in working order at all times. The device maintenance programme is the most extensive. The amount and proportion of preventive and pre-emptive maintenance is optimised.*

- *No functional failures are permitted for a class 2 device during the annual peak consumption. Limited inoperability is permitted at other times. Security systems are kept operable as required by the TTKE. The amount and proportion of preventive and pre-emptive maintenance is optimised.*

- *Limited inoperability is permitted for class 3 devices. The amount and proportion of preventive and pre-emptive maintenance is optimised.*

- *Class 4 devices can be operated in a planned fashion until functional failure. Limited inoperability is permitted for the devices. The condition of the devices is monitored through normal operational monitoring measures alone, without planned maintenance tasks.*

The classification is conducted in a staggered fashion according to the severity of the production loss caused by the failure or the relative reduction in core damage risk (FV) that could be reached if the fault would be rendered impossible, For example, a failure of a criticality class 1 SCC results in a production loss of > 50 GWh or FV > 10^{-6}.

STUK oversees condition monitoring and maintenance measures as well as modification and repair work through regular inspections. The assessment and monitoring of the maintenance activities are also part of the daily tasks of the local inspectors. The aim of the inspections and regulatory control is to ensure that the power companies have implemented the sufficient procedures and resources, such as competent staff, instructions, spare part and material storage and tools, to ensure the sufficiently effective implementation of the condition monitoring and maintenance measures.

The systems maintaining measurement accuracy that are included in periodic preventive maintenance cover separate measurement equipment, process measurements important to safety and other areas, such as mechanical measurements and measurement systems for chemical and radiation parameters. During the current operating licence period, the comprehensive management procedures of the system maintaining measurement accuracy were developed. The traceability of measurement accuracy is managed by means of an external calibration service. The process measurement calibration system has been brought up to date.

Some maintenance targets were observed during the current operating licence period, whose development STUK has deemed to require special monitoring alongside other regulatory control. Examples of these are the emergency diesel generators, main coolant pumps, control rod drives and the reactor pressure vessel's emergency water connections (TH connection).

The faults in the emergency diesel generators and their control systems as well as the related spare parts situation were addressed particularly between 2009 and 2012, after which the situation was improved through the measures implemented by Fortum. Diesel faults have also been monitored because Fortum does not plan to update them and will, instead, ensure their operability through preventive maintenance. Fortum has also planned to update the control systems of the other plant unit before the next periodic interim assessment in order to confirm the availability of spare parts. In addition to this, Fortum has initiated a project to overhaul the cooling pipes (casing and auxiliary cooling water). This will be done by fully renovating the external cooling water pipes to match the original state. The installations have been scheduled for the annual maintenance of 2017 and 2018. In the annual maintenance of 2014 and 2015, the main coolant pump wear parts were found to have sustained more damage than usual, and Fortum has delivered reports on the matter to STUK. Fortum has also initiated a project to obtain more spare parts for the main coolant pumps. Faults were observed in the control rod drives during multiple years, due to which Fortum has procured more spare drives and is working to develop its condition monitoring practices to better anticipate possible drive failures. The reactor emergency cooling system's water connections (TH connections) were first inspected at the Loviisa 1 nuclear power plant unit using the new method in 2016. In the inspection, one connection gave an abnormal result, which was deemed acceptable in STUK's inspection. However, STUK required the method to be qualified and the connection with the abnormal result, along with corresponding connections at the Loviisa 2 unit, will be inspected with the same method in the 2017 annual maintenance, which will take place a year earlier than the normal inspection frequency would require. If the new inspection method, when qualified, differs from the method used in 2016, the other connections of the Loviisa 1 unit will be reinspected.

STUK will inspect the repair and modification plans of the equipment most significant to safety and oversee the manufacturing, installation and commissioning related to the work.

The conclusion is that the maintenance operations of the Loviisa 1 and 2 nuclear power plant units have been implemented as intended in Section 23 of Regulation STUK Y/1/2016.

5.4.2 In-service inspections

Pressure equipment and piping

The condition of the pressure-bearing components of the Loviisa 1 and 2 nuclear power plant units is ensured by means of periodic inspections. During outages, periodically repeatable inspections are conducted on the primary circuit equipment by means of non-destructive material testing methods in accordance with Guide YVL E.5. The results of the in-service inspections are compared with the results of prior inspection or basic inspections performed before commissioning.

The periodic inspection programmes are submitted to STUK for approval before each inspection. The programmes and the related inspection instructions are changed as necessary, with consideration to the development of the requirements and standards in the field, developments in inspection technology, inspection experiences, and nuclear power plant operating experiences in Finland and abroad.

The aim has been to select the areas where faults are most likely to occur for the inspections. These include positions that are susceptible to fatigue due to temperature variation, for example. The process of selecting inspection areas is under constant development. For this purpose, Loviisa 1 and 2 plant units have implemented a risk-informed periodic inspection programme for piping. Risk-informed methods are employed to select the inspection areas and optimise the inspection intervals.

The interval between the periodic non-destructive inspections is usually ten years. The inspection programmes have been supplemented with additional inspections for the reactor pressure vessel and primary circuit piping, and their inspection intervals have been shortened from ten to eight years due to the annual maintenance schedule. The inspection interval for special inspection areas, such as positions susceptible to thermal fatigue, may be shorted – three years, for example.

The latest editions of Guide YVL E.5 and ASME Code, Section XI are used as the approval criteria for the periodic inspection programmes and procedures. A qualification system has been developed for periodic inspections in accordance with European practices. Qualification is obtained for all ultrasonic, eddy current and surface inspection systems used in the periodic inspections prescribed in Guide YVL E.5. The majority of the qualifications have been conducted and STUK has approved them.

The reliability of the non-destructive inspection methods of the primary circuit piping and equipment has been substantially improved after the commissioning of the Loviisa 1 and 2 plant units. The implementation of the qualification system for periodic inspections and the commissioning of the risk-informed periodic inspection programme have been significant operational development targets. The development efforts are continuous.

Fish-eyes were observed in the walls of the reactor pressure vessels at the Belgian Doel 3 and Tihange 2 nuclear power plant units in the 2012 periodic inspections. The Loviisa 1 and 2 reactor pressure vessels have been manufactured in the same way, although in a different location than the Belgian vessels, due to which Fortum decided to inspect the Loviisa vessels using the same methods that yielded the observations at the Belgian plants. Since the Belgian findings were known to not cause an acute threat to safety as was the case in Loviisa, it was possible to conduct the inspections in conjunction with normal annual maintenance (in 2014 at the Loviisa 2 unit and in 2016 at the Loviisa 1 unit). The inspections revealed no fish-eyes in either pressure vessel.

In addition to the inspections mentioned above, the following physical inspections of pressure vessel condition and reliability are conducted as periodic pressure equipment inspections compliant with the Finnish pressure vessel legislation: a full inspection, internal inspection and operation inspection. These inspection include non-destructive tests as well as pressure and leakage tests. Specifications for these types of pipe inspections are provided in the system-specific condition monitoring programmes. These periodic inspections are covered in Guides YVL E.3, YVL E.8, YVL E.9, YVL E.10 and YVL E.11. The periodic inspection programmes of the Loviisa 1 and 2 nuclear power plant units meet the requirements of the YVL Guides.

Electrical and I&C components

The periodic inspection programme of electrical and I&C components and systems that are important to safety is based on official regulations and guidelines, safety standards for electrical work, manufacturer instructions/recommendations, methods of using the equipment, and operating experiences regarding the equipment. The scope and frequency of the periodic tests of individual SCCs is determined in conjunction with the qualification process of the SCCs in question or their modifications, with due consideration to the safety significance of each item.

At the beginning of the current operating licence period during the LARA I&C update project, I&C system equipment platforms were commissioned, which represent new technology and include advanced self-diagnostic and testing features. The periodic inspection programmes for I&C systems are defined in such a way that the specific monitoring and periodic tests of the systems together provide the sufficient coverage.

The periodic inspection activities at the facility are guided and controlled by means of administrative procedures and information systems (e.g. work request system). The maintenance procedures determine the work, methods and approval criteria for specific components and areas in more detail. The procedures are updated every four years or when necessary. Periodic inspections and tests of areas that are important to safety are conducted during the operation and annual maintenance of the plant units, and they have been defined and scheduled in the Technical Specifications, the validity and accuracy of which Fortum assesses on a regular basis.

A large part of the periodic testing of the Loviisa NPP is conducted in connection with annual maintenance outages, at which point STUK controls the tests by reviewing testing records, the coverage of the tests and the appropriateness of the test procedures. STUK also assesses the state of the test procedures in conjunction with the periodic inspection plan for operation.

The conclusion is that periodic tests of the Loviisa NPP have been implemented as intended in Section 23 of Regulation STUK Y/1/2016.

5.5 Radiation monitoring and control of releases of radioactive materials (Section 24)

The radiation levels of nuclear power plant rooms and the activity concentrations of indoor air and the gases and liquids in the systems shall be measured, releases of radioactive substances from the plant monitored and concentrations in the environment controlled.

The detailed requirements related to Section 24 of Regulation STUK Y/1/2016 are presented in Guide YVL C.3, YVL C.6 and YVL 7.7.

The Loviisa nuclear power plant features fixed radiation measurement systems which measure dose rates in rooms, radioactive aerosols in rooms, gases in ventilation systems and the travel of radioactive substances in process systems.

The Loviisa nuclear power plant features technical systems for collecting and storing the majority of radioactive substances released into and contained by the facility's process systems. Only a small portion of the radioactive substances is released into the environment. The radioactive substances are discharged into the air as gaseous or particulate releases through the ventilation stack and into the sea water tunnel and, further, into the marine environment as particles dissolved or mixed in the water. The Loviisa NPP's radioactive releases into the air and the marine environment are monitored along all significant release routes through continuously-operating radiation meters, sampling and nuclide-specific radioactivity specifications conducted in a laboratory. Other possible release routes are monitored by means of sampling and other methods.

The release measurement programme extensively covers the various types of radioactive releases. Separate samples of releases into the air are collected regularly to determine a) radioactive noble gases, b) iodine, c) particulate releases (aerosols), and d) tritium (^{3}H) and ^{14}C. In particulate releases, gamma-active nuclides, the total activity of alpha-active nuclides (nuclide-specific concentrations where necessary), total concentration of beta-active nuclides, and strontium nuclides ^{89}Sr and ^{90}Sr are determined. Samples of releases into the sea are analysed for gamma-active nuclides, tritium, the total activity of alpha-active nuclides (nuclide-specific concentrations where necessary), and strontium nuclides ^{89}Sr and ^{90}Sr are determined. The accuracy of the release measurements meets the requirements of Guide YVL C.3. The measurement results can be used to monitor the fulfilment of the limit value in Section 8 of the Decree. In terms of their dose effect, the airborne releases of nuclides ^{14}C and ^{41}Ar are the most significant.

An extensive environmental radioactivity programme approved by STUK is being implemented in the area surrounding the Loviisa NPP. Within the scope of this programme, the possible passage of radioactive substances into the environment is monitored constantly by analysing the radionuclide concentrations of foodstuffs produced in the area around the facility and samples indicating the propagation of other releases. The results of the monitoring serve to verify and secure the monitoring of radioactive releases at the Loviisa NPP. The current monitoring programme covers years 2012–2016.

The environmental radiation monitoring targets passage routes that are significant in terms of radiation exposure. In addition to this, indicator organisms that efficiently collect radioactive substances from the habitats are analysed. The indicator organisms help to monitor the propagation of radionuclides from the power plants. The monitoring programme covers more than 300 samples a year. Samples are taken of external air, fallout, pasture grass, milk, grain, domestic water, seat water, groundwater and fish, for example. The samples are analysed for the nuclides that are most significant in terms of human radiation exposure: 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.

Radionuclides originating from the facility – ^{60}Co, for example – are occasionally detected in the air, fallout and soil. In water environment samples, nuclides from the facility are observed regularly. Tritium is also found in sea water. Radioactive substances originating from the power plant's emissions have not been detected in any foodstuffs. Concentrations observed in the environment are so low that they bear no significance for humans in terms of radiation protection.

The results also clearly show the effects of the slight fallout situation caused in Finland as a result of the Chernobyl incident. They are evident in the external radiation dose measured at the dosimeter station and the ^{137}Cs content of milk. On this basis, it can be stated that the methods are sufficiently accurate and sensitive for normal in-service environmental monitoring and they clearly indicate the changes of extraordinary situations in measurement results.

The Loviisa NPP area features an automatic external radiation measurement system, the purpose of which is to quickly indicate any changes in radiation level in the environment under emergency conditions. The meteorological system, which is located near the facility and used for estimating the spreading of airborne radioactive releases, is currently being updated.

The conclusion is that the radiation dose rates and passage of radioactive substances at the plant, and the releases of radioactive substances into the environment and their concentrations in the environment are monitored at the Loviisa NPP as intended in Section 24 of Regulation STUK Y/1/2016.

6 Organisation and personnel (STUK Y/1/2016 – Chapter 6)

6.1 Section 25 Management, organisation and personnel: ensuring safety

6.1.1 Safety culture

When designing, constructing, operating and decommissioning a nuclear power plant, a good safety culture shall be maintained. Nuclear safety and radiation safety shall take priority in all operations. The decisions and activities of the management of each organisation participating in the abovementioned activities shall reflect its commitment to operational practices and solutions that promote safety. Personnel shall be encouraged to perform responsible work, and to identify, report, and eliminate factors endangering safety. Personnel shall be given the opportunity to contribute to the continuous improvement of safety.

In the safety and quality policy of Fortum's nuclear power plant operations, the management is committed to a high-level safety culture. The safety and quality policy require all parties involved in the operations to adhere to values and attitudes that promote nuclear safety and quality. The policy requires that those working at the facility act in a responsible manner, commit to the agreed upon practices and goals, understand the safety significance of the operations, and put safety first in all activities. The company encourages its personnel and the organisation towards continuous learning and the utilisation of experiences. The policy also involves a commitment to promoting an open atmosphere and communication.

Fortum regularly assess the state of the safety culture of its nuclear power plant operations and performs development measures based on the assessments. Between 2007 and 2012, development measures were specifically focused on the following areas: management systems and operational processes, well-being and special expertise of the personnel, and mobilisation of the quality and safety policy as part of the working culture of the power plant and external contractors. Fortum and the Loviisa NPP have, in recent years, improved the capacities to develop the safety culture by adding available resources, for example. The power plant has experimented with various self-assessment methods for the safety culture and sought to find a comprehensive approach to its development.

According to Fortum's safety culture report, the importance of safety is understood and emphasised at the Loviisa power plant. The report also indicates that nuclear safety that nuclear safety is never compromised for the purpose of reaching production goals, for example. The management is found to be committed to safety, and the roles and responsibilities of the various actors in the organisation have been defined and understood. Attention has been paid to the development of the instructions, and working conditions have been developed based on employee feedback. The personnel are encouraged to bring up concerns and events related to safety, and efforts are made to learn from various internal and external operational occurrences. The safety culture report lists the remaining development targets in areas such as management practices, human resource planning, usability of instructions, project operations, safety-informed behaviour and development of safety culture.

STUK evaluates the state of the organisation's safety culture regularly through inspections included in the Periodic Inspection Programme and other regulatory control efforts in conjunction with the inspection of operational events and plant modification project, for example. At the turn of 2013 and 2014, STUK also commissioned an independent safety culture study from VTT Technical Research Centre of Finland, which focused on Fortum's Finnish nuclear power plant operations. As a result, VTT stated that the overall safety culture in these activities is at an acceptable level. Safety is a value that guides operations, and Fortum has strong expertise in the field to run its nuclear power plant operations. According to VTT, there are some aspects of the operational culture that require development. At Fortum, nuclear safety is seen as a technical matter, due to which challenges related to the organisation's operating methods are not always regarded as matters of safety. VTT stated that the Loviisa power plant must pay particular attention to addressing deviations and discrepancies promptly and finishing decided development measures systematically throughout the entire organisation. This will ensure that the safety improvements are implemented on time and the operating methods are systematic.

Through its regulatory control efforts, STUK has found that Fortum has developed its management system, supervisory activities and the group's safety-related roles to meet the aforementioned development needs. As an example of making its operating methods more systematic, Fortum has made progress in the implementation of long-developed operating models, such as the Design Authority operations and the "Hyvä työkäytännöt" (Good working practices) programme. However, the development of the safety culture requires further efforts.

The conclusion is that the elements of a good safety culture as required in Section 25 of Regulation STUK Y/1/2016 are verifiable in the operations of the Loviisa facility. STUK utilises the Periodic Inspection Programme and other control methods to ensure that the licensee (Fortum Power and Heat Oy) and the management of the Loviisa facility are aware of the state of their organisation's safety culture and focus appropriate development measures on its continuous improvement.

6.1.2 Safety and quality management

Organisations participating in the design, construction, operation and decommissioning of a nuclear power plant shall employ a management system for ensuring the management of safety and quality. The objective of such a management system is to ensure that nuclear safety and radiation safety are prioritised without exception, and that quality management requirements correspond to the safety significance of the activity and function. The management system shall be systematically assessed and further developed.

The management system shall cover all organisational activities impacting the nuclear power plant's nuclear and radiation safety. For each function, requirements significant to safety shall be identified, and the planned measures described in order to ensure conformity with requirements. The operating methods of the organisation shall be systematic and instructed.

Systematic procedures shall be in place for identifying and correcting deviations significant in terms of nuclear and radiation safety. If during construction or operation, it becomes necessary to make changes to approved designs, they are to be implemented in a systematic and controlled manner.

The licensee shall commit and oblige its employees and suppliers, subcontractors and other partners participating in functions affecting safety, to adhere to the systematic management of safety and quality.

The Loviisa power plant's management system describes the organisation's management relationships, authority, responsibilities and operating methods consisting of written policies, handbooks, procedures and process descriptions. Eight internal audits and independent assessments targeting the functionality of the management system have been conducted between 2010 and 2014. In the assessments, action plans have been prepared for the development targets observed and their implementation is monitored.

The safety and quality policy of the licensee and the Loviisa power plant were updated in March 2015. In this context, numerous policy statements related to separate functions were consolidated to form a quality and safety policy for Fortum's nuclear power plant operations.

Many organisational changes have been implemented in Fortum's organisation for nuclear power plant operations. Safety assessments have been conducted on the changes and submitted to STUK for information. The changes conducted in the Loviisa power plant's quality management unit and the current closer connection to the unit in charge of Fortum's group-level nuclear power plant operations continue to support the development of safety and quality management at the Loviisa nuclear power plant.

The management of the Loviisa nuclear power plant is based on the administrative rules and quality assurance manual. The quality assurance manual for operating the facility is a quality management programme as referred to in Section 36 of the Nuclear Energy Decree. The quality management system described in the quality assurance manual is used to control and manage the organisation's methods and functions related to safety and quality management. The nuclear fuel quality assurance manual, including its instructions, describes the procedures of procuring and using nuclear fuel at the Loviisa NPP.

The operational quality assurance manual covers the following functions: organisation and management, personnel training and qualification, document management, operation, maintenance, safety and support functions, management of production technology, inspection and testing activities, procurement, storage and transport, operating experience feedback, protection activities, monitoring and assessment of operations, occupational safety system and environmental management system.

The requirements related to quality management are described in the quality assurance manual for each function and activity specifically. The methods are described in the administrative procedures, procedural instructions, work and operating instructions, and temporary instructions prepared based on the requirements.

STUK performed conducted regular tests on quality management at the Loviisa power plant. The inspections have required describing the power plant's processes in the manner necessitated by the Guide YVL A.3 (formerly YVL 1.4). The process description has been a significant development effort, and Fortum has implemented the description of the processes included in the Loviisa power plant's management system in conjunction with the management system update. At the primary level, the process map for Fortum's nuclear power plant operations was completed in 2014, and the process description on a general level was conducted as planned by the end of 2015.

The deviation management methods at the Loviisa power plant have been described in the management system. The methods include the observing and documenting deviations and events, assessing and classifying their severity, planning and implementing substitutive and preventive measures, and assessing the efficacy of the measures. Separate procedures and instructions are available for the management of deviations related to design and manufacture. The deviations and corrective measures are entered in the monitoring system for requirements and measures.

Commitment to safety and quality management among personnel and other parties involved in the operations mainly takes place through orientation to the operating methods and training. It is obligation of the plant management to serve as a example, encourage and supervise adherence to the management system.

Requirements for products and services ordered from outside Fortum and their suppliers are presented in the procurement documents. In the context of assignments and projects for the Loviisa power plant, the various Fortum units providing technical support observe the facility's management system. The licensee has developed the procurement of equipment and services important to safety as well as supplier supervision, and the matter has been addressed in STUK inspections during the current operating licence period. However, there is cause to further develop the supervision and management of the supplier chain and include more efficient methods for ensuring the management of safety and quality management in the current operating licence period.

The conclusion is that the management of safety and quality at the Loviisa power plant have been implemented as intended in Section 25 of Regulation STUK Y/1/2016. Fortum also develops its operating system and STUK oversees the implementation of the measures through its Periodic Inspection Programme and other monitoring efforts.

6.1.3 Lines of management, responsibilities and expertise

The lines of management in the licensee's organisation, as well as the positions and related responsibilities of employees, shall be defined and documented. The operation of the organisation shall be evaluated and continuously developed and the risks associated with the organisation's operation are to be evaluated regularly. The safety impacts of significant organisational changes are to be evaluated in advance.

Significant functions with respect to safety shall be designated. Training programmes shall be prepared for developing and maintaining of the professional qualifications of the persons working in such positions, and an adequate command of the functions in question must be verified.

The licensee shall employ adequate and competent personnel for ensuring the safety of the nuclear power plant. The licensee shall have access to the professional expertise and technical knowledge required for the safe construction and operation of the plant, the maintenance of equipment important to safety, and the management of accidents.

The licensee shall as support for the responsible manager, have a group of experts, independent of the other parts of the organisation, convening on a regular basis to handle safety-related issues and giving recommendations thereon if necessary.

The responsibilities and structures related to decision-making are clearly described in the licensee's (Fortum Power and Heat Oy) organisation The organisation is described in the licensee’s management system and Loviisa NPP’s organisation manual. The documents also detail the licensee’s and Loviisa power plant’s relationships of responsibility and their decision-making and reporting procedures.

The tasks, authority and responsibilities of the Loviisa power plant's responsible manager, his/her deputies and the personnel are specified in the administrative rules. In 2014, a deputy director was also appointed for the Loviisa power plant, who is the first deputy of the responsible manager.

The operations of the organisation is assessed and developed regularly by means of management reviews, self-assessments and internal audits. The operations of the Loviisa power plant organisation as a whole was evaluated in the 2007 OSART assessment, 2011 self-assessment and independent management system assessment conducted by the Nuclear Safety Oversight unit in 2013. STUK conducts the annual inspections specified in the Periodic Inspection Programme.

Significant changes have been implemented in the organisation of the licensee and the Loviisa power plant in 2009, 2014 and 2016 in relation to changes spanning the entire Fortum organisation. In 2010, a unit focusing on independent safety assessment was established. One of its tasks is to conduct independent assessments of risks related to the organisation's operations and the safety impacts of any changes. The safety impacts of important modifications are assessed prior to their enforcement. Based on experiences gained from organisational changes, Fortum has identified further needs to develop the organisational change process and related interaction and communications.

In the Loviisa power plant's operating organisation, the tasks related to nuclear safety, responsibility for nuclear materials, security arrangements, and emergency preparedness activities that are important to operational safety and can be separated from the general tasks of the personnel are presented in the task descriptions appended to the administrative rules. Tasks significant to safety have not been named outside the facility's operating organisation. In the future, Fortum plans to assess the significance of the licensee organisation's other tasks in terms of plant safety. The Loviisa power plant is conducting a more detailed specification of the competence requirements for personnel required for the use of nuclear energy.

The Loviisa plant has procedures in place to ensure that the personnel are suitable, qualified and trained for their tasks. Training programmes have been prepared to develop and maintain the professional expertise of persons conducting tasks important to safety but, in 2014, STUK noticed deficiencies in the implementation and follow-up of the training programmes, based on which it required the power plant to take measures to rectify the situation. These measures were later implemented by Fortum. There are separate training programmes for nuclear power plant operators, along with procedures to verify competence and demonstrate skill, which the regulatory control has found to meet the applicable requirements.

The Loviisa power plant's operating history indicates that the facility has been used in a safe and reliable manner. Modifications and safety improvements have been conducted at the facility, largely utilising the professional expertise and technical knowledge of the licensee company's own personnel. This can be regarded as an indication of sufficient competence and technical know-how with regard to the safe use and maintenance of the facility. Fortum seeks to recruit personnel in frontloaded manner and ensure the transference of competence and experience.

The power plant's personnel planning takes into account anticipated long-term changes and short-term needs. In the future, however, attention should be paid to ensuring the sufficiency of the facility's available staff, especially as the facility nears the end of its service life.

The Loviisa Nuclear Safety Committee (LYTT) is an independent advisory expert group that supports the power plant's responsible manager in matters concerning radiation safety and safety culture, and issues that affect them.

The conclusion is that the management relationships, responsibilities and expertise of the Loviisa power plant comply with Section 25 of Regulation STUK Y/1/2016. Among other things, Fortum has presented measures to develop the expertise of persons that perform important tasks. STUK oversees the implementation of the measures through its Periodic Inspection Programme and other monitoring efforts.

7 Security arrangements (STUK Y/3/2016)

7.1 Provisions and requirements laid down by virtue thereof

According to Section 7 l of the Nuclear Energy Act, the security arrangements for the use of nuclear energy shall be based on threat scenarios applicable to the use of nuclear energy and analyses of the need for protection. A nuclear facility shall have security personnel trained for the planning and implementation of arrangements for security (security organisation). Security personnel shall also be employed for securing the transport and storage of nuclear material and nuclear waste. The tasks and qualification requirements of the security organisation and security personnel shall be defined and they shall have monitoring equipment, communication equipment, protective equipment and forcible means equipment available as required for their tasks. This forcible means equipment shall be proportioned to the threat scenarios and protection needs involved, so that they are suitable for the purpose. Measures belonging to the regular security control of a nuclear facility shall be appropriately communicated to the employees of the nuclear facility and other people transacting business within the nuclear facility site.

According to Section 7 n of the Nuclear Energy Act, more detailed provisions on the preparation of the security organisation for the prevention of unlawful action are laid down in the security standing order of a nuclear facility, as approved by the Radiation and Nuclear Safety Authority (STUK) subsequent to consultation with the Ministry of the Interior and the Advisory Committee as referred to in section 56(3). The security standing order shall contain at least the following provisions:
1) on how the security organisation is managed and its operations organised;
2) on the equipment and forcible means equipment in the organisation's possession; and

3) on when the police should be called and how responsibility should be transferred from the security organisation to the police once they have arrived on the scene.
The basic qualification requirements for security personnel are provided by Government decree. Security standing order contains provisions for special training, paying particular attention to the skill level required for using the equipment and forcible means equipment, and demonstrating it.

The statutes regarding security arrangements are presented in the Nuclear Energy Act, the Nuclear Energy Decree and Regulation STUK Y/3/2016. The detailed application instructions of the requirements and STUK's regulatory control measures are described in Guides YVL A.11, A.12 and D.2. Some other YVL Guides also present requirements that take into account the need to prepare for the detection and prevention of unlawful action.

7.2 Responsibility and regulatory control

The law states that the licensee carries the sole responsibility for the safety of a nuclear facility, and STUK serves as the regulatory authority for security arrangements in the context of the use of nuclear energy. For the purpose of addressing unlawful action and preparations for it, the Government has convened the Advisory Committee on Nuclear Security tasked with regularly monitoring and assessing threat scenarios and changes in them, developing operational capabilities and information flow, and defining guidelines for nuclear security arrangements and making related initiatives. In addition to experts from STUK and power companies, the Committee has included representatives of Finland's most essential police authorities and other security authorities. The members of the Committee have access to an extensive international cooperation network, through which information and views on international developments are conveyed to the Committee.

7.3 Licensee’s security arrangements and their assessment

STUK has assessed the currency and sufficiency of the Loviisa NPP's security arrangements based on the rules specified in Section 7.1. The documents concerning security arrangements are processed in confidence. The reason for this is that a party planning unlawful actions gaining possession of these documents could compromise the achievement of the objective of the security arrangements (Section 24(7) of the Act on the Openness of Government Activities 621/1999).

During the current operating licence period, among others the following technical and structural development measures have been implemented at the power plant:

- vehicle barriers were constructed around the entire plant area
- electrical fence was erected at the boundary of the entire plant area
- the double fences of the plant area were updated
- the main gate environment of the plant area, including the gate, were updated
- new revolving gates were constructed at zone boundaries
- unnecessary access openings were removed from the plant area boundary
- an entirely new security surveillance system (TUVA) was constructed, in conjunction with which:
  - a entirely new alarm centre was constructed, including an auxiliary centre for it

  - the electrical systems that supply the system were updated, including the auxiliary electrical systems
  - a new information network was built for the exclusive use of the TUVA system
  - the camera surveillance systems and recording equipment were updated
  - the entire access control system was updated, including the software
  - the biometric readers and ID cards were updated to the most secure options on the market
  - new more specifically restricted access zones were implemented to enable more precise delineation of personal access rights
  - the arrangements for securing process and domestic water
  - arrangements were constructed for command centres at the rescue station and emergency centre

In terms of administration, the security arrangements have been developed by the following means:
- updating visitation rules and practices
- increasing the round-the-clock staffing of the alarm centre
- increasing the number drug tests and updating relevant instructions and testing equipment
- training the personnel of the regional police organisation to operate at the facility
- training the personnel and organising drills for internal personnel and joint drills with various authorities

The safety improvements conducted at the Loviisa plant in relation to the Fukushima incident have also contributed to enhancing the functionality of the security arrangements in various situations. Examples of the updates are the new systems for residual heat removal and improvements to the flood protection of the alarm centre. The modifications implemented due to Fukushima have been more specifically described in Chapter 4.6.

A statement on the sufficiency of the Loviisa power plant’s security arrangements was requested and received from the Ministry of the Interior's Police Department in the autumn of 2015. In addition to the power plant's security arrangements, the statement addressed the emergency response of the Eastern Uusimaa Police Department.

In relation to the periodic safety review, the licensee provided STUK with a report on the security arrangements, to which STUK requested some additional clarifications. Fortum delivered the requested additional clarifications by the end of 2015, with the exception of the description on the utilisation of the PRA in the analysis of security arrangements, which Fortum supplied by the end of 2016. The improvements included in the implementing decision of the new Guide YVL A.11 on security arrangements (55/0010/2014, 18 February 2016) were also primarily completed by the end of 2016. The remaining improvements were completed by 31 December 2017.

Conclusions

The currency and sufficiency of the Loviisa nuclear power plant's security arrangements have been assessed based on, for example, the new Guides YVL A.11, YVL A.12 and YVL D.2 presented above and Regulation STUK Y/3/2016 issued on 22 December 2015 on security in the use of nuclear energy. Based on STUK’s assessment, the security arrangements of the Loviisa power plant are up-to-date and the licensee has sufficient plants for the continuous improvement of the arrangements to improve security at the power plant. According to STUK's assessment, the security arrangements of the Loviisa NPP have been designed and implemented to reliably prevent unlawful action against the facility. The conclusion is that the Loviisa power plant's security arrangements have been implemented as intended in the Nuclear Energy Act, Nuclear Energy Decree and Regulation STUK Y/3/2016.

8 Emergency response arrangements (STUK Y/2/2016)

Pursuant to Section 7 p of the Nuclear Energy Act, *the planning of emergency response arrangements for the use of nuclear energy shall be based on analyses of operational occurrence and accident conditions, and the consequences assessed on the basis of these analyses. In planning emergency response arrangements for a nuclear facility, preparations shall be made for the release of a significant quantity of radioactive materials from the facility. The nuclear facility shall have persons trained in the planning of emergency response arrangements and emergencies (*emergency response organisation*), whose duties shall be specified and who shall have access to the facilities, equipment and communication systems required for their duties. Emergency response arrangements shall be consistent with the rescue and preparedness plans drawn up by the authorities, considering the provisions laid down in Section 9(2) of the Rescue Act (468/2003).*

The statutes regarding emergency response arrangements are presented in the Nuclear Energy Act, Nuclear Energy Decree and the Radiation and Nuclear Safety Authority Regulation on the Emergency Arrangements of a Nuclear Power Plant. During the operating licence period, the Government Decree on Emergency Response Arrangements at Nuclear Power Plants was amended twice: 735/2008 and 716/2013. Decree 716/2013 particularly focused on specifying the design bases for the emergency response arrangements based on experiences gained from the Fukushima nuclear power plant disaster. As of the beginning of 2016, Government Decree 716/2013 was replaced with the Radiation and Nuclear Safety Authority Regulation on the Emergency Arrangements of a Nuclear Power Plant (STUK Y/2/2016).

The detailed application instructions of the requirements and STUK's regulatory control measures are described in Guide YVL C.5. Some other YVL Guides also present requirements concerning emergency response arrangements, with regard to assessing the radiation situation of the environment, radiation and release measurements, and meteorological measurements.

8.1 Planning of emergency response arrangements and the emergency response organisation (Sections 3 and 6)

Pursuant to Section 3 of Regulation STUK Y/2/2016:

Emergency arrangements shall be planned to ensure that emergency situations are quickly brought under control, the safety of the individuals in the site area is assured, and timely action is taken to prevent or limit radiation exposure to the public in the emergency planning zone.

Planning shall take account of a simultaneous risk to nuclear safety occurring in all nuclear facilities in the site area and their potential consequences, especially the radiation situation on the site and in the surrounding area and the opportunities to access the area.

Planning shall take account of the fact that the emergency situation could continue for a prolonged period.

Planning shall be based on analyses of the time-behaviour progress of severe accident scenarios resulting in a potential release. In such a case, variations in the state of the plant, the development of events as a function of time, the radiation situation at the plant, radioactive releases, radioactive release routes and weather conditions shall all be taken into account.

Planning shall take account of events deteriorating safety, their controllability and the severity of consequences, and threats related to unlawful action and the potential consequences thereof.

Emergency arrangements shall be consistent with the operation, fire protection and nuclear security of a nuclear power plant.

Emergency arrangements shall be compatible with the external rescue plan prepared by the authorities for an accident at a nuclear power plant.

The design basis must be regularly assessed and always when seen to be necessary.

and pursuant to Section 6:

The licensee shall have a management system and organisation in place to ensure a timely response in an emergency situation. The tasks of people assigned to act during an emergency situation are to be defined in advance.

The licensee shall ensure that the personnel needed in emergency situations are promptly available. There shall also be enough personnel to bring a long-term emergency situation under control.

Fortum has analysed accident situations and events deteriorating safety, and has presented them in the FSARs and emergency plan of the Loviisa 1 and 2 units. During the past operating licence period, new analyses have been conducted due to plant modifications and the broadening of the design basis. The results of the analyses are used in the planning and development of the Loviisa NPP's emergency response arrangements. Emergency situations are classified and described in the facility’s emergency plan and FSAR. The emergency procedures describe the notifications and alarms required to be issued to plant personnel and authorities and the situational operating range of the emergency response organisation.

The emergency planning and instructions ensure the safety of the personnel by planning the arrangements for warning them and evacuating unauthorised persons from the power plant area.

The Loviisa NPP units responsible for operation and security arrangements as well as the on-site fire brigade have participated in the preparation of the emergency. This ensures the compatibility of the arrangements. The changes caused by the regional arrangements of the rescue operations and the initiation of the emergency response centre operations have been updated into the emergency plan. Fortum has participated in the preparation and updating of the external rescue plan drawn up by the Eastern-Uusimaa Emergency Services Department.

At Fortum, the emergency response arrangements are handled by the person in charge of emergency response arrangements, as per Section 7 i of the Nuclear Energy Act, and his/her deputy. Both person have been approved by STUK in accordance with the applicable requirements. Fortum updated the entire emergency plan in 2010. In the same context, the company revamped its emergency response organisation. The appointed emergency response organisation is part of the Loviisa power plant's emergency plan. The emergency response organisation is updated as needed, typically a few times a year. The operative instructions of the emergency response organisation includes a description of the organisation's alarm arrangements. In an emergency situation, the emergency activities are handled by those leading the emergency response organisation and other personnel deemed necessary. In a plant emergency and general emergency, Fortum's emergency response organisation is alerted in its entirety.

8.2 Preparedness (Section 4–5)

Pursuant to Section 4 of Regulation STUK Y/2/2016:

The licensee shall be prepared to carry out the measures required in emergency situations, the analysis of emergency situations and the consequences thereof, assessment of the anticipated development of emergency situations, the mitigatory actions needed to control or limit the accident, the continuous and effective exchange of information with the authorities, and communications to the media and the members of the public.

When analysing the situation, the technical status of the plant and release of radioactive materials, or threat thereof, and the radiation situation inside the plant and in the site area and emergency planning zone, shall be assessed.

In emergency situations, the licensee shall be prepared to carry out radiation monitoring in the site area and in the precautionary action zone. The licensee shall also take meteorological measurements and shall be capable of assessing the dispersion of radioactive substances and the resulting radiation exposure of the population in the emergency planning zone during an emergency situation.

To prepare for an emergency situation, the licensee shall have appropriate staff alarm systems, places of assembly in the site area, evacuation arrangements, the necessary personnel protective equipment, radiation measuring instruments and iodine tablets available.

The licensee shall provide arrangements for contamination measurements of personnel, and their decontamination.

To manage emergency operations, there shall be an emergency response centre, which shall be able to maintain proper working conditions during an emergency situation, and which shall also be available during prolonged power failures.

There shall be a designated centre outside the site area from which to direct the plant's emergency response operations, if the emergency response centre is not available.

There shall be reliable communication and alarm systems in place to manage emergency response operations for the purposes of internal and external communications of the nuclear power plant.

The licensee shall ensure that there are automatic data transmission systems in place to send information essential in terms of the emergency operations to the emergency response centre of the Radiation and Nuclear Safety Authority.

Licensee's management system and organisation shall ensure maintenance and development of the emergency arrangements.

and pursuant to Section 5.

In addition to what is enacted in Sections 35 and 36 of the Nuclear Energy Decree (161/1988) on regarding the emergency plan and in Section 48 of the Rescue Act (379/2011) regarding the rescue plan, the licensee must draw up the necessary the emergency procedures for the operation of the emergency response organisation.

The Loviisa nuclear power plant has prepared to analyse the effects of an emergency situation, estimate the development of the situation and carry out the measures required to minimise the consequences of each situation. Instructions for the emergency response organisation's operations are provided in the emergency plan.

The emergency response organisation has a dedicated emergency response centre, which includes all systems, information materials and other equipment that the organisation requires to perform its tasks. The data on the facility's process computer can be accessed through various terminals, which display the process state and radiation situation of the facility. The emergency response organisation has an auxiliary command centre in Keilaniemi, Espoo. The facility in Keilaniemi features a sufficient number of systems and documentation to command a situation where the facility cannot be accessed due to extraordinary weather conditions, for example.

Fortum updated the filtered emergency ventilation system of its emergency response centre in 2009. At the same time, the emergency response premises were completely overhauled. Fortum has continued to improve the operational capabilities of the emergency response centre, particularly in relation to external hazards and the handling of prolonged situations. Fortum has updated the emergency diesel supplying electricity to the emergency response facilities and is in the process of updating the flood protection, among other aspects.

The power plant features an assembly location for personnel, protective equipment for emergency situations, and facilities for the contamination measurements and decontamination of personnel. Fortum has reserved iodine tablets for the personnel in the power plant area.

Over the course of the past operating licence period, Fortum has developed the alarm arrangements of the emergency response organisation. The alarm arrangement for the emergency response organisation has been made redundant by ensuring that, in addition to alarm calls made by the alarm service, the Kerava emergency response centre alerts Fortum's emergency response organisation. The alarm arrangements and the ability to reach the appropriate personnel are tested on a regular basis. Public warning systems are used to alert the personnel in the outdoor areas of the Loviisa power plant, whereas audio and light alarms as well as speaker and telephone systems are used indoors. The personnel rehearses the assembly procedure annually. In 2014-2015, Fortum ensured that the alarms can be heard in the accommodation village.

During the operating licence period, Fortum has maintained and updated its ability to assess the radiation situation and the propagation of radioactive substances in an accident situation. In 2014, Loviisa commissioned a new environmental radiation monitoring system, which operates at a five-kilometre range. In 2015, the plant began the trial operation of a new weather mast and observation equipment, which replaced the old equipment in 2016. In conjunction with replacing the weather mast system, an offshore weather station was constructed on the island of Orrengrund some 10 km from the power plant. The ROSA software is used to calculate the possible propagation of radioactive releases and environmental doses in the emergency planning zone.

In 2012, Fortum updated the plant data transmission connection to the STUK and Keilaniemi emergency facilities. The data transmission has been secured with a satellite connection in case of disturbances in the connection utilising the mobile phone network. Instructions for transmitting essential plant data have been provided in the emergency plan even for situations where the automatic system is fully inoperable. Fortum's communication equipment corresponds to the updated requirement level of the YVL Guides, and include satellite phones, among other equipment and solutions. Fortum regularly tests the data transmission and communication connections to STUK.

Communication to the media and the public has been centralised under the group management in Keilaniemi. The communications have been planned and instructed beforehand, and it is rehearsed as part of the emergency operations in conjunction with emergency exercises.

8.3 Maintenance of preparedness (Section 8)

Pursuant to Section 8 of Regulation STUK Y/2/2016:

The licensee shall arrange emergency training for all nuclear power plant personnel and other permanent or temporary employees working at the site area.

The licensee shall arrange emergency exercises on an annual basis. At least once every three years the emergency exercise shall be arranged as a co-operation exercise with the authorities. The emergency exercises shall be evaluated based on the set preparedness objectives.

The licensee shall draw up at least a three-year training plan to ensure that training is given on all aspects of preparedness to act at regular intervals.

Emergency arrangements shall be regularly evaluated. When developing the emergency arrangements, attention shall focus on the experience gained and conclusions drawn con-

cerning the management of emergency situations, the experience gained from the exercises as well as on research and technical developments.

Facilities and equipment reserved for emergency situations shall be available and maintained in operational condition at all times.

The emergency plan and guidelines shall be kept up to date.

Emergency response training and exercises are arranged for the Loviisa NPP's emergency response organisation on an annual basis. Fortum maintains a three-year emergency preparedness training plan, based on which it prepares an annual training plan. The plans have been delivered to STUK according the relevant requirements. The emergency response training has included joint training for the entire emergency response organisation as well as group-specific training. The training has been provided as both classroom education and practical training. In its Periodic Inspection Programme, STUK has annually ensured that the training has been provided.

Emergency response exercises compliant with the requirement level of the YVL Guides have been organised on an annual basis, in addition to which less expansive exercises have been held. In addition to Fortum, the annual emergency response arrangements have been attended by the other essential actors in an emergency situation: STUK, the police, the emergency services department and the ERC Administration. Dozens of organisations have participated in the joint exercises organised every three years. The scenarios of the emergency response exercises have ranged from plant events classified as emergency situations to severe reactor accidents. After the implementation of the expanded design basis, Fortum has also rehearsed a simultaneous emergency situation in both plant units. Feedback collected from the participants and evaluators of prior exercises have been used in planning the new exercises. Members of the emergency response organisation must take part in the exercises regularly. Feedback on the exercises is also assessed in STUK's inspections according to STUK's Periodic Inspection Programme.

The continuous operability of the emergency response premises and equipment has been ensured by means of the preventive maintenance programme. STUK inspects the emergency response premises and equipment as part of the Periodic Inspection Programme and regular control operations. Since the update, Fortum has updated the emergency plan several times a year. Other emergency procedures are updated as needed.

8.4 Action in an emergency situation(Sections 9-12)

The requirements for action in an emergency situation are presented in Sections 9-12 of Regulation STUK Y/2/2016.

The operations of the Loviisa power plant are based on procedures, the most essential of which are the transient and emergency procedure and the emergency plan. In addition to this, other procedures referenced in these procedures are used. Due to the variability of emergency situations, the procedures have been prepared to be flexible and their utilisation does not restrict the operations of the organisation.

The Loviisa power plant's control room are continuously at the ready to commence operations in an emergency situation. At the outset of an emergency, the shift manager serves as the emergency response manager until the appointed emergency response manager of the emergency response organisation assumes control of the situation. The emergency procedure includes a description of initiating the emergency response organisation's operations and the organisation itself, including task descriptions and operating instructions for each role. The methods of issuing notifications and alarms to authorities have been developed during the operating licence period. They are now issued in cooperation with the Kerava emergency response centre. The communication situational awareness in an emergency situation has been developed to keep key authorities up-to-date about the situation at the facility.

As a result of amendments to the applicable provision, the Loviisa power plant's emergency plan and related emergency procedures have been updated and now comply with the current provisions and official procedures. The procedure for the emergency response manager includes operating instructions on issuing recommendations regarding emergency actions to the head of rescue operations until STUK assumes responsibility.

Fortum's emergency response organisation has appointed contact persons whom it will send to the rescue services command centre to provide expert assistance related to nuclear technology and radiation protection.

8.5 Measures pertaining to rescue operations (Section 13)

Section 48 of the Rescue Act 379/2011 obliges nuclear facilities to participate in the preparation of a external rescue plan for locations that present an extraordinary hazard. More specific provisions on the plan are laid down in Decree of the Ministry of the Interior Decree on an external rescue plan for locations that present an extraordinary hazard (612/2015).

The Eastern-Uusimaa Emergency Services Department has drawn up an external rescue plan for the Loviisa power plant. Fortum has assisted in the preparation of the plan. Among other things, the plan consolidates the tasks of all essential actors and the measures to organise the cooperation. Fortum has made preparations to assist the emergency services department during and after emergencies to the extent required. One goal of the emergency exercises is to practice cooperation between organisations, which includes testing the external rescue plan.

Fortum has actively participated in the operations of the SVEPP group, which operates under the Eastern-Uusimaa Emergency Services Department since its establishment. The group's member organisations (Fortum, Eastern-Uusimaa and Kymeenlaakso Emergency Services Departments, Eastern Uusimaa Police Department, STUK, HUS emergency care and Ministry of the Interior's rescue department) participate in the planning of the exercises and processing of exercise feedback, among other things. Based on the feedback, the group selects the joint development targets regarding the Loviisa power plant's emergency activities. The group coordinates the implementation of the development targets and organises joint training events. Emergency equipment suitable for joint use have also been procured as a result of the group's operations.

Operating instructions for accident situations have been distributed to the population in the emergency planning zone in advance. Fortum distributes iodine tablets to the population residing within the zone based on their expiration date. Tablets were last distributed in 2015.

Conclusions

The currency and sufficiency of the Loviisa NPP's emergency response arrangements have been assessed based on the Nuclear Energy Act, Nuclear Energy Decree, Regulation STUK Y/2/2016 and Guide YVL C.5. According to STUK's assessment, the Loviisa power plant's emergency response arrangements are up-to-date and sufficient, and Fortum is developing them actively. The conclusion is that the Loviisa power plant's emergency response arrangements have been implemented as intended in the Nuclear Energy Act, Nuclear Energy Decree and Regulation STUK Y/2/2016.

9 Nuclear waste management (STUK Y/4/2016)

According to Section 20(1)(2) of the Nuclear Energy Act, one requirement for receiving an operating licence for a nuclear facility is that *the methods available to the applicant for arranging nuclear waste management, including final disposal of nuclear waste and decommissioning of the facility, are sufficient and appropriate.*

According to Section 7h of the Nuclear Energy Act, *the nuclear facility shall have the facilities, equipment and other arrangements required to ensure the safe handling and storage of nuclear material required by the plant and any nuclear waste generated during operation. Nuclear waste shall be managed so that after disposal of the waste no radiation exposure is caused, which would exceed the level considered acceptable at the time the final disposal is implemented. The disposal of nuclear waste in a manner intended as permanent shall be planned giving priority to safety and so that ensuring long-term safety does not require the surveillance of the final disposal site. Nuclear waste management plans shall be kept up to date as provided in section 28.*

9.1 Handling, storage and final disposal of power plant waste

Pursuant to Section 13 of Regulation STUK Y/1/2016:

Waste generated during the operation of a nuclear power plant, the activity concentration of which exceeds the limits set by the Radiation and Nuclear Safety Authority (STUK), shall be treated as radioactive waste.

Waste shall be sorted, categorised and handled in an appropriate manner in terms of its storage and disposal, and stored safely.

Regulation STUK/4/2016 lays down general requirements for the safety of the final disposal of nuclear waste. In addition to this, Guide YVL D.5 covers the full life cycle of final disposal facilities for nuclear waste (location surveys, planning, construction, operation and closure) and applies to the safety of the use of final disposal facilities and demonstrating the long-term safety of final disposal.

The starting point for the management of power plant waste at the Loviisa NPP has been to arrange handling and final disposal in the power plant area. No significant safety issues occurred in the management of low and intermediate level waste during the past operating cycle.

At the end of 2014, the full amount of low and intermediate level waste was approximately 3,500 m^3, of which waste in final disposal constituted about 55%. In international comparison, the volumes and activity levels of waste generated at the Loviisa NPP were lower than average.

During the current operating licence period, Fortum has had multiple development projects related to the handling and final disposal of low and intermediate level waste. At the end of 2011, the Loviisa NPP commissioned new more spacious handling facilities for maintenance waste and a separate storage space for waste packages. A new gamma spectrometer was procured for the facilities to measure the radioactivity of waste barrels, and other tools for also acquired for the processing of metal waste, for example. The new premises have improved work organisation by having separate spaces for separate functions. Storing the waste packages in separate rooms has decreased radiation levels in the waste management areas and substantially reduced the radiation doses of workers.

The most important update in the handling of liquid waste is the solidification plant. Fortum applied permission to commission the Loviisa NPP's solidification plant from STUK in June 2015. STUK processed the documentation and approved Fortum's application for initiating the production use of the solidification plant on 15 February 2016 (8/43774/2015 and 12/43774/2015). The liquid and wet radioactive waste generated at the Loviisa power plant are concreted in reinforced steel waste containers. In addition to this, the handling of other smaller batches of liquid waste by means of absorption solidification has also been developed. Later, the method has also been applied for low level resins, activated carbon and sludge. Solidified waste is ultimately placed in the final disposal facility for low and intermediate power plant waste.

The final disposal facility is located in the power plant area at a depth of approximately 110 metres. It includes two final disposal spaces for low level maintenance waste and one for intermediate level solidified waste, which is intended to be commissioned over the course of 2017. In addition to this, the final disposal facility includes a handling and storage space for maintenance waste, which is intended for the long-term storage (over 5 years) of waste that can be later exempted from monitoring.

STUK conducted a commissioning inspection on the maintenance waste space in June 2016. The commissioning inspection was based on the operating licence issued for the space, based on which STUK granted Fortum permission to use the HJT3 space for the sorting and storage of low level maintenance waste. The commissioning inspection was based on the operating licence issued for the space, based on which STUK granted Fortum permission to use the HJT3 space for the sorting and storage of low level maintenance waste. In 2014, Fortum observed corrosion damage in the outer surface of the concrete trough in the solidified waste space (KJT) of the final disposal facility for low and intermediate level waste. As a result, Fortum established a basic renovation project, the purpose of which was to ensure that the release barrier is in the intended condition when the facility closed. Since the concrete trough of the final disposal space for solidified waste (KJT) is being repaired, Fortum submitted an application to STUK for permission to use the HJT3 space for the intermediate storage of concrete waste packages generated in solidification until the end of 2018. STUK granted the permission according to Fortum's application in August 2016. Converting the space for final disposal requires changing the operating licence for the final disposal facility.

Fortum submitted to STUK a periodic safety review on the final disposal facility for low and intermediate level waste at the end of 2013. The periodic safety review included an appendix on the fulfilment of the requirements of Government Decree 736/2008, which was effective at that time, and the fulfilment of the requirements was also evaluated in the STUK safety assessment. In summary of the inspections of matters and documents related to the periodic safety review and the results of continuous monitoring, STUK stated in its decision (2/A42215/2013, 15 December 2014) that operating safety and long-term safety are at a good level in the final disposal facility for low and intermediate level waste, and the licensee has the necessary procedures in place to continue safe use.

STUK's regulations on the safety of a nuclear power plant (STUK Y/1/2016) and the safety of the disposal of nuclear waste (STUK Y/4/2016) came into force on 1 January 2016. The requirements of the regulation concerning the safety of a nuclear power plant in terms of the handling and storage of radioactive waste (Section 13) have not changed from before, and the requirement text has been slightly specified with regard to decommissioning (Section 17). As regards underground operations, the requirement level concerning the safety of the final disposal of nuclear waste has not changed significantly. Fortum will prepare a detailed report on the fulfilment of the regulation's requirements when the long-term safety case of the final disposal space is updated by the end of 2018.

During the current operating licence period, a separate group for power plant waste was established at the Loviisa NPP in 2008. Its responsibilities are the handling of low and intermediate level power plant waste and the use of the final disposal facility for power plant waste. The organisational change has clarified the duties and responsibilities regarding tasks related to the maintenance of power plant waste and increased the availability of expert resources at the power plant. The 2014 organisational change also increased resources at the group level in the nuclear waste unit of NECON (Nuclear Engineering and Co-owned Nuclear) in Keilaniemi, Espoo.

According to STUK's assessment, the maintenance of power plant waste at the Loviisa NPP is handled in a safe manner and the methods employed for the purpose are appropriate and sufficient. The conclusion is that the handling and storage of power plant waste have been implemented as intended in Section 13 of Regulation STUK Y/1/2016. In its decision 2/A42215/2013 (15 December 2014) and the attached periodic safety assessment, STUK assesses the safety of the final disposal facility for low and intermediate level waste. The conclusion is that the final disposal of low and intermediate level waste has been implemented as intended in Regulation STUK Y/4/2016.

9.2 Handling, storage and final disposal of spent nuclear fuel

Section 12 of Regulation STUK Y/1/2016 concerns the handling and storage of nuclear fuel, and its fulfilment is addressed in Chapter 4.5 of this safety assessment. Section 13 of STUK Y/1/2016 includes a corresponding requirement for radioactive waste. Chapter

4.5 covers the fulfilment of the safety principles required in the section listed above in relation to the handling and storage of spent nuclear fuel at the Loviisa NPP. Chapter 4.5 presents the safety improvements that Fortum has implemented in the intermediate storage spaces for spent fuel in order to ensure fuel cooling.

Fortum's Loviisa power plant has two interim storages for spent fuel (KPA storage), where spent nuclear fuel removed from the Loviisa 1 and 2 plant units is stored. The KPA storages hold all the nuclear fuel extracted from the Loviisa NPP reactors, with the exception of the fuel that was transported to Russia before 1996, at which time the export of spent nuclear fuel was ceased as a result of an amendment to the Nuclear Energy Act.

In recent years, Fortum has increased the storage capacity for spent nuclear fuel in the KPA storages by replacing open fuel racks with dense racks. The continued replacement of the fuel racks as planned will ensure that the Loviisa KPA storages have enough storage space until the end of the power plant's service life. The operating licence issued in 2006 grants permission to store a quantity of 1,100 uranium tonnes of spent nuclear fuel in the Loviisa power plant area. When the operation of the Loviisa NPP ends, the plants will have a quantity of spent nuclear fuel corresponding to 1080 uranium tonnes, which is slightly below the quantity specified in the operating licence. The KPA storages will provide sufficient storage space even if the spent fuel final disposal project is delayed for any reason.

The decommissioning of the Loviisa nuclear power plant units is assumed to begin after 50 years of use in approximately 2031. The planned service life of the KPA storages is 40 years. The KPA storage of the Loviisa NPP consists of two parts: KPA1 and KPA2. KPA1 was commissioned in 1976, while the first phase of KPA2 was commissioned in 1984. KPA1 has been planned to be decommissioned in conjunction with the decommissioning of plant in 2031. Storage in KPA2 is intended to continue until 2056. Therefore, KPA1 would exceed its original design life by 15 and the first phase of KPA2 would exceed it by 32 years. The ageing analyses conducted by Fortum on the buildings have not examined the ageing of the KPA storage to any specific degree. Based on the periodic inspections, Fortum has found the structures of the KPA storage to be currently in working order, but it is important to ensure that extension of service life is sufficiently taken into account in the Loviisa maintenance strategy and ageing management.

Furthermore, the spent fuel transfer machine in the KPA storage is also reaching the end of its planned service life, which is why it must be included in the ageing management programme.

STUK has taken notice of the above matters in connection with the periodic safety review and, in its decision 3/A42213/2016 (9 November 2016), required Fortum to submit reports on the issues for information by 31 May 2017.

Posiva Oy (Posiva) was established to handle the final disposal of spent nuclear fuel for Fortum and Teollisuuden Voima Oyj (TVO). Posiva submitted a construction licence application for an encapsulation final disposal facility to the Government at the end of 2012. The Government granted the construction licence to Posiva on 12 November 2015. The final disposal has been planned to begin no earlier than 2023.

In addition to the final disposal of the spent nuclear of the Loviisa NPP, Posiva is in charge of transport container procurement and fuel transport from Loviisa to Olkiluoto. The packaging of spent nuclear fuel in the transport container for transport requires changes in the interim storage for spent nuclear fuel at the Loviisa NPP. The matter will be addressed during the current operating licence period. In its decision 3/A42213/2016 (9 November 2016), STUK has required Fortum to submit a plan on the matter for information by 31 May 2017.

The conclusion is that the storage of the spent nuclear fuel of the Loviisa 1 and 2 nuclear power plant units has been implemented as required in Section 13 of Regulation STUK Y/1/2016. The licensee must ensure that the service life management measures are in place for the KPA storage and the KPA transfer machine in accordance with their service life estimates, in order to ensure the safe interim storage of spent nuclear fuel until the end of the storage facilities' service life.

Posiva is responsible for the final disposal of Fortum's spent fuel. On 12 November 2015, the Government granted a construction licence to Posiva for the construction of an encapsulation and final disposal facility for spent nuclear in Olkiluoto. STUK oversees Posiva's operations in accordance with the Nuclear Energy Act and Regulation STUK Y/4/2016. The packaging of spent nuclear fuel in the transport container for transport requires changes in the interim storage for spent nuclear fuel at the Loviisa NPP, for which the licensee must make preparations well in advance.

9.3 Decommissioning of plant units

According to Section 7 g of the Nuclear Energy Act, *The design of a nuclear facility shall provide for the facility's decommissioning. The related decommissioning plan being kept up to date as provided in section 28 herein. When the operation of a nuclear facility has been terminated, the facility shall be decommissioned in accordance with a plan approved by the Radiation and Nuclear Safety Authority (STUK). Dismantling the facility and other measures taken for the decommissioning of the facility may not be postponed without due cause.*

Pursuant to Section 17 of Regulation STUK Y/1/2016, *The design of a nuclear power plant and its operation shall take account of the decommissioning of plant units so that it is possible to limit the volume of nuclear waste for disposal accumulating during the dismantling of units, and radiation exposure to workers due to the dismantling of the plant, and to prevent radioactive materials from spreading into the environment during decommissioning and the handling of waste.*

Section 28 of the Nuclear Energy Act requires those under the nuclear waste management obligation to prepare a plan for the decommissioning of the nuclear facility every six years. Fortum updated the decommissioning plan for the Loviisa NPP in 2012, and the Ministry of Economic Affairs and Employment requested a statement on it (TEM/2958/04.01./2012, 21 January 2013).

The starting point for the Loviisa NPP's decommissioning plan is the closure of both power plant units after 50 years of use. Immediate decommissioning and dismantling has been selected as the decommissioning strategy. When dismantling the power plant units, the systems and structures containing radioactive materials will be separated in such a way that the portion that will not be dismantled can be released from regulatory control under the Nuclear Energy Act. The radioactive dismantling waste will be disposed of in facilities constructed in connection to the on-site final disposal facility for power plant waste. According to the plan, the reactor pressure vessel and other large components will be placed in final disposal without sectioning them into pieces.

STUK has issued a statement on the Loviisa NPP's decommissioning plan to the Ministry of Economic Affairs and Employment (2/Y48112/2013, 25 June 2013). According to the statement, the decommissioning plan is sufficiently detailed and comprehensive. The plan has been updated to enable the power plant to be dismantled, the dismantling operations to be prepared and the final plan to be created based on it.

STUK's regulations on the safety of a nuclear power plant (STUK Y/1/2016) and the safety of the disposal of nuclear waste (STUK Y/4/2016) came into force on 1 January 2016. The requirements of Regulation STUK Y/1/2016 on the handling and storage of radioactive waste (Section 13) have not changed from before, and the requirement text has been slightly specified with regard to decommissioning (Section 17). The requirement level of Regulation STUK Y/4/2016 with regard to underground operations has not changed substantially. Fortum will prepare a detailed report on the fulfilment of the regulation's requirements when the long-term safety case of the final disposal space is updated by the end of 2018.

In its statement to the Ministry of Economic Affairs and Employment (2/Y48112/2013, 25 June 2013), STUK stated that the preparations for the decommissioning of the Loviisa power plant's units are as intended in Section 20 of Government Decree 717/2013, which is why the preparation plan can be deemed to meet the requirements of Section 17 of the effective Regulation STUK Y/1/2016.

10 Safeguards of nuclear materials (Nuclear Energy Decree, Sections 118 and 118 b)

Pursuant to Section 118 of the Nuclear Energy Decree, STUK maintains a control system of nuclear materials with the purpose of carrying out the safeguards control of the use of nuclear energy that is necessary for the non-proliferation of nuclear weapons as well as the safeguards control that is related to the international agreements on nuclear energy to which Finland is a part STUK sees to it that the licensee has the necessary expertise and preparedness to arrange the supervision and that the licensee for his own part implements the above-mentioned supervision in accordance with the pertinent regulations.

When maintaining the safeguards system referred to in Section 118(1) of the Nuclear Energy Decree , STUK shall take account of the obligations of Commission Regulation (Euratom) No. 302/2005 on the application of the provisions on Euratom safeguards. STUK acts as the site representative, as referred to in the Decree, for all sites.

Pursuant to Section 118 b of the Nuclear Energy Decree, the planning, construction and operation of a nuclear facility shall be implemented so that the obligations concerning the control of nuclear material, as provided and defined in the Nuclear Energy Act and provisions issued thereunder, and in the Euratom Treaty and provisions issued thereunder, are met. The facility shall not contain premises, materials or functions, relevant to the control of nuclear materials, which are not included in the design information The licensee shall have an accounting and reporting system for nuclear material and other nuclear commodity which ensures the correctness, scope and consistency of information in order to implement the supervision necessary for the non-proliferation of nuclear weapons

Fortum has an approved nuclear safeguards manual, which meets the requirements set forth in Guide YVL D.1. The licensee's measures to arrange its own monitoring, to meet the requirements of export control in the nuclear energy field and to enable regulatory control by authorities and international organisations have been appropriate.

Fortum is preparing the capacities to move spent fuel from the plant site to the final display facility before the next periodic safety review. The examined measures include plans to handle and fill the transport packages and prepare them for transport. Based on the examinations, the necessary plans will be prepared on the extent of any possible changes that may be required in the plant premises. Preparations are made in the spent fuel storage for the control measurements ensuring the quantity and quality of the fuel to be placed in the final disposal facility. Major changes are not expected or foreseen. As regards authorities and international control organisations, activity is anticipated to increase at the Loviisa plant by virtue of the planning and implementation of the assurance measures related to fuel to be transferred to final disposal.

According to STUK's assessment, the Loviisa NPP's arrangements for the non-proliferation of nuclear weapons are up-to-date and sufficient.

11 Other requirements

In addition to the safety requirements in the STUK regulations, the Nuclear Energy Act imposes some requirements related to the safety of nuclear power plants. This chapter covers the financial and other prerequisites of the applicant to conduct the operations safely and in accordance with Finland's international agreement obligations (Nuclear Energy Act, Section 20(1)(4)), for the part that the matters fall within STUK's authority. In addition to this, the fulfilment of the conditions related to the current operating licence of the Loviisa 1 and 2 nuclear power plant units will be examined.

11.1 The licensee's financial prerequisites for the operations

In order to receive an operating, the applicant must have the financial and other prerequisites to conduct the operations in a safe manner (Nuclear Energy Act, Section 20(1)(4)). The financial prerequisites are primarily assessed by authorities other than STUK (mainly the Ministry of Economic Affairs and Employment). The licensees have financial obligations related to preparing for the costs of nuclear waste management, for example, (for technical aspects related to the matter, see Chapter 9) and fulfilling the nuclear liability (Chapter 11.2). The licensees' finances and financial operating environment also affect the safety of the facilities, which is why STUK monitors, among other things, the trends of investments to improve safety, organisational changes and the number and competence of personnel at Finnish nuclear power plants.

The electrical market was opened in Finland some 20 years ago, so there is extensive experience in the country with regard to the operation of nuclear power plant companies on open markets. Fortum has adhered to a policy according to which the economic efficiency of the operations is ensured by keeping the facility's utilisation rate high. This gives incentive to avoid even the smallest disturbances, which requires keeping the plant units in good condition. This, in turn, requires investments, which contribute to enhancing safety: the prevention of operational occurrences is always the first goal in safety planning.

On an annual level, STUK monitors the investment amounts in power plant maintenance and the variation in them in present currency. Investments have been increasing during the past operating licence period. For example, investment amounts in 2014 and 2015 have nearly doubled from 2005 and 2006. The largest investment has been the I&C update, which is still under way.

In the descriptions provided to STUK in conjunction with the operating licence application, Fortum states that its profitability and financial standing are good, and that it will remain committed to the continuous improvement of safety at the Loviisa NPP.

In reference to Section 20(1)(4) of the Nuclear Energy Act, STUK indicates that it lacks the authority and competence to assess the licence holder's financial capacity for operating the power plant. In the statement and its appendices , STUK's assessment has focused solely on the licence holder's capabilities to conduct the operations safely and, in this regard, in accordance with Finland's international agreement obligations.

11.2 International agreements

International agreements in STUK's sphere of operations includes international agreements that concern nuclear safeguards and matters regarding nuclear liability, nuclear safety and nuclear waste. In addition to this, Finland is subject to the Treaty establishing the European Atomic Energy Community (Euratom) and the obligations and decrees issued by virtue thereof. These agreements have been incorporated into the national legislation.

Nuclear liability, i.e. the liabilities and obligations resulting from nuclear damage, is governed by the Nuclear Liability Act (484/1972). This Act takes into account the international agreements binding upon Finland that mainly set the minimum levels of liability for nuclear damage. More extensive liabilities can be set forth on a national level.

Finland's updated Nuclear Liability Act imposes on the licensee an unlimited liability to compensate for damage resulting from a nuclear accident that occurs in Finland.

The Nuclear Liability Act was last amended in 2011 (581/2011), wherein Section 18 states that *the maximum liability for nuclear damage from a single nuclear event in locations other that Finland is a special drawing right (SRD) of 600 million* (the SRD specified in the previous Act 493/2005 was 700 million).

Furthermore, the Act specifies that*, on application of the licensee, the Government is entitled to decide to lower the liability from the maximum of SRD 600 million, with due consideration to the size or quality of the facility or the scope of the transport – however, the amount shall be no less than SRD 5 million.* Previously, the minimum limit for the liability was €80 million (Act 493/2005) , which was limited to an individual transport of nuclear materials.

The Nuclear Liability Act which was amended by Act 581/2011 will enter into force through a Government Decree to be issued at a later time. The entry into force of the new Nuclear Liability Act and the ratification of the international agreements are intended to take place simultaneously in all countries bound by the agreement.

Fortum's liability insurances cover the separate nuclear facilities at the plant site, i.e. the Loviisa 1 and 2 nuclear power plant units, and the final disposal facility for power plant waste. The amounts insured meet the requirements in Section 18 of the effective Nuclear Liability Act. The Financial Supervisory Authority has assessed Fortum's liability insurances for 2015 and, in decision 58/02.03.16/2013, 27 December 2013 (STUK matter 1/A41801/2014), stated that they are acceptable. According to Section 20(2) of the Nuclear Energy Act, operating a nuclear facility requires that the licensee's indemnification regarding liability in the case of nuclear damage has been arranged appropriately.

STUK assesses liability insurances related to transport in conjunction with each instance of transport. The insurance policies have been arranged appropriately.

An international Convention on Nuclear Safety, Treaty Series 74/1996 (INFCIRC/449) was signed in 1994. It is a collection of highest level nuclear safety principles that is legally binding to the countries that have signed it. Finland has been part of the Convention, which has been effective since 1996, from the beginning.

Correspondingly, the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, Treaty Series 36/2001 (INFCIRC/546), was signed in 1997. It is a collection of principles regarding the handling of nuclear waste that is legally binding to the member countries. Finland joined the Convention, which has been effective since 2001, from the start.

The matters governed by the international conventions on nuclear safety and nuclear waste are addressed in Finnish legislation, Government decisions and regulations. Compliance with the conventions is assessed every three years in Review Meetings organised by the International Atomic Energy Agency (IAEA), for which each member country must prepare a report on its operations.

The international convention related to nuclear safeguards are assessed in the context of Chapter 10.

In STUK's view, Fortum has met the obligations of the international conventions within STUK's sphere of operations in accordance with Section 20 of the Nuclear Energy Act.

11.3 Fulfilment of the conditions connected to the facility's current operating licence

The Government has, in its decision 6/330/2006, granted to the Fortum Power and Oy's Loviisa Nuclear Power Plant a licence, as referred to in Section 20 of the Nuclear Energy Act (990/1987), to operate and use the nuclear power plant unit Loviisa 1 until 31 December 2027, the Loviisa 2 plant unit until 31 December 2030, and the related buildings and storages necessary for the management of nuclear fuel and nuclear waste until 31 December 2030.

The operating licence presents the following conditions for the licence.

1. *The licensee must prepare comprehensive safety assessments for the Radiation and Nuclear Safety Authority by the end of 2015 and 2023, including interim assessments of the power plant's safety and preparedness plan. The more specific regulations concerning the content of the assessments are included in the STUK Guide YVL A.1 Regulatory oversight of safety in the use of nuclear energy.*
2. *Under the licence granted with this decision, the licensee may possess, produce, handle, use and store nuclear waste and nuclear materials as well as other nuclear use items at the plant site as follows:*
   - *A total of 1,100 tonnes of uranium generated as spent nuclear fuel by the Loviisa 1 and 2 plant units and stored in the spent fuel storage facilities.*
   - *3,000 cubic metres of solid power plant waste generated by the Loviisa plant's operation in storage facilities and the plant area, as well as 2,400 cubic metres of waste in the liquid waste storage and solidification plant.*
   - *Fresh nuclear fuel require in the operation of the Loviisa power plant, other nuclear materials in the plant area and materials, devices, equipment and information materials of the nuclear sector, for the import of which a licence has been granted under the Nuclear Energy Act.*

The licensee has provided the documentation related to the 2015 periodic safety review, as required in Guide YVL A.1 (formerly YVL 1.1), by the deadline of 31 December 2015. The coverage of the descriptions and reports has been assessed in conjunction with STUK reviews, and it has been deemed to meet the scope specified in licence condition 1.

When the operation of the Loviisa NPP ends, the plant units are estimated to have a quantity of spent nuclear fuel corresponding to 1080 uranium tonnes, which is slightly below the quantity specified in the operating licence. The KPA storages will provide sufficient storage space even if the spent fuel final disposal project is delayed for any reason.

As regards the handling of liquid waste, the most important update is the solidification plant, which was approved for production use in 15 February 2016. The liquid and wet radioactive waste generated at the Loviisa power plant are concreted in reinforced steel waste containers. In addition to this, the handling of other smaller batches of liquid waste by means of absorption solidification has also been developed. Later, the method has also been applied for low level resins, activated carbon and sludge. Solidified waste is ultimately placed in the final disposal facility for low and intermediate power plant waste. The amount of liquid power plant waste has been under 2,400 m^3 for the entire operating licence period. During the current operating licence period, the amount of liquid waste stored at the Loviisa power plant has varied between 1,100 and 1,400 m^3. The average annual increase has been 10 m^3 for resin waste and 40 m^3 for slurry. Liquid waste is discharged into the sea after radioactivity measurements approximately every four years.

The amount of solid power plant waste in the storage facilities and the plant area has remained under 3,000 m^3 for the entire operating licence period. The amount of solid waste stored at the plant and in the plant area has varied between 300 and 600 m^3 over the course of the operating licence period.

The Loviisa power plant main holds, handles and stores only fresh fuel required for the facility' s own operations. The provisions of the Nuclear Energy Act and Nuclear Energy Decree have been observed in the import of all nuclear materials, devices and equipment at the plant site.

The conclusion is that Fortum Power and Heat Oy's Loviisa power plant has met the licence conditions specified in the current operating licence.

12 Summary (Nuclear Energy Act, Section 20, Operation of a nuclear facility)

The following is laid down in Sections 5–7 of the Nuclear Energy Act (990/1987) with regard to safety in the 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.

The use of nuclear energy is subject to a licence (Nuclear Energy Act, Section 8). According to Section 20 of the Nuclear Energy Act, the granting of an operating licence requires the following conditions to be met:

1) *the nuclear facility and its operation meet the safety requirements laid down in this Act, and appropriate account has been taken of the safety of workers and the population, and environmental protection; (23 May 2008/342)*

2) *the methods available to the applicant for arranging nuclear waste management, including final disposal of nuclear waste and decommissioning of the facility, are sufficient and appropriate;*

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;*

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; and the planned nuclear facility and the operation thereof otherwise fulfils 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; and

2) *until the Ministry of Economic Affairs and Employment 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 assessed compliance with the provisions falling within its authority as part of the Loviisa power plant's periodic safety review.

As regards Sections 20(1)(1-3) of the Nuclear Energy Act, the arrangements of the Loviisa 1 and 2 nuclear power plant units and of the buildings and storages belonging to them required for the management of nuclear fuel and nuclear waste are sufficient and appropriate in terms of safety.

In reference to Section 20(1)(4) of the Nuclear Energy Act, STUK indicates that it lacks the authority and competence to assess the licence holder's financial capacity for operating the power plant. In this statement and its appendices , STUK's assessment has focused particularly on the licence holder's capabilities to conduct the operations safely and, with regard to matters under STUK's regulatory control, in accordance with Finland's international agreement obligations.

STUK's assessments and inspections has not revealed any issues that would keep the licence holder and the Loviisa NPP from meeting the principles laid down in Sections 5-7 of the Nuclear Energy Act.

As regards Section 20(2)(1) of the Nuclear Energy Act, STUK states that the Loviisa nuclear power plant of Fortum Power and Heat meets the safety requirements, the security arrangements and emergency response arrangements are sufficient, and the control necessary to ensure to non-proliferation of nuclear weapons has been organised appropriately, with due consideration to the safety-related aspects presented below. STUK further states that the liability of the licensee of the nuclear facility for nuclear damage has been arranged according to the relevant regulations.

12.1 Safety-related development targets at the plant

STUK has evaluated the safety of the Loviisa NPP based on the Radiation and Nuclear Safety Authority Regulation on the Safety of a Nuclear Power Plant (STUK Y/1/2016), which was implemented in 2016. This regulation takes into account that operating plants do not need to meet all requirements laid down for new plants (STUK Y/1/2016, Section 27 Transitional provision). In accordance with the principles set forth in Section 7 a of the Nuclear Energy Act, *the safety of nuclear energy use must be maintained at as high a level as practically possible. For the further development of safety, measures shall be implemented that can be considered justified considering operating experience and safety research and advances in science and technology.*

The design bases applicable to the Loviisa NPP have been primarily laid down in the 1970s. The goal for the operating period of the plant has been to ensure the continuous improvement of plant safety. Fortum has updated and renovated the Loviisa NPP significantly and implemented extensive modifications of the equipment, systems and structures in order to improve safety over the course of the plant’s operating history.

Transient and accident analyses

The on-going modification work, extensive I&C update and other plant modifications require the transient and accident analyses to be updated. For this reason, Fortum has not, for the purpose of this periodic safety review, reworked any such analyses that must eventually be updated due to the aforementioned modifications. The intention is to update the analyses immediately after the ELSA I&C update.

The implementing decision of Guide YVL B.3 requires that the design extension conditions (DEC A and B) be submitted to STUK by the end of 2018. The implementing decision of Guide YVL B.1 lays down requirements for identifying design extension conditions (DEC A, B and C) and preparing for them (DEC C).

PRA

During the current operating licence period, probabilistic risk analysis (PRA) has been utilised to systematically identify and eliminate risk factors. The PRA covers all of the facility's operational states and essential events that may threaten safety. The risk assessments have considered both the facility's own operating experiences as well as those of external parties.

The prediction presented by Fortum in 2006 in conjunction with the renewal of the operating licence, which anticipated a decrease in core damage frequency and large release frequency, has been realised, concerning the latest results of the PRA. Updates and plant improvements will be continued, which means that Fortum must also continue its efforts reduce risks at the plant units and, for example, development probabilistic risk analysis of the Loviisa 2 plant unit. STUK will monitor the efforts to implement the improvements and update the PRA, paying special attention to the timely implementation of the safety improvements and the justifications for the changes in the improvement plans.

The analyses conducted based on the Fukushima incident did not identify new external threats or the need to take immediate action, but a decision was made to improve the plant against the loss of the ultimate heat sink and sea water flooding, and to increase the plant's self-sufficiency in the event that power supply is lost. Furthermore, the analysis necessitated a more detailed assessment of the risks related to the loss of cooling in fuel pools and spent fuel storage pools. The assessment of the reactor hall fuel pool (loading) has now been included in the plant unit PRA, but the PRA for the interim storage of spent fuel is yet to be prepared. In conjunction with the implementation of Guide YVL A.7, STUK required that the risk assessment on the interim storage for spent fuel must be drawn up and submitted to STUK by the end of 2018.

In the design of significant plant modifications, earthquakes have been taken into account since 2001. The latest seismic risk analysis is from the year 2010. However, in the context of the seismic risk analysis in question, STUK required Fortum to estimate the need to update seismic risk scenarios and explore the possibilities of improving the supports of the most seismically sensitive equipment. Fortum will continue these efforts and develop the probabilistic risk analysis of external hazards.

Fortum states that fire risks are at an acceptable level. In STUK's view, the fire risk analyses are acceptable overall, but the significance of the steel-coated fire-resistant cables on the galvanised shelves to plant safety has been under prolonged scrutiny. This issue requires the assessment process to be concluded and a specification to be made in the fire PRA, in addition to determining any possible measures based on the results. The issue will be incorporated into STUK's monitoring of the period safety review.

Safety classification

Guide YVL B.2, which came into force in connection with the overall YVL Guide reform, slightly changed the requirement level regarding the safety classification in comparison to the previous YVL Guides on classification, YVL 2.1, YVL 2.6 and YVL 3.3. The most substantial individual changes is the abolishment of safety class 4. In the implementation decision of Guide YVL B.2, STUK required Fortum to prepare a description that presents the new classification for safety-class 4 systems, including justifications, as well as the systems to be incorporated into class EYT/STUK. Fortum will submit the updated classification document to STUK by 31 January 2017. Any possible changes caused by the later DEC analyses will be taken into account once the analyses are complete.

Other matters that are important for classification include specifying the safety significance of structures and buildings addressed in conjunction with the implementation of Guide B.2, the application of seismic classification at the Loviisa NPP, and presenting the safety class specified in Guide YVL B.2 alongside the safety class used at the facility.

In the implementing decision of Guide YVL B.2, STUK further required that the licensee must, in the future, specify the equipment and structures required for safe ramp down in the event of earthquake, as well as any equipment and structures which, when damaged, may cause substantial propagation of radioactive substances inside or outside the facility. The description concerning the seismic classification and the durability of the equipment and structures must be submitted to STUK for approval by the end of 2017. Furthermore, the licensee must, by 31 January 2018, submit to STUK for information a description of any modifications of other equipment or structures – determined based on tours or analyses of the facility – that may in the event of an earthquake compromise equipment with a seismic classification

Ageing management

The 30-year service life, which has been the original design basis for Fortum's current operating licence, will be exceeded by 20 years. The Loviisa power plant has independently and systematically developed the service life management programme and related know-how since the beginning of the 1990s.

In recent years, some plant events have come to light resulting from the weakening of a structural or functional property of a SSC due to physical ageing. Technological ageing of SSCs has also been observed particularly as a result of a lack of spare parts.

The new Guide YVL A.8 on the ageing management of nuclear facilities entered into force at the Loviisa NPP at the beginning of October 2015. According to the Guide's implementing decision, Fortum submitted its updated ageing management programme at the end of 2016. Fortum must also provide the first ageing follow-up report defined in the new Guide to STUK within the first third of 2017. The follow-up report consolidates and replaces Fortum's previous annual ageing management reports from various areas of engineering.

The increase in steel transition temperature as a result of radiation embrittlement has been identified as the most important ageing phenomenon in terms of managing the ageing of the reactor pressure vessel. On the grounds of the assessment presented by Fortum, the embrittlement of the reactor pressure vessels of both plant units can be managed until the end of the 50-year service life with the currently available methods. In its assessment, Fortum emphasises that it will continue to assess the embrittlement rate in order to identify previously unknown phenomena affecting embrittlement speed.

The current brittle fracture analyses that correspond to the 50-year service life of the reactor pressure vessel have been using assumptions of the changes brought about by the Loviisa I&C update protect LARA. Since the LARA project was halted in 2014 and replaced with the less extensive equivalent ELSA, the assumptions utilised in the analyses are no longer fully valid. Fortum has stated that it will update the probabilistic reactor pressure vessel analyses by the end of 2018 and the deterministic analyses by the end of 2023. In STUK's view, these time frames are sufficient from the perspective of assessing the continued use of the reactor pressure vessels. Furthermore, at the end of 2016, Fortum submitted the description required by STUK on the technical means by which the Loviisa 2 reactor pressure vessel's brittle fracture risk will be managed during the final years of the operating licence period. This especially applies to cases where the reactor pressure vessel cools from the outside due to the erroneous activation of the reactor hall spray system, for example. According to the description, Fortum intends to implement a change in 2019 to enable increasing the spray water temperature and, thereby, the brittle fracture margin. Fortum will also continue to examine the possibilities of improving the situation by adding thermal insulation on the exterior of the reactor pressure vessel's core area weld. STUK will monitor Fortum's measures as part of its continuous monitoring and assess the total arrangements in the context of the brittle fracture analyses.

During the current operating licence period, the hydrochemistry of the Loviisa 1 and 2 nuclear power plant units has remained at an acceptable level. There are no future needs for changes to the primary side but, as regards the hydrochemistry of the secondary circuit, it may be necessary to prepare for the eventuality that changes to the EU chemicals legislation may prevent the use of hydrazine to manage hydrochemistry. In the coming years, the Loviisa NPP intends to increase the pH of the secondary circuit water with the aim of reducing the iron in the system and, by extension, the accumulation of magnetite in the steam generators. According to the plans, the last copper parts of the secondary side will be removed in the annual maintenance of 2017, after which the pH can be increased.

The equipment used in the Loviisa NPP's protection and I&C systems represents old technology primarily from the 1960s and 1970s. In recent years, a considerable number of modernisation projects have been conducted on the Loviisa power plant's electrical and I&C systems. The intention is to continue the modernisation efforts in the coming years. The modernisation projects have often stemmed from reasons such as the end of service life, technological obsolescence, end of technical support and lack of spare parts.

In order to management spare parts situation, Fortum has initiated measures to secure the availability of essential spare parts.

I&C updates were initiated under the LARA project as the most important modernisation project. The original purpose of the project was to update the facility's protection I&C, operating I&C and control rooms in phases by the end of 2014. However, Fortum decided to switch to another I&C supplier in 2014, at which point the LARA project was discontinued before the phase 2 installations to be conducted during the 2014 annual maintenance. The updating efforts have been continued through the slightly less extensive ELSA project, which involves updating the remainder of the preventive safety function I&C at both plant units and installing a new process monitoring system (implemented during the annual maintenance of 2016). Furthermore:

- a prioritising system for redundant safety functions will be installed in 2017
- the 2018 updates will target the reactor protection system, reactor-external neutron flux measurement system, power limitation system and power adjustment system, in addition to which manual and automatic functions that ensure the operation of the protection functions.

In conjunction with processing the periodic safety review, STUK required Fortum to provide a report on the spare parts situation and maintained operability of the chemical supply system's (TB), normal make-up water system's (TK) and reactor protection system's (SUZ) frequency converters. Fortum has stated that

- the TB frequency converters will be updated between 2016 and 2018
- The need to update the TK frequency converters will be assessed when operating experiences are gained regarding the new TB frequency converters.

The aim is to update the Loviisa 2 SUZ frequency converters during the annual maintenance of 2019, at which point the decommissioned converters would ensure the availability of spare parts for Loviisa 1.

The operating experiences so far have indicated that the ageing phenomena of the Loviisa power plant's electrical and I&C systems and cables have been sufficiently managed through enhanced maintenance and modernisation of the problem areas. According to the analyses of Fortum's electrical and I&C experts, the facility's electrical and I&C systems, devices and cables are currently in working order thanks to correctly-timed and targeted ageing management measures. Fortum has stated that it will continue to pay special attention to managing the service life of electrical and I&C equipment during the upcoming review period (2016–2023). STUK will monitor the development measures initiated by Fortum as part of ageing management measures.

<u>Qualification</u>

In conjunction with the operating licence renewal, STUK required Fortum to develop its qualification procedure to be more systematic with regard to the traceability of the qualification of the most important systems, structures and equipment to the original qualification requirements, any possible changes in loads and operating and environmental conditions during the plant's operation, safety analysis updates, and any changes in the qualification requirements with the development of the related technology. As a response to the requirement, Fortum presented in action plan for the development of maintained qualification procedures. The purpose of the qualification programme is to utilise existing practices of the Loviisa NPP in the areas of maintenance, the management of spare parts and plant changes, equipment status, monitoring of environmental conditions and failures, operating experiences and quality management. The facility's maintenance information system is planned to be expanded to provide improved management capabilities for the information required for the maintenance of systems, structures and equipment. This development work is intended to be completed by virtue of the changes necessitated in the power plant's procedures and information systems by the implementation of Guide YVL A.8.

The qualification of the Loviisa NPP's containment-external equipment has been examined, and structural improvement measures have been conducted in relation to the cabling and mechanical protection. The measures required for pipe breaks at the feedwater level are intended to be completed in conjunction with the I&C update programme.

Emergency control room

In addition to the main control rooms, the plant units feature emergency control rooms (SAM control room and plant unit-specific emergency control panels), auxiliary and ventilation control rooms, and separate control positions. Together with the local controls and auxiliary control rooms, the controls of the emergency control panels enable stopping the plant unit reactors, cooling the primary circuit and discharging the residual heat of spent fuel if the main control room is lost. STUK will assess the control and monitoring scope of the emergency control panels in conjunction with processing the follow-up reports prepared by Fortum and issue a separate decision on the matter.

Changes implemented due to the Fukushima incident

The analyses conducted based on the Fukushima incident did not identify new external threats or the need to take immediate action, but a decision was made to improve the plant against the loss of the ultimate heat sink and sea water flooding, and to increase the plant's self-sufficiency in the event that power supply is lost.

If necessary to provide protection against sea water flooding, the plant personnel can protect the emergency feedwater pumping facility, which can be used to secure heat removal and keep the power plant in a controlled state in the early phases of an accident. The protection arrangement was mainly completed in 2014. In order to reach the final safe state, the power plant has planned to use the additional residual heat removal system, which is meant to be protected against flooding. In addition to this, the additional residual heat removal system requires redundant power supply to function. The intention is to conduct the work during 2017. The floodgate closing the sea water discharge channel was made higher, which improved protection of the facility against high sea levels during the annual maintenance work. The replacement of the floodgates with gates that reach all the way to the yard level further improves the protection. This modification work has been partially implemented and will be completed for all discharge channels during the 2018 annual maintenance.

In 2015, a system that can discharge the residual heat produced by a shutdown reactor into the atmosphere was commissioned at the Loviisa NPP. Thanks to this improvement, the facility can be maintained in a safe state for a long period of time. This solution almost fully eliminates any future risks caused by the loss sea water cooling. In case of accident situations that last longer than three days, the fuel-related self-sufficiency and availability of the emergency diesel generators has been bolstered with plant improvements implemented in 2016.

The original design of the Loviisa power plant did not ensure the 72-hour residual heat removal from reactor fuel and spent nuclear fuel in the refuelling pool and storage pools in situations caused by a rare external event or a disturbance in the facility's internal power distribution network. Currently, the removal of residual heat from the refuelling pool and during outages in situations where the primary circuit is not leak-tight requires the restoration of external sources of water and electricity before the 72 hours is up. For this situation, the Loviisa power plant has initiated a project that ensures residual heat removal from the refuelling pool and open reactor using water circulation inside the containment or movable water sources and systems designed for managing severe accidents. If normal cooling is prevented, residual heat is removed from the spent fuel storage pools by evaporating the water and feeding makeup water into the pool from an external source. The project to ensure the removal of residual heat (ALPO) is intended to be completed by the end of 2018.

Management, organisation and safety culture

According to STUK's assessment, Fortum strives to maintain an advanced safety culture in accordance with the applicable requirements. To support the regulatory control efforts at the turn of 2013 and 2014, STUK commissioned an independent safety culture study from VTT Technical Research Centre of Finland, which focused on Fortum's Finnish nuclear power plant operations. As a result, VTT stated that the overall safety culture in these activities is at an acceptable level. Through its regulatory control efforts, STUK has found that Fortum has developed its management system, supervisory activities and the group's safety-related roles to meet previous development needs. As an example of making its operating methods more systematic, Fortum has made progress in the implementation of long-developed operating models, such as the Design Authority operations and the "Good working practices" programme concerning the use of Human Performance (HuP) methods. STUK will monitor the development of Fortum's safety culture.

Requirements for products and services ordered from outside Fortum and their suppliers are presented in the procurement documents. The licensee has developed the procurement of equipment and services important to safety as well as supplier supervision, and the matter has been addressed in STUK inspections during the current operating licence period. However, there is cause to further develop the supervision and management of the supplier chain and include more efficient methods for ensuring the management of safety and quality.

STUK performed conducted regular tests on quality management at the Loviisa power plant. The inspections have required describing the power plant's processes in the manner necessitated by the Guide YVL A.3 (formerly YVL 1.4). The process description has been a significant development effort, and Fortum has implemented the description of the processes included in the Loviisa power plant's management system in conjunction with the management system update. At the primary level, the process map for Fortum's nuclear power plant operations was completed in 2014, and the process description on a general level was conducted as planned by the end of 2015. The description of operating processes will continue as part of the organisation's development measures, the implementation of which monitors through its Periodic Inspection Programme and other regulatory control efforts.

The Loviisa NPP has procedures in place to ensure that the personnel is suitable, qualified and trained for their tasks. The power plant's personnel planning takes into account anticipated long-term changes and short-term needs. In the future, however, attention should be paid to ensuring the sufficiency of the facility's available staff, especially as the facility nears the end of its service life. Among other things, Fortum has presented measures to develop the expertise of persons that perform important tasks. STUK monitors the implementation of the measures through its Periodic Inspection Programme and other regulatory control efforts.

Security arrangements

The improvements included in the implementing decision of the new Guide YVL A.11 on security arrangements were primarily completed by the end of 2016. The remaining improvements were completed by 31 December 2017. STUK monitors the implementation of the measures through its Periodic Inspection Programme and other regulatory control efforts.

Storage and final disposal of spent nuclear fuel

The original planned service life of the spent fuel storages (KPA1 and KPA2) is 40 years. Fortum has planned to decommission KPA1 in conjunction with decommissioning the Loviisa NPP in 2031, and to continue storage in KPA2 possibly to 2056. This would clearly exceed the original planned service life of the storage facilities. The fuel transfer machine is also reaching the end of its planned service life. Furthermore, the packaging of spent nuclear fuel in the transport container for transport to the final disposal facility requires changes in the interim storage for spent nuclear fuel at the Loviisa NPP, for which the licensee should make preparations well in advance.

STUK has required Fortum to submit for information a description of the ageing management of the spent fuel storage and transfer machine, and the transport arrangements for spent nuclear fuel by 31 May 2017.

12.2 Fortum's action plan to improve plant safety

Based on the conclusions in its periodic safety review, Fortum states it will pay special attention to the following during the upcoming operating licence period:

- developing its management system
- developing deterministic analyses
- the ELSA project and managing the service life of I&C and electrical equipment (LARP programme)
- completing the on-going projects to improve safety (e.g., ensuring fuel pool cooling, improving the storage and availability of diesel fuel, improving flood protection, se-

curing secondary-circuit safety functions, and updating the steam generator safety valves)
- lifting of heavy objects and related changes
- developing the Technical Specification, FSAR and classification document
- developing Human Performance (HuP) methods

12.3 Conclusion

In conclusion, STUK presents as its overall assessment that, as regards its sphere of authority and operations, the requirements of Sections 5-7 and 20(1) of the Nuclear Energy Act (990/1987) for granting an operating licence for the Loviisa 1 and 2 nuclear power plant units and the included buildings and storages required for the management of nuclear fuel and nuclear waste are met. In connection with preparing this safety assessment, STUK has found that the matters and arrangements referred to in Section 20(2)(1) of the Nuclear Energy Act are in order, with the specifications presented above.

In summary with regard to the inspections and assessments of matters and documents related to the periodic safety review and the results of continuous monitoring, STUK states that Fortum Power and Heat Oy has ensured the safety of the Loviisa 1 and 2 nuclear power plant units in accordance with the effective provisions, for the parts that are applicable to operating facilities. The licensee has presented measures to further improve safety at the Loviisa nuclear facility during the current operating licence period. In STUK's assessment, the licensee has the required capabilities, procedures, competence and resources to continue safe operations. STUK will monitor the timely and compliant implementation of Fortum's safety-improving methods.

Fortum has prepared its own periodic safety review on the safety of the Loviisa 1 and 2 nuclear power plant units and the interim storage facilities for spent fuel, intermediate level waste and low level waste, and on possible development targets and continued safety in accordance with Guide YVL A.1.

During this periodic safety review, STUK has simultaneously prepared an extensive implementation of the YVL Guides revised at the end of 2013 for operating nuclear power plants. As a result of the implementation process, STUK has, based on clarifications and presentations from the licence holder, defined the acceptable deviations from the new YVL Guides as well as the necessary licence holder measures to meet the requirements of the new YVL Guides.

These measures have been considered in the safety assessment and the further monitoring of the measures will be consolidated with other necessary measures that were highlighted as a result of the period safety review.