STUK-B 225 / JUNE 2018

B

Regulatory oversight of nuclear safety in Finland

Annual report 2017

Erja Kainulainen (ed.)

Säteilyturvakeskus
Strålsäkerhetscentralen
Radiation and Nuclear Safety Authority
STUK

STUK-B 225 / JUNE 2018

Regulatory oversight of nuclear safety in Finland

Annual report 2017

Erja Kainulainen (ed.)

STUK • SÄTEILYTURVAKESKUS
STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY

Osoite/Address • Laippatie 4, 00880 Helsinki
Postiosoite / Postal address • PL / P.O.Box 14, FIN-00881 Helsinki, FINLAND
Puh./Tel. (09) 759 881, +358 9 759 881 • Fax (09) 759 88 500, +358 9 759 88 500 • www.stuk.fi

ISBN 978-952-309-421-5 (nid.) Erweko Oy, Helsinki 2018
ISBN 978-952-309-422-2 (pdf)
ISSN 0781-1713

KAINULAINEN Erja (ed.). Regulatory oversight of nuclear safety in Finland. Annual report 2017. STUK-B 225. Helsinki 2018. 37 pp. + Appendices 57 pp.

Keywords: nuclear energy, nuclear facility, nuclear waste, nuclear safeguards, regulatory oversight, indicators

Introduction

This report constitutes the report on regulatory oversight in the field of nuclear energy which the Radiation and Nuclear Safety Authority (STUK) is required to submit once a year to the Ministry of Economic Affairs and Employment pursuant to section 121 of the Nuclear Energy Decree. The report is also delivered to the Ministry of Social Affairs and Health, the Ministry of the Environment, the Finnish Environment Institute, and the regional environmental authorities of the localities in which nuclear facilities are located.

The report is a compilation of the regulatory oversight of nuclear safety performed by STUK and its results in 2017. The regulatory oversight concerned the engineering, construction and operation of nuclear facilities, planning for their decommissioning, nuclear waste management and nuclear safeguards.

In addition to safety oversight, the report discusses other subjects including the development and implementation of the nuclear energy regulatory framework as well as the main features of safety research programmes regarding nuclear safety and nuclear waste management in Finland.

The safety indicators for nuclear power plants, significant events at the facilities as well as summaries of the inspections carried out by STUK have been compiled in the appendices to the report. Furthermore, the report includes the summary of the licenses granted by STUK pursuant to the Nuclear Energy Act in 2017 as required by the Nuclear Energy Decree.

STUK's Financial Statements and Annual Report for 2017 also includes an assessment of the attainment of performance targets set out in the performance agreement between the Ministry of Social Affairs and Health and STUK for the regulatory oversight of nuclear energy.

Contents

1 Development and implementation of legislation and regulations

Disambiguation of the Nuclear Energy Act

The President of Finland approved the act (905/2017) amending the Nuclear Energy Act (990/1987) in a plenary session of the Council of State on 14 December 2017. The act entered into force on 1 January 2018. The Ministry of Economic Affairs and Employment (MEAE) had initiated the project in summer 2016 when the work for preparing the bill for amending the act started. The bill was circulated for comments in spring 2017 and submitted to Parliament in late August.

This amendment of the Nuclear Energy Act implemented the supplement of the Nuclear Safety Directive (2014/87/EURATOM) that had been amended to be more detailed following the Fukushima accident, and supplemented the 2013 implementation of the Directive of Safe Management of Spent Fuel and Radioactive Waste (2011/70/EURATOM) due to the additional questions by the Commission. The most significant changes caused by the directives concerned transparency, the licensee's obligation to provide information and its responsibility for contractors and subcontractors, involvement of the general public in the decision-making process on nuclear facility licensing international peer reviews and the licensee's obligations. At the same time, the provisions of the act regarding pressure equipment were updated due to the new Pressure Equipment Act (1144/2016) that entered into force on 1 January 2017. In addition to the above, national legislation was deemed to require disambiguation on matters related to the decommissioning of nuclear facilities and nuclear waste management, which is why further specifications were entered in the act regarding these matters, and the decommissioning licence was added as a new licencing phase for nuclear facilities.

The Nuclear Energy Act amendment proposals concerning security arrangements in the use of nuclear energy were withdrawn from the Nuclear Energy Act amendment bill following the comments round a for separate preparation by the Ministry of Employment and the Economy, STUK, the Ministry of the Interior and the Ministry of Justice. This amendment of the act will possibly enter into force during 2018. The amendments to the Nuclear Energy Act required by the Council Directive (2013/59/Euratom) laying down basic safety standards for protection against the dangers arising from exposure to ionising radiation are included in the Radiation Act amendment bill and will enter into force as an annex act to the new Radiation Act.

The steering group appointed by the Ministry of Economic Affairs and Employment and the management of STUK made the policy decisions regarding the matters included in the Nuclear Energy Act amendment (905/2017). Two working groups comprising representatives of MEAE, STUK, universities and licensees as well as VTT evaluated the changes needed by the directives and licensing-related matters, and made proposals regarding them. The Ministry of Social Affairs and Health (STM) is in responsible for the overall reform of the Radiation Act which will implement the radiation safety directive (Basic Safety Standards) issued by Euratom in 2013. STUK is also actively participating in the reform of radiation legislation.

Government decrees on the amendment of the Nuclear Energy Decree and on preparing for the costs of nuclear waste management

The Nuclear Energy Decree (161/1988) was amended by Government Decree 1001/2017 due to the amendments made to the Nuclear Energy Act and due to the entry into force of the new Act on Environmental Impact Assessment procedure (252/2017). The decree entered into force on 1 January 2018.

Licensing provisions further specifying the licencing procedure were added to the Nuclear Energy Decree, and oversight provisions regarding the decommissioning of nuclear facilities were added in the decree chapter concerning regulatory oversight by STUK. Provisions regarding the minimum contents of the national nuclear waste management programme were also added to the decree. The references to the EIA procedure in the Nuclear Energy Decree were updated due to the new act (252/2017). Furthermore, provisions regarding the phases of and documents related to the procedure were amended for compliance with the new act. Some minor technical corrections and specifications were also made to the Nuclear Energy Decree.

The Government Decree on preparing for the costs of nuclear waste management (991/2017) entered into force on 28 December 2017. The Government decree now in force will renew and supersede the current Government Decision 165/1988. The competence for issuing the decree and the decree itself are based on the Nuclear Energy Act (990/1987). The point of law includes provisions of how the party with the waste management obligation must prepare for the future costs caused by nuclear waste. In addition to certain technical corrections (name of the ministry, currency), further specifications have been made in the decree regarding, e.g., the calculation of reserve fund targets, and the accrual period is extended from the current 25 years to 40 years.

Update of STUK regulations and YVL Guides

The Radiation and Nuclear Safety Authority (STUK) issues more detailed regulations regarding the technical details on the general safety objectives of nuclear facilities prescribed in chapter 2 a of the Nuclear Energy Act (990/1987) in compliance with section 7 q of the act. The first five regulations by STUK concerning the safety of nuclear facilities were issued on 1 January 2016. Until then, these regulations concerning the safety of nuclear power plants and the safety of disposal of nuclear waste as well as emergency arrangements and nuclear security had been issued as Government decrees. At that time, STUK also issued a totally new regulation further specifying the provisions of the Nuclear Energy Act with regard to radiation safety for mining or ore enrichment operations for producing uranium or thorium.

According to section 7 r of the Nuclear Energy Act (990/1987), the Radiation and Nuclear Safety Authority (STUK) will specify detailed safety requirements concerning the implementation of safety level in accordance with the Nuclear Energy Act. STUK publishes the safety requirements as YVL Guides. There are currently 44 of these guides. Most of them entered into force on 1 January 2013.

STUK Regulations and YVL Guides issued pursuant to the Nuclear Energy Act are updated to conform with the Nuclear Energy Act amendments that have entered into force and those entering into force as an annexed act to the new Radiation Act, as well as with the planned amendments of the act regarding the security arrangements in the use of nuclear energy. To advance this work, STUK initiated a project of its own (RYSÄ) in early 2016. In relation to the implementation of directives, only some requirements at the STUK regulation level remained pending implementation, because the additional requirements needed due to the Fukushima accident were already entered in 2013 in the Government decrees in force at the time, and the other new requirements of the Nuclear Safety Directive were taken into account when amending the Nuclear Energy Act. STUK Regulations and YVL Guides are mainly subject to clarifications, amendments to legislative references and minor adjustments to the requirements. When updating the regulations and guides, the feedback from licensees regarding implementation of the YVL Guides is taken into account. Lightening the regulatory burden is also a particular objective when updating the YVL Guides.

In 2017, the updates to five different STUK Regulations each advanced at different stages so that STUK Regulation on the Preparedness Arrangements of Nuclear Power Plants was almost completed, awaiting only finishing touches, and three other regulation drafts were undergoing an external statement round. All regulations, apart from that concerning security arrangements in the use of nuclear energy, contain references to the radiation legislation being reformed and to the amendments of the Nuclear Energy Act entering into force as an annex act to it, which is why their publication will wait for the publication of the new Radiation Act and decrees. The YVL Guide update work began in 2017. Most of the YVL Guides will be updated using the short circulation procedure of drafts where the same guide draft is simultaneously sent internally within STUK, outside STUK and to the Advisory Commission on Nuclear Safety.

In addition, the drafts are published on STUK's website for feedback from the general public. In 2017, 13 YVL Guides were sent for statements. STUK Regulations and the YVL Guides to which significant amendments to the requirement levels are being made are updated following a normal circulation procedure of drafts. Last year, more than 100 people participated in STUK in the regulation and YVL Guide update project, using approximately five person-years. It is likely that the same amount of resources will be used in 2018.

Implementation of the YVL Guides

Last year, the project for implementing the YVL Guides published in 2013 (SYLVI) was completed for nuclear facilities in operation and under construction. STUK made the decisions on applying the YVL Guides to Olkiluoto 3 so that they will enter into force when the operating licence is granted. For the Loviisa and Olkiluoto nuclear facilities already in operation, as well as for VTT's FiR 1 research reactor, the YVL Guides have already entered into force (in 2015, 2016). STUK assessed guide-specific reports from the licensees, particularly focusing on processing non-conformances and measures proposed by the licensees. Furthermore, STUK made policy decisions last year regarding the application of the YVL Guides to Posiva's plants and facilities during their construction phase and during the future licensing phases.

2 Results of regulatory oversight of nuclear power plants in 2017

2.1 Loviisa 1 and 2

STUK oversaw the safety of the Loviisa nuclear power plant and assessed its organisation in different areas by reviewing materials provided by the licensee, carrying out inspections in line with the periodic inspection programme and the YVL Guides, and by overseeing operations at the plant. On the basis of this regulatory oversight, STUK can state that operations did not cause a radiation hazard to the employees, population or the environment. Summaries of inspections included in the periodic inspection programme for 2017 are included in Appendix 4. In addition, a decision was made regarding the Loviisa nuclear power plant's periodic safety review assessment that was begun in 2015. The safety assessment shows that the technical condition of the plant and the development actions planned for it, as well as the licensee's procedures, competencies and resources are sufficient for the safe operation of the plant until the expiry of its operating licence.

2.1.1 Safe operation of the plant

Radiation safety of the plant, personnel and the environment

The collective occupational radiation dose of the employees in 2017 was 0.24 manSv at Loviisa 1 and 0.27 manSv at Loviisa 2. The collective radiation dose of Loviisa 1, as well as the combined radiation dose for both units (0.51 manSv) are the lowest ever recorded. The collective radiation dose during the annual outage of Loviisa 1 (0.19 manSv) was the lowest ever recorded for the plant. The collective radiation dose during the annual outage of Loviisa 2 (0.24 manSv) was slightly lower than anticipated. The positive development is the result of development of the working methods to lower the radiation doses and the replacing of reactor coolant pump seals that contained activated antimony with seals that do not contain antimony between 2011 and 2014. The dose rate levels of the primary circuit pipelines at Loviisa 1 have further decreased from the previous years. Dose rate measurements indicate that the rate of decrease in radiation levels of the primary circuit at Loviisa 2 has slowed down compared with the previous year.

The annual effective dose from radiation work for a worker may not exceed 100 mSv during a period of five years (on average 20 mSv per year) and a maximum of 50 mSv during any single year. The actual radiation doses remained clearly below these limits. The largest individual dose received at the Loviisa power plant was 6.31 mSv, mainly caused by electrical and I&C work during the annual outage, was also the lowest ever recorded.

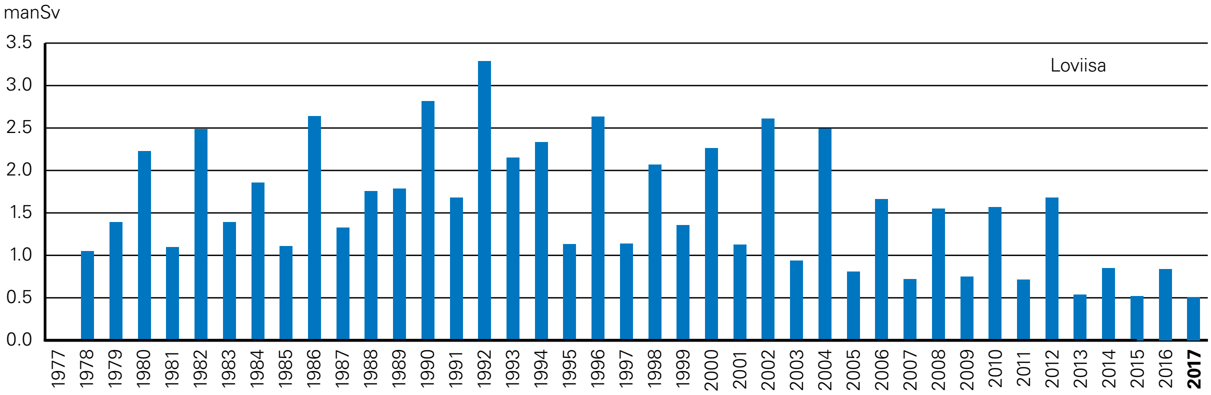


Figure 1. Collective occupational doses since the start of operation of the Loviisa nuclear power plant.

As in previous years, Fortum carried out an eye dose measurement campaign for different employee categories during the annual outages to assess the need for eye dosimetry. The measurement results indicate that the eye doses were not significantly different from the whole body doses, which is why Fortum does not see any need for continuous measurement of eye doses for employees working in the controlled area. However, eye doses can be measured on a case by case basis using a separate eye dosimeter.

Radioactive releases into the air and sea remained clearly below the set limits. The calculated radiation dose of the most exposed individual in the vicinity of the plant was about 0.22 µSv per annum, i.e. less than 1% of the set limit (Appendix 2, indicator A.I.5c).

A total of approximately 500 samples were collected and analysed from the land and marine environment surrounding the Loviisa nuclear power plant in 2017. The measured concentrations were so low that they are insignificant in terms of radiation safety concerning the environment or people. The exposure to radioactivity of residents in the vicinity of the nuclear power plant was also measured. No radioactive substances originating from the Loviisa power plant were detected in them.

Operational events and operating experience feedback

In spite of individual events, the plant's operations went well in 2017, and safety practices were fully observed.

In 2017, Fortum reported the results of 25 event investigations to STUK. Of these, 23 concerned individual events. One investigation concerned deviations occurring in nuclear fuel transfers as a whole, while another concerned erroneous signals in the plant protection system. The purpose of these thematic investigations was to establish whether there are any common factors behind events of the same type that have not been possible to identify and solve merely by investigating individual events.

STUK verified by reviewing reports that Fortum has investigated the underlying causes of the events and initiated the necessary actions to correct technical faults and deficiencies in its operations methods and prevent reoccurrence of the events. STUK considered the event investigations sufficient. In one case, STUK requested Fortum to further investigate the underlying causes of an event and to assess the sufficiency of the measures taken to improve the operations. In two cases, STUK suggested that the observations should be taken into account in further work undertaken by Fortum.

Most of the events revealed areas for improvement in procedures and activities. Three events were deviations from managing the operability of components which are important to safety. This was because periodic tests required by the operational limits and conditions (OLC) were not carried out or were delayed. These events were caused by problems in the use of the IT system used for managing the tests. STUK required Fortum to assess whether the problems could be solved by investigating individual events, or whether the subject warrants a more holistic analysis. In addition, STUK will make a separate inspection regarding the use and maintenance of the IT system concerned in 2018.

One significant individual event was the falling of a fresh nuclear fuel assembly in connection with a transfer carried out in the reactor hall. The event showed that the new deviation occurred because Fortum had failed to identify or rectify problems on the basis of events occurring in 2016. Following the latest event, STUK enhanced its oversight in order to ensure that Fortum will solve these problems. In 2018, STUK will target one inspection on the effectiveness of the feedback on operating experience.

The most important operational events are described in Appendix 3. STUK subjected operating experience feedback to one inspection included in the periodic inspection programme. The inspection investigated the functionality of internal and external processes concerning operating experience feedback. The periodic inspections are discussed in Appendix 4.

Annual outages and maintenance operations

The annual outages of the plant units were implemented as planned in terms of nuclear and radiation safety. In addition to refuelling and modifications, a large number of maintenance measures and inspections are carried out during each annual outage to ensure the safe and reliable operation of the nuclear power plant.

The most significant modification carried out during the short annual outages in 2017 was phase two of the I&C reform. It included an extension of manual back-ups and the monitoring system. The annual outage inspections were carried out on schedule and in the planned scope. Because an indication was found in the ultrasonic inspection of an emergency water system nozzle in the pressure vessel of Loviisa 1 in 2016, that nozzle and the equivalent nozzles in Loviisa 2 were inspected during the annual outage. The indication at Loviisa 1 had not changed, and no indications were observed in the nozzles at Loviisa 2.

More information on the annual outages is available in Appendix 3 and a summary of the periodic inspections carried out during the annual outage is included in Appendix 4.

Operational waste management

The processing, storage and disposal of low- and intermediate-level waste (operational waste) at the Loviisa nuclear power plant were carried out as planned. The volume and activity of operational waste in relation to reactor power remained low compared with most other countries. Early in the summer, STUK carried out an operational oversight inspection regarding the release of waste from control, where the organisation, instructions and procedures were inspected. The inspection did not give rise to any remarks.

In 2014, Fortum detected corrosion damage on the outer surface of a concrete vault in the hall for solidified waste for low- and intermediate-level waste (KJT). Fortum has launched a renovation project to repair the vault. The purpose of the project is to ensure that the engineered barrier will be in the planned condition when disposal in the facility begins. The project includes removal of aluminium nails that pose a corrosion risk from the vault structures and the maintenance of the surrounding rock surfaces, among other repair actions. The intention is to remove the aluminium nails from the KJT vault structures during 2018. Low- and intermediate-level waste was also discussed in the periodic inspection regarding nuclear waste management. Appendix 4 has a summary of the periodic inspection carried out in Loviisa regarding the waste disposal facilities.

Production use of the solidification facility for liquid radioactive waste began on 15 February 2016, and it has progressed as planned. In 2017, Fortum continued the development of the concrete mix used for solidification. The intention is to optimise the amount of waste to be disposed of and to improve the quality control of the solidified end product.

Fortum has a development programme for spent fuel disposal for the years 2016–2030, because the transport of spent nuclear fuel to the Posiva facility in Olkiluoto and its disposal require actions to be taken at the Loviisa nuclear power plant. The actions under the development programme have proceeded as planned in 2017. In connection with the programme, STUK reviewed a report by Fortum on the service life of the spent fuel storage facility and transfer machine as well as a conceptual plan for packaging the spent nuclear fuel for transportation by Posiva. These documents were requested in connection with the periodic safety assessment. The development programme covers all modification work on the storage, transfer and disposal of spent nuclear fuel required by the Posiva disposal project. The condition of the transfer machine in the spent nuclear fuel storage will be surveyed during 2018. Fortum updated the commissioning plan for the Loviisa nuclear power plant in 2012. The next update of the plan is scheduled for 2018.

Nuclear safeguards

The Radiation and Nuclear Safety Authority granted Fortum two licences concerning items for nuclear use (Appendix 8). The Loviisa plant submitted the nuclear safeguards reports and notifications it was responsible for in time, and they were consistent with the observations made during inspections.

In 2017, a total of nine nuclear safeguards inspections were conducted at the Loviisa nuclear power plant. STUK performed an inspection pertaining to the physical inventory verification of nuclear materials together with the IAEA and the European Commission both before and after the annual outages. Furthermore, STUK inspected the locations of the fuel assemblies in the reactor core prior to closing of the reactor cover in Loviisa 1 and Loviisa 2. The IAEA and Commission carried one inspection on short notice in the material balance area at Loviisa. No remarks were made in the inspections.

The oversight and inspections by the Radiation and Nuclear Safety Authority indicated that the Loviisa plant fulfilled its nuclear safeguard obligations.

Nuclear security

The state of the security arrangements at the Loviisa power plant is good, and the activities are being constantly developed. STUK assessed the security arrangements in a periodic inspection (Appendix 4) and by participating in the security arrangement exercise organised at the plant. The periodic inspection concerned both physical security arrangements and information security, and included the plant's structural, technical, operational and organisational security arrangements. In 2017, STUK approved the new versions of the Loviisa nuclear power plant's security plan and standing orders regarding security.

Related to the implementation of the YVL Guides, an independent, external assessment of security arrangements, required by Guide YVL A.11, was carried out at the Loviisa plant in late 2017.

Fire safety

Fire safety at the Loviisa nuclear power plant is at a good level. In 2017, STUK oversaw the fire safety of the nuclear power plant by means of site visits, and by reviewing reports submitted by Fortum. The oversight focussed on the implementation of fire protection arrangements during annual outages.

The renewal of the hydraulic units of the turbine bypass valves, initiated in 2016, was completed in 2017. The oil-operated hydraulic units were replaced by water hydraulics, which also improved the plant units' fire safety.

Following the fires in high-rise buildings, e.g. in Great Britain and Dubai, in the autumn of 2017 STUK studied the insulation materials and other materials used in the facades, ceilings or roofs of the Loviisa nuclear power plant which could potentially spread fire, as well as the way in which the fire safety of facades has been ensured. STUK required Fortum to submit a report by 31 March 2018 on the structure types and materials used in the facades of buildings in the Loviisa nuclear power plant site, as well as an updated assessment of the significance of these structure types in the plant's fire safety.

2.1.2 Technical condition of the plant and preparing for exceptional events

Development of the plant and its safety

Several reform projects that will improve plant safety are currently in progress at the Loviisa nuclear power plant. The most significant of these projects is the I&C reform of the Loviisa plant. In its first phase, the control and indication system of preventive safety functions and the I&C status monitoring system were renewed for both plant units in the 2016 annual outage. The second phase covering manual back-up and the extension of monitoring system was installed during the 2017 annual outage. The preliminary installations for the third phase were also done at that time. In addition, STUK continued its review of the Loviisa I&C renewal documents for the last phase and monitored the factory tests of the system. The safety I&C, the element which is most important for the safety of the I&C reform, will be installed during the 2018 annual outages. The other safety-related modifications carried out in 2017 were mainly minor component modifications. Hence, the main focus was on planning the modification work, paving the way for major system-level improvements to be carried out in 2018.

The renewal project for the polar cranes in the reactor halls of the Loviisa power plant progressed as planned in 2017. STUK reviewed the documents related to the modification and oversaw the manufacture and factory tests. The crane parts were transported to the plant in late 2017 when the preliminary installation work also started. The intention is to carry out the installation and commissioning of the polar cranes in both plant units before the 2018 annual outages.

During the annual outages, Fortum replaced one high pressure safety injection pump motor and the motor heat exchanger at both Loviisa plant units. The same operation was performed at both plant units in 2016. The pumps are important to safety, and this action ensures their operability and the availability of spare parts until the end of the plant units' service lives.

The modifications started after the assessments done due to the Fukushima accident were continued in 2017. As part of the preparations for high seawater levels, Fortum added flood protection for the rest of the systems that could be needed under extreme conditions. Fortum started the installation of a auxiliary outage cooling system in late 2017. A similar type of protection was installed in 2015 and 2016 for the auxiliary emergency feedwater pumping stations. The installation of an additional system for ensuring the cooling of fuel pools under highly exceptional conditions was also started in the 2017 annual outage. According to Fortum's plans, the final installation and commissioning of the modification will take place in 2018 when a similar system will also be installed at the spent fuel storage facility.

New top doors were installed in both plant units for the ice condensers inside the containment. Among other things, these ice condensers secure the cooling of steam released in a major leak of the primary circuit and thus also control the pressure. The modification improves the operation of the doors in accident situations and their insulation capability during normal operation.

Reports and analyses

In order to further specify the earthquake risk of the Loviisa power plant, Fortum updated the seismic hazard reports and the earthquake response spectrum during 2017. These serve as the basis for the seismic plant walk-around required in connection with implementation of the YVL Guides. Fortum has planned to implement the plant walk-around in 2018. During the plant walk-around, the intention is to determine the earthquake tolerance of all the components which are important to safety.

Emergency preparedness arrangements

STUK oversaw the ability of the Loviisa nuclear power plant emergency preparedness organisation to act under exceptional conditions with inspection visits and by reviewing reports and emergency response plan updates submitted by Fortum. No events requiring emergency response actions took place at the Loviisa nuclear power plant in 2017. The annual preparedness exercise was organised at the plant in May and it went well. When the results of the exercise were assessed, the use of certain emergency preparedness-position-specific tools and evaluation of the composition of some emergency groups were identified as possible areas for development. Emergency preparedness arrangements at the Loviisa nuclear power plant have been systematically developed and the plant's emergency preparedness arrangements comply with all the key requirements.

2.1.3 Organisational operations and quality management

In 2017, STUK monitored the impacts of the organisational change made by Fortum in the previous year, migration to a process-based management system, development of the modification work process and particularly the Design Authority function included in it, as well as development activities related to the safety culture. Regarding quality management, the annual inspection concentrated on supplier audits. The summaries of periodic inspections regarding the management system, management and safety culture are included in Appendix 4.

STUK's oversight findings indicate that the organisational change of 2016 was implemented without any major challenges affecting operations, albeit that some changes were also seen as necessary in the past year. The Nuclear Projects organisation has continued to develop the structure and areas of responsibility in the organisation. In fuel-related work the organisational changes of the team (Fuel Usage) is intended to ensure the availability of the required competencies. However, sufficient induction training and competence management must be ensured for the new positions. At the end of the year, Fortum was in the process of carrying out a post-assessment of the organisational change.

Fortum completed the development of the modification work process, and established the Design Authority function supporting it. Some lower-level processes have also now been created, but their development work is still ongoing. The licensee has also developed its key indicator system used for monitoring the results of activities and implementation of plant safety.

There are many actions in progress at the plant for developing and assessing the safety culture, but the relations between the actions and their overall coordination still have to be further developed. Extensive training has been provided at the plant for Human Performance procedures, for example, but putting these procedures into practice has not yet been completed. In its regulatory oversight, particularly in connection with the events that have occurred when handling fuel, STUK has also required the timely identification of local safety culture challenges and solving them. The assessment of safety culture and organisational changes, as well as their related development actions, have also been to some extent delayed by the common, scarce resources allocated for them. The matter will be monitored in inspections of the area in 2018.

The internal audits of the Loviisa power plant have been implemented in compliance with the annual plan. STUK has participated in Fortum's supplier audits as an observer and found that the audit activities seem appropriate and compliant with the procedures.

2.1.4 More extensive assessments at the plant

Periodic safety assessment

In early 2017, STUK made a decision regarding the periodic safety assessment that was begun in 2014. The safety assessment shows that the technical condition of the plant and the development actions planned for it, as well as the licensee's procedures, competence and resources are sufficient for the safe operation of the plant until the expiry of its operating licence.

The actions specified by Fortum concerned development of the management system and HUP methods, updating and development of deterministic safety analyses, the I&C reform and service life management of I&C equipment and electrical equipment, completion of the on-going modification work to improve safety (e.g. the improvements initiated following the Fukushima accident), modifications regarding heavy lifts (including the renewal of polar cranes) and development of documents such as those describing operational limits and conditions (OLC), as well as the final safety analysis report (FSAR) and the classification document.

STUK is overseeing the timely implementation of actions improving the safety of the Loviisa power plant in compliance with the requirements as part of its annual oversight.

2.2 Olkiluoto 1 and 2

STUK oversaw the safety of the Olkiluoto nuclear power plant and assessed its organisation in different areas by means of reviewing materials provided by the licensee, carrying out inspections in line with the periodic inspection programme and the YVL Guides, and by overseeing operations at the plant. On the basis of this regulatory oversight, STUK can state that operations did not cause a radiation hazard to the employees, population or the environment. Summaries of inspections included in the periodic inspection programme for 2017 are included in Appendix 4.

2.1.2 Safe operation of the plant

Radiation safety of the plant, personnel and the environment

The collective occupational radiation dose of the employees in 2017 was 0.22 manSv at Olkiluoto 1 and 0.73 manSv at Olkiluoto 2. The collective radiation doses during annual outages was 0.12 manSv at Olkiluoto 1 and 0.66 manSv at Olkiluoto 2. The collective radiation dose during an unscheduled refuelling outage of Olkiluoto 1 was 0.05 manSv,

Radioactive releases into the air and sea remained clearly below the set limits. The calculated radiation dose of the most exposed individual in the vicinity of the plant was about 0.08 µSv per annum, i.e. less than 1% of the set limit (Appendix 2, indicator A.I.5c).

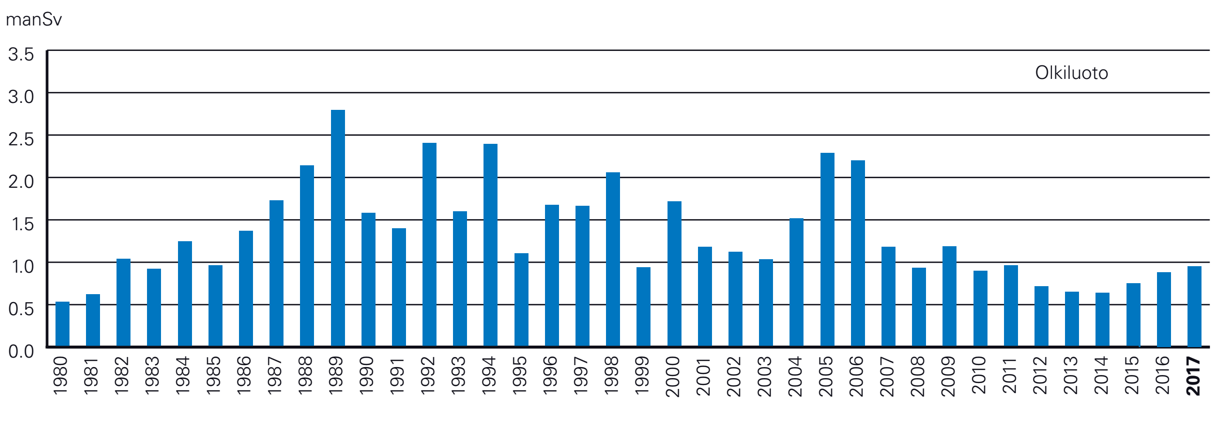


Figure 2. Collective occupational doses since the start of operation of the Olkiluoto units 1 and 2.

The annual effective dose from radiation work for a worker may not exceed 100 mSv during a period of five years (on average 20 mSv per year) and a maximum of 50 mSv during any single year. The actual radiation doses remained clearly below these limits. The largest individual dose at the Olkiluoto nuclear power plant was 9.0 mSv, caused by cleaning work.

As in previous years, TVO carried out an eye dose measurement campaign for different employee categories during the annual outages to assess the need for eye dosimetry. The measurement results indicated that the eye doses were not significantly different from the whole body doses, which is why TVO does not see any need for continuous measurement of the eye doses of employees exposed to radiation. However, the eye doses can be measured on a case by case basis using a separate eye dosimeter. TVO intends to continue surveying the need for eye dosimetry during the 2018 annual outage.

A total of approximately 450 samples were collected and analysed from the land and marine environment surrounding the Olkiluoto nuclear power plant in 2017. Small amounts of radioactive substances originating from the plant were observed in some of the analysed environmental samples. The measured concentrations were so low that they are insignificant in terms of radiation safety of the environment or people. The exposure to radioactivity of residents in the vicinity of the nuclear power plant was also measured. No radioactive substances originating from the Olkiluoto power plant were detected in them.

Operational events and operating experience feedback

In 2017, TVO reported the results of 20 event investigations to STUK. Of these, two were extensive investigations (root cause analyses), in which TVO wanted to find out why making one safety improvement at Olkiluoto 2 has been delayed by one year and why the connection between two deviations was not identified in the decision-making during annual outage.

Most of the events at the plant units revealed areas for improvement in procedures and activities. The operational transients resulting in reductions of power were typically caused by equipment failures. Small amounts of radioactive material were released into the environment in one event (fuel leak at Olkiluoto 1). The amounts were clearly below the emission limits, and the event had no impact on the radiation safety of the population or environment. The most important operational events are described in Appendix 3.

By reviewing reports STUK verified that TVO had investigated the underlying causes of the events and initiated the necessary actions to correct technical faults and deficiencies in its operational methods and to prevent the reoccurrence of the events. STUK deemed TVO's event investigations sufficient. There are problems in the operation or reactor hall pool gates of the plant units and in keeping them open. These problems were evidenced by two events (breaches of operational limits and conditions) in 2017. STUK then deemed it necessary to emphasise that TVO must demonstrate in its activities its commitment to the timely and planned implementation of the actions it has specified.

In addition to reviwing documents, STUK carried out inspections at the plant regarding the impacts of event investigations. In its inspections, STUK found deficiencies and weaknesses which explain why the event investigations cannot always solve the problems. STUK required TVO to improve its investigation process in 2017 and 2018. The inspection is described in in closer detail in Appendix 4.

Annual outages and maintenance operations

STUK oversaw the annual outages from their planning to re-starting the plant units. The annual outages of plant units were implemented as planned in terms of nuclear and radiation safety. TVO had to postpone some of the originally planned work to be carried out in future annual outages. One of the reasons for postponing the work was the delay in detailed planning of the modifications. A large number of maintenance measures and inspections are also carried out during each annual outage to ensure the safe and reliable operation of the nuclear power plant. Non-destructive inservice inspections of pressure equipment were implemented in compliance with an inservice inspection programme approved by STUK.

The annual outage of Olkiluoto 2 had a longer duration than normal maintenance outages due to extensive maintenance and reconditioning operations. During the outage, TVO carried out other operations in addition to normal maintenance and refuelling, for example an extensive operation where the reactor coolant pumps were replaced. TVO replaced all six reactor coolant pumps and their frequency converters with new ones. Furthermore, TVO carried out repairs in the reactor pressure vessel during the annual outage. The nozzles of the pressure vessel commissioned in 1980 were repaired using a method never before used in Finland. More information about annual outages of the plant units and STUK's regulatory oversight is available in Appendix 3. A summary of STUK's periodic inspection of annual outages is also presented in Appendix 4.

In October, an unscheduled refuelling outage took place at Olkiluoto 1 to remove leaking fuel from the reactor. At the same time, TVO carried out some maintenance and repair work at the plant. The unscheduled refuelling outage is discussed in Appendix 3.

Operational waste management

The processing, storage and disposal of low- and intermediate-level waste (operational waste) at Olkiluoto nuclear power plant were carried out as planned. The volume and activity of operational waste in relation to reactor power remained low compared with most other countries. The nuclear power plant pays attention to keeping the amount of waste generated as low as possible by tightly packing the waste and releasing from control waste with so low a level of radioactivity that no special measures are needed. In the holistic development of waste management, the planning has been concentrated on harmonisation of the waste solidification processes in plant units already in operation and Olkiluoto 3 to be commissioned, and on underground disposal. Olkiluoto stores radioactive waste for which the Government is responsible. This was sorted in 2016 into waste to be disposed and waste to remain in the small waste storage facility. The disposal of radioactive waste accumulated so far was implemented at the end of 2016 and the start of 2017.

Nuclear safeguards

STUK granted TVO seven licences concerning the use of nuclear items for the Olkiluoto plant units in operation (Appendix 8). STUK approved the new deputy for the TVO employee responsible for nuclear safeguards to for taking care of the nuclear safeguards duties at the Olkiluoto power plant. TVO submitted the nuclear safeguards reports and notifications it was responsible for on time, and they were consistent with the observations made during the inspections.

A total of 17 nuclear safeguards inspections of TVO's operating plants and the spent fuel storage facility were performed, plus one inspection regarding procurement of uranium by TVO. STUK performed, together with the IAEA and the European Commission, inspections on the physical inventory of nuclear materials at both plant units and the spent nuclear fuel storage facility both before and after the annual outages. Furthermore, STUK inspected the locations of the fuel assemblies in the reactor core prior to the closing of the reactor cover in Olkiluoto 1 and Olkiluoto 2. A similar inspection was also performed after the unscheduled refuelling outage of Olkiluoto 1. STUK also performed two periodic inspections of nuclear safeguards at both plant units and at the spent fuel storage facility. Furthermore, the European Commission, IAEA and STUK carried out an additional inspection due to the unscheduled refuelling outage for verifying the materials after the reactor cover had been closed. STUK also participated in an inspection at the spent fuel storage facility, carried out by IAEA and the European Commission on short notice. No cause for remarks was found in the inspections.

The oversight and inspections by STUK indicated that the Olkiluoto plants in operation fulfilled their nuclear safeguard obligations.

Nuclear security

During 2017, STUK approved the updates of the security standing order at Olkiluoto, the security plan for Olkiluoto and the security plan for the transport of nuclear fuel. TVO carried out the updates as part of the application for renewal of its operating licence. When processing the documents, STUK requested the statements prescribed in the Nuclear Energy Act from the Ministry of the Interior and the Advisory Commission on Nuclear Security. Among other things, the statements required TVO to improve the compatibility of its standing security order with the procedures of the police.

In 2017, STUK carried out one periodic inspection regarding nuclear security. Among other things, the inspection concerned TVO's risk management process from the perspective of security arrangements and its results, information security and the effectiveness of security arrangements. In addition, the fence of the plant area was inspected, as well as the procedures related to goods transports and the security organisation's capabilities to observe and respond. A more detailed summary of the inspection is presented in Appendix 4. STUK also carried out a separate transport inspection regarding security arrangements where the communications and management conditions were particularly assessed.

The security arrangements comprise an extensive package of administrative, technical and operational procedures. Although the results of inspections may require rectifications and improvements regarding several areas, the security arrangements as a whole meet the requirements.

Fire safety

Fire safety at the Olkiluoto nuclear power plant is at an acceptable level. In 2017, STUK oversaw fire safety of the nuclear power plant by means of regulatory inspections and site visits, and by reviewing reports submitted by TVO.

Following the fires in high-rise buildings, e.g. in Great Britain and Dubai, in the autumn of 2017 STUK studied the insulation materials and other materials used in the facades, ceilings or roofs of the Olkiluoto plant units in operation which could potentially spread fire, as well as the way in which the fire safety of facades has been ensured. STUK required TVO to submit by 31 March 2018 a report on the structure types and materials used in the facades of buildings in the nuclear power plant site of Olkiluoto 1 and 2 plant units, as well as an updated assessment of the significance of these structural types to the plant's fire safety. In addition, STUK required TVO to describe how the cases of insulation materials igniting during the construction of the Olkiluoto 3 plant unit have been taken into account when assessing the fire risks of all Olkiluoto plant units.

2.2.2 Technical condition of the plant and preparing for exceptional events

Development of the plant and its safety

Several modification projects that will improve plant safety that were designed based on assessments of the Fukushima accident are currently ongoing at the nuclear power plant. These modifications will improve the provisions for extreme external threats. TVO will install a steam turbine-driven core-cooling system to manage a situation where a total loss of AC power has occurred. The plan is to commission the system at both plant units during the 2018 annual outage.

Dependence of the auxiliary feedwater system from the seawater cooling was clearly reduced by implementing a modification at Olkiluoto 1 in 2014. Abnormal vibrations and sounds were nevertheless observed during the test run in one new recirculation line. During 2017, TVO continued investigating the problems observed and submitted an action plan to STUK for its approval for eliminating the problems and for continuing the recirculation line modification work. STUK approved the plan and the pre-inspection documents of the system accordingly updated late in the year. According to the schedule proposed by TVO, the modifications for eliminating the problems will be carried out at Olkiluoto 1 during load operations and the 2018 annual outage. According to the schedule, the equivalent recirculating line modification would be introduced to all trains at Olkiluoto 2 in spring 2019.

A project to replace the reactor coolant pumps and the frequency converters needed to control and supply power to the pumps, as well as a project to replace the nuclear power plant's emergency diesel generators are also ongoing at the Olkiluoto nuclear power plant. TVO started with the replacement of one of the six pumps in Olkiluoto 1 during the 2016 annual outage. During the 2017 annual outage, TVO replaced all the reactor coolant pumps at Olkiluoto 2. TVO will commission another five new pumps for Olkiluoto 1 during the 2018 annual outage. STUK continued its review of documents pertaining to replacement of the reactor coolant pumps and the supervision of manufacture. In the emergency diesel generator project, eight of the power plant's emergency diesel generators will be replaced and a ninth generator will be built. TVO has estimated that the first new emergency diesel generator will be commissioned in spring 2018. Then, the remaining eight emergency diesel generators will be installed and commissioned one by one in such a manner that the last one will be commissioned in spring 2022. The new diesel generators can be cooled with seawater and air. The current ones can be cooled only with seawater. STUK is overseeing the upgrade and in 2017 inspected its related design documents and oversaw the manufacture.

Emergency preparedness arrangements

STUK oversaw the ability of the Olkiluoto nuclear power plant emergency preparedness organisation to act under exceptional conditions with inspection visits and by reviewing reports and emergency response plan updates submitted by TVO. No events requiring emergency response actions took place at the Olkiluoto nuclear power plant in 2017. In September, an extensive cooperation exercise regarding the Olkiluoto 3 plant unit was organised at the Olkiluoto nuclear power plant. The cooperation exercise has extensive participation from different public-sector organisations which were able to respond, in cooperation, to all the key challenges of the exercise. When the exercise was assessed, maintenance of a joint view of the situation and the IT and communication systems supporting it were identified as areas for development. These would also support the coordination of communications during the situation. Emergency preparedness arrangements at the Olkiluoto nuclear power plant have been constantly developed and the power plant's emergency preparedness arrangements comply with all the key requirements.

2.2.3 Organisational operations and quality management

In recent years, TVO has had significant problems with the atmosphere at work, and employee turnover has increased from earlier years. A motivated and competent personnel are essentially important for the maintenance of a good safety culture. In early 2017, STUK assessed that the degraded atmosphere at work poses a risk to maintaining competence and the smooth, concentrated and safety-oriented performance of work at TVO. In spite of the organisational challenges, no significant events affecting safety have so far occurred, but TVO has, e.g., had difficulties in complying with time schedules it has set for different improvement actions. In May, STUK required that in order to solve the problems regarding the workplace atmosphere and safety culture, the management of TVO must make a policy decision, and communicate and implement the actions with which the management can improve, e.g., the personnel management and take safety matters into account in decision-making, and with which the availability of resources required for safe operations are systematically ensured.

In order to solve the challenges, TVO has started to develop its operations with various actions. At the same time, TVO has re-organised certain functions in order to be able to better respond to the commissioning of the Olkiluoto 3 plant unit. During 2017, STUK made oversight visits where it viewed the grounds, method of implementation, progress and effectiveness of new development actions implemented by TVO, among other things by discussing with the management and by interviewing personnel. In addition, STUK monitored the development of TVO's own safety indicators. The actions carried out by TVO include management training courses completed by the management and supervisors of TVO, as well as a substantial increase in the number of employees. TVO's resource planning is also now more systematic. TVO is engaged in continuous development work sorting out basic issues, and STUK is of the opinion that the actions are taking the company in the correct direction. In the personnel interviews carried out by STUK in December, many employees felt that taking safety matters into account in decision-making is on a good level and that responsibilities are now less ambiguous than a couple of years ago. However, no clear improvement was seen to have taken place in the working atmosphere or relationships between the personnel and management at TVO. Shortages in human resources affecting the implementation of work were also still reported.

STUK will continue the additional oversight of TVO's organisation. Furthermore, STUK will carry out an additional inspection in January 2018 for verifying the impact of TVO's actions and the ways in which the development of different areas is monitored, measured and further developed.

2.2.4 More extensive assessments at the plant

Renewal of the operating licence

The current operating licence of Olkiluoto 1 and Olkiluoto 2 plant units will expire on 31 December 2018. On 26 January 2017, TVO submitted an application to the Government for continuing the operating licence for 20 years. The Ministry of Economic Affairs and Employment (MEAE) preparing the matter has requested STUK to issue a statement regarding TVO's application. At the end of 2016, TVO submitted to STUK the reports associated with the periodic safety review in compliance with Guide YVL A.1. In spring 2017, STUK made a request for supplementary information regarding the documentation, on the basis of which TVO supplemented the documentation and submitted the updated reports in summer 2017.

During 2017, STUK prepared a safety assessment concerning the plant units for the statement to be issued for MEAE. STUK's safety assessment is based on the review of various issues and documentation associated with the operating licence application as well as the inspection of TVO's own periodic safety review carried out by STUK, as well as the results of regulatory oversight. STUK requested a statement from the Ministry of the Interior on emergency preparedness and nuclear security, and a statement from the Advisory Commission on Nuclear Safety on STUK's draft statement. The Advisory Commission on Nuclear Safety will only issue its statement when the matters presented as pending in the draft have been processed. At the end of 2017, the matters still pending included the organisational and working atmosphere challenges of TVO as well as the ageing management of I&C systems. In 2017, STUK carried out additional oversight of the organisation. For more information on the oversight of the organisation, see section 2.2.3. STUK's statement and safety assessment will be completed in early 2018.

2.3 Olkiluoto 3

STUK inspected the operating licence documentation of the Olkiluoto 3 plant unit and oversaw the trial operation of the plant unit and TVO's preparation for the future operational phase and the finishing touches of the construction and installation work.

The operating licence application has been processed almost in its entirety. Only the review of parts of the largest documentation items – the final safety analysis report and probabilistic risk assessment – is still in progress. In October, the plant supplier announced an additional delay of approximately five months in the project. The operating licence statement by STUK will be postponed accordingly, because STUK will only issue its statement when the trial operation tests have shown that the plant operates as planned. The operating licence is required before starting the plant operation. The operation is deemed to start once nuclear fuel is loaded in the reactor.

The Olkiluoto 3 project has moved from the construction phase to the commissioning phase. At the same time, the construction and installation work is being finalised. In addition to the trial operation of components and systems, the commissioning phase includes other preparations for plant operation, such as the production of instructions required for operation, personnel training and the completion of emergency preparedness and security arrangements, for example. The new phase also affected the oversight by STUK. STUK carried out several inspections of functions related to preparations for plant operation and oversaw the trial operation and testing of instructions using a plant simulator, for example. As part of the preparations for plant operation, the transports of fresh fuel for the Olkiluoto 3 plant unit started in the autumn. STUK inspected the prerequisites for fuel imports.

The oversight of trial operations constituted a large part of oversight work carried out by STUK in 2017. The oversight includes the inspection of test plans and results, as well as the oversight of certain tests. In addition, STUK inspected the prerequisites for progressing in the trial operation, first from testing individual systems to the cold run tests of the whole plant before loading fuel, and then on to hot run tests.

Based on these oversight measures, STUK observed that most of TVO's procedures and operations are at a good level. In summary, based on the results of regulatory oversight, STUK can state that the safety goals of the plant can be achieved.

Processing of the operating licence application

STUK continued to process the operating licence application. TVO submitted its operating licence application to the Ministry of Economic Affairs and Employment (MEAE) in April 2016.

When reviewing the operating licence application STUK will verify that the prerequisites for the safe operation of the plant are met. Detailed safety requirements are included in STUK's regulations and nuclear power plant guidelines (the YVL Guides). STUK assesses compliance with these requirements during the operating licence review process. On the basis of its review, STUK will produce a safety assessment regarding the application and submit a statement on the matter to the MEAE. STUK's safety assessment will not be based solely on a review of the operating licence documentation; instead, STUK will utilise in its assessment all of the results from its oversight operations, such as the general oversight on the plant site, its inspections and results obtained during the commissioning tests of the plant.

The operating licence application documentation has been processed almost in its entirety. Section 36 of the Nuclear Energy Decree specifies the documents making up the operating licence documentation. Of these documents, a review of the final safety analysis report and the probabilistic risk assessment, was still in progress at the end of the year. The operating licence documentation also includes a report on the fulfilment of the safety requirements. STUK has assessed the fulfilment of safety requirements in connection with review of the operating licence application documents and will make its decision regarding the report when all other operating licence documents have been reviewed. STUK has approved other operating licence documents. STUK will not issue a statement on the operating licence until it has been demonstrated in commissioning tests that the plant and its systems operate as planned. STUK oversees the testing on site at Olkiluoto. If the trial operation proceeds as planned, STUK will issue its statement on the operating licence application in April 2018. According to the present schedule, the loading of nuclear fuel will take place in August-September 2018.

Review of other licensing documents

I&C component suitability analyses and stress analyses of mechanical components and piping, among other documents, were submitted to STUK in 2017.

STUK monitored the progress of the I&C component qualification and reviewed the suitability analyses of the I&C equipment and systems. Documentation work regarding the qualification tests and production of the suitability analyses will continue in 2018. However, the final suitability analyses must be submitted to STUK in good time before loading the fuel. The suitability analyses submitted to STUK in 2017 have mainly been of good quality, and STUK has not had any objections regarding them.

During the year, STUK processed a large number of stress analyses of mechanical components. The purpose of these analyses is to demonstrate that the design and dimensioning of pipelines is compliant with the requirements. Approval of the stress analyses is one precondition for trial operation at high temperatures. The stress analyses have also been of good quality, and STUK has approved nearly all the analyses submitted without objections.

Minor modifications were made to the plant on the basis of observations made during trial operation. E.g. flow limiters in the systems have been changed to make the flow rates compliant with the design values. STUK has inspected the safety-related modifications.

Manufacture, installation and construction

STUK continued its oversight of manufacture, installation and construction.

The factory tests of pressurizer safety relief valves were completed during 2017, and the valves were brought to Olkiluoto and installed. The valves will protect the plant's primary circuit from overpressure. Some parts of the valves represent new design, and several modifications of the design have been made during the project. STUK oversaw the factory tests of these valves, their on-site tests before installation in Olkiluoto and the installation work. Although acceptable results were achieved in the factory tests and tests at the plant, the valve appears to be sensitive to variations in assembly, for example. STUK has required TVO to produce plans and justification for the future inspections, maintenance and monitoring of the valves.

Irregularities regarding the manufacturing documentation of the reactor coolant pumps came to light in a plant supplier review. The deviations were related to the oil lifting and lubrication oil systems of the reactor coolant pumps, as well as to the compliance of support structure welding instructions and traceability of the structural materials. STUK required that the deviations are finally cleared before hot tests. Parts of the oil lifting system will be remanufactured due to the irregularities. The oil lifting and lubrication oil systems are essential for trouble-free electricity production, but they only have a minor impact on safety.

The plant supplier has observed cracking in the gasket face in certain valves. The problem is related to the use of a cobalt-free welding coating. Some valves with cracks have been found in the inspections. Hot cracks occurring during welding and residual stresses have been found to be the cause of the problem. Large valves are more susceptible to this risk. Heat transfer is faster in large articles, which increases the cooling-induced stresses. The valve inspections are still continuing, and they will still be carried out in 2018 after the trial operation before fuel loading. The required valves and/or valve parts will be remanufactured using optimised welding procedures and installed before fuel is loaded. In some valves, the cobalt-free coating will be replaced with stellite, because no reliable cobalt-free coating material has been found for large and massive tapered valve gates. Usually, the use of cobalt in nuclear power plants should be avoided, because cobalt may become activated and thus increase the radiation doses of employees. However, the use of cobalt cannot be avoided altogether, because it is difficult to find a replacement material for it. Cobalt has been used in the hard coatings of certain parts inside the reactor, reactor coolant pumps and the control rod drive mechanism. Replacing cobalt-free coating with stellite in a few large valves will not significantly increase the amount of cobalt or the dose rates. STUK has also assessed that the modification is acceptable from the radiation protection perspective. STUK has reviewed the associated inspection and repair plans and overseen the manufacture of new valves.

In the spring, Areva completed the review of the manufacturing documents of Olkiluoto 3 components manufactured at the Creusot Forge factory. Malpractices had been observed at the factory, which is why Areva initiated extensive investigations regarding the products manufactured at the factory. As requested by STUK, TVO submitted a summary report of the matter in time at the end of April. More detailed reports regarding individual deviations were submitted to STUK after that. The quality of materials used for manufacturing the components for Olkiluoto 3 were sufficiently verified by inspections and reports by TVO. The conclusion is, that the deviations do not impact the quality or integrity of parts installed at the Olkiluoto 3 plant unit.

Oversight of commissioning

The purpose of trial operation is to verify that the plant's systems, structures and components operate as planned and have been successfully installed. Large-scale trial operations at the Olkiluoto 3 plant unit already began in 2016 when components and systems were tested. The joint operation systems tests began in 2017. The joint operation tests consists of cold tests where the systems are kept in a cold state, and of hot tests where the reactor coolant pumps are used to heat the systems in the nuclear island and the turbine island to their correct operating temperatures.

The trial operation of individual systems still continued in 2017. Early in the year, the trial operation concentrated on tests which had to be completed before the cold tests that began in the summer. Not all of the plant systems are required in the cold or hot tests, and testing of these systems continues in parallel with the joint operation tests. Such systems include the separate systems related to waste processing, for example. The cold tests were performed in the summer, after which the preparations for hot tests began. The hot tests began in December.

STUK reviewed both test programmes for individual systems and the test programmes for the cold and hot tests. The test programmes had to be approved before the tests could begin. Among other things, the test programmes describe the methods, goals and acceptance criteria of the tests. In its reviews, STUK pays particular attention that all functions which are important to safety are tested and to having appropriate acceptance criteria for the tests. Most of the test programmes plans have been of good quality, and STUK has approved most of them without any requirements. Reports of the trial operation results have also been submitted to STUK. The reports submitted so far have mainly concerned systems of the turbine island. The result reports have been comprehensive, and STUK has not had any objections regarding them. However, STUK has paid attention to the long time it takes to produce the reports.

STUK inspected the preparedness for starting cold and hot tests. The issues verified in the inspections included the degree of completion of the systems and equipment required in the tests, and the planning by TVO regarding its participation and monitoring. For the hot tests, STUK required TVO to also ensure the availability of resources for overseeing the tests in the evenings and weekends.

The main objective of the cold tests was to demonstrate the integrity of the primary circuit in a primary circuit pressure test. The integrity is important for two reasons: firstly, it ensures that the reactor receives sufficient cooling at all times, and secondly, in case of any leaks in the fuel cladding, integrity of the primary circuit will stop them from spreading in the plant. STUK oversaw the primary circuit pressure test on site. The test results were acceptable, and no leaks through the pressure-bearing primary circuit interface were observed. A detailed report of the test results has been submitted to STUK for review.

In addition to the primary circuit pressure test, STUK has also overseen other tests, such as tests of the emergency diesel generators, and commissioning activities in general. One of the four emergency diesel generators was damaged in trial operation, and the crankshaft of the engine had to be replaced. Investigations regarding the root cause of the fault are in progress. STUK has required that the cause is established before continuing trial operation of the diesel generator.

Oversight of preparation for operation

In addition to the technical readiness of the plant, a prerequisite for safe operation of the plant is the organisation's ability to use the plant in a safe manner. Procedures that cover the different functions of the plant and a variety of exceptional situations must be in place and competent employees for the plant must be available. For example, only a person approved by STUK for the position may act as a nuclear plant operator in the control room of the plant.

STUK reviewed the production of the instructions for operation and maintenance of the plant as part of its construction inspection programme. The status of the procedures was a theme in the electrical and I&C engineering inspections, for example. Validation of the procedures for emergency and abnormal operation situations with a plant identical simulator began in 2017. Validation of the procedures will continue in 2018. STUK reviewed the validation plans and oversaw the validation work. Furthermore, STUK oversaw the validation of control room user interfaces.

The simulator training of operators began in February. STUK has monitored the arrangements and progress of training and required TVO to systematically monitor the development of operators' competence.

The import of fresh fuel for the Olkiluoto 3 plant unit started in the autumn. Before allowing the import, STUK inspected that the prerequisites for the import were in place. The inspection covered the security and emergency and safeguards preparedness arrangements, readiness of the required facilities and equipment, as well as the required instructions and training of personnel.

STUK granted TVO four licences concerning nuclear use items for the Olkiluoto plant unit under construction (Appendix 8). TVO submitted the nuclear safeguards reports and notifications regarding Olkiluoto 3 that it was responsible for on time, and they were consistent with the observations made during inspections. STUK inspected the nuclear safeguard preparations of Olkiluoto 3 in three inspections together with the European Commission and the IAEA. The European Commission installed the nuclear safeguards surveillance equipment early in the year. In summer 2017, the IAEA, the Commission and STUK reviewed the basic technical characteristics document, i.e., details of the plant. The survaillance equipment was switched on before the first fuel batch was received in October. The inspections covered nuclear safeguards design data and the installation and commissioning of monitoring instruments. The oversight and inspections by STUK indicated that the Olkiluoto plant under construction fulfilled the nuclear safeguards obligations.

The annual emergency preparedness exercise of the Olkiluoto power plant in 2017 was a cooperation exercise organised by public authorities every three years. The Olkiluoto 3 plant unit was the scene of the exercise. One of the objectives of the exercise was to demonstrate the operation of the emergency preparedness plan and organisation in a emergency situation concerning Olkiluoto 3. In cooperation, the organisations were able to respond to all the key challenges of the exercise. When the exercise was assessed, the areas for development identified at TVO included preparations for long-lasting situations and accuracy of communications. Furthermore, there were still minor deficiencies in the components and instructions; these need to be rectified before operation of the plant unit begins. TVO will submit its own assessment of the exercise and the plans for rectifying the deficiencies identified within three months from the exercise.

In recent years, TVO has had significant problems with the atmosphere at work, and employee turnover has increased from earlier years. This matter is discussed in more detail in section 2.2.3 of this report.

2.4 Hanhikivi 1

The documents submitted to STUK in connection with the construction licence application regarding the Hanhikivi 1 plant unit of Fennovoima (FV) were not complete, and Fennovoima has supplemented and will supplement its construction licence application in stages. Submission of the supplementary documentation has been delayed for the estimates presented in the construction licence application and the first licensing plan. Fennovoima has regularly updated its licensing plan to correspond to the status of document deliveries. In December 2017, Fennovoima announced that it will deliver most of the licensing documents regarding the Hanhikivi 1 nuclear power plant unit for processing by STUK by summer 2018, with the last documents delivered in autumn 2018. This would allow STUK to complete the safety assessment in 2019.

Interaction between Fennovoima, the plant supplier and STUK continued in 2017. Dozens of bilateral and trilateral meetings took place during the year between Fennovoima, the plant supplier and the main design organisations. In addition to project and management meetings, matters discussed in topic-specific meetings included the time schedule of documents to be delivered during the construction licence phase and piloting of the contents of documents, starting the manufacture of main components of the plant, taking radiation protection into account in the plant design, the management strategy for serious reactor accidents, taking security arrangements into account in the plant design, nuclear safeguards, and the safety culture of the organisations participating in the project.

STUK monitored the development of management systems and quality assurance of Fennovoima, the plant supplier and its main subcontractors, and assessed the organisations' capabilities to begin construction of the nuclear power plant. STUK participated in the audits carried out by Fennovoima in its supply chain, for example at the factory of EMSS Kramatorsk, the producer of materials for the main components of the plant. STUK has also monitored, as an observer, the design review by the plant supplier and Fennovoima.

The submission of documentation to STUK has been delayed, among other things, by the fact that the basic design work and configuration management of the plant, i.e. the management of its technical composition, have not been completed yet: for example, the updated general part of the preliminary safety analysis report has not yet been submitted for review by STUK. Without an updated general view of the plant and its systems, the results of topic-specific meetings with STUK will be less productive, because it is difficult to form an opinion of individual safety characteristics in the absence of an overall view. STUK discussed the matter with Fennovoima, and Fennovoima suggested a series of meetings at the end of the year for presenting the design concepts to STUK. These activities began at the beginning of 2018 and will continue as the different design concepts are completed.

Fennovoima submitted the nuclear safeguards reports and notifications it was responsible for in time. The results of STUK’s oversight indicate that Fennovoima was capable of fulfilling the nuclear safeguards obligations regarding data subject to a licence and preliminary planning of nuclear safeguards. The plan for arranging the safeguards that are necessary to prevent the proliferation of nuclear weapons is being assessed by STUK.

Management systems, quality management and safety culture

The quality management of the major actors (including Fennovoima, the plant supplier RAOS project Oy, the project supervisor Titan 2) is still being developed. Management systems which are compliant with requirements must be created in a safety-critical field of activity, and the operations must be conducted accordingly.

The development of Fennovoima’s management system has fallen somewhat behind schedule, and there is no readiness to start the construction work yet. Fennovoima is expected to produce preliminary safety analysis report by the summer in 2018 with a description of how the readiness for construction is to be ensured in practice before starting any activities which are important to safety. However, the results of the regulatory inspection programme (RKT) during the construction licence process indicate that Fennovoima's situation has developed and is better than a couple of years ago.

The management system development plan of the plant supplier, RAOS Project Oy (RAOS), is also behind schedule by several sets of processes and instructions. The activities of main designer Atomproekt and main designer of the primary circuit, Gidropress, have progressed, but in spite of the large amount of work done, STUK still does not have any comprehensive proof of the design processes (including configuration and compliance management) fully meeting the Finnish requirements. STUK is keeping an eye on the situation, among other things by monitoring the development of quality plans and in connection with review of technical documentation. This allows STUK to satisfy itself that the design processes are systematic and the design solutions are traceable.

The quality management of the sub-supplier chain of Long Lead Items (LLI) has been convincing throughout the project, and no significant deviations have taken place. However, some of the organisations in the supply chain are still unfamiliar with the Finnish quality inspection requirements and intensity of the control procedures.

The survey of the safety culture in the Hanhikivi 1 project, ordered by STUK from VTT Technical Research Centre of Finland, was completed in autumn 2017. The subjects of the survey were Fennovoima, the plant supplier RAOS Project Oy and the project supervisor Titan 2. VTT assessed the safety culture at Fennovoima to be acceptable when seen as a whole. VTT's assessment indicates that there is significant room for development in the state of safety cultures at RAOS Project Oy and Titan 2. In its decision on the matter, STUK required that the recommendations of the survey are taken into account in the project. Fennovoima was required to enhance its supply control and the guidance and monitoring of its suppliers. Fennovoima must also ensure that the suppliers' understanding of the project requirements is appropriate. Fennovoima must also develop its organisation and methods of operation so that the long-term impacts are better taken into account in decision-making related to safety matters and the development as a licensee is in balance with the short-term project objectives. Fennovoima must improve the actions of its management team when dealing with safety matters. Furthermore, STUK required Fennovoima to take actions regarding the concerns and rumours that have emerged in the project. The matter was discussed in detail in STUK's media release of October 2017 (in Finnish): http://www.stuk.fi/-/stuk-vaatii-parempaa-turvallisuuskulttuuria-pyhajoen-ydinvoimalaitoshankkeeseen.

The geological surveys performed by the plant supplier on the plant site in spring 2017 revealed uncertainties regarding, e.g., the standards and requirements to be followed when performing the surveys and the way in which the results of the survey s are to be taken into account in the plant design. Fennovoima initiated its own investigation into the matter. STUK has suggested to Fennovoima that in addition to the comprehensiveness and correctness of methods and results, the actions of organisations in the planning, implementation and assessment of geological surveys should also be investigated. Fennovoima will present the results of the first phase of investigations to STUK in early 2018 regarding the acceptability and sufficiency of the geological surveys which have been carried out. STUK will assess the suitability of the plant site and process the associated reference reports as part of processing the preliminary safety assessment report in 2018.

Technology

According to section 55 of the Nuclear Energy Act, the licence applicant can also submit plans and manufacturing documents regarding long lead items in addition to other construction licence application documents for processing by STUK. In 2017, STUK analysed the plans concerning the design bases and materials of the reactor pressure vessel. One key item in the analysis was the suitability of materials to be chosen for the pressure vessel and their endurance during their planned service life of 60 years. The most significant decision requirements by STUK concerned carrying out an accelerated embrittlement study of basic and welding materials of the reactor pressure vessel before commissioning the plant, and additions to the load cases to be analysed in the Hanhikivi 1 plant design compared to a reference plant. In the meetings STUK has also discussed the supplier control and guidance by Fennovoima regarding the manufacture of major components. According to Fennovoima, the first supplier-specific delivery control plans describing the scope and methods of Fennovoima's controls, are being prepared.

Regarding construction engineering, the application of Finnish official requirements to the design of the Hanhikivi plant and delivery of a 3D model describing the plant to STUK were discussed in 2017.

In 2017, STUK also discussed the plant's I&C systems with Fennovoima and the plant supplier and participated, as an observer, in the audits of the I&C design organisations. The supply chain of I&C technology for the duration of the plant design, construction and commissioning is yet to be defined. Sufficient initial data has also not yet been obtained on the plant and process design for designing the I&C system. Preparation of the licensing documentation regarding I&C to be submitted for review by regulatory authority has been postponed until 2018.

2.5 Research reactor

VTT submitted the operating licence application regarding decommissioning to the Government in June 2017, and at the same time also submitted the first set of decommissioning documentation to STUK for inspection. The most significant document submitted for inspection was the final decommissioning plan of the research reactor, describing, among other things, the phases of the dismantling work, the dismantling methods to be used, radiation protection and the arrangements for nuclear safeguards. VTT has planned that it will submit the rest of the safety documentation regarding the operating licence application to STUK in the first half of 2018. STUK monitored safety of the research reactor by reviewing the licensing materials provided by the licensee, as well as by carrying out inspections in line with the periodic inspection programme.

VTT submitted a waste management plan for the research reactor to the Ministry of Economic Affairs and Employment (MEAE) in June 2017. The waste management plan includes the details of VTT's provisions for nuclear waste management costs during decommissioning of the research reactor. The main change from the previous year was the further specification of estimated volumes of work and costs, made on the basis of the detailed dismantling plan. STUK submitted a statement to the MEAE on the nuclear waste management plan where STUK stated that VTT has continued the decommissioning planning of the research reactor and negotiations with nuclear power companies regarding intermediate storage of the decommissioning waste. In addition, VTT has commissioned a preliminary safety analysis of the disposal of waste. STUK commented on its observation made in connection with its inspection of the waste management plan regarding the fact that there are still considerable uncertainty factors associated with VTT's cost estimate for decommissioning the research reactor. These uncertainties are caused by the fact that the nuclear waste management plans have not been finalised. The uncertainty of the cost estimate is further increased by the uncertainties regarding the timing of the return of spent nuclear fuel to the USA.

In 2017, the nuclear use items of the research reactor's experimental research activities in the material balance area were transferred to VTT's new Centre for Nuclear Safety. Concerning nuclear safeguards, the material balance area of VTT's research reactor includes nuclear materials in the Otakaari 3 building and their related activities. VTT's plant site, which is compliant with the Additional Protocol of the Safeguards Agreement, includes the buildings in the material balance areas of both the research reactor and the Centre for Nuclear Safety. In June 2017, STUK inspected the nuclear material accountancy of the research reactor together with the European Commission. The oversight and inspections by STUK indicated that VTT has fulfilled its nuclear safeguards obligations.

2.6 Spent nuclear fuel encapsulation and disposal facility

In 2017, Posiva continued the construction of the disposal facility. Auxiliary rooms, such as vehicle routes, connection tunnels of canister lift shaft, parking halls and personnel shaft were excavated for the disposal facility. Excavation of the central tunnel for the shared testing area began in late 2017.

The regulatory oversight during the construction stage of the nuclear fuel encapsulation and disposal facility covers the design, manufacture, construction and installation of the nuclear waste facility and its safety-classified systems, structures and components, as well as drawing up the justifications for the long-term safety for oversight purposes. The oversight also includes the commissioning of the nuclear waste facility, at which time STUK will oversee Posiva's operations during commissioning, oversee testing, review test plans and test results, and perform commissioning inspections of components, structures and systems.

Construction of the disposal facility

Posiva continued the construction of the first tunnel contract (LTU1) included in the scope of the disposal facility covered by the construction licence. The facilities to be excavated during LTU1 include vehicle connections, connection tunnels of canister lift shaft, the tunnel network of a shared testing area and central tunnels 1 and 2 of the first disposal area. STUK has set the extent of regulatory oversight for the design and implementation so that it is in line with the safety importance of the subject to be overseen.

In addition to the technical planning, it must be ensured when constructing the disposal facility that the areas to be excavated have been positioned in a manner that meets the rock suitability criteria required for ensuring long-term safety. STUK has monitored the development work and reviewed the rock suitability assessment for the shared testing area. Posiva will further develop its procedures for the assessment of the rock classification of the actual disposal facilities. The procedures must be completed before starting excavation of the first central tunnel of the disposal area.

Oversight of requirements set at the construction licence phase and Posiva's development work

During the construction licence application review, STUK set requirements on Posiva that must be taken into account during the construction or before submitting the operating licence application. STUK has systematically monitored compliance with the requirements set based on the construction licence application review and Posiva's plans to ensure compliance with the requirements.

Posiva took into account the requirements set by STUK during the construction licence review in the system design. According to the schedule it has produced Posiva has submitted system design documents for review by STUK. In 2017, STUK has reviewed the documentation regarding rock caverns, canisters, lifting and transfer equipment, radiation measurements, protection automation, air conditioning and drainage water collection systems for the controlled area of the disposal facility.

Posiva has launched projects for the planning and development of long-term safety and engineered barriers. STUK has reviewed project plans and programmes, and they have been discussed at meetings with Posiva. In 2017, Posiva submitted the validation plan for fracture network modelling as well as project plans related to development of the disposal concept to STUK for approval. With its oversight, STUK ensures that the project plans and programmes have sufficiently taken into account the requirements set by STUK during the construction licence review.

STUK has developed its own analytical capabilities for supporting its oversight. Their purpose is to produce comparison analyses for the analyses of the safety case produced by Posiva. Comparison analyses will be made of the thermo-hydro-geochemical (THC) modelling describing the lines of evolution in the near-field of the disposal facility, of the radionuclides released from the canisters migrating above ground and of the scenario analysis estimating possible lines of evolution in final disposal.

Organisational operations and quality assurance

STUK has overseen the activities of Posiva's organisation in inspections included in the construction inspection programme. The areas assessed in the inspections have included analysis activities, maintenance of the disposal facility, manufacturing operations, management system processes and management. The inspections and their results, as well as the requirements set by STUK, are described in more detail in Appendix 7.

In addition to the construction inspection programme, the actions of Posiva's organisation have been assessed by an externally produced assessment report of the self-assessment of the management system and safety culture by Posiva and of the safety culture action plan it has submitted.

The results of the report have been discussed with Posiva, and it has been noted that Posiva's safety culture action plan has been systematically implemented.

In 2017, STUK continued oversight and assessment of Posiva's auditing activities by participating in ten audits of Posiva's suppliers. The oversight has shown that Posiva's supplier audits are compliant with STUK's requirements.

Preparations for the operating licence phase

Posiva has established an operating licence project and submitted a plan regarding it to STUK for information. STUK has commented on the project plan, and regular discussions are taking place with Posiva regarding the operating licence phase. In Posiva's operating licence project, STUK has paid attention to the phasing of submitting the operating licence documentation and to how Posiva manages the changes caused in the licencing documentation by the industrialisation of the disposal activities.

Preparations for operating activities

Posiva has established a project for production preparations, including test operation of the facility, demonstrations of disposal operations and planning of the operating activities of the plant. The project is still at its initial stages, and it has been presented to STUK. Regarding the demonstrations of disposal operations, STUK has reviewed the project plans and monitored the installation equipment demonstrations, for example.

Nuclear safeguards

STUK implemented nuclear safeguards for the final disposal in compliance with the national regulatory plan.

In 2017, STUK approved the nuclear safeguards manual updated by Posiva, describing safeguards arrangements of the encapsulation plant and the disposal facility during construction. In December, STUK approved a deputy for the person responsible for nuclear safeguards. STUK inspected the plant site which was reported by Posiva to be compliant with the Additional Protocol of the Safeguards Agreement and the construction activities in two periodic inspections, as well as in connection with an inspection carried out with the IAEA and the European Commission. Posiva has submitted the nuclear safeguards reports and notifications it is responsible for in good time. The oversight and inspections by STUK indicate that Posiva has fulfilled its nuclear safeguards obligations.

In 2017, STUK continued its close cooperation with the IAEA and the European Commission aimed at ensuring that the plans on arranging the international nuclear safeguards for the encapsulation plant and disposal facility will proceed in line with the design of the facility and also meet national requirements.

A meeting was organised at STUK with the European Commission and the IAEA, where the status of Posiva's plant plans and designs was reviewed and the continuation of oversight and update of the monitoring equipment plan were agreed. Similar oversight has so far not been implemented anywhere else in the world. STUK continued its negotiations with the IAEA, the European Commission and Posiva on the facility attachments regarding the encapsulation plant in which the communications, nuclear material accountancy and oversight in the material balance area concerned are formally agreed.

STUK's project aimed at developing the methods and equipment for verifying the disposal of spent nuclear fuel progressed during the year within the framework of international cooperation. The new Passive Gamma Emission Tomography (PGET) equipment suitable for verifying spent nuclear fuel was tested in Olkiluoto and Loviisa in spring 2017. At the end of the year, the IAEA approved the equipment for use in the verification of spent nuclear fuel also in the IAEA's inspection activities.

2.7 Other uses of nuclear energy

Producers of uranium, parties in possession of small amounts of nuclear use items or nuclear information subject to a licence, and research facilities participating in research of the nuclear fuel cycle are also included in the scope of regulatory nuclear energy oversight. STUK oversees that the users of nuclear energy (operators) meet the set requirements. In 2017, STUK approved eight nuclear safeguard manuals prepared by operators. In line with the respective applications, STUK approved the responsible managers or deputies for VTT's Centre for Nuclear Safety and Terrafame Oy.

STUK granted the University of Helsinki a licence in compliance with the Nuclear Energy Act for continuing the activities for ten years at the Department of Chemistry. The IAEA paid a complementary access type inspection visit with STUK to the site of the Laboratory of Radiochemistry at the University of Helsinki. An inspection was carried out at the Department of Chemistry of the University of Helsinki, where the safety of the use of radiation and security arrangements were inspected in addition to the nuclear materials.

STUK granted VTT a licence to import and possess nuclear information subject to the particular safeguards obligations from South Korea. In June, STUK inspected the nuclear material inventory at the VTT Centre for Nuclear Safety together with the European Commission. In November, STUK carried out a commissioning inspection of VTT's new laboratory facilities, where the safety of the use of nuclear energy and radiation, security arrangements and nuclear safeguards were inspected. In addition, the IAEA and European Commission took environmental swap samples of the initial situation before operations in the hot cell began in the presence of STUK's representative. The inspection results indicate that the use of nuclear energy at the VTT Centre for Nuclear Safety fulfils the requirements regarding safety, security arrangements and nuclear safeguards.

Terrafame Oy applied for a licence from STUK for starting trial uranium extraction operations and for establishing the details of the uranium extraction process, and STUK granted this licence in December 2017. Terrafame submitted an application to the Finnish Government for starting the extraction of uranium in the uranium extraction plant earlier built in the mine area. Terrafame did not submit the safety documentation to STUK related to the licence application during 2017, which is why STUK could not start its inspection work before 2018.

Of the uranium producers, the reports and notifications submitted by Freeport Cobalt Oy plant in Kokkola and Norilsk Nickel Harjavalta Oy plant in Harjavalta were inspected by STUK. In addition, STUK received a notification concerning the concentration of uranium as a result of the zinc metal production process and a licence application from Boliden Kokkola Oy for the production and possession of the above uranium. Boliden Harjavalta Oy has also submitted preliminary basic technical characteristics documents to STUK and the Commission. STUK is in the process of evaluating the licence application from Boliden Oy.

The other operators have also submitted the required nuclear safeguards reports and notifications. Of these operators, the nuclear material inventories of the Radiation and Nuclear Safety Authority, the University of Helsinki and the University of Jyväskylä were inspected by STUK in 2017. No remarks were made in the inspections.

STUK revised the special nuclear safeguards report from RAOS Project Oy on the unauthorised import of nuclear information falling under the scope of limitations on the country of origin and approved the corrective actions proposed by RAOS Project Oy in the special report. STUK also revised the special report submitted by the Department of Physics at the University of Jyväskylä (JYFL) regarding the loss of a uranium sample. STUK required JYFL to update its ordering and reception procedures for nuclear use items and to include them in the nuclear safeguards manual.

STUK inspected the stakeholders' annual reports on nuclear fuel cycle related research and development activities and produced a report on their basis for the IAEA.

On the basis of the inspections, as well as the reports and notifications submitted, STUK has satisfied itself that other use of nuclear energy in Finland has been implemented in compliance with the nuclear safeguards obligations.

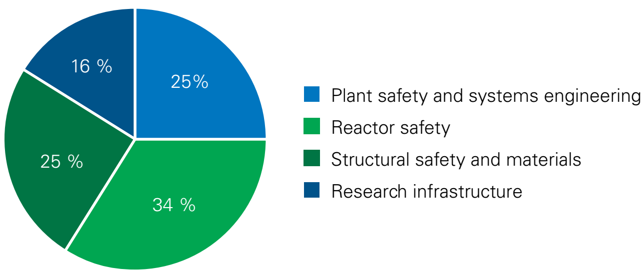
3 Safety research

Publicly funded safety research on the use of nuclear energy has a key role in the development and maintenance of nuclear technology expertise in Finland. A new four-year nuclear safety programme, SAFIR2018, and a four-year nuclear waste management programme, KYT2018, continued in 2017, which was the third year of these programmes.

Without safety research programmes like SAFIR and KYT, developing the expertise needed to support the authorities would not be possible in Finland. According to the Nuclear Energy Act, research funded by the Finnish State Nuclear Waste Management Fund (VYR) aims at ensuring that the authorities have access to comprehensive nuclear expertise. Both STUK and the licensees have hired several people who have obtained their training for expert positions in the field of nuclear energy use and oversight in publicly funded research programmes. The safety research programmes also have an important role in the training of organisations that provide STUK with technical support services, such as the VTT Technical Research Centre of Finland, the University of Helsinki, the Aalto University, the Geological Survey of Finland and Lappeenranta University of Technology.

The SAFIR2018 safety research programme consists of 30 projects that were selected in the autumn of 2016 based on a competitive bidding. The available VYR funding for the research was around EUR 3.7 million. The total funding of the research programme remained at the 2016 level. The research projects are larger than in the previous programme, and the goal has been to create multidisciplinary projects to promote multidisciplinary cooperation and achievement of an overall idea of safety. Volume of the SAFIR2018 research programme is EUR 6.5 million, which is divided into three areas as illustrated in image 3 a: 1) overall safety and management of design, 2) reactor safety and 3) structural integrity and materials. The VTT Technical Research Centre of Finland and Lappeenranta University of Technology (LUT) will use around 17% of the entire public funding for safety research when reforming the national infrastructure. This mainly covers the work related to the acquisition and commissioning of infrastructure-related investment objects. VYR finances equipment investments from a separate re-search-related funding portion aimed at the renewal of nuclear safety level hot chambers and the thermohydraulic test equipment of LUT. In 2017, the funding was channelled to VTT in the manner required by the Nuclear Energy Act, and it amounted to EUR 2.74 million. The research programme covers all issues integral to nuclear safety, and it will establish and maintain the expertise, analysis methods and experimental readiness to resolve any unforeseen safety issues.

The SAFIR2018 research projects are controlled by six steering groups in addition to the three



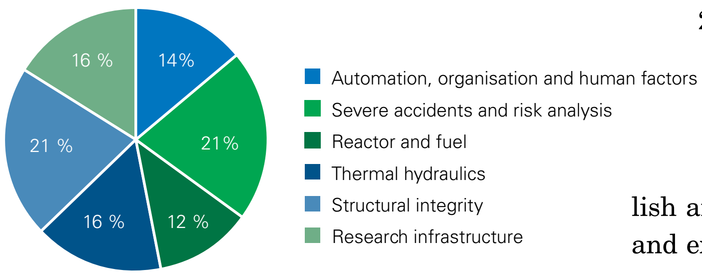


Figure 3. Research areas of SAFIR2018 programme and their shares of the total funding in 2017.

research areas. The steering groups take care of the academic control of research. Members of the supporting groups were named from organisations important to the research of the use of nuclear energy. The supporting groups are: 1) I&C, organisation and human factors, 2) severe accidents and research of risks, 3) reactors and fuel, 4) thermal hydraulics, 5) structural integrity and 6) research infrastructure. The supporting groups were named based on the research areas. All of the projects included in one support group are usually part of a single research area. An exception to this is the second support group, which includes both projects pertaining to the determination of plant design bases and projects developing safety analysis methods. The infrastructure support group operates in the SAFIR2018 safety research organisation alongside the research areas (Fig. 4).

The projects included in the SAFIR2018 programme for 2017 meet the requirements set for VYR-funded research. Special challenges of the research programme include reduced funding and a large share of infrastructure funding. High-class research on the use of nuclear energy requires a modern architecture.

The SAFIR2018 projects includes several projects for developing capabilities, e.g. for avoiding accidents of the type that occurred at the Tepco Fukushima Daiichi nuclear power plant, or for understanding the sequence of events in such accidents. The projects' subject matters range from design bases of nuclear facilities and the analysis of accidents to the operation of organisations during accidents and as systems comprising several organisations. An international research project that started in 2015 has offered as reliable information as possible about the course of the Tepco Fukushima Daiichi accident in order to create Finnish accident analyses and compare results globally.

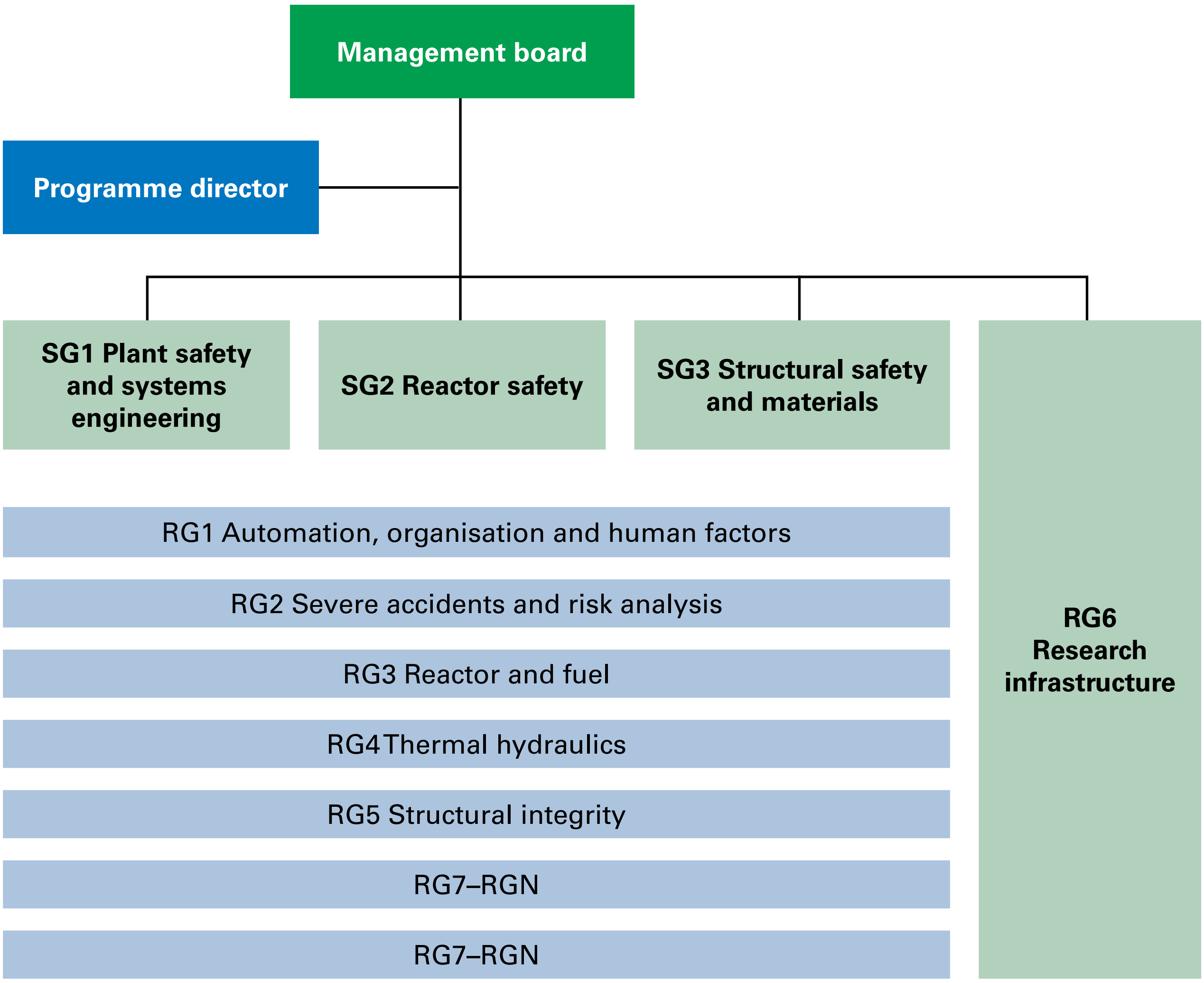


Figure 4. The administrative structure of SAFIR2018 research programme.

Table 1. Distribution of VYR funding by research area in 2016–2017. Research area/1000€. Administration project budged is not included in the total funding.

Research area/1000 €	2016	2017
Safety assessment	61	70
Buffer and backfill materials	341	385
Long-term durability of the canister	253	255
Microbiology	220	230,3
Other safety relevant research	414	418
Social science studies related to nuclear waste management	40	100
New and alternative technological solutions	88	62
Research infrastructure	143	143
Total	1560	1663.3

In addition to the above, the SAFIR2018 management group may fund small projects aimed at helping the development of research projects with new topics into becoming members of the programme. This procedure has been in use from the beginning, and it has proven to be an efficient way to promote the creation of high standard topical research projects. Of the earlier small projects, those studying the ageing of polymers and disruptions in the electrical grid have led to new research projects in the programme. The objectives for small projects in 2017 included promoting the requirements for seismic measurements during the operation of nuclear power plants and continued development of the overall safety. The research assessed the totality formed by licence holders, public authorities and stakeholders and the functioning of defence-in-depth in this context.

The four-year KYT2018 research programme was launched in 2015. The programme consists of re-search areas which are important for national expertise. It aims at extensive coordinated research pro-jects, particularly regarding the research areas related to the performance of buffer and backfilling materials as well as the long-term durability and microbiology of final disposal canisters. When the Nuclear Energy Act was amended (in 2016), funding of the research infrastructure was added to the KYT2018 programme. In 2017, the programme continued with much the same contents as in 2016. The distribution of funding during the framework programme is shown in Table 1 and Figure 5.

Figure 5. Distribution of VYR funding by research area in 2017.

The KYT management team provided funding recommendations to the Ministry of Economic Affairs and Employment based on assessments by the support groups, and the applicability and content of the subject matter. In 2017, the total funding of the KYT2018 programme from the National Nuclear Waste Management Fund (VYR) was about EUR 1.7 million. In 2017, the research programme provided funding for 29 research projects representing new and alternative technologies for nuclear waste management (2 projects), safety research concerning nuclear waste management (25 projects), social nuclear waste management research (1 project) and research infrastructure (1 project). The most important coordinated research subjects were buffer and backfilling materials, long-term durability of canisters and microbiology.

The international group of experts appointed by the Ministry of Economic Affairs and Employment assessed the KYT2018 research programme in 2017. The assessment group interviewed the project managers and produced a report on the basis of these interviews. Entitled the "KYT2018 Review Report", the report was published by the Ministry of Economic Affairs and Employment. The results of the assessment will be utilised when preparing the next KYT framework programme period.

4 Oversight of nuclear facilities in figures

4.1 Processing of documents

A total of 3,740 documents were submitted to STUK for processing in 2017. Of these, 1,080 concerned the nuclear power plant unit under construction and 148 concerned the disposal facility for spent nuclear fuel. The review process of a total of 3,529 documents was completed, including documents submitted in 2017, those submitted earlier and licences granted by STUK by virtue of the Nuclear Energy Act, which are listed in Appendix 8. The average document review time was 65 days. The number of documents and their average review times in 2013–2017 are illustrated in Figure 6. Figures 7–10 illustrate the review time distribution among documents from the various plant units and documents about Posiva.

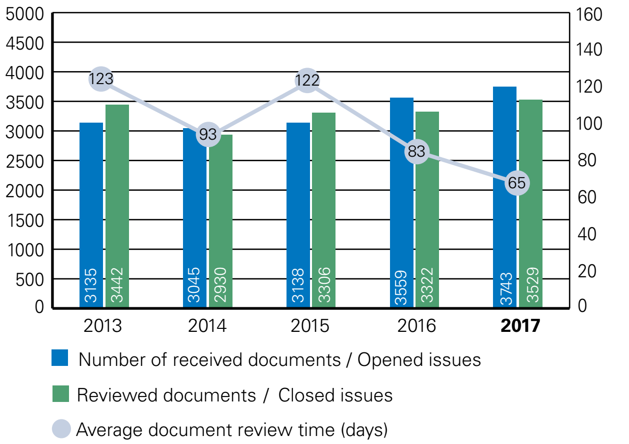


Figure 6. Number of documents received and reviewed as well as average document review time.

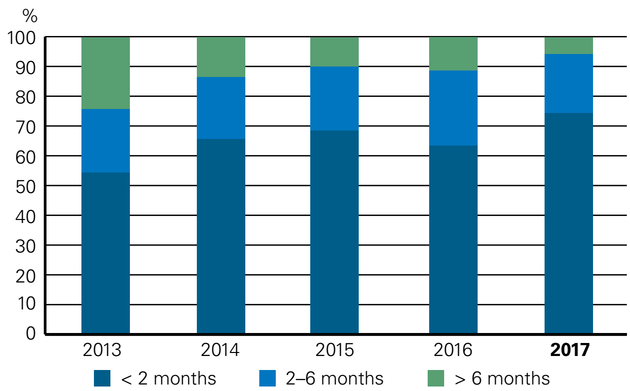


Figure 7. Distribution of time spent on preparing decisions on the Loviisa plant.

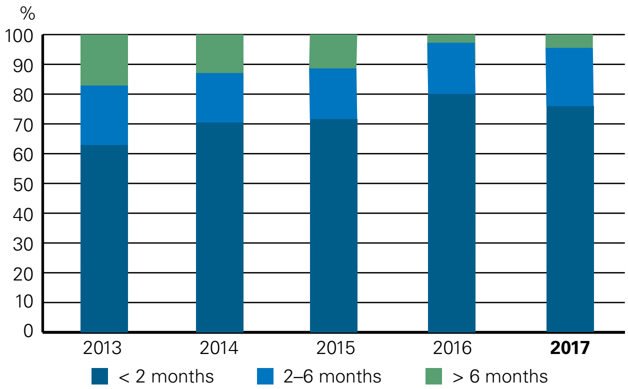


Figure 8. Distribution of time spent on preparing decisions on the operating plant units of Olkiluoto.

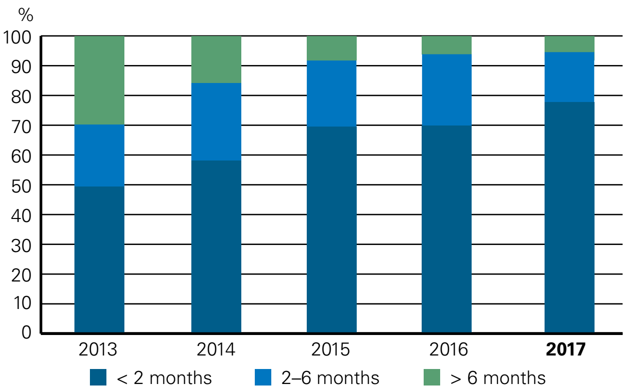


Figure 9. Distribution of time spent on preparing decisions on Olkiluoto plant unit 3.

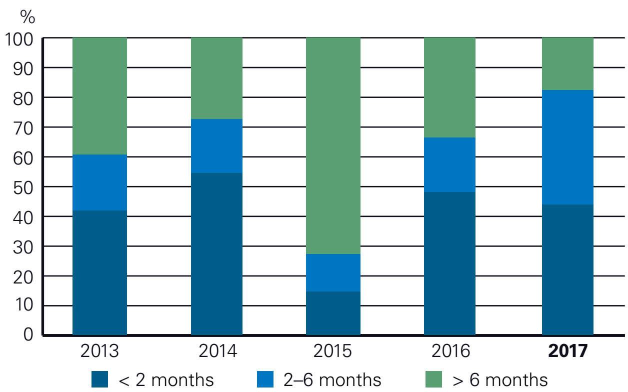


Figure 10. Distribution of time spent on preparing decisions on Posiva.

4.2 Inspections at nuclear power plant sites and suppliers' premises

Inspection programmes

A total of 12 inspections at the Loviisa nuclear power plant and 13 inspections at the Olkiluoto nuclear power plant were carried out under the 2017 periodic inspection programme (Appendix 4). STUK carried out 13 inspections within the Olkiluoto 3 construction inspection programme (Appendix 5) and 12 inspections pertaining to the processing of Fennovoima's construction licence application (Appendix 6). Five inspections of the encapsulation plant and disposal facility construction inspection programme were carried out in 2017 (Appendix 7). The key findings of the inspections are presented in the appendices and the chapters on regulatory oversight.

Other inspections at plant sites

A total of 2,079 inspections were carried out on site or on the suppliers' premises in 2017 (other than the above-mentioned construction inspection programme inspections and nuclear safeguards inspections, which are separately described). An inspection comprises one or more sub-inspections, such as a review of results, an inspection of component or structure, a pressure or leak test, a functional test or a commissioning inspection. Of the inspections, 885 were related to the regulatory oversight of the plant under construction and 1194 to that of the units in operation.

The number of inspection days on site and on the component manufacturers' premises totalled 3,321. This number includes not only inspections pertaining to the safety of nuclear power plants but also those associated with nuclear waste management and nuclear safeguards as well as audits and inspections of the underground research facility at Olkiluoto. Five resident inspectors worked at the Olkiluoto power plant and two resident inspectors at the Loviisa power plant. The numbers of onsite inspection days in 2013–2017 are illustrated in Figure 11.

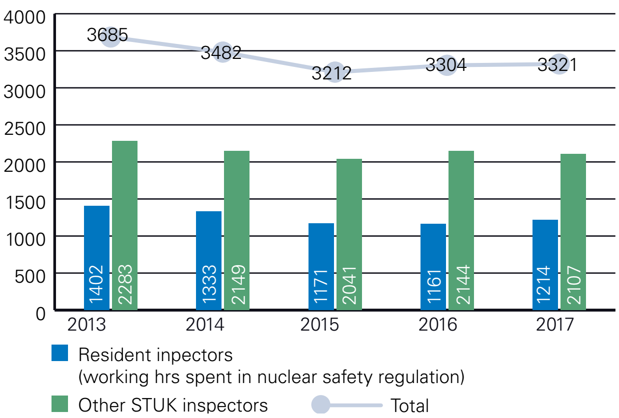


Figure 11. Number of inspection days onsite and at component manufacturers' premises. Overtime work is included.

4.3 Finances and resources

The duty area of nuclear safety regulation included basic operations subject to a charge, as well as operations not subject to a charge. Basic operations subject to a charge mostly consisted of the regulatory oversight of nuclear power plants, with their costs charged to those subject to the oversight. Basic operations not subject to a charge included international and domestic cooperation, as well as emergency response operations and communications. Basic operations not subject to a charge are publicly funded. Overheads from the preparation of regulations and support functions (administration, development projects in support of regulatory activities, training, maintenance and development of expertise, and reporting, as well as participation in nuclear safety research) were carried forward into the costs of both types of basic operation and of contracted services in relation to the number of working hours spent on each function.

In 2017, the costs of the regulatory control of nuclear safety subject to a charge were EUR 18.0 million. The figure includes the radiation monitoring in the immediate vicinity of nuclear power plants that was changed from a service operation to regulatory oversight in 2015. The total costs of regulatory oversight of nuclear safety were EUR 20.1 million. Thus, the share of activities subject to a charge was 89.6%. Figure 12 shows the annual costs of the regulatory oversight of nuclear safety in 2013–2017.

Attainment of the cost price for the regulatory oversight of nuclear safety is ensured by adjusting the invoicing with a balancing bill to correspond to actual costs after annual cost accounting. Consequently, the cost correlation of the regulatory oversight was 99.0%. The difference between income and costs is due to the charges on oversight of small amounts of radioactive waste and on ra-

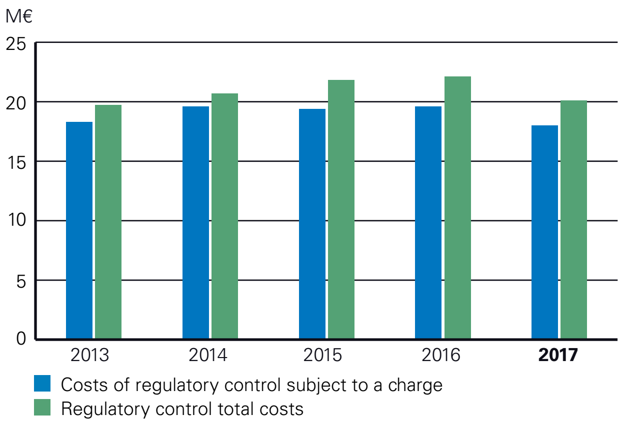


Figure 12. Income and costs of nuclear safety regulation.

diation monitoring in the vicinity of nuclear power plants which were excluded from the balancing. The balancing bills for these activities are not included in the nuclear plant specific balancing bills issued at year-end. The income from the regulatory oversight of nuclear safety in 2017 totalled EUR 17.8 million (including radiation monitoring in the vicinity of nuclear power plants). Of this, EUR 3.0 million and EUR 9.0 million came from the oversight of the Loviisa and Olkiluoto nuclear power plants, respectively. In addition to the operating units, the income from Olkiluoto NPP includes income derived from the regulatory oversight of the Olkiluoto 3 construction project. Income from the oversight of the Fennovoima nuclear power plant project amounted to EUR 2.7 million. The regulation of Posiva Oy's operations yielded EUR 2.2 million.

The time spent on the inspection and review of Loviisa nuclear power plant was 13.9 man-years or 9.2% of the total working time of the regulatory personnel. The time spent on the Olkiluoto nuclear power plant's operating units was 16.8 man-years or 11.2% of the total working time. In addition to the monitoring of the operation of the nuclear power plants, these figures include nuclear safeguards. The time spent on the inspection and review of Olkiluoto 3 was 21.9 man-years or 14.6% of the total working time. Work related to new nuclear power plant projects amounted to 10.0 man-years or 6.6% of the total working time. A total of 8.5 man-years or 5.7% of the total working time was spent on inspection and review of Posiva's operations, and that spent on the FiR 1 research reactor was 0.7 man-years. Figure 13 shows the division of working hours of the personnel engaged in nuclear safety oversight (in man-years) by subject of oversight during 2010–2017.

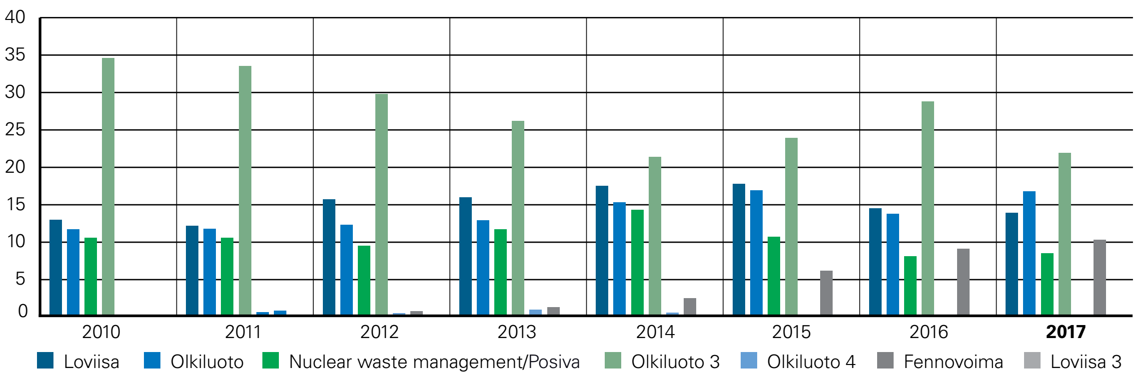


Figure 13. Distribution of working hours (person-years) of the regulatory personnel by subject of oversight in 2010–2017. Until 2011 the nuclear waste management includes both the oversight of the operating nuclear power plants' nuclear waste management as well as the oversight of Posiva, since 2012 only the oversight of Posiva. The oversight of the operating nuclear power plants' nuclear waste management is combined with the oversight of the power plants.

Table 2. Distribution of working hours (person-years) of the regulatory personnel in each duty area.

Duty area	2013	2014	2015	2016	2017
Basic operations subject to a charge	69.7	72.0	76.6	74.9	72.0
Basic operations not subject to a charge	5.0	3.5	2.6	4.0	4.0
Contracted services	1.6	2.9	2.8	2.1	4.3
Rule-making and support functions	45.3	41.8	42.2	44.5	42.9
Holidays and absences	25.1	25.3	26.4	26.6	26.9
Total	146.7	145.5	150.5	152.1	150.1

Where necessary, STUK commissions independent safety analyses and research in support of regulatory decision-making. Figure 14 illustrates the costs of such assignments in 2013–2017. The expenses in 2017 were mainly associated with the comparison analyses of Hanhikivi 1, Olkiluoto 3 and Olkiluoto 1&2, with independent assessments and reports, as well as assessment of the safety of the spent fuel disposal project.

Distribution of the annual working time of the nuclear safety regulation personnel to the various duty areas is shown in Table 2. The figures do not include the work for radiation monitoring in the surrounding environment.

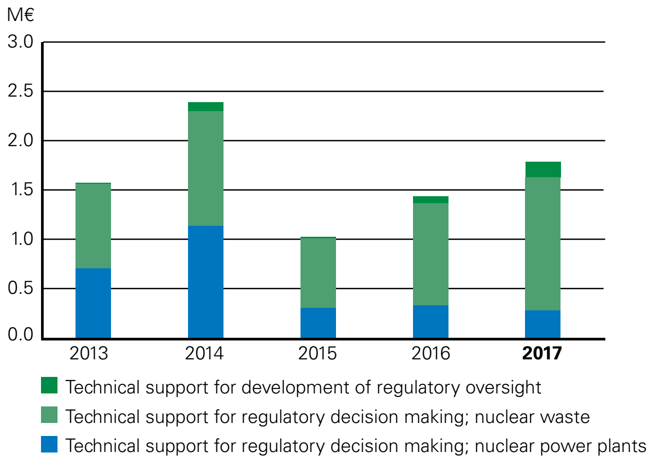


Figure 14. The costs of research and commissioned work.

5 International cooperation

International conventions

Starting from 1999, Finland has produced national reports which are compliant with the Convention on Nuclear Safety every three years. The latest report was produced in 2016. A review meeting in compliance with the Convention was held in spring 2017, and STUK representatives participated in the meeting with other Finnish actors. The review meeting focussed on reporting the attainment of the objectives of the Vienna Declaration (VDNS) that describes the general safety objectives of nuclear facilities. In the EU, the objectives have been recorded in the Nuclear Safety Directive and are currently being implemented in national legislation of the Member States, but the declaration has led or is leading to essential changes in regulations or plant safety in very few non-EU countries.

The reports compliant with the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management have been produced since 2003, with the latest report produced in 2017. The report submitted to the IAEA in October will be reviewed in a review meeting to be held in May–June 2018. In May 2017, STUK participated in an extraordinary JC meeting where proposals for developing the Convention were discussed. Minor amendments were made to the Convention text as a result of the meeting. STUK also participated in the May organisation meeting for preparing the 2018 review meeting where the arrangements and officials for the meeting were decided.

MDEP

The Multinational Design Evaluation Programme (MDEP) was established on the initiative of the United States nuclear safety authority (Nuclear Regulatory Commission, NRC). It involves 16 countries with the objective of improving cooperation in the field of the assessment of new nuclear power plants and developing convergent regulatory practices. In addition to the United States of America, the following countries are participating in the programme: Canada, China, Finland, France, Hungary, India, Japan, Korea, Russia, South Africa, Sweden, Turkey, the United Arab Emirates and United Kingdom, as well as Argentina as a new member. Participants in the programme include only those countries with new nuclear power plants at some stage of assessment by the regulatory authorities. The OECD Nuclear Energy Agency functions as the secretariat for the programme.

The MDEP's work is organised in design-specific and issue-specific working groups. In addition, the MDEP has a Policy Group and a Technical Steering Committee. Petteri Tiippana, the Director General of STUK, is the chair of the Policy Group. There are six Design-Specific Working Groups: The EPR Working Group, AP1000 Working Group, APR1400 Working Group, VVER Working Group and ABWR Working Group, as well as the new Working Group for the Chinese HPR1000 plant type. Of these, STUK has participated in the EPR Working Group and the VVER Working Group, because an EPR plant is under construction in Olkiluoto (the Olkiluoto 3 project) and Fennovoima has submitted a construction licence application for the construction of a VVER plant in Pyhäjoki (the Hanhikivi 1 project). The MDEP Working Groups which are independent of plant design dealt with the following two subjects: supply chain inspections and pressure equipment standards. In 2017, the third subject-specific group on digital I&C was transferred to part of the cooperation performed under the framework of the CNRA. STUK participated in the activities of all three Issue-Specific Working Groups.

Cooperation within the IAEA

The IAEA continued to develop its safety standards on nuclear safety and security. STUK had a representative on the Commission on Safety Standards (CSS) managing the preparation of the standards as well as in the committees dealing with the content of the standards, i.e. the Nuclear Safety Standards Committee (NUSSC), the Waste Safety Standards Committee (WASSC), the Radiation Safety Standards Committee (RASSC), the Transport Safety Standards Committee (TRANSSC) and the Nuclear Security Guidance Committee (NSGC). STUK issued statements on the IAEA safety standards under preparation. An expert of STUK has been named in the Advisory Committee on Nuclear Security to the Director General of the IAEA (AdSec) for the term 2016–2018.

Cooperation within the OECD/NEA

The Nuclear Energy Agency of the OECD (NEA) coordinates international cooperation in the field of safety research in particular. The organisation also provides an opportunity for cooperation between regulatory authorities. STUK was represented in all main committees of the organisation dealing with radiation and nuclear safety issues. The main committees' fields of activity are:

- Nuclear safety regulation (CNRA, Committee on Nuclear Regulatory Activities)
- Safety research (CSNI, Committee on the Safety of Nuclear Installations)
- Radiation safety (CRPPH, Committee on Radiation Protection and Public Health)
- Nuclear waste management (RWMC, Radioactive Waste Management Committee).

DGRRF

The Deep geological repository regulators forum is a cooperation forum for six nuclear and radiation safety authorities (USA, Canada, Sweden, France, Switzerland and Finland) where disposal projects for spent nuclear fuel and high-level nuclear waste are discussed from the perspective of public authorities. In 2017, the forum organised a workshop in Sweden for discussing the challenges of the permit process for disposal facilities. STUK participated in this workshop.

VVER Forum

The VVER Forum is a cooperation group for authorities operating Russian VVER pressurized water type nuclear facilities, mainly concentrating on developing oversight activities of plants operating in its member countries. The annual meeting of the VVER Forum was organised in May in Iran, and STUK participated in the meeting. STUK also took part in activities of the Forum's working groups during 2017.

Cooperation within the EU

WENRA WGWD

STUK actively participated in the work of WENRA's Working Group on Waste And Decommissioning (WGWD) in 2017. The working group convened twice. Self-assessments and peer reviews of reference levels associated with disposal were completed during the year, and a reference level report on nuclear waste processing facilities was finalised. The peer review of Finnish regulations concerning disposal facilities was successfully completed in 2017.

ENSREG

STUK participated in the activities of the European Nuclear Safety Regulators Group (ENSREG) and in three of its subgroups (nuclear safety, nuclear waste management and communication). ENSREG decided that the theme of the first Topical Peer Review, which will be arranged every six years from now on according to the Nuclear Safety Directive that was updated in 2014, is management of the ageing of nuclear power plants. In cooperation with Finnish power companies, STUK produced a national report on the peer review and published it on its website at the end of December 2017. Finland will participate in the peer review of EU countries in the spring of 2018.

The next national report regarding the directive on the management of radioactive waste and spent nuclear fuel will be sent to the Commission in August 2018. ENSREG updated its reporting guidelines during 2017.

In spring 2017, ENSREG organised the fourth nuclear safety conference for public authorities in Brussels. STUK participated in organising the conference, and the Director General of STUK acted as its President.

Bilateral cooperation

STUK continued its regular meetings with the Swedish nuclear safety authority SSM, focusing on topical issues concerning nuclear power plants. The issues included topical oversight matters concerning plants, management systems as well as competence and resource issues of the authorities, STUK's new strategy, as well as the renewal of Swedish safety requirements.

STUK started regular cooperation with the French nuclear safety authority Autorité de Sûreté Nucléaire (ASN) and its technical support organisation Institut de Radioprotection et de Sûreté Nucléaire (IRSN) when the Olkiluoto 3 project was launched in the early 2000s. Regulatory practices and safety requirements of the countries involved have been compared, and challenges and problems pertaining to the EPR plants under construction (Olkiluoto 3 and Flamanville 3) have been discussed. In September 2017, STUK met with ASN and IRSN in the bilateral meeting held in Paris. Topical issues regarding commissioning and mechanical components were discussed in the meeting. The Flamanville 3 site was visited after the meeting.

Cooperation with the Russian nuclear safety authority Rostechnadzor (RTN) was expanded to also cover issues pertaining to the safety assessments of AES2006-type VVER plants. Four AES-2006 plants are currently under construction in Russia. Of them, the Leningrad 2 plant in Sosnovyi Bor is the reference plant for Fennovoima's Hanhikivi 1 project. In 2017, five cooperation meetings with RTN were arranged to review the construction status of the new plant units. STUK visited the construction site of the Leningrad 2 nuclear power plant twice related to cooperation. In 2017, STUK made two visits with Fennovoima to witness the commissioning tests of the Leningrad 2 power plant. One of these was the containment pressure and leak tightness test. During the visit, pressure in the containment had not reached the maximum test pressure. The second visit to witness the commissioning tests concerned new passive safety systems. The visits gave STUK a good understanding of how the commissioning tests for new plants are carried out in Russia. STUK has stated to Fennovoima and the plant supplier that the results of the tests cannot be utilised as a safety case for the Hanhikivi 1 construction licence application.

An AES-2006 plant is also under construction in Astravets, in Belarus. In autumn 2017, the nuclear safety authority of Belarus Gosatomnadzor (GAN) and STUK held a cooperation meeting in Helsinki. Further cooperation was agreed in the meeting and STUK is to visit Astravets in 2018.

The Hungarian radiation and nuclear safety authority HAEA has also started preparation for a safety assessment of an AES-2006 nuclear power plant (PAKS-2 project). In 2017, STUK and HAEA held two meetings concerning plant design issues.

APPENDIX 1 Objects of regulation

Loviisa nuclear power plant

Plant unit	Start-up	National grid	Nominal electric power, (gross/net, MW)	Type, supplier
Loviisa 1	8 Feb1977	9 May 1977	531/507	Pressurized water reactor (PWR), Atomenergoexport
Loviisa 2	4 Nov 1980	5 Jan 1981	526/502	Pressurized water reactor (PWR), Atomenergoexport

Fortum Power and Heat Oy owns the Loviisa 1 and 2 plant units located in Loviisa.

Olkiluoto nuclear power plant

Plant unit	Start-up	National grid	Nominal electric power, (gross/net, MW)	Type, supplier
Olkiluoto 1	2 Sep 1978	10 Oct 1979	910/880	Boiling water reactor (BWR), Asea Atom
Olkiluoto 2	18 Feb 1980	1 Jul 1982	920/890	Boiling water reactor (BWR), Asea Atom
Olkiluoto 3	Construction license granted 17 Feb 2005		Approx. 1,600 (net)	Pressurized water reactor (PWR), Areva NP

Teollisuuden Voima Oyj owns the Olkiluoto 1 and 2 plant units located in Olkiluoto, Eurajoki, and the Olkiluoto 3 plant unit under construction.

Hanhikivi nuclear facility project

Plant unit	Supplemented Decision-In-Principle approved	Nominal electric power, net (MW)	Type, supplier
Hanhikivi 1	5 Dec 2014	Approx. 1200	Pressurised Water Reactor (PWR), ROSATOM

Hanhikivi nuclear power plant FH1 is a power plant project of Fennovoima.

Olkiluoto encapsulation plant and disposal facility

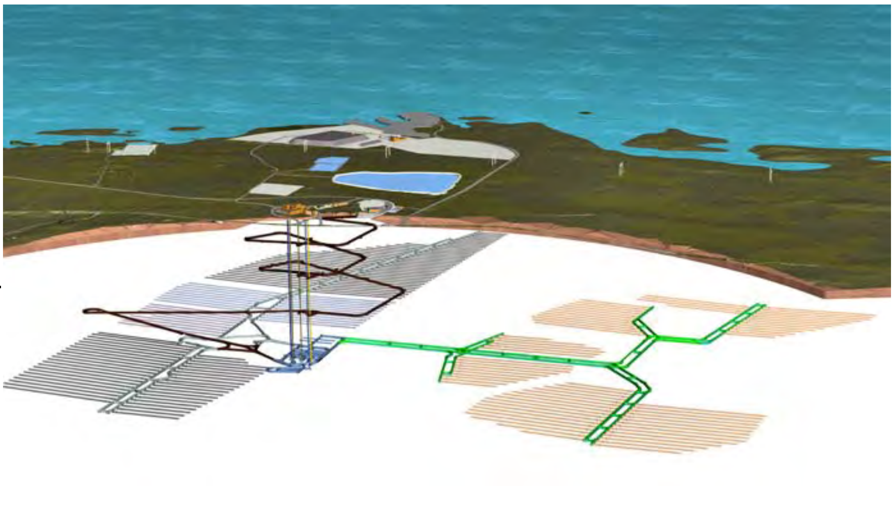
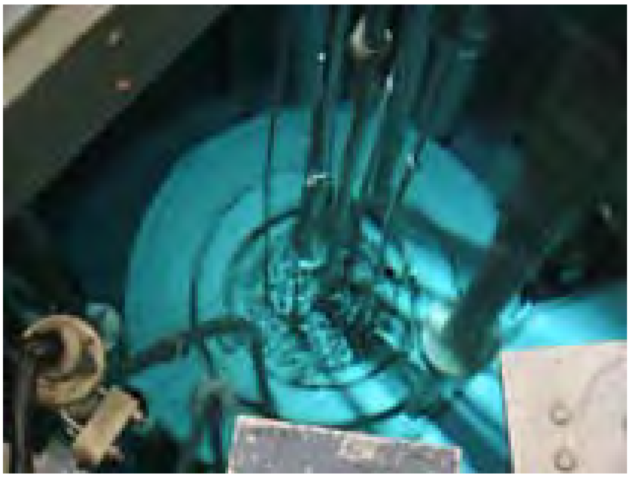


Diagram of the encapsulation and disposal facility in Olkiluoto (Posiva Oy).

In November 2015, the Government granted Posiva a construction licence for the Olkiluoto encapsulation plant and disposal facility. The planned facility consists of a surface facility for the encapsulation of spent nuclear fuel, an underground disposal facility, and supporting buildings. Posiva has already built an access tunnel, three shafts and a technical facility and research area at a depth of 420–437 metres as parts of the underground research facility Onkalo. For the actual disposal facility, the underground facility will be expanded by two additional shafts and the disposal tunnels that will be excavated in stages. The construction of an underground research facility was a prerequisite for granting a construction licence. Onkalo provides an opportunity for more detailed study of the rock volumes best suited for the disposal of spent nuclear fuel, and allow for the testing of disposal facility construction methods and installation of the disposal system components.

FiR 1 research reactor



Facility	Thermal power	In operation	Fuel	TRIGA reactor's fuel type
TRIGA Mark II research reactor	250 kW	March 1962–June 2015	Reactor core consists of 80 fuel rods which contain 15 kg of uranium	Uranium–zirkonium-hybrid combination: 8% uranium 91% zirkonium and 1% hydrogen

The FiR 1 research reactor, operated by VTT Technical Research Centre of Finland, was commissioned in March 1962. VTT stopped using the reactor in June 2015 and placed in permanent shutdown. VTT submitted the operating licence application for the decommissioning phase to the Government in June 2017.

Other uses of nuclear energy

The regulation also applies to mining and any mineral processing aiming at obtaining uranium or thorium. Such operations are practiced at the production plants of Norilsk Nickel Harjavalta Oy and Freeport Cobalt Oy. The planned Terrafame uranium extraction plant is also part of this group. STUK granted Terrafame a licence for small-scale pilot level production of uranium in December 2017. In addition, a few laboratories have small amounts of controlled nuclear materials. The regulation also applies to nuclear equipment, systems and information as well as nuclear fuel cycle-related research and development activities and the transport of nuclear materials and nuclear waste.

APPENDIX 2 STUK's safety performance indicators for NPP's in 2017

Summary of the safety performance indicators for nuclear power plants

Background and objectives of the indicator system

Safety is a primary prerequisite for the operation of nuclear power plants. The power companies and STUK evaluate and oversee the safety and operation of the plants in many ways. Along with inspections and safety assessments, indicators are a further method of acquiring information on the safety level of nuclear power plants and on any changes therein.

The objective of the indicator system is to recognise changes in plant safety as early on as possible. If the indicators weaken, the underlying factors influencing the development must be determined and changes to plant operation and STUK's oversight of the area must be considered. The indicators can also be used to monitor the efficiency and effectiveness of corrective measures. Furthermore, the information yielded by the indicators is used when communicating nuclear safety.

In the indicator system, nuclear safety is divided into three sectors: 1) operation and maintenance, 2) operational events and 3) structural integrity. The indicators, their maintenance procedures and the interpretation of the results are presented at the end of this summary. A brief summary of the safety status of both the Loviisa and Olkiluoto NPPs in 2017 on the basis of safety indicators is presented below, followed by detailed results for each indicator.

STUK began developing its indicator system in 2016. The indicator system will be further revised in 2018, when the new system will be launched and integrated more closely into STUK's other inspection activities and overall safety assessment. Therefore, from 2016 onwards, the annual reports will not include the entire indicator system but only the indicators that best describe the plant safety in different sectors in 2017.

<table>
<tr><th colspan="3">Nuclear safety</th></tr>
<tr><th>A.I Operation and maintenance of a nuclear facility</th><th>A.II Operational events</th><th>A.III Structural integrity</th></tr>
<tr><td>1. Failures and their repairs</td><td>1. Number of events</td><td>1. Fuel integrity</td></tr>
<tr><td>2. Exemptions and deviations from the Operational Limits and Conditions</td><td>3. Risk-significance of events</td><td>2. Primary and secondary circuits integrity</td></tr>
<tr><td>3. Unavailability of safety systems</td><td>4. Accident risk of nuclear facilities</td><td rowspan="4">3. Containment integrity</td></tr>
<tr><td>4. Occupational radiation doses</td><td rowspan="3">5. Number of fire alarms</td></tr>
<tr><td>5. Radioactive releases</td></tr>
<tr><td>6. Investments in facilities</td></tr>
</table>

__Operation and maintenance__ are assessed on the basis of information concerning the radiation protection and the operation and maintenance of the plant. The operation and maintenance of the plant is monitored using the failure and maintenance data for the components with an effect on the safe operation of the plant, as well as by monitoring compliance with the operational limits and conditions (OLC). The success of radiation protection is monitored on the basis of the employees' radiation doses and radioactive releases into the environment. Attention is also paid to investments to improve the plant and to the up-to-dateness of the plant documentation.

The indicators concerning __operational events__ are used to monitor special situations and significant disturbances at the plant. Special situations include events with an effect on the safety of the plant, the personnel or the environment. A special report is required for any special situations. Correspondingly, a transient report must be prepared for any significant disturbances occurring at a plant unit. Such transients include reactor and turbine trips, and other operational transients leading to a forced reduction of more than 5% in the reactor power or average gross power. Risk indicators are used to monitor the safety effect of component unavailability and development of the plant's risk level. The results provide insight into the operational activities at the plant and the efficiency of the operating experience feedback system.

__Structural integrity__ is assessed on the basis of the leak-tightness of the multiple radioactivity confinement barriers – the fuel, primary and secondary circuits, and the containment. The integrity must meet the set objectives while the indicators must show no significant deterioration. Fuel integrity is monitored on the basis of the radioactivity of the primary coolant and the number of leaking fuel bundles. The water chemistry indicators are used to monitor and control the integrity of the reactor coolant system and the secondary circuit. The monitoring is done by indices depicting the maintenance of water chemistry and by following selected corrosive impurities and corrosion products. Integrity of the containment is monitored by testing the leak tightness of isolation valves, penetrations and air locks.

Results of the safety performance indicators for the nuclear power plants in 2017

Summary of indicator results for the Loviisa nuclear power plant

Operation and maintenance

Ageing management and maintenance at the Loviisa power plant have been fully functional and the development measures taken have been correct. Preventive maintenance has ensured sufficient operability. The number of operation restrictions on components subject to the OLC and the ratio of preventive maintenance to fault repairs remained at a stable, acceptable level. The number of fault repairs has increased in the past few years because more components were repaired while they were still operable – the number of immediate faults has remained at the same level. The average component repair times have also remained stable. The fact that the average repair time at Loviisa 2 was clearly longer than in recent years was due to a few individual repair operations taking somewhat longer. The detection and anticipation of faults have been continuously improved in the maintenance operations of Loviisa nuclear power plant and components have been replaced, which is why there have been no faults that would have had a major impact on the safe operation of the plants, and the operability of components has remained good.

This development was also reflected in the good availability of safety systems. The availability of the high-pressure safety injection system, emergency feedwater system and the emergency diesel generators was excellent in 2017.

No common-cause failures important to safety occurred. Very few events affecting production occurred, and they did not affect the safe operation of the plant. Only one event important to safety (INES ≥1) took place in 2017. That event was related to handling nuclear fuel. Following the event, extensive remedial actions were taken in Loviisa during 2017 with regard to activities, the organisation responsible for the operation concerned, as well as the condition monitoring and ageing management of the refuelling machine. In 2018, STUK will also closely monitor the transfers of nuclear fuel and impacts of the actions taken. There were five events where the plant was non-compliant with the OLC. However, these were isolated events and their safety significance was low. Three of them concerned a failure to carry out periodic tests, one was a momentary deviation from chemical limit values, while one concerned the inoperability of a measurement device which was important to safety. The most important events in 2017 are described in Appendix 3. The main purpose of the OLC exemption procedure is to verify that the safety level specified in the OLC is achieved during modifications, more extensive maintenance or during fault repairs. An average number of exemptions were granted in 2017, and they were all related to on-going modification work aimed at improving safety.

Radiation safety at the Loviisa power plant has been appropriately handled, and it is being developed in a determined manner. Radiation doses are mainly accumulated during outages. Thanks to improvements in radiation safety, the employees' radiation doses were very low in 2017 – the lowest ever measured at Loviisa 1 – and remained well below the individual dose limits and the collective occupational dose limit. In 2017, the average of the ten largest doses was also a record-low. In 2017, radioactive releases into the air and water from Loviisa NPP were of the same magnitude as in previous years, which are well below the emission limits set.

Operational events

The number of reported events remained the same or decreased slightly. The number of simultaneous safety significant events (INES 1 or higher) decreased in the short and long term, which indicates a positive development trend. Of the major events submitted for approval in 2017, nearly all were single events referred to above, and were events of low safety significance where the plant was non-compliant with the OLC. The safety significance of the events is also reflected in the events' risk significance, which has remained low and continued to slightly decrease over the years. The accident risk to the Loviisa nuclear power plant (the core damage frequency), which describes the technical safety and reliability of the plant, has continued to decrease over the last ten years at both plant units, and new risk factors, discovered as the scope of the PRA has been extended, have been efficiently eliminated. Fire safety at the Loviisa nuclear power plant remained at the good level of the previous years – there were no events classified as fires in 2017. The number of fire detection system faults has remained at the same level for the past ten years.

Structural integrity

The structural integrity of the fuel, the primary circuit and the containment has remained good at the Loviisa nuclear power plant.

There was no leaking fuel in the reactors of the Loviisa plant units in 2017, which is why the maximum iodine (I-131) activity value of the primary coolant was also low. The indicators describing fuel integrity have remained at a good and stable level in 2014–2017.

Among other things, the condition of primary and secondary circuits is monitored using chemistry indicators. The small number of leaks and all of the chemistry indicators demonstrate that the integrity of the primary circuits of the Loviisa plant units was good in 2017.

Integrity of the containment remained at a good level at both of the Loviisa plant units. Total leakage through containment penetrations and isolation valves remained low, clearly below the set limits, in 2017 as in the previous years.

Summary of indicator results for Olkiluoto nuclear power plant

Operation and maintenance

Ageing management and maintenance at the Olkiluoto nuclear power plant have been functional and the development measures taken in the past few years have been successful, which is clearly indicated by the fact that the number of faults has remained low since 2012. Preventive maintenance has ensured good operability. The inoperability times for OLC components were also short. Although the number of fault repairs has slightly increased, the number of immediate faults leading to inoperability has decreased at both units. Detection and anticipation of faults have been continuously improved in the maintenance operations of Olkiluoto nuclear power plant and components have been replaced, which is why there have been no faults that have a major impact on the safe operation of the plant units. The number of preventive maintenance actions performed has increased, with the result that the ratio of preventive maintenance to fault repairs has remained unchanged. The average repair times of faults causing inoperability of components subject to the OLC have also remained short. This positive development is also reflected in the good availability of safety systems (the containment spray system, the auxiliary feedwater system and the emergency diesel generators).

There was one common-cause failure important to safety: jamming of the control rod actuators due to an installation error. During the unscheduled refuelling outage of Olkiluoto 1 in autumn 2017, one jammed control rod actuator was repaired and three others serviced for safety reasons. One of the three had the same installation error as the jammed rod. The common-cause failure could have prevented pushing the control rods into the reactor by screwing, but the hydraulic scram function would nevertheless have operated.

In 2017, Olkiluoto power plant had six events during which the plant was non-compliant with the OLC, which was more than on average. However, they these isolated events and their safety significance was low. The most important events in 2017 are described in Appendix 3.

The main purpose of the OLC exemption procedure is to verify that the safety level specified in the OLC is achieved during modifications, more extensive maintenance or fault repairs. In 2017, more applications (11) than average were submitted due to the large number of plant modifications. Two of the applications concerned test arrangements during the ramp-up of Olkiluoto after the unscheduled refuelling outage and in the VLJ repository.

Radiation safety at the Olkiluoto plant has been good and is being developed in a determined manner. The employees' radiation doses were low due to improvements in radiation safety and were well below the individual dose limits and the collective occupational dose limit. In 2017, the average of the ten largest doses was at the previous years' level and lower than in 2016. In 2017, radioactive releases into the air from the Olkiluoto 2 nuclear power plant unit were of the same magnitude as in the previous years. Due to the fuel leaks at Olkiluoto 1 in 2016 and 2017, the noble gas and iodine releases from Olkiluoto were higher than in previous years. A minor release also took place at Olkiluoto in May 2017 from the turbine island facilities. However, the release consisted of short-lived nuclides which decay before spreading into the environment, and hence there was no impact on the radiation safety of the surrounding environment. Releases into the environment remained clearly below the limits set at both plant units. In 2017, the radiation doses in the surroundings of Olkiluoto were very low, and were less than 1% of the 100 mSv limit set in the Nuclear Energy Decree (161/1988).

Operational events

No events important to safety occurred at the Olkiluoto nuclear power plant in 2017. The number of reported events remained the same or decreased slightly. The number of simultaneous safety significant events (INES 1 or higher) has decreased in the short and long term, which indicates a positive development trend. Of the major events submitted for approval in 2017, most were single events or events of low safety significance where the plant was non-compliant with the OLC.

This is also reflected in the risk significance of the events which has remained low all the time. The accident risk level of the Olkiluoto nuclear power plant, which describes technical safety and reliability of the plant, has continued to decrease in the long run at both plant units, and new risk factors, discovered as the scope of the PRA has been extended, have been systematically eliminated. At the end of 2017, the core damage frequency of both Olkiluoto units was of the same order as in 2016.

Fire safety at the Olkiluoto nuclear power plant has remained at the same good level as in previous years – no events classified as fires occurred in 2017 and the number of fire detection system faults has remained at the same very low level for the past ten years.

Structural integrity

The structural integrity of the primary circuit and the containment has remained good at the Olkiluoto nuclear power plant. One leaking fuel assembly was detected and removed from Olkiluoto 1 in 2017. STUK is also monitoring the maximum activity of primary coolant (I-131). The low concentration indicates the absence of any leaks. The activity levels of primary coolant due to the presence of I-131 were elevated at Olkiluoto 1 due to a fuel leak. The activity level corresponds to that measured at Olkiluoto 1 in 2016 when six leaking fuel assemblies were removed from the reactor. The fuel leaks are discussed in Appendix.

Condition of the primary and secondary circuits is monitored with the chemistry indicators, in particular. The small number of leaks and the chemistry indicators show that the integrity of the primary circuits of the Olkiluoto plant units was good in 2017.

Integrity of the containment has remained good at both plant units. STUK monitors leak test results of the outer isolation valves, total leakage and as-found leakages from containment penetrations and airlocks. The number of leaks has remained steady and were clearly below the set limits at both plant units. The total found leakage rate of containment penetrations and airlocks increased slightly from the previous years' level, particularly at Olkiluoto 2, but was still very small compared to the permissible values.

Safety performance indicators

A.I Operation and maintenance

A.I.1 Faults and repairing them

A.I.1a Faults in components subject to the OLC

Definition

The number of faults causing the unavailability of components during load operation defined in the operational limits and conditions (OLC) is monitored as an indicator. The faults are divided by plant unit into two groups: faults causing an immediate operation restriction and faults causing an operation restriction in connection with repair work.

Source of data

The data is obtained from the work order systems and the operational documents of NPPs.

Purpose

The indicator is used to assess nuclear power plant lifecycle management and development of the condition of components.

Interpretation of the indicator

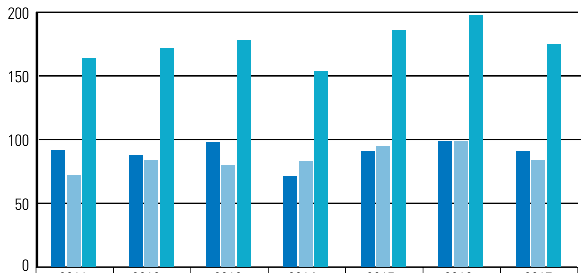
Loviisa

The total number of faults causing an operation restriction of components subject to the OLC in 2017 was 175. The average number of faults during the four previous years was 179, which means that there was no increase in the number of faults in 2017 or in the fault trend.

The number of faults per year remained stable. Any variation therein has been caused by the random occurrence of faults that occurs in any large number of components. Fault detection and anticipation have been continuously improved in plant maintenance operations at Loviisa, and components have been replaced. Due to these measures, the management of component availability has been successful.

Based on the above, it can be stated that the indicator or the underlying fault data does not show any significant negative effects associated with the ageing of the facilities, which is an indication of well-functioning component lifecycle management and component maintenance.

Number of failures of OLC components causing unavailability during power operation, Loviisa NPP



	2011	2012	2013	2014	2015	2016	2017
LO1	92	88	98	71	91	99	91
LO2	72	84	80	83	95	99	84
LO1,2	164	172	178	154	186	198	175

Interpretation of the indicator

Olkiluoto

The number of failures occurring during power operation and leading to the lack of availability of components subject to operational limits and conditions has decreased during the period 2012–2016.

In 2012, the number of faults was nearly double the number of faults in 2009. In 2012, the number of faults decreased back to the level of 2010, and the number of faults did not change in 2013 or 2014. According to this indicator, the year 2016 was similar to the years 2014 and 2015. The number of defects increased slightly in 2017. The increase was very moderate, and the number of faults was practically the same as in 2015.

The indicator shows that maintenance of the plants has been successful.

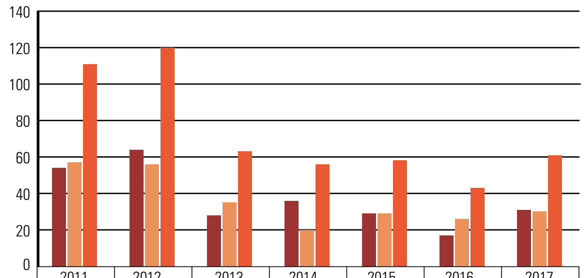
Occurrences of the "immediate operation restriction on detection of fault" indicator decreased considerably in 2016. The considerable decrease was because most of the faults in the systems subject to the OLC were in components whose failure did not cause an immediate operation restriction. In 2017, the total at both plants was zero.

Most of the times of inoperability for OLC components at OL1 during all four quarters of 2017 were brief. An exception was one of the control rods of the plant's reactor which failed in a periodic test on 29 December 2016 and was moved to its inner position as a control rod group in compliance with the instructions. A second failure in the same component group occurred on 28 June 2017. In this case, the control rod group including the failed rod was also moved to its inner position, and no operation restriction was caused.

At OL2, most of the inoperability times of OLC components were brief in 2017. The longest inoperability times concerned radiation measurement systems and their measurement results. They did not cause operation restrictions either, because these measurements are duplicated. The other fault reports did not concern any particular system.

Due to the above reasons, the operating restrictions on components have slightly increased from 2016, although one must bear in mind that immediate operation restrictions on the detection of a fault have at the same time considerably decreased.

Number of failures of OLC components causing unavailability during power operation, Olkiluoto NPP



	2011	2012	2013	2014	2015	2016	2017
OL1	54	64	28	36	29	17	31
OL2	57	56	35	20	29	26	30
OL1,2	111	120	63	56	58	43	61

A.I.1b Maintenance of components subject to the OLC

Definition

The indicator is used to follow the number of fault repairs and preventive maintenance work orders for components subject to the operational limits and conditions (OLC) by plant unit.

Source of data

The data is obtained from the nuclear power plant work order systems, from which all preventive maintenance operations and fault repairs are retrieved.

Purpose

The indicator describes the volumes of fault repairs and preventive maintenance, and illustrates the condition of the nuclear power plant and its maintenance strategy. The indicator is used to assess the maintenance strategy implemented at the NPP.

Interpretation of the indicator

Loviisa

When considering the annual variation in the volume of fault repairs and particularly in the number of preventive maintenance jobs, the scheduling of various annual outages (refuelling outage, short annual outage, four-year annual outage, eight-year annual outage) included in the maintenance strategy of the Loviisa NPP during a four-year cycle should be considered, as it can have a significant impact on the annual figures. In 2017, a short annual outage (a refuelling outage) was implemented at LO1 and LO2.

According to the data on which the indicator is based, the year 2017 showed no major deviation from the average numbers of fault repairs and preventive maintenance volumes of the four previous years.

In 2017, the number of maintenance tasks on components subject to OLC was 3% lower than the average. The volume of preventive maintenance was 8% lower and the number of fault repairs 19% higher than the average. The number of fault repairs includes the repair of faults and repairs of components that are still operable. The indicator's increase was due to the increased number of the latter. The number of immediate faults has remained unchanged.

The ratio of preventive maintenance to fault repairs was 4.4. The ratio is 36% lower than 6.0, the average of the four previous years, which means that the share of preventive maintenance of all maintenance work has continued to decrease from the previous years' level.

However, the large share of preventive maintenance operations reflects the selected maintenance strategy, the purpose of which is to keep the number of faults and the effects of faults at a tolerable level.

Interpretation of the indicator

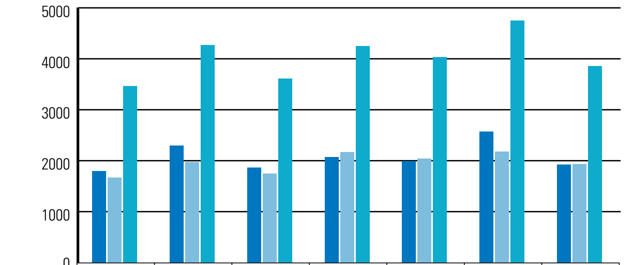
Olkiluoto

In 2017, the number of fault repairs that led to component inoperability increased slightly from the 2016 level and was at the 2015 level. The number of preventive maintenance operations slightly increased, keeping the ratio of preventive maintenance to fault repairs unchanged, as there was a slight increase in both.

The number of preventive maintenance operations increased at OL2. The number of faults repaired at OL2 remained at the same level as in 2015 and the relative number of preventive maintenance tasks also increased more than at OL1, which is why the maintenance ratio increased to 1.09 at OL1 and to 1.56 at OL2. These are close to the 2013 values.

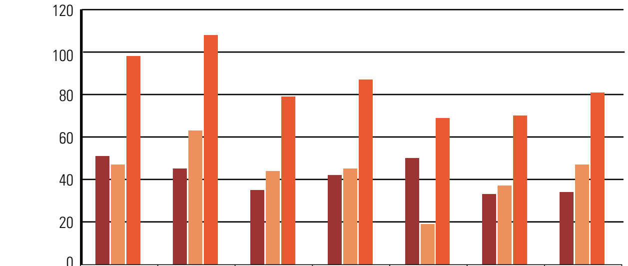
Based on the development of the ratio of preventive maintenance work to fault repairs and an assessment of the work on which the figures are based, the maintenance strategy can be considered successful.

Number of annual preventive maintenance works of OLC components, Loviisa NPP



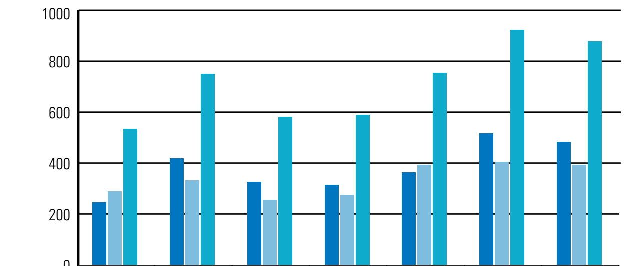
	2011	2012	2013	2014	2015	2016	2017
LO1	1795	2298	1866	2074	1992	2569	1918
LO2	1663	1967	1741	2171	2039	2178	1933
LO1,2	3458	4265	3607	4245	4031	4747	3851

Number of annual preventive maintenance works of OLC components, Olkiluoto NPP



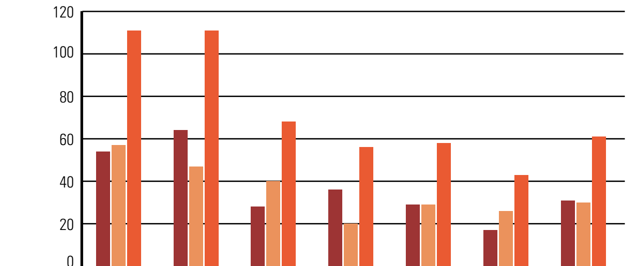
	2011	2012	2013	2014	2015	2016	2017
OL1	51	45	35	42	50	33	34
OL2	47	63	44	45	19	37	47
OL1,2	98	108	79	87	69	70	81

Number of annual failure repair works of OLC components, Loviisa NPP



	2011	2012	2013	2014	2015	2016	2017
LO1	245	419	326	314	363	517	484
LO2	289	332	256	276	392	405	393
LO1,2	534	751	582	590	755	922	877

Number of annual failure repair works of OLC components, Olkiluoto NPP



	2011	2012	2013	2014	2015	2016	2017
OL1	54	64	28	36	29	17	31
OL2	57	47	40	20	29	26	30
OL1,2	111	111	68	56	58	43	61

A.I.1c Repair times of components subject to the OLC

Definition

As an indicator, the average repair time of faults causing the unavailability of components defined in the operational limits and conditions (OLC) is monitored. For each repair, the time recorded is the time of inoperability. In the case of a fault that causes an immediate operation restriction, it is calculated from the detection of the fault to the end of the repair work. If the component is operable until the beginning of repairs, only the time it takes to complete the repairs is taken into account.

Source of data

The data is obtained from the nuclear power plants' work order systems as well as maintenance and operation documentation.

Purpose

The indicator shows how quickly failed components subject to the OLC are repaired when compared to the repair time allowed in the OLC. The indicator is used to assess the strategy, resources and effectiveness of NPP maintenance.

Interpretation of the indicator

Loviisa

The OLC define the maximum allowed repair times for components based on the components' safety significance. The times vary from four hours to 21 days. Furthermore, faults in OLC components are to be repaired within the allotted time without undue delay.

Due to the small amount of work requiring operation restrictions and the varying allowed repair times, an individual repair operation may have a significant effect on the indicator, even if it is completed within the allotted time. This aspect of the indicator is taken into account in the interpretation of the indicator by evaluating the significance of individual long-term fault repairs in terms of maintenance strategy, resources and efficiency of operations.

The average repair times of faults causing unavailability of components have remained stable at the Loviisa NPP for several years. In 2017, the average repair time in the plant units was approximately 19 hours, while the average of the four previous years was approximately 18 hours. The higher figure for Loviisa 2 in 2017 is explained by a few individual repair operations, the longest one being the 360-hour repair operation of the air conditioning damper of SAM diesel 21EY05.

Based on the 2017 indicators and the underlying data, the plant's maintenance operations can be considered appropriate. Despite the positive development in repair times, attention still needs to be paid to ensuring the necessary resources are available for fault repairs, and for carrying out the repairs without unnecessary delays.

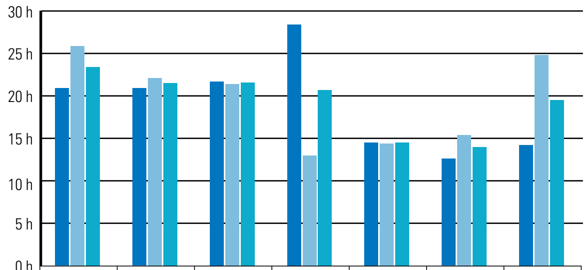
Interpretation of the indicator

Olkiluoto

The indicator is used to monitor the repair times of components subject to the operational limits and conditions (OLC). The repair time allowed in the OLC is usually 30 days for faults concerning one subsystem and three days for faults concerning two subsystems. Depending on the system and the component, other allowed repair times may also be defined in the OLC.

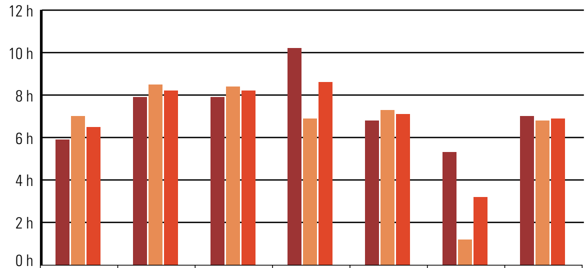
In the long term, the average repair time has varied between six to ten hours.

Average of real repair times of OLC component failures, Loviisa NPP



	2011	2012	2013	2014	2015	2016	2017
LO1	20.9	20.9	21.7	28.4	14.5	12.6	14.2
LO2	25.9	22.1	21.4	13.0	14.4	15.4	24.8
LO1,2	23.4	21.5	21.6	20.7	14.5	14.0	19.5

Average of real repair times of OLC component failures, Olkiluoto NPP



	2011	2012	2013	2014	2015	2016	2017
OL1	5.9	7.9	7.9	10.2	6.8	5.3	7.0
OL2	7.0	8.5	8.4	6.9	7.3	1.2	6.8
OL1,2	6.5	8 2	8.2	8.6	7.1	3.2	6.9

In 2015, the average repair time of faults causing inoperability of components subject to the OLC at OL1 and OL2 was around 7 h. At both plant units, the average repair time for faults leading to component inoperability subject to OLC was lower in 2016 than in the previous year, and at OL2 it was exceptionally low. This was due to the low number of faults and that no long-term faults occurred.

In 2017, the values of this indicator returned to earlier years' level, i.e. 7 h for OL1 and 6.8 h for OL2.

On the basis of the 2017 indicators and the underlying data, the NPP's maintenance operations were appropriate.

A.I.2 Exemptions and deviations from the OLC

Definition

As indicators, the number of non-conformances with the operational limits and conditions (OLC), as well as the number of exemptions granted by STUK, are monitored.

Source of data

Data for the indicator is collected from applications for exemption by the power companies and from event reports.

Purpose

The indicator is used to follow the power companies' activities in accordance with the operational limits and conditions: compliance with the OLC and identified situations during which it is necessary to deviate from the OLC; conclusions regarding the appropriateness of the OLC can also be made based on this data.

Interpretation of the indicator

The main purpose of the OLC exemption procedure is to enable modifications and maintenance that will improve safety and plant availability.

Non-conformance with the OLC refers to a situation where the NPP or a system or component of the NPP is not in a safe state as required by the operational limits and conditions. The objective is to have zero non-conformance events at the NPPs. The licensee must always prepare a special report on each non-conformance and any corrective measures, and submit it to STUK for approval.

Loviisa

Exemptions

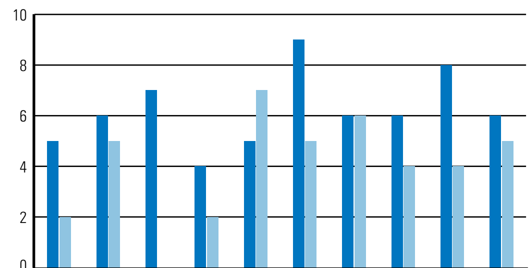
Based on the last ten years (2007-2016), the Loviisa NPP applies for STUK's approval for exemptions from the OLC six times per year on average. The number of applications in 2017 (six applications) was in line with the average. All six applications were related to modifications. As the planned deviations had no significant safety implications, STUK approved the applications.

Non-conformance with the OLC

In 2017, five events during which the plant did not comply with the OLC without an advance safety analysis and approval were detected at the Loviisa nuclear power plant. Such events have occurred on average four times a year in the past ten years (2007–2016).

Loviisa NPP analyses all non-conformances with the OLC within a month of detection. The analysis includes finding out the underlying causes, assessing the safety significance of the event and determining corrective measures to prevent reoccurrence of the non-conformances. The results of the analysis are documented in a special report (indicator A.II.1). One key issue is identifying the possibility of reoccurrence, i.e. studying whether a similar event has occurred in the past and whether the corrective measures implemented at the time were sufficient. One issue in common to several of the events in 2012-2017 was non-compliance with the OLC during the changing of a plant unit's operating mode, i.e. either when switching the unit from load operation to shutdown or from shutdown to load operation. The shutdown or start-up of a plant unit is implemented in stages. Before moving on to the next stage, it must be verified that all the requirements for the next stage have been met.

Number of deviations from the OLC, Loviisa NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Exemptions	5	6	7	4	5	9	6	6	8	6
Deviations	2	5	0	2	7	5	6	4	4	5

One must make sure that there are no defects that could lead to an inadvertent deviation in people's knowledge of the OLC, procedures related to compliance with the OLC or the formatting of the OLC themselves.

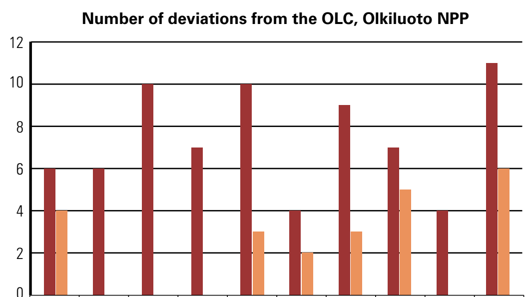
Olkiluoto

Based on data from the last ten years (2008-2017), the Olkiluoto nuclear power plant applies for STUK's approval for exemptions from the OLC seven times per year on average. Hence, the number of applications in 2017 (11) was above average. Most of the applications concerned modifications. For example, the construction work of the foundation of the pump in the new high-pressure safety injection system required an exemption from the OLC at both plant units. In the unscheduled refuelling outage of OL1, an exemption from carrying out a criticality test after refuelling was applied for. Sufficient subcriticality was demonstrated by computational means instead of a test. Validity of the exemption granted for the gas generation test in the VLJ repository was extended. STUK approved all exemptions applied for.

Non-conformance with the OLC

In 2017, Olkiluoto had six events during which the plant was non-compliant with the OLC without an advance safety analysis or STUK's permission. Two of the situations non-compliant with the OLC were related to fuel pool gates when the associated administrative requirements deviated at both plant units. At OL1, the fuel pool gate was tied open with a rope during the annual outage, and at OL2, the fuel pool gate was left open during a load operation after the transfers of sample pieces. During annual maintenance at OL1, the relief train was insufficiently tested. During annual maintenance at OL2, the door of the auxiliary building was left open in breach of the OLC. At OL2, the root valve of the auxiliary feedwater system was incorrectly closed in connection with maintenance work, causing an incorrect reading in the flow rate measurements. At OL1, the replacement power supply was not switched on within the required time in connection with a malfunction in the battery-backed power supply. The events in breach of the OLC did not compromise plant safety, and TVO has analysed the events.

The average number of events for the past ten years is three events non-compliant with the OLC per year.



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Exemptions	6	6	10	7	10	4	9	7	4	11
Deviations	4	0	0	0	3	2	3	5	0	6

A.I.3 Unavailability of safety systems

Definition

As the indicators, the unavailability of safety systems is monitored separately for each plant unit. The systems monitored at the Olkiluoto nuclear power plant are the containment spray system (322), the auxiliary feedwater system (327) and the emergency diesel generators (651–656). Those followed at the Loviisa nuclear power plant are the high-pressure safety injection system (TJ), emergency feedwater system (RL92/93, RL94/97) and the emergency diesel generators (EY).

Essentially, the ratio of a system's unavailability hours and its required availability hours is used as the indicator. Unavailability hours are the combined unavailability of redundant trains divided by the number of trains.

Annual plant criticality hours are the availability requirement for the systems 322, 327, TJ and RL. For diesel generators, the requirement is continuous, i.e. equal to the annual operating hours.

The unavailability hours of a subsystem include the time required for the planned maintenance of components and unavailability due to faults. The latter includes, in addition to the time spent on repairs, the estimated unavailability time prior to fault detection. If a fault is estimated to have occurred in a previous successful test but to have escaped detection, the time between inservice tests is added to the unavailability time. If a fault has occurred between tests but its date of occurrence is unknown, half of the time that has lapsed between tests will be added to the unavailability time. If the fault clearly occurred during an operational, maintenance, testing or other event, the time between the event and the defection of the fault is added to the unavailability time.

Source of data

Data for the indicators is collected from the power companies. The licensee's representatives submit the necessary data to the relevant responsible person at STUK.

Purpose

The indicator indicates the unavailability of safety systems. The indicator is used to track the condition of safety systems and any identifiable trends.

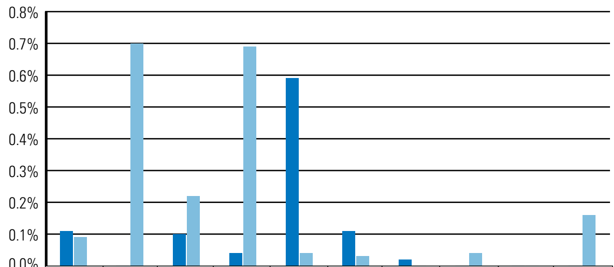
Interpretation of the indicator

Loviisa

TJ system

Analysis of the unavailability figures for the high-pressure safety injection systems of the plant units in 2017 and their background information shows that no faults leading unavailability occurred at Loviisa 1 and two faults, which caused the system to be unavailable for 13 hours due to repairs, occurred at Loviisa 2. In other words, their condition and availability were good.

Unavailability of high pressure safety injection system (TJ), Loviisa NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LO1	0.11	0.00	0.10	0.04	0.59	0.11	0.02	0.00	0.00	0.00
LO2	0.09	0.70	0.22	0.69	0.04	0.03	0.00	0.04	0.00	0.16

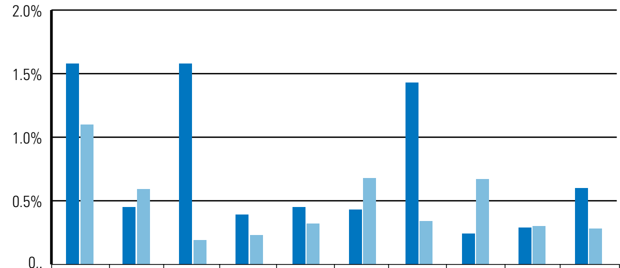
RL system

In Loviisa 1, the total unavailability time of the emergency feedwater systems was 199 hours in 2017, of which 97 hours were spent for fault repairs during load operations. The rest of the unavailability time (102 hours) was caused by periodic maintenance of a diesel generator for the emergency feedwater system RL-94 during the annual outage of Loviisa 1, which is done every four years.

The total unavailability time for the emergency feedwater systems at Loviisa 2 was 91 hours in 2017. There was no unavailability during load operation. The whole period of unavailability was caused by the periodic maintenance of a diesel generator for the RL-97 emergency feedwater system during the annual outage of Loviisa 2, which is done every four years.

The unavailability of the auxiliary feedwater systems was low in 2017, i.e. their condition and availability were good.

Unavailability of auxiliary feed water system (RL92/93, RL94/97), Loviisa NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LO1	1.58	0.45	1.58	0.39	0.45	0.43	1.43	0.24	0.29	0.60
LO2	1.10	0.59	0.19	0.23	0.32	0.68	0.34	0.67	0.30	0.28

EY system

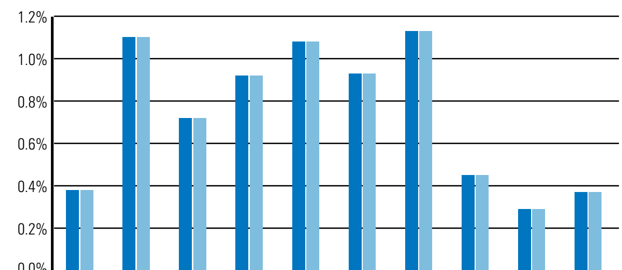
In 2017, the unavailability time of the eight emergency diesel generators was a total of 262 hours.

In 2017, there were a total of 21 emergency diesel generator events leading to unavailability (10 events in 2016). Of these faults, nine caused an immediate operation restriction and 12 led to an operation restriction starting at the beginning of the repair work.

Most of the repairs (12) were due to leaks in the engines' air, fuel and cooling/mantle water pipelines. The plant will replace cooling/mantle water pipelines during future annual outages.

The unavailability rate for the emergency diesel generators in 2017 was 0.37% and is almost of the same level as the value for the previous year (2016), which was 0.29%, i.e. the availability level was good.

Unavailability of emergency diesel generators (EY), Loviisa NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LO1	0.38	1.10	0.72	0.92	1.08	0.93	1.13	0.45	0.29	0.37
LO2	0.38	1.10	0.72	0.92	1.08	0.93	1.13	0.45	0.29	0.37

Interpretation of the indicator

Olkiluoto

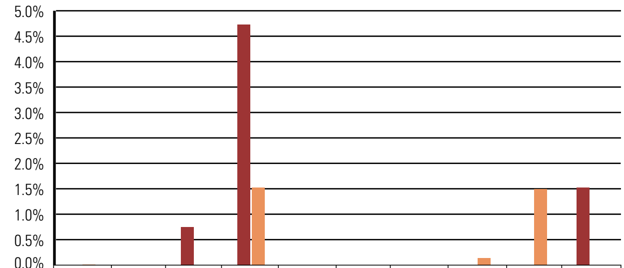
The unavailability rate for the containment spray system and the diesels has remained at a good level in recent years. The unavailability rate of the auxiliary feedwater system in 2016 and 2017 was also stable and remained at a relatively low level.

The unavailability rate of the containment spray system was good in 2008–2017, with either zero or almost zero throughout the period.

The unavailability rate of the auxiliary feedwater system has varied over the years. There were no significant faults in 2008 or 2009, and the unavailability of the auxiliary feedwater system decreased to zero in 2009 at both plant units. In 2010, unavailability of OL1 was still zero but unavailability of OL2 slightly increased from the previous year, mainly as a result of several new faults discovered during the annual outage. In 2011, the figure for OL1 was multiplied from the previous years as the result of a hidden fault in one auxiliary feedwater system valve that remained inoperable for 504 hours; In 2013, the unavailability rate for the auxiliary feedwater system was restored to the level prior to 2011 and remained at this level until 2015. The unavailability rate increased somewhat at OL2 in 2016 and in 2017 at OL1. The higher unavailability rate in 2017 at OL1 was caused by a latent fault in valve 327V102. The fault was detected in April.

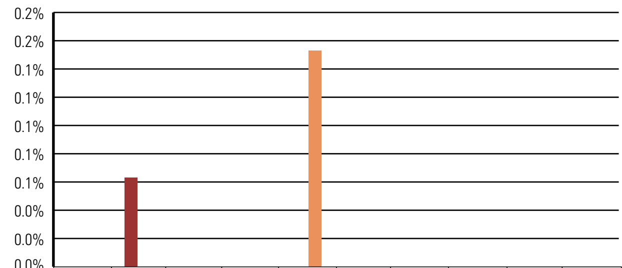
The unavailability rate of diesels varied from one year to the next during the period under review, but has been low in recent years. In 2008, the unavailability rate of diesels increased by almost 95% compared to the previous year. The increase was due to hidden faults in the compressed air motors of the diesels at both plant units. In 2009, the unavailability of the diesel generators decreased considerably from the 2008 figures. In 2010, unavailability increased somewhat from the previous year as a result of faults occurring in connection with in-service testing. At OL1, the stator winding of a diesel generator failed in connection with an in-service test in August 2010, and the generator was replaced with an overhauled unit. In 2011, the unavailability of the emergency diesel generators was more than four times higher than in 2010, the highest figure ever recorded during the time this parameter has been monitored. The reason for the increase was the above-mentioned diesel generator fault, which may have lasted as long as from August 2010 to May 2011. In addition, there were faults in exhaust manifolds and exhaust pipes in 2011. In 2012, the unavailability of the diesel generators was zero. The unavailability of the diesel generators slightly increased in 2014 but still remained very low. The unavailability increased again to 0.96 in 2015. The unavailability of the diesel generators in both units was zero in 2016 and 2017. due to preventive maintenance and improvements that were successfully realised during planned maintenance outages.

Unavailability of auxiliary feed water system (327), Olkiluoto NPP



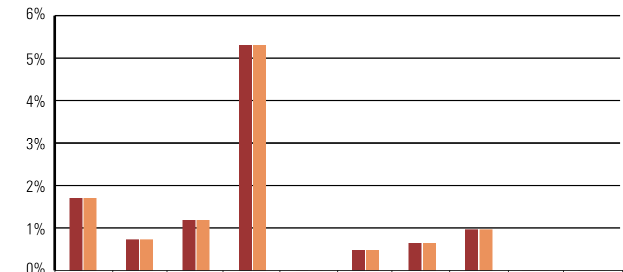
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OL1	0.00	0.00	0.74	4.73	0.00	0.00	0.00	0.00	0.00	1.52
OL2	0.01	0.00	0.00	1.52	0.00	0.00	0.00	0.13	1.49	0.00

Unavailability of containment spray system (322), Olkiluoto NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OL1	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OL2	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00

Unavailability of emergency diesel generators (651…656), Olkiluoto NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OL1	1.71	0.72	1.18	5.30	0.00	0.48	0.64	0.96	0.00	0.00
OL2	1.71	0.72	1.18	5.30	0.00	0.48	0.64	0.96	0.00	0.00

A.I.4 Radiation exposure

Definition

As the indicators, collective radiation exposure of nuclear power plant employees by plant site and the annual average of the ten highest occupational doses are monitored.

Source of data

The data on collective radiation exposure is received from the quarterly and annual reports of the nuclear power plants as well as the national dose registry. The data on individual radiation doses is obtained from the national dose registry.

Purpose

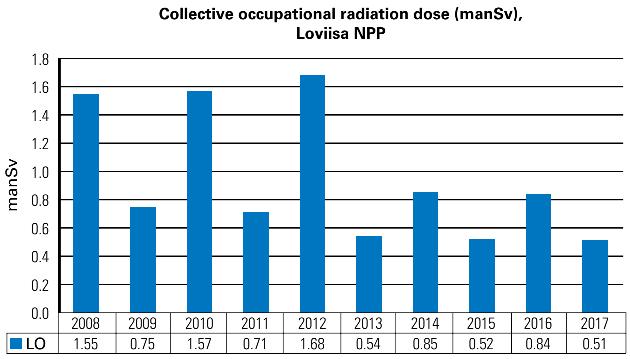
The indicators are used to control the radiation exposure of employees. The collective occupational doses describe the success of the nuclear power plant's ALARA programme. The average of the ten highest doses indicates how close to the 20 manSv dose limit the individual occupational doses at the nuclear power plants are. It also indicates effectiveness of the nuclear power plant's radiation protection unit.

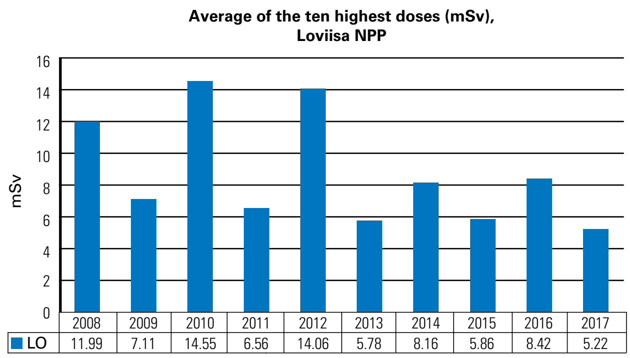
Interpretation of the indicator

Loviisa

Most doses are incurred through work done during outages. Thus, the duration of the outage and the amount of work having significance on radiation protection affect the annual radiation doses. Both Loviisa plant units have more extensive annual outages every four and eight years (the four-year annual outage and the eight-year annual outage) so that both plant units never have a major annual outage during the same year. The four-year and eight-year outages have been arranged in even-numbered years and normal annual outages in odd-numbered years. In 2017, there was a short annual outage at both plant units. The effect of annual outages on collective occupational doses can be seen in the graph *Collective occupational dose, Loviisa*. Thanks to improvements in radiation safety, the employees' radiation doses were very low in 2017 – the lowest ever measured at LO1 – and remained well below the individual dose limits and the collective occupational dose limit.

In 2017, the average of ten largest doses was also record-low. The Radiation Decree (1512/1991) stipulates that the effective dose for a worker from radiation work may not exceed the 20 manSv/year average over any period of five years, or 50 manSv during any one year.



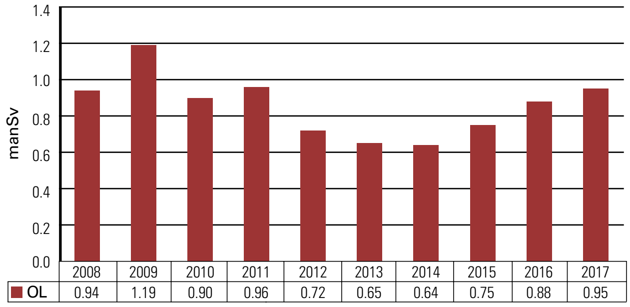


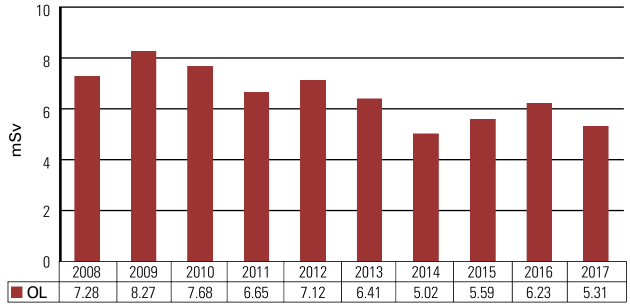
Interpretation of the indicator

Olkiluoto

Most doses are incurred through work done during outages. Thus, the duration of the outage and the amount of work having significance on radiation protection affect the annual radiation doses. The annual outages of the Olkiluoto plant units are divided into two groups: refuelling outages and maintenance outages. The refuelling outage is shorter in duration (approximately 7 days). The length of the maintenance outage depends on the amount of work (2–3 weeks). Annual outages are scheduled so that in the same year, one plant unit undergoes a maintenance outage and the other a refuelling outage. In 2017, a refuelling outage took place at OL1, while a maintenance outage of record-breaking duration and extent took place at OL2.

The radiation doses have clearly decreased after the installation of new moisture separators in 2005–2007. The radiation level in the turbine buildings has continued to decrease after the installation of the moisture separators, and this has also decreased the collective occupational dose. Furthermore, improvements aiming at reducing the employees' radiation doses have been made in the radiation protection of the plant. In 2017, the collective occupational dose of employees was 0.22 manSv at OL1 and 0.73 manSv at OL2. The annual effective dose from radiation work for a worker may not exceed 100 mSv during a period of five years (on average 20 mSv per year) and a maximum of 50 mSv during any single year. The actual radiation doses remained clearly below the limits prescribed in the Radiation decree (1512/1991).





A.I.5 Releases

Definition

As the indicators, radioactive releases into waterways and the air from the nuclear power plants are monitored, together with the calculated dose due to releases to the most exposed individual in the vicinity of the nuclear power plant.

Source of data

Data for the indicators is collected from the power companies' quarterly and annual reports. From this data, the calculated radiation dose for the most exposed individual in the vicinity of the plant is determined.

Purpose

The indicator is used to monitor the amount and trend of radioactive releases and assess factors having a bearing on any changes in them.

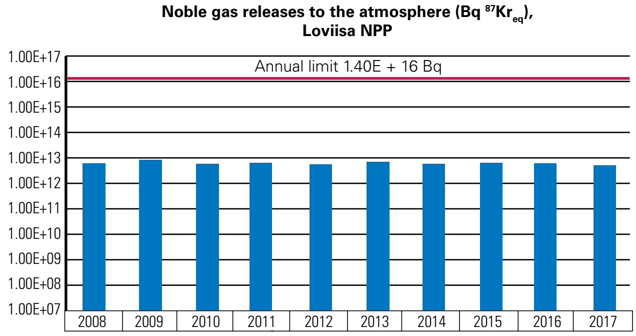
A.I.5a Releases into the air

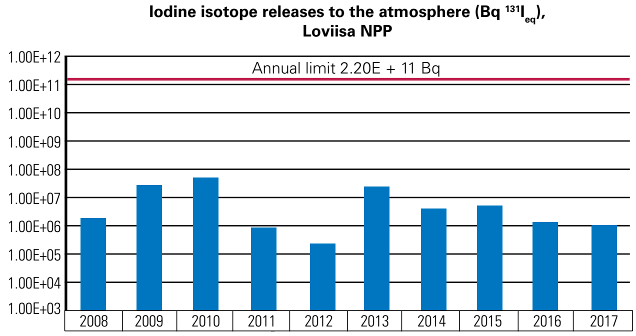
Interpretation of the indicator

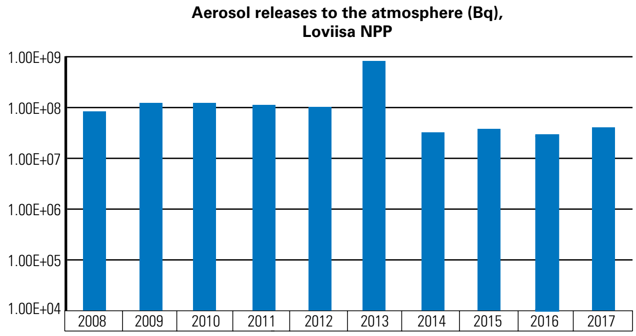
Loviisa

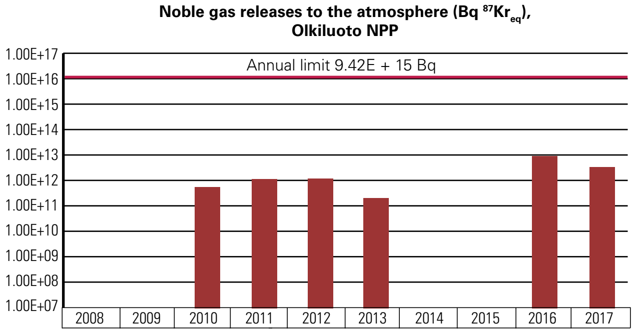
In 2017, radioactive releases into the air from the Loviisa nuclear power plant were of the same magnitude as in the previous years.

No fuel leaks were detected at Loviisa in 2017. Aerosol nuclides (including activated corrosion products) are released during maintenance work.

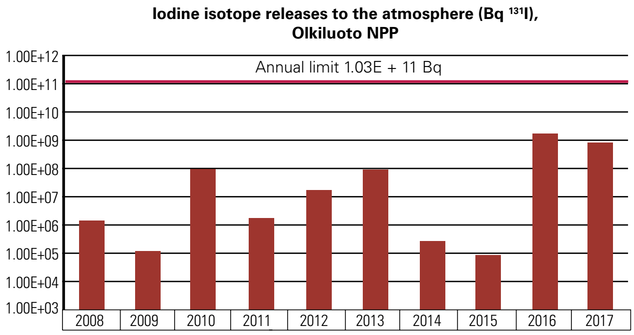


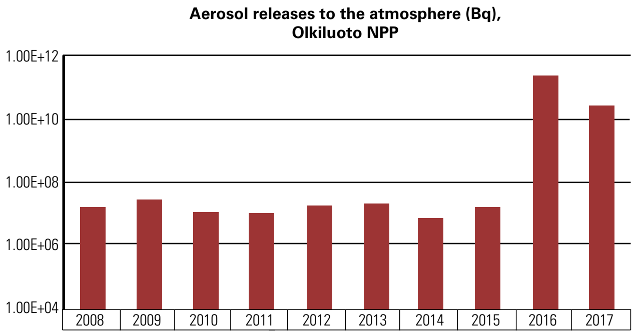






Releases in 2008, 2009, 2014 and 2015 were below the detection limit.





Olkiluoto

In 2017, radioactive releases into the air from the Olkiluoto 2 nuclear power plant unit were of the same magnitude as in the previous years. The releases remained clearly below the limits set. A fuel leakage was detected at Olkiluoto 1 in the summer, and one leaking fuel assembly was removed from the reactor during an unscheduled outage in October. As a result of the fuel leakage, there were larger releases of fission products. The releases remained clearly below the limits set also at Olkiluoto 1, however. In May, a release from the turbine building occurred at Olkiluoto. It caused a short-term noble gas and aerosol nuclide release past the delay systems directly into the vent stack. The event increased the aerosol nuclide release level in particular, but the impact of the short-lived nuclides on radiation safety is minimal as they will decay into stable elements in the immediate vicinity of the vent stack. The level of longer-lived aerosol nuclides during the release at Olkiluoto remained at the same level as in the previous years.

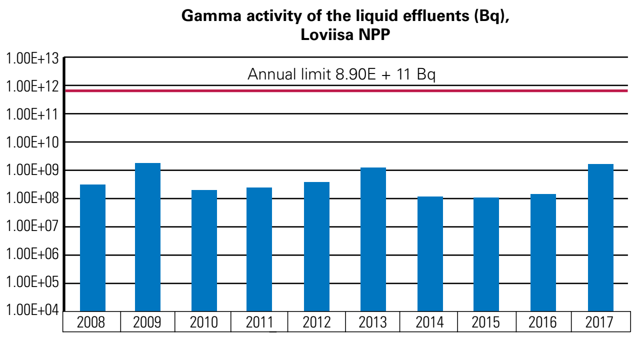
Gaseous fission products, noble gases and iodine isotopes originate from leaking fuel rods, from the minute amounts of uranium left on the outer surfaces of fuel cladding during fuel fabrication and from reactor surface contamination due to earlier fuel leaks. Due to the fuel leaks at Olkiluoto 1 in 2016 and 2017, the noble gas and iodine releases from Olkiluoto were clearly higher than in previous years.

A.I.5b Releases into the sea

Interpretation of the indicator

Loviisa

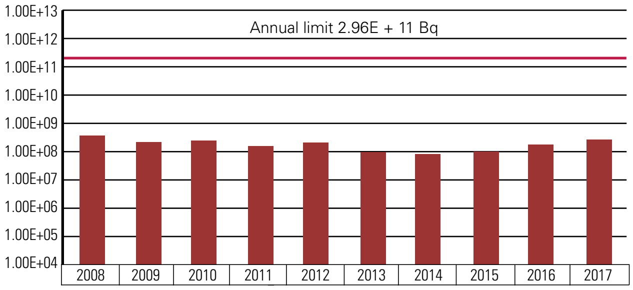
Releases of radioactive substances emitting gamma radiation into the environment from the Loviisa nuclear power plant remained clearly below the set limits. In 2009, 2013 and 2017, the Loviisa power plant released low-activity evaporation bottom into the sea as planned. Consequently, the releases of substances with gamma activity were larger than the average in those years.



Olkiluoto

Releases of radioactive substances emitting gamma radiation into the environment from the Olkiluoto nuclear power plant remained clearly below the set limits. The releases of substances with gamma activity into the sea from Olkiluoto have decreased in the long term.

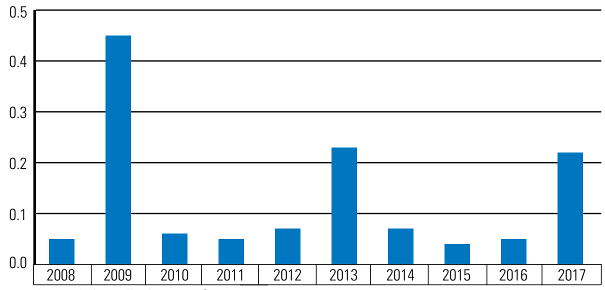
Gamma activity of the liquid effluents (Bq), Olkiluoto NPP



Loviisa

The radiation dose of the most exposed individual in the vicinity of the Loviisa nuclear power plant assessed by means of calculations in 2017 was at the same level of 2013 due to the release of evaporation residue, but still less than 1% of the 100 mSv limit set in the Nuclear Energy Decree (161/1988).

The calculated dose (μSv) of the most exposed individual in the environment of Loviisa NPP



Annual dose limit 100 μSv

A.I.5c Population exposure

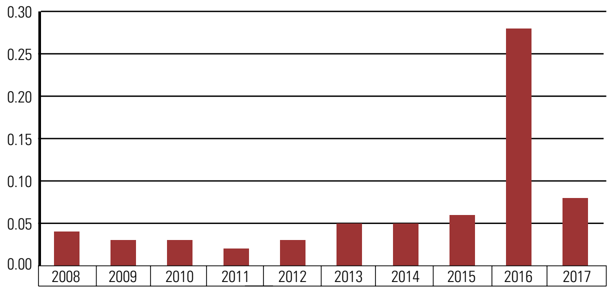
Interpretation of the indicator

Assessment of the radiation dose of the most exposed individual in the vicinity of a nuclear power plant is based on information about the plant's releases and meteorological measurements. The exposure routes that are taken into account include external radiation and internal radiation, i.e. radiation caused by radioactive materials ending up inside the body via air or food. The estimated doses given here are lower than the values reported by the plants due to, for instance, the different modelling system of the dose caused by the nuclide C-14.

Olkiluoto

In 2017, the radiation dose in the vicinity of Olkiluoto was very small in spite of a fuel leak, and was less than 1% of the 100 mSv limit set in the Nuclear Energy Decree (161/1988).

The calculated dose (μSv) of the most exposed individual in the environment of Olkiluoto NP



Annual dose limit 100 μSv

A.II Operational events

A.II.1 Number of events

Definition

As the indicator, the number of operational event reports is monitored in compliance with Guide YVL A.10. Guide YVL A.10 entered into force in late 2015, which is why the old term "events warranting a special report" is still used in the indicator. In addition to special reports and transient reports, the new operational event reports include other plant events submitted to STUK for information. A special report corresponds to an operational event report submitted for approval in the new Guide YVL A.10.

Source of data

Data for the indicator is obtained from the STUK document management system (SAHA).

Purpose

The indicator is used to follow the number of safety-significant events.

Interpretation of the indicator

Loviisa

Based on data from the previous ten years (2006-2016), the average number of annual events warranting a special report is five per year, while the average number of events warranting a transient report is four per year. The number of events warranting a special report was normal in 2017 (five in total), while the number of events warranting a transient report (six in total) was slightly above average. Many of the events warranting a special report are deviations from the operational limits and conditions (OLC). The development of events non-compliant with the OLC is considered under indicator A.I.2.

When considering the indicators concerning special and transient reports, it must be noted that the number of reports does not give a correct idea of the division of events by plant unit since, for technical reasons, the reports that concern both plant units have been entered for Loviisa 1 alone. No events warranting a special report or events warranting a transient report that involved both plant units took place in 2017, however.

Olkiluoto

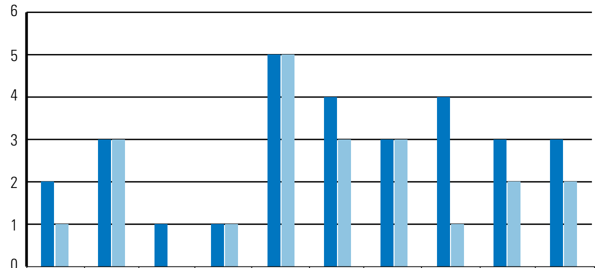
No reactor trips occurred at the Olkiluoto nuclear power plant in 2017. Based on the data from the last ten years, an average of 0–1 reactor trips per year occur at the Olkiluoto nuclear power plant. During the previous decade (1993–2001), an average of almost three to four reactor trips per year occurred. The larger number of trips is explained by the fact that it also includes reactor trips during annual outages that occurred, for example, in connection with testing of the reactor protection system.

Based on data from the previous ten years (2008–2017), the average number of annual events warranting a special report is four per year, while the average number of events warranting a transient report is five per year. In 2017, the number of events warranting a special report (seven in total) was higher than average, while the number of events warranting a transient report (three in total) was lower than the annual average. Many of the events warranting a special report are deviations from the operational limits and conditions (OLC). The development of events non-compliant with the OLC is considered under indicator A.I.2.

Events warranting a special report in 2017 are described in Appendix 3.

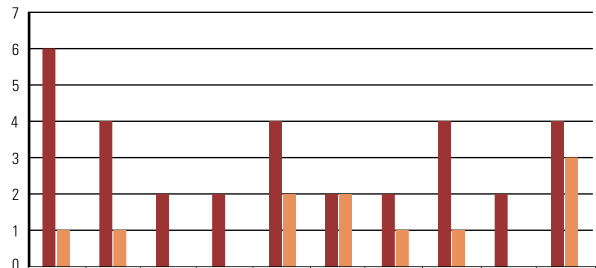
When considering the indicators concerning special and transient reports, it must be noted that the number of reports does not give a correct idea of the division of events for each plant unit since,

Number of Special Reports, Loviisa NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LO1	2	3	1	1	5	4	3	4	3	3
LO2	1	3	0	1	5	3	3	1	2	2

Number of Special Reports, Olkiluoto NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OL1	6	4	2	2	4	2	2	4	2	4
OL2	1	1	0	0	2	2	1	1	0	3

for technical reasons, reports that concern both plant units or the interim storage facility for spent nuclear fuel have been entered for Olkiluoto 1 alone. No special report concerned the interim storage facility for spent nuclear fuel in 2017.

A.II.3 Risk-significance of events

Definition

As the indicator, the risk-significance of events caused by component unavailability is monitored. An increase in the conditional core damage probability (CCDP) associated with each event is used as the measure of a risk. CCDP takes the duration of each event into consideration. Events are divided into three categories: 1) unavailability due to component failures, 2) planned unavailability and 3) initiating events.

Unavailability caused by work for which STUK has granted an exemption is included in category 2. Any non-conformances with the OLC that can be applied to this indicator are included in category 1. Non-compliances with the OLC are also dealt with in Chapter A.I.2.

Calculations concerning the Olkiluoto nuclear power plant have been made with FinPSA software and those concerning Loviisa nuclear power plant with RiskSpectrum software. For Loviisa, calculations of a simultaneous fault in several components are based solely on the load operation model, which means that the results are not as exact as for single faults which have been calculated for all operating modes. The modelling of simultaneous faults across all operating modes (17 of them) would be possible, but the calculation time would be too long when compared to the benefits gained. This year, no simultaneous faults of several components with the highest risk-significance occurred.

Source of data

Data for the calculation of the indicator is collected from the power companies' reports and applications for exemptions.

Purpose

The indicator is used to follow the risk-significance of component unavailability and to assess risk-significant initiating events and planned unavailability. Special attention is paid to recurring events, common cause faults, simultaneously occurring faults and human errors. Another objective of the event analysis is to systematically search for any signs of a deteriorating organisational and safety culture.

Interpretation of the indicator

The combined total CCDP divided by the probability of a severe accident gives an overview of the risk-significance of operational events. To facilitate analysis, risk calculation is based on conservative assumptions and simplifications, which materially weakens the applicability of the results for trend monitoring. If the risk-significance remains at the same average level year after year, the annual fluctuation does not warrant particular attention.

Loviisa

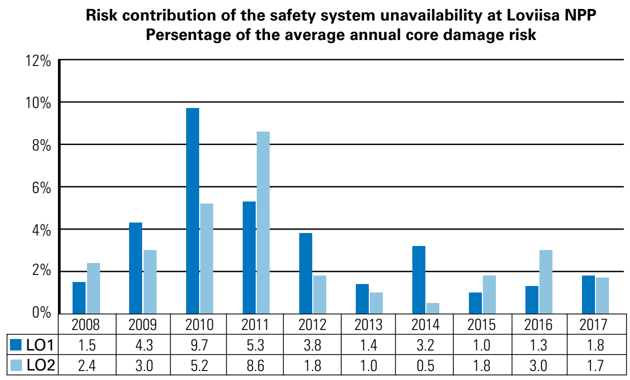
At Loviisa 1 and 2, the risk caused by operational activities remained at around the same level as in the past years in 2017. A brief description of the most significant events regarding risks is provided below.

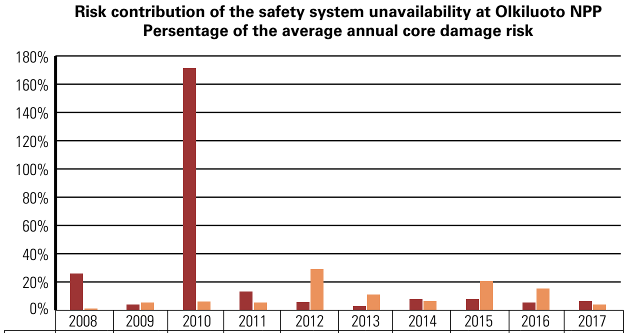
Loviisa 1:

No events of the highest risk category.

Loviisa 2:

1. The maintenance of the start-up and shutdown pump system of LO1 took 126 hours during the annual outage of LO1. This caused a risk to LO2 which was in load operation, because the start-up and shutdown pump system of LO1 can also be used for cooling LO2. The calculated CCDP was 1.7E-7.
2. Air cooling machine UV45B002 in the instrumentation facilities was faulty for 344 hours. The calculated CCDP was 1.1E-7.





	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OL1	26.1	4.0	171.4	13.1	5.9	2.8	7.9	8.0	5.3	6.5
OL2	1.3	5.4	6.3	5.4	29.0	11.0	6.4	20.5	15.3	4.0

Olkiluoto

At OL1, in 2017 the risk caused by operational activities was of the same order of magnitude as in previous years. A brief description of the significant events is given below.

Olkiluoto 1:

1. Preventive maintenance of a diesel generator in the D train took 108 h. CCDP: 1.1E-07.
2. When the auxiliary feedwater system was tested, it was found that the isolation valve of train A failed to open. It was a latent fault. The valve was faulty for 507 hours. The calculated CCDP was 2.4E-7.

   Olkiluoto 2:

1. Preventive maintenance of a diesel generator in the B train took 110 h. CCDP: 1.0E-07
2. Preventive maintenance of a diesel generator in the D train took 109 h. CCDP: 1.1E-07.

A.II.4 Accident risk at nuclear power plants

Definition

As the indicator, the annual probability of an accident leading to severe damage to nuclear fuel (core damage frequency) is monitored. The accident risk is presented per plant unit.

Source of data

The data is obtained as the result of probabilistic risk assessments (PRA) of the nuclear power plants. The PRA is based on detailed calculation models, which are continuously developed and complemented. A total of 200 man-years have been used at Finnish NPPs to develop the models. The basic PRA data includes globally collected reliability information of components and operator activities, as well as operating experience from the Finnish NPPs.

Purpose

The indicator is used to follow the development of the nuclear power plant's accident risk. The objective is to operate and maintain the plant in such a manner that the accident risk decreases or remains stable. Probabilistic risk assessments can assist in detecting a need to make modifications to the plant or revise the operating methods.

Interpretation of the indicator

When assessing the indicator, one must keep in mind that it is affected by both the development of the nuclear power plant and the development of the calculation model. Plant modifications and changes in methods, carried out to remove risk factors, will decrease the indicator value. An increase of the indicator value may be due to the model being extended to new event groups, or the identification of new risk factors. Furthermore, developing more detailed models or obtaining more detailed basic data may change the risk estimates in either direction. For example, an increase in the Loviisa indicator in 2003 was due to the PRA being extended to cover exceptionally harsh weather conditions and oil accidents at sea during a refuelling outage. In the following year, the indicator value decreased, partly as a result of a more detailed analysis of these factors.

Loviisa

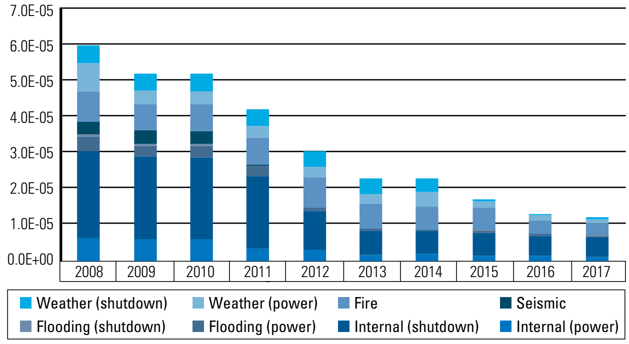
Accident risk of the Loviisa nuclear power plant has continued to decrease over the last ten years, and new risk factors, discovered as the scope of the PRA has been extended, have been efficiently eliminated. The indicator decreased in 2007 due to a new service water line completed during the period. The new line allows for the alternative intake of seawater from the outlet channel to cool the plant when it is at a shutdown. The change decreased the risks in situations where algae, frazil ice or an oil spill endangers the availability of seawater via the conventional route. A decrease of the indicator in 2008 and in the following years resulted from more detailed assessments performed in conjunction with the renewal of the operating licence, as well as changes at the plant planned to be carried out earlier or in connection with the licence renewal. Such changes include decreasing the probability of a criticality accident using, for example, boron analysers, and decreasing the probability of an external leak. At the end of 2017, the core damage frequency or annual probability of core damage calculated with the PRA model for Loviisa 1 was around $1.2{\cdot}10^{-5}$/year, which is around 8% less than in 2016 ($1.3{\cdot}10^{-5}$/year). The core damage frequency for Loviisa 2 was $1.5{\cdot}10^{-5}$/year, which is 6% less than in 2016 ($1.6{\cdot}10^{-5}$/year). The difference between the plant units' risk assessments is due to differences in ventilation and air conditioning systems that contain safety systems, for example. The following plant modifications and changes in procedures reduced the risk in 2017: 1) the rest of the RC stations were also replaced by oil-free ones, which reduced the core damage risk due to fires by $2{\cdot}10^{-7}$/a at LO1 and by $8{\cdot}10^{-8}$/a at LO2; 2) a priority system for accident management at both plant units; 3) the last temporary dam will be replaced by sluices during the 2018 annual outage, the building of temporary dams no longer has to be taken into account in the risk assessment for 2017; 4) filling the sea water channels before raising the sluices reduced the risk by $8{\cdot}10^{-8}$/a; 5) opening the steam generator -specific emergency feedwater valves in advance in case of high seawater levels.

Olkiluoto

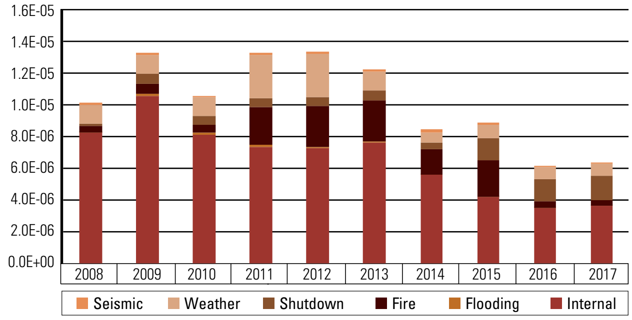
The indicator for the Olkiluoto nuclear power plant decreased by approximately 30% in 2008 compared to previous years' relatively stable values. The decrease was mainly due to the more detailed modelling of earthquake events and changes carried out at the plant to improve seismic qualification. The increase in 2009 was due to the fact that a heat exchanger in the screening system could not be used for residual heat removal after all, contrary to earlier assessments. The decrease of the risk in 2010 was due to changes in the modelling of DC systems 672 and 679 (inclusion of battery diversity), while the increase in 2011 resulted from reassessment of fire frequencies. At Olkiluoto, the most important factors affecting the overall accident risk include internal events during power operation (component failures and pipe ruptures leading to an operational transient).

At the end of 2017, the calculated core damage frequency for OL1 was $0.64{\cdot}10^{-5}$/year, i.e. more or less the same as in 2016. At the end of 2017, the calculated core damage frequency for OL2 was $1.1{\cdot}10^{-5}$/year, i.e. also more or less the same as at the end of the previous year. The addition of planned isolations to the PRA models has caused a slight change in the core damage frequencies. The difference between the plant units is mainly caused by the fact that OL1 underwent modifications in 2014 that ensured operability of the auxiliary feedwater system, which is used to cool the reactor in case seawater cooling is lost because of a blockage at the seawater intake or due to component failures. Such modifications have not been implemented at OL2 yet.

Fluctuation of the calculated annual core damage frequency for Loviisa plant units during 2008–2017



Fluctuation of the calculated annual core damage frequency for Olkiluoto plant units during 2008–2017



A.II.5 Number of fire alarms

Definition

As indicators, the number of fire alarms and actual fires are monitored.

Source of data

Data for the indicators is collected from the power companies. The licensees submit the data needed for the indicator to the person responsible for the indicator at STUK.

Purpose

The indicators are used to follow the effectiveness of fire protection at the nuclear power plants.

Interpretation of the indicator

Loviisa

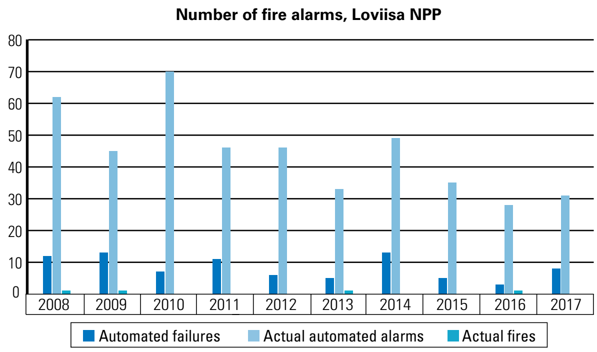
No events classified as fires occurred in the Loviisa plant area in 2017. There was one extinguishing operation outside the plant area, when the tracks of a forest machine created a small fire in the timber felling area by the Atomitie road approximately 500 metres from the gatehouse towards the town. Initial extinguishing had been carried out when the plant's fire brigade arrived and ensured the fire was extinguished by watering the terrain. The number of fire detection system faults and the number of actual alarms made by fire detectors at the Loviisa nuclear power plant have remained stable for the past ten years. Alarms from the fire detection system have also remained at a relatively low level. Most of the alarms were caused by dust, smoke or humidity. Advance alarms issued by the fire detection system are no longer included in these statistics.

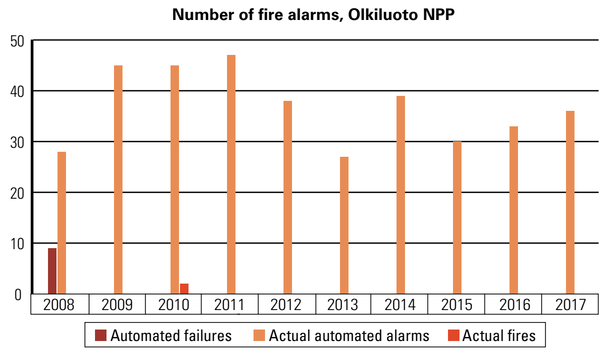
The average fire safety of the Loviisa nuclear power plant has remained at around the same level. There have been four events classified as fires at the Loviisa plant site in the past ten years. The number of alarms from the fire detection system is affected by the amount of maintenance and repair work performed at the nuclear power plants. Fire detection systems are not always disconnected in a wide enough area during maintenance work.

Olkiluoto

No events classified as fires occurred at the Olkiluoto nuclear power plant area (OL1/OL2) in 2017. Two small fires occurred outside the plant area. A fire ignited in a woodworking shop in the outdoor area when the blade of a circular saw hit a screw in a plank. The plant's fire brigade extinguished a fire smouldering in the sawdust hose and silo of the circular saw. Another small fire started at Posiva's disposal facility, when a bearing in the track roll of an excavator overheated. Initial extinguishing had been carried out when the plant's fire brigade arrived and completed the extinguishing. No fire detection system faults were observed at the Olkiluoto power plant (OL1/OL2) in 2017. No faults were observed during the eight past years, either. Correct alarms of the fire detection system have remained at a fairly low level over the past ten years. This lower trend started after the year 2007. Advance alarms issued by the fire detection system are no longer included in these statistics.

The average fire safety of the Olkiluoto nuclear power plant has remained at around the same level. The trend of events classified as fires in Olkiluoto is decreasing: the last event classified as a fire occurred at the plant area (OL1/OL2) seven years ago. The number of alarms from the fire detection system is affected by the amount of maintenance and repair work performed at the nuclear power plants. Fire detection systems are not always disconnected in a wide enough area during maintenance work.





A.III Structural integrity

A.III.1 Fuel integrity

Definition

As indicators, the plant unit-specific maximum level and the highest maximum activity value of the iodine-131 activity concentration (I-131 activity concentration) in the primary coolant in steady-state operation (startup operation or load operation for Loviisa and load operation for Olkiluoto) are followed. The change in activity concentration of I-131 in primary coolant due to depressurisation in conjunction with shutdowns or reactor trips and the number of leaking fuel assemblies removed from the reactor are also followed as indicators.

Source of data

The licensees submit the indicator values directly to the person in charge of the indicator at STUK. The maximum activity levels are also available in the quarterly reports submitted by the power companies.

Purpose

The indicators describe fuel integrity and the fuel leakage volume during the fuel cycle. The indicators for shutdown situations also describe the success of the shutdown in terms of radiation protection.

A.III.1a Primary circuit activity

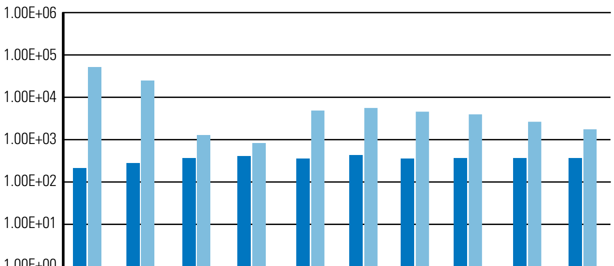
Interpretation of indicators (Loviisa)

There were no leaking fuel assemblies in the reactors of LO1 or LO2 in 2017. The last time a leaking fuel assembly was removed from the LO1 reactor was in 2010, and the last time a leaking fuel assembly was removed from LO 2 was during the annual outage of 2013. As a result of these measures, the maximum activity (I-131) of the primary coolant has remained low. The indicators describing fuel integrity have remained at a good and stable level in 2014-2017.

Interpretation of indicators (Olkiluoto)

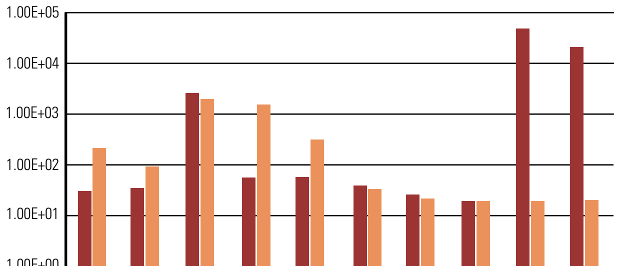
One fuel assembly was removed from the OL1 reactor in 2017, and the primary coolant activity level caused by iodine-131 at Olkiluoto 1 was elevated. Leaking fuel assemblies were last detected at Olkiluoto 1 in 2016. In 2017, the primary coolant activity caused by I-131 was at the same level as in 2016.

Fuel integrity:
Iodine (I-131) maximum activity concentration level of primary coolant (kBq/m³) in power operation, Loviisa NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LO1	2.00E+02	2.60E+02	3.80+02	3.90E+02	3.70E+02	4.00E+02	3.50E+02	3.40E+02	3.41E+02	3.38E+02
LO2	4.90E+04	2.40E+04	1.20+03	8.50E+02	4.71E+03	5.40E+03	4.60E+03	3.90E+03	2.52E+03	1.70E+03

Fuel integrity:
Iodine (I-131) maximum activity concentration level of primary coolant (kBq/m³) in power operation, Olkiluoto NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OL1	3.00E+01	3.50E+01	2.45E+03	5.50E+01	5.58E+01	3.92E+01	2.55E+01	1.92E+01	5.23E+04	2.14E+04
OL2	2.10E+02	9.10E+01	1.87E+03	1.46E+03	3.03E+02	3.43E+01	2.13E+01	1.94E+01	1.90E+01	2.00E+01

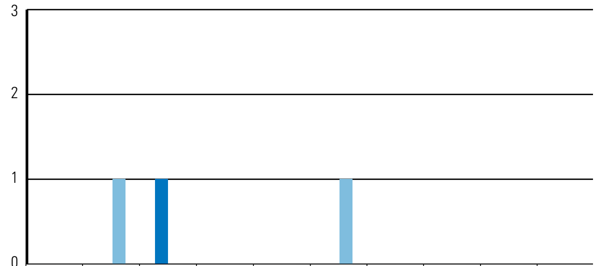
A.III.1b Number of leaking fuel assemblies

All leaking fuel assemblies are removed during annual outages. Both licensees use an external party when identifying leaking assemblies. This means that a subcontractor handles the actual equipment and provides the operators, but the plant's own radiochemistry laboratory analyses the water samples from the reactor. The leaking fuel assembly is identified based on the analysis results.

Interpretation of indicators (Loviisa)

There were no leaking fuel assemblies in the reactors of LO1 or LO2 during the period under review.

Number of leaking fuel bundles removed from the reactor, Loviisa NPP

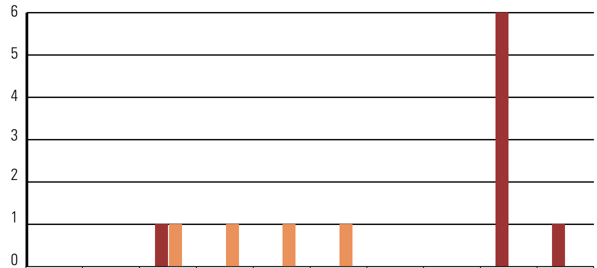


	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LO1	0	0	1	0	0	0	0	0	0	0
LO2	0	1	0	0	0	1	0	0	0	0

Interpretation of indicators (Olkiluoto)

There was one leaking fuel assembly in the reactor of OL1 in 2017. The leaking fuel was removed from the reactor during a cold outage in October. The damage is thought to have been caused by a foreign particle. The chemical target limits of were momentarily exceeded due to the leaking fuel. There was no leaking fuel in the reactor of OL2 in 2017. The fuel leak of OL1 is discussed in Appendix 3 to this report.

Number of leaking fuel bundles removed from the reactor, Olkiluoto NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OL1	0	0	1	0	0	0	0	0	6	1
OL2	0	0	1	1	1	1	0	0	0	0

A.III.3 Containment integrity

Definition

As indicators, the following parameters are monitored:

- Total as-found leakage of outer isolation valves following the first integrity tests compared with the maximum allowed total leakage from the outer isolation valves.
- Percentage of isolation valves tested during the year in question at each plant unit that passed the leak test at the first attempt (i.e. as-found leakage smaller than the acceptance criteria of the valve and no consecutive exceeding of the attention criteria of a valve without repair).
- Combined as-found leakage rate of containment penetrations and airlocks in relation to their maximum allowed total leakage. The combined leakage rate at Olkiluoto includes leaks from personnel airlocks, the maintenance dome and the containment dome. At Loviisa, the combined leakage rate comprises the leak test results from personnel airlocks, the material airlock, cable penetrations of inspection equipment, containment maintenance ventilation systems (TL23), main steam piping (RA) and feedwater system (RL) penetrations; seals of blind-flanged penetrations in ice-filling pipes are also included.

Source of data

Data is obtained from the power companies' leak-tightness test reports that are submitted by the licensees to STUK for information within three months from the completion of an annual outage. STUK calculates the total as-found leakages, as the reports give total leakages as they are at the end of the annual outage (i.e. after the completion of repairs and re-testing).

Purpose

The indicators are used to monitor the integrity of containment isolation valves, penetrations and airlocks.

Interpretation of the indicator

Loviisa

Based on the indicators, containment integrity at the Loviisa units is good.

Total leakage of the outer isolation valves compared to the maximum allowed total leakage has increased at both plant units. The as-found leakage of both units remains clearly below the set limit.

The number of isolation valves passing the leak test in the first attempt has decreased in both plant units but is still at a good level. The leaking isolation valves have been repaired so that they meet the operational limits and conditions.

The overall as-found leakage rate of containment penetrations and airlocks has remained low at both plant units.

Olkiluoto

Based on the indicators, containment integrity at the Olkiluoto units is good.

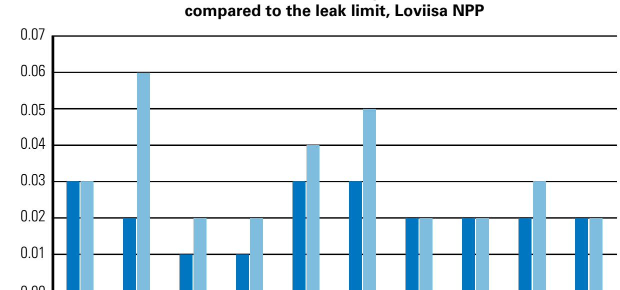
The total number of found leakages of outer isolation valves at OL1 have increased but are still low and remain clearly below the below the limit set for overall found leakage in the OLC.

The overall found leakages of outer isolation valves at OL2 had decreased from the previous year, and were clearly below the limit set in the OLC.

The percentage of isolation valves that passed the leak test at first attempt remained high for both plant units. The percentage decreased somewhat at OL1 and increased somewhat at OL2. The leaking isolation valves have been repaired so that they meet the operational limits and conditions.

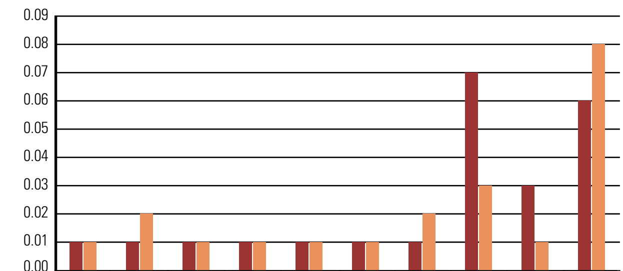
The total found leakage rate of containment penetrations, for which TVO includes leakages in the upper and lower personnel airlocks, the maintenance dome and the containment dome, was low at both plant units.

compared to the leak limit, Loviisa NPP



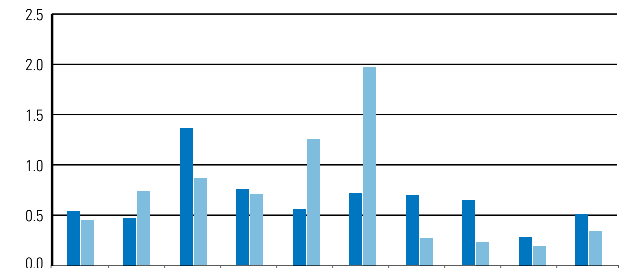
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LO1	0.03	0.02	0.01	0.01	0.03	0.03	0.02	0.02	0.02	0.02
LO2	0.03	0.06	0.02	0.02	0.04	0.05	0.02	0.02	0.03	0.02

Combined leak rate of containment penetrations and air locks compared to the leak limit, Olkiluoto NPP



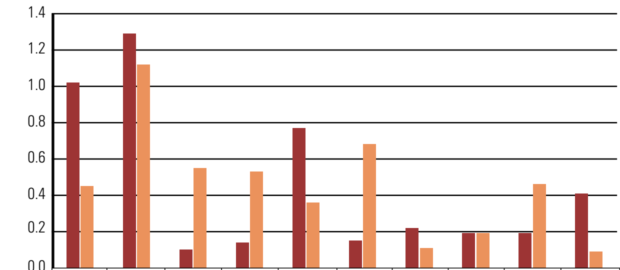
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OL1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.03	0.06
OL2	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.03	0.01	0.08

The overall as-found leakage of outer isolation valves compared with the highest allowed overall leakage of outer isolation valves, Loviisa NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
LO1	0.54	0.47	1.37	0.76	0.56	0.72	0.70	0.65	0.28	0.51
LO2	0.45	0.74	0.87	0.71	1.26	1.97	0.27	0.23	0.19	0.34

The overall as-found leakage of outer isolation valves compared with the highest allowed overall leakage of outer isolation valves, Olkiluoto NPP



	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
OL1	1.02	1.29	0.10	0.14	0.77	0.15	0.22	0.19	0.19	0.41
OL2	0.45	1.12	0.55	0.53	0.36	0.68	0.11	0.19	0.46	0.09

APPENDIX 3 Significant events at nuclear power plants in 2017

Loviisa nuclear power plant

Annual outages at Loviisa, 6 August – 20 September 2017

The annual outages of the plant units were implemented as planned in terms of nuclear and radiation safety. This year, both units had short annual outages where Fortum carried out a refuelling operation in deviation from the normal regime, as well as several modification operations – the most significant ones being installations of the ELSA I&C renewal project for which phase 2 was implemented for both units. The plan is to complete the I&C renewal during the 2018 annual outage.

The annual outage inspections were carried out on schedule and in the planned scope. The ultrasonic inspection of reactor pressure vessel nozzles, carried out for the first time during the 2016 annual outage, was repeated on STUK's request this year for both plant units, because in 2016 the inspection method gave a deviant result for one nozzle at Loviisa 1. Now the same Loviisa 1 nozzle that had given the deviant result was inspected, together with all similar nozzles at Loviisa 2. The inspection result at Loviisa 1 had not changed, and no indications were observed in the nozzles in Loviisa 2. The current magnitude of the indication in the Loviisa 1 nozzle does not affect the safe use of the reactor pressure vessel. Fortum monitors the condition of the reactor pressure vessels in compliance with the inspection programme approved by STUK.

The radiation doses of the employees who participated in the annual outages remained well below the dose limits set in the Radiation Decree and the target levels set by Fortum. The radiation dose rates measured from the primary circuit at Loviisa 1 were lower than in the previous year and the combined radiation dose of the plant unit's employees, 186 mmanSv, was the lowest ever measured for the plant unit.

Radioactive materials did not pose any danger outside the plant either. STUK is monitoring the

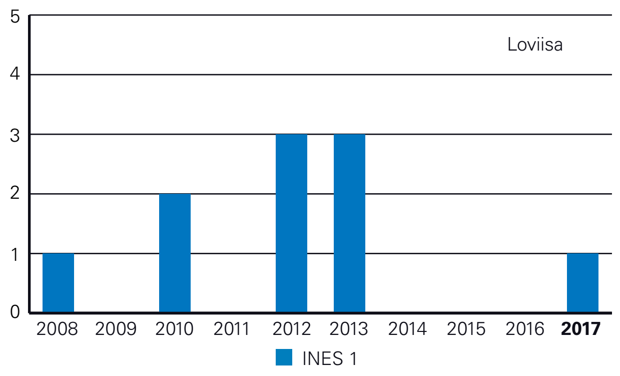


Figure A3.1. INES classified events at the Loviisa plant (INES Level 1 or higher).

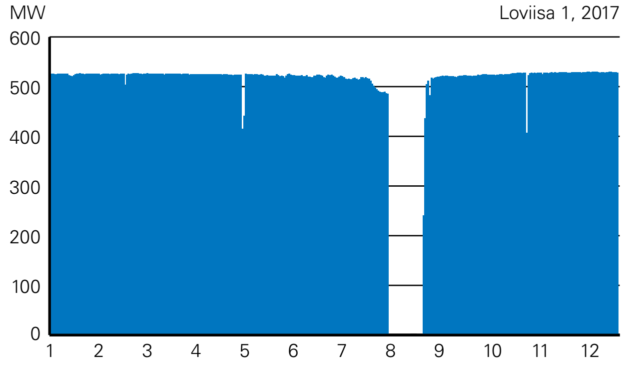


Figure A3.2. Daily average gross electrical power of the Loviisa 1 plant unit in 2017.

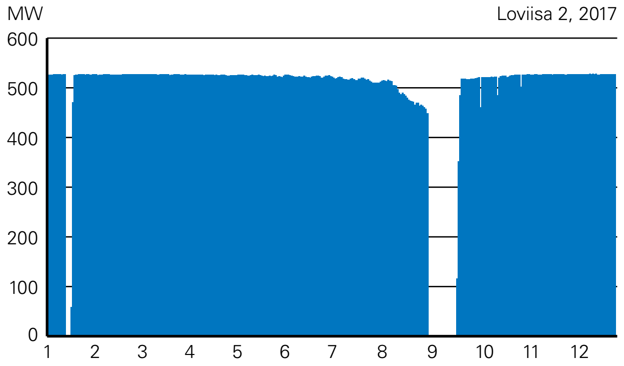


Figure A3.3. Daily average gross electrical power of the Loviisa 2 plant unit in 2017.

radioactivity in the surroundings of the Loviisa nuclear power plant by regularly taking samples from the air, soil and sea. The measurements did not indicate the presence of any radioactive substances that would pose a hazard to people or the environment.

Approximately 30 experts from STUK oversaw the annual outages. They ensured that Fortum managed the radiation and nuclear safety and carried out the maintenance work in a safe manner. STUK also oversaw the activities of the organisation in the annual outage and carried out an inspection of the annual outages under the periodic inspection programme. With this inspection, STUK verified that there are instructions for the operations, the instructions are being followed and the instructions are up to date. No safety deficiencies that require STUK's immediate action were observed during the inspection. A summary of the inspection is presented in Appendix 4. In addition, STUK oversaw the transfers of fuel which were carried out in compliance with the new procedure.

Fall of a fresh fuel assembly in the fuel transfer pool of Loviisa 2

The most significant operational event in 2017 was the fall of a fresh nuclear fuel assembly in the fuel transfer pool on 28 February 2017. The event was rated as an INES category 1 event. The event did not compromise nuclear or radiation safety, but it did reveal obvious deficiencies in the power company's activities and in the condition of the refuelling machine.

In the event, transfers of fresh nuclear fuel assemblies were carried out in the reactor hall of Loviisa 2 on 28 February 2017. The fresh fuel assemblies were first brought in a fuel transport basket to the interim storage pool intended for the reactor hall transfer vessels. From there, the refuelling machine moved them one by one to the reloading pool where all the fresh fuel required for the next reactor refuelling are collected. The employees performing the transfers did not notice that one fresh fuel assembly remained caught in the gripper mechanism in the refuelling machine mast as it was being transferred to the reloading pool. This was only noticed when attempting to fetch the next assembly from the transfer basket. The employees decided to move the assembly still caught in the gripper mechanism to a vacant space in the transfer basket. As they started lowering the refuelling machine mast, the fuel assembly fell off the gripper mechanism and landed in the fuel basket approximately three meters below. The refuelling operation was suspended, and Fortum carried out extensive inspections of the fuel, transfer basket and refuelling machine. The fuel assembly that fell into the transfer basket did not break – its lower end was just deformed, and the support structure of the transfer basket bottom was bent. A surface defect was observed in the affixing surface of the gripping mechanism, possibly causing the jamming.

As this was fresh fuel, there was no radiation hazard, but as similar transfers are also carried out for spent fuel, the event was significant. Similar mistakes have been made in fuel handling at the Loviisa NPP in recent years. Due to the situation, STUK sent a request to Fortum, stating that Fortum can only continue fuel transfers after STUK has assessed the rectifying actions proposed by Fortum as sufficient for preventing similar events.

The inspections and necessary immediate rectifying actions specified by Fortum were acceptably completed, and the personnel were provided with additional training before the operations could continue with STUK's permission on 18 April 2017. In addition, STUK carried out an operational control inspection regarding refuelling activities in the summer for ensuring that the long-term development actions promised by Fortum have progressed and monitored the activities during annual outage.

On the basis of processing and investigating the matter, it is obvious that Fortum has significantly reformed its refuelling methods. The refuelling machine modernisation project has also been considerably progressed. The organisational change related to reforming the refuelling activities is to enter into force from the beginning of 2018. STUK will monitor the effects of Fortum's organisational change in its inspection in 2018 and ensure through its other oversight activities that the refuelling machine modernisation project advances and the lessons of the event are taken into account in the activities.

Furthermore, STUK carried out its own internal investigation regarding its activities concerning the event in order to develop its activities during the next strategy period. The investigation was completed at the end of 2017 and resulted in recommendations regarding the oversight of transfer and lifting equipment as well as regarding the oversight processes of STUK in general.

Olkiluoto nuclear power plant

Annual outages at Olkiluoto, 23 April – 17 July 2017

The annual outages at Olkiluoto began on 23 April 2017 when TVO shut down the Olkiluoto 1 plant unit for refuelling. In the annual outage of plant unit 1 ending on 1 May, TVO carried out the normal maintenance operations for an annual outage, replacing, among other things, approximately one-fifth of the fuel with fresh fuel. The annual outage of the Olkiluoto 2 plant unit began on May 10 and had a longer duration than normal maintenance outages due to extensive maintenance and repairing operations. During the outage, TVO carried out other operations in addition to normal maintenance and refuelling, for example an extensive operation where the reactor coolant pumps were replaced. TVO replaced all six reactor coolant pumps and their frequency converters with new ones. Furthermore, TVO carried out repairs in the reactor pressure vessel during the annual outage. The annual outages ended when Olkiluoto 2 was reconnected to the national grid on 17 July following the start-up permission granted by STUK.

The radiation doses of the employees who participated in the annual outages were well below both the dose limits set in the Radiation Decree and the dose limits set by the power company. Due to the large extent of the annual outage of plant unit 2, the collective occupational radiation dose was nevertheless higher than in the previous annual outage.

Radioactive materials did not pose any danger outside the plant either. STUK is monitoring the radioactivity in the surroundings of the Olkiluoto power plant by regularly taking samples from the air, soil and sea. No radioactive substances originating from the power plant were detected in the air samples taken from the surroundings of the power plant during the annual outage.

Approximately 30 experts from STUK oversaw the annual outages. They ensured that TVO managed the radiation and nuclear safety during the annual outage. STUK's oversight work always includes an inspection of the maintenance plan and on-site monitoring of the work. STUK also oversaw the activities of the organisation during the annual outage. This year, the annual outages involved a lot of work and challenges for TVO's organisation. During the annual outages, STUK also carried out an annual outage inspection included in the scope of the periodic inspection programme. The inspection indicated that the annual outage was completed safely and almost all the scheduled work was completed. No safety deficiencies that require STUK's immediate action were observed during the inspection. A summary of the inspection is presented in Appendix 4.

Repair of reactor pressure vessel nozzles

In the annual outage of Olkiluoto 2, the nozzles of the reactor pressure vessel commissioned in 1980 were repaired using a method never before used in Finland. TVO had noticed cracks when inspecting the reactor pressure vessel during earlier annual outages. The cracks were found in two welded joints of a reactor pressure vessel nozzle. TVO has inspected the nozzles every year and assessed the safety implications of the cracks. STUK has required TVO to investigate the reasons for the cracking and to propose actions for preventing the emergence of new cracks.

In 2016, STUK approved a plan submitted by TVO for proactive repairs of all reactor pressure vessel nozzles in Olkiluoto 1 and Olkiluoto 2. There are a total of ten nozzles in both plant units. The nozzles will be repaired by machining the weld from the inside and by welding new filler material into the joint using a material that is less susceptible to stress corrosion. The method has never before been used in Finnish NPPs. At the same time, TVO will repair the identified cracks in the nozzles.

TVO started the nozzle repair work according to the plan in the 2017 annual maintenance by repairing the cracks detected in plant unit 2. The reactor was emptied of fuel for the repair operation. The repair of the reactor pressure vessel nozzles

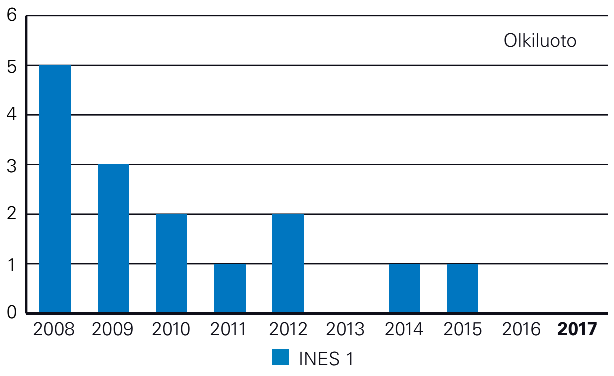


Figure A3.4. INES classified events at the Olkiluoto plant (INES Level 1 or higher).

was implemented on a smaller scale than planned. There were a lot of problems in the repair work, among others with the tools used for machining and welding. TVO decided to only repair during the annual outage the two nozzles where cracks had been detected in earlier annual outages. No cracks have been detected in the other eight nozzles. STUK oversaw the repair work on site and inspected and approved the results.

At the end of 2017, TVO submitted an application to STUK for acceptance regarding an amendment to the policy of proactive repairs of pressure vessel nozzles. TVO proposes that the proactive nozzle repairs at the plant units are discontinued. TVO will continue to ensure the operability of nozzles by carrying out regular inspections under the periodic inspection programme. Furthermore, TVO will maintain repair capabilities for the eventuality of new nozzle repairs. STUK will process TVO's application during the beginning of 2018.

Unscheduled refuelling outage at Olkiluoto 1

The first indication of a fuel leak was detected at Olkiluoto 1 during exhaust gas system measurements on 18 July 2017. Approximately one-fifth of the fuel cycle had been run when the fuel leak was detected. TVO monitored the activity in the exhaust gas system with measurements and noted that the activity level continued to increase. TVO assessed that it would be impossible to run for the entire fuel cycle when the fuel leak rate increased significantly during September–October. TVO decided on 11 October 2017 to shut the plant unit down for an extra refuelling outage. The refuelling outage began on 18 October 2017 as the fuel leak had continued for three months.

During the refuelling outage, TVO checked all fuel assemblies in the reactor for their tightness. TVO located and removed one leaking fuel assembly from the reactor. TVO aims to establish the root cause of the leak in the inspections to be carried out when the assembly is repaired. The current plan is to carry out the repair in autumn 2018. The possibility of Pellet Cladding Interaction (PCI) damage is excluded because the rod was undergoing the first cycle in the reactor where the gas gap between the pile of pellets and the cladding still remains open even at high linear power, which means that there is no tensile stress that would facilitate the progress of a PCI fracture. No significant pulls of the control rods were carried out at the time the leak was detected, and the leaking rod was also a long way from the control rod.

TVO also inspected the manufacturing history of the fuel rod and found nothing exceptional about it. The probability that the leak was caused by a manufacturing error appears small. TVO has assessed that the most probable cause of the leak is damage caused by a foreign particle. International operating experience shows that this is the most common type of damage with all fuel suppliers.

These factors lead to the assessment that the damage to the assembly had no connection with the fuel leaks that occurred in 2016. Instead, this leak seems to be an isolated incident. As part of its continuous oversight, STUK monitors the work carried out by TVO and the fuel supplier for establishing the root cause.

The event was rated at level 0 on the international INES scale because it had no significance to nuclear or radiation safety. The event did not have any impact on the safety of the plant, the employees or the environment.

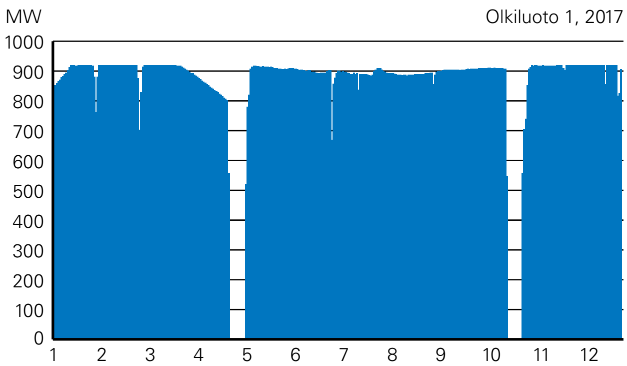


Figure A3.5. Daily average gross power of the Olkiluoto 1 plant unit 2017.

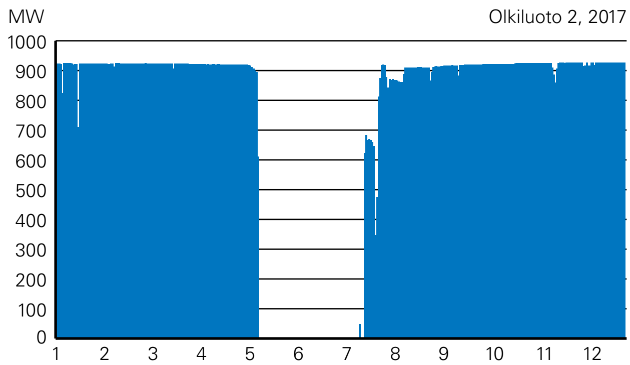


Figure A3.6. Daily average gross power of the Olkiluoto 2 plant unit 2017.

APPENDIX 4 Periodic inspection programme of nuclear power plants 2017

Inspections included in the periodic inspection programme focus on safety management, operational main processes and procedures, as well as the technical acceptability of systems. The compliance of safety assessments, operation, maintenance and protection activities with the requirements of nuclear safety regulations are verified with the inspections. No material deficiencies with an effect on the safety of the plant, the personnel or the environment were observed in the 2017 inspections.

	Inspections in 2017	
Basic programme	**Loviisa 1 and 2**	**Olkiluoto 1 and 2**
Personnel resources and competence		x*
Management and safety culture	x	x
Management system	x	x
Disposal facilities	x	
Chemistry		
Operating experience feedback	x	x
Operation		x
Plant maintenance**		
Fire protection		x
Utilisation of the PRA	x	
Structures and buildings	x	
Radiation protection	x	x
Nuclear security	x	x
Safety planning		x
Safety functions	x	x
Emergency preparedness arrangements	x	x
Reactor waste		x
Annual outage	x	x
Nuclear safeguards		
Special subjects		
Establishing the reason for operational events and impact of the actions		x

* The inspection of human resources and competence was carried out in cooperation with the construction inspection programme of Olkiluoto 3.

** In exemption from the normal cycle of the basic programme, no plant maintenance inspection was carried out in 2017. The subject was comprehensively reviewed as the licensees' updates to the ageing management programme were processed, as well as through the 2017 peer assessment of ageing management, compliant with EU's Nuclear Safety Directive.

Matters concerning Olkiluoto 3 can also be reviewed in the periodic inspection programme of Olkiluoto if the matters to be reviewed are common for the whole of TVO, not merely plant unit -specific.

Inspections of the periodic inspection programme at Loviisa nuclear power plant

Management and safety culture, 13–15 February 2017

Fortum changed the structure of its organisation in 2016. In the inspection, STUK investigated how Fortum is managing the change, how the organisation sets its goals and how it uses key indicators and safety indicators for measuring results. The procedures for assessing and developing the safety culture were also investigated in the inspection.

The inspection indicated that the plant organisation at Loviisa has primarily had a positive attitude towards the organisational change, and no significant situations hampering operations have emerged. However, STUK issued a requirement that the licensee must develop its procedures related to monitoring the safety impacts of changes. Furthermore, the new organisation has functions closely associated with nuclear and radiation safety in different units, which is why STUK required that the instructions should describe how the Nuclear Safety Unit obtains an up-to-date picture of them. The plant organisation monitors the results of activities using a multi-level indicator system where safety is included. Both the plant management and the licensee's management monitor safety by monitoring the indicators. There are many actions in progress at the plant for developing and assessing the safety culture, but the relations between the actors and the overall coordination need to be further developed. STUK issued a requirement for updating the safety culture programme and for ensuring that an overall picture of the current state of the safety culture is obtained.

Management system, 19–20 October 2017

The inspection covered functionality of the licensee's integrated management system from the perspective of nuclear and radiation safety. It was investigated in the inspection how the licensee produces its management system, observes it in its activities, assesses and develops it. In 2017, the inspection concentrated on supplier audits, assessments and approvals by the licensee, document management and assessment of the management system (including internal and external audits and self-assessments). Before the inspection, the persons conducting supplier audits were interviewed regarding audit procedures and supplier approval. In addition, STUK monitored the basic training in document management at Fortum.

The inspection indicated that the supplier auditors of the Loviisa power plant are familiar with the audit procedures observed in Loviisa. The findings of the inspection indicate that the supplier audit procedure and assessment and approval of suppliers at Loviisa was compliant with the procedures established for Loviisa. Regarding document management, the procedures observed at the plant were reviewed, and e.g. the results of an internal audit concerning document management were verified. In the inspection, the covering letters of documents sent to STUK were discussed. STUK noted that the covering letter template used in Loviisa only has limited guiding effects. There have been deficiencies in the covering letters, and STUK brought these up in the inspection. A requirement was issued regarding the matter, according to which Fortum has to develop its covering letters and the way they are drawn up. In addition, the internal audits, self-assessments and external audits regarding operations in Loviisa were reviewed in the inspection. The inspection verified that the operations have been active and compliant with Loviisa's procedures.

Disposal facilities, 27–28 September 2017

The inspection assessed whether the disposal facilities for operational waste (the VLJ repository) at the Loviisa power plant and their use comply with the general safety principles of nuclear waste management and with the official requirements. The inspection also included the results and conclusions from the licensee's self-monitoring and the monitoring programme regarding bedrock and groundwater around the operational waste disposal facility. The organisation-related part of the inspection focussed on the processes developed for Fortum related to the use of the VLJ repository and to the monitoring programme. This year, the visit to the VLJ repository during the inspection also included a visit to maintenance waste facilities (HJT1–3). Particular attention was paid in the inspection to the reinforcements of the solidified waste facility (KJT) and its arch.

Fortum has clearly developed many matters compared to the situation in the equivalent inspection in 2015 including: the production of process charts related to the VLJ repository, development of monitoring-related alert and action limits, development of a systematic approach to ageing management, development of the representativeness and reliability of monitoring results from different fields of science, common interpretation of monitoring results from different fields of science, as well as significant reductions in the amount of operational waste, among other things by developing sorting and packaging methods. STUK recorded several positive observations, as well as observations regarding matters that could be further developed. Three requirements were issued in the inspection, all concerning the planning of inspection of the reinforcement of the condition and adhesion of shotcrete in the solidified waste facility, performance of the inspection work, repair of points possibly requiring repairs as well as planning the ageing management of the solidified waste facility for the entire service life of the facility. The solidified waste facility was excavated 20 years ago, and the arc of the facility has never been inspected in the manner required since it was excavated. The actions on the solidified waste facility are much easier to carry out now than after intermediate-level waste has been brought to the facility. STUK will inspect the implementation of the requirements before the commissioning inspection of the solidified waste facility.

Operating experience feedback, 6, 11 and 13 April 2017

In the inspection of operating experience feedback, STUK satisfied itself that the requirements specified in the Guide YVL A.10 had been fulfilled. Furthermore, STUK targeted the inspections so that the July 2016 organisational change at Fortum was taken into account. The organisational change resulted in several changes of persons and job descriptions regarding operating experience feedback. In its inspection, STUK primarily reviewed the sufficiency of Fortum's human resources, the competence development of new employees, as well as documentation and functionality of the feedback procedures concerning operating experience. STUK carried out the inspection by studying Fortum's instructions and by examining the results of event interpretations. In addition, STUK interviewed Fortum's employees, monitored the activities and verified documents required in Fortum's instructions.

Fortum has reserved sufficient human resources for managing the internal and external operating experience feedback. Fortum has established procedures for identifying and investigating events at the Loviisa power plant and for processing the events taking place at other plants. The procedures are under continual development. STUK observed some development needs that need to be met to achieve full compliance with the requirements of Guide YVL A.10. On the basis of inspection findings, STUK issued requirements related, among other things, to learning from events at the Loviisa power plant and other plants, competence development of new personnel and implementation of own event interpretations.

Utilisation of the PRA, 23 November 2017

The inspection concerned the utilisation of the probabilistic risk assessment (PRA) in safety management inspection, the current status of PRA models and applications, the expansions being prepared and the development of PRA results. The inspection also covered the licensee's PRA organisation, resources and guidelines. Organisational PRA processes were also assessed. The modelling of internal floods and fires in certain premises were discussed as separate issues.

The PRA model has been extensively updated over the course of the past two years. The Loviisa 2 plant unit model has been further developed, and the work will continue in 2018. The software used for the PRA has also been developed. PRA applications have been produced, e.g. for different change projects and to support the licensee's decision-making processes. The PRA level 2 analysis will be supplemented at the end of 2017 with an early emission analysis, and the PRA will be extended in 2018 to cover spent fuel storage in compliance with the requirements of the implementation decision regarding Guide YVL A.7. The licensee is using the PRA as planned and in a versatile manner to support safety management. STUK did not pose any requirements on the licensee based on the inspection.

Structures and buildings, 11–12 April 2017

The inspection focussed on the steel and concrete structures of buildings, their condition monitoring, maintenance instructions, the inspections and repairs carried out, and examined the ageing management procedures and procedures related to modification work.

The inspection verified the implementation of management system processes and the actions taken as a consequence of implementing YVL Guide instructions. Furthermore, the existing instructions, repairs and results of the periodic inspection were revised. It was also verified that feedback reports on international operating experiences have been utilised to a sufficient level of accuracy in meetings and that there was comprehensive participation from all essential parties.

One requirement was issued in the inspection. It concerned the planning and scheduling of a repair that was mentioned in the periodic inspection report and was classified as significantly urgent. Two earlier requirements remain open. They concern an instruction update and carrying out a risk assessment for repair work. The records reviewed indicate that the day-to-day operations of the Maintenance Unit are appropriate. The unit systematically collects comments and observations for the purpose of updating instructions. Electronic work and information management systems also support the activities of the personnel.

Radiation protection, 25–26 October 2017

This year, the inspection concerning radiation protection focussed on measuring radiation at the nuclear power plant. The special inspection subject in this year's inspection was the monitoring of emissions and radiation measurement instruments.

The inspection reviewed the management of radioactive emissions to the aquatic environment and air from the Loviisa power plant and examined the responsibilities from sampling to reporting. Although the emission management responsibilities are described in the power plant's instructions, STUK nevertheless required Fortum to update and further specify the responsibilities in its documentation. STUK also requires a report of the actions with which Fortum intends to improve contamination management in sampling and sample processing. STUK recommended that the qualifications of sampling staff should be ensured and developed. The fairly extensive review round of emission reports before their approval and the analyses of trends in the results for detecting any deviations were considered to be a good practice.

In the inspection, STUK found that some fixed radiation meters had very few spare parts in stock. Although the situation has not been critical lately, STUK recommended that Fortum should pay attention to the spare parts situation for instruments and to the increasing failure risk due to ageing instruments. Fortum has appropriately taken care of the renewal of portable measuring instruments and their suitability assessments.

In the inspection, STUK presented two requirements and eight observations, from which the power company will assess any development actions.

Nuclear security, 27–28 October 2017

The inspection of nuclear security was mainly implemented in two parallel working groups: one for conventional (physical) security arrangements and the other for information security. In these two working groups, an inspection was carried out extensively, including the structural, operative and organisational security arrangements of the nuclear power plant.

Two requirements were issued in the inspection. The actions due to the requirements issued in earlier inspections (for all 12 requirements in two separate inspections) had been appropriately carried out apart from one exception.

Safety functions, 8–9 January 2018

The inspection was postponed by just over one month from the originally scheduled time, which is why it was only performed in 2018. The inspection concerned one of the annually changed subjects, this time "Fuel cooling and residual heat removal". The systems constituting the main subject of the inspection were the sea water cooled residual heat removal system, and applying the diversity principle, the heat sink which is independent of sea water cooling that can be connected to it. The control room and field actions were reviewed during a site tour in compliance with the action instructions for the systems.

The situation regarding actions taken following the Fukushima nuclear power plant accident was also reviewed in the inspection, including plant modifications as well as impacts on instructions and training. In this context, e.g. the situation concerning the power supply modification to be implemented from a separate diesel generator to a diverse residual heat removal system was reviewed.

No requirements were imposed in the inspection. No open requirements were remaining from the previous inspection. A total of 12 observations were recorded in the inspection protocol, concerning, among other things, the operation of a separate diesel generator in cold conditions, the selection criteria of the most significant events compiled in ageing monitoring reports, the spare parts situation for many equipment locations and minor inaccuracies contained in the above instructions.

Emergency preparedness arrangements, 7 November 2017

The emergency preparedness arrangements inspection comprehensively covered the nuclear power plant's emergency preparedness arrangements. Issues that are regularly inspected include emergency preparedness guidelines, emergency preparedness facilities, emergency preparedness equipment, the emergency preparedness organisation and training for the emergency preparedness organisation. For emergency preparedness, equipment and facilities, the weather observation system, nuclide identification and facilities of the repair team were reviewed.

Two deputies approved by STUK have been in charge of arrangements for emergency preparedness at the Loviisa plant since the beginning of September. The plant has a plan for filling the position of the person in charge of these arrangements, and until that happens, the duties are handled by contingency arrangements. There have not been any major changes in the organisation of emergency preparedness during the period under review. Fortum has introduced a process-type arrangement for maintenance training concerning emergency preparedness. The arrangements include competence planning for emergency preparedness, induction training of personnel and planning emergency preparedness drills.

Fortum has expanded its weather observation system with a metering station out on the sea, at Orrengrund. The equipment damage at the new metering station caused by a lightning strike a short while after the system was commissioned has been repaired, and the reason for the measurement results deviating from those provided by the Finnish Meteorological Institute has been identified and rectified.

In compliance with the requirement issued during the previous inspection, Fortum has developed the contamination management arrangements at the command posts of the emergency preparedness organisation and integrated them into the emergency preparedness plan.

The inspection included a site walk-about during which the additional new premises for the emergency preparedness organisation were reviewed. The work has begun on preparing facilities for the emergency preparedness organisation repair team below the actual emergency preparedness centre in the space left empty after removal of the earlier emergency diesel generator. The facilities are now partly in use.

In the inspection, STUK issued four requirements, mainly concerning the arrangements for a police-led emergency preparedness situation, the audibility of alarms in the steam generator room and update of the emergency preparedness plan with the changed nuclide inventories. STUK also recorded three possible development subjects and two good practices. The good practices were related to the development of facilities for the emergency preparedness repair team and development of training process.

Annual outage, 6 August – 27 September 2017

The purpose of STUK's annual outage inspection is to verify that the licensee plans and implements annual outages in a safe manner in terms of radiation and nuclear safety and that the licensee uses staff with sufficient competence and provides adequate resources. STUK also performs general oversight of the plant site by means of regular site walk-arounds and overseeing the progress of planned work, for example. Furthermore, STUK oversees the way in which safety is prioritised in the licensee's decision-making process.

In 2017, the annual outage inspection of the Loviisa power plant was mainly implemented by interviewing employees using a questionnaire form prepared in advance. In its inspection, STUK verified that there were instructions for operations, and that the instructions are being followed and are up to date.

No deviations requiring STUK's immediate action were observed in the power plant's activities. Based on the inspection, STUK presented four observations to be assessed by the Loviisa power plant as potential development areas and issues to be continuously improved. The observation concerned the start-up meeting procedure, use of the plant's HUP procedures (taking the human factor into account), emphasis on safety in urgent work operations and knowledge of loose particle procedures.

The power plant also receives observations regarding its operations from other sources (such as internal audits). This way, the NPP is able to see the whole picture to assess whether the inspection observations include any new or recurring issues that require improvements or additional measures.

Inspections of the periodic inspection programme at Olkiluoto nuclear power plant

Management and safety culture, 23–24 March 2017

The inspection reviewed the status of the working atmosphere and safety culture at TVO, as well as actions taken by TVO's management for monitoring and developing them. The inspection also reviewed how TVO's management monitors the performance of the organisation using safety indicators and other key indicators.

It was found in the inspection that although TVO has functional procedures in place for assessing the working atmosphere, safety culture and overall picture of safety, the management does not appear to have a uniform view of the meaning of the results. Based on the inspection, STUK stated that TVO must immediately ensure that actions for developing the workplace atmosphere the and safety culture are sufficient. The organisation has challenges which may become problems, e.g. for carrying out demanding annual outages in the future and for commissioning the Olkiluoto 3 plant unit in a concentrated, smooth and safety-oriented manner. STUK issued two requirements: to present the results of workplace atmosphere surveys and rectifying actions to STUK, and competence development of TVO's personnel, particularly its management, for identifying the human and organisational factors associated with the safety culture.

Management system, 1–2 November 2017

The subjects reviewed were process indicators, risk management in projects and modification operations, as well as integration of the management system of the Olkiluoto 3 plant unit with TVO's operating system. In the inspection, persons from different levels of organisation and different units were interviewed, and material from the licensee's systems and documentation was verified.

Following the inspection, STUK issued four requirements. Among other things, it was found in the inspection that different project managers use different procedures for risk management. The understanding and uniform practices of risk management must be enhanced, e.g. through training, discussions, events for learning from experience, and the harmonization of practices. The allocation of risk handling responsibilities between project managers, project steering groups and the technical services steering group must be clarified. Furthermore, TVO must assess the risks of projects at every stage more extensively than the supplier, taking also into account the risks related to the organisations participating in the project and risks to the plant environment, for example.

Operating experience feedback, 9–10 February 2017

This was a follow-up inspection where STUK verified the situation of the requirements it had issued in the operating feedback experience inspection in 2016.

It was found in the inspection that TVO had initiated improvement measures regarding all inspection requirements. However, some of the changes in activities were minor and in some respects the situation was still much the same as a year ago. For this reason STUK deemed it necessary to repeat three requirements.

Furthermore, STUK noted that fulfilling some of the requirements of new YVL Guides A.10 and A.3 took one year, and fulfilling one of the requirements will take two years longer than the schedule proposed by TVO and approved by STUK. In the inspection, STUK required that even this requirement must be fulfilled by autumn 2017.

STUK took the view that the overall result of the inspection showed that TVO has failed to reserve sufficient time and resources for improving the activities concerning operating experience feedback and for developing the relevant personnel competencies. The observation concerns the management. STUK required TVO to provide a report on the appropriateness of organisation of the resources and work regarding operating experience feedback. A deadline was set so that the report can be taken into account when processing the application for operating licence renewal for Olkiluoto 1 and 2 and the statement request concerning the operating licence of Olkiluoto 3.

In the inspection, TVO presented results of its internal control procedures, showing that the challenges related to fulfilling the requirements of YVL Guides are more extensive. Internal control has informed the management of TVO of the observation. TVO's internal control procedure seem good. TVO identifies deviations important to safety itself and reacts to them.

Operational activities, 19–20 October 2017

The inspection of operational activities concerned the activities and resources of TVO's Operation Support Unit. Among other things, the unit is responsible for the maintenance and development of instructions and documents related to the operation of the plant units.

The purpose of the inspection was to establish the situation concerning the development of the operating instructions for the Olkiluoto 1 and 2 plant units, particularly with respect to instructions for disturbances and emergency situations. The inspection also verified the implementation of procedures which were compliant with the report concerning the renewal of the plant units' operating licences.

In the inspection, STUK found that the resource situation concerning the development work on operating instructions had been challenging due to several changes of staff and absences of personnel. However, the situation has improved following an increase in resources in late 2017. In the inspection, STUK found that there was scope for development in the validation procedure for instructions for disturbances and emergency situations, for example with regard to the independence and goals of validation. STUK did not issue a requirement on the matter, but it will monitor the validation procedures as part of its normal inspection activities.

At the end of 2017, TVO completed the systematic development work on instructions for disturbances and emergency situations that started in 2012. Completion of the development work was delayed by two years from the original plan. TVO intends to continue the development work in 2017–2019. The company has made a comprehensive survey of the subjects for development, and the development work has already started for some of them. However, the development work is not regularly monitored at TVO. STUK considers it important that the planned development actions are implemented in the planned time schedule.

Based on the inspection, STUK issued two requirements. TVO must check the paper printouts of instructions for transient and emergency situations kept in the main control room, emergency shutdown station, as well as in the facilities of the emergency preparedness team and support team for any printing errors. Checks must also be made when updating the said printouts. The requirements are based on a problem observed at TVO which means that the texts in flow diagrams are not shown in the documents due to a reason attributable to information technology. The checks must be continued until the problem is reliably solved.

Fire protection, 14–15 September 2017

The inspection focused on fire protection arrangements at the nuclear power plant, including structural fire protection, fire detection, extinguishing systems and operative fire protection. In the inspection, the efficiency of the NPP's fire protection arrangements and the power company's operations was assessed and the amendment plans for fire protection arrangements were analysed.

Following the inspection, it can be stated that the matters related to fire protection are generally in order. The organisation responsible for fire protection at TVO has been satisfied with the organisational change of 2015, and the necessary resources are available for carrying out the work according to the planned schedule. Minor modernisation and modification operations have been carried out on the sprinkler and fire detection systems. During the period under review, no significant cases of ignition have taken place in the plant units in operation.

No new requirements were issued on the basis of the inspection. Two positive observations were highlighted in the inspection. TVO's own fire protection audits were deemed to be of high quality. Furthermore, the mock-up workspace used in the occupational safety training organised by TVO was considered to be very useful for practical internalisation of matters.

Radiation protection, 14–16 February 2017

The radiation protection inspection focussed on the nuclear power plant's radiation protection, radiation measurements, as well as emissions and environmental monitoring. This year, special attention was paid to radiation measurements. The special focus of the inspection was the monitoring of emissions and portable radiation measurement instruments.

During the inspection, the parties had a general discussion on the types of temporary arrangements TVO has planned for situations where fixed radiation measurement instruments have to be replaced with contingency arrangements. STUK considered it important that clear instructions should be been issued for the contingency arrangements and that measurement instruments whose suitability for the purpose can be demonstrated in advance are used in these arrangements. Therefore, the suitability assessments for portable radiation measurement instruments are an important part of the process where new instruments are commissioned at the plant.

The errors detected in reporting the emissions were discussed in the inspection. STUK required that corrected reports are to be submitted to STUK. STUK also stated that TVO must process the errors detected in the official reports as deviations in accordance with its instructions.

STUK required TVO to assess and justify the sufficiency of personnel in the Radiochemistry Laboratory and the related substitution and staff backup arrangements. In addition to the normal workload and operating events in the plants in operation, the review must take into account commissioning of the new plant unit and the extensive development projects planned for the laboratory in the near future.

Nuclear security, 5–9 June 2017

The inspection concerned the nuclear security of Olkiluoto plant units 1, 2 and 3. In the inspection, TVO's risk management process was reviewed from the perspective of nuclear security, together with its results, information security and the effectiveness of nuclear security. The information security subjects reviewed included the networked systems important to safety as well as the overall architecture of information security. The security arrangement subjects reviewed included the training and exercises of the security personnel, security arrangement events and observations, as well as internal audits and assessments. In addition, the fence of the plant area was inspected, as well as the procedures related to goods transports and the security organisation's capabilities to observe and respond.

Following the inspection, STUK issued 10 requirements. The security arrangements were included in TVO's security monitoring report as actual results of the corporate security monitoring programme, one of the quality indicators. The procedures generally used in the Group will be applied to assessing the risk of unlawful activities, and the risks are discussed in the management team for corporate and information security. STUK took the view that a more detailed breakdown of risks in the risk matrix would help in the definition of targeted management actions as well as communications and awareness of the risks. In the inspection, STUK observed the improvements made to the operational capabilities of the security organisation. Exercises are used for assessing, demonstrating and improving the operational capabilities. However, TVO still needs to further develop the planning and reporting of exercise activities.

Safety planning, 10–11 January 2018

The inspection was postponed by just over one month from the originally scheduled time, which is why it was only performed in 2018. The inspection focussed on the current status of TVO's modification work process, as well as the application of the diversity principle of I&C equipment and taking the principle into account in planning and design work. In the inspection, the status of the modification work process and plans for further development were revised. It was also investigated how the diversity principle has been taken into account in the instructions guiding the I&C equipment design work.

TVO intends to reform the description of the modification work process and its associated instructions during the first half of 2018. This reform will reduce the ambiguity of instructions guiding the operations. In the inspection, STUK paid attention to the fact that preparations for plant modifications should be initiated in good time to ensure a trouble-free commissioning phase.

Following the inspection, STUK issued one requirement. The instructions currently in use at TVO take into account the diversification of electrical and I&C equipment and the way in which the design solutions are documented. However, it did not become clear in the inspection how the diversification solutions already made were documented so that future plant modifications would not violate the principles earlier used in the design work. TVO must specify the procedures for ensuring the documentation of solutions made for implementing the diversity principle in the continuously updated plant documentation in a manner that supports planning and maintenance functions.

Safety functions, 26–27 September 2017

The inspection of safety functions assesses the licensee's procedures used to ensure that the systems implementing safety functions are in a state required for safety and that their basis is correct. In 2017, the inspection concerned "Fuel cooling and residual heat removal". The inspection focussed on the auxiliary feedwater system and its associated auxiliary systems. The actions decided on the basis of the safety assessments made following the Fukushima nuclear power plant accident and their status were also discussed in the inspection. These actions included various plant modifications and their impacts on instructions and training. The inspection verified documentation and involved site walk-arounds, during which actions specified in the instructions were simulated with staff in TVO's shift crew.

Regarding the fuel cooling function, the equipment instructions, fault reports and spare parts situation of the auxiliary feedwater system were inspected. No cause for remarks regarding these was found in the inspection. TVO has continued its investigations into the sound and vibration detected in the recirculation line of the auxiliary feedwater system. The current action plan includes adding a choke valve at the end of the recirculation line and taking the end of the return line below the water level in the reservoir pool. It has also been found in trial operations that pressure transients exceed the design pressure of the pipeline. TVO is in the process of producing new strength analyses for justifying an increase in the design pressure. According to the draft schedule drawn up by TVO, the modifications to the recirculating line will be completed by autumn 2018. However, this will require making modifications during power operation and deviations from the operational limits and conditions. TVO will produce a safety assessment and present its final schedule plan as part of the pre-inspection documents of the system to be submitted to STUK for approval.

In order to manage a situation where a total loss of AC power has occurred, TVO is in the process of installing an automatically starting steam turbine-powered high-pressure auxiliary water system. In addition to the high-pressure system, TVO is planning an arrangement for manually feeding auxiliary water after pressure reduction to the reactor using the fire water system. The low-pressure auxiliary water system has been installed and commissioned at the Loviisa 2 plant unit. According to the schedule, other modification operations will be completed so that after the 2018 annual outages both plant units will have both high- and low-pressure auxiliary water systems in place.

Following the inspection, STUK issued three requirements. Irregularities were observed in the commissioning and associated inspection procedures of the low-pressure auxiliary water system installed for the Olkiluoto 2 plant unit. TVO must process the observed irregularities and determine corrective actions. Furthermore, ambiguity of the instructions associated with the system must be reduced, errors in them corrected and the personnel must be trained in the field actions specified in the instructions. In order to ensure power supply, TVO has implemented several modifications to the plants' electrical systems. In the inspection, the instructions regarding operation of the acquired mobile diesel aggregates were inspected, and it was found that the instructions were not up to date with regard to all flooding valves.

Emergency preparedness arrangements, 28–29 September 2017

The emergency preparedness arrangements inspection comprehensively covered the nuclear power plant's emergency preparedness arrangements. Issues that are regularly inspected include emergency preparedness guidelines, emergency preparedness facilities, emergency preparedness equipment, the emergency preparedness organisation and training for the emergency preparedness organisation. Regarding emergency preparedness equipment and facilities, the automatic radiation protection network and nuclide identification system were inspected. The procedures and equipment of the emergency preparedness facilities related to contamination management were a particular subject of the inspection.

The development and training of TVO's emergency preparedness organisation has particularly focussed on the commissioning of Olkiluoto 3. Malfunctions in the stations of TVO's external radiation monitoring network have decreased to a typical level, and the measurement stations acquired for Olkiluoto 3 will be moved from the test field to their final locations in the spring. Contamination management by TVO's emergency preparedness organisation has not been planned, instructed or trained as a whole. With the help of additional arrangements, the facilities related to the management of TVO's emergency preparedness organisation can be brought up to a sufficient level regarding contamination management. Contamination management arrangements are difficult to implement for part of the facilities of the emergency preparedness teams.

In the inspection, STUK issued four requirements related to the contamination management, availability and equipment of emergency preparedness facilities for a situation where a significant radioactive fallout has spread across the plant area.

Operational waste, 3–4 October 2017

STUK regulates and inspects the processing and final disposal of radioactive operational waste at the Olkiluoto nuclear power plant. Low- and intermediate-level waste is generated during maintenance and repairs as well as during the treatment of circulating water. An inspection of operational waste focused on remarks made during the last inspection, development since the last inspection and any important issues that have occurred. The inspection focused on waste management processes, HR planning and the occupational radiation dose. The condition of facilities in which waste is processed and stored, radiation levels in these facilities, their classification and their markings were inspected during the site visit.

No major non-conformances or development needs were detected in the inspection. In the holistic development of waste management, the planning at TVO has concentrated on the harmonisation of the waste solidification processes in all three plant units and also for underground disposal. During the current year, human resources have been increased for waste management, and the staff work in all three plant units. The waste management personnel incur radiation doses when they process waste during annual outages, during waste transport, and when packaging waste and solidifying liquid radioactive waste. The radiation doses have been low and are clearly below the individual dose limits set for employees doing radiation work.

Annual outage, 23 April - 14 September 2017

The inspection covered and verified the power plant's annual outage actions used to maintain safety as well as the actions used to manage and control operations during an annual outage. Inspectors from several fields of technology from STUK's nuclear reactor regulation department participated in the inspection. They had their own predetermined inspection areas. During the inspection, STUK monitored the activities, conducted site walk-arounds, interviewed employees and oversaw the progress of planned work.

The particular subjects of this year's inspection were the renewal work regarding the reactor cooling pumps at Olkiluoto 2 and their frequency converters, as well as the repairs to reactor pressure vessel nozzles. STUK oversaw these extensive modification works with the help of experts from several different fields of technology. Other subjects of the inspection included work order procedures, maintenance operations for control rod actuators, management procedures regarding loose articles and radiation protection of employees.

The inspection indicated that the annual outage was completed safely and almost all the scheduled work was completed. No safety deficiencies that require STUK's immediate action were observed during the inspection. STUK recorded a total of 52 observations of varying degrees of significance in the inspection protocol. In addition to deviations, observations were also recorded for observed good practices and activities compliant with instructions. On the basis of the observations made, one requirement was recorded concerning development of the work order procedures.

STUK's observations indicated that the renewal of reactor coolant pumps and frequency converters at Olkiluoto 2, a special subject of the inspection, went well. The first new reactor coolant pump was installed at Olkiluoto 1 in 2016, and the experience gained from the installation work could be utilised and activities could be improved. The second special subject was the repair of the reactor pressure vessel nozzles at Olkiluoto 2, and this was implemented on a smaller scale than planned. There were a lot of problems in the repair work, among others with the tools used for machining and welding. During the annual outage TVO decided to only repair the two nozzles where cracks had been detected in earlier annual outages. No cracks have been noticed in the other eight nozzles, which is why their proactive repairs could be postponed until future annual outages. The observations made by STUK indicated that producing the plans for repair operations, construction of equipment, performance of factory tests and submission of documentation to STUK was very challenging with regard to the implementation schedule specified for the project. STUK has required TVO to submit a report of the deficiencies regarding project management.

Establishing the reason for operational events and impact of the actions, 14–16 November 2017

The purpose of the inspection was to establish how TVO utilises feedback procedures on operating experiences to learn from events and how the procedures have been put into practice in the organisation. The general objective is that the organisational units should identify and solve problems in their respective areas of responsibility using different procedures, such as managerial work and self-assessments. In addition, TVO has an independent body monitoring deficiencies and helping solve them, when required by event investigations. STUK carried out an inspection to determine why problems of the same type are recurring even though attempts have already been made to solve the problems with the help of event investigations. The events are the ultimate stimulus, and at the latest on their basis, solutions must be found and the necessary improvements must be introduced for the problems The inspection concentrated on establishing interfaces and cooperation between the organisation responsible for event investigations and other organisational units. The inspection was implemented by interviewing TVO's personnel and by verifying TVO's instructions and documentation. Event investigations carried out by TVO and their results were utilised in the inspection.

STUK found deficiencies and weaknesses in the interfaces which handle operating experience feedback, which for their part explain why the event investigations cannot always solve the problems. On the basis of its observations, STUK arrived at the following conclusion: when events occur, the problem solving ownership is transferred to the investigative team, away from the unit responsible. The current investigation process allows excluding the organisational units from the process of solving the problems which have emerged, with the result that learning in the organisational units only begins when reading the reports of event investigation results and when actions are taken. In this context, the term 'investigation process' refers to those event investigation procedures where all organisational units participate in continual improvement of operations.

Following the inspection, STUK issued one requirement. STUK required TVO to improve its investigation process so that learning in the organisation starts at the appropriate time. The investigation process must support the ownership of units responsible for solving the problems.

The project managers are well aware of their key duties as the project managers. They have plenty of responsibilities (on budget, schedule and quality), which is why having sufficient competence and the support of the rest of the organisation is important. TVO has arranged training for the project managers and the project managers are supported in their work by the licensing manager and the chief engineers, among others. There is no risk management support person, however. STUK's impression after the inspection is that TVO has encountered some challenges in providing the personnel resources projects need and there are some gaps due to internal transfers caused by the organisational reform.

The persons in charge of projects do not record many non-conformances in TVO's operations. Based on the interviews, TVO does not have any shared view of who is responsible for assessing the need for the authorities to process project non-conformances. Based on the inspection, STUK is of the opinion that lessons learned from TVO's event investigations are not being reviewed to a sufficient extent in the case of projects, which is why STUK imposed a requirement on development of the operations. STUK is of the opinion that operating experience and lessons learned from other plants are covered to a sufficient extent.

APPENDIX 5 Construction inspection programme of Olkiluoto 3 in 2017

The objective of the Olkiluoto 3 construction inspection programme is to verify that the operations required by the construction of the unit ensure a high quality implementation according to the approved plans and in compliance with official regulations, without compromising the operating units within the site. The inspection programme assesses and oversees the licensee's operations in constructing the unit, implementation of procedures in various technical areas, the licensee's competence and use of expertise, the processing of safety matters, as well as quality assurance and control. The inspection programme of Olkiluoto 3 was launched in 2005 when construction of the unit started. The number of annual inspections has varied between nine and fifteen.

In 2017, 13 inspections included in the construction inspection programme were implemented, one of which was an unannounced inspection. Special focus areas of the construction inspection programme included commissioning procedures and provisions made for operation. Below is a brief description of the inspection findings for which STUK required improvements from TVO. On the whole, the inspections have led to the conclusion that the procedures and resources of TVO's organisation are adequate.

The quality management inspection focussed on TVO's sub-project entitled *Tuotantoon valmistautuminen* (Preparing for production). The objective of the sub-project is to control and ensure that the different units in TVO's organisation make sufficient and systematic preparations for the operation and maintenance of Olkiluoto 3. The matters discussed in the inspection included the progress and administration of the sub-project in general, and the areas inspected in closer detail included: maintenance, production of instructions, as well as design tools and design data . No requirements were imposed by STUK following the inspection. However, STUK paid attention to the employee turnover and resources and emphasised the importance of induction training as well as the importance of reserving enough time for managerial work.

Subject of inspection	Date
Quality management	18–19 January
Security arrangements	26–27 January
PRA	9 February
Management and processing of safety issues	15–17 February
Storage and inspections of spare parts, unannounced inspection	29–31 March
Commissioning of the controlled area	29–30 March
Commissioning, preparedness for starting cold tests	16–17 May
Training and resources	29–31 May
Prerequisites for importing fuel for security arrangements	22–24 August, 12–14 September
Preparedness for fuel import	29–30 August
Electrical engineering	21–22 September
I&C	28–29 November
Commissioning, preparedness for starting hot tests	29–30 November

The matters discussed in the inspection focusing on leadership and safety matters included the procedures and activities concerning project management for ensuring safety and in relation to changes in responsibilities when the project moves from the construction phase to commissioning, as well as the results of safety culture and workplace atmosphere surveys and the actions to be taken on their basis. It was found in the inspection that safety aspects are taken into account in decision-making, but the grounds of decisions are not comprehensively recorded in the minutes. It would be beneficial for a culture emphasising safety if the backgrounds to decisions were also available to others than just the persons participating in the decision-making. No requirement was issued on the matter, because TVO had recognised the matter itself and initiated actions for rectifying the situation.

Transports of fresh fuel to the site started in the autumn. STUK carried out several inspections regarding preparations for importing the fuel. The preparedness of security arrangements was verified in inspections as the arrangements progressed. STUK also inspected commissioning of the controlled area. A controlled area refers to an area where special instructions have to be observed regarding radiation protection and where access is controlled. Following the inspection, STUK required a more detailed description of access control to be added to the commissioning plan. STUK also required that the authority of the radiation protection personnel to carry out actions for reducing radiation doses and to stop work must be recorded in the instructions in use at the plant. The third requirement issued in the inspection concerned informing STUK of the content and plans for radiation protection training. In the last inspection related to the import of fuel, STUK inspected different aspects regarding capabilities for receiving fuel. The inspections reviewed the state of readiness of necessary premises and systems, as well as other preparations in the organisation for importing fuel. It was found in the inspection that the necessary tasks have been identified, but the work is still in progress. STUK monitored the progress of work and in a separate decision granted permission to bring fuel to the plant unit once the capabilities wew in place.

The aspects covered in the inspection of the Probabilistic Risk Assessment (PRA) included the responsibilities and resources regarding PRA during the construction and operating phases, as well as instructions pertaining to the inspection, maintenance and use of the PRA. STUK noted that TVO has functional PRA procedures in place in the Olkiluoto units in operation, and it is important that the procedures and responsibilities for OL3 are also unambiguous when the plant starts operation.

STUK carried out an inspection of spare parts storage and receiving inspection procedures without prior notification. In the inspection, the activities and storage conditions in different storage facilities were verified. In addition, the instructions, resources and training of personnel for monitoring and inspecting spare parts at TVO were inspected. One requirement concerning documenting the maintenance activities during storage was issued during the inspection.

The topics of the inspection concerning competence, training and resources were the procedures TVO uses for assessing and developing staff competence and resources. Based on the inspection, STUK issued requirements concerning assessment of the impact of training and work performance, utilisation of trial operations for induction training, as well as utilisation of the probabilistic risk assessment for training the entire personnel.

In the inspections regarding preparedness for starting cold and hot tests, the fulfilment of prerequisites for starting the tests were verified. The preparedness for starting the tests was assessed both from the perspective of the plant's technical readiness and the organisation of the commissioning activities. Matters related to preparations for both tests were still in progress during both inspections, but TVO presented the procedures for completion before starting the tests. STUK monitored the completion of unfinished aspects after the inspection. Regarding hot tests, STUK required TVO to ensure the sufficiency of its own oversight resources irrespective of the timing of the tests.

The electrical engineering inspection focussed on performance and results of power source transfer tests, preparations for operation and continuity measurements of signal cables. The preparations for operation are yet to be completed, but the necessary actions have been planned and the work is in progress. Regarding the power source transfer tests, problems related to time stamps and signal delays observed in the tests were reviewed. The report with the final results is not available yet. For this reason a report on the acceptability of the power source transfer tests was required in the inspection before moving on to the next phase of commissioning.

Preparations for the operating phase were the subject of the I&C inspection. In the inspection, the preparations for commissioning inspections and the status of instructions and tools required during the operating phase were discussed. In addition, the resource allocation for overseeing trial operations and procedures and observations in configuration management were verified. The preparations for operation are yet to be completed, but the necessary actions have been planned and the work is in progress. No requirements were imposed in the inspection.

In addition to the inspections under the construction inspection programme, matters were also discussed from the point of the OL3 plant unit in several inspections under the periodic inspection programme regarding OL1/2.

APPENDIX 6 Inspections pertaining to the processing of Fennovoima's construction licence application

STUK inspects and assesses the management systems of Fennovoima and the other organisations participating in the project. Furthermore, STUK performs inspections of the organisations to ensure that their actual operations comply with what is specified in the management systems and that they meet the necessary requirements.

STUK launched the inspections included in the regulatory inspection programme (RKT) in September 2015. They are planned six months in advance. In 2017, STUK carried out a total of 12 inspections in line with its inspection programme. One planned inspection was postponed to December 2018. The inspection results will be used by STUK when preparing a safety assessment and statement on the construction licence. Summaries of inspections are presented below.

Radiation protection (Salmisaari)

The inspection focussed on the planning and implementation of radiation protection, radiation measurements and preparedness arrangements. Fennovoima's actions and procedures when identifying, monitoring and processing radiation safety issues were revised in the inspection. The inspection covered, e.g. the following issues: requirements management in radiation protection, planning resources for radiation protection, assessment of radiation conditions inside the plant, radiation protection calculations, taking radiation protection into account when designing the plant layout and systems, material choices, as well as utilisation of information obtained from reference plants and taking preparedness situations into account. During the inspection, STUK verified Hanhikivi 1 -specific instructions, procedures and plans as well as their related documents.

Subject of inspection	Date
Radiation protection (Salmisaari)	8–9 February 2017
Nuclear Island (Salmisaari)	13–14 February 2017
PRA (Salmisaari)	13–15 March 2017
JSC Gidropress (Podolsk)	4–6 April 2017
I&C (Salmisaari)	3–5 May 2017
Petrozavodsk branch of AEM-Technology JSC, Petrozavodsk	16–18 May 2017
Management and inspection procedures (Salmisaari)	6–8 June 2017
Fennovoima, Electrical engineering, Salmisaari	6–7 September 2017
Fennovoima, Civil engineering, Salmisaari	17–18 October 2017
LLI, Salmisaari	25–26 October 2017
Fennovoima's management and management system as well as its safety culture, Salmisaari	6–8 November 2017
Fennovoima, nuclear waste, Salmisaari	20–21 November 2017
RAOS Project Oy, Salmisaari	28-30 November 2017

On the basis of the inspection results, STUK required that the radiation protection requirements are taken into account at all stages of the nuclear facility planning and design process. The experts responsible for radiation protection must be provided with a possibility to participate in the processes during different design phases, document inspections (including pilots), reviews and decision-making affecting the implementation of radiation protection. Furthermore, in its annual plans Fennovoima must assess the necessity of the main designer's follow-up audit regarding radiation protection. Fennovoima must also ensure that the calculations and dose rates required for radiation protection are made and established on the basis of data specific to the Hanhikivi 1 plant unit. Regarding laboratory functions, the design work must take into account the sufficient availability of premises and equipment in all situations, taking into account occupational and radiation safety. The locations and routes of operations essential for preparedness situations must be taken into account when designing the plant layout, and their radiation conditions in possible accident situations must be estimated in order to ensure that the operating locations can be used.

Nuclear Island (Salmisaari)

The inspection covered The Nuclear Island Unit of Fennovoima's Project Department. In the inspection, issues related to the unit's organisation, duties and resources were revised by verifying the documentation of these matters in Fennovoima's document management system and in employee interviews.

The matters reviewed in the inspection included the allocation of the unit's duties to staff responsible for systems, and inspection responsibilities regarding licensing documents the unit is responsible for, with the help of an inspection matrix. Furthermore, Fennovoima's meeting procedures and escalation of open technical issues to higher levels of decision-making in the organisation, when required, were verified in the inspection. A deficiency concerning the organisation was noted in the inspection: no deputy was specified for the head of the unit in the management system documents. A deficiency in the inspection duties concerning control rooms was also observed in the inspection.

In the inspection, Fennovoima submitted that the persons responsible for the buildings of the NI Project Unit would monitor the progress of the design (installations and commissioning) of systems in a specified building and seek to ensure the compatibility of systems – for example so that the electrical system required for the process has been correctly designed or that the controls required for the same system have been correctly designed. In this context, the idea emerged in the inspection that the persons responsible for buildings could also monitor the progress of the system design work through the configuration baselines; and that the system design documents belong to the same configuration baseline and are compatible with each other.

During the inspection, Fennovoima stated that the planning of human resources is rather challenging in the absence of any clear idea of the volume and timing of work. The time schedules for progressing the design work have changed, which is why documents have not been received for inspection and review at the expected rate. The fact that there will be a lot of design documents to be handled simultaneously is likely to constitute a small risk regarding the sufficiency of resources.

Following the inspection, STUK issued one requirement concerning presentation of the Description of Project Areas to STUK.

Probabilistic risk assessment (PRA) (Salmisaari)

The scope of the inspection included Fennovoima's procedures in reviewing and utilising the PRA during the plant design and processing of the construction licence application. During the inspection, STUK verified Hanhikivi 1 -specific instructions, procedures and plans related to the scope of inspection, as well as the documents concerning them. On the second day of the inspection, Fennovoima's control and inspection procedures were verified using examples.

Following the inspection, STUK required Fennovoima to plan the resources, volumes of work, need for external experts and documentation related to the PRA review work in closer detail. The PRA review plan must cover different sections of the PRA, and the review plan must be submitted to STUK. STUK found that Fennovoima has not verified the procedures of the party producing the PRA regarding the production, development and maintenance of the PRA. It was also not possible to verify the utilisation of the PRA in support of design work. Following the inspection, STUK issued the requirement that Fennovoima must audit the PRA function of the main designer Atomproect.

Gidropress (Podolsk)

A follow-up inspection of main designer OKB Gidropress was carried out. The inspection focussed on management and practices, the requirements issued in the previous inspection (in 2016) and the actions taken on their basis, as well as the requirements specified in chapter 8 of Guide YVL E.4 regarding quality management of strength analyses. The verification carried out in the inspection allowed several of the requirements issued in the previous inspection to be closed.

In the inspection, deterministic analyses, severe accidents and the design of mechanical components were discussed and verified using selected examples. In the inspection, activities compliant with the instructions were verified using selected examples.

It was stated in the inspection that STUK's safety assessment and statement regarding the construction licence application will partly be based on independent comparison analyses carried out or commissioned by STUK. In order to facilitate these analyses, Fennovoima must provide STUK with the initial data required for producing the analysis models. Production of the analysis models and the actual performance of the analyses will be time-consuming, which is why the initial data should be received in good time.

It was also noted that the design configuration baseline has not yet been frozen. The documents to be submitted for processing by the authorities in the construction licencing phase must be descriptive of the Hanhikivi 1 plant and based on a uniform configuration, i.e. on a baseline configuration of technological items. In this respect, the requirement issued in the previous inspection remained an open question, because STUK is yet to receive the design documentation frozen at the baseline configuration level, which would allow STUK to state that the requirements have been met.

It was found in the inspection that as the main designer of the nuclear island, OKB Gidropress carries out strength analyses of safety class 1 components. Requirement 801 of Guide YVL E.4 requires that the organisation conducting strength analyses must have a quality management system documented and implemented for this purpose. According to the requirement stated by STUK, OKB Gidropress must assess its management system against the strength analysis -related ASME NQA-1-2008 requirements. On the basis of the assessment, OKB Gidropress must implement the actions required for its management system to meet the requirements of ASME NQA-1-2008.

I&C (automation), Helsinki

In the inspection regarding I&C, the duties of Fennovoima's I&C Unit and other I&C-related organisational units were reviewed. In the inspection, taking human factors into account in design aspects (Human Factors Engineering, HFE), was also assessed. STUK verified Fennovoima's instructions, procedures and plans related to the scope of inspection, as well as the documents concerning them.

Following the inspection, STUK required Fennovoima to plan and issue instructions regarding how independent assessments of I&C are to be carried out and resources allocated for them. Furthermore, Fennovoima must analyse the critical major risks associated with I&C and split them into smaller and more easily managed entities, including HFE. Fennovoima must ensure that the new I&C Unit employees are provided with induction training, including the consultants providing support to Fennovoima's own personnel. Fennovoima must also update the instructions regarding design guidance and control to correspond to the current practices. It was suggested in the inspection that Fennovoima must identify in its licensing planning and related plans and schedules that the licensing documents that cannot yet be defined, e.g. due to supplier selections or plans (such as quality plans) that have not yet been completed.

Petrozavodsk branch of AEM-Technology JSC, Petrozavodsk

The subject of the inspection were the management and delivery capabilities of the PetrozavodskMash factory of AEM-Technology (AEM-T) in Petrozavodsk, Russia. At the time of the inspection, the factory did not yet have a supply agreement with the plant supplier, and the preparations for starting manufacture were in their very early stages. For this reason, observations requiring development actions were presented in the inspection instead of scheduled requirements. Thanks to the cooperation between Finnish and Russian nuclear safety authorities (STUK-RTN Rostechnadzor), the inspection was attended by representatives of Rostechnadzor and VO-Safety, the technical support organisation of the Russian authority.

In the inspection, STUK identified areas for development, e.g. in safety culture related procedures for establishing open reporting of errors and a "blame-free" atmosphere, version management of documents, in risk management planning and in the compliance with destructive and non-destructive testing (DT and NDT) laboratories. STUK stated that it will determine the development actions Petrozavodskmash must take in order to handle these issues in connection with Fennovoima's audit monitoring and approval procedures for its laboratories.

Fennovoima's management and inspection procedures, Salmisaari

This inspection concerned the role and actions of Fennovoima's management in the Hanhikivi 1 project. The inspection covered the actions of Fennovoima's management in identifying, monitoring and processing safety issues. The inspection focussed on core management processes, such as the processing of safety issues, project management including licensing planning and configuration management, i.e. management of the technical configuration including change management and requirement management.

In the inspection, STUK required Fennovoima to commence using a configuration management tool and to also ensure the compatibility between different delivery parts and procedures used by different actors. In addition, Fennovoima must ensure and demonstrate the realisation of a designer-independent safety assessment in a situation where Fennovoima itself participates in the design work. Fennovoima must also organise, instruct and allocate resources for a quality control (QC) function in the project and assess the risks associated with the manufacture of the main components in case consultants are used for control in addition to Fennovoima's own personnel. Fennovoima's quality and safety departments must assess the suitability of a document describing different parts of the project for activities compliant with the management system and the impact of the policy decisions in the document on the appropriate processing of safety issues. Based on the assessment, Fennovoima must plan and implement possible further actions in order to ensure consistency between activities and the management system. Furthermore, Fennovoima must ensure and instruct that the suppliers' quality plans must be approved before starting to assess the plans produced by the suppliers.

Electrical engineering, Salmisaari

The inspection focussed on development work undertaken by Fennovoima on the basis of electrical engineering requirements set out after an inspection under the regulatory inspection programme in 2016. A new topic was Fennovoima's preparations for future quality control (QC) functions, with the main focus on electrical engineering. The structure and status of documents for the construction licence were also discussed.

The verifications carried out by the inspection team and the documentation submitted allowed requirements of the previous inspection to be closed. No new requirements were imposed in the inspection.

Civil engineering, Salmisaari

This inspection concerned the civil engineering functions of Fennovoima, and the requirements of the earlier inspection entitled "Fennovoima's civil engineering and facility/layout design – provisions for internal and external hazards (Helsinki)" which remained open were also discussed.

The inspection revealed deficiencies in the documentation of the design bases, scheduling of long-term concrete tests and lack of systematic approach in the site functions.

Control of design and manufacture of Long-Lead Items (LLI), Salmisaari

The inspection concerned the control of manufacture of Long-Lead Items by Fennovoima, i.e. the LLI functions.

The inspection showed that Fennovoima has good capabilities for LLI control. The situation is made more difficult by the supplier's uncertain time schedules which mean that Fennovoima cannot plan its activities accurately enough. This is also reflected in the annual planning and resource allocation at STUK.

Fennovoima's management and management system as well as its safety culture, Salmisaari

This inspection concerned Fennovoima's management, integrated management system and development of its safety culture. Many earlier requirements were closed in the inspection.

Regarding the safety culture, the management is expected to take a clearer stand on the safety culture related recommendations by experts, and STUK also required that work on the safety culture at the work site is ensured. During the inspection, Fennovoima explained that bypassing experts has not occurred in the organisation. The inspection showed that Fennovoima must ensure that the information produced by the Nuclear Safety Awareness process is utilised in the organisation. The comments by the management team of Fennovoima on the state of the safety culture, its development needs and development actions must be unambiguous and traceable.

Some earlier requirements regarding management were closed after verification. STUK still requires further improvements to be made, e.g. to designer-independent safety assessments, completion of escalation instructions for safety issues, updates to the organisation manual regarding responsibilities for sub-projects, as well as instructions and resource allocation for quality control (QC). Earlier requirements, save a few, regarding management were closed. The requirements which still remained open were for determining the risk management interfaces with other processes and for ensuring the compatibility between FV's processes and the plant supplier's processes.

The following new requirement was issued: Fennovoima must establish and assess the reasons why the planning and implementation related to observations are deployed. The possible actions for developing the process must be planned and implemented on the basis of the assessment.

The general view following the inspection was that much has improved in the operations of Fennovoima in the last two years, albeit that there is still room for development.

RAOS Project Oy, Salmisaari

The follow-up inspection focussed on the management and operations of RAOS Project Oy, Salmisaari, Helsinki (RAOS). The actions and procedures at RAOS when identifying, monitoring and processing safety matters, as well as quality management, were discussed in the inspection. The inspection focussed on the following management system processes important to safety: the processing of safety issues, quality management (QA/QC), project and design management (including licensing planning and the management of open issues in the supply chain), configuration management (including change management) and management of requirements.

The inspection allowed several of the requirements issued in the previous inspection to be closed on the basis of earlier delivered documents and verification. New requirements were issued on the basis of the inspection: RAOS Project Oy must ensure the appropriate and traceable processing of safety concerns and deviations, including concerns related to activities brought up by persons participating in the project, RAOS Project Oy must, in good time before the construction licence is granted, plan the procedures and produce the necessary instructions for processing changes compliant with the Nuclear Energy Decree, and RAOS Project Oy must define procedures for managing the requirements of STUK's provisions in the supply chain.

APPENDIX 7 Construction inspection programme for the encapsulation plant and the disposal facility

In 2017, the encapsulation plant and disposal facility oversight project at STUK systematically continued the inspections included in the construction inspection programme. The aim of these inspections was to assess the functionality of Posiva's management system, as well as the sufficiency and appropriateness of the procedures for implementing and controlling the plant construction work and for taking the safety requirements into account in the project. Inspections included in the programme may also be targeted at Posiva's suppliers who are important to safety. The 2017 inspections only focused on the licensee's operations.

The 2017 programme included five inspections on current activities important to the safety of the construction phase. The number of inspections was systematically reduced from the level of previous years, because in 2016, Posiva's organisation was subjected to a comprehensive assessment in the con-struction inspection programme and supplementary inspections. The extended inspection programme was based on Posiva's application for starting the construction phase of the disposal facility. The inspection results indicated that Posiva's organisation and management system were sufficient for starting the construction phase. No significant changes have taken place in Posiva's operations since that time, and for this reason STUK decided to focus its 2017 inspections on certain key functions of the construction phase instead of assessing Posiva's basic operations. Based on the results of STUK's inspection, it was noted that Posiva's operations and management system procedures in the assessed areas of operation are sufficiently compliant with STUK's requirements.

Brief descriptions of the inspections as well as the key observations made, based on which STUK has required Posiva to carry out improvements and development actions, are presented below.

Analyses

One of the aims of the inspection was to asses Posiva's procedures, that are applied to ensure the integrity and safety of the encapsulation plant and its systems design by analysing it during the construction, operation and decommissioning of the plant. The procedures Posiva deploys to integrate the analyses as part of the plant and system design was also a key subject of inspections.

According to Posiva, some of the analyses used for supporting the encapsulation plant design work are based on the basic design phase, while some are performed during the implementation planning phase as part of the construction plan documentation. The analyses based on the system design include the design phase PRA, deterministic safety analyses, analyses of internal and external threats, as well as emission, radiation dose and radiation dimensioning analyses, preliminary system fault tolerance analyses, common-cause failure analyses, thermal analyses and deterministic fire and exit analyses.

Subject of inspection	Date
Analyses	20–21 March 2017
Maintenance and ageing management of the disposal facility	17–18 May 2017
Manufacture	19–20 September 2017
Management system processes	4–5 October 2017
Management	23–24 November 2017

Posiva primarily seeks to carry out the required analyses itself. However, if it does not have the necessary resources available for a certain task, it will order implementation of the safety analyses from the TVO Group. However, part of the planning and design work, such as the analyses based on system design, have had to be implemented as consultancy work, in which case the work has been monitored and guided in compliance with Posiva's management system. It was verified in the inspections that the performance of the analyses has been appropriately monitored and guided even in cases where they were performed by a supplier, Group company or an external company.

The inspection results indicate that Posiva's analysis activities are progressing alongside the design process and have appropriate links to it. The inspection did not reveal any deficiencies in Posiva's analysis activities or its control measures. No requirements were set on Posiva by STUK based on the inspection results.

Maintenance and ageing management of the disposal facility

Maintenance related to the ageing management of nuclear facility structures helps ensure that the engineered barriers operate as planned. The inspection focussed on nuclear safety and did not include any personnel safety or occupational safety aspects. Posiva has developed instructions for the maintenance and ageing management of the reinforcement and sealing structures of underground rooms. The procedures used are described in these instructions. The maintenance and the procedures used in it are based on Posiva's principal plan for ageing management.

The inspection concerned the maintenance programme of reinforcement and sealing structures in Posiva's underground rooms (bolting, mesh reinforcements, shotcreting and its subsurface drainage as well as injecting) as part of the ageing management of these structures. It was found in the inspection that Posiva has identified problems associated with the condition management of tunnels. Posiva has started looking for alternative methods to carry out condition monitoring and has surveyed laser scanning and thermal camera imaging as potential methods.

The inspection indicated that the development of maintenance as part of ageing management is systematic at Posiva, and hence no requirements were imposed following the inspection. However, STUK pointed out several observations made during the inspection, and these should be assessed for further developing the maintenance operations related to ageing management.

Manufacture

The manufacture of engineered barriers for the disposal solution and control of these manufacturing operations were assessed in the inspection. The inspection also assessed Posiva's procedures related to the manufacture of the above-mentioned systems and its control procedures. Posiva's plans related to the subjects were also discussed during the inspection.

Posiva has issued extensive instructions for the manufacturing activities and their control. Among other things, the instructions for producing structural plans were assessed in the inspection.

The inspection also revised the manufacturing chain and its control procedures using an example case, as well as the control of manufacturing activities as a whole. The assessment results allowed STUK to state that Posiva's instructions cover the design and manufacture as well as control of the entire supply chain. If was found in the inspection that Posiva has instructions in place for selecting and approving manufacturers, as well as for selecting and approving testing and inspection organisations, or for having them approved.

To summarise the inspection, it was found that Posiva has produced sufficient basic instructions for manufacturing and its control. However, there is scope for improvement in the instructions, and Posiva will take this into account in its development work. No requirements were imposed by STUK following the inspection.

Management system processes

Posiva's procedures for producing, maintaining and further developing support processes were assessed in the inspection. The assessment also covered the measurement methods and procedures required for continual improvement of the processes. Posiva's design process and its functionality were also assessed using example cases. The objective was to assess whether the process is implemented according to plans in order to ensure its impact and control.

Six support processes, aimed at fulfilling the requirements of STUK's instructions, have been defined by Posiva's management system. The inspection found that the support processes comply to a sufficient degree with STUK's requirements regarding the processes. It was noted in the inspection that Posiva must develop the procedures for monitoring and measuring support processes and the procedures for assessing their functionality to better support the control of operations. The most significant functional change at Posiva was that certain processes now rely on the TVO Group.

APPENDIX 8 Licences STUK has granted in accordance with the Nuclear Energy Act in 2017

Teollisuuden Voima Oy

- 1/C42214/2017, 24/03/2017: OL1/OL2 – Import licence for a dummy control rod. Last date of validity 31/12/2017.
- 2/C42214/2017, 07/04/2017: OL1/OL2 – Import licence for graphite actuation nuts for control rod actuators. Last date of validity 31/12/2017.
- 3/G42214/2017, OL3 – Import licence for dual-use item spares. Last date of validity 31/12/2018.
- 1/G42214/2017, 19/05/2017: OL3 – Import of neutron detectors and radiation samples from Germany. Last date of validity 31/12/2018.
- 5/G42214/2017, 19/05/2017: OL3 – Import licence for the inner part of reactor coolant pump. Last date of validity 31/12/2018.
- 3/C42214/2017, 15/06/2017: OL1 – Export licence for spent nuclear fuel rods. Last date of validity 31/12/2017.
- 7/G42214/2017, 21/06/2017: OL3 – Import of test rods. Last date of validity 31/12/2018.
- 8/C42214/2017, 17/10/2017: Import of nuclear fuel with Euratom obligation code "P" from Sweden (OL2 e 38). Last date of validity 31/12/2018.
- 9/C42214/2017, 17/10/2017: Import of nuclear fuel with Euratom obligation code "C" from Germany (OL1 e 40). Last date of validity 31/12/2018.
- 10/C42214/2017, 17/10/2017: Import of nuclear fuel with Euratom obligation code "S" from Germany (OL2 e 38). Last date of validity 31/12/2018.
- 11/C42214/2017, 21/12/2017: Licence for import and possession of a sample fuel assembly. Last date of validity for import 31/12/2018 and for possession 31/12/2030.

Fortum Power and Heat Oy

- 1/A42214/2017, 24/05/2017: Import of intermediate shafts for control rod mechanisms for Loviisa 1 and 2. Last date of validity 31/12/2017.
- 2/A42214/2017, 21/12/2017: Loviisa 1 and 2 – Licence for the export and transfer of spent nuclear fuel rods. Last date of validity 31/05/2018.

Others

- 1/J42214/2017, 23/2/2017: Fennovoima / Licence for the import of nuclear information subject to the particular safeguards obligation from Russia – replacement for licence 2/J42214/2014. Last date of validity 31/12/2023.
- 13/Y42214/2017, 05/06/2017: S. Metso / Licence for the possession of nuclear information subject to the particular safeguards obligation. Last date of validity 31/4/2022.
- 7/Y42214/2017, 03/10/2017: RAOS Project Oy / Licence to import, possess and transfer nuclear information subject to the particular safeguards obligation (superseded the incorrect licence granted on 3/3/2017 under the same item number). Last date of validity 31/12/2023.
- 26/Y42214/2017, 05/12/2017: University of Helsinki / Licence to possess, use and store nuclear materials and nuclear waste on the premises of the Chemical Department of the University of Helsinki. Last date of validity 31/12/2027.
- 27/Y42214/2017, 20/12/2017: VTT Technical Research Centre of Finland / Licence for the import of nuclear information subject to the particular safeguards obligation from South Korea and for possession of the imported information. Last date of validity 31/12/2021.
- 1/Y42211/2017, 13.12.2017: Terrafame Oy / Licence to produce and possess nuclear materials (in maximum 6 kg natural uranium). Last date of validity for production is 30/06/2018 and for possession 31/12/2023.