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Regulatory oversight of nuclear safety in Finland

Annual report 2016

Erja Kainulainen (ed.)

Säteilyturvakeskus
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Radiation and Nuclear Safety Authority

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Management review

In 2016, all Finnish nuclear power plants operated safely and caused no danger to their surrounding environment or employees. The collective radiation doses of employees were yet again historically low in almost all of the plant units and radioactive releases into the environment very small. The low employee radiation doses were the result of short annual outages and improvements implemented at the nuclear power plants. In spring 2016, three leaking fuel assemblies were replaced at Olkiluoto 1 during an extra refuelling outage, and then three more assemblies were replaced in connection with the annual outage due to subsequent leaks. The fuel leaks were one reason why the employee radiation doses at the plant unit were somewhat higher than in the previous years.

Over the course of 2016, Fortum Power and Heat Oy (Fortum) submitted to STUK a total of 20 operational event reports. The operational events did not compromise nuclear or radiation safety. STUK performed an annual outage inspection in compliance with the periodic inspection programme during the annual outage. During the annual outages, Fortum inspected – according to a programme agreed with STUK – that there was no hydrogen flaking in the reactor pressure vessel of the power plant unit 1. Hydrogen flaking could have occurred during manufacture of the pressure vessel. A similar inspection on the pressure vessel of Loviisa 2 was performed in 2014. No hydrogen flaking was detected in either of the pressure vessels. In 2016, STUK focused its regulatory oversight on the Fortum's organisation, inspecting Fortum's management, competence, resource and procurement processes. Also in 2016, Fortum completed a major organisational renewal, and STUK oversaw its implementation and initial impact as part of its regulatory oversight.

In 2016, Teollisuuden Voima Oyj (TVO) submitted to STUK 11 operational event reports. Some radioactive materials were released into the environment in the case of two of the events. One of the events involved fuel leaks and the other an error during maintenance. The set limits were not exceeded and neither of the events compromised radiation safety of the population. Both events increased the radiation level inside the plant, which was taken into account when planning the work to be done by the employees. STUK performed an annual outage inspection in compliance with the periodic inspection programme during the annual outage. TVO implemented a new organisation and operations model in 2015. Based on inspections by STUK, the new operations model has been largely established, but there are still some challenges pertaining to the atmosphere at the company and the adequacy of resources. STUK will continue to monitor as part of its regulatory oversight the situation and the actions taken by TVO to maintain the organisation's safety culture during the challenging change.

At both Olkiluoto and Loviisa, modifications required for improving safety continued. New main steam line safety valves were installed at Loviisa 1 during the 2016 annual outage. They will also operate in a case where water flows through them in addition to steam. A similar installation was carried out at Loviisa 2 in 2014. New main steam line radiation measuring instruments were also installed and commissioned at Loviisa 1. Of the improvement measures started after the Fukushima accident, further improvements of the flood protection and securing the cooling of the fuel pools are still remaining. Their planning proceeded in 2016. An improvement project of the diesel fuel storage and transfer system was completed in 2016. STUK continued its review of the Loviisa I&C renewal documents and supervised installation work of the renewal's first phase during the 2016 annual outage. The first phase included a preventive safety function control and indication system as well as modernisation of the I&C status monitoring system. The rest of the I&C renewal installations will be completed during the 2017 and 2018 annual outages.

As a result of the Fukushima accident, Olkiluoto will improve, for example, systems used to cool the reactor and add whole new systems for pumping water into the reactor in case of a complete loss of AC power. Another ongoing project at Olkiluoto is an upgrade of the reactor coolant pumps and the emergency diesel generators. In 2016, first of the six reactor coolant pumps in Olkiluoto 1 was replaced. TVO plans to commission the new reactor coolant pumps between 2016 and 2018. STUK continued its review of documents pertaining to the modifications and the supervision of manufacture.

The installation and construction work of Olkiluoto 3 are nearing the end, and full-scale testing of the systems and components was started in 2016. Testing of the I&C systems started at the beginning of the year and the first process system tests were performed in April 2016. TVO submitted an operating licence application for the plant unit to the Ministry of Economic Affairs and Employment (MEAE) in April 2016. At the same time, TVO submitted the documents on the plant and its operation required by virtue of the Nuclear Energy Decree to STUK for approval. In 2016, STUK focused its regulatory oversight on review of the operating licence application and on oversight of the remaining installations and the commissioning activities. While reviewing the operating licence application, STUK also prepared implementation decisions for Olkiluoto 3 of the updated YVL Guides that were published in 2013. The new YVL Guides will enter into force for Olkiluoto 3 as soon as the operating licence is granted.

Due to suspected product forgeries involving manufacturers in France, STUK required reports from the power companies on whether the suspicions involve manufacture of the components used at Olkiluoto 3 or whether any components from the said manufacturers have been used at the operating nuclear power plants. The report on Olkiluoto 3 must be submitted to STUK by the end of April 2017. No forgeries have been detected at the operating plant units, but the reports on Loviisa will be supplemented in early 2017.

In June 2015, Fennovoima submitted to the MEAE a construction licence application for a new nuclear power plant. At the same time, Fennovoima submitted to STUK for review documents required by the Nuclear Energy Decree. Fennovoima has supplemented and will supplement the construction licence application in stages between 2015 and 2018. Delivery of documents has been delayed from the schedule of the first licensing plan due to slower organisation than expected of the project and its supply chain and due to a lack of resources in the design organisation. STUK monitored the development of Fennovoima's management system and quality management, and assessed the company's organisational resources to begin construction of a nuclear power plant. In September 2015, STUK launched the inspections included in the regulatory inspection programme, and a total of 15 inspections of Fennovoima and key organisations of the plant supplier were carried out in 2016. Furthermore, STUK's experts participated as observers in audits of the plant supplier and its subcontractors, arranged by Fennovoima.

The handling and storage of spent nuclear fuel and operational waste and the disposal of operational waste were implemented safely, and no events compromising safety were detected at the Loviisa or Olkiluoto nuclear power plants. Due to the successful planning of operations, the plants accumulated clearly less operational waste than nuclear power plants on average. An important positive development in the waste management of the plants was the fact that operation of a solidification facility for liquid radioactive waste at the Loviisa nuclear power plant started on 15 February 2016 after STUK had approved the related application. Fortum continued the planning of repairs of the damage observed in the outer surface of the concrete vault in the solidified waste disposal facility, which is why the disposal of solidified waste could not be started yet.

The operating licence for the research reactor FiR 1 of VTT Technical Research Centre of Finland is valid until the end of 2023. VTT shut down the research reactor for financial reasons in June 2015 and has been preparing decommissioning of the research reactor ever since. STUK has conducted all the measures necessary for the oversight of the reactor that was shut down and prepared for the review of the application on the decommissioning of the reactor. VTT submitted a nuclear waste management plan for the research reactor to the Ministry of Economic Affairs and Employment in September 2016. The report described all measures since the 2015 report and all planned measures up until 2022. STUK stated in its statement to the MEAE that VTT had clearly progressed with the planning of the research reactor's decommissioning over the course of the past year. The most important open issues regarding the decommissioning of the research reactor involve the return of spent fuel to the United States and the storage and disposal of dismantling waste.

After Posiva Oy received a construction licence from the Government on 12 November 2015, STUK's oversight has focused on the construction of the encapsulation and disposal facility. The regulatory oversight during the construction stage covers design, manufacture, construction and installation of the nuclear waste facility and its safety-classified systems, structures and components. This stage also includes the nuclear waste facility's commissioning stage, at which time STUK will oversee Posiva's operations, review testing programmes and results, and perform commissioning inspections. In 2016, STUK's oversight focused particularly on the assessment of Posiva's readiness for construction after the submission of the construction licence. STUK continued to oversee construction of the underground research facility by Posiva, Posiva's system design, activities of the Posiva organisation and development of Posiva's safety analyses. An important stage in 2016 was the start of the construction of the disposal facility according to the construction licence. STUK comprehensively assessed Posiva's readiness for construction before the construction work was started.

In June 2016, Fennovoima submitted to the MEAE its environmental impact assessment programme on the disposal of spent nuclear fuel as required in the 2010 decision-in-principle. The submission of the EIA programme started Fennovoima's spent fuel disposal project and the selection process of the disposal facility site. Fennovoima has proposed Sydänneva in Pyhäjoki and Eurajoki as the potential sites. The more exact research area in Eurajoki has not been determined as of yet. In its statement on the EIA programme, STUK emphasised the fact that the proposed process would last a long time, the need to regularly assess the programme to ensure that it is up to date and the fact that the exact research area in Eurajoki must be determined as soon as possible.

In addition to the operation and construction of a nuclear facility, the use of nuclear energy as laid down in section 2 of the Nuclear Energy Act includes the possession, manufacture, production, transfer, handling, use, storage, transport, export and import of nuclear material. Furthermore, components, systems and information required by nuclear facilities are subject to licensing and oversight by virtue of the Nuclear Energy Act. In 2016, STUK became aware of two cases of import without the proper licence.

Nuclear safeguards in Finland were implemented in compliance with the international treaties. Nuclear safeguards ensure that nuclear materials and other nuclear items remain in peaceful use in compliance with the relevant licences and declarations and that nuclear facilities and related technologies are only utilised for peaceful purposes. STUK maintains a national control system which aim is to take care of the necessary oversight of use of nuclear energy for the non-proliferation of nuclear weapons. STUK processed reports and declarations on nuclear materials and performed safeguards inspections together with the International Atomic Energy Agency (IAEA) and the European Commission. STUK actively promoted with the IAEA and the European Commission the development of nuclear safeguards for the disposal of spent fuel. Key issues in this development work were the development of a new oversight model and a new fuel measuring technology.

Contents

1 Development and implementation of legislation and regulations

Amendments and preparation of nuclear energy legislation

An amendment of the Nuclear Energy Act that provides STUK with the authority needed to issue binding orders on nuclear safety issues entered into force at the beginning of 2016. It emphasises the independence of STUK and its regulatory oversight.

The Ministry of Economic Affairs and Employment (MEAE) has regularly studied the need to reform nuclear energy legislation. STUK has also been active in this work. In the summer of 2016, the MEAE decided to establish a project that aims at clarifying the Nuclear Energy Act by the beginning of 2018.

The decision to clarify the Act was made because of three Directives published by the European Commission in 2013 and 2014: an amendment of the Nuclear Safety Directive (2014/87/EURATOM), a Directive that establishes basic safety standards for the protection against the dangers arising from ionising radiation (2013/59/EURATOM) and an amendment of the Directive on environmental impact assessments (2014/52/EU), which must be enforced in national legislation by the end of 2017. In the summer of 2016, the Commission also posed additional questions about the enforcement of the Directive on safe management of spent fuel and radioactive waste (2011/70/EURATOM) in 2013, which should be studied in the same connection.

The MEAE established a steering committee that makes decisions on the project policies and two working groups: one to assess the amendments caused by the Directives and make proposals on them and another to address licensing issues. Representatives of STUK were named to both working groups and the sub working groups of the working groups.

Most of the policies on the amendment of the Nuclear Energy Act and the proposals required by them were completed by the end of 2016. The most important amendment proposals involve issues based on the Directives, such as nuclear facility decommissioning licence, transparency and licensee's obligation to provide information, participation of the general public in the decision-making process on nuclear facility licensing, international peer reviews and the licensee's obligations.

The proposals for amending the Act and their justification will be further processed in early 2017. Preparation of an amendment of the Nuclear Energy Decree will also be started. The goal is for the amended Nuclear Energy Act and Decree to enter into force on 1 January 2018.

Update of STUK regulations and YVL Guides

STUK's regulations adopted by virtue of the Nuclear Energy Act and the YVL Guides will be updated between 2016 and 2018. To proceed with this work, STUK initiated a project of its own (RYSÄ) in early 2016. For a start RYSÄ focused on assessing the needs to amend the regulations.

When updating the STUK regulations, the primary important issue is taking into account the amendments of the Act and Decree, but the Reference Levels for operating nuclear facilities, for waste and nuclear waste disposal facilities and for decommissioning by the Western European Nuclear Regulators Association (WENRA) in 2014 and 2015 also have impact on the regulations. The WENRA member states are committed to enforcement of the Reference Levels in their national regulations by the end of 2017. The International Atomic Energy Agency (IAEA) has also published updated safety standards that take into account lessons learned from the Tepco Fukushima Daiichi accident, among other things. According to STUK's guidelines, the IAEA standards must be taken into account when preparing the national regulations.

Implementation of the YVL Guides

The nuclear safety guidelines (YVL Guides) cover all issues influencing the safety of nuclear facilities, such as design, operation, safety of the facility and its environment, nuclear materials, nuclear waste, structures and equipment. The renewed YVL Guides were competed in late 2013 and have been applied as such to the planning of new nuclear facility projects, such as the Fennovoima nuclear power plant project, ever since.

In 2015, STUK made YVL Guide implementation decisions to the operating units at Loviisa and Olkiluoto and VTT's FiR research reactor. In 2016, STUK prepared YVL Guide implementation decisions to Olkiluoto 3. The decisions will be finalised in 2017 and the new YVL Guides will enter into force for Olkiluoto 3 as soon as the operating licence is granted.

In the YVL Guide implementation project, STUK assessed guide-specific reports by the licensees, focusing on the processing of non-conformances and measures proposed by the licensees. The project covered 42 YVL Guides and the around 8,000 requirements included in them. More than 60 people participated in the STUK implementation project, using 2.2 man-years.

2 Results of regulatory oversight of nuclear power plants in 2016

2.1 Loviisa 1 and 2

STUK oversaw the safety of the Loviisa 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 2016 are included in Appendix 4. The periodic safety assessment that was started in 2014 was also continued. It will be finalised in 2017.

Radiation safety of the plant, personnel and the environment

The collective occupational radiation dose of the employees in 2016 was 0.25 manSv at Loviisa 1 and 0.32 manSv at Loviisa 2. The combined radiation dose of both units (0.84 manSv) was one of the lowest doses ever when compared to all the years during which a longer annual outage was performed. The collective occupational dose during the annual outage of Loviisa 1 was clearly lower than originally anticipated and clearly lower than during the reference year (2008). The collective occupational dose at Loviisa 2 complied with the advance estimate. 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. Activated antimony that attached itself to the primary circuit piping was a major source of radiation in the steam generator room. According to primary circuit dose rate measurements performed during the annual outage and nuclide-specific measurements, the radiation levels are clearly lower than in the previous years. Fortum also performed some eye dose measurements during the annual outages. As radiation legislation will be revised, which means that the equivalent dose limit for the lens of the eye will become stricter, the work on determining the eye doses must be continued.

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 Loviisa nuclear power plant was 9.8 mSv; this dose was the result of work on insulation materials during the annual outage.

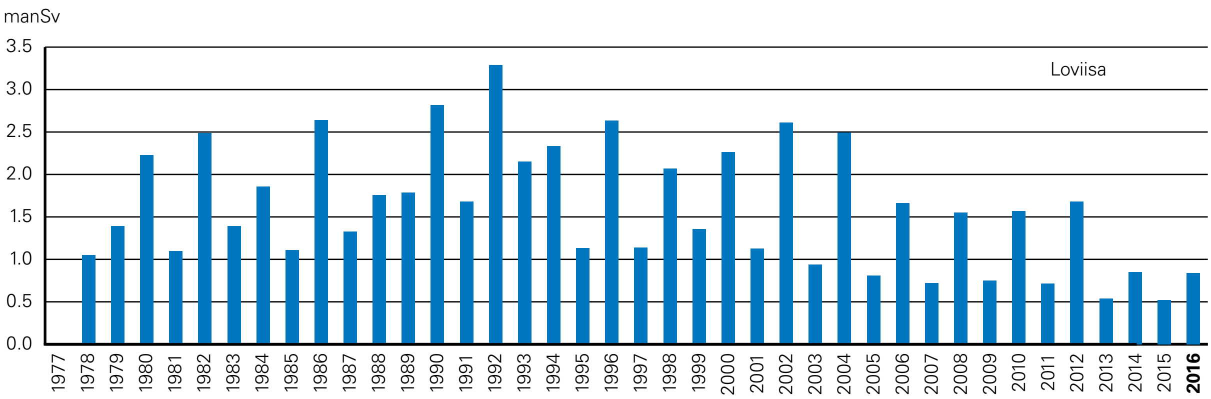


Figure 1. Collective occupational doses since the start of operation of the Loviisa nuclear power plant.

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 around 0.05 µSv per year or less than 0.1% of the set limit (Appendix 1, 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 2016. Small amounts of radioactive substances originating from the plant were observed in some of the analysed environmental samples. The amounts were so low that they are insignificant in terms of the 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 Loviisa power plant were detected in them.

Operation and operational events

In 2016, Fortum reported the results of twenty event investigations to STUK. Most of the events revealed development areas involving procedures and operating methods, such as compliance with the operational limits and conditions and guidelines, sufficiency of instructions, planning of work and communication. Around half of the events took place during the annual outages. The operational events in 2016 did not compromise nuclear or radiation safety, and all of the events were rated as category 0 events on the international INES scale. The most important operational events are described in Appendix 3.

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 most of Fortum's event investigations sufficient. However, STUK required that Fortum further investigate the underlying causes of one of the events. In the case of some events, STUK required minor additional actions or pointed out issues that Fortum should take into account in its further development. Furthermore, STUK wished to verify in the case of some of the events that Fortum is able to achieve changes with the actions it has taken. To monitor this issue, STUK requested that Fortum submit reports on the impact of the corrective actions at a later date.

STUK uses the results of the event investigations also when choosing the focus areas of its plant inspections. In the 2016 inspections, STUK studied issues such as the underlying reasons for delays of pressure equipment inservice inspections and Fortum's improvement actions, as well as nuclear fuel refuelling machine personnel resources and qualification of these employees. STUK is of the opinion that Fortum's reporting indicates a willingness to develop the operations in order to learn from the events.

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 annual outage inspections were carried out on schedule and in the planned scope. During the annual outages, Fortum inspected – in accordance with a programme agreed with STUK – that there was no hydrogen flaking in the reactor pressure vessel of the power plant unit 1. No observations indicating hydrogen flaking were made. A similar inspection on the pressure vessel of Loviisa 2 was performed during the 2014 annual outage. The most important events during the annual outage involved the refuelling of Loviisa 1, and STUK required a report on these events from Fortum. An indication from an emergency water system nozzle was found at Loviisa 1 with a new inspection method, and STUK required that Fortum conduct similar inspections of both plant units also during the 2017 annual outages. More information about the annual outages is available in Appendix 3 and a summary of the annual outage inspection is included in Appendix 4.

Development of the plant and its safety

Several modification projects that will improve plant safety are currently ongoing at the nuclear power plant. The largest project is the Loviisa I&C renewal. Installations included in the first phase of the project were completed at both plant units during the 2016 annual outage. This phase included a preventive safety function control and indication system as well as modernisation of the I&C status monitoring system. STUK continued its review of the Loviisa I&C renewal documents for the subsequent phases. The rest of the I&C renewal installations will be completed during the 2017 and 2018 annual outages.

A replacement project of Polar cranes in the reactor buildings of the Loviisa nuclear power plant has started well and STUK reviewed construction plans related to the modification in late 2016. The construction inspections started at the end of the year. According to Fortum's plans, installation and commissioning of the cranes will take place before the 2018 annual outages.

During the 2016 annual outage, new main steam line safety valves were installed in Loviisa 1. The valves have also been qualified with a steam-water mixture to prevent them from getting stuck in the open position, which will prevent a primary-secondary circuit leak, for example. A similar installation was carried out at Loviisa 2 during the 2014 annual outage. In 2016, STUK approved, based on analyses and reports, changes made by Fortum in its guidelines according to which the forced opening function of the valves will be utilised to reach a safe state also in more infrequent cases if the other means are not available. The reports involved opening of the valve slowing down during continuous operation.

New main steam line radiation measuring instruments were also installed and commissioned at Loviisa 1 to replace the old, aged instruments. The new measuring instruments are more sensitive than the old ones and are better at detecting any leaks from the steam generators to the secondary circuit. Similar instruments were installed at Loviisa 2 in 2015.

A new weather mast and related sensors were commissioned at Loviisa in the summer of 2016. The weather mast had been tested parallel to the old system since 2015. When the weather mast system was replaced, a marine weather observation point to support the power plant's weather mast was constructed on Orrengrund island, which is located around 10 kilometres from the power plant.

During the annual outages, Fortum replaced one high pressure safety injection pump motor and the related heat exchanger at both units. The pumps themselves were replaced in 2006 (LO2) and 2008 (LO1). 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 work will be continued in 2017, at which time the rest of the motors (three in total) at both units will be replaced.

The modifications started after the assessments done due to the Fukushima accident were continued in 2016. As part of the preparations for high seawater level, Fortum conducted additional studies and continued the planning of added flooding protection for the rest of the emergency systems that could be needed under extreme conditions. The raising of the stop-log gates is ongoing and, in addition to the flooding protection of the auxiliary emergency feedwater pumping plant, Fortum is planning a similar protection system for the additional residual heat removal system. The plan is to realise it in 2017. In 2016, STUK also approved Fortum's updated plans regarding securing the cooling of the fuel pools under highly exceptional conditions. According to Fortum's plans, installation and commissioning of the modification will take place in 2018. Some improvements in the storage and availability of diesel fuel were also made in 2016 to ensure that diesel fuel will be available to all of the systems required during an emergency for a minimum period of 72 hours.

The original plan was for modifications aiming at securing the safety functions of the secondary circuit in the turbine hall in case of a high energy pipe break to be implemented during the 2016 annual outage, but Fortum postponed the modifications to 2018 because further planning was necessary.

Periodic safety assessment

In 2016, STUK continued the finalisation of its periodic safety assessment that was started in 2014, and the work will be completed in 2017. According to the terms of the operating licence that was granted to Fortum in 2007, the licensee must prepare comprehensive safety assessments for the Radiation and Nuclear Safety Authority by the end of the years 2015 and 2023. STUK will create its own safety assessments based on these assessments and require actions from Fortum to correct deficiencies or improve safety, if necessary.

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 2016. An extensive cooperation drill was arranged at the plant in April. Several public administration organisations participated in the drill. In cooperation, the organisations were able to respond to all key challenges practiced in the drill. Potential development areas identified when assessing the drill included an assessment of the emergency preparedness organisation's alarm arrangements, the introduction of status logs for the holders of different posts and replacement of the keys to the plant needed by repair teams. 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.

Security arrangements

STUK assessed the security arrangements of the Loviisa nuclear power plant with an inspection included in the periodic inspection programme (Appendix 4) and by participating in oversight during the annual outage (Appendix 3). Fortum's security arrangements drill plan was realised as planned in 2016. STUK participated in the drills mainly to test the connections, i.e. to practice the reception of announcements and the initiation of operations.

In late December 2016, Fortum submitted new versions of the Loviisa nuclear power plant's security plan and security standing order to STUK for approval.

A new head of the corporate security unit and a new head of information security were appointed in connection with Fortum's organisational renewal. STUK approved these changes as part of the Loviisa nuclear power plant's administrative rules.

Fire safety

Fire safety at the Loviisa nuclear power plant is at a good level. In 2016, STUK oversaw the plant's fire safety with an inspection included in the periodic inspection programme (Appendix 4), with site visits and by reviewing reports submitted by Fortum.

Modifications that improved fire safety in 2016 included a modification of the hydraulic turbine bypass stations into water-powered ones, for example.

Organisational operations and quality management

Based on STUK's oversight, one can state that with a view to ensuring safety, the Loviisa nuclear power plant organisation has operated in a systematic and development-oriented way. STUK oversaw the operations of the Loviisa nuclear power plant organisation and competence management by, for example, performing two inspections included in the periodic inspection programme (Appendix 4). Furthermore, resource planning was the general theme of all of the inspections included in the periodic inspection programme in 2016. STUK focused its regulatory oversight particularly on Fortum's management, competence management, resource management and procurement processes. In 2016, Fortum realised a comprehensive organisational renewal that also involved the operations and personnel of the Loviisa nuclear power plant. The new organisational structure entered into force on 1 July 2016. The change did not influence the annual outages which started in August, as the annual outage organisation had been determined based on the old areas of responsibility. STUK did not detect any special impact on nuclear safety caused by the organisational renewal in 2016, but the issue will be reassessed and impacts will be monitored also in 2017.

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. 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. The most important development in waste management in 2016 was the fact that operation of a solidification facility for liquid radioactive waste started on 15 February 2016 after STUK had approved the related application.

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) in 2014. 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 at the time when the facility is closed. 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 renovation will continue in 2017.

STUK performed a commissioning inspection of the maintenance/waste room 3 (HJT3) in June 2016. The commissioning inspection was based on an operating licence granted by STUK that allows Fortum to use HJT3 for the sorting and storage of low-level waste. As the concrete vault in the hall for solidified waste (KJT) is currently being repaired, Fortum applied from STUK a licence to use HJT3 as the interim storage facility for concrete waste packages crated during the solidification process until the end of 2018. STUK granted the applied permit in August 2016.

Fortum initiated a spent fuel disposal development programme for the years 2016–2030 because the transport of spent fuel to the Posiva facility in Olkiluoto and its disposal require actions to be taken at the Loviisa nuclear power plant. The development programme covers all of the work on the storage and disposal of spent fuel required by the Posiva disposal project. At the first phase at the end of 2016, Fortum has started the planning of the modernisation of gantry cranes to be used in the interim storage facility for spent nuclear fuel.

Nuclear safeguards

In 2016, a total of ten nuclear safeguards inspections were conducted at Loviisa nuclear power plant. STUK performed an inspection pertaining to the verification of the physical inventory 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. Also in 2016, STUK performed a nuclear fuel reception inspection. No remarks were made in the inspections.

2016 was the first year when STUK included the Loviisa nuclear power plant nuclear safeguards inspections in its periodic inspection programme (see Appendix 4).

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 overseeing operations at the plant. Summaries of inspections included in the periodic inspection programme for 2017 are included in Appendix 4. 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.

Radiation safety of the plant, personnel and the environment

The collective occupational radiation dose of the employees in 2016 was 0.64 manSv at Olkiluoto 1 and 0.24 manSv at Olkiluoto 2. The slightly higher radiation dose than in the previous years at Olkiluoto 1 was partly due to the fuel leaks in the plant unit. The event is described in more detail in Appendix 3.

Due to the fuel leaks, releases into the air from Olkiluoto 1 were larger than in the previous years. Furthermore, a leak in a flange of the exhaust gas system's radiation measuring system inside the turbine building of Olkiluoto 1 was detected after the annual outage in June. Due to the leaking flange, some of the radioactive materials in the exhaust gas (most of them short-lived) moved from the interior of the plant unit to the vent stack without entering the exhaust gas system delay tanks, which increased the noble gas and aerosol releases of the plant unit, in particular. Radioactive releases into the air and sea remained clearly below the set limits despite the above-mentioned events. The calculated radiation dose of the most exposed individual in the vicinity of the plant was around 0.28 µSv per year or less than 1% of the set limit (Appendix 1, indicator A.I.5c).

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 8.1 mSv; this dose was the result of mechanical maintenance work.

Fission product activity levels at Olkiluoto 1 will be elevated in the next few years due to the fuel leaks. Radioactive iodine was detected in the systems of many of the employees in full-body measurements performed by STUK during the annual outage, but the internal dose recording threshold (0.1 mSv) was not exceeded in the case of any of the employees.

A total of approximately 450 samples were collected and analysed from the land and marine environment surrounding the Olkiluoto nuclear power plant in 2016. Small amounts of radioactive substances originating from the plant were observed in some of the analysed environmental samples. Unlike in the past years, small amounts of radioactive iodine were detected in the analysed air samples. This was to be expected, as more iodine than before was released from the plant into the environment in connection with the annual outages in the spring due to the leaking fuel rods. The level of radioactivity detected in the environmental samples was so low that it was insignificant in terms of the 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.

Operation and operational events

In 2016, TVO reported the results of 11 event investigations to STUK. Nine of the investigations involved single events and two of the investigations involved several events occurred during the annual outages. Most of the events revealed development areas involving procedures and operating methods, such as compliance with guidelines, sufficiency of instructions and the planning of work. Development areas in employee orientation were identified in some of the investigations. Some radioactive materials were released into the environment in the case of two of the events. One of the events involved fuel leaks and the other an error during maintenance. The set limits were not exceeded and neither of the events compromised radiation safety of the population. Both events increased the radiation level inside the plant. The employees' radiation exposure was limited by, for example, properly scheduling the work and ensuring that the employees use protective equipment. The most important operational events are described in Appendix 3.

STUK verified by reviewing event reports that TVO 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 most of TVO's investigations of the single events sufficient. In one case, STUK requested TVO to further investigate the underlying causes of an event and assess sufficiency of the measures taken to improve the operations. In one case, STUK wished to verify that TVO is able to achieve changes with the actions it has taken. To monitor this issue, STUK requested that TVO submit reports on the impact of the corrective actions at a later date.

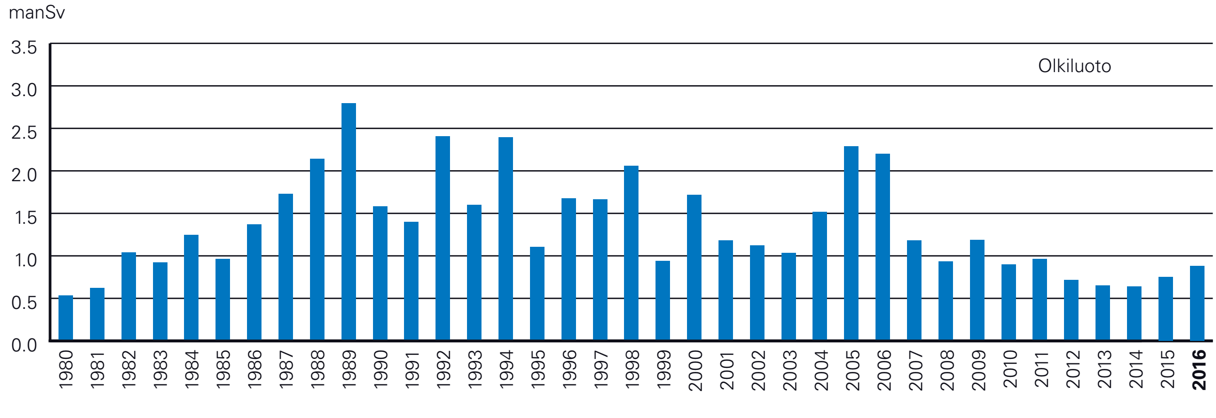


Figure 2. Collective occupational doses since the start of operation of the Olkiluoto units 1 and 2.

The annual outages of the plant units were implemented as planned in terms of nuclear and radiation safety. 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. STUK performed an annual outage inspection in compliance with the periodic inspection programme during the annual outage. A summary of the inspection is presented in Appendix 4. More information about annual outages of the plant units and STUK's regulatory oversight is available in Appendix 3.

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 in 2017 and 2018.

Dependence of the auxiliary feedwater system from the seawater cooling was clearly reduced by implementing a modification at Olkiluoto 1 in 2014. Abnormal vibration and sounds were detected during testing in one of the new recirculation lines, however, and TVO continued to investigate the problems in 2016. A similar modification of the recirculation line will not be implemented at Olkiluoto 2 until the studies are completed. A reliable total view of how the modification will be completed could not be reached based on the reports submitted to STUK, which is why STUK required from TVO a report that describes the current status of the auxiliary feedwater system and justifies operability of the system in Olkiluoto 1. The report must indicate how the problems detected by TVO are being resolved and the schedule of the repairs. The report must be submitted to STUK in early 2017.

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. TVO plans to commission the rest of the new reactor coolant pumps in 2017 and 2018. STUK continued its review of documents pertaining to replacement of the reactor coolant pumps and the oversight 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. In 2016, STUK reviewed related design documents.

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 2016. In September, an emergency preparedness drill that covered both operating plant units and the spent fuel storage facility was arranged at the Olkiluoto nuclear power plant. An emergency preparedness drill that covers several plant units has not been arranged before at Olkiluoto. The key emergency preparedness actors participated in the drill: TVO, STUK, the rescue services and the police. In cooperation, the organisations were able to respond to all the key challenges practiced. Potential development areas identified when assessing the drill included the equipment available at the maintenance assembly point, the introduction of status logs for the holders of different posts and providing more training on the INES classification system. Even though more construction activities are ongoing at the Olkiluoto 3 construction site, the construction site's influence on emergency preparedness arrangements was low. The emergency preparedness arrangements have been continuously developed, and future commissioning of Olkiluoto 3 has been taken into account in the development. Emergency preparedness at Olkiluoto nuclear power plant complies with the key requirements.

Nuclear security

STUK assessed the plant's security arrangements in inspections included in the periodic inspection programme (Appendix 4). Drills are part of the development of security arrangements and the assessment of their effectiveness. In 2016, two emergency preparedness drills on threatening situations and training on threatening situations were arranged by TVO and the police together. Monitoring and reporting of the security organisation training programme have been developed in the past few years, and the plan is to use training more in the demonstration of the effectiveness of the security arrangements.

TVO submitted to STUK for approval a security standing order and a security plan as well as updated versions of the transport security plan, for which STUK issued a request for clarification.

Fire safety

Fire safety at the Olkiluoto nuclear power plant is at an acceptable level. In 2016, STUK oversaw fire safety of the nuclear power plant by means of regulatory inspections and site visits, and by reviewing reports submitted by TVO.

Organisational operations and quality management

Based on STUK's oversight and the results of operating activities, it can be stated that with a view to ensuring safety, TVO's organisation has operated in a systematic and development-oriented way. The operating model adopted by TVO in 2015 has been largely established, but there are clear challenges involving the atmosphere in the company. Their effects on the quality of the operations must be analysed and managed by the management of the company. Based on the regulatory oversight of STUK, there is reason to suspect that the organisation will also face challenges with the adequacy of resources. STUK will continue to monitor the actions taken by TVO to maintain the organisation's safety culture during the challenging change.

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. Disposal of radioactive waste originating from the use of radiation at the operational waste disposal facility in Olkiluoto started at the end of 2016. These sources have been removed from use and classified radioactive waste. According to the Radiation Act and the Radiation Decree, such waste is under the responsibility of the state and the management of STUK.

An expansion of the spent fuel interim storage facility at Olkiluoto was completed in early 2015. Due to the expansion, TVO submitted to STUK for approval updated materials from the final safety analysis report (FSAR) of the facility, which STUK reviewed and approved.

Nuclear safeguards

A total of 19 nuclear safeguards inspections of TVO's operating plants and the spent fuel storage facility were performed. 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 extra outage of Olkiluoto 1. In addition, STUK completed a nuclear safeguards inspection on both plant units and the spent fuel storage facility, as well as a fuel reception inspection at Olkiluoto 1. STUK also participated in three inspections of IAEA and Euratom in Olkiluoto at short notice. Two of these inspections involved Olkiluoto 1 and one the spent fuel storage facility.

2016 was the first year when STUK included the Olkiluoto nuclear power plant nuclear safeguards inspections in its periodic inspection programme. The inspection covered the procedures

TVO uses to meet the requirements posed by legislation, the YVL Guides and EU Regulations. Two requirements were imposed in the inspection. Compliance with them will be verified in 2017.

TVO imported measuring instrument shields (protective sleeves of SIRM detectors) without a licence which was not in compliance with the Nuclear Energy Act and submitted a special nuclear safeguards report on the event to STUK. STUK required that TVO update its nuclear safeguards manual so that it includes clear instructions to avoid similar events in the future.

Renewal of the operating licence

The current operating licence for Olkiluoto 1 and Olkiluoto 2 is valid until the end of 2018. TVO will submit an application on renewal of the operating licence to the Ministry of Economic Affairs and Employment in early 2017. The procedure to be followed when an application for the renewal of an operating licence for a nuclear facility currently in operation is filed is the same as that for filing an application for an operating licence for a new nuclear facility. A periodic safety assessment of the facility is always performed before renewing the operating licence. TVO submitted to STUK its periodic safety assessment and the related reports as laid down in YVL Guide A.1 at the end of 2016. STUK has started the review of the documents and the preparation of its safety assessment. Both of these tasks will be completed by the end of 2017.

2.3 Olkiluoto 3

STUK oversaw the construction and testing of the Olkiluoto 3 plant unit and TVO's preparation for the future operational phase. In 2016, STUK focused its regulatory oversight on review of the operating licence application and on oversight of the remaining installations and the commissioning activities.

TVO submitted an operating licence application to the Ministry of Economic Affairs and Employment (MEAE) in April 2016. At the same time, TVO submitted the documents on the plant and its operation required by virtue of section 36 of the Nuclear Energy Decree to STUK for approval.

Installation of almost all of the systems and components in Olkiluoto 3 was completed and large-scale testing started in 2016. Testing of the I&C systems started at the beginning of the year and the first process system tests were performed in April 2016. Many more tests have been started after that time.

STUK's oversight consisted of assessing the acceptability of documents, monitoring the licensee's operations and safety culture, inspecting the licensee's operations in compliance with the construction inspection programme (RTO), a variety of component and system inspections to verify the compliance of products and general oversight at on site.

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 is able to state that the original safety targets of the plant can be achieved.

Review of the operating licence application

TVO submitted an operating licence application to the Ministry of Economic Affairs and Employment (MEAE) in April 2016. At the same time, TVO submitted the documents on the plant and its operation required by virtue of section 36 of the Nuclear Energy Decree to STUK for approval. The operating licence documents were submitted to STUK as an entity from which only the fire risk analyses are missing. STUK had granted a permission to submit the fire risk analyses at a later date. The fire risk analyses were submitted to STUK in October 2016.

STUK will verify when reviewing the operating licence application that the prerequisites for 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.

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 of the plant site, its inspections and results obtained during the commissioning of the plant.

As STUK has already reviewed and approved the design of the systems and components during construction, i.e. before the submission of the operating licence application, the focus of the operating licence review does not lie in the assessment of design. Instead, STUK assesses the readiness of the organisation to start operational activities, the analyses performed to demonstrate the safety level and the status of open issues from the previous stages.

STUK has proceeded with the operating licence review according to plan. The first decisions on the documents referred to in section 36 of the Nuclear Energy Act have been made. Review of the larger documents, such as the final safety analysis report, the operational limits and conditions and the probabilistic risk assessment, will continue in 2017.

STUK will not issue a statement on the operating licence until it has been proven with commissioning tests that the plant and its systems operate as planned. Large-scale testing started at Olkiluoto in the spring of 2016. The plan is to complete the tests of single systems and components by the summer of 2017, after which time the plant will be tested as a single entity before the loading of nuclear fuel. STUK oversees the testing on site at Olkiluoto. If the testing proceeds as planned, STUK will issue its statement on the operating licence application at the end of 2017. According to the present schedule, the loading of nuclear fuel will take place in April 2018.

Review of other licensing documents

I&C component suitability analyses and stress analyses of mechanical components and piping, among other documents, are still to be submitted to STUK.

STUK monitored progress of the I&C component qualification and reviewed the component suitability analyses. The documentation of the qualification tests and the preparation of the suitability analyses will continue until the beginning of 2018. The final suitability analyses must be

Suspected product forgeries by component manufacturers

In May, the French nuclear safety authority ASN informed STUK of suspected malpractice at the Creusot Forge factory that manufactured important components for the Olkiluoto 3 reactor coolant circuit, such as forged parts of the pressurizer and the primary circuit pipes. Deficiencies, negligence and forgeries had been detected in the documentation delivered by the factory.

At the same time, TVO announced that it had received information about uncertainties detected in material certificates from SBS (Spécial Brides Service), a company that had delivered materials to several subcontractors. STUK required from TVO a report on whether these suspicions are connected to the manufacture of components for Olkiluoto 3 and if so, what is their significance. Furthermore, in connection with this issue STUK required from TVO and Fortum reports on whether any components subject to similar quality uncertainties had been delivered by the said company to any of the currently operating Finnish nuclear power plants.

Areva's report on Creusot Forge's OL3 documentation was still unfinished at the end of the year. In November, STUK participated in an international regulatory inspection of the Creusot Forge factory. TVO visited the factory in December. According to preliminary information, the investigation at the factory will be completed by the end of March 2017, after which time Areva will submit the results and conclusions to TVO. STUK has required a report from TVO on the issue once the document review at the factory has been completed. The report must be submitted to STUK by the end of April. STUK is currently reviewing the operating licence application of the OL3 plant unit. This matter must be cleared up before STUK can issue a statement on the operating licence application. STUK is scheduled to issue a statement on the operating licence at the end of 2017.

According to TVO, Areva has thoroughly reinvestigated all of SBS' deliveries to Olkiluoto 3. TVO does not have the final documentation on the material deliveries at its disposal yet, which is why TVO has not been able to perform a new documentation review itself. STUK has required that TVO perform a new review of the documentation of SBS' OL3 deliveries before loading of the fuel.

TVO submitted to STUK a report on the operating plants at the end of October. According to the report, there are no forgeries among the components delivered to the Olkiluoto 1 and 2 plant units, and all the inspected components complied with the requirements. STUK received a report on the Loviisa nuclear power plant from Fortum at the end of December. According to the report, no defective or forged documents have been found as of yet, but the investigation needs to be continued because the investigation process is difficult and time-consuming. Additional information should be available by 31 March 2017.

submitted to STUK in due time before the loading of the fuel.

Over the course of the year, STUK processed several fatigue analyses of mechanical components.

Oversight of commissioning

The purpose of commissioning is to verify that the plant's systems, structures and components operate as planned and were successfully installed. Large-scale testing of the OL3 plant unit started in 2016.

I&C testing started at the beginning of the year and testing of the nuclear island process systems started in April. STUK reviewed testing plans and oversaw the testing on site. Based on the review of the testing plans, STUK was not convinced of the coverage of the I&C function testing. STUK imposed a requirement on this issue to TVO in the I&C commissioning inspection. As a response to the requirement, TVO prepared a description of the testing strategy and the procedures used to verify coverage of the I&C function testing, and submitted the description to STUK. STUK did not have any remarks on the report.

The other commissioning plans have been of a good quality and STUK has been able to approve most of them without any remarks.

The procedures used at the testing stage were reviewed in several construction inspection programme inspections. Some requirements on clarifying the roles and responsibilities of the organisation and the guidance provided to personnel were imposed in these inspections. In general, STUK considered TVO's procedures to be sufficient for commissioning and testing.

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 oversaw and inspected TVO's preparations for the operation of the plant. An important part of the training provided to the operators is training in a plant simulator. STUK oversaw the acceptance testing of the simulator. The testing demonstrated that the simulator sufficiently accurately depicts the plant, and training with the simulator could be started. Operator training was more comprehensively assessed in an inspection included in the construction inspection programme. Two requirements about deputy practices were imposed in the inspection.

STUK reviewed preparation of procedures on the 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. Maintenance procedures were reviewed in the ageing management inspection. STUK performed a separate inspection of verification and validation of emergency operating procedures. Even though the preparation of the procedures in some disciplines has just been started or being planned, it seemed based on the inspections that TVO is prepared to complete the work before starting operation.

STUK also inspected the emergency preparedness arrangements and preparations related to the management of ageing. Both the emergency response plan and the ageing management programme were submitted to STUK as part of the operating licence application.

According to the present schedule, transport of fresh nuclear fuel to the plant will start in the autumn of 2017. STUK approved an application on the fuel import licence. STUK inspected the nuclear safeguards preparations in two inspections, one of which was completed in cooperation with the European Commission. The inspections covered nuclear safeguards design infromation; i.e. the basic technical characteristics, and the installation of monitoring instruments.

Manufacture, installation and construction

STUK continued its oversight of manufacture, installation and construction.

Almost all piping installations were completed by the end of the year. STUK oversaw the installation activities and performed the installation inspections laid down in the YVL Guides. Modification of cabling in the nuclear island also continued in 2016. STUK oversaw the work on the cabling on site in connection with its site visits.

In the spring, TVO informed STUK of two problems at the construction site: some valve components had been accidentally installed at the wrong locations and it was observed during a ventilation duct leaktightness test that the leaktightness requirements imposed during design were not met in all cases.

TVO submitted to STUK for approval a proposal on how to correct the problems involving the ventilation ducts: if leaktightness without a special reason was demanded during design, the requirement can be made more lenient, but if there is an actual need for the duct to be leaktight (to prevent the spreading of radioactivity), the installations will be repaired. STUK approved the proposal but imposed some related requirements on, for instance, verifying the leaktightness of the ducts that must be leaktight due to radiation protection reasons.

In relation to the valve installations, TVO submitted to STUK a report on the underlying causes of the mix-up and the lessons learned. All of the errors made during the installation can be traced and corrected.

Pressurizer safety valves have not been installed yet. 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. Implementation and testing of the modifications continued in 2016, and STUK oversaw and inspected the work and the related documentation. In France, a similar valve station that will be installed in an EPR unit currently under construction In France, was tested. The purpose of the tests in France was to obtain operating experience feedback on the new type of valve. The valve was opened and closed several hundred times during the test. STUK monitored the testing and has required from TVO an assessment on the test results.

As part of the oversight of the construction site, STUK performed a combined security arrangements and I&C system site visit at Olkiluoto 3 in the summer of 2016. During this site visit, a site walk-down covering all rooms that include important I&C systems was made. STUK made some observations regarding the access control of the rooms, and corrective measures have been performed due to these observations.

2.4 Hanhikivi 1

On 30 June 2015, Fennovoima submitted a construction licence application for a new nuclear power plant (AES-2006) to the Ministry of Economic Affairs and Employment (MEAE). Fennovoima simultaneously submitted licensing documents by virtue of the Nuclear Energy Decree to the Radiation and Nuclear Safety Authority for the initiation of a safety assessment. On 8 September 2015, the MEAE submitted a request for a statement to STUK. In the request, the MEAE asked STUK to provide a statement and a safety assessment as well as a statement from the Advisory Committee on Nuclear Safety on the project by the end of 2017, if possible.

When processing reports linked to the construction licence application of the Hanhikivi 1 plant project, STUK assesses both technical compliance of the plant and ability of the organisations of the licensee, the plant supplier and the main service providers to construct and ultimately operate a nuclear power plant.

Review of the construction licence application

The documents submitted to STUK in connection with the construction licence application were not complete, and Fennovoima has supplemented and will supplement its construction licence application in stages between 2015 and 2018. Delivery of the Fennovoima construction licence documents has been delayed from the construction licence application and the first licensing plan submitted in 2015. Furthermore, Fennovoima has updated its licensing plan since 2015. STUK is of the opinion that the delays in the delivery of the construction licence documents were mainly caused by the project and its supply chain being organised slower than expected and a lack of resources in project management and the design organisation.

More meetings between Fennovoima, the plant supplier and STUK were held in 2016. Topical issues covered in the meetings included the core catcher, air plane crash, civil engineering, electrical engineering and the turbine island. STUK also participated as an observer in audits of the Fennovoima supply chain.

Regulatory inspection programme (RKT)

STUK assesses the management systems of Fennovoima and the other organisations participating in the project by, for example, participating in Fennovoima's supply chain audits. Furthermore, STUK performs inspections of the organisations to ensure that their actual operations comply with the requirements.

STUK launched the inspections included in the regulatory inspection programme (RKT) in September 2015. The inspections are planned six months in advance. In 2016, STUK performed a total of 15 inspections of different functions of Fennovoima and key organisations of the plant supplier (RAOS Project Oy, JSC Atomproekt, OKB Gidropress and the Kurchatov Institute). Summaries of the RKT inspections performed in 2016 are included in Appendix 6.

Based on the 2016 RKT inspections, STUK can state that Fennovoima has clearly developed its management system based on STUK's previous requirements. Issues that still require further development include securing the interfaces between the processes of Fennovoima and the plant supplier, taking into account nuclear safety issues in project management and clarifying the responsibilities of Fennovoima's different departments in the processing of safety issues at the plant, architecture and system level.

In STUK's opinion, organisation and development of the required management systems of the plant supplier selected by Fennovoima, RAOS Project Oy, do not comply with the plans submitted in connection with the application. Many issues involving project quality management are still being developed and STUK is of the opinion that the organisation is not ready for nuclear construction yet. Determined development of the entire supply chain is necessary in order to comply with the Finnish requirements.

Agreements have not been signed with many of the key organisations yet and there is no clear, frozen plan of the plant I&C system suppliers, for example. In the summer, Fennovoima announced a turbine agreement with the plant supplier. The placement of the turbine island at the plant site and its connections to the nuclear island must be taken into account in basic design of the plant and in the safety assessment. As an agreement has been signed, the parties can now start further specifying the basic design of the plant site.

EIA program for disposal of spent fuel

In June 2016, Fennovoima submitted to the Ministry of Economic Affairs and Employment (MEAE) its environmental impact assessment programme (EIA programme) on the disposal of spent nuclear fuel. In its statement to the MEAE, STUK paid attention to the fact that it is a long-term process and the EIA report will not be completed until 2040. Therefore, the current status of the EIA programme should be reassessed during the process, such as after commissioning of the nuclear power plant when Fennovoima will submit to the MEAE a waste management plan every three years. STUK also pointed out that the research area for the site investigation in Eurajoki should be selected as soon as possible, and that the EIA process should assess seismic properties of the research areas, the proximity of natural resources, radioactive releases from the operations under normal conditions and accident conditions and the radioactive waste generated in the process. The project's EIA must take into account the entire project lifecycle, including the decommissioning of the encapsulation facility and the related processing and disposal of waste.

2.5 Research reactor

In 2012, VTT Technical Research Centre of Finland made, for financial reasons, a decision to shut down its research reactor and start the preparations for its decommissioning. The reactor was placed in permanent shutdown in June 2015, and VTT started to prepare an operating licence application for the decommissioning of the research reactor. VTT aims to submit the operating licence application to the Government in early 2017.

STUK monitored safety of the research reactor by reviewing materials provided by the licensee, as well as by carrying out inspections in line with the periodic inspection programme and the YVL Guides. Furthermore, STUK prepared for future assessment of the operating licence application by establishing a separate subproject.

VTT submitted a nuclear waste management plan for the research reactor to the Ministry of Economic Affairs and Employment in September 2016. The report included all measures since the 2015 report and all planned measures. The report included a proposed schedule for the decommissioning phase of the research reactor, which extends until 2022. According to a request for a statement by the MEAE, STUK submitted to the MEAE a statement on the nuclear waste management report where STUK stated that VTT had made clear progress in the design of the research reactor's decommissioning in the past year. Progress in the preparation of the dismantling plan has been systematic and material inventory surveys are being prepared. STUK pointed out that there are still uncertainties regarding the storage and disposal of low- and intermediate-level waste, and that the related plans must be further specified in the operating licence application on the decommissioning. Furthermore, the effects of the uncertainties in the spent nuclear fuel return procedure and the alternative spent nuclear fuel maintenance programme on the research reactor decommissioning project must be assessed in the final decommissioning plan.

In terms of nuclear safeguards, VTT's material balance area and research reactor site cover the nuclear materials and related activities in the Otakaari 3 building. As the experimental research activities in the VTT Centre for Nuclear Safety are started, the plan is to expand VTT's nuclear safeguards site to cover both buildings. In 2016, STUK approved VTT's updated the nuclear safeguards manual of the research reactor's material balance area. STUK inspected the nuclear material accountancy together with the European Commission in June, and in November STUK performed a nuclear safeguards system inspection of VTT to assess the procedures VTT uses to ensure compliance with legislation, the YVL Guides and EU Regulations.

2.6 Spent nuclear fuel encapsulation and disposal facility

At the end of 2015, Posiva received a decision from the Government that authorised it to construct the spent nuclear fuel encapsulation and disposal facility. In 2016, Posiva prepared for the start of construction operations. STUK assessed Posiva's readiness to start construction with its construction inspection programme (RTO) inspections and readiness inspections at the end of 2016. In its decision issued in late November, STUK stated that Posiva had achieved the level of readiness needed to start construction. STUK also issued a statement to the MEAE on Posiva being ready to start construction. The statement also noted that Posiva had started the construction activities during the validity period of the construction licence laid down in the Government decision.

The regulatory oversight during the construction stage covers design, manufacture, construction and installation of the nuclear waste facility and its safety-classified systems, structures and components. The oversight also includes the future nuclear waste facility's commissioning stage, 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

In 2016, tunnel contract 6 (TU6) that includes vehicle connections and an underground parking garage was completed at the underground research facility (Onkalo). Oversight of the rock construction in Posiva's Onkalo has consisted of inspections of the different construction stages. STUK has performed commissioning inspections of the facilities included in the scope of Onkalo.

Posiva has prepared a plan on delivery of the disposal facility construction design documents for regulatory review. STUK approved the plan, and it will be used as the framework for the oversight of the design documents.

Posiva started the first tunnel contract included in the disposal facility for which a construction licence has been granted (LTU1) in December 2016 after having received a decision from STUK which stated that Posiva was ready to start construction. The facilities to be excavated during LTU1 include vehicle connections, niches in the canister shaft, the central tunnel of a shared testing area and central tunnels 1 and 2 of the first disposal area.

In addition to technical planning, an assessment to verify that the areas to be excavated have been positioned in a suitable manner (based on the rock quality criteria) to ensure long-term safety must be made during construction of the disposal facility. Posiva will further develop its procedures for the assessment of the rock classification of the actual disposal facilities. The procedures must be completed before the excavation of the central tunnels is started. Posiva submitted implementation plans for the first stages of the LTU1 contract to STUK. STUK also assessed the rock suitability analysis on which the location of the facilities is based.

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

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

Posiva took into account the requirements imposed by STUK during the construction licence review in the system design. Posiva has submitted to STUK a licensing plan that takes into account the delivery of updated system design documents. Posiva has submitted on schedule to STUK system design documents for review, and STUK has issued decisions regarding the documents after having reviewed them.

Posiva has launched long-term safety and rock classification criteria development projects, and a project on the design and development of engineered barriers. STUK has reviewed project plans and programmes, and they have been discussed at meetings with Posiva. With this oversight, STUK verifies that the project plans and programmes sufficiently take into account the requirements imposed by STUK during the construction licence review.

Organisational operations and quality management

Due to Posiva's organisational renewal, the schedule of the disposal facility project and its changes, Posiva updated its management handbook and the programmes of its projects. STUK reviewed the updated documents. Special attention was paid to Posiva's organisation and guidelines in the inspections involving the start of construction, as the organisation and the operating model had experienced significant changes since the safety assessment that was submitted in connection with the construction licence application.

In inspections included in the construction inspection programme (RTO), STUK assesses the performance of Posiva's management system, the sufficiency of procedures and their ability to guide design, manufacture, construction and installation operations, as well as the taking into account of safety requirements at different stages of the project. The programme also aims at assessing Posiva's procedures to ensure that a safe nuclear facility of a high quality will be constructed. Nine RTO inspections were performed in 2016. The inspections focused on the following areas: quality management, design operations, personnel resources and training, rock classification and detailed model descriptions, nuclear safeguards, rock construction procedures, project management and quality management of the encapsulation and disposal facility, safety culture and long-term safety. One of the goals of these inspections was to assess readiness of the Posiva organisation to carry out the construction project. The inspections and their results, as well as the requirements by STUK, are described in more detail in Appendix 7.

STUK continued oversight and assessment of Posiva's auditing activities by participating in five supplier audits by Posiva in 2016.

Nuclear safeguards

STUK has implemented nuclear safeguards of final disposal in compliance with the national regulatory plan. Finland is the first country in the world to implement safeguards of nuclear materials on a final disposal facility, which is why STUK holds a key position in the development and implementation of international safeguards of nuclear materials regarding geological repositories.

In 2016, Posiva updated the handbook on regulatory oversight of nuclear safeguards that was taken into use in 2005. It provides instructions on the nuclear safeguards of Onkalo. The new nuclear safeguards manual describes nuclear material arrangements of the encapsulation and disposal facility during construction. STUK approved Posiva's new nuclear safeguards manual. STUK inspected Posiva's announced construction operations in three inspections and performed a nuclear safeguards inspection as part of the inspections on the readiness to start the construction of the disposal facility. The IAEA, the Commission and STUK performed an onsite inspection on short notice at the Posiva site in April.

In 2013, Posiva drafted the first notices of the technical basic characteristics (BTC) of the encapsulation and disposal facility included in the construction licence application design documentation to the European Commission and the IAEA.

Based on the technical baseline, the Commission and the IAEA prepared in 2014 a plan on surveillance and monitoring instruments to be installed in the encapsulation facility. STUK works in close cooperation with the IAEA and the European Commission to ensure that the plans on arranging international safeguards of the encapsulation and disposal facility will proceed in line with the design of the facility and meet the national requirements. Similar oversight has not been realised anywhere else in the world, and STUK has launched a separate project to develop the spent fuel verification method and equipment.

2.7 Other uses of nuclear energy

In addition to the operation and construction of a nuclear facility, the use of nuclear energy as laid down in section 2 of the Nuclear Energy Act includes the possession, manufacture, production, transfer, handling, use, storage, transport, export and import of nuclear waste. Furthermore, components, systems and information needed at nuclear facilities are subject to licensing and oversight by virtue of the Nuclear Energy Act. Thus, producers of uranium, parties in possession of small amounts of nuclear materials 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 the nuclear safeguards.

All users of nuclear energy must nominate responsible persons for their operations and describe in their nuclear safeguards manual the procedures the operator uses to ensure compliance with its obligations by virtue of the Nuclear Energy Act. Furthermore, parties in the possession of nuclear materials must report to Euratom in the manner laid down in the Commission's Safeguards Regulation. In 2016, STUK approved seven nuclear safeguards manuals on such operations. STUK approved the responsible managers or deputies for these operations as laid down in the applications for the Aalto University, the University of Helsinki, Norilsk Nickel Harjavalta Oy and the Geological Survey of Finland.

STUK reviewed uranium production inventory reports and, together with the Commission in June, inventories of Freeport Cobalt Oy's Kokkola production facility and Norilsk Nickel Harjavalta Oy's production facility. Nuclear material inventories of the Radiation and Nuclear Safety Authority and the University of Helsinki were also inspected. No remarks were made in the inspections.

Operators submitted their annual reports on research and development activities of the nuclear fuel cycle to STUK, and STUK prepared the Finnish summary report to the IAEA.

The plan is to transfer some laboratory functions from VTT's reactor building to the new Centre for Nuclear Safety. STUK approved the nuclear safeguards manual for the material balance area of the Centre for Nuclear Safety, and in November 2016 granted the Centre for Nuclear Safety an operating licence as laid down in the Nuclear Energy Act.

In December 2016 STUK received a special nuclear safeguards report from RAOS Project Oy on unauthorised import of nuclear information subject to the particular safeguards obligation and a special report from the University of Jyväskylä Department of Physics on a lost uranium sample. These special reports are still being reviewed, and the measures taken by the operators to prevent reoccurrence of the events will be assessed and inspected in 2017.

In a sulphide mine at Talvivaara in Sotkamo, metals are separated by means of bioheapleaching, where uranium is dissolved from the ore in addition to other metals. Talvivaara Mining Company Plc prepared for the extraction of uranium by building a separate unit, but the commissioning of the unit has been delayed. A Government decision on a permit for the extraction of uranium by virtue of the Nuclear Energy Act was appealed and the permit is not legally valid. In 2015, a new company, Terrafame Oy, started operations at the Talvivaara mine. Terrafame has not applied for a new licence, which means that the commissioning of the uranium separation extraction unit not proceed at all in 2015.

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 2016, which was the second 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 29 projects that were selected in the autumn of 2015 based on a competitive bidding. The available VYR funding for the research was around EUR 3.8 million. Cancellation of the decision-in-principle for the Olkiluoto 4 nuclear power plant unit of TVO meant that the research funding of the SAFIR2018 programme decreased from the previous year. 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. 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. The research programme covers all issues integral to nuclear safety, and it will create and maintain expertise, analysis methods and experimental readiness to resolve any surprising safety issues.

In addition to the three research areas, the SAFIR2018 research projects are controlled by six steering committees. 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 ac-

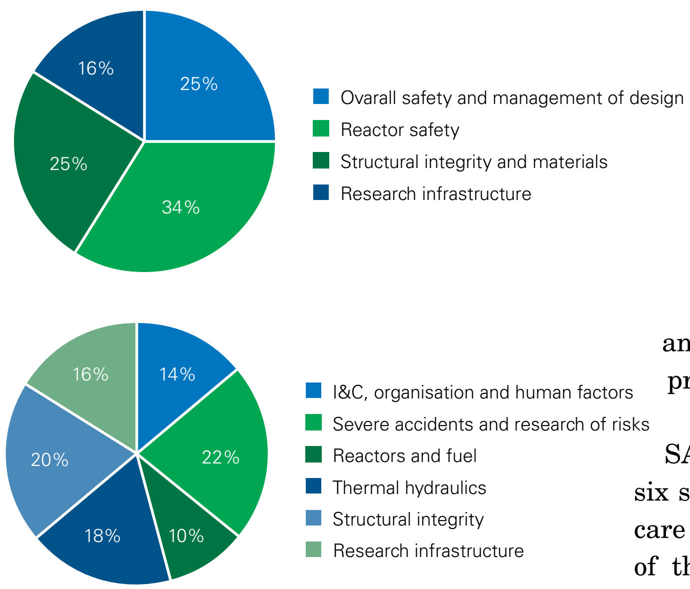


Figure 3. Research areas of SAFIR2018 programme and their shares of the total funding in 2016.

cidents 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 2016 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 project entity consists of several projects that develop the competencies needed to avoid accidents similar to the Tepco Fukushima Daiichi nuclear power plant accident or to better understand 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.

The four-year KYT2018 research programme was launched in 2015. The programme's key research areas are more or less the same as the KYT2014 programme. The programme consists of research issues important to national expertise. It aims at extensive coordinated research projects. Such have been formed particularly regarding the

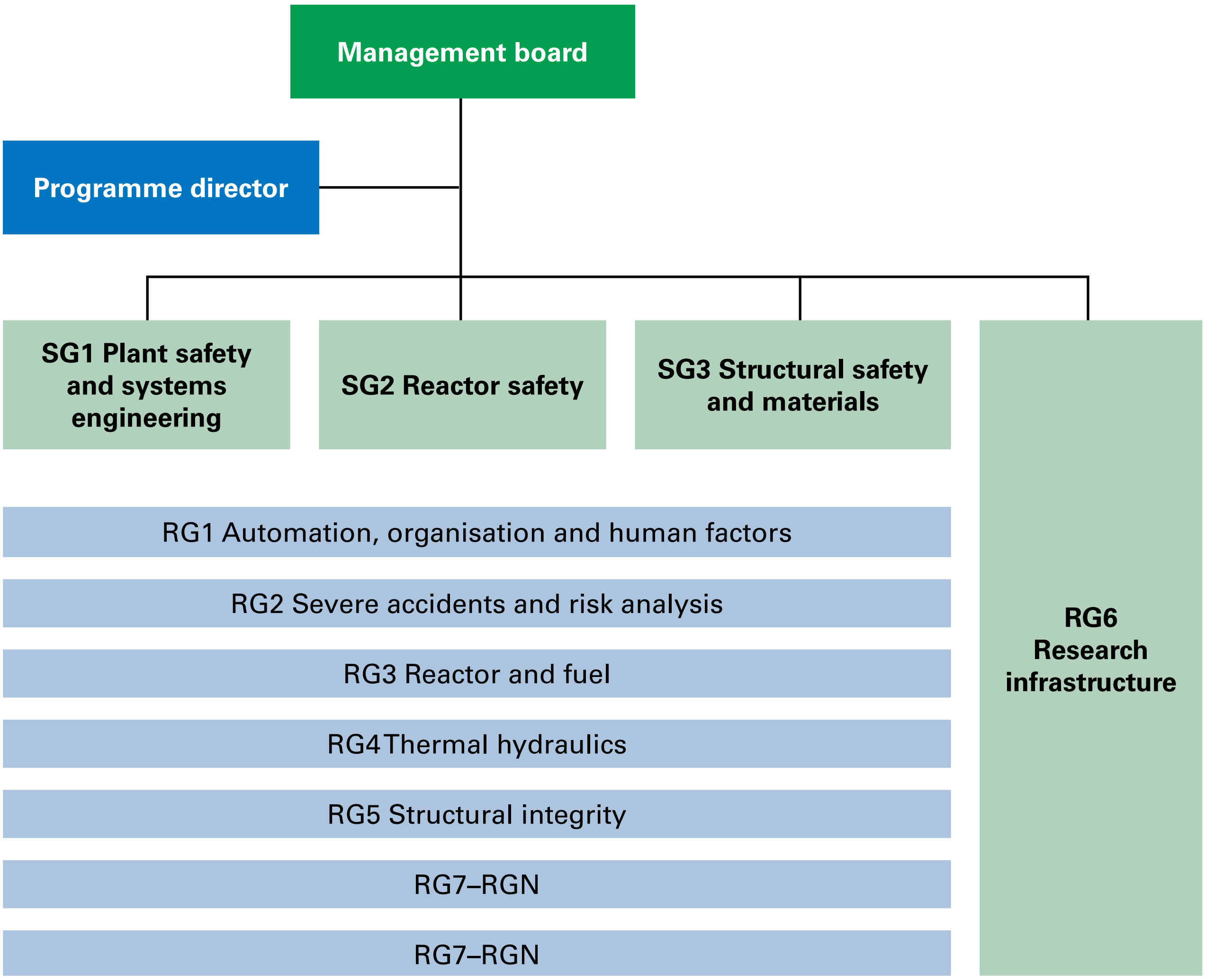


Figure 4. The administrative structure of SAFIR2018 research programme.

Table 1. Distribution of VYR funding of KYT2014 research areas in 2015–2016.

Research area/1000 €	**2015**	**2016**
Safety assessment	73	61
Buffer and backfill materials	478	341
Long-term durability of the canister	350	253
Microbiology	227	220
Other safety relevant research	593	414
Social science studies related to nuclear waste management	45	40
Administration	112	112
New and alternative technological solutions	80	88
Research infrastructure	–	143
Total	1958	1672

research areas of performance of buffer and backfilling materials as well as the long-term durability of final disposal canisters. A new research area added to the KYT2018 programme in 2016 due to an amendment of the Finnish Nuclear Energy Act is funding of research infrastructure.

The KYT management team provided funding recommendations to the Ministry of Economic Affairs and Employment based on assessments by the support groups, applicability of the subject matter and content of the research project. In 2016, the total funding of the KYT2018 programme from the National Nuclear Waste Management Fund (VYR) was about EUR 1.6 million. In 2016, the research programme provided funding for 30 research projects representing new and alternative technologies for nuclear waste management (2 projects), safety research on nuclear waste management (26 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.

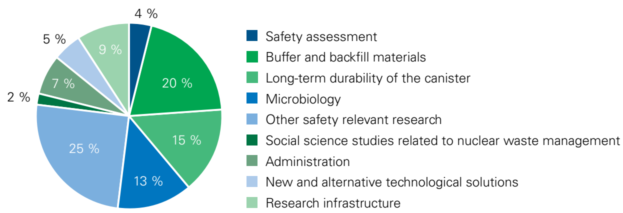


Figure 5. Research areas of KYT2018 programme and their shares of the total funding in 2016.

4 Oversight of nuclear facilities in figures

4.1 Processing of documents

A total of 3,559 documents were submitted to STUK for processing in 2016. Of these, 1,190 concerned the nuclear power plant unit under construction and 178 the disposal facility for spent nuclear fuel. The review process of a total of 3,322 documents was completed, including documents submitted in 2016, 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 83 days. The number of documents and their average review times in 2012–2016 are illustrated in Figure 6.

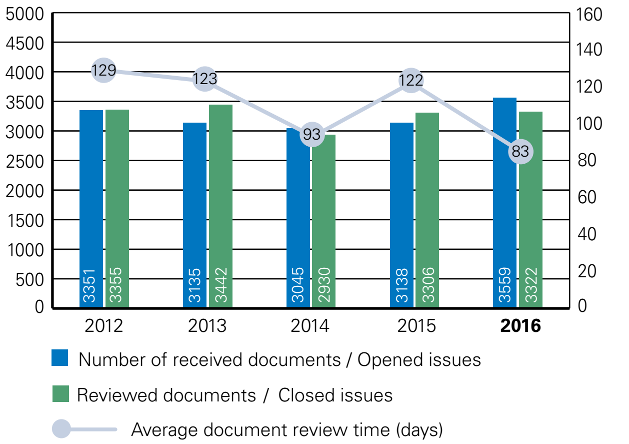


Figure 6. Number of documents received and reviewed as well as average document review time.

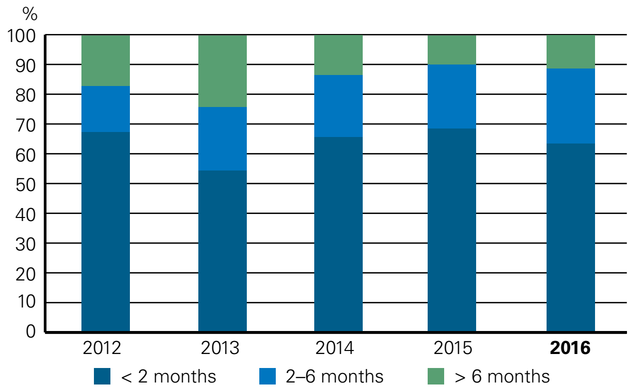


Figure 7. Distribution of time spent on preparing decisions on the Loviisa plant.

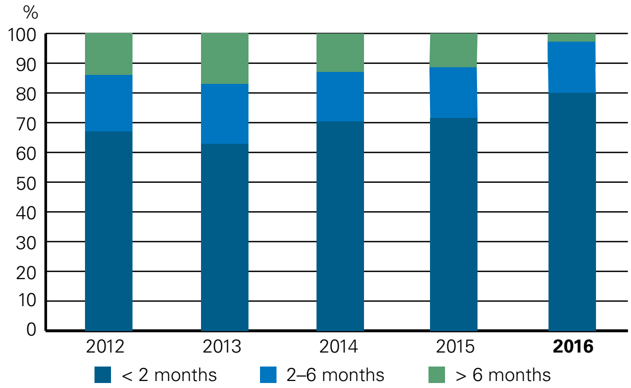


Figure 8. Distribution of time spent on preparing decisions on the operating plant units of Olkiluoto.

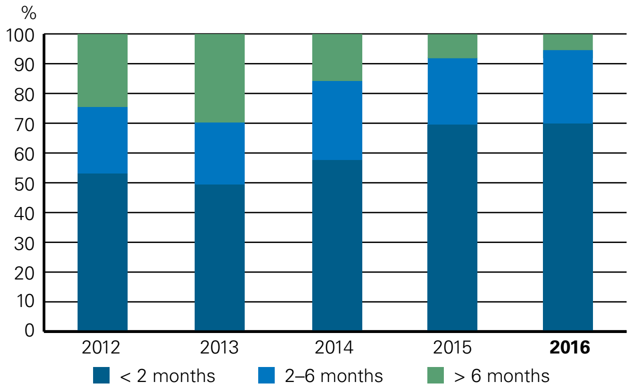


Figure 9. Distribution of time spent on preparing decisions on Olkiluoto plant unit 3.

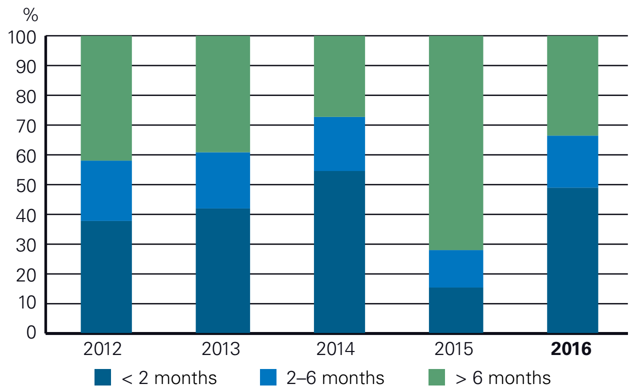


Figure 10. Distribution of time spent on preparing decisions on Posiva.

Figures 7–10 illustrate the review time distribution among documents from the various plant units and documents about Posiva.

4.2 Inspections at nuclear power plant sites and suppliers' premises

Inspection programmes

A total of 13 inspections at the Loviisa nuclear power plant and 13 inspections at the Olkiluoto nuclear power plant were carried out under the 2016 periodic inspection programme (Appendix 4). STUK carried out 15 inspections within the Olkiluoto 3 construction inspection programme (Appendix 5) and 11 inspections pertaining to the processing of Fennovoima's construction licence application (Appendix 6). Nine inspections of the encapsulation plant and disposal facility construction inspection programme were carried out in 2016 (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 2,141 inspections onsite or at suppliers' premises were carried out in 2016 (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, 982 were related to the regulatory

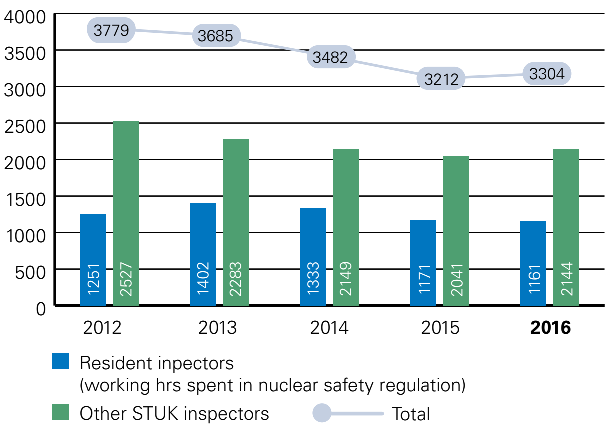


Figure 11. Number of inspection days onsite and at component manufacturers' premises. Overtime work is included.

oversight of the plant under construction and 1,159 to that of the units in operation.

The number of inspection days on site and at component manufacturers' premises totalled 3,304. 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. Four resident inspectors worked at Olkiluoto nuclear power plant and three resident inspectors at Loviisa nuclear power plant. The numbers of onsite inspection days in 2012–2016 are illustrated in Figure 11.

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 2016, the costs of the regulatory control of nuclear safety subject to a charge were EUR 19.6 million. The total costs of nuclear safety regulation were EUR 22.1 million. Thus, the share of activities subject to a charge was 88.9%.

The income from nuclear safety regulation in 2016 was EUR 19.6 million. Of this, EUR 3.4 million and EUR 10.3 million came from the inspection and review 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. Costs arising from the oversight of the Fennovoima nuclear power plant project amounted to EUR 2.6

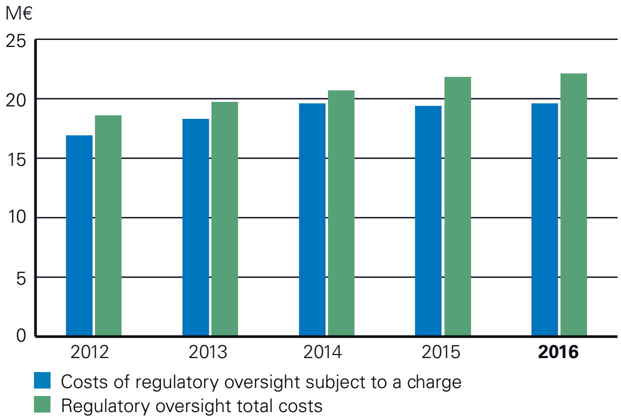


Figure 12. Income and costs of nuclear safety regulation.

million. The regulation of Posiva Oy's operations yielded EUR 2.3 million. Figure 12 shows the annual income and costs from nuclear safety regulation in 2012–2016.

The time spent on the inspection and review of Loviisa nuclear power plant was 14.5 man-years or 9.5% of the total working time of the regulatory personnel. The time spent on the Olkiluoto nuclear power plant's operating units was 13.8 man-years or 9.1% of the total working time. In addition to the monitoring of the operation of the nuclear power plants, these figures include the safeguards of nuclear materials. The time spent on the inspection and review of Olkiluoto 3 was 28.8 man-years or 19.0% of the total working time. Work related to new nuclear power plant projects amounted to 9.1 man-years or 6.01% of the total working time. A total of 8.1 man-years or 5.3% 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 0.5 man-years. Figure 13 shows the division of working hours of the personnel engaged

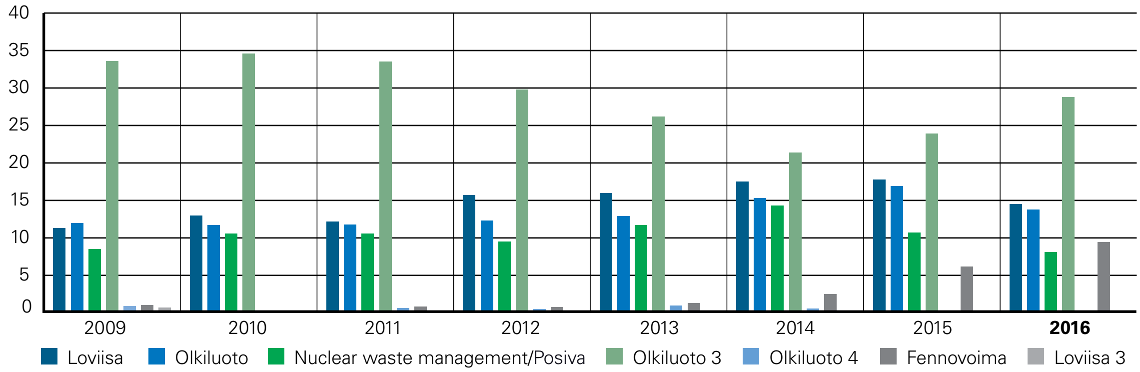


Figure 13. Distribution of working hours (person-years) of the regulatory personnel by subject of oversight in 2009–2016. Until 2011 the nuclear waste management includes both the oversight of the operating nuclear power plants' nuclear waste management as well as the oversight of Posiva, since 2012 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.

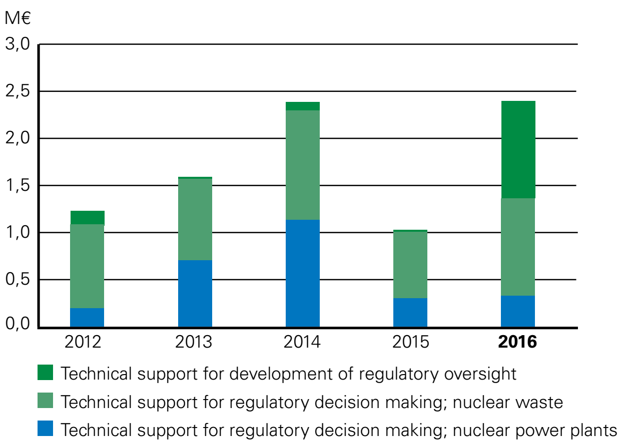


Figure 14. The costs of research and commissioned work.

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

Duty area	2012	2013	2014	2015	2016
Basic operations subject to a charge	68.9	69.7	72.0	76.6	74.9
Basic operations not subject to a charge	5.6	5.0	3.5	2.6	4.0
Contracted services	2.2	1.6	2.9	2.8	2.1
Rule-making and support functions	46.3	45.3	41.8	42.2	44.5
Holidays and absences	24.7	25.1	25.3	26.4	26.6
Total	147.7	146.7	145.5	150.5	152.1

in nuclear safety oversight (in man-years) by subject of oversight during 2009–2016.

Where necessary, STUK commissions independent safety analyses and research in support of regulatory decision-making. Figure 14 illustrates the costs of such assignments in 2012–2016. Most expenses in 2016 involved preparation of plant models for Hanhikivi 1, comparison analyses of Olkiluoto 3, independent assessments and reports, and 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.

5 International cooperation

International conventions

The International Convention on Nuclear Safety requires the submission of a report on how its obligations have been met every three years. STUK was responsible for the preparation of Finland's report, and it was submitted to the IAEA, the secretariat of the Convention, according to the agreed schedule in autumn 2016. Corresponding reports have previously been submitted in 1999, 2002, 2004, 2007, 2010 and 2013. Compliance with the obligations of the Convention and related reporting will be assessed at an international meeting of the parties in Vienna in spring 2017. The Convention also includes an opportunity to pose questions about the actions of the other countries. STUK reviewed the reports of Finland's neighbouring countries and countries with which STUK has been involved in the scope of its international cooperation. STUK posed around 114 questions about the contents of the reports of other countries, while 160 questions were posed to Finland.

In 2016, two meetings included in the scope of the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management which a representative of STUK attended were arranged. The meetings covered responsibilities and obligations for a disposal facility shared by two or more countries and lightening of the Convention's reporting and review obligations in the case of non-nuclear countries in particular.

Amendment to the Convention on Physical Protection of Nuclear Material and Nuclear Facilities (CPPNM-A) entered into force in 2016. Finland submitted to the IAEA a report on national enforcement of the Convention as stipulated by Article 14.

MDEP

The Multinational Design Evaluation Programme (MDEP) was established upon the initiative of the United States nuclear safety authority (Nuclear Regulatory Commission, NRC). It involves fifteen 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 participate in the programme: South Africa, India, United Kingdom, Japan, Canada, China, Korea, France, Sweden, Finland, Turkey, Russia, Hungary and the United Arab Emirates.

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 management group and a steering group. Petteri Tiippana, the Director General of STUK, is the chair of the management group.

There are five Design-Specific Working Groups: the EPR Working Group, the AP1000 Working Group, the APR1400 Working Group, the VVER Working Group and the ABWR Working Group. Of these, STUK has participated in the EPR Working Group and the VVER Working Group, because an EPR plant is under construction at Olkiluoto (the Olkiluoto 3 project) and Fennovoima has submitted a construction licence application on construction of a VVER plant in Pyhäjoki (the Hanhikivi 1 project).

The MDEP Working Groups independent of plant design dealt with the following three subjects: plant and plant supplier inspections and reviews, pressure equipment standards and programmable I&C. STUK participated in the activities of all three Issue-Specific Working Groups.

Cooperation within the IAEA

The IAEA continued to revise its regulatory guides on nuclear safety. STUK had a representative on the Commission on Safety Standards (CSS) managing the preparation of the regulatory guides as well as in the committees dealing with the content of the regulatory guides, 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 regulatory guides 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.

Representatives of STUK were included in expert groups summoned by the IAEA; the groups reviewed the regulatory authorities' operations in Lithuania, South Africa and Belorussia, and participated in international peer reviews of security arrangements in Malesia and Sweden.

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).

Cooperation within the EU

WENRA RHWG

STUK actively participated in the work of WENRA's Reactor Harmonisation Working Group (RHWG) in 2016 even though it was able to attend only two of the working group's three general meetings. This year, the working group's key tasks were a peer review of the updated reference levels for the operating nuclear power plants that were published in 2014 and the preparation of a Technical Specification for the first Topical Peer Review in accordance with the EU Nuclear Safety Directive. The reference level peer review studied how the member states have included the requirements that were added or modified after the Fukushima accident in their own regulations. Results of the Finnish review state that eleven requirements need to be specified in the regulations – the results of the self-assessment stated that only two of the requirements needed further specifications. Taking into account these deficiencies will not change the Finnish procedures in practice, but their inclusion in the regulations will further specify the requirements. The first Topical Peer Review in accordance with the Nuclear Safety Directive will start in 2017.

WENRA WGWD

STUK actively participated in the work of WENRA's Working Group on Waste And Decommissioning (WGWD) in 2016. The working group convened twice. Self-assessments and peer reviews of reference levels connected to disposal were completed during the year, a reference level report on nuclear waste processing facilities was prepared and a draft on a summary of WGWD's reference level reports was prepared.

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. STUK actively participated in the preparation of the peer review guidelines in the ENSREG nuclear safety subgroup. A national peer review report will be prepared by the end of 2017 and Finland will participate in the peer review of the EU member states in spring 2018.

Bilateral cooperation

STUK continued its regular meetings with the Swedish nuclear safety authority SSM, focusing on topical issues about nuclear power plants, such as the Swedish regulations, requirement management, competence of the authorities, resource issues and periodic safety review of the Loviisa nuclear power plant.

STUK started regular cooperation with the French nuclear safety authority Autorité de Sûreté Nucléaire (ASN) and its support organisation Institut de Radioprotection et de Sûreté Nucléaire (IRSN) when the Olkiluoto 3 project was launched in the early 2000s. Regulatory practices and statutory requirements of the countries have been compared, and challenges and problems pertaining to the EPR plants under construction in both countries (Olkiluoto 3 and Flamanville 3) have been discussed.

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 2016, six cooperation meetings with RTN were arranged to review the construction status of the new plant units, for example. STUK visited the construction site of the Leningrad 2 nuclear power plant three times with the nuclear safety authority and three times in issues pertaining to plant cooperation. RTN has also studied the local inspection activities at Olkiluoto 3.

The Hungarian radiation and nuclear safety authority HAEA and the Turkish nuclear safety authority TAEK have also started preparation for a safety assessment of AES-2006 nuclear power plants (PAKS-2 and Akku-yu). In 2016, STUK visited both of these sister organisations to discuss the plant projects and the plants' safety assessments.

Also in 2016, STUK made together with the Canadian nuclear safety authority CNSC an initiative on international cooperation in the regulation of the disposal of spent fuel. A regulatory working group was established for this cooperation. In addition to Finland and Canada, representatives of Sweden, Switzerland, France and the United States participate in the working group. The working group's goal is to share experience and develop regulatory practices and requirements for disposal facilities constructed in the bedrock. The working group started its work in 2016 and will focus in the future in licensing of disposal facilities and requirements of the different licensing stages, among other 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	526/502	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	910/880	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

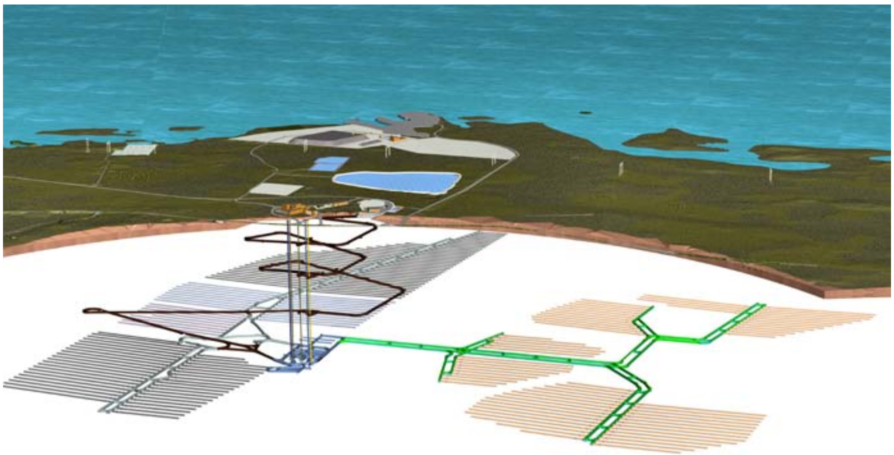
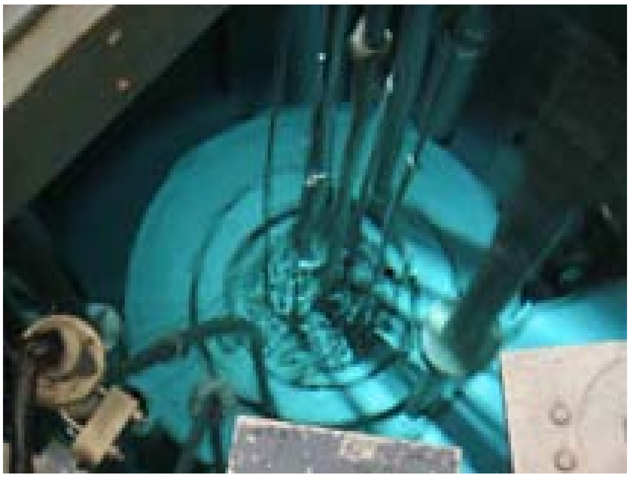


Diagram of the encapsulation and disposal facility in Olkiluoto (Posiva Oy).

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 will provide 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-reaktorin polttoainetyyppi
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 is preparing an application on revising the reactor operating licence.

Other uses of nuclear energy

The regulation also applies to mining and any preparation of ore aiming at obtaining uranium or thorium. Such operations are practiced at the production plants of Norilsk Nickel Harjavalta Oy and Freepoint Cobalt Oy. A planned uranium preparation plant at Talvivaara is also part of this regulatory group. There are small amounts of regulated materials at some laboratories. The regulation also applies to nuclear equipment, systems and nuclear information as well as nuclear fuel cycle research and development activities and the transport of nuclear materials and nuclear waste.

APPENDIX 2 STUK's safety performance indicators for NPP's in 2016

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. Along with inspections and safety assessments, indicators are a method of acquiring information on the safety level of the 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 factors behind the development are investigated and changes to plant operation and STUK's oversight of the area are considered. The indicators can also be used to monitor the efficiency and effectiveness of corrective measures.

In the indicator system, nuclear safety is divided into three sectors: 1) operation and maintenance, 2) operational events and 3) structural integrity. STUK began the development of its own indicator system in 1995. Nominated STUK representatives are responsible for the maintenance and analysis of the indicators. 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 each plant in 2016 is given below, followed by detailed results by indicator.

STUK will develop its indicator system in 2016 and 2017. The indicator system will be revised in 2017. The new system will be more closely integrated into STUK's other inspection activities and total safety assessment. Therefore, this annual report does not include the entire indicator system but only the indicators that best describe what plant safety was like in the different sectors in 2016.

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

***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 2016

Summary of indicator results for Loviisa nuclear power plant

Ageing management and component maintenance at the Loviisa nuclear power plant have been 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 or even decreased. In addition, the average component repair times have decreased in the long term. Detection and anticipation of faults have been improved in the maintenance operations of the Loviisa 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 and the plant has been able to manage the operability of components well.

This development was also reflected in the good availability of safety systems. Availability of the high pressure safety injection system and the emergency feedwater system was excellent and availability of the emergency diesel generators was good in 2016.

No common-cause failures important to safety occurred. Some events that influenced production occurred, but they did not influence the safe operation of the plant. The Loviisa nuclear power plant was operated in compliance with the good safety culture and the OLC. No events important to safety (INES ≥1) took place. When granting exemptions from the OLC, STUK has assessed that the safety level would remain good despite modifications, more extensive maintenance or fault repairs. More such jobs than normally were carried out in 2016.

Radiation safety at the Loviisa nuclear power plant is good and being developed in a determined manner. The main part of the radiation doses is received during outages. Despite the long annual outages, the employees' radiation doses remained low also in 2016 due to improvements of radiation safety, remaining well below the individual dose limits and the collective occupational dose limit. In 2016, the average of the ten largest doses was close to the average for the previous years. In 2016, radioactive releases into the air from the Loviisa nuclear power plant were of the same magnitude as in previous years, remaining clearly below the set limits.

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. Events warranting a special report in 2016 were single 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 steadily decrease over the years. Accident risk of the Loviisa nuclear power plant, which describes 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 – only one event classified as a fire occurred in 2016, and a repairman was able to extinguish the smouldering fire with a fire extinguisher. 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 have been no leaking fuel assemblies at Loviisa since 2013.

There was no leaking fuel in the reactors of the Loviisa units in 2016, which means that the maximum iodine (I-131) activity value of the primary coolant remained low.

Condition of the primary and secondary circuits is monitored with the chemistry indicators, in particular. 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 2016.

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 2016 as in the previous years.

Summary of indicator results for Olkiluoto nuclear power plant

Operation and maintenance

Component 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. Furthermore, components subject to the OLC have been inoperable only for short periods of time and the number of faults causing inoperability of components 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. Preventive maintenance has ensured sufficient operability. The number of preventive maintenance actions performed has increased, which has improved the ratio of preventive maintenance to fault repairs. The average repair times of faults causing inoperability of components subject to the OLC have become shorter, i.e. the development has been positive. This positive development was also reflected as good availability of safety systems (the containment spray system, the auxiliary feedwater system and the emergency diesel generators).

No common-cause failures important to safety occurred. Investigations about the fuel leaks at Olkiluoto 1 are still ongoing, however (see the section on structural integrity). Slightly more events that influenced production occurred, but they did not influence the safe operation of the plant because the most important events were planned repair outages of both plant units. No safety significant events (INES ≥1) or situations where the plant was non-compliant with the OLC occurred in 2016. The most important events in 2016 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. Plenty of modifications were implemented in 2016, but less exemptions from the OLC than in the previous years were requested.

Radiation safety at the Olkiluoto nuclear power plant is good and being developed. The main part of the radiation doses is received during outages. In 2016, the radiation doses of the employees were slightly higher than in the previous years due to the fuel leaks at Olkiluoto 1. The doses still remained clearly below the dose limits set in the Radiation Decree, however. In 2016, the average of the ten largest doses was close to the average for the previous years. In 2016, radioactive releases into the air from Olkiluoto 2 were of the same magnitude as in previous years, remaining clearly below the set limits. Releases at Olkiluoto 1 were clearly higher than in the previous years due to the fuel leaks, but still remained well below the set limits.

In June, a release from the turbine building occurred at Olkiluoto (see Appendix 3 to this annual report). 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. Due to the fuel leaks, the noble gas and iodine releases from Olkiluoto were clearly higher than in the previous years as well.

Operational events

No events important to safety occurred at the Olkiluoto nuclear power plant in 2016.

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. This is also reflected in the risk significance of the events which has remained low and continued to steadily decrease over the years. 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 2016 and the number of fire detection system faults has remained at the same level for the past ten years.

Accident risk of the Olkiluoto nuclear power plant, which describes 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.

Structural integrity

Structural integrity of the primary circuit and the containment has remained good at the Olkiluoto nuclear power plant, but a large number of fuel leaks have occurred – in 2016, six leaking fuel assemblies were detected in and removed from Olkiluoto 1. This is an exceptionally high number of leaking assemblies. TVO took corrective action to improve the situation and will study the assemblies closer to determine the root causes of the leaks.

In addition to the number of removed assemblies, parameters monitored by STUK include maximum activity concentration of the primary coolant (I-131), which clearly shows an increase due to the leaking bundles in 2016. The values still remained clearly below the limit set in the OLC, however.

Condition of the primary circuit is monitored with the chemistry indicators and by studying allowed leaks. A valve leak was detected at both units during the fuel cycle. This slightly increased the leak volume but the leak volume has remained low when compared to the limit set in the OLC. The small number of leaks and all of the chemistry indicators demonstrate that the primary circuits of the Olkiluoto plant units were relatively leaktight and their integrity was at a relatively good level in 2016.

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, clearly below the set limits at both plant units, and the as-found leakages from containment penetrations and airlocks have been low at both plant units.

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

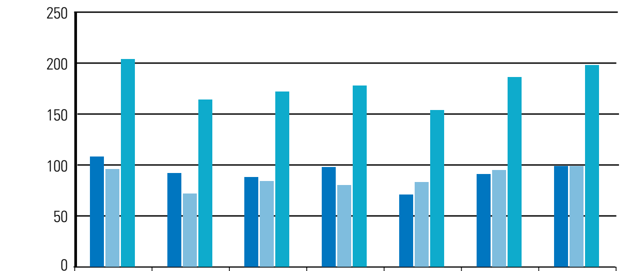
Loviisa

The total number of faults causing an operation restriction of components subject to the OLC in 2016 was 198. The average number of faults during the four previous years was 173, which means that there was no significant increase in the number of faults in 2016 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



	2010	2011	2012	2013	2014	2015	2016
LO1	108	92	88	98	71	91	99
LO2	96	72	84	80	83	95	99
LO1,2	204	164	172	178	154	186	198

Interpretation of the indicator

Olkiluoto

The number of failures occurring during power operation and causing the unavailability of components subject to the operational limits and conditions has been decreasing since 2012.

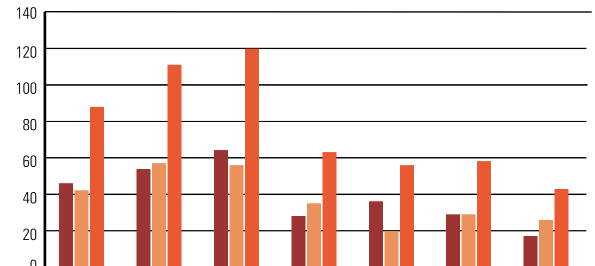
In 2012, the number of faults was nearly double the number of faults in 2009. In 2012, the number of faults decreased back to the level of 2010, and the number of faults did not change in 2013 or 2014. According to this indicator, the year 2016 was similar to the years 2014 and 2015. The number of faults indicates that maintenance has been successful.

The indicator "immediate operation restriction on detection of fault" decreased considerably. The considerable decrease was caused by the fact that most of the faults in the systems subject to the OLC were in components whose failure did not cause an immediate operation restriction.

The unavailability times of OLC components in OL1 during all four quarters of 2016 were brief. The number of faults causing an immediate operation restriction decreased at both plants. The decrease started already in 2014.

In OL2, most of the unavailability times of OLC components were brief in 2016. Furthermore, the observed faults in OLC components did not occur in any specific system alone.

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



	2010	2011	2012	2013	2014	2015	2016
OL1	46	54	64	28	36	29	17
OL2	42	57	56	35	20	29	26
OL1,2	88	111	120	63	56	58	43

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 2016, a four-year annual outage was implemented at LO1 and a short annual outage (a refuelling outage) at LO2.

According to the data on which the indicator is based, the year 2016 showed no major deviation from the average numbers of fault repairs and preventive maintenance volumes of the four previous years. A slight increase was observed in both.

In 2016, the number of maintenance tasks on components subject to the OLC was 20.4% higher than the average. The volume of preventive maintenance was 17.6% higher than the average and the number of fault repairs 37.7% higher. 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 stable or somewhat decreased.

The ratio of preventive maintenance to fault repairs was 5.1. The ratio is 18.5% lower than the 6.1% average of the four previous years, which means that the share of preventive maintenance of all maintenance work has remained at almost the same level as in the previous years.

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

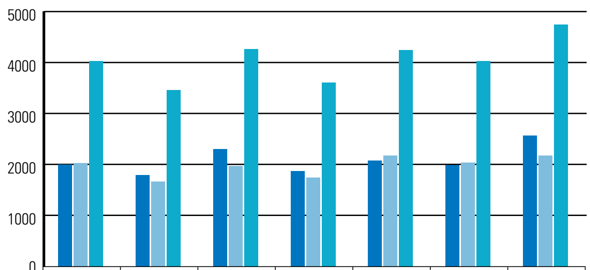
Olkiluoto

The number of maintenance works causing inoperability of components, included in the indicator, decreased in 2009–2012 due to the lower number of fault repairs. In 2010, the number of faults repaired increased while the number of preventive maintenance operations decreased.

In 2016, the number of fault repairs that caused inoperability of components decreased from the level of 2011–2015. The number of preventive maintenance operations slightly increased, improving the ratio of preventive maintenance to fault repairs from 2015. 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 1.9 at OL1 and to 1.4 at OL2. These are close to the 2012 values.

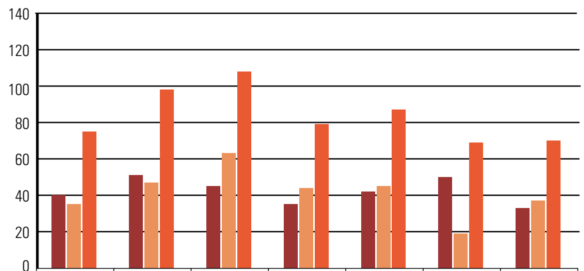
Based on the development of the ratio of preventive maintenance work to fault repairs and an assessment of the work on which the figures are based, the maintenance strategy can be considered successful.

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



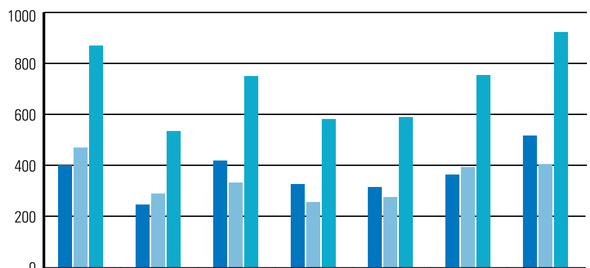
	2010	2011	2012	2013	2014	2015	2016
LO1	2002	1795	2298	1866	2074	1992	2569
LO2	2026	1663	1967	1741	2171	2039	2178
LO1,2	4028	3458	4265	3607	4245	4031	4747

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



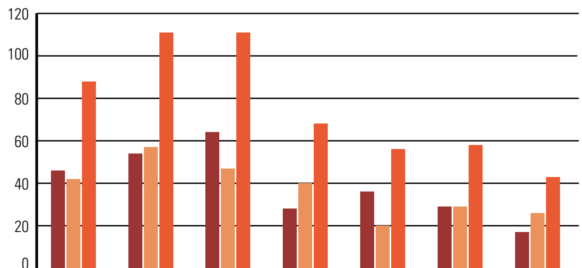
	2010	2011	2012	2013	2014	2015	2016
OL1	40	51	45	35	42	50	33
OL2	35	47	63	44	45	19	37
OL1,2	75	98	108	79	87	69	70

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



	2010	2011	2012	2013	2014	2015	2016
LO1	401	245	419	326	314	363	517
LO2	469	289	332	256	276	392	405
LO1,2	870	534	751	582	590	755	922

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



	2010	2011	2012	2013	2014	2015	2016
OL1	46	54	64	28	36	29	17
OL2	42	57	47	40	20	29	26
OL1,2	88	111	111	68	56	58	43

A.I.1c Repair times of components subjectto 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.

Sourc♦e 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 2016, the average repair time for the plant units was 14 hours, while the average of the four previous years was 19.6 hours, i.e. there was an improvement of 40%.

Based on the 2016 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 having the necessary resources available for fault repairs, and for carrying out the repairs without unnecessary delays.

Interpretation of the indicator

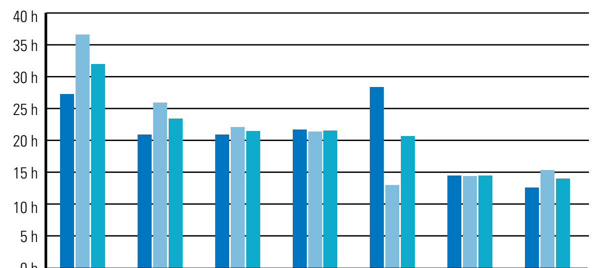
Olkiluoto

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.

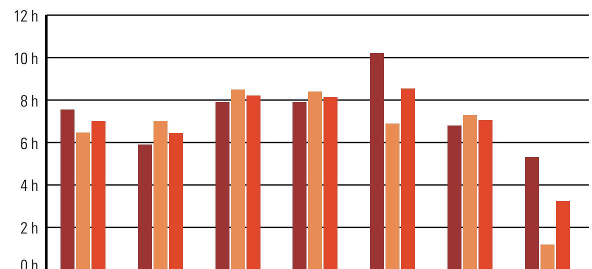
In 2015, the average repair time of faults causing inoperability of components subject to the OLC at OL1 and OL2 was around 7 h. In the case of

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



	2010	2011	2012	2013	2014	2015	2016
LO1	27.3	20.9	20.9	21.7	28.4	14.5	12.5
LO2	36.6	25.9	22.1	21.4	13.0	14.4	15.4
LO1,2	32.0	23.4	21.5	21.6	20.7	14.5	14.0

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



	2010	2011	2012	2013	2014	2015	2016
OL1	7.5	5.9	7.9	7.9	10.2	6.8	5.3
OL2	6.5	7.0	8.5	8.4	6.9	7.3	1.2
OL1,2	7.0	6.5	8.2	8.2	8.6	7.1	3.2

both plant units, the average repair time of faults causing inoperability of components subject to the OLC was lower than in the previous years in 2016, and at OL2 it was exceptionally low. This was due to the low number of faults and the fact that no long-term faults occurred.

On the basis of the 2016 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.

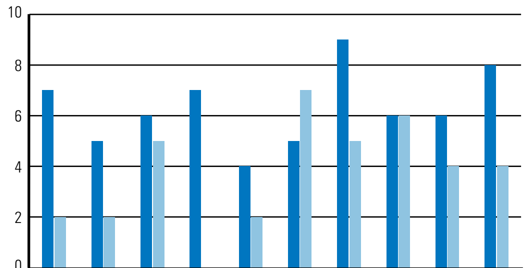
Loviisa

Exemptions
Based on the last ten years (2006–2015), the Loviisa NPP applies for STUK's approval for exemptions from the OLC six times per year on average. The number of applications in 2016 (eight applications in total) was slightly higher than the average. Six of the applications involved modifications, one involved the testing of steam generator safety valves and one involved an error in a system alarm on the margin to boiling. As the planned deviations had no significant safety implications, STUK approved the applications.

Non-conformance with the OLC
In 2016, four 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 three times per year on average during the past ten years (2007–2015). All events that were non-compliant with the OLC in 2016 are described in Chapter 4.1.2 of this annual report and in Appendix 3.

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 2012–2016 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

Number of deviations from the OLC, Loviisa NPP



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Exemptions	7	5	6	7	4	5	9	6	6	8
Deviations	2	2	5	0	2	7	5	6	4	4

to load operation. The shutdown or startup 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. These inspections were not fully successful in the case of these events. 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. The events in 2016 involved repairs and maintenance.

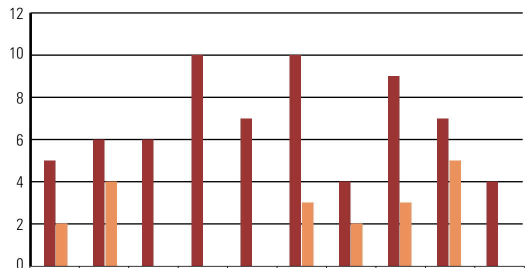
Olkiluoto

Based on data from the last ten years (2007–2016), the Olkiluoto nuclear power plant applies for STUK's approval for exemptions from the OLC seven times per year on average. The number of applications in 2016 (four applications in total) was slightly lower than the average. Two of the applications involved repairs and modifications during the annual outage. In one of the cases, a permission to deviate from a requirement on the maintenance of the control rod actuators was sought, and the other case was about provisions for a possible power outage when commissioning a new backup power supply battery bank. The other two applications for exemption involved the draining of an emergency diesel generator fuel tank to perform an internal inspection. STUK approved all four applications.

Non-conformance with the OLC

In 2016, Olkiluoto power plant did not report any events during which the plant was non-compliant with the OLC without an advance safety analysis and STUK's permission. The average number of events for the past ten years is three events non-compliant with the OLC per year. The last year when there were zero events non-compliant with the OLC was 2010.

Number of deviations from the OLC, Olkiluoto NPP



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Exemption	5	6	6	10	7	10	4	9	7	4
Deviations	2	4	0	0	0	3	2	3	5	0

A.I.3 Unavailability of safety systems

Definition

As the indicator, the unavailability of safety systems per plant unit is monitored. The systems followed at 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 Loviisa nuclear power plant are the high pressure safety injection system (TJ), the auxiliary 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 are calculated as the indicator. The unavailability hours are the combined unavailability of redundant subsystems divided by the number of subsystems.

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

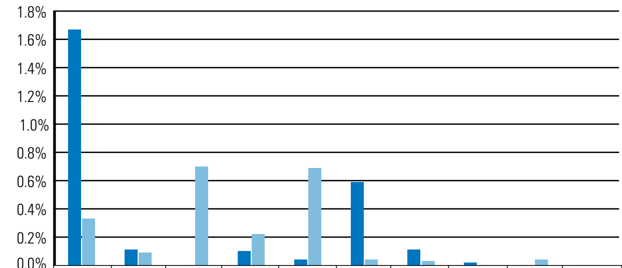
The indicator indicates the unavailability of safety systems. The indicator is used to track the condition of safety systems and any identifiable trends.

Interpretation of the indicator

Loviisa

TJ system

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



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LO1	1.67	0.11	0.00	0.10	0.04	0.59	0.11	0.02	0.00	0.00
LO2	0.33	0.09	0.70	0.22	0.69	0.04	0.03	0.00	0.04	0.00

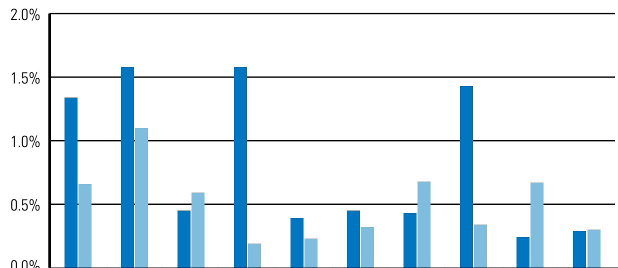
Analysis of the unavailability figures of the high pressure safety injection systems of the plant units in 2016 and their background information shows that no faults occurred at Loviisa 1 and Loviisa 2, i.e. their condition and availability were excellent.

RL system

The total unavailability time of the Loviisa 1 backup emergency feedwater system RL94 was 91 hours in 2016. There was no unavailability during load operation. The entire unavailability time was caused by periodic maintenance of the system during the annual outage of Loviisa 1.

The total unavailability time of the Loviisa 2 backup emergency feedwater system RL97 was 98 hours in 2016. There was no unavailability during load operation. The entire unavailability time was caused by periodic maintenance of the system during the annual outage of Loviisa 2.

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



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LO1	1.34	1.58	0.45	1.58	0.39	0.45	0.43	1.43	0.24	0.29
LO2	0.66	1.10	0.59	0.19	0.23	0.32	0.68	0.34	0.67	0.30

The unavailability of the auxiliary feedwater systems was low in 2016, i.e. their condition and availability were excellent.

EY system

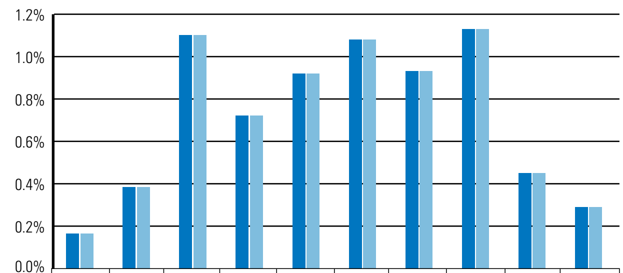
In 2016, the unavailability time of the eight emergency diesel generators was a total of 233 hours. 75 hours of the unavailability time was caused by repairs of the seawater cooling pump 22EY03D05 of the diesel generator 22EY03 during load operation.

In 2016, there were a total of ten emergency diesel generator events causing unavailability. Of these faults, two caused an immediate operation restriction and eight an operation restriction starting at the beginning of the repair work.

Most of the repairs were due to leaks in the motors' cooling/shell water pipelines. Some of these pipelines will be replaced during future annual outages of the plant.

The unavailability rate of the emergency diesel generators in 2016, 0.29%, is still clearly lower than the value for the previous year (2015), which was 0.45%, i.e. the availability level was good.

Unavailability of emergency diesel generators (EY), Loviisa NPP



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LO1	0.17	0.38	1.10	0.72	0.92	1.08	0.93	1.13	0.45	0.29
LO2	0.17	0.38	1.10	0.72	0.92	1.08	0.93	1.13	0.45	0.29

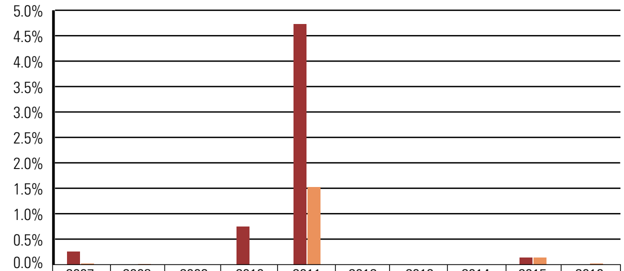
Interpretation of the indicator

Olkiluoto

Unavailability of the containment spray system in 2007, 2008, 2010, 2011 and 2013 was zero for both plant units, and almost zero in 2009 and 2012.

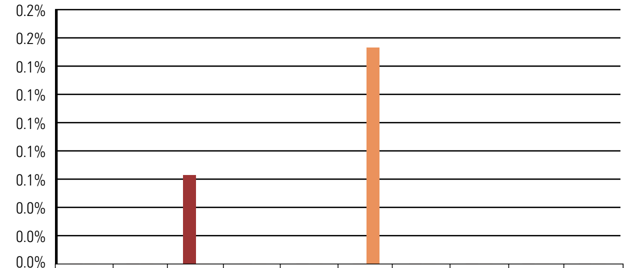
Unavailability of the auxiliary feedwater system increased significantly from 2014, but was practically zero (0.13). The increased unavailability of Olkiluoto 1 in 2006 was due to faults in the recirculation and safety valves in system 327. There were no significant faults in 2007, 2008 or 2009, and the unavailability of the auxiliary feedwater system decreased to zero in 2009 at both plant

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



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OL1	0.25	0.00	0.00	0.74	4.73	0.00	0.00	0.00	0.13	0.00
OL2	0.02	0.01	0.00	0.00	1.52	0.00	0.00	0.00	0.13	0.01

Unavailability of containment spray system (322), Olkiluoto NPP

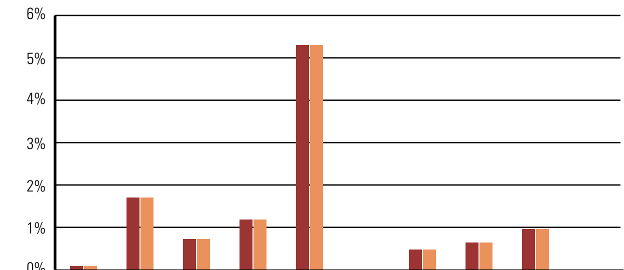


	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OL1	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00
OL2	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00

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; cf. Chapter A.II.3. In 2013, the unavailability of the auxiliary feedwater system returned to the level of prior to 2011. This level was retained in 2016 at OL1, and the unavailability of OL2 was almost zero.

The unavailability of the emergency diesel generators decreased in 2006 and 2007, and was very low as a result. In 2008, the value increased by nearly 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

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



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OL1	0.09	1.71	0.72	1.18	5.30	0.00	0.48	0.64	0.96	0.00
OL2	0.09	1.71	0.72	1.18	5.30	0.00	0.48	0.64	1.00	0.00

decreased considerably from the 2008 figures. In 2010, unavailability increased somewhat from the previous year as a result of faults occurring in connection with inservice testing. At OL1, the stator winding of a diesel generator failed in connection with an inservice 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 due to preventive maintenance and improvements that were successfully realised during planned maintenance outages.

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 mSv 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 years and normal annual outages in odd years. In 2016, like in 2008, a four-year annual outage took place at Loviisa 1 and a short annual outage at Loviisa 2. The effect of annual outages on collective occupational doses can be seen in the graph *Collective occupational dose, Loviisa*. Due to improvements in radiation safety, the radiation doses of employees have decreased, and the collective occupational dose in 2016 was clearly lower than the reference year of 2008.

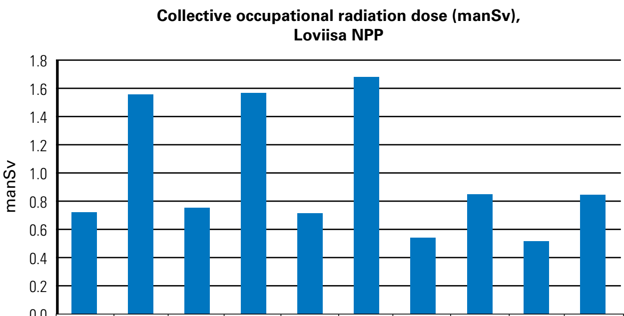
The radiation doses for employees of Loviisa nuclear power plant remained below the individual dose limits. In 2016, the average of the ten largest doses was clearly lower than during the reference year. The Radiation Decree (1512/1991) stipulates that the effective dose for a worker from radiation work may not exceed the 20 mSv/year average over any period of five years, or 50 mSv during any one year.

Interpretation of the indicator

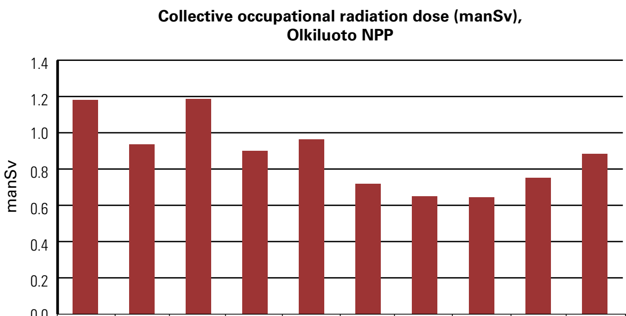
Olkiluoto

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). Length of the maintenance outage depends on the amount of work to be done (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 2016, Olkiluoto 1 underwent a maintenance outage and Olkiluoto 2 a refuelling outage.

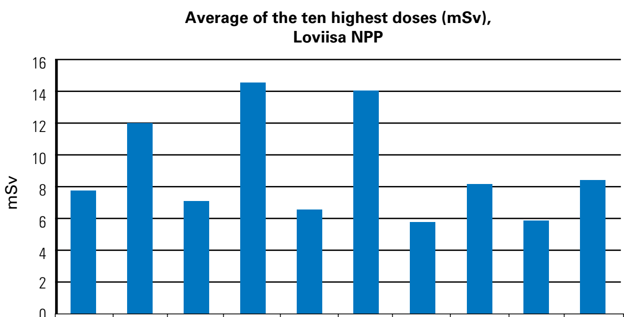
The radiation doses have clearly decreased after the installation of new moisture separators at the plant units in 2005–2007. The radiation level



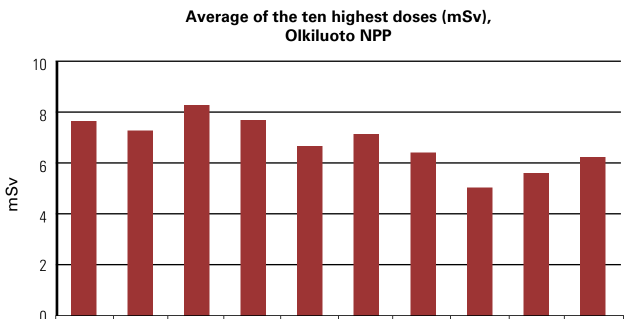
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LO	0.72	1.55	0.75	1.57	0.71	1.68	0.54	0.85	0.52	0.84



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OL	1.18	0.94	1.19	0.90	0.96	0.72	0.65	0.64	0.75	0.88



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LO	7.76	11.99	7.11	14.55	6.56	14.06	5.78	8.16	5.86	8.42



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OL	7.63	7.28	8.27	7.68	6.65	7.12	6.41	5.02	5.59	6.23

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 2016, the doses of the employees were slightly higher than in the previous years due to fuel leaks in Olkiluoto 1. The dose limits set in the Radiation Decree (1512/1991) were not exceeded.

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.

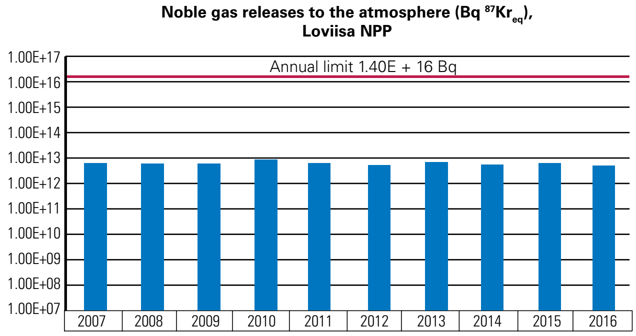
A.I.5a Releases into the air

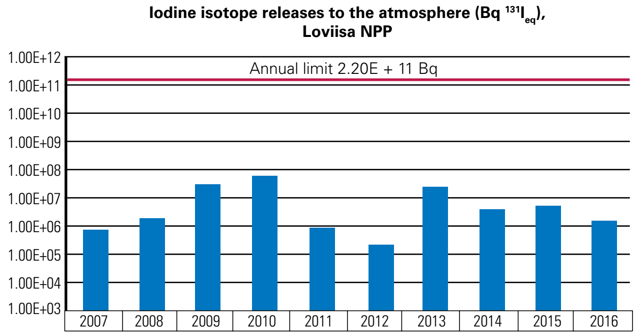
Interpretation of the indicator

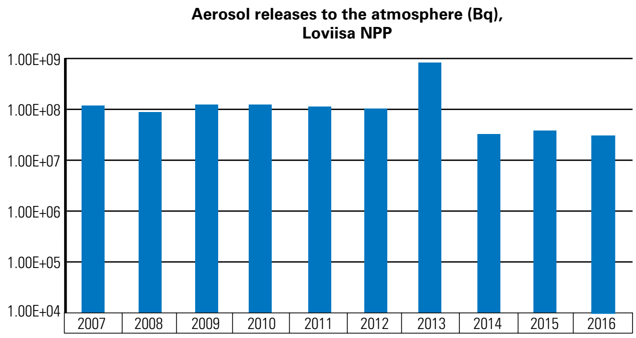
Loviisa

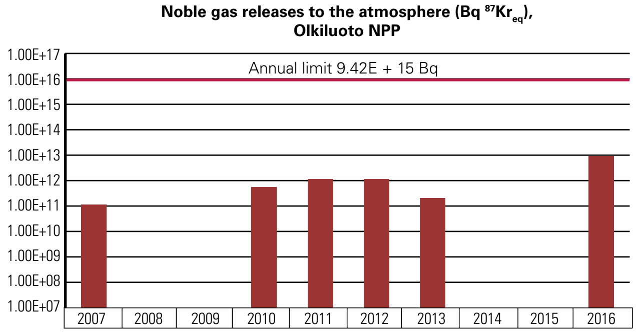
In 2016, radioactive releases into the air from the Loviisa nuclear power plant were of the same magnitude as in the previous years.

No fuel leaks were detected at Loviisa in 2016. Aerosol nuclides (including activated corrosion products) are released during maintenance work.

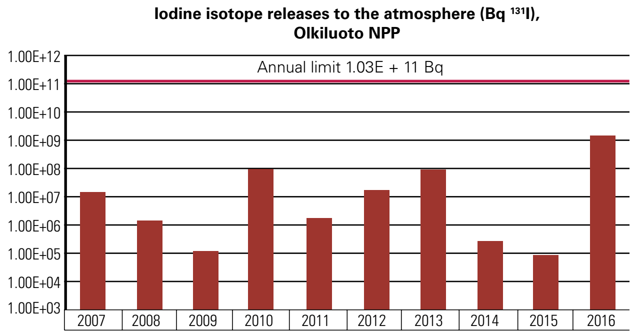


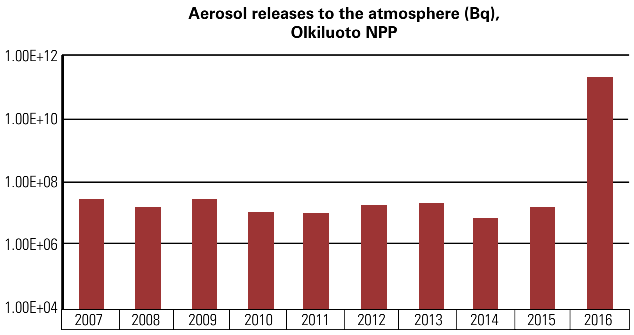






Releases in 2008, 2009, 2014 and 2015 were below the detection limit.





Olkiluoto

In 2016, 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 set limits. During the spring, six leaking fuel rods were detected at Olkiluoto 1. The releases of fission products were clearly higher than in the previous years due to the leaking fuel rods. The releases remained clearly below the set limits also at Olkiluoto 1, however. In June, 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 the released longer-lived aerosol nuclides at Olkiluoto remained at the same level as in the previous years.

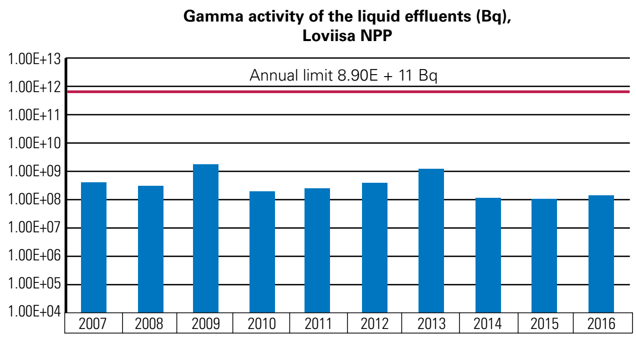
Gaseous fission products, noble gases and iodine isotopes originate from leaking fuel rods, from the minute amounts of uranium left on the outer surfaces of fuel cladding during fuel fabrication and from reactor surface contamination due to earlier fuel leaks. Due to the fuel leaks at Olkiluoto 1, the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

A.I.5b Releases into the sea

Interpretation of the indicator

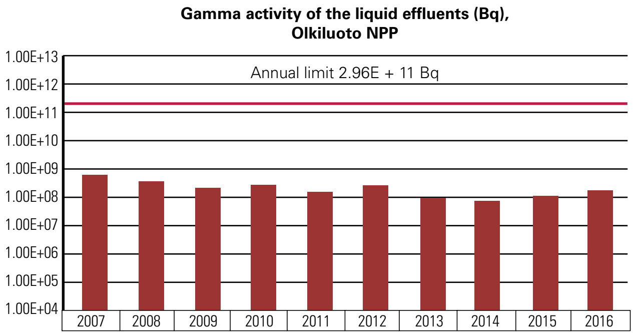
Loviisa

Releases of radioactive substances emitting gamma radiation into the environment from the Loviisa nuclear power plant remained clearly below the set limits. In 2009 and 2013, the Loviisa nuclear power plant released evaporator concentrate waste into the sea as planned. Consequently, the releases of substances with gamma activity were larger than the average in those years. Releases of substances with gamma activity into the sea from the Loviisa nuclear power plant have decreased in recent years.



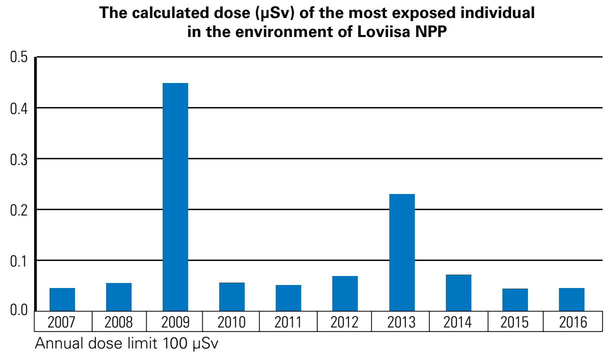
Olkiluoto

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.



Loviisa

The radiation dose of the most exposed individual in the vicinity of the Loviisa nuclear power plant assessed by means of calculations in 2016 was at the regular level and less than 0.1% of the 100 µSv limit set in the Nuclear Energy Decree (161/1988).



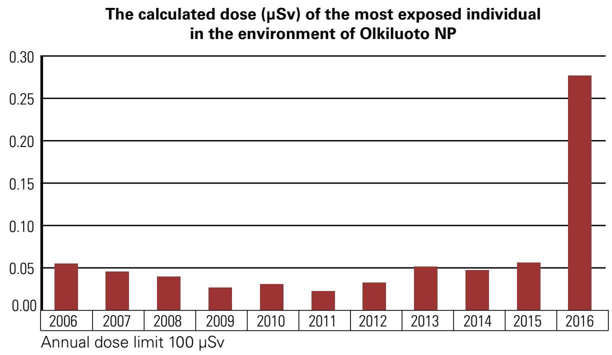
A.I.5c Population exposure

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 2016, the radiation dose in the vicinity of Olkiluoto was the highest since 1997 due to the fuel leaks, among other issues. The radiation doses from Olkiluoto were still very low or less than 1% of the 100 µSv limit set in the Nuclear Energy Decree (161/1988).



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 YVL Guide A.10. YVL Guide 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 YVL Guide 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

No reactor trips occurred at the Loviisa nuclear power plant in 2016.

Based on data from the previous ten years (2006–2015), 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 2016 (five in total) and the number of events warranting a transient report (two in total) was below the 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 2016 are described in Appendix 3.

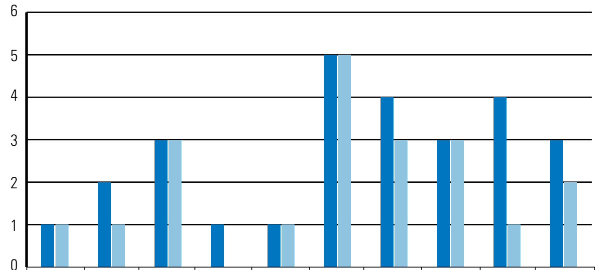
When considering the indicators concerning special and transient reports, it must be noted that the number of reports does not give a correct idea of the division of events by plant unit since, for technical reasons, the reports that concern both plant units have been entered for Loviisa 1 alone. No events warranting a special report or events warranting a transient report that involved both plant units took place in 2016, however.

Olkiluoto

No reactor trips occurred at the Olkiluoto nuclear power plant in 2016. Based on the data from the last ten years, an average of zero to one reactor trips per year occurs 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.

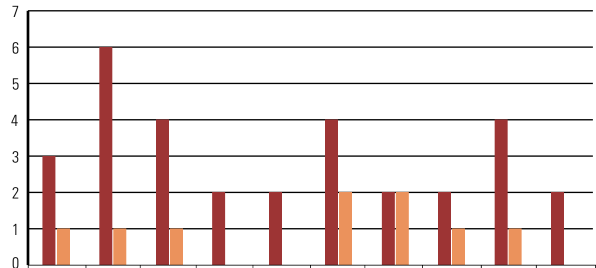
Based on data from the previous ten years (2007–2016), the average number of annual events warranting a special report is four per year, while the average number of events warranting a transient report is five per year. In 2016, the number of events warranting a special report (two in total) was lower than the average and the number of events warranting a transient report (three in total) was also lower than the annual average. Many of the events warranting a special report are deviations from the operational limits and conditions

Number of Special Reports, Loviisa NPP



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LO1	1	2	3	1	1	5	4	3	4	3
LO2	1	1	3	0	1	5	3	3	1	2

Number of Special Reports, Olkiluoto NPP



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OL1	3	6	4	2	2	4	2	2	4	2
OL2	1	1	1	0	0	2	2	1	1	0

(OLC). The development of events non-compliant with the OLC is considered under indicator A.I.2.

Events warranting a special report in 2016 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 by plant unit since, 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 2016.

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.

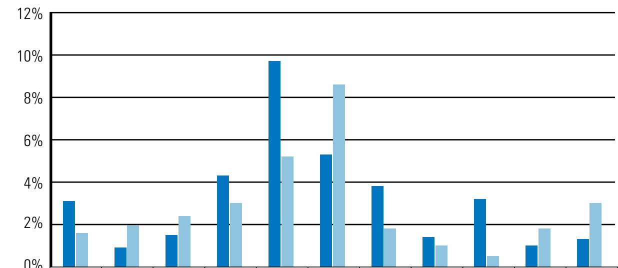
Purpose

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

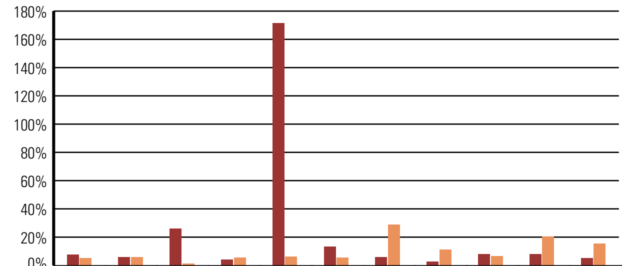
The combined total CCDP divided by the probability of a severe accident gives an overview of the risk-significance of operational events. To facilitate analysis, risk calculation is based on conservative assumptions and simplifications, which materially weakens the applicability of the results for trend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

Risk contribution of the safety system unavailability at Loviisa NPP
Persentage of the average annual core damage risk



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LO1	3.10	0.90	1.50	4.30	9.70	5.30	3.80	1.40	3.20	1.00	1.30
LO2	1.60	1.95	2.40	3.00	5.20	8.60	1.80	1.00	0.50	1.80	3.00

Risk contribution of the safety system unavailability at Olkiluoto NPP
Persentage of the average annual core damage risk



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OL1	7.60	6.00	26.10	4.00	171.40	13.10	5.90	2.80	7.90	8.00	5.30
OL2	5.00	6.00	1.30	5.40	6.30	5.40	29.00	11.00	6.40	20.50	15.30

Loviisa

At Loviisa 1 and Loviisa 2, the risk caused by operational activities remained at around the same level as in the past years in 2016.

A brief description of the most significant events regarding risks is provided below.

Loviisa 1:

1. Maintenance of auxiliary emergency feedwater system of LO2 took 99 hours during the annual outage of LO2. This caused a risk for LO1 that was in power operation because the auxiliary emergency feedwater system of LO2 can also be used to cool LO1. The calculated CCDP was 1.7E-7.

Loviisa 2:

1. Maintenance of auxiliary emergency feedwater system of LO1 took 92 hours during the annual outage of LO1. This caused a risk for LO2 that was in power operation because the auxiliary emergency feedwater system of LO1 can also be used to cool LO2. The calculated CCDP was 2.0E-7.

Olkiluoto

At Olkiluoto 1, the risk caused by operational activities remained at around the same level as in the past years in 2016. Two hidden faults in emergency core cooling systems at Olkiluoto 2 increased the additional risk from operational activities to a fairly high level (15.3%).

A brief description of the significant events is given below.

Olkiluoto 1:

1. Preventive maintenance of a diesel generator in the subsystem A took 266 h. CCDP: 2.4E-07.

Olkiluoto 2:

1. During inservice testing of subsystem 327 C of the emergency feedwater system, it was noted that valve 327V307 in the recirculation line was defective. During inservice testing of subsystem 323 C of the core spray system, it was noted that there was a fault in the flow measurement. Both of these faults were hidden, and the components were simultaneously defective for 337 hours. The fault in the 327 system persisted for 555 hours. CCDP: 1.5E-06.
2. Preventive maintenance of a diesel generator in the subsystem A took 184 h. CCDP: 1.7E-07.
3. Preventive maintenance of a diesel generator in the subsystem C 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.

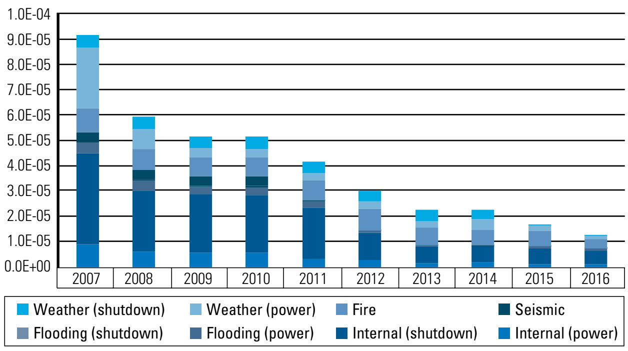
At the end of 2016, the core damage frequency or annual probability of core damage calculated with the PRA model of Loviisa 1 was around 1.3 × 10^{-5}/year, which is around 25% lower than in 2015 (1.7 × 10^{-5} /year). The core damage frequency of Loviisa 2 was 1.6 × 10^{-5}/year, which is 20% less than in 2015 (2.0 × 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 risk was lower than in the previous year due to the reduced fire risk significance in the demineralization plant, the development of emergency operating procedures for leaks, a new procedure on using the backup emergency feedwater pumping plant without DC power supply and the fact that the control system of the turbine bypass valves was modified into an oil-free system.

Olkiluoto

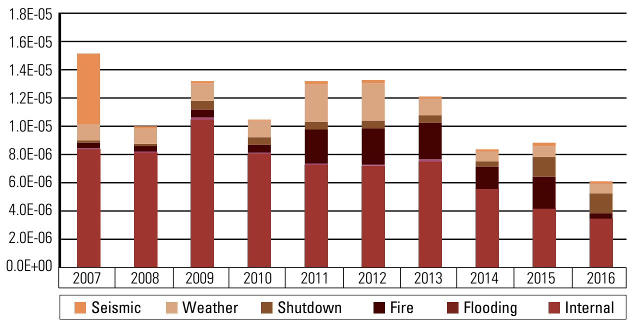
The indicator for the Olkiluoto nuclear power plant decreased by approximately 30% in 2008 compared to previous years' relatively stable values. The decrease was mainly due to the more detailed modelling of earthquake events and changes carried out at the plant to improve seismic qualification. The increase in 2009 was due to the fact that a heat exchanger in the screening system cannot be used for residual heat removal, 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 2016, the calculated core damage frequency for Olkiluoto 1 was 0.64 x 10^{-5}/year, which is around 30% lower than in 2015 (0.90 x 10^{-5}/year). At the end of 2016, the calculated core damage frequency of Olkiluoto 2 was 1.13 x 10^{-5}/year, which is around 23% lower than in 2015 (1.46 x 10^{-5}/year). The changes in the core damage frequency were caused by updates of the confidence data and updates of the ignition frequencies used in the PRA, among other issues. The difference between the plant units is mainly caused by the fact that Olkiluoto 1 underwent modifications in 2014

Fluctuation of the calculated annual core damage frequency for Loviisa plant units during 2007–2016



Fluctuation of the calculated annual core damage frequency for Olkiluoto plant units during 2007–2016



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 component failures. Such modifications have not been implemented at Olkiluoto 2 yet.

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
In 2016, there was one extinguishing task at Loviisa 2 (LO2) in the turbine hall's exciter room. The turbine had been shut down for warranty testing when the employees noticed smoke coming from an electrical cabinet. A repairman extinguished the smouldering fire with a fire extinguisher. The rescue personnel confirmed fire safety of the area. 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.

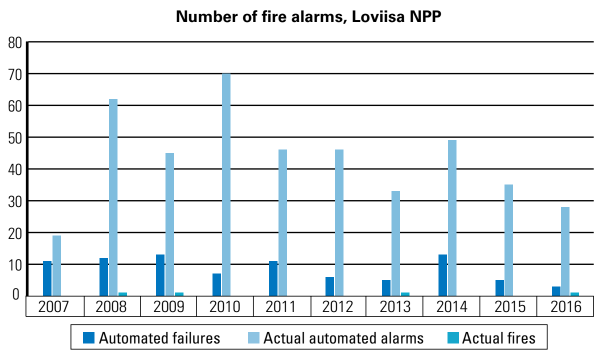
The fire detection system of the Loviisa nuclear power plant was renovated in 2000. After the renovation of the fire alarm system, the number of alarms increased at the plant due to the more sensitive detectors. Advance alarms issued by the fire detection system are no longer included in these statistics.

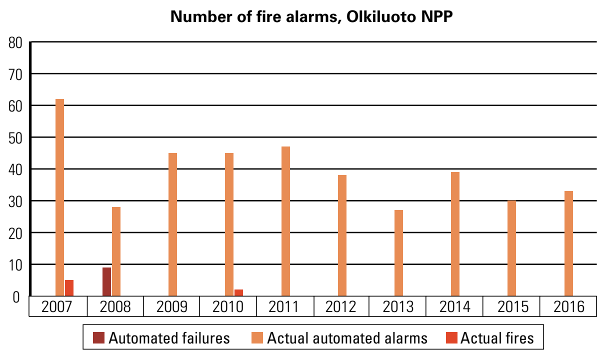
The average fire safety of the Loviisa nuclear power plant has remained at around the same level. There have been four events classified as fires at the Loviisa plant site in the past ten years. The number of alarms from the fire detection system is affected by the amount of maintenance and repair work 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 (OL1/OL2) in 2016. One fire event took place outside the plant site: a solenoid valve in a cooling device of a freezer in the cafeteria caught fire. The employees of the cafeteria extinguished the fire with a fire blanket and the rescue personnel used a fire extinguisher to verify fire safety of the area. No fire detection system faults were observed at the Olkiluoto nuclear power plant (OL1/OL2) in 2016. No faults were observed during the seven 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.

The fire detection system of the Olkiluoto nuclear power plant was renovated in 2001. After the renovation of the fire alarm system, the number of alarms increased at the plant due to the more sensitive detectors. 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 for events classified as fires in Olkiluoto is decreasing: the last event classified as a fire occurred six 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

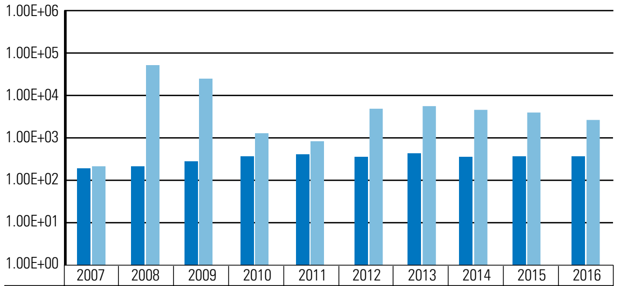
The indicators describe fuel integrity and the fuel leakage volume during the fuel cycle. The indicators for shutdown situations also describe the success of the shutdown in terms of radiation protection.

A.III.1a Primary circuit activity

Interpretation of indicators (Loviisa)

There were no leaking fuel assemblies in the reactors of Olkiluoto 1 and Olkiluoto 2 in 2016. The last time a leaking fuel assembly was removed from the Loviisa 1 reactor was in 2013 and the last time a leaking fuel assembly was removed from Loviisa 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. After removal of the leaking fuel assemblies, the maximum iodine-131 activity values associated with shutdowns also returned to the level before the leaks. The indicators describing fuel integrity have remained at a good and stable level in 2014–2016.

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

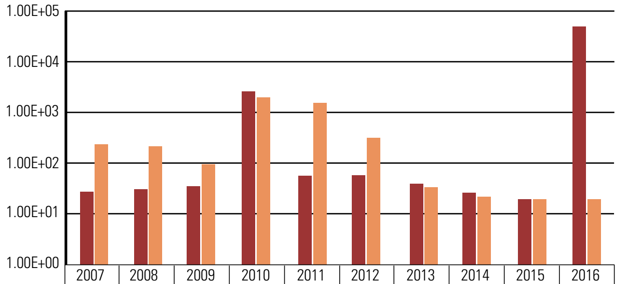


	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LO1	1.90E+02	2.00E+02	2.60E+02	3.80+02	3.90E+02	3.70E+02	4.00E+02	3.50E+02	3.40E+02	3.41E+02
LO2	2.10E+02	4.90E+04	2.40E+04	1.20+03	8.50E+02	4.71E+03	5.40E+03	4.60E+03	3.90E+03	2.52E+03

Interpretation of indicators (Olkiluoto)

A total of six fuel assemblies were removed from the Olkiluoto 1 reactor in 2016, and the primary coolant activity level caused by iodine-131 at Olkiluoto 1 was elevated. A leaking fuel assembly was last detected at Olkiluoto 1 in 2010. On the basis of other inspections carried out during the annual outage, the fuel types at both plant units have mostly behaved normally. Several fuel leaks have occurred in the 2000s at Olkiluoto 2. In 2016, the primary coolant activity caused by iodine-131 was at the same level as in 2015. The last time the activity level at Olkiluoto 2 was markedly elevated was in 2012.

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



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OL1	2.70E+01	3.00E+01	3.50E+01	2.45E+03	5.50E+01	5.58E+01	3.92E+01	2.55E+01	1.94E+01	5.23E+04
OL2	2.30E+02	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

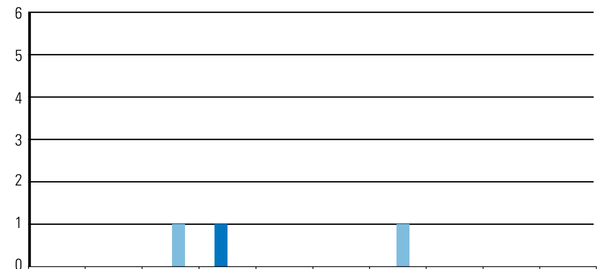
A.III.1b Number of leaking fuel assemblies

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 Loviisa 1 or Loviisa 2 during the period under review.

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

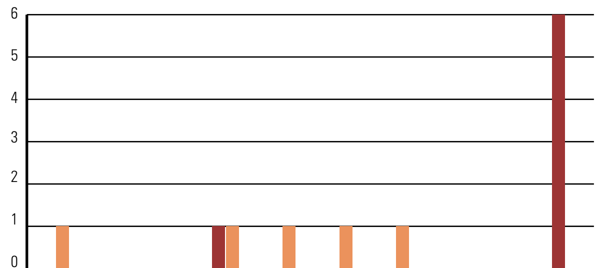


	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LO1	0	0	0	1	0	0	0	0	0	0
LO2	0	0	1	0	0	0	1	0	0	0

Interpretation of indicators (Olkiluoto)

There were no leaking fuel assemblies in the reactor of Olkiluoto 2 in 2016. In the reactor of Olkiluoto 1, there were six leaking fuel assemblies. The number of leaking fuel assemblies was exceptionally high. TVO has already taken corrective action to remedy the situation. The leaking fuel assemblies will also be studied to identify the root cause of the faults. Most of the previous leaks have been caused by small loose objects entering the reactor during maintenance operations. The coolant flow may cause the loose objects to vibrate and break the fuel cladding. To minimise the problem, new Triple Wave+ foreign object sieves have been adopted at Olkiluoto 2.

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



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OL1	0	0	0	1	0	0	0	0	0	6
OL2	1	0	0	1	1	1	1	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 somewhat decreased at both plant units. The as-found leakage of both units remains clearly below the set limit.

The number of isolation valves that passed the leak test at first attempt has clearly increased at both plant units in the past few years, reaching 100% at both units in 2016.

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.

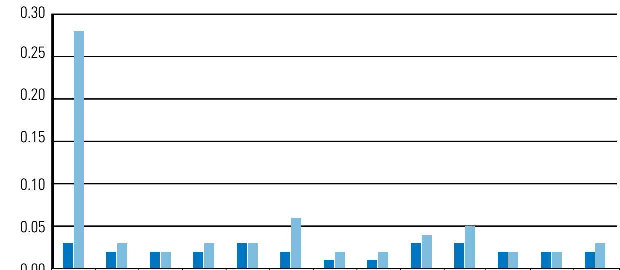
The total as-found leakages of outer isolation valves at the Olkiluoto 1 plant unit remained at a low level, clearly below the limit set in the operational limits and conditions (OLC).

The overall as-found leakage of the outer isolation valves of Olkiluoto 2 increased when compared to the previous year, but remained 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. There was a slight decrease from 2014 at Olkiluoto 2 in 2016.

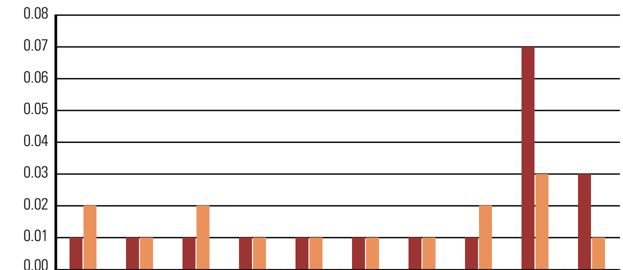
The total as-found leakage rate of containment penetrations, in which TVO includes leakages in the upper and lower personnel airlocks, the maintenance dome and the containment dome, returned to the level of the previous years in 2016, i.e. was low at both plant units.

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



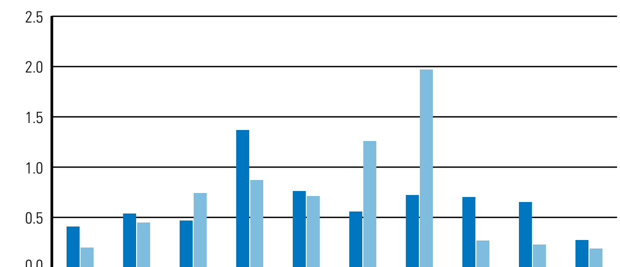
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LO1	0.03	0.02	0.02	0.02	0.03	0.02	0.01	0.01	0.03	0.03	0.02	0.02	0.02
LO2	0.28	0.03	0.02	0.03	0.03	0.06	0.02	0.02	0.04	0.05	0.02	0.02	0.03

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



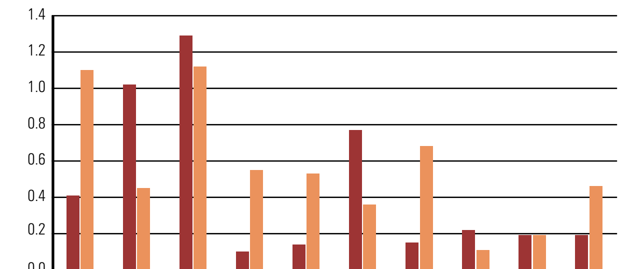
	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OL1	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.03
OL2	0.02	0.01	0.02	0.01	0.01	0.01	0.01	0.02	0.03	0.01

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



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
LO1	0.41	0.54	0.47	1.37	0.76	0.56	0.72	0.70	0.65	0.28
LO2	0.20	0.45	0.74	0.87	0.71	1.26	1.97	0.27	0.23	0.19

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



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OL1	0.41	1.02	1.29	0.10	0.14	0.77	0.15	0.22	0.19	0.19
OL2	1.10	0.45	1.12	0.55	0.53	0.36	0.68	0.11	0.19	0.46

APPENDIX 3 Significant events at nuclear power plants in 2016

Loviisa nuclear power plant

Annual outages at Loviisa, 7 August – 7 October 2016

This year, Loviisa 1 underwent a four-year maintenance outage that lasted around 38 days. In addition to refuelling, the power company performed comprehensive inspections and large-scale modifications. Due to this, all the fuel was removed from the reactor for the duration of the maintenance work. The shorter annual outage at Loviisa 2 started on 17 September 2016 and lasted around 20 days.

In addition to the refuelling, the largest modification was the installation of the first phase of the Loviisa I&C renewal in both plant units, including a preventive safety function control and indication system as well as modernisation of the I&C status monitoring system. The plan is to complete the rest of the I&C renewal installations in stages during the 2017 annual outage (phase 2B) and the 2018 annual outage (phase 1 or the final phase). Fortum completed the installations according to plan during the annual outage.

The annual outage inspections were carried out on schedule and in the planned scope. During the annual outage, Fortum inspected – according to a programme agreed with STUK – that there was no hydrogen flaking in the reactor pressure vessel of Loviisa 1. Hydrogen flaking was detected in the walls of the reactor pressure vessels in Belgian nuclear power plants Doel 3 and Tihange 2 during the 2012 inservice inspections, and the plants were out of operation for a long time because of the hydrogen flaking. A similar inspection on the pressure vessel of Loviisa 2 was performed during the 2014 annual outage; no hydrogen flaking was detected in Loviisa 2 either.

During the 2016 annual outage, Fortum inspected the reactor safety injection system nozzles of Loviisa 1 with an ultrasound method for the first time ever. The result obtained from one of the noz-

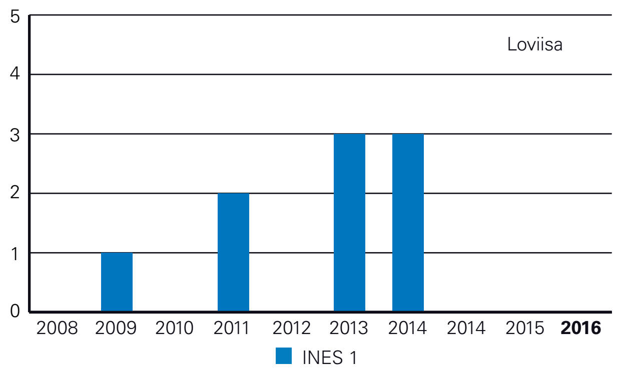


Figure A3.1. INES classified events at the Loviisa plant (INES Level 1 or higher).

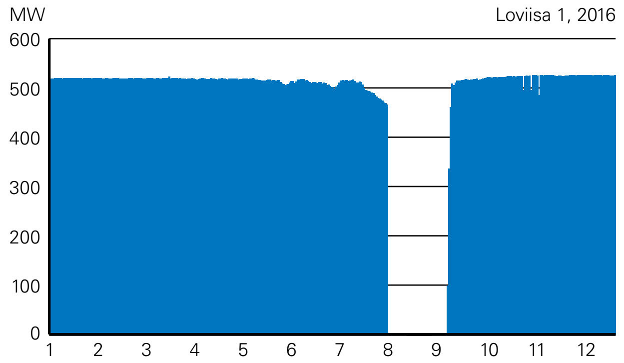


Figure A3.2. Daily average gross electrical power of the Loviisa 1 plant unit in 2016.

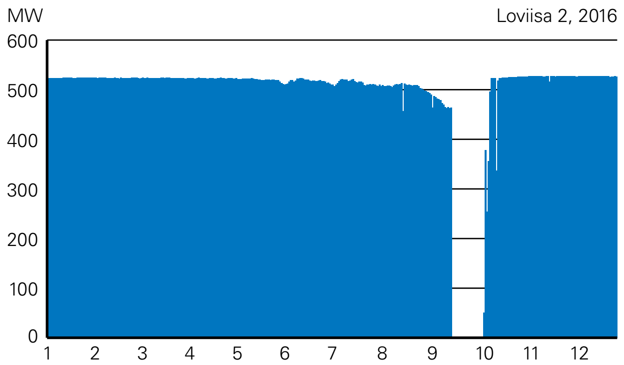


Figure A3.3. Daily average gross electrical power of the Loviisa 2 plant unit in 2016.

zles was abnormal. As the nozzles are components important to safety, STUK required that the power company prepare a detailed report of the inspection result. Based on the inspection, STUK determined that the reactor pressure vessel can be safely operated. STUK required, however, that the new inspection method must be qualified and the nozzle from which the abnormal result was obtained and any similar nozzles in the second unit must be inspected using the same method during the 2017 annual outage. The inspections at Loviisa 2 are not scheduled until for the year 2018 in the inspection programme, which means that the inspections will be brought forward by one year. According to the information currently available, similar inspections have not been carried out in the other VVER plants because it is a very challenging inspection from the technical viewpoint.

During the annual outage of Loviisa 1, additional work for the employees was caused by a fuel element storage bottle that was accidentally taken into the reactor during refuelling and a cable break in the refuelling machine. STUK oversaw the removal of the bottle and the subsequent removal of parts of the broken cable from the reactor. These events did not pose any danger, but the power company submitted more detailed reports about them to STUK before the startup of the plant unit.

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 reactor coolant circuit of Loviisa 1 were lower than in the previous year and the combined radiation dose of the plant unit's employees, 492 mmanSv, was less than half of the dose during the last four-year maintenance outage, which was used as the reference point. The combined radiation dose of the employees at Loviisa 2 was 300 mmanSv, which complied with Fortum's advance estimate.

Radioactive materials did not pose any danger outside the plant either. STUK oversaw radioactivity in the surroundings of the Loviisa nuclear power plant by regularly taking samples from the air, soil and sea. Very small amounts of radioactive materials originating from the power plant were detected in one of the air samples and one of the sludge samples taken from the power plant's wastewater treatment plant. The activity concentrations were so low that they could be detected in very accurate laboratory measurements only. They did not pose any danger to people or the environment.

Four events non-compliant with the OLC took place in 2016

In 2016, four events that were non-compliant with the OLC took place at the Loviisa nuclear power plant. The short-term events were separate from each other, and they did not compromise nuclear or radiation safety. All of the events were rated as INES category 0 events. Fortum investigated all of the events and submitted reports on them to STUK in compliance with the requirements. Furthermore, Fortum specified corrective measures to prevent reoccurrence of the events. STUK approves the events as part of the operational event report and oversees during its regulatory duties that the corrective measures are properly realised.

The most important of the events was an unintentional activation of a signal from the plant protection system during the Loviisa 2 annual outage. In this event, a signal from the plant protection system that isolates the feedwater line and main steam line due to low steam line pressure was unintentionally activated on two days (22 September and 27 September 2016) a total of three times. According to the power company's report, all of the activations were caused by the removal of a bypass during the annual outage. The removal of this bypass of around 30 bar was due to transients caused by the work done during the annual outage, which means that it does not compromise reliable operation of the signal while the plant is in operation. The protection signal is of safety significance only during load operation, at which time it will isolate an affected steam generator in case of a steam pipe leak. The protection signal is not necessary during an annual outage, which is why it is bypassed to avoid unnecessary protection functions.

STUK required from Fortum a report on the event before the startup of the plant. STUK also studied the events and their causes on site and determined based on the inspection results that the licensee's view is correct. One activation of the signal was caused by several jobs being simultaneously carried out, but the cause of the other two events has not been determined with full certainty. Fortum considers it most likely that the system's ability to withstand the changes of the testing and connection status during an annual outage may have been deteriorated due to ageing of the components. STUK has deemed the situation acceptable in terms of safety, but will continue to monitor the condition of the system as part of its ongoing oversight duties.

The other three events were short-term non-conformances with the OLC

- On 30 September 2016 during the annual outage of Loviisa 2, a subsystem that cools important systems and rooms, which was being used by the clean component cooling system, was lost for a period of 28 minutes due to an operating error of a manual valve when restoring another system.
- On 12 September 2016 as Loviisa 1 was being started up after the annual outage, the allowed repair time of a pressurizer, which is eight hours, was exceeded by around one hour. The fault would not have prevented operation of the plant protection system.
- Electricity supply to one isolation valve inside the containment of Loviisa 1 was not restored during the 2016 annual outage. The non-conformance was detected two days after startup of the unit when the unit was in load operation on 16 September 2016. The power supply was immediately restored. Due to the non-conformance, the plant protection signal would not have closed one of the valves. Containment isolation would still have been possible, as there was an exterior isolation valve paired with the said valve.

Olkiluoto nuclear power plant

Fuel leaks during the fuel cycle at Olkiluoto 1

The first indication of a fuel leak was detected in Olkiluoto 1 during exhaust gas system measurements on 27 February 2016. Soon after this, neptunium was detected in the reactor water, which indicated that the leak was larger than normal. Fuel leaks are not completely unusual, even though there have not been many leaks at the Finnish plants in the past few years. TVO monitored the activity in the exhaust gas system with measurements and noted that the activity level continued to increase. By conducting tests where the control rods were moved, TVO was able in early April to specify that the leaks were in three of the adjustment positions.

Due to increased coolant activity levels, TVO decided on 11 April 2016 to shut the plant unit down for an extra refuelling outage. TVO has not performed any similar extra refuelling outages due to leaking fuel rods in the past. Three damaged fuel assemblies were identified with the leakage detection system. The fuel assemblies were removed from the reactor and visually inspected while in the fuel pool. The type of damage does not suggest the presence of any foreign objects, nor were any foreign objects detected in the inspected fuel elements. The observed longitudinal cracks are typical for secondary damage that is caused by water that has penetrated the rod due to primary damage. Hydrides weaken the fuel cladding, and it cracks because of power changes caused by the movements of the rod. The fuel rods had been moved around the time the leaks started, which strongly suggests that the damage was caused by PCI (Pellet Cladding Interaction). Nothing can be said about the cause of the primary damage with any level of certainty before more accurate investigations have been conducted. TVO will continue to investigate the root cause together with the fuel supplier.

New leaks were detected soon after the plant had been started up again, in April 2016. They were yet again located to the adjustment positions by moving the control rods. During the annual outage in May, TVO removed three more leaking fuel assemblies from the reactor. STUK required from TVO before starting up the plant a separate report on what kind of plans would be used to ensure safety of the future fuel cycle in terms of the use of

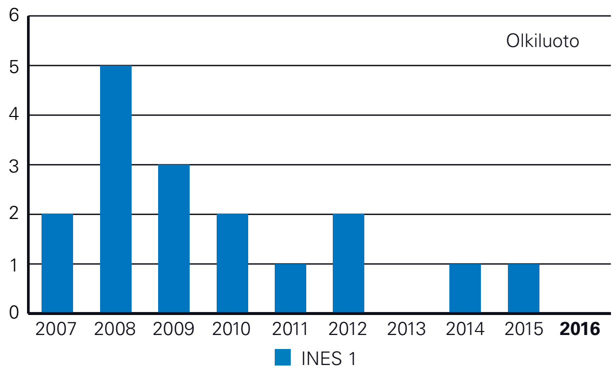


Figure A3.4. INES classified events at the Olkiluoto plant (INES Level 1 or higher).

fuel. In the report, TVO described the actions it will take to reduce the probability of fuel leaks. STUK assessed the proposed measures and deemed them adequate, even though the probability of a fuel failure could be eliminated with full certainty.

Releases from OL1 were higher than in the previous years due to the leaks, but the releases still remained well below the set limits. The increase of the radiation level inside the plant due to the leaks was also moderate, and the radiation doses of the employees did not experience a significant increase due to the leaks. 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.

Annual outages at Olkiluoto, 8 May – 9 June 2016

The annual outages were performed safely and all the scheduled works were completed at both plant units. Olkiluoto 2 underwent a refuelling outage

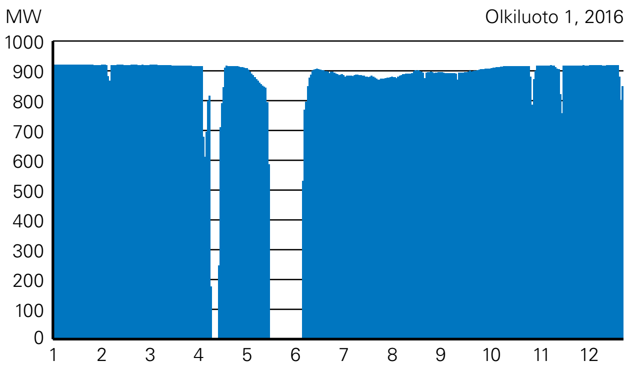


Figure A3.5. Daily average gross power of the Olkiluoto 1 plant unit 2016.

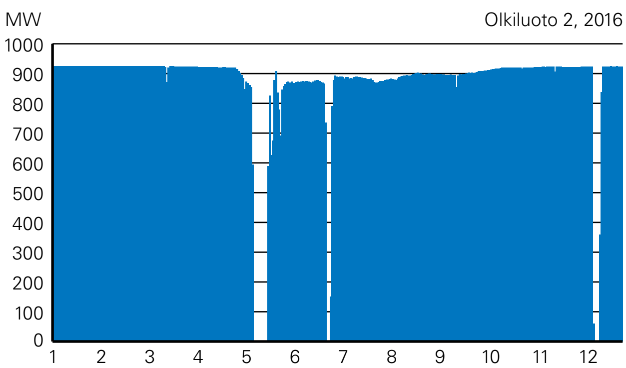


Figure A3.6. Daily average gross power of the Olkiluoto 2 plant unit 2016.

that lasted around nine days (8–18 May 2016), during which time the power company replaced around one fifth of the fuel in the reactor. During the maintenance outage of Olkiluoto 1, TVO replaced fuel and performed major modifications, which is why the outage lasted for around 21 days (18 May – 9 June 2016).

Important work done in Olkiluoto 1 included replacement of one of the reactor coolant pumps with a new pump and replacement of the pump's frequency converter, renovation of the neutron flux calibration system and replacement of low voltage switchgear in one subsystem. In addition, one of the feedwater line and reactor cooling line mixing points were replaced in Olkiluoto 1. The other mixing point had already been replaced during the 2015 annual outage, i.e. both of the mixing points have now been replaced. Furthermore, TVO performed an approved containment leak test at the end of the annual outage.

TVO will replace the ageing reactor coolant pumps of both plant units during this annual outage and the annual outages of the two following years. TVO started with the replacement of one of the six pumps in Olkiluoto 1 during the 2016 annual outage. All of the six reactor coolant pumps in Olkiluoto 2 will be replaced next year, and finally the five remaining reactor coolant pumps in Olkiluoto 1 will be replaced during the 2018 annual outage. Installation and commissioning of the new reactor coolant pump and the related frequency converter were also one of the special themes of the annual outage inspection that is part of STUK's periodic inspection programme. A summary of the inspection is presented in Appendix 4 to this annual report.

The radiation doses of the employees who participated in the annual outages remained well below both the dose limits set in the Radiation Decree and the dose limits set by the power company. An extra challenge during the annual outage of OL1 was the fact that there had been leaks in the reactor fuel elements during the fuel cycle and the level of radioactivity in many of the plant's systems was higher than normal. This had to be taken into account when planning and realising the maintenance work. Employees had to use more protective equipment than normally and some work had to be started later than originally planned.

STUK also monitored the surroundings of the plant during the annual outages. Very small amounts of radioactive iodine were observed at the sampling points close to the plant. This was expected, as some of the fuel rods that had been damaged during the fuel cycle were replaced during the annual outage. The detected level of iodine was so low that the very accurate measuring instruments were barely able to detect it. It did not have any impact on the safety of the environment or people.

Oil leak in the turbine hall of Olkiluoto 2

The Olkiluoto 2 plant unit was being shut down for a maintenance outage on 24 June 2016 to replace the motor of a reactor coolant pump when a fire alarm was activated in the turbine hall. It was observed that oil was releasing at high pressure from a bearing of the turbine in the turbine hall and there was oil mist in the turbine hall. The TVO alarm centre issued an alarm to the Pori emergency response centre due to the related fire risk.

The shutdown was continued normally while the leak in the turbine hall was being located. TVO was able to locate the leaking point: a jacking oil pipe to the turbine bearing. The leaking point was isolated by closing a valve in the jacking oil system, and the leaking of oil stopped. Oil had leaked into the turbine hall and the area below the turbine hall from the leaking jacking oil pipe. The oil was collected with absorption containers and mats. The cleaning work and the repair of the jacking oil pipe were completed by the end of the weekend.

The event did not compromise radiation or nuclear safety, nor did it cause any risk to the employees of the plant. The fire risk in the turbine hall increased due to the event, however. The plant unit was being shut down when the leak started and the temperature of the turbine components had already dropped to some extent, but had the leak occurred in the beginning of the year, the hot surfaces of the pipes could have ignited the oil mist. The turbine hall is large when compared to the volume of the leak, however, which is why ignition of the air-oil mixture that occurs at a temperature of 200°C would have been highly unlikely.

Noble gases released into the turbine building

After the annual outage of Olkiluoto 1 on 16 June 2016, TVO noticed that radioactive noble gases and a small amount of iodine had been released into some of the rooms in the plant unit's turbine building. TVO located the leak to the radiation measuring system of the exhaust gas system. The leak was minor and the event did not compromise the safety of the plant's employees.

There was a leak into a room from the flange of a valve in the radiation measuring system. The leak stopped when a new flange gasket was installed. The flange had been opened during the annual outage to perform maintenance work. TVO stated that the most likely cause for the event was that the gasket of the flange was not replaced but the old gasket was reinstalled. The procedures state that the gasket must always be replaced after having opened a flange. Due to the event, TVO will offer its maintenance personnel training on procedures related to gaskets during the maintenance day in spring 2017.

Because of the event, STUK wanted to perform extra measurements to verify whether iodine could be detected in the surroundings of the plant, but no iodine was detected in the air samples. The measuring station closest to Olkiluoto 1 is around three kilometres from the plant unit. At the measuring station, particles from the air are collected into a fibreglass and activated carbon filter with a pump to be analysed in a laboratory. This method is able to detect very small amounts of radioactive substances.

During the event some of the radioactive materials moved from the interior of the plant unit to the vent stack without entering the exhaust gas system delay tanks, which increased the noble gas and aerosol releases of the plant unit, in particular. Most of the releases consisted of short-lived noble gas and aerosol nuclides. The impact of such nuclides on environmental radiation safety is minimal as they will very quickly deteriorate into stable elements. The releases caused by the event remained well below the plant's set limits.

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.

Cracks in nozzles of feedwater and reactor core spray system at Olkiluoto 2

The crack in a feedwater nozzle at Olkiluoto 2 is located in a weld in between the reactor pressure vessel nozzle butt weld and its joint (safe-end) on the inside of the nozzle. The crack may be a manufacturing fault that was originally left undetected and whose actual depth could not be determined until before new inspection techniques were introduced. On the other hand, the crack may also be a fault caused by stress corrosion that has grown over time and may continue to grow. The crack was detected in 2003 and has been monitored ever since. During the 2013 annual outage, TVO had the area of the crack inspected from the outside by means of phased array ultrasonic testing. The depth of the internal crack was determined as 23 mm (wall thickness 33 mm). The inspection result was a surprise: the depth of the crack was given as 23 mm compared to the 10–15 mm that had been determined with the inspection techniques used before. During the 2013 annual outage, STUK approved a strength analysis submitted by TVO and a procedure where the crack would be monitored for the next three years. Based on inspections done during the 2016 annual outage, the crack has not grown.

When the internals of the reactor pressure vessel were being inspected during the 2015 annual outage of Olkiluoto 2, cracks were observed in a welded joint between a reactor core spray system nozzle and a safe-end. At that time, STUK approved a procedure proposed by TVO where the weld would be inspected more often for at least the next three years. Based on inspections done during the 2016 annual outage, the cracks had not grown.

STUK has also required that TVO continue to study the causes of the cracks in the reactor pressure vessel nozzles and continue its work on preventing new indications and preventing the old indications from spreading. TVO submitted to STUK for approval at the beginning of 2016 a plan on related further measures. TVO has decided that preventive repairs of all the reactor pressure vessel safe-end nozzles in Olkiluoto 1 and Olkiluoto 2 will be performed. There are a total of ten nozzles in each plant unit. The nozzles will be repaired by machining the buffer/joint weld a couple of millimetres from the inside and welding new filler material into the joint using a welding wire that is less susceptible to stress corrosion. TVO will repair the identified cracks in the nozzles at the same time. The plan is to complete these repairs at Olkiluoto 2 during the 2017 annual outage and at Olkiluoto 1 during the 2018 annual outage.

APPENDIX 4 Periodic inspection programme of nuclear power plants 2016

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 2016 inspections.

Inspections of the periodic inspection programme at Loviisa nuclear power plant

Personnel resources and competence, 18–19 May 2016

The inspection covered the licensee's HR planning, resource requirements and competence management. The 2016 inspection focused on development of the licensee's competence management and resource management. There were three main themes: determination of competence requirements; resources and duties of the training team; and good practices implemented at the plant in 2016.

No requirements were imposed by STUK following the inspection, but one recommendation was given: based on the inspection observations, STUK recommends that the competence development project should focus much more on the commitment of supervisors and communication about the project's goals and benefits.

	Inspections in 2016	
Basic programme	**Loviisa 1 and 2**	**Olkiluoto 1 and 2**
Personnel resources and competence	x	
Management and safety culture		x
Management system	x	x
Disposal facilities		x
Chemistry	x	
Operating experience feedback		x
Operation	x	
Plant maintenance	x	x
Fire protection	x	
Utilisation of the PRA		x
Structures and buildings		x
Radiation protection	x	x
Nuclear security	x	x
Safety planning		
Safety functions	x	x
Emergency preparedness	x	x
Reactor waste	x	
Annual outage	x	x
Nuclear safeguards	x	x
Additional inspections		
Implementation of YVL Guides		x
Management of projects and modifications		x

Management system, 30 November – 1 December 2016

The inspection covered functionality of the licensee's integrated management system from the perspective of nuclear and radiation safety. The inspection focused on maintenance and development of the licensee's management system; the related organisation; the review process of applications pertaining to modifications; and the implementation of changes. Furthermore, Fortum's development measures to ensure compliance with the new YVL Guides were studied.

It was noted that Fortum needs to reassess the cooperation procedure between the head of the HR unit and the head of the business unit (the management representative in issues pertaining to the development of the management system) and people in other positions important for the development of the management system. STUK imposed a requirement on this matter. It was also noted that Fortum has made plans to develop the modification work process. STUK considered the plans necessary and wants to monitor the development work; STUK imposed a requirement on this matter. STUK did not have any remarks as to the maintenance of the management system (assessments, etc.) or development/continuous improvement.

Chemistry, 25–26 April 2016

In the chemistry inspection, the licensee's procedures regarding the maintenance and development of the water chemistry conditions of the primary and secondary circuit, as well as the radiochemistry conditions, laboratory operations and decontamination were studied. Special focus areas included ensuring that the systems and components used to manage the water chemistry and radiochemistry conditions are properly maintained, and that the results of their inservice testing and the experience gained from operating activities are taken into consideration. The inspection also included a site walk-down.

The inspection verified that the employees in the chemistry laboratory are motivated and their work is of a high quality. Management of the laboratory encourages the employees to expand their competence areas.

No requirements were imposed by STUK following the inspection. Seven observations were made during the inspection. Two of the observations were about good practices. The observations involved the organisation; the identification of competence development requirements and development of the employees' competence; the marking of faulty or broken components; and continued identification of the sources of silver in the primary circuit. In addition, STUK recommended that a plan on reducing the frequency of primary circuit boron acid content sampling during annual outages be submitted to the nuclear safety unit for comments to generate an internal safety assessment of the change.

Operational activities, 20 December 2016

The inspection covered operational activities of the nuclear power plant as well as closely related actions and practices. Operational processes and activities of the organisation that the nuclear power plant uses to ensure and verify compliance with the set requirements on nuclear safety, radiation protection, reliability of the operational activities and quality management were assessed and verified in the inspection.

The 2016 operational activities inspection focused on a training simulator in the Loviisa nuclear power plant's operational unit and the simulator team. STUK inspected how well the simulator corresponds to the currently operating plants and instructions on simulators, as well as how the simulator training has been realised when compared to the plans. In the field of HR planning, STUK inspected the effects of Fortum's organisational change and training plans for the simulator instructors and the shift supervisors/operators.

No material deficiencies or development needs of the simulator or the training were observed, nor were any requirements imposed. No remarks regarding the HR planning were made and the procedures were up to date. The inspection verified that the employees in the simulator team are motivated and their work is of a high quality.

Plant maintenance, 2–3 November 2016

The inspection covered the resources, functions and tasks Fortum uses to ensure long-term operability of the systems, structures and components in its plant units. The focus areas of this inspection were HR planning in maintenance, monitoring of the plant components' profitability and coverage of their condition monitoring. Furthermore, Fortum's replies to requirements imposed in the previous inspections on plant maintenance and mechanical engineering were reviewed during the inspection.

A new subunit added to the maintenance organisation due to Fortum's organisational change is service life management. The change did not influence the number of employees in maintenance. The impressions about the new maintenance arrangements for the Loviisa plant units that were taken into use last summer are positive. STUK will monitor feedback on the maintenance operations as well as any plans to outsource maintenance of the site and related actions. One observation made during the inspection was that pipelines from control valves to injectors in the external containment spray system were not included in the scope of the inspections, which is why one section that is critical for the performance of the system has not been tested since its commissioning (in 1990). Even though blockages in these spray valve lines that are open at one end is unlikely, the possibility of a blockage cannot be completely overruled without testing. Therefore, Fortum was required to verify unobstructed flow in these pipelines by means of testing.

Fire protection, 21–22 April 2016

The fire protection inspection assessed effectiveness of the plant units' fire protection arrangements and the power company's operations and the fire protection unit organisation – changes therein, procedures of the organisation, and training and drills of the fire brigade personnel.

It was verified that the nuclear power plant's fire alarm and fire prevention systems have been inspected in compliance with the maintenance programme and the work order practices. Performance of the fire protection arrangements has been assessed with regular internal audits and also by the Eastern Uusimaa Fire and Rescue Services, the Finnish Safety and Chemicals Agency (Tukes) and the Nordic Nuclear Insurers insurance pool. STUK studied the improvement proposals from these inspections. Furthermore, the organisation, its responsibilities and implemented/planned changes were studied, and the status of procedure updates was verified.

No requirements were imposed on the licensee due to the inspection. No remarks regarding the HR planning were made and the procedures were up to date. Positive inspection observations included properly arranged training and competence development programme of the fire protection unit. Furthermore, work to reduce the fire risk – modifying the hydraulic turbine bypass stations RC into water-powered ones – will start during the 2016 annual outages. Other observations included prolonged fire pump inspection intervals, a need to test the fire pumps with a higher flow than their operating point in the future as well as a need to specify more clearly the ignition used in reporting and the safety index. STUK will monitor these issues in its future inspections. The actions required based on previous inspections had been properly performed.

Radiation protection, 27–28 October 2016

A radiation protection inspection covers the nuclear power plant's radiation protection, radiation measurements, emission monitoring and environmental monitoring. The focus areas this year were administrative radiation protection, the organisation, ALARA operations and the processing of events.

It was noted that Fortum has successfully reached its ALARA goal. The radiation dose rate in the steam generator room, for example, has continued to reduce at both plant units. The key reason for the lowered dose rate is a project in which antimony was successfully removed from the primary coolant.

Four requirements were imposed in the inspection. The requirements involved job descriptions, training programmes and radiation protection procedures. Furthermore, STUK required that Fortum continue its survey on radiation exposure to the eyes. The survey is necessary in order to determine whether separate eye dosimeters are needed for some of the jobs performed at the nuclear power plant.

Nuclear security, 11–15 April 2016

An extensive inspection of the security arrangements was performed in accordance with the inspection plan. The inspection covered the monitoring and management of keys; the protection of key targets and access control procedures; and practices involving unauthorised drones being flown at the plant site, to mention a few issues.

Five requirements were imposed in the inspection. Measures resulting from requirements made in the course of earlier inspections had been appropriately implemented.

Safety functions, 25 November and 30 November 2016

The inspection covered the licensee's procedures used to verify correctness of the status and design bases for the systems implementing safety functions. Focus areas of this year's inspection included scope of inservice tests on the reactor trip function and monitoring of the reactor core; testing, inspection and maintenance procedures of the fuel handling equipment; and the qualification of refuelling machine operators. HR planning in the design and maintenance organisation was also covered.

Furthermore, STUK will perform an operational oversight inspection of transfer and hoisting operations in early 2017 to monitor Fortum's ongoing refuelling and hoisting operations development measures and the qualification of refuelling and hoisting machinery operators.

Emergency preparedness arrangements, 12 October and 18 October 2016

Issues that are regularly inspected in emergency preparedness arrangement inspections include emergency preparedness guidelines, emergency preparedness facilities, emergency preparedness equipment, the emergency preparedness organisation and training for the emergency preparedness organisation. The focus areas in 2016 included HR planning and training plans as well as feedback on emergency preparedness drills and development areas identified based on the drills. The inspection of the emergency preparedness facilities focused especially on the management of contamination.

HR plans and training programmes for the employees handling the emergency preparedness arrangements are in order. As comes to the emergency preparedness organisation, Fortum has been able to add more employees in radiation protection positions, in particular, and name mechanics in charge of repairs in the emergency preparedness organisation. Fortum is about to launch an emergency preparedness training review project. The project will cover training as a whole, including basic training, refresher training and guidelines. The Fortum emergency preparedness centre practiced contamination management in 2015, and principles of the operation were carefully considered before this drill. However, contamination management in the emergency preparedness facilities is not a fully planned entity with comprehensive procedures. The inspection included a site walk-down during which the backup power supply of the emergency preparedness centre and a flood protection project were studied.

STUK imposed one requirement in the inspection: Fortum must plan the contamination management arrangements in the emergency preparedness facilities, prepare procedures that cover these operations and place the necessary equipment at the planned locations.

Operational waste, 1–2 June 2016

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

No material deficiencies or development needs were observed, nor were any requirements imposed based on the inspection. A positive observation made during the inspection was that based on the indicators on the waste packing room, operations at the packing room have been developed by introducing a pre-classification system for waste and packing the waste more tightly, for example.

Annual outage, 7 August – 10 October 2016

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 predetermined inspection areas. STUK also performed general oversight of the plant site by means of, for instance, regular site walk-downs and overseeing the progress of planned work. Furthermore, STUK studied how well safety is prioritised in the licensee's decision-making process.

A focus area in this year's inspection was replacement of the high-pressure safety injection system's motors and heat exchangers; STUK oversaw mechanical engineering, electrical and I&C engineering, radiation protection and operational safety of the replacement, among other issues. Other focus areas of the oversight during the annual outage included employee orientation to tasks important for the annual outage, management of personnel resources, HR planning, Fortum's operating experience feedback process linked to the annual outages, heavy lifting in the turbine hall and reactor building during annual outages, civil engineering and fire protection.

Based on the inspection results, one can state that Fortum's annual outage operations comply with the requirements and have been successful. A total of 26 observations were made and two requirements were imposed during the annual outage inspection. The requirements involved reporting and processing of operational events.

Nuclear safeguards, 19–21 April 2016

The inspection focus areas were the nuclear safeguards system of Fortum's Loviisa nuclear power plant and the manner in which the plant takes care of its nuclear safeguards obligations. The inspection covered the procedures Fortum uses to meet the requirements posed by legislation, the YVL Guides (Guide YVL D.1 in particular) and EU Regulations. Separate nuclear safeguards inspections had been performed before, but this was the first time nuclear safeguards were included in the periodic inspection programme. The inspection covered the role of management in the arrangement of nuclear safeguards; the plant's actions and responsibilities involving the maintenance and development of the nuclear use item accountancy and reporting system; actions linked to compliance with the nuclear safeguards obligations and related responsibilities; and actions and responsibilities that enable regulatory oversight (by the IAEA and the European Commission, for example).

The inspection verified that the management of the Loviisa nuclear power plant is strongly involved in HR planning and securing the resources needed to ensure compliance with the nuclear safeguards requirements, as new people who will do their part in ensuring compliance with the nuclear safeguards obligations are currently being qualified for both procurement and storage operations. Furthermore, the recent organisational renewal strengthens the resources and authorisation of the person in charge of nuclear safeguards and their deputies.

One of the development areas observed during the inspection was that a security guide for inspectors (of the IAEA and the European Commission) to be read prior to working close to the open reactor pool would be beneficial.

Deficiencies in compliance with the agreed issues and the rules (the Commission's plant-specific particular safeguard provisions) when updating the plant's technical basic data and during internal inspections of the nuclear safeguards manual approved by STUK were observed during the inspection. Requirements pertaining to these given during the inspection included an update of the technical basic data in due time before the next inspections of the IAEA and the Commission and performing the annual internal inspection in compliance with the handbook in such a manner that an inspection of the plant's nuclear-use items or other nuclear material inventory will also be completed by an independent party who is not the person in charge of nuclear safeguards.

Inspections of the periodic inspection programme at Olkiluoto nuclear power plant

Management and safety culture, 9–10 March 2016

The inspection covered how the management has ensured with its actions and communication that safety is the priority in the organisation culture despite the organisational renewal and personnel cuts. In addition, the inspection studied what kind of safety indicators and operation process indicators the management of TVO uses to monitor quality and safety of the organisation's actions. At the inspection, TVO presented a safety culture programme that was created to be used as the framework for the development of safety culture. Other issues covered in the inspection included security arrangements as part of safety, management and safety culture.

The management of TVO was of the opinion that the organisational renewal has not influenced the priority of safety or safety at the Olkiluoto nuclear power plant. Analyses of the organisational renewal have been performed and the organisation has initiated a variety of actions to discuss and clarify the goals and impact of the organisational renewal. It was not verified during the inspection whether the management has a sufficiently clear idea of the practical challenges faced by the organisation after the organisational renewal, however. Such challenges include clarity of responsibilities and the adequacy of competence and resources, among other issues.

Following the inspection, STUK imposed two requirements. TVO must assess the connection between the weaker personnel survey results and the criticality of the personnel and the quality and safety of the operations. Furthermore, STUK required that TVO supplement its safety culture programme to make it more comprehensive.

Management system, 23–24 November 2016

The inspection covered tasks of TVO's quality management organisation; resources and development of competence; and supplier audits as well as the qualifications and competence of auditors. Furthermore, the inspection verified actions pertaining to procurement and project management that are requirements in the implementation decisions of YVL Guide A.3, *Management system for a nuclear facility* and YVL Guide A.5, *Construction and commissioning of a nuclear facility*. The inspection was carried out by verifying information from documents, such as supplier audit reports, and interviewing personnel of the licensee at the plant site.

No requirements were imposed by STUK following the inspection. STUK did make some observations on further development of the operations, however. All documents pertaining to supplier audits, such as audit plans and reports, should be saved in such a manner that they could be found from the same location when needed. Furthermore, TVO should consider using more specific auditing criteria and developing the audit report template and the description of the most important issues to be included in the reports.

Disposal facilities, 5–6 October 2016

The inspection covered the concrete and rock structures of the operational waste disposal facility (the VLJ repository) at Olkiluoto. Inspected issues included the related TVO organisation, processes and functions; operating procedures; TVO's own inspections; status of ongoing research; and maintenance procedures. In the personnel section of the 2016 inspection, STUK focused on HR planning.

The person in charge of monitoring the VLJ repository, research and coordination of related reporting resigned from TVO in August 2016. At the time the inspection was held, in early October 2016, the situation with responsibilities was unclear. The unclear situation will also influence the preparation of the next VLJ repository monitoring programme. Following the inspection, STUK imposed three requirements involving the use, maintenance and research of the VLJ repository in Olkiluoto; the VLJ repository monitoring programme for 2018–2022; and development of reporting on the VLJ repository and submission of reports to the regulatory authority.

STUK also made positive observations during the inspection. TVO had ordered an assessment of the representativeness of the VLJ repository's hydrogeochemistry samples and observations from highly qualified suppliers. The results of the assessment can also be used as an aid in the preparation of the next VLJ repository monitoring programme. TVO is searching for alternative rock displacement measuring methods for monitoring sites in the top part of the intermediate-level waste silo where these measurements cannot be conducted due to the radiation status. The displacement measurements are necessary to survey the normal state of the bedrock before starting expansion of the VLJ repository.

Operating experience feedback, 2–3 March 2016

In the inspection, STUK verified adequacy of TVO's operating experience feedback personnel resources, the development of competence as well as documentation and functionality of TVO's operating experience feedback procedures. The inspection also covered TVO's operating experience feedback goals and the procedures used to reach these goals. STUK conducted the inspection by studying TVO's manuals and procedures, interviewing TVO's personnel, verifying the documentation required in TVO's procedures and monitoring the operations. The inspection was fairly extensive because a new

YVL Guide on operating experience feedback, YVL A.10, entered into force in late 2015 and STUK wished to verify that its requirements had been met.

The inspection indicated that TVO has properly taken care of its operating experience feedback personnel resources and procedures. TVO monitors and assesses the success of its operating experience feedback operations and specifies measures to develop and improve the operations. STUK observed some development needs that need to be met to achieve full compliance with the requirements of YVL Guide A.10. On the basis of the inspection observations, STUK imposed some requirements regarding the goals of the operating experience feedback operations, improvement of competence in specific sectors, documentation and use of interpretation methods, prioritisation of actions determined based on TVO's own operating experience feedback and assessment of effectiveness. Furthermore, STUK offered some inspection observations regarding operating experience feedback responsibilities and documentation of the procedures for TVO to assess and take into account when developing the operations.

Plant maintenance, 30–31 March 2016

The inspection covered the resources, functions and tasks TVO uses to ensure long-term operability of the systems, structures and components in its plant units. Special inspection focus areas included maintenance HR planning; fuel handling equipment and pipelines to a limited extent; ongoing modifications; and requirements on maintenance of electrical and I&C equipment in the YVL Guides. The new YVL Guides entered into force in late 2015.

Following the inspection, STUK imposed six requirements. Some of the requirements involved actions to be completed to ensure compliance with the new YVL Guides. TVO must prepare a plan on determination of operability of the emergency diesel generators' fuel transfer pipelines. In addition, TVO must assess by means of visual inspections during the 2016 annual outages whether there are any small-diameter pipelines important to safety in any areas that are not accessible during load operation whose defective supports could lead to a fatigue failure. Furthermore, TVO was required to create and present at the next inspection procedures that it will use to reduce the possibility of the use of forged products at the plant units.

Utilisation of the PRA, 5 December 2016

The inspection on the utilisation of the PRA covered the PRA update status and key results, PRA applications, adequacy of personnel resources and maintenance of guidelines on the PRA. A special theme covered was the corrective measures planned due to a leak in a rotameter during the annual outage and their significance in terms of the PRA.

The inspection indicated that TVO has maintained a sufficient resource base despite the personnel changes and the PRA update has proceeded as planned. Plenty of PRA applications have been prepared to support plant modifications, suitability analyses and annual outage planning, as well as to be used in the quarterly operational event risk monitoring reviews. The PRA guidelines are up to date and the PRA is used as planned and in a versatile manner to support the management of safety. No deficiencies were observed in the inspected issues.

Structures and buildings, 2–3 November 2016

Special focus area of the inspection of the maintenance procedures of structures, buildings, seawater channels and tunnels was civil engineering and structural engineering maintenance personnel resources and procedures. In addition, the results of inspections carried out by the power company and modifications made were discussed.

The inspection indicated that TVO's procedures are up to date and civil engineering works have been completed on time despite the organisational renewal and the changes in personnel resources. Notes regarding the workload of the personnel and the planning of training were made during the inspection.

Radiation protection, 8–9 March 2016

Special focus areas of the radiation protection inspection included procedures used in radiation protection planning, adequacy of personnel resources and radiation protection guidelines. The inspection indicated that TVO has properly handled radiation protection of the plant. The employees' low radiation doses prove this. As a good practice, STUK noted extensive processing of plant modifications that influence radiation safety within the organisation. The radiation protection guidelines are up to date and have been supplemented with new procedures.

STUK observed some development needs that need to be met to achieve full compliance with the requirements of Guide YVL A.4. Based on the inspection observations, STUK imposed requirements relating to the documentation of the deputies of radiation protection personnel and the preparation of training programmes important to safety.

Nuclear security, 25–29 April 2016

Practical implementation of the new Guides YVL A.11 and A.12 and the key design basis threat requirements was studied during the inspection. The inspection covered both physical protection and information security. The inspection focus areas included demonstration of the effectiveness of the security arrangements, the determination of vital areas and practical implementation of the security arrangements.

TVO is currently developing its security arrangement self-assessment with the help of a supervision plan. In addition to its internal audit procedure and independent third-party assessments, TVO will improve the reporting of security arrangements to its management. Monitoring and reporting of the security organisation training programme have been developed in the past few years, and the plan is to use training more in the demonstration of the effectiveness of the security arrangements.

Based on the inspection, STUK issued requirements on development of the practical implementation of security arrangements and the documentation on the planning, assessment and implementation of security arrangements.

Safety functions, 8–9 November 2016

The inspection covered the licensee's procedures used to verify that the systems managing reactiveness comply with the design bases. The management of reactivity includes stopping the reactor and retaining it subcritical. Issues covered in the inspection included the chain of systems that implement the trip function and maintenance of their performance and reliability. Procedures for periodic testing of the protection function were verified during the inspection. The performance of tests was verified with random tests. The inspection also included a walk-down of the warehouse and an inspection of spare part management.

Based on the inspection, STUK can state that TVO's reactivity management procedures are proper and the guidelines are up to date. The organisation's resources, competence and introduction are also sufficient. Following the inspection, STUK imposed two requirements. TVO must assess how systematic development of the inservice testing programme can be achieved. The responsibilities and procedures must be described in the guidelines. Another requirement involved the clarification of reporting on different systems and plant functions, and the determination of responsibilities. Following the inspection, STUK issued four recommendations. It recommended, for example, that TVO assess the need to clarify the descriptions and structure of the descriptions of periodic test instructions.

One of the inspection focus areas were fuel handling equipment. The inspection covered inservice inspections of refuelling machines, guidelines, qualification of operators and ageing management. Based on the inspection, STUK can state that the guidelines are comprehensive and regularly updated. Inservice inspections of refuelling machines are also properly realised. TVO has different alternatives for the modernisation of the refuelling machines and ageing management of the refuelling machines is appropriate.

Emergency preparedness arrangements, 8–9 September 2016

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. The focus areas in 2016 included HR planning and training plans as well as feedback on emergency preparedness drills and development areas identified based on the drills. In the case of emergency preparedness equipment, the automatic radiation protection network and pressurized air respirators were covered. How TVO uses global operating experience feedback in the development of its emergency preparedness arrangements was studied. The pressurized air respirators were used as an example of the operating experience feedback operations. The inspection also covered the current status of rescue arrangements at the Olkiluoto 3 construction site.

HR plans and training programmes for the employees handling the emergency preparedness arrangements are in order. TVO has continued the systematic development of the training of its emergency preparedness organisation. More emergency preparedness arrangement personnel resources had been added during the period under review. TVO is about to launch a development project on the normal use of respirators and their use in emergency situations. There have been long-term data transfer interruptions at some of TVO's external radiation network stations. The affected stations are not located next to each other, however, which means there are no dead spaces that would compromise the emergency preparedness arrangements.

STUK imposed three requirements in the inspection. TVO must study how the emergency preparedness training of people who have completed the introduction training has been arranged at other nuclear power plants. TVO must include a better description of the evacuation arrangements at the OL3 construction site in its emergency response plan. The emergency preparedness guides in the emergency preparedness facilities must be updated (the latest versions must be used).

Annual outage, 8 May – 8 June 2016

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 participated in the inspection. They had predetermined inspection areas. A focus area in this year's inspection was installation of a new reactor coolant pump and the installation and commissioning of the related frequency transformer in Olkiluoto 1. STUK oversaw mechanical engineering, electrical and I&C engineering, radiation protection and operational safety of the replacement, among other issues. According to the observations made by STUK, the replacement of the reactor coolant pump was successful, even though such a challenging modification was now implemented for the first time. A positive observation was the fact that the reactor coolant pump commissioning tests were realised in a calm and systematic manner. TVO's expertise was deemed to be of a high level. STUK issued a recommendation on developing the commissioning test procedures of pumps.

Based on the inspection, TVO's operations during annual outages are proper. STUK recorded a total of 54 observations during the inspection. Most of them were neutral observations which verified that the procedures comply with the regulatory requirements and the plant's own guidelines. No safety deficiencies that require STUK's immediate action were observed during the inspection. Three requirements were imposed based on the observations made. Two of them involved procedures for the orientation of new employees and one involved radiation protection of the plant. STUK also gave a remark on the importance of completing on schedule all corrective measures determined based on operational events. According to the observations made, some corrective measures had not been implemented as planned.

Nuclear safeguards, 13–15 September 2016

The inspection focus areas were the nuclear safeguards system of TVO's Olkiluoto nuclear power plant and the manner in which TVO takes care of its nuclear safeguards obligations. The inspection covered the procedures TVO uses to meet the requirements posed by legislation, the YVL Guides (Guide YVL D.1 in particular) and EU Regulations.

The inspection covered the role of management in the arrangement of nuclear safeguards; the plant's actions and responsibilities involving the maintenance and development of the nuclear use item accountancy and reporting system; actions linked to compliance with the nuclear safeguards obligations and related responsibilities; and actions and responsibilities that enable regulatory oversight (by the IAEA and the European Commission, for example).

Following the inspection, STUK imposed two requirements. The inspection verified that the management of the Olkiluoto nuclear power plant is involved in HR planning and securing the resources needed to ensure compliance with the nuclear safeguards requirements, but there is no plan on supporting the persons in charge of nuclear safeguards activities and ensure that the necessary resources are available. Procedures on granting visitor permits to inspectors of the IAEA and Euratom have not been prepared; instead, the operations have been based on oral instructions. To ensure that the inspectors will always have access to the plant and the areas to be inspected, written visitor procedures that include all of the necessary issues must be prepared and a reference to these procedures must be added to the nuclear safeguards manual.

Additional inspections conducted in connection with the periodic inspection programme at Olkiluoto nuclear power plant

Implementation of YVL Guides, 28 September 2016

In 2015, STUK evaluated how well the Olkiluoto 1 and 2 plant units comply with the requirements of the new nuclear safety guidelines (YVL Guides). The improvement measures specified in connection with the implementation decision are currently being implemented. The inspection covered how the licensee monitors the implementation of the measures needed to comply with the requirements that were left as open in the YVL Guide implementation decisions and how the licensee ensures that the new procedures will be included in the practices of the different organisational units.

Based on the inspection, STUK can state that the tools needed to systematically monitor the open measures are available. No major deficiencies were observed in the list of issues to be monitored. Responsibilities for the performance of the measures had also been clearly defined and the management monitors achievement of the goals on schedule. There are instructions on the procedures to be used when postponing the deadline of a measure and communication about the postponement to STUK. Completion of measures was verified with random tests during the inspection. All of the inspected measures had been completed on schedule and included in TVO's management system.

TVO has arranged its employees training on the new YVL Guides. When preparing training materials, the fact that new people have been added to the organisation has been taken into account and the training covers key content of the new YVL Guides in addition to the new and changed regulatory requirements. TVO will repeat the training in spring 2017.

Based on the inspection, STUK required that TVO reassess and update (if necessary) its guidelines on testing organisations. Furthermore, STUK required that TVO review the measures given in connection with the implementation decision of Guide YVL B.1 and add any deficiencies in the monitoring list.

Management of projects and modifications, 14–15 December 2016

In this additional inspection, STUK assessed procedures pertaining to investments and modifications important to safety and TVO's project expertise. The inspection focused on quality and risk management procedures of projects for which project managers carry the main responsibility (such as the management of non-conformances and the utilisation of experience).

STUK is of the opinion that TVO's project management procedures are systematic. The investment process has been properly described, there are guidelines about it and the responsibilities have been specified. The procedures and templates for projects take into account the requirements of the YVL Guides and there is a licensing manager within the organisation who verifies compliance of the process.

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 renewal.

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 2016

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 issues, 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 2016, 11 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.

An inspection on the testing of the I&C systems focused on TVO's role during the testing, the status of the I&C system testing, coverage of the I&C tests and commissioning inspections of the I&C systems. One requirement on ensuring sufficient coverage of the I&C testing was given during the inspection.

Goal of the maintenance and ageing management inspection was to study TVO's readiness for maintenance and ageing management of mechanical components. The inspection covered the status of the maintenance procedures as well as procurement and storage of spare parts. Status of the training given to the maintenance personnel and training plans was also assessed. TVO's maintenance strategy and maintenance monitoring methods were assessed with selected components. The inspection also covered maintenance of the components and structures during the commissioning stage and TVO's views on and provisions for the elimination of negative effects caused by the plant's long installation stage. No requirements were imposed in the inspection.

The emergency preparedness arrangement inspection covered the emergency preparedness arrangements, guidelines, facilities and training as well as security arrangement issues. STUK im-

Subject of inspection	Inspection date
I&C system testing	27–28 January 2016
Maintenance and ageing management	9–10 February 2016
Emergency preparedness arrangements	22–23 March 2016
Commissioning	12–13 April 2016
Quality management – safety culture during commissioning	10–12 May 2016
Verification and validation of operator procedures	13–14 June 2016
Commissioning inspection of nuclear island components and systems	31 May – 1 June 2016
Management of modifications and configuration	21–22 September 2016
Electrical engineering	6–7 October 2016
Training and licensing of operators	11–12 October 2016
I&C	29–30 November 2016

posed three requirements based on the inspection: a list of emergency preparedness procedures must be submitted to STUK; the emergency response plan must be supplemented with key tasks related to the management of threats; and announcements between the plant units during an emergency situation must be fluent.

The commissioning inspection covered TVO's operation during commissioning, maintenance of the situation assessment and employee orientation during commissioning. The inspection also covered the utilisation of operating experience feedback from the OL3 unit and other nuclear power plants during commissioning. One requirement on clarifying the roles and responsibilities of the different organisations was given.

The quality management inspection covered the safety culture at the commissioning stage. The inspection also covered security arrangement issues as part of the safety culture. One requirement was imposed based on the inspection: the personnel must be provided instructions on how to prepare for a variety of external threats to the security arrangements, such as phishing.

The operator procedures inspection covered background materials used when preparing the procedures, methods used to verify emergency operating procedures and the validation plan. The inspection verified that the operations and documentation comply with the procedures. The current status of simulator tests and the validation plan were also reviewed. Based on the inspection, STUK required that the methodicalness and traceability of testing be improved and that the testing be made more comprehensive in that it would cover all of the issues covered by the procedures, transitions between procedures and a variety of faults. Furthermore, STUK required that a party independent of the planning of the procedures must be used in the planning and approval of testing.

In the unannounced inspection, STUK inspected TVO's preparation for the commissioning inspections of the nuclear island (the components and systems will undergo a commissioning inspection before testing is started to verify that the prerequisites for starting testing have been met). No non-conformances from the agreed practices were observed and STUK noted that TVO and the plant supplier have actively developed their operations over the course of the last year. Some development areas were observed, such as the need to eliminate some overlapping work tasks, but no requirements were imposed based on the inspection.

The inspection on the management of modifications and configuration assessed TVO's procedures in the processing of design and construction site modifications and the manner in which TVO receives information about modifications and oversees the plant supplier's modification and configuration management process. It was observed that TVO's operations comply with the guidelines and TVO receives plenty of information about planned modifications. TVO has clearly developed its procedures during the project period. The processing of modifications is well documented and traceable. One requirement on instructions on the statutory approval of construction site modifications and related documentation was made.

The 2016 electrical engineering inspection covered the licensee's observations about the commissioning of the electricity systems of OL3 and provisions for the operation of OL3, regarding harmonisation of TVO's electrical engineering operation/maintenance procedures for OL1/2 and OL3. One requirement on distribution of the design basis current in SBO's parallel generator cables was given.

The operator training and licensing inspection covered training plans for the operating personnel to be licensed, the related background materials and the planned operating personnel licensing routines. Four representatives of the operating personnel were interviewed prior to the inspection to study the views of the people being trained. Two requirements were imposed in the inspection: the training provided to the OL3 operators must include a section where the manner in which operators and shift supervisors can act as each other's deputies and the deputy practices for the OL3 division manager must be properly planned.

The I&C inspection covered the current status of operating procedures, the progress of the resolution of technical problems observed during testing and the management of modifications and configuration. In connection with the latter, a walk-down of the plant supplier's office and the construction site was arranged to verify appropriateness of document modification markings. One requirement on recording daily observations on the commissioning of the I&C systems was given.

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

When processing reports linked to the construction licence application of the Hanhikivi 1 plant project, STUK assesses both technical compliance of the plant and ability of the organisations of the licensee, the plant supplier and the main service providers to construct and ultimately operate a nuclear power plant.

In addition to studying the management systems of these actors, STUK conducts inspections to verify that the operations of the organisations comply with the requirements in practice. STUK launched the inspections included in the regulatory inspection programme (RKT) in September 2015. Inspections are planned six months in advance. In 2016, STUK carried out a total of 15 inspections. The inspection results will be used when preparing STUK's safety assessment and statement on the construction licence.

Operations relating to the initiation of the manufacturing of long lead items (LLI) at Fennovoima (Helsinki)

Based on the inspection, Fennovoima must develop its plans related to LLI procurement. Aspects to be taken into account in the development include actions needed for procurement, responsibilities, the utilisation of resources and interfaces. "Critical components" must be distinguished from other "LLI components", treated as a separate item, and presented as examples of STUK's early inspection components. Furthermore, a general description of critical components must be prepared to facilitate the starting of STUK's early inspection. Critical components include the reactor pressure vessel and pressurizers, for example. The details of the procedures must be agreed on with STUK as these processes become current.

Subject of inspection	Date
Operations relating to the initiation of the manufacturing of long lead items (LLI) at Fennovoima (Helsinki)	8–10 March 2016
Management at Fennovoima and the processing of safety issues (Helsinki)	29 February – 2 March 2016
Review procedures and safety assessment of the plant supplier, RAOS Project Oy (Helsinki/St. Petersburg)	22–24 March 2016
Fennovoima's civil engineering and facility/layout design – provisions for internal and external hazards (Helsinki)	26–28 April 2016
Review procedures and safety assessment of the principal designer of the plant's primary circuit, OKB Gidropress (Podolsk)	27–29 April 2016
Fennovoima's management system and key processes (Helsinki)	25–27 May 2016
JSC Atomproekt (St. Petersburg)	31 October – 2 November 2016
Fennovoima Oy, nuclear safeguards (Helsinki)	25–27 October 2016
Fennovoima Oy, safety culture (Helsinki)	12–14 October 2016
Fennovoima Oy, personnel resources (Helsinki)	21–23 November 2016
JSC Group TITAN-2 (St. Petersburg)	9–11 November 2016
Fennovoima Oy, security arrangements (Helsinki)	7–11 November 2016
Kurchatov Institute (Moscow)	16–18 November 2016
Fennovoima Oy, electricity (Helsinki)	25–27 October 2016
RAOS Project Oy (St. Petersburg)	19–21 December 2016

Management at Fennovoima and the processing of safety issues (Helsinki)

Based on the inspection, Fennovoima must develop its operations by, among other things, harmonizing procedures with the plant supplier's configuration management to ensure the compatibility of the entire process, by clarifying the structure of the configuration management guidelines and by introducing a configuration management tool, and by ensuring communication processes between configuration management, design management and licensing. Configuration management or the management of the technical configuration is a systems engineering process. It maintains the integrity of design and implementation with the help of identification, control, accounting and monitoring of the configuration.

Fennovoima must also assess the structure of the current organisation, the allocation of competences and resources as well as the organisation's authority and responsibility relationships with respect to reaching the safety and quality objectives. Fennovoima is planning to allocate its review resources to the processing of construction licence materials based on the plant supplier's engineering schedule. Fennovoima must ensure through its project design that it has plans and sufficient resources for ensuring the integrity and conformity of design in the document review of the construction licence phase.

Review procedures and safety assessment of the plant supplier, RAOS Project Oy (St. Petersburg)

Based on the inspection, STUK noted that RAOS Project Oy's management system does not currently comply with the Finnish requirements. Fennovoima must ensure that the management system of RAOS is developed.

Inspection observations indicate that insufficient personnel resources prevent RAOS Project Oy from fulfilling the requirements placed on the plant supplier. Furthermore, RAOS Project Oy must specify the organisations responsible for engineering at the construction licence stage.

It was observed in the inspection that the plant engineering configuration baseline has not been frozen. All construction licence materials to be submitted to STUK for review must be based on one and the same frozen configuration baseline. It was noted during the inspection that the configuration management process and the related instructions are still being developed. In order to meet the YVL Guide requirements, RAOS Project Oy must complete the preparation of, and implement, the configuration management procedures and instructions.

Fennovoima's civil engineering and facility/layout design – provisions for internal and external hazards (Helsinki)

Based on the inspection, Fennovoima must provide instructions for such facility/layout design guide procedures as are required to ensure the implementation of design requirements relating to layout, provisions for internal and external hazards, radiation protection as well as security and emergency preparedness arrangements at the various design stages. Fennovoima must identify at least the following facility/layout design requirements and ensure that they are taken into account in the design (the National Building Code and the YVL Guides).

Fennovoima must take into account the potential facility/layout design problem areas identified by STUK in its preliminary safety assessment of 2014 in the control of the design also in other respects than an airplane crash.

Furthermore, Fennovoima must arrange construction-related quality assurance and inspections, and personnel resources must be designated.

STUK noted that the experience gained and lessons learnt from the construction of the reference facility and other AES-2006 plants, and, where applicable, VVER-1000 plants, must be utilized in the FH1 plant unit facility/layout design process. In addition, systematic gathering and utilisation of observations and experiences relating to the FH1 construction site must be started.

Review procedures and safety assessment of the main designer of the plant's primary circuit, OKB Gidropress (Podolsk)

Based on the inspection, a documented process for the managing of safety issues must be added into the OGB Gidropress management system and the project-specific guidelines must be finalised.

Based on the inspection observations, OKB Gidropress must develop its Human Factors Engineering (HFE) strategy to also cover the design of systems, structures and components, and HFE must be made part of the design process.

It was noted during the inspection that only frozen and approved calculation codes may be used in the deterministic safety analyses of the construction licence application and that the data must be based on the same frozen configuration.

The plant engineering configuration baseline has not been frozen. Fennovoima must ensure that the project uses standardised configuration management definitions. Change management procedures between the frozen baselines must be described in the guidelines.

Fennovoima's management system and key processes

STUK continued its regulatory inspection programme (RKT) on the construction licence application with an inspection of Fennovoima's management system and key processes. During the inspection, STUK noted that Fennovoima had clearly developed its management system due to STUK's previous requirements.

Requirements given during the inspection included, for instance, securing the interfaces between the processes of Fennovoima and the plant supplier, taking into account nuclear safety issues in project management, i.e. in the operations of the Project Execution Committee, as well as clarifying the responsibilities of Fennovoima's different departments in the processing of safety issues at the plant, architecture and system level.

JSC Atomproekt (St. Petersburg)

In the follow-up inspection of the principal designer (the first inspection took place on 16–18 December 2015), STUK assessed the engineering and quality management procedures of Atomproekt. STUK's follow-up inspection verified development of the principal designer's management system and whether the design operations of AP comply with the Finnish requirements. The inspection focused especially on Atomproekt's engineering management procedures and guidelines. First, the inspection verified compliance with the requirements given in the first inspection. After the procedures had been reviewed and the verification was complete, half (5/10) of the requirements imposed in the first inspection could be closed.

STUK inspected the setting of plant and system level design bases for external hazards and their approval status, as well as changes in the position of the principal designer and links between new design organisations and the principal designer. The inspection also covered the approval of design subcontractors and delivery control, the management of design changes and the preparation of deterministic safety analyses.

Based on the follow-up inspection, STUK issued new requirements pertaining to, for instance, resource planning of the principal designer and allocation of resources, guidelines on the preliminary safety analysis report (PSAR), quality planning, continuity of the principal designer function, management of design changes and provisions for deterministic analyses. Based on the inspection, STUK noted clear development in the operations of Atomproekt, but also noticed continuous deficiencies in the design resources of the Hanhikivi 1 project.

Fennovoima Oy, nuclear safeguards (Helsinki)

The inspection covered Fennovoima's nuclear safeguards system and Fennovoima's plans for arranging the safeguards necessary to ensure the non-proliferation of nuclear weapons. The inspection focused on the plans and procedures Fennovoima uses to meet the requirements posed by legislation, the YVL Guides (Guide YVL D.1 in particular) and EU Regulations.

The inspection focus areas were: the management system, processing of nuclear safeguards issues by management teams, cooperation and communication with persons in charge of nuclear safeguards activities, development of nuclear safeguards and training, risk management and risk assessments in nuclear safeguards, nuclear safeguards resource allocation, nuclear safeguards manual and its approval, Fennovoima's nuclear safeguards system and enabling the oversight of authorities and international organisations.

Based on the inspection, STUK issued recommendations regarding annual reporting, information security criteria and codes of conduct in an appendix to the nuclear safeguards manual. Based on the inspection, STUK imposed requirements on planning and scheduling the nuclear safeguards system, the processing of documents and the management of non-conformances.

Fennovoima Oy, safety culture (Helsinki)

Fennovoima's procedures in assessing and developing its safety culture were assessed in the safety culture follow-up inspection. Special attention was paid to Fennovoima's procedures to ensure a good safety culture throughout its supply chain. The inspection also studied Fennovoima's measures regarding the requirements imposed in the 2015 safety culture inspection.

In the inspection, STUK assessed that the management of Fennovoima aims to develop its safety culture competence and an overall idea of the development of Fennovoima's safety culture by, for instance, reporting safety culture development measures in FMT. It was also observed that the development of Fennovoima's safety culture is active and its importance has been recognised by the Fennovoima organisation. STUK verified that Fennovoima did not perform a systematic safety culture self-assessment or a third-party assessment in 2016, which means that the view of Fennovoima's management on the situation having improved is based particularly on a survey that measures functionality of the work community which includes some safety culture questions and the fact that no reports on significant safety concerns have been submitted, which – in STUK's opinion – does not provide a sufficiently reliable idea of the actual situation. The view of Fennovoima's management on the status of safety culture in the supply chain was scattered.

Based on the inspection, STUK stated that Fennovoima needs to develop the entire process it uses to verify the safety culture of its organisation and supply chain and to effectively react to any disadvantages. Thus, STUK imposed a requirement that the Fennovoima management system must include procedures that the management can use to achieve a comprehensive and reliable idea of the safety culture status in Fennovoima and in its supply chain, as well as compliance of the safety culture. Fennovoima must describe these procedures and use them. Scope and correct timing of the actions included in the safety culture action plan must be verified taking into account issues such as the progress of plant design and manufacture. Fennovoima must ensure that there are sufficient resources to complete these actions. STUK will verify the development in a separate meeting to be arranged in March 2017.

Fennovoima Oy, personnel resources (Helsinki)

The personnel resources follow-up inspection focused on resource and competence management at Fennovoima with regard to further developing nuclear safety and meeting the needs of the plant project. Status of the requirements from the previous inspection and competence development plans and procedures for the responsible persons as laid down in YVL Guide A.4 were reviewed.

Based on the inspection, STUK stated that Fennovoima must develop its competence and resource management procedures and ensure that all duties important to safety in the different organisations included in the supply chain have been determined and competence of the people in these positions is sufficient. For this reason, STUK imposed a requirement that Fennovoima must systematically verify sufficient competence and resources in its organisation. Procedures must be described and related guidelines must be updated. Any tasks important to safety or related to safety must be taken into account in the development work. The procedures must guarantee the organisation's sufficient professional competence, technical know-how and safety competence, as well as identification of competence deficiencies and resource gaps. Furthermore, Fennovoima must develop its procedures for the identification of tasks important to safety in the different organisations included in the supply chain, the setting of related requirements, and the monitoring and securing of competencies.

JSC Group TITAN-2 (Sosnovyi Bor)

Purpose of the TITAN-2 inspection was to verify the supplier's ability to act as the main contractor of a nuclear power plant construction site. The inspection verified through selected samples that the project and design management processes are implemented according to the instructions at TITAN-2. STUK verified procedures and plans on Hanhikivi 1 as well as related documents and databases.

Based on the inspection, STUK imposed requirements on assessment and certification of the TITAN-2 management system, requirement management, risk management, presentation of Finnish requirements in the project, and systematic utilisation of construction experience from other VVER plants and nuclear power plant projects. No training on Finnish safety requirements, the Hanhikivi 1 design basis, the management system of the Hanhikivi 1 project or construction experience was found in the TITAN-2 training programme.

Fennovoima Oy, security arrangements (Helsinki)

The inspection covered the security arrangements of Fennovoima, which are considered to include structural, technical, operative, and organisational arrangements in order to detect, delay and prevent illegal or unauthorised activity.

Based on the inspection, STUK imposed requirements on, for instance, Fennovoima having to more clearly take into account the Finnish security arrangement requirements in engineering and construction realised by the plant supplier and the description of buildings classified as EYT in the preliminary safety analysis report (PSAR) from the viewpoint of the realisation of security arrangements.

Kurchatov Institute (Moscow)

The inspection covered the UNPP department of the Kurchatov Institute. The focus areas were the organisation, configuration and quality management, deterministic safety analyses and the Institute's material testing operations. During the inspection, STUK was informed that the organisation will be merged with other organisations that do not participate in the Hanhikivi 1 project. Due to the merger, the VVER subunit is now called UNPP. The change will influence the management system documentation; it must be updated.

It was observed during the inspection that the Kurchatov Institute's configuration management plan is still being prepared. STUK imposed a requirement that Fennovoima must ensure that the plan is completed and that it is in line with Fennovoima's configuration management. All construction licence documents to be assessed and reviewed by STUK must be based on one and the same frozen configuration baseline.

According to the inspection observations, the preliminary safety analysis report (PSAR) materials have already been prepared by the Institute. STUK imposed a requirement that Fennovoima must ensure that the PSAR chapters delivered in connection with the construction licence documentation comply with the Finnish requirements and any differences from the Hanhikivi 1 plant are determined and presented in the PSAR. It was also noted that Fennovoima has not yet approved the Kurchatov Institute's quality plan. According to the inspection observations, work has been done without an approved quality plan. Fennovoima must ensure that the quality plan is completed and taken into use. The Kurchatov Institute must improve its document management guidelines.

Fennovoima Oy, electricity (Helsinki)

The inspection covered Fennovoima's electrical engineering and emergency power supply units. Issued covered in the inspection included Fennovoima's electricity and emergency power supply unit personnel resources as well as actions and procedures when identifying, monitoring and processing safety issues. The inspection focused on the following safety-critical key functions: design of personnel resources, engineering control and monitoring, reviewing technical plans, supplier approval and oversight of suppliers and procurement. The above-mentioned functions were verified by means of examples in the inspection.

Based on the inspection, STUK imposed requirements on, for instance, verifying the level of expertise in power distribution to manage Fennovoima's own design and that of its subcontractors, as well as to assess the design of the plant supplier and its subcontractors. Fennovoima must develop its introductory training on knowledge of the plant to electrical engineering consultants, introductory training on Fennovoima's management system and introductory training on the Finnish nuclear safety requirements to electrical engineering employees. Fennovoima must determine the status of electrical engineering concepts in the design efforts and the construction licence documents and demonstrate that the quality plans are used to guide the design processes of electrical engineering concepts, architectures and systems. After the inspection, STUK required that Fennovoima add electrical engineering design guidelines to its management system.

RAOS Project Oy (St. Petersburg)

The follow-up inspection of the plant supplier covered actions by RAOS Project Oy (“RAOS”) and its procedures in the identification, monitoring and processing of safety issues and in quality management. The inspection focused on central safety-critical management system processes, such as the processing of safety issues, quality management (QA/QC), project management 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 verified through selected samples that the above-mentioned project and design management processes are implemented according to the instructions at RAOS. STUK verified instructions, procedures and plans on Hanhikivi 1 as well as related documents and databases. When compliance with the requirements given in the first inspection was being verified, it was noted that RAOS has determinedly developed its management system. After the procedures had been reviewed and the verification was complete, most (13/15) of the requirements imposed in the first inspection could be closed. The requirements that were still left open involve assessment scope for the RAOS management system and freezing of the configuration baseline CB 0. It was observed during the inspection that the plant supplier’s organisation does not include all the necessary personnel resources yet. RAOS must submit reports on its personnel resource plans to Fennovoima and STUK. A requirement on supplier audits and their approval in the supply chain was also imposed. In addition, requirements on design management terminology and the management of document revisions were imposed.

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

In 2016, the oversight project continued the inspections included in the construction inspection programme (RTO). Inspections included in the programme assess the performance of Posiva's management system, the sufficiency of procedures and their ability to guide design, manufacture, construction and installation operations, as well as the taking into account of safety requirements at different stages of the project. The programme also aims at assessing Posiva's procedures to ensure that a safe nuclear facility of a high quality will be constructed. Inspections included in the programme may also be targeted to Posiva's suppliers important to safety. The 2016 inspections only focused on operations of the licensee, however.

The 2016 programme consisted of nine inspections. Below are brief descriptions of the inspections, as well as the key observations made based on which STUK had required improvements and development actions from Posiva. A total of around thirty requirements on correcting observed deficiencies or further developing the operations were submitted to Posiva in the inspection decisions.

Quality management

One goal of the inspection was to assess the impact of Posiva's 2015 organisational renewal on quality assurance and quality control operations and personnel resources. The inspection also covered personnel resources in the organisational units in charge of quality assurance and quality control. A topical special theme was quality control of the clay-based engineered barriers used during disposal, the buffer block and the tunnel filling material.

Posiva is in the process of merging some of its procedures to comply with TVO's operations. To ensure that the merger is completed in a controlled manner, Posiva was required to prepare a plan that includes the scope of the development work, development areas, personnel resources and schedule. Posiva's procedures when processing suspicious products or forgeries in the non-conformance management system were assessed in the inspection. In addition to the regular processing of product non-conformances, such products may require other actions, such as communication of information, notifications to the authorities or disposal of products. The inspection demonstrated that Posiva must assess the need to update its non-conformance management process to ensure that any suspicious products or forgeries will be sufficiently comprehensively processed.

Design operations

The design operations inspection covered Posiva's design operations, the control and guidance of de-

Subject of inspection	Date
Quality management	25–26 January 2016
Design operations	30–31 March 2016
Personnel resources and training	23–25 May 2016
Rock classification and detailed model descriptions	2–3 June 2016
Nuclear safeguards	6–8 June 2016
Rock construction procedures	19–20 September 2016
Project management and quality management of the disposal and encapsulation facility	15–19 September 2016
Safety culture	8–9 November 2016
Long-term safety	23–24 November 2016

sign, design guidelines and the sufficiency of personnel resources. Two examples were used to verify that the control and guidance of design are realised in compliance with Posiva's procedures.

Posiva has updated its design processes and guidelines to comply with its changed operations model and organisation. The inspection determined that the tasks, responsibilities and obligations of the plant technology function that carries the responsibility for the detailed design of the nuclear waste facility have been specified in detail.

Posiva has taken into account the impact of the organisational renewal in its configuration management plan, for example. A stage where the basic design and the requirement specification are verified was added in connection with the update to ensure that Posiva's design is sound and balanced. The new stage also aims at verification of the readiness of the design to move forward to the implementation planning stage.

As a summary for the inspection, STUK stated that Posiva has continued the systematic development of its design operations in compliance with the principle of continuous improvement laid down in Posiva's management system. STUK is of the opinion that if the procedures are followed, Posiva will be able to verify that the nuclear waste facility and its systems, components and structures are designed, manufactured, constructed, installed and commissioned in compliance with the approved plans and procedures.

Personnel resources and training

In 2016, STUK implemented a comprehensive and detailed inspection of the planning of Posiva's personnel resources and personnel training. The inspection covered Posiva's personnel resource plans and the current status of the organisation for projects involving the disposal facility and its construction, the encapsulation facility, manufacture and long-term safety. The inspection verified how well the resource plans have identified all of the key competence areas from the project plans, how well the correct number of experts for all the goals listed in the project plans have been allocated and whether the personnel resources have been correctly scheduled. Furthermore, the inspection verified adequacy of Posiva's personnel resources and the competence of the employees on safe construction of a nuclear waste facility.

Twelve employees from the Posiva organisation were interviewed on the first day of the inspection. The interviews aimed at determining experiences of the employees on the current status of the organisation, on personnel resource planning, on the development of competence and on the safety significance of their work duties.

Posiva has in place orientation procedures for people recruited from outside the organisation and people who are transferred from the TVO organisation to the Posiva organisation. Posiva does not have a clear orientation procedure for people who are employed by TVO and work less than 50% of their working hours in the Posiva organisation, however. To eliminate this deficiency, Posiva was required to create a procedure to ensure that the non-Posiva employees working in the Posiva organisation will receive systematic orientation training.

It was also determined that Posiva should use a more systematic procedure to prepare for personnel turnover, and Posiva was required to take action to ensure better preparation for personnel turnover and long recruitment times. Based on the inspection, STUK noted, however, that the recruitment operations as a whole have been systematic.

One of STUK's requirements based on the inspection results was that Posiva must use development programmes to ensure that sufficient competence will be achieved and maintained in all positions important to safety. Furthermore, Posiva must make sure that the development programmes include project management training to verify that there is sufficient project management expertise for all of Posiva's projects important to safety.

Rock classification and detailed model descriptions

The inspection covered Posiva's rock classification system and detailed rock model descriptions. The inspection covered processes that Posiva uses to verify compliance with the regulations in the aplicability classification of the disposal site and the rock in the disposal facility that is part of the design and construction of the disposal facility. Posiva must demonstrate that the procedures used in the applicability classification of the bedrock and the provisions for the detailed model descriptions are documented and that the procedures, classification and descriptions are not too dependent on the personal views of the experts.

The inspection demonstrated that Posiva has documented document review procedures at a general level in its procedures, but compliance with the principle of independence in the preparation, review and approval of documents has been somewhat subject to interpretation. Therefore, Posiva was required to document the document review and approval procedures used in the rock classification to ensure that sufficient independence will be achieved.

Another issue observed in the inspection was that the rock classification procedures, which are extensive enough, are not up to date. Posiva must make several additions and modifications to the procedure. The plan is to separate some parts of the procedure into supplementary classification procedures. At least some of them are still at the planning stage. As the update process is still ongoing, STUK required that Posiva submits to STUK a plan on the updating of the procedures required for the rock classification and a schedule for the updates. Posiva was also required to implement the document management procedures required for the rock classification in its document management system in such a manner that it will be able to verify that the latest classification data is available for both design and decision-making.

Nuclear safeguards

The inspection focus areas were the nuclear safeguards system of Posiva and the manner in which Posiva takes care of its nuclear safeguards obligations. The inspection focused on the procedures Posiva uses to meet the requirements posed by legislation, STUK's YVL Guides and EU Regulations.

A nuclear safeguards handbook, which is part of Posiva's management system, includes actual operations and issues regarding nuclear safeguards and references to other documents that describe more general administrative instructions for the management system. In the inspection, Posiva was required to verify in connection with the next update of the handbook that all the requirements in STUK's Guide YVL D.1, *Regulatory control of nuclear safeguards*, that apply to the construction of Posiva's nuclear facility are identified and taken into account. Furthermore, when updating the nuclear safeguards handbook or the related guidelines, more specific approval practices for international inspectors and the enabling of inspections by technical experts must be added.

Rock construction procedures

The inspection covered processes that Posiva uses to verify compliance with the regulations and quality management in the rock engineering and rock construction of the disposal facility. The inspection covered Posiva's rock engineering and implementation processes and functions as well as their interfaces with other processes, such as initial data, rock classification and long-term safety. The inspection verified that procedures on construction of the disposal facility, the management of changes, quality management and quality assurance are properly planned and documented, and the operations comply with the guidelines.

The goal with the construction of Posiva's disposal facility is to construct a facility that complies with the requirements. According to STUK's view, issues that Posiva needs to further develop in its construction activities include the recording, administration and processing of instances when the construction action limits are exceeded, the monitoring of the implementation of actions and the closing of the actions so that the procedure includes a schedule and determines the persons responsible for the processing of the actions. Advanced procedures will ensure that all events that could lead to situations that compromise compliance of the operations are properly processed. Another important requirement to Posiva by STUK was the delivery to STUK of a plan on the development of the rock construction methods to be used to ensure construction of the disposal facility in compliance with the requirements.

Project management and quality management of the disposal and encapsulation facility

The inspection covered Posiva's project planning and the procedures Posiva uses to ensure good quality of projects. The inspection studied the procedures Posiva uses when reconciling and managing personnel resources in the line organisation and projects, as well as verified how issues important to nuclear and radiation safety are processed by the management of the project organisation. Other inspection focus areas included management of internal and external communication of projects, management of stakeholders and project reporting. The comprehensive inspection included a section in which Posiva's experts who participate in the encapsulation and disposal facility project were interviewed.

The inspection demonstrated that there are some areas that need updating in the plans for both the disposal facility project and the encapsulation facility project based on both the YVL Guides and Posiva's own guidelines. Furthermore, the quality management descriptions in the project plans need to be supplemented and further developed. Due to the observations made, Posiva was required to ensure that STUK's requirements on project management and Posiva's own guidelines will be taken into account to a sufficient extent when the project plans are updated the next time. In the case of project management, Posiva was required to take care in general that people working in all projects are provided a systematic orientation to the project plans.

It was noted during the inspection that Posiva recently completed the reporting of experiences from the research facility (the Onkalo project). Posiva was required to take the report into account in the construction of the disposal facility and the development of its operations.

Posiva submitted a risk management plan for the construction project in connection with its construction licence application. However, it was noted during the inspection that the project is currently using a new risk management guideline, which means that the risk management plan submitted in connection with the construction licence application is no longer valid. Posiva was required to submit to STUK for information the project's updated risk management plan.

Safety culture

The inspection covered Posiva's safety culture assessment and development procedures, Posiva's 2016 safety culture action plan and implementation of TVO Group's safety culture programme at Posiva in 2016. The inspection also covered Posiva's safety culture development resources and the related organisation as well as verified how Posiva has communicated information about the safety culture and promoted its safety culture principles. Other inspection areas included Posiva's safety culture follow-up and assessment methods and their results.

It was noted after the inspection that Posiva is currently developing its safety culture development and assessment operations to reach the level specified by STUK's requirements. No requirements for Posiva were made during the inspection.

Long-term safety

The inspection covered the preparation of Posiva's safety case, which is required to demonstrate long-term safety. The plan is to include the safety case in Posiva's operating licence application that should be submitted by the end of 2020.

The inspection covered the operations and procedures that Posiva uses to verify compliance with the regulations and requirements when preparing its TURVA-2020 safety case and the safety case documentation. Other areas covered by the inspection included communication about changes in the research and development operations to STUK and the role of the Swedish company SKB in the preparation of TURVA-2020.

The descriptions of some of the responsible roles in the documents reviewed during the inspection were unclear and the terminology used was not harmonised. Posiva was required to assess these documents to verify that the content of the documents is unambiguous. A need to update the TURVA-2020 project and quality plan was also detected. Reconciliation of the quality plan schedule with the schedule of the disposal project must be taken into account in the quality plan and the schedules of the work packages therein must be updated.

APPENDIX 8 Licences and approvals in accordance with the Nuclear Energy Act in 2016

Teollisuuden Voima Oy

- 3/C42214/2016, 22 March 2016: OL1/OL2 – import of SIRM protective sleeves from Germany. Last date of validity 31 January 2016.
- 5/G42214/2016, 19 May 2016: OL3 – import of dummy fuel assembly and control rod from Germany. Last date of validity 31 January 2016.
- 7/C42214/2016, 9 September 2016: OL1/OL2 – import of reactor coolant pump components from Germany. Last date of validity 31 December 2017.
- 8/C42214/2016, 17 October 2016: Import of nuclear fuel with Euratom obligation code "S" from Germany (OL1 e 39). Last date of validity 31 December 2017.
- 9/C42214/2016, 17 October 2016: Import of nuclear fuel with Euratom obligation code "P" from Sweden (OL2 e 37). Last date of validity 31 December 2017.
- 12/G42214/2016, 12 December 2016: Replacing import licence 4/G42214/2011 for dual-use products required in the construction and operation of the OL3 nuclear power plant unit and its extension decision 5/G42214/2013 with a new import licence (import from France or Germany). Last date of validity 31 January 2018.
- 13/G42214/2016, 12 December 2016: Import of nuclear fuel with Euratom obligation codes "N", "P" and "S" from Germany (OL3 initial core loading and backup assemblies). Last date of validity 31 December 2020.

Fortum Power and Heat Oy

- 12/A42214/2015, 21 January 2016: Import of neutron flux sensors from Russia. Last date of validity 31 January 2016.
- 1/A42214/2016, 27 April 2016: Import of in-core neutron flux sensors from Canada. Last date of validity 31 January 2016.

Others

- 1/Y42214/2016, 26 January 2016, VTT Technical Research Centre of Finland; import of design documents of the Fukushima Daiichi nuclear reactors and fuel assemblies from Japan and their possession. Last date of validity 31 January 2025.
- 14/Y42214/2016, 24 November 2016: Operating licence for VTT Centre for Nuclear Safety. Last date of validity 31 January 2026.
- 5/Y42214/2016, 16 May 2016: Operating licence for nuclear-use items for the Department of Applied Physics of the Aalto University. Last date of validity 31 May 2026.