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Regulatory oversight of nuclear safety in Finland

Annual report 2014

Erja Kainulainen (ed.)

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Strålsäkerhetscentralen
Radiation and Nuclear Safety Authority

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Management review

In 2014, 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 and the radioactive releases into the environment very small. The low employee radiation doses were the result of short annual outages and improvements implemented by the NPPs. Radioactive waste generated in the operational processes of the NPPs accumulated as anticipated. Its processing and final disposal in underground facilities took place in a controlled manner. An emergency preparedness drill was arranged at the Loviisa NPP in November to practice, for the first time in Finland, a simultaneous emergency at two plant units.

In 2014, six events warranting a special report were reported by Loviisa NPP. These events did not influence the safety of the employees or the area surrounding the plant. Fortum Power and Heat Oy (hereinafter referred to as "Fortum") has several pending long-term nuclear safety development projects that involve development of the management system, processing of operational events, as well as maintenance of the operational limits and conditions. STUK will monitor their progress and assess effectiveness of the measures. As part of the oversight of the organisation, STUK ordered a study to assess the nuclear safety culture of Fortum and the functionality of related procedures. The report states that safety is appreciated at Loviisa NPP and the safety culture in general is at an acceptable level. However, the NPP must continue active development of the safety culture.

In 2014, three events warranting a special report were reported by the operating units at Olkiluoto. These events did not influence the safety of the employees or the area surrounding the plant. STUK performed an annual outage inspection in compliance with the inspection programme during the annual outage. Good operations and examples of continuous improvement were observed during the inspection. During inservice inspections carried out during the annual outage, Teollisuuden Voima Oyj (hereinafter "TVO") detected cracks in the feedwater lines of both plant units. The cracked mixing points will be replaced during the next annual outage. In 2014, STUK focused its regulatory oversight on the plant's management, modification and procurement processes. A reformed modification work process was introduced in 2014.

At both Olkiluoto and Loviisa, modifications required for improving safety continued regarding plant systems, structures and components as well as operating procedures. An expansion project of the interim storage facility for spent nuclear fuel at Olkiluoto proceeded as planned in 2014. System modifications have been completed. A decision on an application to increase the capacity of the interim storage facility for spent nuclear fuel is being processed by STUK. An upgrade project regarding the reactor coolant pumps, their control and the frequency converters needed to supply power to the pumps has been started at Olkiluoto. STUK approved the project's conceptual design plans in 2014. 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. In 2014, a modification of an auxiliary feedwater system recirculation line was implemented at Olkiluoto 1. It reduces the system's dependence on seawater cooling.

The purpose of an I&C renewal project launched at Loviisa NPP in 2005 was to digitalise almost the entire I&C system of the plant. In 2014, Fortum announced that the supplier of the modernisation had been changed and the scope of the renewal project had been significantly cut back, which is why the project would not be completed until by the end of 2018. Modifications implemented in 2014 included improving reliability of the reactor coolant system's pressure control system at Loviisa 2 and installing qualified safety valves for the secondary side water and water/steam flow. As a result of the Fukushima accident, four air-cooled heat exchangers have been installed that will ensure cooling of the fuel in the reactor and the fuel pools in case heat transfer to the sea is lost. Furthermore, separate flood protection components have been installed in some systems important to safety. The protection elements take into account exceptionally high seawater levels during a storm.

Most of the detailed design of the Olkiluoto 3 plant unit has been approved by STUK, and the volumes of construction work and component manufacture have decreased. Installation activity at the Olkiluoto 3 construction site has also slowed down starting in early 2014. Manufacture and installation of the emergency diesel generator auxiliary system pipelines were almost the only works still ongoing in 2014. Pressure and leak tightness tests of the containment took place at the nuclear island in February. STUK inspected the plant site before testing and oversaw the testing. Results of the tests clearly met the acceptance criteria. The most important open issue regarding plant design at Olkiluoto 3 is the I&C systems. In 2014, the licensing of I&C proceeded well as STUK approved the overall I&C plan, i.e. architecture, and found that the analysis of I&C active failures were acceptable. Next, STUK started reviewing the technical I&C materials. In 2014, STUK ordered a preliminary report on the safety culture during commissioning of Olkiluoto 3. Challenges highlighted in the report included the highly complex stage during the lifecycle of the plant and the fact that open items and deviations from the construction stage tend to cumulate. Issues that were deemed especially challenging included potential slow processing of unexpected events and people focusing only on their own work in a very narrow sector. The results will assist STUK in targeting its regulatory oversight to the key issues and challenges during the commissioning stage.

In 2014, STUK drafted preliminary safety assessments on supplementary applications for the decisions-in-principle on Fennovoima's Hanhikivi 1 and TVO's Olkiluoto 4. In its preliminary safety assessment on Fennovoima's Hanhikivi 1 plant unit, STUK stated that an AES-2006 nuclear power plant of Rosatom can be constructed in a manner that meets the Finnish safety requirements. However, STUK raised some issues where meeting of the Finnish safety requirements would require changing of the NPP design, such as provisions for an airplane crash, internal floods, fires and severe accidents. STUK also stated that Fennovoima must improve its expertise and develop its management system in order to be capable to assess and ensure the safety of a new NPP, as well as to draft the construction license materials to be submitted to STUK. In its supplementary application, TVO applied for an extension of five years to the deadline for submitting a construction license application for the new nuclear power plant unit at Olkiluoto in compliance with the 2010 decision-in-principle. STUK stated that there are no nuclear safety issues that would prevent the extending of the deadline. The Government approved Fennovoima's supplementary application for the decision-in-principle and the Parliament ratified it. The Government refused TVO's application on an extension to the deadline for the construction license application. In 2014, STUK continued its preparations for the processing of the construction license applications.

The processing and storage of nuclear waste and spent nuclear fuel, as well as the nuclear fuel repository project, proceeded safely, and no problems were detected at Loviisa or Olkiluoto. Due to the successful planning of operations, the plants accumulated clearly less nuclear waste than NPPs on average. At Loviisa NPP, STUK supervised the commissioning of a liquid waste solidification facility. Damage was observed in concrete containers used in solidification at the end of 2013. Trial runs were discontinued to study their cause. STUK deemed the conclusions made based on reports correct. Loviisa NPP continued its activities and studies pertaining to the commissioning of the solidification facility, and the trial runs should be completed by the end of 2015. STUK reviewed and approved a periodic safety assessment of the Loviisa low- and intermediate-level operational waste repository and stated that the safety level of the repository is good and its operation can be safely continued. VTT Technical Research Centre of Finland is preparing the decommissioning of a research reactor at Otaniemi. STUK issued statements on the environmental impact assessment program for the decommissioning and a related report.

The project by Posiva Oy (hereinafter referred to as "Posiva") on final disposal of spent nuclear fuel has proceeded: Posiva submitted a construction license application for the encapsulation plant and disposal facility to the Government in late 2012. Posiva submitted to STUK the safety documentation required by the Nuclear Energy Decree and STUK started reviewing the materials in early 2013. The fact that some of the application materials were submitted to STUK late and the need for additional information to some documents was postponed the review process, which was completed in late 2014. A statement by the Advisory Committee on Nuclear Safety on the Posiva construction license application and the preliminary safety assessment by STUK, as well as STUK's statement, could not be submitted to the Ministry of Employment and the Economy until in early 2015. The process was very demanding because it was the first preliminary safety assessment for a repository of this type in the world. STUK used a team of Finnish and international experts from a variety of technical sectors as an aid in its review. In addition to reviewing the documents, STUK conducted inspections of Posiva's management system and organisation. STUK was able to determine that the encapsulation plant and disposal facility can be constructed in such a manner that it will be safe. In separate decisions on documents by virtue of section 35 of the Nuclear Energy Act, STUK presented specific requirements regarding the construction stage. The requirements included supplementing the system design of the encapsulation plant in compliance with the construction stages, further studies on the performance of the barriers of the repository and development of the long-term safety case for the operating license application.

The construction of the underground research facility (Onkalo) was completed for the most part by the end of 2012. In 2014, Posiva excavated facilities to be used to test the final disposal method, as well as the last of the shafts and tunnels, and completed structural engineering works. STUK supervised the construction of the underground research facility, the operations of Posiva's organisation and the research carried out at Onkalo.

The safeguards of nuclear materials in Finland was implemented in compliance with the international agreements. Annual verifications of design information were implemented for the nuclear power plant units under construction and the physical inventories of nuclear materials of the operating NPPs were verified. STUK verified the correctness of stored fuel data by means of spent fuel measurements. Furthermore, STUK inspected the operations of other nuclear material holders and physical inventory results. As a summary of the inspections and oversight in 2014, STUK could state that nuclear energy was used in compliance with the reports and no unannounced activities took place. Inspection results submitted by the IAEA and the European Commission as well as conclusions made based on the inspection activities also support STUK's observations. In 2014, the IAEA and the Commission started electronic transfer of surveillance data from Loviisa NPP directly to the Commission and further to the IAEA. Enabling the electronic transfer of monitoring data is an obligation laid down in the Additional Protocol of the Safeguards Agreement between Finland and the IAEA. STUK's duty was to support the NPPs and international organisations when they ensure that the electronic data transfer complies with all requirements pertaining to nuclear security and information security. In 2014, STUK participated in a laser scanning campaign of the Onkalo facility carried out by the Commission and the IAEA where it was verified that Onkalo has been constructed as reported. The results of the campaign can be used as reference data in future inspections of Onkalo.

Introduction

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

The regulatory control of nuclear safety in 2014 included the engineering, construction and operation of nuclear facilities, as well as nuclear waste management and nuclear materials. The control of nuclear facilities and nuclear waste management, as well as nuclear non-proliferation, concern two STUK departments: nuclear reactor regulation and nuclear waste and material regulation.

The first parts of the report explain the fundamentals of nuclear safety regulation as part of STUK's duties, as well as the objectives of the operations, and briefly introduce the objects of regulation. The chapter concerning the development and implementation of legislation and regulations describes changes in nuclear legislation, as well as the progress of STUK's YVL Guide reform work.

The section concerning the regulation of nuclear facilities contains an overall safety assessment of the nuclear facilities currently in operation or under construction. For the nuclear facilities currently in operation, the section describes plant operation, events during operation, annual maintenance and observations made during regulatory activities. Data and observations gained during regulatory activities are reviewed with a focus on ensuring the safety functions of nuclear facilities and the integrity of structures and components. The chapters describing the development of the plants and their safety also include summaries of the development targets established after the Fukushima accident. For the existing NPPs, the report describes the regulation and inspections of the interim storage of spent nuclear fuel, management of operating waste, and the provisions for the costs of nuclear waste management. The report also includes a description of the oversight of the operations and quality management of organisations, oversight of operational experience feedback activities, and the results of these oversight activities. The radiation safety of nuclear facilities is examined on the basis of employees' individual doses, collective doses, radioactive releases and the results of environmental radiation monitoring. The report also includes summaries on STUK's regulatory oversight concerning nuclear security, emergency preparedness and safeguards of nuclear materials at the nuclear power plants. For the Olkiluoto 3 plant unit currently under construction, the report includes descriptions of the regulation of design, construction, manufacturing, installation, and commissioning preparations, as well as regulation of the operations of the licensee and the organisations participating in the construction project. At the end of the chapter on the regulation of nuclear facilities there is a summary of new plant projects and the regulation of the research reactor.

The chapter concerning the regulation of the final disposal project for spent nuclear fuel describes the preparations for the final disposal project and the related regulatory activities. In addition, the oversight of the design and construction of the research facilities (Onkalo) currently under construction in Olkiluoto, as well as the assessment and oversight of the research, development and design work being carried out to specify further the safety case for final disposal are included in the report.

In addition to actual safety regulation, the report describes safety research, regulatory indicators and the development of regulatory operations, as well as emergency preparedness, communication and STUK's participation in international nuclear safety cooperation.

Appendix 1 presents a detailed study of the safety performance of the nuclear power plants by means of an indicator system. Appendix 2 includes a summary of employees' doses at the nuclear power plants. Appendix 3 describes exceptional operational events at the nuclear power plants. Appendix 4 lists the licenses granted by STUK pursuant to the Nuclear Energy Act in 2014. Summaries of inspections included in the periodic inspection programme of nuclear power plants are presented in Appendix 5, and the Olkiluoto 3 construction inspection programme is in Appendix 6. Inspections included in the construction period inspection programme for Onkalo are listed in a table in Appendix 7 and the inspection programme for the construction license application period of the spent fuel repository are listed in Appendix 8. A table in Appendix 9 lists the amount of nuclear materials in Finland. Appendix 10 lists the most important assignments funded by STUK concerning the safety of nuclear power plants and final disposal of nuclear waste in 2014. Appendix 11 contains definitions of terms and abbreviations used in the report.

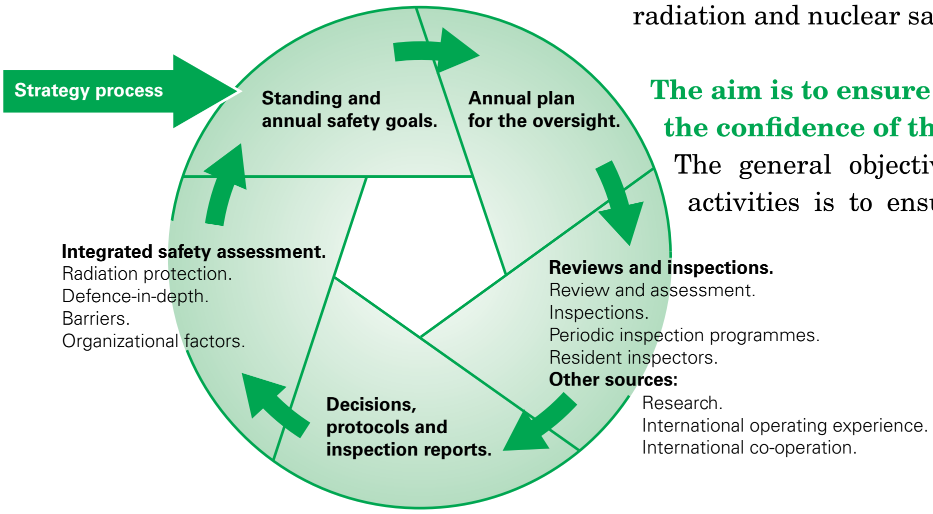
Contents

1 Fundamentals of nuclear safety regulation

Regulatory control by STUK is based on the Nuclear Energy Act.
The Radiation and Nuclear Safety Authority (STUK) is responsible for the regulatory control of nuclear safety in Finland. Its responsibilities include the control of nuclear security and emergency response, as well as the safeguards for nuclear materials necessary to prevent nuclear proliferation.

STUK lays down detailed requirements concerning nuclear safety.
STUK contributes to the processing of applications for licenses under the Nuclear Energy Act, controls compliance with the license conditions, and formulates the detailed requirements. STUK also lays down qualification requirements for personnel involved in the use of nuclear energy and controls compliance with these requirements. In addition, STUK submits proposals for legislative amendments and issues general guidelines concerning radiation and nuclear safety.

The aim is to ensure safety and maintain the confidence of the general public.
The general objective of STUK's regulatory activities is to ensure the safety of nuclear



STUK functions for the oversight of nuclear power plants

Oversight of New Plant Projects and Plant Modifications
- Changes at the nuclear facility

Safety Assessments and Analysis
- Deterministic safety analysis
- Probabilistic risk analysis (PRA)
- Safety performance indicators; analysis and feedback

Oversight of Operations
- Compliance with Technical Specifications
- Incidents
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Oversight of Management in Regulated Organizations
- Safety management
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Oversight of Nuclear Waste Management and Nuclear Materials
- Safeguards of nuclear materials
- Nuclear waste management
- Transport of nuclear material and nuclear waste
- Licences for the nuclear materials and nuclear waste

Figure 1. Oversight of nuclear facilities; from strategy to implementation.

Defence in depth

The safety of a nuclear power plant is ensured by preventing the harmful effects of reactor damage and radiation through successive and mutually-redundant functional and structural levels. This approach is called the "defence in depth" principle. Safety-ensuring functions may be divided into preventive, protective and mitigating levels.

The aim of the preventive level is to prevent any deviations from the plant's normal operational state. Accordingly, high quality standards apply to component design, manufacture, installation and maintenance, as well as plant operation.

The protective level refers to providing for operational transients and accidents through systems aimed at detecting disturbances and preventing their development into an accident.

If the first or second level functions fail to stop the progress of an accident, its consequences must be mitigated. In such a case, the main thing is to ensure the integrity of reactor containment and the operation of its associated systems.

In addition to the functional levels, the defence in depth approach includes the principle of multiple successive barriers to potential radioactive releases, and a number of good design and quality management principles.

facilities, so that plant operation does not cause radiation hazards that could endanger the safety of workers or the population in the vicinity or cause other harm to the environment or property. The most important objective is to prevent a reactor accident that would cause a release of radioactive substances, or the threat of a release. Another objective is to maintain public confidence in regulatory activities.

STUK ensures the adequacy of safety regulations and compliance with their requirements.

It is STUK's task to ensure in its regulatory activities that safety regulations contain adequate requirements for the use of nuclear energy and that nuclear energy is used in compliance with these requirements.

Advisory Commission on Nuclear Safety

Pursuant to the Nuclear Energy Act, the preliminary preparation of matters related to the safe use of nuclear energy is vested with the Advisory Commission on Nuclear Safety. It is appointed by the Government and functions in conjunction with STUK. Its term of office is three years. The Commission was appointed on 1 October 2012 and will remain in office until 30 September 2015.

In 2014, the Chairman of the Commission was Dr. Sc. (Tech.) Seppo Vuori, and the Vice-Chairman was senior specialist Miliza Malmelin (Ministry of the Environment). Members of the Commission were professor Riitta Kyrki-Rajamäki (LTY), customer director Rauno Rintamaa (VTT), chief commercial officer Timo Okkonen (Inspecta Oy), customer manager Ilona Lindholm (VTT) and Dr. Sc. (Tech.) Antero Tamminen. Petteri Tiippana, Director General of STUK, was a permanent expert to the Commission.

The Commission has two committees, the Reactor Safety Committee and the Nuclear Waste Safety Committee. Foreign and Finnish experts have been invited to join the committees. English is the working language in the committees, and more extensive questions of principle will be brought to them for preparation. Nuclear industry experts from the UK, France, Sweden, Germany, Switzerland, Hungary and the United States have been invited to join the committees. Both of the Committees convened twice in 2014. The members of the actual Commission also participate in the work of the committees

Regulation by STUK ensures the attainment of safety objectives.

STUK ensures, by means of inspections and controls, that the operational preconditions and operations of the licensee and its subcontractors and the systems, structures and components of nuclear facilities are in compliance with regulatory requirements. STUK's operations are guided by annual follow-up plans, presenting the key items and activities for inspection and review. STUK carries out inspections of plans for nuclear facilities and other documents that the licensee is obliged to request STUK to do. The compliance of activities with the plans is verified through inspections carried out at the plant site or at subcontractors' premises. In

Nuclear liability

The Nuclear Liability Act prescribes that the users of nuclear energy must have a liability insurance policy, or other financial guarantee, for a possible accident at a nuclear facility that would harm the environment, population or property. Fortum Power and Heat Oy and Teollisuuden Voima Oy (TVO) have prepared for damage from a nuclear accident as prescribed by law by taking out an insurance policy for this purpose, mainly with the Nordic Nuclear Insurance Pool.

International negotiations concerning the renewal of the Paris/Brussels nuclear liability agreements were completed in 2004. It was agreed that the funds available for compensation were to be increased, and plant owners were to have unlimited liability. However, the entry into force of these international agreements has been repeatedly postponed. Consequently, the decision was taken in Finland to legislate nationally regarding a higher amount of insurance and impose an unlimited liability on license holders. A temporary amendment of the Nuclear Liability Act entered into force at the beginning of 2012. The legislative amendment will be revoked once the agreements discussed above will become valid.

In case of an accident, the funds available for compensation come from three sources: the licensee, the country of location of the facility and the international liability community. In 2014, a total of 600,000,000 SDR was available for compensation from these sources. SDR refers to Special Drawing Right, an international reserve asset defined by the International Monetary Fund (IMF), whose value is based on a basket of key international currencies. In 2014, the value of the SDR was about EUR 1.18.

In Finland, the Financial Supervisory Authority is responsible for ascertaining the contents and conditions of the licensee's insurance arrangements. The Financial Supervisory Authority has approved both Fortum Power and Heat Oy's and Teollisuuden Voima Oy's liability insurance, and STUK has verified the existence of the policies as required by the Nuclear Energy Act.

The Nuclear Liability Act also covers the transport of nuclear materials. STUK ascertains that all nuclear material transport has had liability insurance either approved by the Financial Supervisory Authority or by the authorities of the sending state in accordance with the Paris Convention.

addition to these inspections and reviews, STUK has separate inspection programmes for periodic inspections of operating plants and inspections during construction. STUK also employs resident inspectors at the plants, who supervise and witness the construction, operation and condition of the plant and the operations of the organisation on a daily basis and report their observations. An overall safety assessment is conducted annually on each nuclear facility, dealing with the attainment of radiation protection objectives, the development of defence in depth, and the operation of organisations constructing or operating nuclear facilities and providing services to them.

STUK evaluates the safety of nuclear facilities starting from the application for a decision-in-principle

The construction of a nuclear power plant, intermediate storage for spent fuel and a final disposal facility require a Government decision-in-principle that the project is in line with the overall good of society. The task of giving a statement on and preparing a preliminary safety assessment of the application for the decision-in-principle is vested with STUK. The safety assessment will state, in particular, whether any issues have been discovered that would indicate that the necessary prerequisites for the construction of a nuclear power plant in compliance with the Nuclear Energy Act do not exist. In connection with the application for the decision-in-principle, the applicant also presents a report on the environmental impact assessment. When an application for a construction or operating license for a nuclear facility has been submitted to the Government, STUK issues a statement on it and includes its safety assessment.

STUK regulates the different nuclear facility design and construction stages

The principles and detailed approach of STUK's inspection activities are described in the YVL Guides issued by STUK. Guide YVL 1.1 describes the oversight and inspection procedures at a general level, while the detailed procedures are described in other YVL Guides. The purpose of oversight and inspection activities regarding plant projects is to allow STUK to verify that the prerequisites for operations of a high standard exist, that the plans are acceptable before the implementation begins and that the implementation is compliant with regulations before the operating license is granted.

Pursuant to the Nuclear Energy Act, the licensee must ensure safety. Through its oversight, STUK ensures that the licensee meets its responsibilities. STUK oversees and inspects the implementation of the plant and the organisations participating in its implementation and operation. STUK does not monitor and inspect every detail; instead, the oversight and inspections are targeted on the basis of the safety implications of each subject. To this end, the plant is divided into systems, structures and equipment, which are further classified according to their importance to plant safety. The safety classification of the plant is reviewed by STUK at the stage of applying for the construction license. STUK inspects and monitors the design and manufacture of the equipment and structures that are most critical from the point of view of safety. Inspection organisations approved by STUK have been trusted with the inspection of equipment and structures with lesser safety implications. STUK oversees the operations of these inspection organisations.

In plant projects, STUK ensures with its oversight and inspections, the bulk of which are scheduled to take place in advance, that the power company planning to build the plant and the plant supplier responsible for its implementation, and its main sub-contractor, have the necessary capabilities for a high-quality implementation.

During the construction license stage, the plant design work and quality assurance of implementation are evaluated in order to make sure that the plant can be implemented in compliance with high quality standards and Finnish safety requirements. During construction, inspections and oversight are deployed in order to ensure that the plant is implemented in compliance with the principles approved at the construction license stage. The inspections are based on detailed documentation delivered to STUK and onsite inspections at the suppliers' premises. Before the manufacture of equipment and structures may commence, STUK inspects both the respective detailed plans and the capabilities of the manufacturing organisations to produce high-quality results. During manufacture and building, STUK carries out inspections in order to verify that the equipment and structures are manufactured in compliance with the plans approved by STUK. Regarding the installation of equipment and structures, STUK carries out inspections in order to verify that the installations are made in compliance with the approved plans and that the requirements set out for installations are fulfilled. Approval by STUK after inspection is a prerequisite for trial operation of the equipment. After that, STUK inspects the results of the trial operation before the actual commissioning.

Before operating the plant, STUK must be provided with documentation proving that the plant was designed and implemented in compliance with Finnish safety requirements. In addition, STUK has to be provided with evidence verifying that the prerequisites exist for safe operation of the plant. These include personnel that have been trained and verified to be competent, the instructions required for operating the plant, safety and preparedness arrangements, maintenance schedule and staff, as well as radiation protection staff. Having verified that the implementation is safe and the organisation has the required capabilities, STUK prepares the safety assessment and report required for the operating license. Obtaining the operating license is a prerequisite for loading the reactor with fuel.

Comprehensive safety assessment is a prerequisite for extending the operating license

In Finland, operating licenses are granted for a fixed term, typically 10 to 20 years. A comprehensive safety assessment is required to renew the operating license. If the operating license is granted for a period exceeding 10 years, an interim safety assessment is carried out during the license period. The scope of the interim assessment is similar to that carried out in conjunction with renewing the operating license. During the assessments, the state of the plant is investigated, paying particular attention to the effects of ageing on the plant and its equipment and structures. In addition, the capabilities of the operating personnel for continued safe operation of the plant are assessed.

Regulation of operating plants includes continuous safety assessment.

STUK's regulation of operating nuclear facilities ensures that the condition of the facilities is and will be in compliance with the requirements, the facilities function as planned and are operated in compliance with the regulations. The regulatory activities cover the operation of the facility, its systems, components and structures, as well as the operations of the organisation. In this work, STUK employs regular and topical reports submitted by the licensees, on the basis of which it assesses the operation of the facility and the plant operator's activities. In addition, STUK assesses the safety of nuclear power plants by carrying out inspections on plant sites and at component manufacturers' premises, and based on operational experience feedback and safety research. On the basis of the safety assessment during operation, both the licensee and STUK evaluate the need and potential for safety improvements.

Safety analyses provide tools for assessing the safety of nuclear facilities

Safety analyses ensure that the nuclear facility is designed to be safe and that it can be operated safely. Deterministic and probabilistic approaches complement each other.

Deterministic safety analyses

For the purpose of STUK's regulatory YVL Guides, deterministic safety analyses are analyses of transients and accidents required for justifying the technical solutions employed by nuclear power plants. The licensees update these analyses in connection with the renewal of operating licenses, periodic safety reviews and any significant modifications carried out at the plant.

Probabilistic risk analyses

Probabilistic risk analysis (PRA) refers to quantitative estimates of the threats affecting the safety of a nuclear power plant and the probabilities of chains of events and any detrimental effects. PRA makes it possible to identify the plant's key risk factors, and can contribute to the design of nuclear power plants and the development of plant operation and technical solutions. The licensees employ PRA for the maintenance and continuous improvement of the technical safety of nuclear facilities.

STUK reviews the deterministic safety analyses and probabilistic risk analyses related to construction and operating licenses and the operation of a nuclear power plant. When required, STUK has its own independent comparison analyses made in order to verify the reliability of results.

STUK oversees modifications from planning to implementation

Various modifications are carried out at nuclear facilities to improve safety, replace aged systems or components, facilitate plant operation or maintenance, or improve the efficiency of energy generation. STUK inspects the plans for extensive or safety-significant plant modifications and oversees the modification work by reviewing the documents submitted by the licensee and carrying out inspections on site or at manufacturers' premises.

As a consequence of modifications implemented at the plant, several documents that describe the plant's operation and structure – such as the Operating Limits and Conditions, the Final Safety Analysis Report and the operating and maintenance procedures – have changed. STUK oversees the document revisions and generally follows the updating of plant documentation after the modifications.

Operability of the plant is overseen during operation and annual maintenance

The technical operability of nuclear facilities is overseen by assessing the operation of the facility in compliance with the requirements laid down in the operational limits and conditions, and overseeing annual maintenance outages, plant maintenance and ageing management, fire safety, radiation safety, nuclear security and emergency preparedness.

Operational limits and conditions

The operational limits and conditions (OLC) of nuclear facilities lay down the detailed technical and administrative requirements and restrictions concerning the plant and its various systems, equipment and structures. The licensee is responsible for keeping the operational limits and conditions up-to-date and ensuring compliance with them. STUK controls compliance with the plants' operational conditions and limits by witnessing operations on site. Special attention is paid to the testing and fault repairs of components subject to the operational limits and conditions.

When annual maintenance outages end, STUK ascertains the plant unit's state in compliance with the operational limits and conditions prior to start-up. Any changes to and planned deviations from the operational limits and conditions must be submitted to STUK for approval in advance. In addition, the licensee is responsible for reporting to STUK without delay all situations deviating from the requirements under the operational limits and conditions. In the report, the power company presents its corrective action for approval by STUK. STUK oversees the implementation of corrective action.

Oversight of operation, incidents during operation and reporting the operation to STUK

STUK oversees the safe operation of plants through regular inspections and reports submitted by the power companies. In addition, STUK's local inspectors working on plant sites oversee the operation on a daily basis. The local inspectors assess faults and oversee their repairs, as well as tests of safety-critical equipment. The inspections of the periodic inspection programme focus on major faults, incidents and progress made in corrective actions, as well as on operating procedures. The inspections are based on the regular reports submitted by power companies and inspections and walkdown inspections conducted on site.

The power companies are obliged to report any operational transients and any matters that may compromise safety. STUK assesses the safety implications of the incidents and the power company's ability to detect safety deficiencies, take action and carry out corrective actions.

The licensees submit event reports to STUK on operational events at nuclear facilities, comprising special reports, operational transient reports and scram reports. In addition to event reports, the facilities submit daily reports, quarterly reports, annual reports, outage reports, annual environmental safety reports, monthly individual radiation dose reports, annual experience operational feedback reports and safeguard reports to STUK.
Internal processing and reporting is also required for events or near-misses not subject to a special or operational transient report. Reports on such events are submitted to STUK for information if the event is or may be relevant to nuclear or radiation safety or STUK's communication activities.

Annual maintenance

Work that cannot be done during plant operation is carried out during annual maintenance of nuclear power plants. These include refuelling, preventive equipment maintenance, periodic inspections and tests, as well as failure repairs. These actions ensure the preconditions for operating the power plant safely during the following operating cycles.

STUK is responsible for controlling and ensuring that the nuclear power plant is safe during the annual maintenance and future operating cycles, and that the annual maintenance does not cause a radiation hazard to the workers, the population or the environment. STUK ensures this by reviewing the documents required by the regulations, such as outage plans and modification documentation, and by performing on-site inspections during annual maintenance.

__The majority of radioactive substances created during the operation of a nuclear reactor__ are contained in the nuclear fuel. In addition, radioactive substances are contained in the reactor cooling system, as well as in the related purification and waste systems. The liquid and atmospheric effluents from the plant are purified and delayed so that their radiation impact on the environment is very low compared with the impact of radioactive substances normally existing in nature. The emissions are carefully measured to ensure that they remain clearly below the prescribed limits.

__Radioactive emissions from a nuclear power plant__ into the air and sea are verified through comprehensive radiation monitoring. Radiation monitoring in the environment of a power plant comprises radiation measurements and determination of radioactive substances, conducted to analyse the radioactive substances existing in the environment. In case of potential accident situations, continuously-operating radiation measurement stations monitoring the external radiation dose rate are installed in the vicinity of nuclear power plants at distances of a few kilometres. The measurement data from these stations are transferred to the power plant and to the national radiation-monitoring network.

Plant maintenance and ageing management

In its regulatory activities concerning the ageing management of operating nuclear facilities, STUK controls the plants' ageing management strategy and its implementation ensures the maintenance of sufficient safety margins for safety-significant systems, components and structures throughout their lifetime. The organisation of the licensee's operations, the prerequisites for the organisation to carry out the necessary actions, and the condition of components and structures important to safety are subject to inspection and review. Regulatory control and inspections ensure that the power companies have the lifetime management programmes in place that enable them to detect potential problems in time. In addition, corrective action must be carried out in a way that ensures the integrity and operability of safety-significant components and structures so that safety functions can be activated at any time.

STUK monitors ageing management through the inspections of the periodic inspection programme and inspections related to modifications and annual maintenance. The key issue in operation license renewal and periodic safety assessments is the management of plant ageing.

Every year, the power companies provide STUK with reports on the ageing of electrical and I&C equipment, mechanical structures and equipment, as well as buildings. These reports describe the most salient ageing phenomena to be monitored, observations related to the ageing process and actions required for extending the service life of equipment and structures.

The licensee must carry out periodic inspections of safety-critical equipment and structures (such as the reactor pressure vessel and reactor coolant system). STUK approves the inspection programmes prior to the inspections and monitors the inspections and their results on site. The final result reports will be submitted to STUK for approval after the annual maintenance.

Radiation safety

STUK oversees occupational radiation safety by inspecting and reviewing dosimetry, radiation measurements, radiation protection procedures, radiation conditions and radiation protection arrangements for work processes at each facility. The dosimeters used for measuring the occupational radiation doses undergo annual tests carried out by STUK. The test comprises irradiating a sample of dosimeters at STUK's measurement standard laboratory and reading the doses at the power plant. In addition, STUK oversees the meteorological dispersion measurements of radioactive substances, release measurements and environmental radiation monitoring, and also reviews the relevant result reports.

Emergency preparedness

Besides the periodic inspections of other operations, STUK controls the readiness of the organisations operating nuclear power plants to act in abnormal situations. The inspection focuses on training in emergency response organisation, arrangement of rooms, securing the connections used for the transfer of meteorological measurement data during an emergency situation and radiation monitoring of the surrounding environment, as well as the development of internal alarm procedures at the power plant. Emergency exercises test the operation of the emergency response organisation, the functionality of the emergency response guidelines and the usability of the alert areas in practice, which are developed on the basis of the feedback received for the exercises. STUK monitors the actions of power companies during these emergency drills.

Oversight of the operation of organisations is part of the process of ensuring plant safety

STUK oversees the operation of organisations by reviewing safety management, the management and quality systems, the competence and training of the staff of nuclear facilities and operational experience feedback activities. The aim is to ensure that the organisations of the power company as a whole and its key suppliers operate in a manner that ensures the safety of the plant at all levels and in connection with safety-related actions.

Training and qualifications of personnel

STUK monitors the training and qualifications of personnel through inspections included in the periodic inspection programme, by assessing the suitability and approving the appointment of certain key personnel and by assessing the ability of the power company to ensure safety in conjunction with incidents and annual maintenance operations. The key persons whose appointment must be approved by STUK are the director in charge of the construction and safe operation of the nuclear facility, the operators working in the plant control rooms and the persons in charge of materials related to preparedness, safety and nuclear technology. In addition, STUK's approval is required for personnel carrying out certain integrity checks on materials. In case events reveal flaws in the operation of the organisation, number of personnel or their competence, STUK will require the power company to take rectifying action as required.

Operational experience feedback

According to Government Decision VNA 733/2008, the advancement of science and technology and operating experience must be taken into account for the further enhancement of the safety of nuclear power plants. This principle is not limited to operational experience from Finnish nuclear power plants, but feedback from abroad must also be analysed systematically, and action must be taken to improve safety as necessary. STUK controls and ensures that the power companies' operational experience feedback activities effectively prevent the reoccurrence of problematic events. STUK pays particular attention to the power companies' ability to detect and identify the causes of the events and to remedy the underlying operational weaknesses. In addition, STUK analyses Finnish and foreign operational experience data and, as necessary, lays down requirements to enhance safety.

STUK controls the operational experience feedback activities by reviewing the event reports submitted by the licensee and the annual summary of operational feedback activities. During inspections included in the periodic inspection programme, the operational experience feedback activities of the plant and utilisation of international experience are monitored.

Event investigations

An event investigation team is appointed when the licensee's own organisation has not operated as planned during an event or when it is estimated that the event will lead to significant modifications to the plant's technical layout or procedures. A STUK investigation team is also set up if the licensee has not adequately clarified the root causes of an event.

Pressure equipment critical to nuclear safety is monitored by STUK

In addition to regulating the design and manufacturing of pressure equipment, STUK oversees the operational safety of pressure equipment included in the most important safety classes and performs periodic inspections of such equipment. Pressure equipment in other safety classes is inspected by inspection organisations authorised by STUK. STUK oversees the operation of the manufacturers and testing and inspection organisations authorised by it in connection with its own inspection activities, and by reviewing documents and making follow-up visits.

Regulatory oversight of nuclear non-proliferation is a basic requirement for using nuclear energy

Oversight of nuclear non-proliferation ensures that nuclear materials and other nuclear commodities remain in peaceful use in compliance with the relevant licenses and notifications, and that nuclear facilities and the related technologies are only utilised for peaceful purposes. Another objective of the oversight of non-proliferation is to ensure that appropriate security arrangements are in place for nuclear items.

The operator is responsible for managing the nuclear items in its possession, accounting for them and reporting on plant sites and its activities relating to the nuclear fuel cycle to STUK and submitting their reports on nuclear materials to the European Commission. STUK maintains a national control system the purpose of which is to carry out the safeguards for the use of nuclear energy that are necessary for the non-proliferation of nuclear weapons. In compliance with the Safeguards Agreement and its additional protocol, STUK forwards data on activities relating to the nuclear fuel cycle in Finland to the International Atomic Energy Agency (IAEA). STUK verifies the correctness of the notifications, accounting and reporting through on-site inspections and participates in all inspections carried out by the IAEA and the European Commission.

The National Data Centre (NDC), which is based on the CTBT, contributed to the work of the Preparatory Commission for the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) in establishing a cost-effective NDC organisation that is functional from the Finnish perspective.

Oversight of nuclear waste management extends from planning to final disposal

The aim of the regulation of nuclear waste management is to ensure that nuclear waste is processed, stored and disposed of safely. The control of nuclear waste processed at plant sites is part of the regulatory control of operating plants mentioned above. STUK oversees the nuclear waste management of nuclear power plants through document reviews and inspections within the periodic inspection programme. In addition, STUK approves the clearing of waste from control and reviews plants' nuclear waste management and decommissioning plans, on the basis of which the licensees' nuclear waste management fees are determined.

The final disposal project for spent fuel requires special attention. STUK inspects and reviews Posiva Oy's plans and research work for project implementation and is overseeing the construction of an underground research tunnel called Onkalo at Olkiluoto. Onkalo is also being used to test suitable working methods for the final disposal facility and mapping the underground premises. The plan is to later convert the research tunnel into an entrance for the repository.

2 Objects of regulation

Loviisa NPP

Plant unit	Start-up	National grid	Nominal electric power, (gross/net, MW)	Type, supplier
Loviisa 1	8 Feb1977	9 May 1977	520/496	PWR, Atomenergoexport
Loviisa 2	4 Nov 1980	5 Jan 1981	520/496	PWR, Atomenergoexport

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

Olkiluoto NPP

Plant unit	Start-up	National grid	Nominal electric power, (gross/net, MW)	Type, supplier
Olkiluoto 1	2 Sep 1978	10 Oct1979	910/880	BWR, Asea Atom
Olkiluoto 2	18 Feb 1980	1 Jul 1982	910/880	BWR, Asea Atom
Olkiluoto 3	Construction license granted 17.2.2005		about 1,600 (net)	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.

Onkalo

Posiva Oy is constructing an underground research facility (Onkalo) in Olkiluoto, where bedrock volumes suitable for final disposal of spent nuclear fuel can be investigated in more detail. Bedrock research at the planned final disposal depth is a requirement for granting a construction license for the final disposal facility. Posiva has designed Onkalo to function as one of the entrance routes to the planned final disposal facility, so STUK is applying the same regulatory procedures to the construction of Onkalo as those of a nuclear facility.

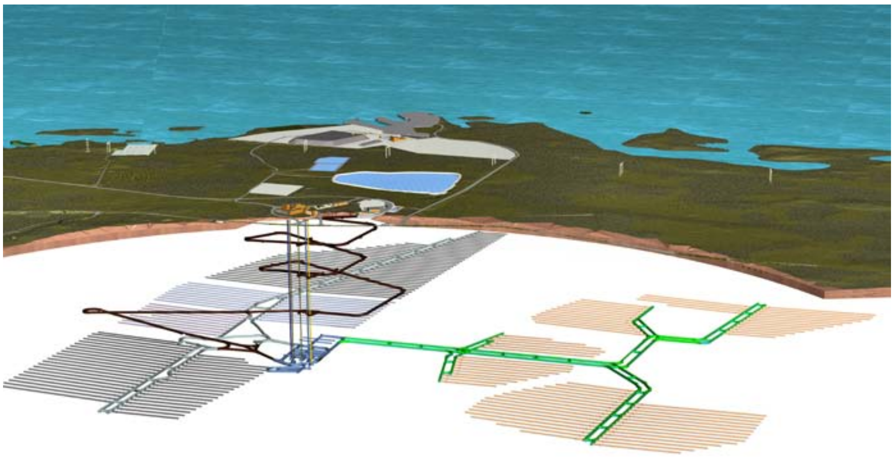


Figure 2. Diagram of the encapsulation and disposal facility in Olkiluoto (Posiva Oy).

The underground research facility consists of a drive tunnel, three shafts and a research gallery quarried to a depth of 437 m. Posiva started constructing Onkalo in 2004. By the end of 2011, the excavation of the drive tunnel had reached a depth of 455 m, and the length of the tunnel was 4913 m. In addition, intake air and personnel shafts had been quarried using raise boring techniques to a depth of 290 m and exhaust air shaft to a depth of 437 m.

Research reactor

In addition to nuclear power plants, STUK regulates the FiR 1 research reactor operated by VTT Technical Research Centre of Finland. The reactor is located in Otaniemi, Espoo, and its maximum thermal power is 250 kW. It was started in March 1962, and its current operating license will expire at the end of 2023. The reactor is used to manufacture radioactive tracers, perform activation analyses and train students. The reactor was also used to treat cancer with the boron neutron capture therapy (BNCT), but this operation was stopped in January 2012.

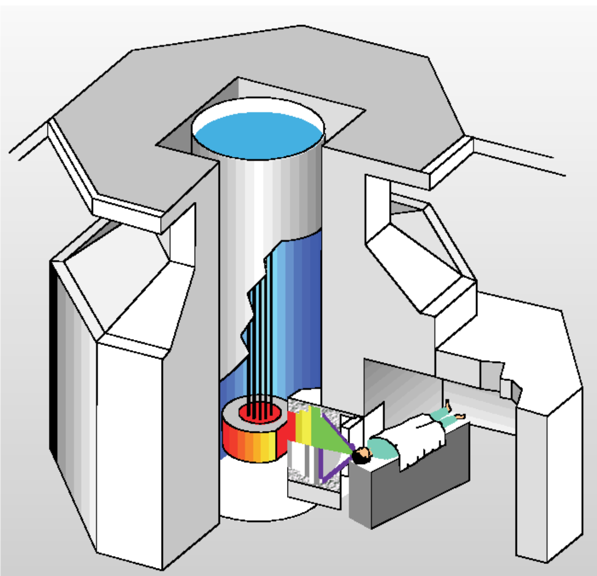


Figure 3. FiR 1 research reactor and the BNCT station.

- TRIGA Mark II research reactor
  Thermal power 250 kW
- Fuel of the core:
  80 fuel rods with 15 kg uranium
  TRIGA reactors have a unique fuel type;
  uranium–zirconium hybrid combination
  8% uranium
  91% zirconium
  1% hydrogen

Other uses of nuclear energy

The regulation also applies to mining and milling 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 extraction 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 data as well as nuclear sector research and development activities and the transport of nuclear materials and nuclear waste.

3 Development of regulations

No amendments to the Nuclear Energy Act (990/1987) or any related Decrees were implemented in 2014. STUK prepared in cooperation with the Ministry of Employment and the Economy an amendment of the Nuclear Energy Act, based on the results of the international IRRS evaluation on STUK's regulatory work in 2012, that would change the monitoring of the surroundings of nuclear power plants and mines into one of STUK's regulatory duties and also implement other changes that would emphasise STUK's independent position in the regulation of nuclear safety. The bill included, for instance, a proposal on giving STUK the authorisation to issue binding regulations. The bill proposes that most of the technical requirements that are currently issued as Government Decrees would be changed into STUK's regulations starting from the beginning of 2016. The Government bill also involves a proposal on increasing the funding to ensure nuclear safety expertise. The increased funding would ensure retention of an up-to-date Finnish nuclear safety research infrastructure. The Government bill was issued in December 2014.

One new YVL Guide was added to the YVL Guides published in 2013. This means that there are now 45 YVL Guides in total. The Guide on environmental radiation monitoring was divided into two separate instructions, one on assessing population radiation doses and the other on regulatory oversight of the environment. This enabled the finalising of requirements on environmental radiation monitoring before the processing of the abovementioned Government bill. Two YVL Guides, YVL A.9, Regular reporting on the operation of a nuclear facility, and YVL E.10, Emergency power supplies of a nuclear facility, were published in 2014. It was noted that some of the requirements in the already published Guides need to be supplemented. As a result of an assessment of modification needs, seven Guides were updated and new versions were published. These were Guides about management systems, competence of personnel, construction of a NPP, occupational radiation protection, non-destructive testing and testing facilities. Four old YVL Guides are still valid. These Guides are about environmental radiation monitoring.

Translations into English of forty YVL Guides were published in 2014.

Systematic training on application of new YVL Guides has been provided for STUK's personnel involved in nuclear safety regulation. Furthermore, three courses in English, meant for stakeholders, were arranged in 2014.

The new YVL Guides are applied as such to new NPPs. In the case of NPPs under construction and operating NPPs, the YVL Guides will be brought into effect by means of a separate implementation decision by the end of 2015. Related requests for supplementary information were sent to the NPPs currently in operation, the NPP under construction and the research reactor in early 2014. STUK requested from the licensees an assessment on compliance of the operating NPPs and the research reactor with the requirements as well as any development plans by the end of 2014. Assessment of the compliance of the NPP under construction will be completed in connection with the operating license process.

Structure of the new YVL-guides

A Safety management of a nuclear facility	B Plant and system design	C Radiation safety of a nuclear facility and environment	D Nuclear materials and waste	E Structures and equipment of a nuclear facility
A.1 Regulatory oversight of safety in the use of nuclear energy	B.1 Safety design of a nuclear power plant	C.1 Structural radiation safety at a nuclear facility	D.1 Regulatory control of nuclear safeguards	E.1 Authorised inspection body and the licensee's in-house inspection organisation
A.2 Site for a nuclear facility	B.2 Classification of systems, structures and components of a nuclear facility	C.2 Radiation protection and exposure monitoring of nuclear facility workers	D.2 Transport of nuclear materials and nuclear waste	E.2 Procurement and operation of nuclear fuel
A.3 Management system for a nuclear facility	B.3 Deterministic safety analyses for a nuclear power plant	C.3 Limitation and monitoring of radioactive releases from a nuclear facility	D.3 Handling and storage of nuclear fuel	E.3 Pressure vessels and piping of a nuclear facility
A.4 Organisation and personnel of a nuclear facility	B.4 Nuclear fuel and reactor	C.4 Assessment of radiation doses to the public in the vicinity of a nuclear facility	D.4 Predisposal management of low and intermediate level nuclear waste and decommissioning of a nuclear facility	E.4 Strength analyses of nuclear power plant pressure equipment
A.5 Construction and commissioning of a nuclear facility	B.5 Reactor coolant circuit of a nuclear power plant	C.5 Emergency arrangements of a nuclear power plant	D.5 Disposal of nuclear waste	E.5 In-service inspection of nuclear facility pressure equipment with non-destructive testing methods
A.6 Conduct of operations at a nuclear power plant	B.6 Containment of a nuclear power plant	C.6 Radiation monitoring at a nuclear facility	D.6 Production of uranium and thorium	E.6 Buildings and structures of a nuclear facility
A.7 Probabilistic risk assessment and risk management of a nuclear power plant	B.7 Provisions for internal and external hazards at a nuclear facility	C.7 Radiological monitoring of the environment of a nuclear facility		E.7 Electrical and I&C equipment of a nuclear facility
A.8 Ageing management of a nuclear facility	B.8 Fire protection at a nuclear facility			E.8 Valves of a nuclear facility
A.9 Regular reporting on the operation of a nuclear facility				E.9 Pumps of a nuclear facility
A.10 Operating experience feedback of a nuclear facility				E.10 Emergency power supplies of a nuclear facility
A.11 Security of a nuclear facility				E.11 Hoisting and transfer equipment of a nuclear facility
A.12 Information security management of a nuclear facility				E.12 Testing organisations for mechanical components and structures of a nuclear facility

Collected definitions of YVL-guides: same data is shown both as the collection and within the guides.

Figure 4. The structure of the new YVL guides at the end of 2014.

4 Regulatory oversight of nuclear power plants and its results in 2014

4.1 Loviisa NPP

4.1.1 Overall safety assessment of Loviisa NPP

STUK oversaw safety of Loviisa NPP 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 by overseeing operations onsite.

Radiation doses of the employees were low in 2014 partly because of the brief annual outages but also because of improvements in radiation protection procedures and modifications implemented in order to decrease the number of materials causing the radiation dose. Radioactive releases into the environment were also low; they remained clearly below the set limits. Thus, they did not influence the radiation exposure of the environment or people. An emergency preparedness drill was arranged at the Loviisa NPP in November to practice, for the first time in Finland, a simultaneous emergency at two plant units. On the basis of inspections carried out and the drill, the emergency preparedness of Loviisa NPP complies with the requirements. The NPP introduced a new environmental monitoring system that includes more measurement stations than the previous system and a new weather observation system. On the basis of this regulatory oversight, STUK can state that plant operations did not cause a radiation hazard to the employees, population or the environment.

If necessary, the release of radioactive materials to the environment will be limited by the reactor coolant system and the containment. Based on tests completed, the leaktightness requirements for the outer containment isolation valves at Loviisa NPP were met. Furthermore, leaks from containment penetrations and openings, such as personnel airlocks, have remained low at both plant units. No leaking fuel assemblies were observed at either of the plant units nor had ageing phenomena compromised structural integrity of the reactor coolant system components. Based on tests and inspections, the reactor coolant system and containment have remained in the condition laid down in the design specifications.

In 2014, the NPP reported six events warranting a special report. The number of events and the observed defects in procedures clearly require further measures of the licensee. The licensee has several pending long-term nuclear safety development projects that involve development of the management system, processing of operational events and maintenance of the operational limits and conditions. STUK will monitor their progress and assess effectiveness of the measures. According to STUK's assessment, the risk caused by operational activities at Loviisa NPP in 2014 remained at around the same level as in the past years. STUK is of the opinion that plant operation has been systematic and safe.

A large number of maintenance measures and modifications are carried out at the NPP each year to ensure safe and reliable operation of the plant. The purpose of an I&C renewal project that was launched at Loviisa NPP in 2005 was to digitalise almost the entire I&C system of the NPP. In 2014 Loviisa NPP announced that the supplier of the modernisation had been changed and the scope of the renewal project had been significantly cut back, which is why the project would not be completed until by the end of 2018. The safety significance of the updated modernisation project will be comprehensively assessed the next time in connection with the periodic safety review of Loviisa NPP in 2015. In addition to this major modification project, a watertight ceiling was constructed to protect the main control room of Loviisa 1 from any leaks at the feedwater tank level, ventilation units of the Loviisa 1 main control room were replaced,

Table 1. Events at the Loviisa units warranting the power company's special report or root cause analysis. All events subject to reporting are discussed in Appendix 1 (indicator A.II.1). Appendix 3 describes events warranting a special report in more detail.

Event	Non-compliances with the OLC	Erikoisraportti	INES-luokka
Inoperability of the noble gas measuring system that participates in the monitoring of radioactive material releases at Loviisa 1 due to a human error		Special report	INES rating
Out of date operational limits and conditions of Loviisa 2 with respect to thermal load of the spent fuel storage pool	•	•	0
Non-compliance with the operational limits and conditions during shutdown stage of Loviisa 1 annual outage	•	•	0
Brief malfunction of Loviisa 2 containment ventilation system during annual outage	•	•	0
Safety injection system valve erroneously closed at Loviisa 2	•	•	0
Some inservice inspections of Loviisa weather mast not performed		•	0

reliability of the reactor coolant system's pressure control system at Loviisa 2 was improved, it was ensured that there will be no defects like hydrogen flaking in the structural materials of the Loviisa 2 reactor pressure vessel, and qualified safety valves were installed for the secondary side water and water/steam flow.

Several upgrade projects that will improve plant safety and which have been designed based on assessments of the Fukushima accident are also ongoing at the NPP. In 2014, Fortum installed four air-cooled heat exchangers that will ensure residual heat removal from the fuel in the reactor and the fuel pools in case heat transfer to the sea is lost. Furthermore, separate flood protection components have been installed in some systems important to safety. The protection elements take into account exceptionally high seawater levels during a storm. The calculated core damage frequency of Loviisa 1 was around 8% lower than at the end of 2013. The reduction of the risk is due to several system and software modifications and an update of reliability information. The annual probability of a severe reactor accident calculated for Loviisa 2 was somewhat lower than that for Loviisa 1.

Fortum Power and Heat Oy implemented an organisational reform in the spring of 2014. The reform boosted the licensee's role in the management and monitoring of Loviisa NPP. The organisational reform included the establishment of a new unit at Loviisa NPP. The new unit is in charge of the development of the NPP's processes, quality management, operating experience feedback, safety culture and actions as a notified body. Based on the inspections implemented over the course of the year, STUK required improvements regarding functionality of the licensee's processes, the management of non-conformances and the competence of personnel. As part of the oversight of the organisation, STUK ordered a study to assess the nuclear safety culture of Fortum and the functionality of related procedures. The report states that safety is appreciated at Loviisa NPP and the safety culture in general is at an acceptable level. However, the NPP must continue active development of their safety culture. Fortum Power and Heat Oy and the Loviisa NPP organisation have operated in a systematic and development-oriented way to ensure safety of the plant. On the other hand, STUK has required, based on its oversight, that the NPP develop more explicit procedures for monitoring of a variety of development measures and verifying their effectiveness.

Final disposal of the low- and intermediate-level operational waste generated during the operation of Loviisa NPP is arranged at a repository located in the plant area. Based on a periodic safety review implemented in 2014 as a prerequisite for the operating license of Loviisa NPP, STUK stated that safety level of the repository is good in terms of operational safety and long-term safety, and that the licensee has implemented the procedures needed to continue safe operation.

4.1.2 Plant operation, events during operation and prerequisites of safe operation

Compliance with operational limits and conditions

The operational limits and conditions (OLC) list the values within which nuclear power plant units must remain during operation. The OLC must be kept up-to-date at all times, i.e. the licensee must assess the need to update the OLC when planning modifications, for example. The licensee must comply with the OLC. Deviations from the OLC are only allowed based on a safety analysis, provided that the deviation will not compromise plant safety or radiation safety and that STUK has approved the deviation. A deviation may be justified to ensure, for instance, occupational safety or to implement a modification that will improve safety. STUK assesses the OLC and verifies that they are up to date both when inspecting modifications and reviewing analyses, and in connection with oversight at the plant site.

Fortum applied for permission from STUK for six planned deviations from the operational limits and conditions. Three of the applications concerned modifications and three concerned the enabling of the plant unit's startup after the annual outage. As the planned deviations had no significant safety implications, STUK approved the applications. The number of applications for exemptions from the OLC is included in indicator A.I.2, included in Appendix 1 to this report.

In 2014, Loviisa NPP reported six events to STUK where the plant was non-compliant with the OLC without an advance safety analysis and STUK's permission. Three of the events occurred during the annual outage, and these events concerned planning and management of work: two of the events involved simultaneous performance of different types of jobs even though the necessary prerequisites had not been met. In the third event, a valve was erroneously left in the closed position after a leak test. Two of the events concerned operability of measuring instruments used to monitor releases of radioactive materials and predict their spreading. One of the events concerned maintenance of the OLC and compliance with the OLC. Fortum analysed all six OLC deviations and determined corrective measures to prevent the events

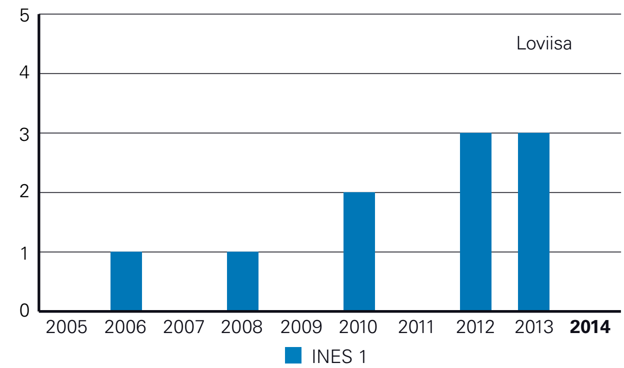


Figure 5. INES classified events at the Loviisa plant (INES Level 1 or higher).

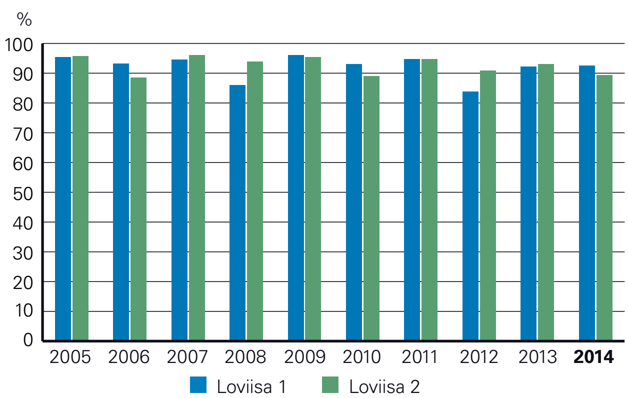


Figure 6. Load factors of the Loviisa plant units.

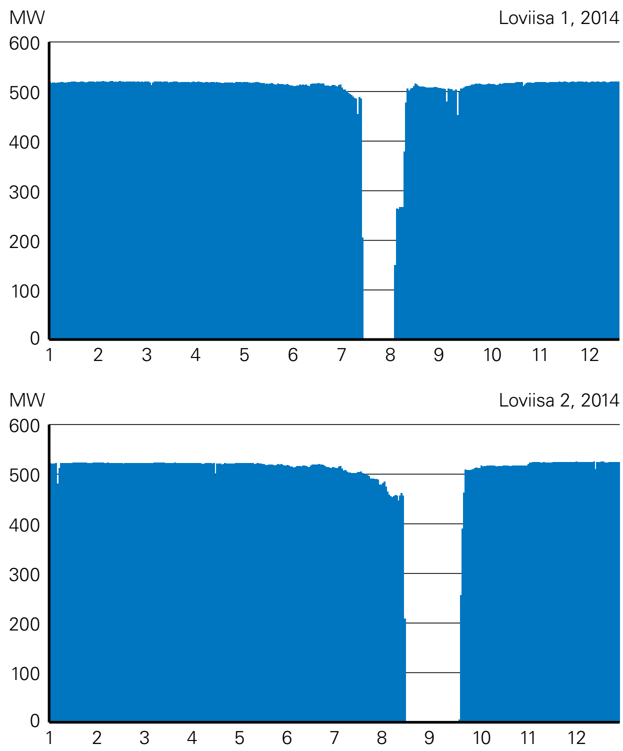


Figure 7. Daily average gross electrical power of the Loviisa plant in 2014.

from recurring. The events are described briefly below in the section on operational events and in more detail in Appendix 3.

The number of events non-compliant with the OLC is included in indicator A.I.2, included in Appendix 1 to this report. Chapter 4.1.2 in STUK's annual reports for 2012 and 2013 describe six OLC deviations involving changing of the operating mode and the root cause analysis initiated based on them. Fortum implemented the analysis at the turn of the year 2013/2014. In the analysis, Fortum studied why the events have recurred and determined measures to prevent their recurrence. All of the measures will be implemented by the 2015 annual outages. Effect of the measures can be verified during future annual outages and repair outages (if any). One similar event occurred during the annual outage of 2014.

Fortum maintained the operational limits and conditions in 2014 by submitting a total of 17 proposed amendments to the OLC to STUK for approval. Most of the amendments were necessary because of modifications implemented at the NPP and changes to operating methods. STUK approved eleven of the proposals as such. No justification was given for some of the proposed changes in four of the proposals, which is why STUK was unable to assess whether these changes were acceptable and thus decided to accept these changes only in part. STUK requested supplements to two proposals that were submitted at the end of the year in order to continue their processing. The processing of these proposals will be continued in 2015.

In 2013, STUK requested Fortum to supply an action plan on studying whether the OLC are up to date and on developing the OLC maintenance procedures (see Chapter 4.1.2 of the STUK annual report for 2013). STUK verified the status of the actions proposed in the plan by conducting an unannounced inspection at the plant site in December 2014. The results of the inspection are described in Appendix 5 to this report.

Operation and operational events

*One of the Loviisa 1 vent stack **emission monitors (noble gas monitoring) was inoperable in March** for several hours because the pump regulating the sample flow was inadvertently not restarted after a sample filter had been replaced. The operating personnel detected the deviation from the measurement results and started the pump.*

*In March 2014, it was observed that the Loviisa NPP **operational limits and conditions (OLC) were not up to date in all respects.** Some of the requirements pertaining to the spent fuel storage facility had not been updated in connection with modifications made years ago. Thus, the OLC and the work performance instructions were not fully consistent, which led to non-compliance with the OLC in December 2013: the thermal load of one of the storage pools exceeded the maximum thermal load laid down in the OLC by approximately 1%.*

*The administrative procedures used during the shutdown of the NPP unit Loviisa 1 in preparation for the annual outage 2014 were not successful in all respects. **The shutdown of the unit was continued even though the preconditions for transferring to the next stage had not been met**; some isolating valve leak tests were still being performed.*

***Negative pressurisation of the Loviisa 2 containment did not meet the OLC requirements when the reactor pressure vessel internals were being lifted back into place** after refueling during the 2014 annual outage. This event was caused by another simultaneous task: control valves of the containment ventilation system closed because of maintenance work carried out on a switchboard.*

*During an onsite inspection in November, the operating personnel of Loviisa 2 noticed that **one of the safety injection system valves had been left closed after a leak test performed during the annual outage** even though the valve should have been open. The valve is located in a pressurizer spray line that would be used after an accident.*

*During one of the inspections carried out in compliance with the periodic inspection programme, STUK observed that the Loviisa NPP **had not completed all of the meteorological measuring system inspections in compliance with the OLC**; the calibration of four temperature transmitters was not completed in 2013. Meteorological measuring is used to assess the spreading of any radioactive materials released from the NPP into the atmosphere.*

The events are described in more detail in Appendix 3.

Operation and operational events

STUK oversaw the operation at the plant site on a daily basis by reviewing regular reports on operating activities and event reports, and by conducting one operational inspection. The results of the reviews and inspections are described in Appendix 5 to this report.

No events leading to a reactor trip occurred at Loviisa NPP. Four events classified as operational transients occurred: one of the isolating valves in a steam line at Loviisa 2 was closed due to a fault in a relay card and one of the reactor coolant pumps of Loviisa 2 stopped due to a bearing temperature measurement fault in April and December. A turbine trip occurred at Loviisa 1 when the plant unit was being prepared for the annual outage; the chain of events started when an air hose of a level control valve for the condensate drains collecting tank ruptured. The number of operational transients and changes therein are studied in more detail in Appendix 1 (indicator A.II.1).

Loviisa NPP drafted special reports for other significant events. Six events warranting a special report were detected in 2014 (see the enclosed list). The events are described in more detail in Appendix 3.

In 2014, the risks caused by component malfunctions, preventive maintenance and other events causing unavailability of equipment were 3.2% (Loviisa 1) and 0.5% (Loviisa 2) of the expected value of the annual accident risk calculated using the plant's risk model. The result is in line with those of previous years.

Annual maintenance outages

Some of the nuclear fuel is replaced with fresh fuel during an annual outage. Other measures implemented during an annual outage include inspecting, maintaining, replacing or modifying equipment and structures important to plant safety. These measures ensure the preconditions for operating the NPP safely during the following fuel cycles.

STUK is obligated to verify that the licensee properly handles radiation and nuclear safety. STUK oversees the planning, implementation and assessment of annual outages, in practice by reviewing documents pertaining to the planning and implementation, as well as by conducting inspections onsite. The startup of a plant unit after an annual outage always requires a permit from STUK. Prior to issuing the permit, STUK will verify that the reactor core has been designed in such a manner that it is safe, and check that the work on all equipment and structures important to plant safety has been completed and all malfunctions have been properly studied.

During the annual outages, some events were observed at the Loviisa NPP. These events were documented and decisions on further studies and corrective measures were made. Two of the events were identified as the most significant events, and special reports were drafted for these events.

According to the observations made by STUK, operation during the 2014 annual outage was mostly fine. Some issues where further studies are needed and some potential improvement objects in terms of compliance with instructions and plans,

Annual outage of Loviisa 1

The annual outage of Loviisa 1 took approximately 21 days. The outage was around 1.5 days longer than planned. The delay was caused by several repairs and leak tests related to the leaktightness of one of the containment isolation valves.

One quarter of the fuel was replaced with fresh fuel during the annual outage. Furthermore, inspections, maintenance, repairs and testing of systems, equipment and structures were carried out. No extensive modifications or repairs were implemented, since the 2014 outage was a short annual outage.

Annual outage of Loviisa 2 (16 August – 20 September 2014)

The annual outage of Loviisa 2 took around 35 days. The outage was four days longer than planned. The delay was caused by observations made during the commissioning tests of new main steam line safety valves and the study of these observations.

It was a more extensive annual outage that is implemented every four years. In addition to the normal annual outage work, major modifications were implemented, such as modernisation of the reactor coolant system pressure control system, replacement of the main steam line safety valves and an upgrade of the circulating water piping. One quarter of the fuel was replaced with fresh fuel also in Loviisa 2.

orientation, instructions, work supervision and documentation were observed.

4.1.3 Ensuring plant safety functions

Deterministic safety analyses

An extensive assessment of the transient and accident analyses (deterministic safety analyses) carried out to verify the safety functions of Loviisa NPP was performed in connection with the renewal of the plant's operating license in 2007. The licensee has later supplemented the deterministic safety analyses with an extension of postulated accidents and in connection with plant modifications. The licensee did not submit any updated analyses to STUK in 2014.

Probabilistic risk assessments

The risk of a severe nuclear accident is evaluated on the basis of a probabilistic risk assessment (PRA). As a rule, PRA calculations utilise regularly updated information on the occurrences of initiating events and the unavailability of equipment together with a logical model of the plant's systems and their interdependencies. The model is used to assess, for example, the annual risk of severe reactor fuel failures, which is also called the core damage frequency.

In 2014, Fortum reassessed the frequency of seawater flooding at Loviisa NPP in cooperation with the Finnish Meteorological Institute. According to the preliminary updated reports, the frequency of flooding that exceeds the flooding limit of +3.0 metres in the NPP facilities 10^{-5}/year) is clearly higher than that determined in a previous assessment (approximately 5×10^{-7}/year). The change caused an increase of around 25% to the core damage frequency assessment. However, Fortum has improved the plant's flood protection during power operation in 2014 and 2015 in such a manner that one of the cooling systems will remain operational until the seawater level reaches the height of approximately +4.0 m. The risk assessment for seawater flood still remains slightly higher than before when the improvements are taken into account. The impact on the total risk remains low, however.

The PRA model for Loviisa NPP used to describe the plant unit Loviisa 1. In 2014, Fortum completed a separate PRA model for Loviisa 2. There are some relatively minor technical differences between the units in the ventilation system for the safety system equipment rooms, for instance. These differences influence the core damage frequency assessments. In 2014, Fortum used the preliminary results of the new PRA model to improve its instructions on ventilation system malfunctions at Loviisa 2.

At the end of the year the calculated core damage frequency for Loviisa 1 (prior to the flood protection improvements) was around 3.1×10^{-5}/year, which is around 25% higher than in 2014 (2.5×10^{-5}/year). The core damage frequency after the flood protection improvements is 2.3×10^{-5}, which is around 8% lower than at the end of 2013. The reduction of the risk is due to several fairly minor system and software modifications and an update of reliability information. The estimated probability of a severe reactor accident for Loviisa 2 at the turn of the year was around 2.5×10^{-5}/year.

The accident risk at Loviisa NPP and its changes are discussed in more detail in Section A.II.4 of Appendix 1, *Accident risk of nuclear power plants*.

4.1.4 Integrity of structures and equipment

Reduction in the frequency of internal reactor pressure vessel inspections

STUK approved a proposal to reduce the frequency of visual inspections of the internals in the reactor pressure vessels at Loviisa NPP from every four years to every eight years. Fortum justified the new inspection frequency by stating that the risk of falling heavy loads would be lower and the collective occupational dose would be smaller if the internals were no longer dismantled every four years. A prerequisite determined for the change was that the visual internal inspection would have to be replaced with a qualified external ultrasound inspection that would have to cover the entire pressure vessel core area and critical welds. The core area has been identified as the most important part of a pressure vessel in terms of safety, and the new procedure will increase the effectiveness of its inspections. The inspection technique to be used will also allow detection of planar faults parallel to the surfaces throughout the entire wall thickness. The technique can be used to overrule the possibility of hydrogen flaking in the structural material of reactor pressure vessels. Such defects have been detected at the Belgian NPPs, for example. Such a verification inspection was performed at Loviisa 2 during the 2014 annual outage. Nothing to report was observed during the inspection. The pressure vessel of Loviisa 1 will undergo a similar inspection during the 2016 annual outage.

Reactor coolant system pressure control valve

A new reactor coolant system pressure control valve (PORV) that was installed during a pressure control system modification at Loviisa 1 in 2012 allowed steam from the reactor coolant system to leak into the drain system because the seats of the main valve and its control valve were not fully leak tight. The leak was minor when compared to the limit set for unidentified leaks in the OLC (0.2 m^3/h). Planned operation of the valves was not compromised. Fortum has stated that the leaks are an availability problem and will cause extra maintenance work during annual outages. Fortum has studied the cause of the leaks with the valve manufacturer and ordered a damage report from VTT Technical Research Centre of Finland. Attempts to improve the valve's leaktightness have been made by replacing components and repairing a machining fault observed during the studies in the sealing face of the control valve.

Leak in spray valve bonnet

Pressurizer spray valves were replaced with a new type during the reactor coolant system pressure control system modification at Loviisa 1. The modification was implemented during the 2012 annual outage. A similar modification was carried out at Loviisa 2 during the 2014 annual outage. The new valves are solenoid-operated bevel-fit valves.

When replacing the valves, Fortum wanted to develop the valve type, which is why Fortum ordered valves equipped with continuous bonnet leak detection. The leak detection was implemented by adding a second seal in the bonnet and adding pressure measuring in the space between the seals. This means that the control room will be notified of any minor leaks in the inner seal while the outer seal is still keeping the bonnet leak tight. Such a leakage indication concerning one of the spray valves at Loviisa 1 was received during the fuel cycle preceding the annual outage.

The sealing solution had already been improved once in 2013. At that time, the inner graphite seal was replaced with a seal whose density is better suited for the application. The desired results were not achieved, however. The clearance in between the bonnet and sleeve of the valve for which a leakage indication had been issued was increased by means of abrasion during the 2014 annual outage. Based on the operating experience obtained so far, this modification was successful. If the valves in both units continue to operate as planned, Fortum will discontinue extra monitoring of the valves. The extra monitoring has included onsite inspection visits as well as temporary humidity and temperature measuring in the area.

Fuel

The fuel elements closest to the reactor pressure vessel wall were replaced with protective elements manufactured from steel in both units of Loviisa NPP during the early stages of operation in order to slow down the radiation embrittlement process of the wall. The top tie plates of these protective elements include springs that prevent the elements from moving upwards during operation. Fortum ordered new spring packs for the protective elements. The plan was to commission the new spring packs during the annual outage of Loviisa 2 in August and September 2014. Since their delivery was not completed on time, however, Fortum decided to reassess the usability of the backup spring packs that were rejected during an acceptance inspection in 2005. After the reassessment, 207 spring packs for the protective elements were accepted. During the autumn, Fortum conducted several manufacturing control inspections of the 2014 delivery and accepted the new spring packs as well.

During the 2014 annual outage, wear and deformation measurements conducted according to plan on six control rods at Loviisa 2 and results of visual inspections showed that there are no foreseeable obstacles for extending the control rods' service life to 30 years.

During fuel inspections conducted with the pool inspection equipment according to the 2014 research plan, no deviations were detected in an assembly equipped with unanodised fuel cladding, a condition monitoring assembly that is subject to long-term monitoring or a test assembly without fuel and equipped with a mixing spacer grid. One leaking rod was observed in an assembly where a leak was observed in 2009. Inspections to determine the cause of a leak in an assembly where a leak was observed in 2008 were postponed to 2015. A fuel assembly that started to leak in December 2012 was removed from the reactor of Loviisa 2 during the 2013 annual outage. It has not been studied yet to determine the cause of the leak.

Maintenance, ageing management, spare parts management

The Ageing Management Committee plans and coordinates STUK's regulatory duties pertaining to the management of ageing of nuclear power plants. The regulatory activities at the Finnish NPPs focus on any cases where faults or increased repair needs have been observed in structures or components important to safety. The committee addresses such cases and demands corrective measures by the licensee if it deems that condition monitoring or maintenance has been defective. The committee also assesses events at NPPs outside of Finland and any links between them and the monitoring of the ageing of the Finnish NPPs. The Ageing Management Committee has monitored at Loviisa, for instance, stator blades of the reactor coolant pumps, operability of the emergency diesel generators, indications in steam generator tubes and – because of cracks observed in other VVER plants – bimetal welds in steam generator collectors.

Loviisa NPP assessed the spare parts management of plant components important to safety. Procurement, reception, storage and handover for operation of spare parts and supplies were studied during the inspection. Warehouses may contain very old products, even ones dating back to the commissioning of the NPP. Fortum is currently drafting instructions on ensuring operability of spare parts and reviewing the spare part stock, consumption and the fault histories of components in order to assess adequacy of spare parts, their quantities and the correct times to place orders for new spare parts.

Inservice inspections

The inservice inspections of Loviisa 1 and Loviisa 2 were implemented in compliance with an inservice inspection programme approved by STUK. The programme included video inspections of reactor pressure vessel internals, as well as inspections of steam generator tubes and dissimilar metal welds. Pipelines were subjected to inservice inspections and erosion measurements. The tubes of two steam generators were inspected at both units. Nothing to report was observed during the inspection of dissimilar metal welds in steam generators.

Emergency diesel generators

The diesel engines of the emergency diesel generators date back to their installation year, and Loviisa NPP no longer plans to replace them. Spare parts are still available, and operability of the engines is ensured by means of maintenance and inspection programmes. They are subjected to mechanical stress, particularly during sequence tests that are annually implemented at each unit. There are plans to arrange these tests less often or to simulate them. Their mechanical components have required more repairs in the past few years, but reduced operability has never been determined as the cause for a failure of the unit to start during testing. There are bearings at the bottom ends of the connecting rods in the diesel engines that are currently in use at the Loviisa units. They were replaced with new ones in an overhauled diesel engine in 2012 because the previously used bearings had worn out faster than expected. The new bearings were tested and approved by the engine manufacturer. At that time, STUK required that the new bearings are monitored and the results reported to STUK. No wear that was out of the ordinary was observed in a visual inspection of a bearing during the 2013 annual outage. No deviations were detected in the lubricating oil analyses, either. New bearings have now been replaced also in the other diesel engines. A bearing that was taken into use in 2012 was visually inspected during the 2014 annual outage. Based on the inspections, the new bearings are well suited for such an application.

Containment

The containments at Loviisa meet the design requirements. Based on leak tests implemented in 2014, two valves were repaired at Loviisa 1 and one valve and one containment penetration were repaired at Loviisa 2. Furthermore, STUK demanded that one of the valves repaired at Loviisa 1 be replaced with a valve that meets the detection limit requirements during the 2015 annual outage.

Pressure equipment manufacturers and inspection and testing organisations

STUK approved, pursuant to the Nuclear Energy Act, six manufacturers of nuclear pressure vessels for the Loviisa power plant on application by the Loviisa power plant of Fortum Power and Heat Oy. In addition, STUK approved, on application by the Loviisa power plant of Fortum Power and Heat Oy and pursuant to the Nuclear Energy Act, four testing organisations to carry out tests related to the manufacture of mechanical equipment and structures. Testing operators from three testing organisations were approved for carrying out periodic tests of mechanical equipment and structures in accordance with YVL Guide 3.8.

4.1.5 Development of the plant and its safety

I&C renewal at Loviisa NPP

A continuation project for the Loviisa NPP I&C renewal, ELSA, was launched in June 2014. The project is a continuation for the discontinued LARA project, which was concluded based on a mutual agreement of the equipment supplier and the licensee. The ELSA project will modernise a large part of the I&C system of the plant, switching it to a digital equipment platform. ELSA's scope is not as comprehensive as that of LARA. For example, no major modifications will be implemented in the control room and the diesel I&C system will not be changed either. The plan is to install the first stage of the renewal in 2016. In 2014, STUK's oversight and inspection activities focused on quality assurance procedures and instructions used in the planning processes of the new project.

Replacement of main control room ventilation units

A watertight ceiling will be constructed to protect the control room of Loviisa NPP from any leaks at the feedwater tank level. The ventilation ducts and the control room ventilation units will be replaced in connection with this modification. The ducts and ventilation units maintain the predetermined environmental conditions. In a modification implemented at Loviisa 1, the main control room ventilation units were moved to a room next to the control room and cooling water pipes were moved to above the watertight ceiling. The system's operating principle was not changed. Functionality of the new units has been tested. The trial runs will continue in 2015. STUK inspected the modification plans, oversaw the construction and trial runs, and implemented commissioning inspections. The remaining modifications, tests and inspections will be implemented in 2015. A similar modification will be started at Loviisa 2 in 2015.

Reactor coolant system pressure control system upgrade

Modernisation of the Loviisa 2 reactor coolant system pressure control was carried out according to plan during the annual outage. The modification aimed at improving the usability and reliability of the pressure control system. The modification included replacing of the pressurizer spray valves and relief valve. The modification also involved changes to the I&C systems, electricity systems and pipelines required in the implementation of the new pressure control system. STUK inspected the modification plans, oversaw the manufacture of the mechanical components and carried out a construction inspection on the components. When the installation work was complete, STUK performed the necessary construction inspections and system commissioning inspections onsite.

A similar modification was implemented at Loviisa 1 in 2012. Fortum assessed the problems encountered in planning, implementation and commissioning during the modification at Loviisa 1 and developed its procedures for the Loviisa 2 modification. The operating methods and organisation were changed, and sufficient resources for the project were reserved. The modification was implemented according to plan and on schedule without any major deficiencies.

Replacement of safety valves

Each of the Loviisa NPP secondary circuit main steam lines has two safety valves (with staggered set pressures). These have been qualified for steam flow only. The safety valves with the lower set pressure at Loviisa 2 (six valves) were replaced during the 2014 annual outage. The plan is to implement a similar modification at Loviisa 1 in 2016.

The new valves are qualified for steam, water and a mixture of the two. Fortum received the new valves for Loviisa 2 in June 2014, approximately six months behind the original schedule. The valves were being installed and tested for the entire five-week annual outage. The first major deviation during the implementation of this modification occurred when a subcontractor failed to follow the qualified welding instructions when welding the first valve nozzle of the pipeline. Fortum detected the problem early on in an inspection and the technical deviation was corrected by dismantling the already started weld. After some rearrangement, the faulty weld could be replaced with a new one that was welded in compliance with the qualified welding instructions, which were approved in connection with the construction plan.

Another deviation occurred during the commissioning testing of the valves: it was noted that the forced control of the valves did not work at such a low system pressure as originally planned. The lowest opening pressure in the plan was around 3 bar. During testing, it was observed that the valves opened at 10 bar, and the manufacturer verified that the lowest possible opening pressure is 7.5 bar. The purpose of the forced control of the valves is to cool the reactor coolant system in case of a highly exceptional accident where none of the other reactor coolant system cooling methods from the secondary side are available. Fortum has submitted to STUK for processing supplementary information on the impact of the modification on accident management. At the end of 2014, STUK was still processing the report.

Development targets determined when renewing the operating license

The last periodic safety review of Loviisa 1 and Loviisa 2 took place during the operating license renewal project in 2006 and 2007. Development targets and projects were determined in connection with the review. STUK has monitored their status as part of its regulatory oversight. Most, but not all of the monitored projects and tasks have been completed, mainly because some large projects of Fortum have been delayed. Such projects include the renewal of the plant's I&C systems, modernisation of a polar crane and modernisation of the refueling machine. The processing and assessment of the outstanding issues will continue in connection with the currently ongoing periodic safety review (PSR2015), for example.

Development targets based on Fukushima accident

After the Fukushima accident in 2011, STUK sent a decision to the licensees concerning provisions and plans to be made by the power companies for natural phenomena and power supply disruptions. In 2014, Fortum installed, in compliance with plans approved by STUK, four air-cooled heat exchangers that will ensure residual heat removal from the fuel in the reactor and the fuel pools in case heat transfer to the sea is lost. Two towers were constructed at both units, one for residual heat removal from the reactor and the other for residual heat removal from the fuel pools.

To improve flood protection during power operation, Fortum decided to use a technical concept that involves sealing rooms in limited areas. The plan is to focus on protecting the backup emergency feedwater pump room from flooding. According to a preliminary schedule, the improvements will be implemented in the next two years. Flood protection during outages will be ensured by using stop-log gates that will prevent seawater from flooding the plant facilities. Fortum raised the structures of one of the stop-log gates at each unit in 2014. Deviating from the original plan, Fortum has proposed an extension on raising the second stop-log gates. STUK has accepted the extension, provided that Fortum submits an assessment of the risks caused by the new implementation schedule. According to the new schedule, the stop-log gates of Loviisa 1 will be raised in 2016 and the gates of Loviisa 2 in 2018.

At the end of 2014, Fortum submitted to STUK updated conceptual design plans on ensuring emergency cooling of the refueling pools and spent fuel storage pools in the containment. According to the plans, a redundant system for ensuring the cooling of the fuel pools in the reactor building will be built, and new connections will be added for the spent fuel storage pools to supply make-up water to the pools. STUK will continue the review of the materials in 2015.

Loviisa weather observation system upgrade

A new 115-metre mast for weather observation was built close to the Loviisa NPP in 2014. Weather observation system components were installed both in the mast and on the ground, but system trial run stage could not be started yet. The plan is to start the commissioning of the new weather observation system after final testing by the end of 2015. The new weather observation system will allow Loviisa NPP to obtain more specific data about weather conditions in the immediate vicinity of the plant. This data will be used when calculating the spreading of radioactive releases during normal operation of the plant and in case of an accident.

Loviisa environmental radiation measuring system upgrade

Loviisa NPP commissioned a new environmental monitoring system in 2014. The upgrade increased the number of measuring stations in the vicinity of the plant from 17 to 28. There are radiation measuring system stations at the plant site, two kilometres from the plant and five kilometres from the plant. Five new stations were installed in the plant site. The other new stations are farther away, most of them in the archipelago. The new environmental monitoring system stations are more accurate than the old ones and their integrated batteries ensure that they can remain in operation without any intervention for up to several years.

Main steam activity measuring system upgrade

Fortum is about to start an upgrade of a radiation measuring system that was commissioned in the 1990s. The system is used to measure the activity concentration of main steam. The radiation measuring system will detect any leaks between the primary coolant system and the secondary circuit. Spare parts are no longer available for the old radiation measuring instruments. When upgrading the system, Fortum plans to implement structural improvements based on operating experience. STUK approved a conceptual design plan on the system modification in 2014.

4.1.6 Spent nuclear fuel storage and NPP operational waste

The processing, storage and final disposal of low and intermediate level waste (NPP operational waste) at Loviisa NPP 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 contributing factors include the high quality requirements for nuclear waste management and nuclear fuel, the planning of maintenance and repair operations, decontamination as well as component and process modifications. In addition, the NPP employs efficient procedures for reducing the volume of waste destined for final disposal. Because of waste monitoring and sorting, some waste types that contain very little radioactive materials can be released from control. Waste released from control included operational waste, scrap metal for recycling and non-radioactive hazardous waste to be further processed, such as waste oil and waste chemicals. STUK has approved the licensee's procedures on releasing waste from control. STUK will monitor the activities, the amount of waste exempted from control and its activity concentrations.

In 2014, STUK oversaw operational waste management and final disposal of operational waste as well as the concrete and rock structures of the repository. STUK reviews and approves reports and other documents submitted to it, as well as performed regulatory inspections and inspections included in the periodic inspection programme. No significant deficiencies or development needs were observed during the inspections carried out in 2014.

Quantities of spent fuel and low-and intermediate-level waste in Loviisa

The volume of spent nuclear fuel stored on-site at the Loviisa power plant at the end of 2014 was 4,831 assemblies (582 tU), an increase of 174 assemblies (21 tU). The volume of low- and intermediate-level waste finally disposed of was 1,927 m³ at the end of 2014. The total increase of volume from 2013 is 40 m³. Approximately 57% of the waste has been finally disposed of.

Construction and commissioning of solidification facility for liquid radioactive waste

In 2014, commissioning of the solidification facility for liquid radioactive waste at Loviisa NPP proceeded to a stage where the systems were handed over to the NPP's operating organisation. However, the trial run of the facility was interrupted in early 2014 to study the cause of leaks observed in concrete waste containers. The leaks were observed during solidification tests in late 2013.

In 2014, Loviisa NPP launched a project that aims at ensuring the start of the facility's production operation and studying the underlying causes of the cracks in the waste containers. The project also includes reassessing the ingredients of the concrete used and drafting proper storage instructions for cast concrete containers. Furthermore, Loviisa NPP will plan and implement modifications of the solidification facility for liquid radioactive waste to improve availability of systems and components.

Loviisa NPP discovered two underlying reasons for the cracks in the waste containers. The aggregate had separated from the concrete in one corner of the container, which is why there were very few large stone particles in the area. The second reason was that the interior form had been detached with a pneumatic percussion tool, which had caused a crack in the inner corner of the container. The pneumatic percussion tool and the separated aggregate combined caused cracks to form in the container wall. These conclusions are supported by observations made when removing test containers from their forms with wedges instead of a pneumatic percussion tool: no similar cracks were detected in these containers. STUK has assessed the studies implemented by Loviisa NPP and deemed them adequate.

In 2014, Loviisa NPP performed preliminary testing of concrete containers with an updated list of concrete ingredients. STUK approved the concrete casting plans, reviewed the new concrete work instructions and the preliminary testing programme, and oversaw the casting of the containers.

Loviisa NPP drafted a report on the preliminary testing of the new concrete ingredients and its results. In addition, the NPP drafted a project plan and will update the commissioning plan to complete the commissioning of the solidification facility. STUK will continue the assessment by reviewing the above-mentioned materials.

According to the plans drafted by Loviisa NPP, the solidification facility commissioning tests will be completed by the end of 2015. When the commissioning tests are complete, the NPP will submit an application to STUK on starting production operation of the solidification facility.

Periodic safety review of Loviisa repository

Final disposal of the low- and intermediate-level operational waste generated during the operation of Loviisa NPP is disposed at a repository located in the immediate vicinity of the plant. With its decision dated 2 April 1998, the Government granted Fortum permission to use the repository until 31 December 2055. According to permit condition no. 2 of the operating license, the licensee must draft the first periodic safety review by the end of 2013 and then repeat the review every 15 years.

Fortum submitted a periodic safety review for the low- and intermediate-level operational waste repository on 16 December 2013 to STUK for approval. STUK drafted its own safety review, which is a summary of review of the licensee's periodic safety review, related issues and reviews of related documents, as well as results of STUK's continuous regulatory activities.

STUK's safety review and decision dated 15 December 2014 states that the safety level of the Loviisa low- and intermediate-level operational waste repository is good in terms of operational safety and long-term safety, and that the licensee has implemented the procedures needed to continue safe operation. STUK approved the periodic safety review of the Loviisa low- and intermediate-level operational waste repository carried out by Fortum. Schedules of the plans and reports on the Loviisa low- and intermediate-level operational waste repository, as well as their reconciliation will be determined once Fortum has submitted a justification on the long-term safety of the low- and intermediate-level operational waste repository and an update of the NPP's final decommissioning plan. These reports are due by the end of 2018.

Provisions for the costs of nuclear waste management

In compliance with section 88, subsection 2 of the Nuclear Energy Decree, Fortum submitted to the Ministry of Employment and the Economy revised and supplemented waste management schemes as well as information on costs and prices of nuclear waste management measures. A supplemented waste management scheme includes an updated cost estimate of the remaining waste management costs.

STUK reviewed the documents submitted in compliance with the Nuclear Energy Decree and submitted a statement regarding them to the Ministry of Employment and the Economy. In its statement, STUK assessed the cost estimates on which the financial provisions are based, considered them acceptable and stated that they can be used as the basis for the cost provisions. Fortum's extent of liability was €1,083.9 million at the end of 2014.

According to the Nuclear Energy Decree, supplemented waste management schemes for technical and financial plans, as well as related calculations, must be prepared every three years. The next revision will take place in 2016.

4.1.7 Organisational operations and quality assurance

Based on STUK's oversight, it can be stated that Fortum organisation has operated in a systematic and development-oriented way when it comes to ensuring safety. The licensee organisation of Loviisa NPP is Fortum Power and Heat Oy. An organisational reform of Fortum Power and Heat Oy was implemented in the spring of 2014. The reform boosted the licensee organisation's role in the management and monitoring of Loviisa NPP. A new unit, Nuclear Power Quality and Sustainability, was established during the reform for Loviisa NPP. It is in charge of developing processes at the plant level, quality assurance, operating experience feedback, safety culture and actions as a notified body. The unit also includes a function called Design Authority, which aims at ensuring compliance of the organisation with nuclear power legislation, official regulations and guidelines as well as retention of the NPP in the state required by the operating license. Instructions for this function will be supplemented by the end of 2015.

In connection with the safety assessment of its organisational reform, Fortum submitted to STUK a plan on a reform of its management system. The licensee's NSA unit (Nuclear Safety Assurance) will be in charge of the reform project. Over the course of the year, it has been independently monitoring the management and management system development measures at Loviisa NPP. STUK has monitored the progress of the reform during its regulatory activities and found that the reform proceeds in a systematic manner. Loviisa NPP has updated its administrative rules due to the organisational reform.

Over the course of the year, STUK paid special attention in functionality of the plant processes, management of deviations and personnel competence, as well as resources. The process descriptions are still unfinished and they will be supplemented when instructions are updated, for instance. Based on its oversight, STUK determined that the management of the NPP has not sufficiently monitored and ensured refresher training of employees who are important to safety. Based on its oversight, STUK demanded that proper training must be arranged and implementation of training must be monitored.

In its inspection, STUK verified that the NPP has improved the updating of instructions for the operating and maintenance units, and will continue to monitor the updating of the instructions for the operating and maintenance units. STUK found that the NPP has also developed its instructions on the management of deviations and the assessment of effectiveness, and will continue to assess the impact of the development of instructions on the NPP's activities during its regulatory oversight in 2015. Over the past few years, the NPP has developed its supplier audit process, related competence and related procedures. Based on its oversight, STUK determined that the procurement development project that was launched in 2013 was concluded in 2014.

Fortum currently has several ongoing long-term development projects on its management system for nuclear operations and management in general. STUK will continue to monitor their progress as part of its regulatory oversight. The development projects that are being monitored involve the safety culture, descriptions and development of management system processes, processing of operational events and maintenance of the OLC, for example.

In 2014, STUK observed some deficiencies in the scope of the development of the NPP's documents, regulatory requirements and operations. STUK will continue to monitor these issues and any changes in the operations by means of targeted inspections, for example. During its oversight, STUK paid special attention in the monitoring of development measures and the manner in which their effectiveness is ensured, and required that the NPP implement more explicit procedures on managing these issues.

Based on an order from STUK, VTT Technical Research Centre of Finland conducted a study on the status of the safety culture of Fortum's nuclear operations and functionality of assessment procedures. The study report was submitted to STUK for information in early 2014. The observations made by VTT in its study are similar to the observations made by STUK during its oversight. The study by

VTT stated that the safety culture of Loviisa NPP is at an acceptable level in general. However, some characteristics the researchers did not deem part of good safety culture were also observed. Thus, active development of the safety culture at Loviisa NPP must be continued.

In 2014, STUK approved a person named by the licensee as the person in charge of the NPP's safeguards of nuclear materials.

STUK oversaw the oral examinations of shift personnel at Loviisa NPP where the shift managers, operators and trainee operators prove that they are competent in all key issues related to plant operation and safety. In 2014, STUK granted 16 licenses to shift managers and operators based on applications by the power company and following a successful oral examination. All except one of the granted licenses were renewed licenses. One of the employees was applying for the shift manager license for the first time.

The results of the examinations were around the same level as in the previous years. All the participants passed their examinations in 2014. The longest possible license, four years, was granted to ten people, a three-year license to five people and a two-year license to one person, i.e. the one who was applying for the license for the first time.

4.1.8 Fire safety

Fire safety at the Loviisa NPP was acceptable. No events classified as fires occurred at Loviisa NPP or in its immediate vicinity in 2014. In 2014, STUK oversaw the maintenance and upkeep of the fire protection systems that ensure fire safety of the plant by means of regulatory inspections and by reviewing reports submitted by Fortum. An inspection included in the periodic inspection programme and onsite inspections by the resident inspectors were performed onsite.

Fortum continuously develops fire safety at Loviisa NPP. Condition of the fire water supply system is being assessed as part of an intermediate assessment of the plant's operating license. A manually triggered extinguishing system is to be installed in the reactor coolant pump room in the reactor building. Its construction started in 2014. A new extinguishing system has also been installed in the waste management facilities in the controlled area. The NPP has an appropriate fire safety training programme.

4.1.9 Operating experience feedback

STUK assessed the operating experience feedback activities and corrective measures on the basis of reports, regulatory inspections and inspections within the periodic inspection programme.

Over the course of the year 2014, a total of 51 events for which operational event reports were drafted took place at Loviisa NPP. Loviisa NPP reported to STUK a total of 13 events, six of which were events warranting a special report. All of the events warranting a special report involved an event that was non-compliant with the OLC. The special reports were prepared and submitted to STUK in accordance with the requirements, but the power company's investigation of some of the events remained superficial and incomplete. The events warranting a special report are described in more detail in Appendix 3. No events classified as Level 1 or higher on the International Nuclear Event Scale (INES) took place in 2014.

Two root cause analyses were completed at Loviisa NPP in 2014. The root cause analyses concerned heavy lifting and changing of operating modes.

In an operating experience feedback inspection, STUK verified operating processes and the organisation, as well as related guidelines, procedures and practices. An operating experience and safety culture committee has been established for Loviisa NPP. It is responsible for the maintenance and development of the plant's operating experience feedback process. The operations have been continuously developed, procedures are currently being improved and some resource changes were implemented over the course of the year. The inspection included verification of the implementation of corrective measures at Loviisa and at other NPPs on the basis of example cases. STUK found that there was still room for improvement in the follow-up of corrective actions decided on the basis of operational events at the plant, as well as in reliable assessment of the effectiveness of corrective actions. Sufficiency of resources must be ensured also from the viewpoint that high-quality reporting and operation must be implemented at the right time. STUK also demanded changes in the format and content of the plant's event reports and annual reports.

Regarding the latest events at the Loviisa units, STUK saved in the International Reporting System for Operating Experience (IRS) maintained by the IAEA three new reports on lead blankets accidentally left on top of reactor coolant system pipes during the fuel cycle, problems with the movements of control rods that occurred during the startup after the 2013 annual outage of Loviisa 2 and relay faults in the control circuits of the Loviisa NPP emergency diesel generators.

Loviisa NPP uses methods to assess and utilise operating experiences from other plants. Event reports and events at other plants outside of Finland are systematically and comprehensively reviewed. Fortum itself conducts pre-screening of the reports coming from various sources, mainly via the World Association of Nuclear Operators (WANO) and the IRS database maintained by the IAEA. The plant is in direct contact with other VVER plants. All the information on events and malfunctions at the other plants is assessed to determine whether it applies to Loviisa.

4.1.10 Radiation safety of the plant, personnel and the environment

Occupational radiation safety

STUK carried out a radiation protection inspection as part of the periodic inspection programme of Loviisa NPP, focusing on radiation measurements in particular. The scope of the inspection included the environmental radiation monitoring programme and the instruments intended for measuring radiation at the plant. Special attention was paid to the representativeness of radiation measurement and analyses, as well as the environmental monitoring programme. STUK required after the inspection that the power company update the radiation monitoring part of its final safety analysis report and draft a summary of a report by the power company on the representativeness of the measuring data provided by the radiation measuring system channels.

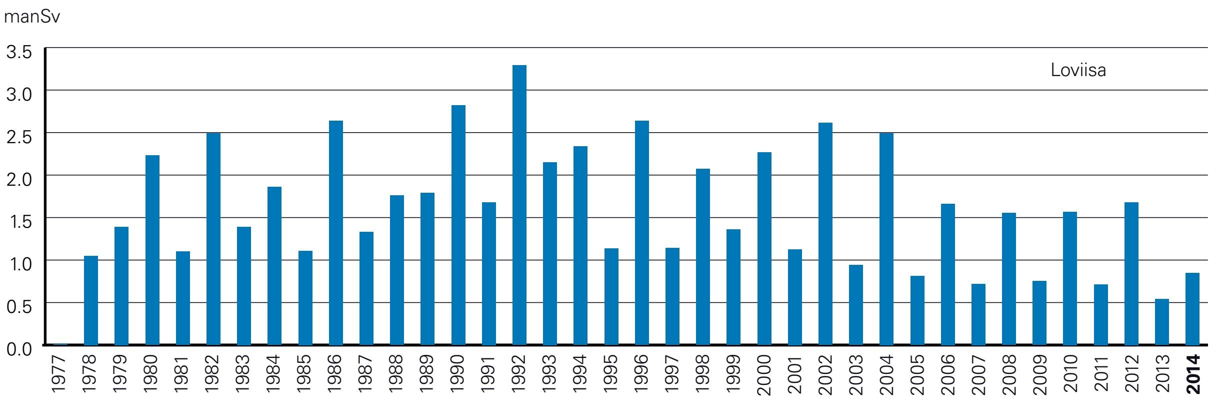


Figure 8. Collective occupational doses since the start of operation of the Loviisa nuclear power plant.

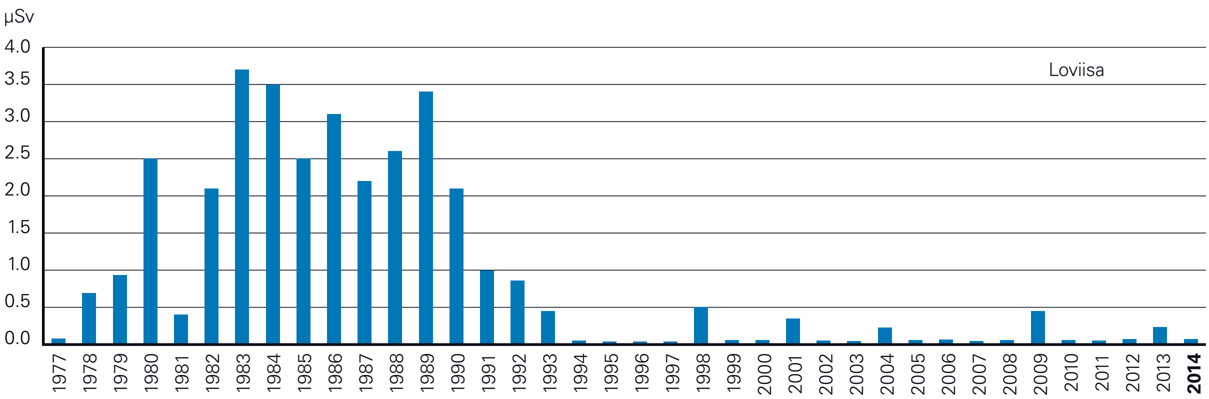


Figure 9. Annual radiation doses to the most exposed person of the public since the start of operation of the Loviisa nuclear power plant. Over the recent years, the doses calculated based on the radioactive discharges have remained below one percent of the set limit, 0.1 milliSv.

The dosimeters used for measuring the occupational radiation doses underwent annual tests. The tests comprised irradiating a sample of dosimeters at STUK's measurement standard laboratory and reading the doses onsite. The test results showed that the plant's dosimeters are in working order.

STUK carried out targeted radiation protection inspections during the annual outages. Radiation protection activities of the plant's radiation protection personnel and employees within the controlled area were assessed during these inspections. Based on the inspection results, radiation protection at the NPP is good: no major defects were observed. Individual development targets were also observed in the inspections, concerning boundary arrangements of radiation control areas requiring the use of additional personal protective equipment, the use of personal protective equipment, markings and management of the processing of circulating water. The plant's radiation protection organisation has developed methods to improve the occupational radiation safety of employees doing specific jobs.

In order to reduce activity levels of the reactor coolant system, Loviisa NPP continued to replace pump seals with types that do not contain any antimony. The rest of the seals, three in total, were replaced at Loviisa 1 and two seals were replaced at Loviisa 2. This means that all of the twelve reactor coolant pump seals of the NPP are now antimony-free. The dose rates are expected to decrease in the next few years, particularly in the steam generator room, since activated antimony (Sb-122 and Sb-124) has been a major cause of radiation doses at the NPP. It was observed during the 2014 annual outage that the dose rates in the steam generator room had already somewhat decreased from the level of the past years.

Radiation doses

In 2014, a short annual outage took place at Loviisa 1 and a four-year annual outage at Loviisa 2. The occupational radiation doses of nuclear power plant workers mostly accumulate during work carried out during annual outages. The highest individual dose incurred during the annual outage at Loviisa 1 was 4.5 mSv, while the same dose at Loviisa 2 was 8.8 mSv. The highest individual dose incurred during the entire year was 9.2 mSv. This dose was caused by work on insulation materials.

The radiation doses for plant employees remained below the individual dose limits. The effective dose for a worker from radiation work may not exceed the 20 manSv/year average over any period of five years, or 50 manSv during any single year.

The collective occupational radiation dose for the entire year was 0.32 manSv at Loviisa 1 and 0.53 manSv at Loviisa 2. Due to improvements in radiation safety, the collective occupational dose of employees at Loviisa 1 was the lowest ever recorded and the collective occupational dose at Loviisa 2 was also low even though a four-year annual outage was implemented. The collective occupational radiation dose caused by work carried out during the annual outage was 0.30 manSv at Loviisa 1 and 0.51 manSv at Loviisa 2. The collective occupational radiation doses at Loviisa NPP were lower than the average dose of similar pressurized water reactors (VVER) in OECD countries.

According to the YVL Guide issued by STUK, the threshold for one plant unit's collective dose averaged over two successive years is 2.5 manSv per one gigawatt of net electrical power. This means a collective dose value of 1.24 manSv per each Loviisa plant unit. This threshold was not exceeded at either of the units.

The individual radiation dose distribution of employees at the Loviisa and Olkiluoto NPPs in 2014 is given in Appendix 2.

Radioactive releases and environmental radiation monitoring

Radioactive releases into the environment from Loviisa NPP remained well below the authorised annual limits in 2014. Releases of radioactive noble gases into the air were approximately 5.8 TBq (as Kr-87-equivalent activity), which is approximately 0.04% of the set limit. The releases of radioactive noble gases were dominated by argon-41, an activation product of argon-40 originating in the air space between the reactor pressure vessel and the main radiation shield. Releases of iodine into the air were approximately 4 MBq (as I-131-equivalent activity), which is approximately 0.002 % of the set limit. Releases through the vent stack into the air also included radioactive particulate matter amounting to 32 MBq, tritium amounting to 0.1 TBq and carbon-14 amounting to approximately 0.4 TBq.

The tritium content of liquid effluents released

Table 2. NPP originated radioactive nuclides found in the environmental samples of the Loviisa power plant in 2014.

Sample types containing detected radionuclides. Figures indicate the number of positive samples in a sample group. Several different nuclides may be found in the same sample.

Radionuclide / Type of sample	H-3	Mn-54	Co-58	Co-60	Nb-95	Zr-95	Ag-108m	Ag-110m	Te-123m	Sb-124	Sb-125	I-131	Hf-181	Total
Air		1		4										5
Fallout			1	13				13	1	4				32
Plants (reindeer lichen)				1										1
Seabed fauna (Saduria Entomon)				1				1						2
Aquatic plants		1	2	7				8	1	2	1			22
Perifyton		1	2	3	1	1		2	2	2				14
Sedimenting materials				9			1	8		1				19
Seawater	7													7
Sludge		1	1	2	1	1		2	1	2		1	1	13
Total	7	4	6	40	2	2	1	34	5	11	1	1	1	115

into the sea was 13 TBq, which is approximately 8% of the release limit. The total activity of other nuclides released into the sea was approximately 0.1 GBq, which is 0.01% of the plant location-specific release limit.

The calculated radiation dose of the most exposed individual in the vicinity of the plant was around 0.07 µSv per year, i.e. less than 0.1% of the set limit (Appendix 1, indicator A.I.5c). An average person living in Finland receives an equivalent radiation dose from radiation sources in nature and in space in around 30 minutes.

A total of approximately 300 samples were collected and analysed from the land and marine environment surrounding the Loviisa power plant in 2014. External background radiation and the exposure to radioactivity of people in the vicinity of the NPP were also regularly measured. Extremely small amounts of radioactive materials originating from the NPP were observed in some of the analysed samples. The amounts were so small that they are insignificant in terms of the radiation exposure of the environment or people.

4.1.11 Emergency preparedness

STUK oversees the capability of the emergency preparedness organisations of nuclear power plants to act under abnormal conditions. No events requiring emergency response actions occurred at Loviisa NPP in 2014.

Emergency preparedness at Loviisa NPP complies with the key requirements. The Loviisa NPP emergency preparedness organisation consists of the organisation of the Loviisa NPP and of Fortum's technical support organisation at Keilaniemi. STUK's inspection of the emergency preparedness arrangements, which is part of the periodic inspection programme, was implemented in 2014. It focused on the emergency preparedness organisation, drills, alarm arrangements, the environmental monitoring system, meteorological measurements at the plant site and drafting of spreading forecasts. Based on the inspection, STUK demanded improvements in the assessment of the supporting materials used in emergency preparedness activities and testing of how well the alarms that are used to alert the general population can be heard indoors. A deviation from the OLC requirement on calibration intervals of the meteorological system was observed during the inspection. Modifications of the emergency preparedness operations based on the Fukushima accident have been completed. The amended Government Decree on Emergency Response Arrangements at Nuclear Power Plants (VNA 716/2013) entered into force in October 2013. Some of the new requirements of the Government Decree have been met, while the details of others will be specified in the implementation decision of YVL C.5 in 2015.

Emergency preparedness drill Loviisa-14 was arranged at Loviisa NPP in November. In addition to the plant itself, participants in the drill included STUK, Eastern Uusimaa Fire and Rescue Services, Eastern Uusimaa Police Department and Kerava Emergency Response Centre. The Government Decree VNA 716/2013 expanded the basis of emergency preparedness to cover a simultaneous emergency at all of the units of a NPP. Loviisa-14 was the first drill in Finland where a simultaneous emergency at two plant units was being rehearsed.

4.1.12 Nuclear security

A new surveillance system for Loviisa NPP was mostly completed in 2014. The project included renovating the alarm control centre and backup alarm control centre. Both of them were equipped with new safety engineering components, servers and communication hardware. The access control system was completely renovated (zones, readers, ID cards, card manufacturing points, etc.). The recording camera surveillance system was also renovated and new key cabinets were added. Redundant electricity systems that supply power to the above-mentioned safety systems and components were also renovated.

STUK implemented a comprehensive inspection of nuclear security in compliance with the inspection plan. An example of the issues studied is nuclear security of the repositories for low- and intermediate-level waste. No significant deviations were detected in the inspection. The measures resulting from remarks made in the course of earlier inspections were also considered to be appropriately implemented.

Furthermore, STUK studied how the security arrangements (both nuclear security and information security) and the safeguards of nuclear materials are linked to the Loviisa NPP management system and safety management. The inspection focused on descriptions of processes related to nuclear security and the safeguards of nuclear materials in the management system, how nuclear security and the safeguards of nuclear materials have been taken into account in the risk management process and how these issues influence duties of the involved employees. Furthermore, discussions on how nuclear security has been taken into account when assessing and developing the organisation's safety culture were conducted. In addition to management interviews, the inspection interviews focused on the employees' knowledge of their responsibilities and obligations regarding nuclear security, communication channels used for issues pertaining to nuclear security, adequacy of information and how the employees react to deviations.

4.1.13 Safeguards of nuclear materials

In 2014, a total of fourteen safeguard inspections were conducted at Loviisa NPP. The number of inspections increased because a fuel container was transferred from the reactor building during the annual outage while the reactor cover was open. 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 reactor fuel assemblies prior to closing of the reactor cover at Loviisa 1 and Loviisa 2. STUK performed two interim safeguards inspections and one interim safeguards inspection together with the Commission and the IAEA. A partially empty fuel container was transferred three times from the reactor building while the reactor cover was open during the outage at Loviisa. Each of these transfers gave rise to the number of in-

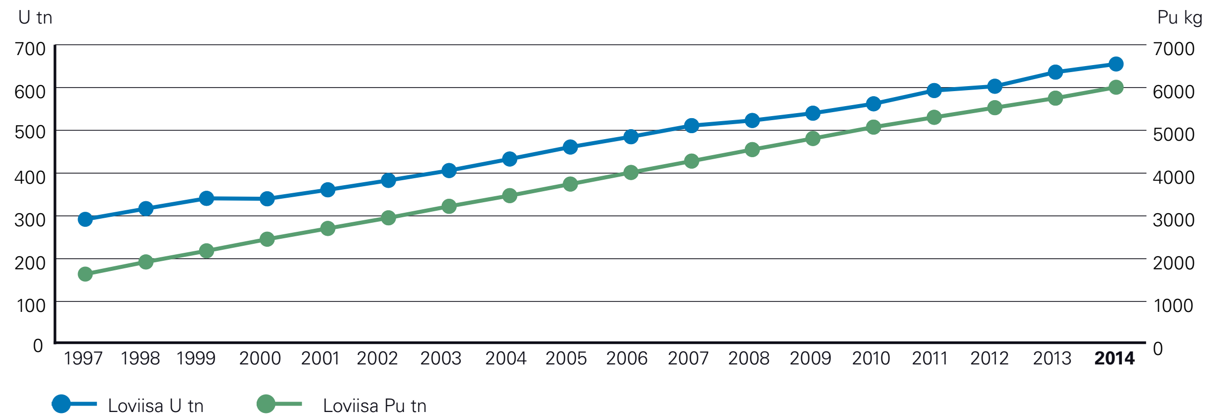


Figure 10. Amounts of uranium and plutonium at the Loviisa NPP.

spections carried out by STUK, the IAEA and the Commission. In addition to these inspections and the regular inspections, one inspection on installation of components required for remote data transmission was implemented. No remarks were made in the inspections.

In 2014, the IAEA and the Commission started to use remote data transmission in the safeguards of nuclear materials at Loviisa NPP. New cameras were installed in the reactor buildings before the annual outages in July and the required data connections were installed in August and September in connection with the annual outages. In September, the first images were electronically transferred to the Commission in Luxemburg and further to the IAEA in Vienna. According to the new procedure, Euratom and the IAEA receive images from the NPP once a day.

4.2 Olkiluoto nuclear power plant units 1 and 2

4.2.1 Overall safety assessment of Olkiluoto 1 and Olkiluoto 2

STUK oversaw the safety of Olkiluoto NPP 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. On the basis of this regulatory oversight, STUK can state that plant operations did not cause a radiation hazard to the employees, population or the environment. Radiation doses of the employees were lowest ever during the history of the NPP and clearly lower than the collective occupational doses of employees working at boiling water reactors in OECD countries, mostly because of plant modifications that reduced the humidity level of the steam drained to the turbine island. Radioactive releases into the environment were also low; they remained below the set limits. Emergency preparedness at Olkiluoto NPP complies with the requirements. The processing, storage and final disposal of low- and intermediate-level waste (NPP operational waste) at the power plant have been arranged in compliance with the requirements.

Based on tests and inspections, condition of the containment, which prevents the release of radioactive materials into the environment, and the reactor coolant system comply with the requirements. An indication of a possible fuel leak occurred at Olkiluoto 1 at the end of the fuel cycle. Attempts to find the leaking fuel assembly were made during the annual outage, without result. The possible leak has no significance for the radiation safety in the area surrounding the NPP.

Plant operation has been systematic and safe. In 2014, three events warranting a special report were reported. These events did not influence the safety of the employees or the area surrounding the NPP. Defects in the safety culture were observed in connection with one of these events. As a result of this event, TVO launched a project where it uses interviews to study the level of safety culture in production operation. TVO will submit the results to STUK. The events are described in more detail in Appendix 3.

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 NPP. STUK performed an annual outage inspection in compliance with the inspection programme during the annual outage. Good operations and examples of continuous improvement were observed during the inspection. In the inservice inspections carried out during the annual outage, cracks were detected in the feedwater lines of both plant units. The cracks are at a mixing point of pipelines from the feedwater system and the shutdown coolant system where flows at different temperatures mix. The cracked mixing points will be replaced during the next annual outage.

Several modification projects that will improve plant safety that were designed based on assessments of the Fukushima accident are currently ongoing at the NPP. These modifications will improve the provisions for extreme external threats. For example, the modifications will improve 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. In 2014, a modification of all the four trains of the auxiliary feedwater system was implemented at Olkiluoto 1. The modification will reduce the system's dependence on the seawater cooling. TVO also submitted a conceptual design plan on a turbine-driven high pressure coolant injection system. Processing of the conceptual design plan and more detailed system design are currently ongoing.

Other ongoing projects include an upgrade of the power plant's emergency diesel generators where the eight diesel generators will be replaced and a ninth generator will be built. Furthermore, the NPP is planning to build remote shutdown stations to improve functionality of the current remote control systems. Also in 2014, STUK approved conceptual design plans on replacing the reactor coolant pumps and the frequency converters needed when controlling and supplying power to the pumps. The pumps are replaced because of their ageing.

The extension project of the interim storage facility for spent nuclear fuel proceeded as planned in 2014. System modifications were completed and some were also commissioned. Two of STUK's commissioning inspections regarding the entire facility were arranged over the course of the year. A decision on an application to increase the storage capacity of the interim storage facility for spent nuclear fuel is currently being prepared.

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. Over the course of the year, STUK focused its oversight on TVO's management procedures, modification and procurement processes. TVO continues to invest in the development of its operations. A reformed modification process has been taken into use. As part of the development project, TVO implemented an organisational reform to better manage all of the Group's projects and to manage all demanding modification projects in a centralised manner.

4.2.2 Operation of the plant units, events during operation and prerequisites for safe operation

Compliance with operational limits and conditions

TVO has ensured that the operational limits and conditions (OLC) of Olkiluoto NPP are up to date. The OLC list the values within which nuclear power plant units must remain during operation. STUK has monitored compliance with the requirements and limits laid down in the OLC, the process used to ensure that the OLC remain up to date when modifications, tests and safety analyses are reviewed, and supervised the licensee's actions onsite. When the annual outages were concluded, STUK verified that the OLC were up to date and the plant unit complied with the OLC prior to issuing a permit to startup of the unit. TVO continued development of the OLC to improve their justification and clarify the requirements.

In 2014, TVO reported three events during which the plant was non-compliant with the OLC or a deviation from the OLC was made without an advance safety analysis and STUK's permission. Both measuring channels of the radioactivity monitoring system were simultaneously detached at Olkiluoto 2 due to a human error during calibration of the system. Some of the covers that protect the pools in the interim storage facility for spent nuclear fuel from an airplane crash were lifted with an unapproved hoisting device. A generator grounding carbon brush was replaced at Olkiluoto 1 in a manner that violated the NPP's administrative procedures. A special report on all of the three deviations from the OLC was submitted to STUK for approval. The individual events did not compromise the safety of the plant or its surrounding environment. TVO analysed the events and defined corrective measures to prevent recurrence of the events. STUK oversees the licensee's operations onsite and carries out random inspections to ensure compliance with the requirements and limits of the OLC. No deviations were observed in the 2014 inspections.

Over the course of the year, TVO submitted to STUK for approval 28 amendment proposals to the operational limits and conditions. Most of the amendments were due to modifications and component replacements carried out at the plant, as well as an OLC development project. During the annual outages in the spring, TVO introduced new fuel types that required an update of the OLC. TVO submitted for approval four pairs of figures pertaining to the OLC development project. The development project is described in Chapter 4.2.5. STUK approved most of the proposed amendments as such or with minor additional requirements. Some of the proposed amendments are still being processed by STUK.

TVO applied for permission from STUK for nine planned deviations from the operational limits and conditions (Appendix 1, indicator A.I.2). Three of the applications concerned installation of a recirculation line in the auxiliary feedwater system of Olkiluoto 1 and three concerned the expansion and modernisation of the interim storage facility for spent fuel. STUK approved all the applications, except for one. STUK refused TVO's application to increase the trip limit for high circulating water temperature that starts the cooling circuits of the condensate pool because TVO did not provide sufficient justification on the operation of the unit being safe at the proposed condensate pool temperature. When processing this issue, it was noted that the currently valid OLC allow operation of the plant in a range that is not included in the scope of the analyses of the final safety analysis report (FSAR). STUK did not issue any requirements on amending the OLC during the processing of the exemption. Instead, the issue will be studied when

Table 3. Events at the Olkiluoto plant units warranting the power company's special report or root cause analysis. All events subject to reporting are discussed in Appendix 1 (indicator A.II.1).

Event	Non-compliances with the OLC	Special report	INES rating
Simultaneous detaching of radiation measuring channels in the reactor building of Olkiluoto 2	•	•	0
Using an unapproved hoisting device at the Olkiluoto spent fuel storage facility	•	•	0
Replacing carbon grounding brushes of the generator during power operation	•	•	1

processing the chapter on the containment submitted for approval in connection with the OLC development project.

Operation and operational events

STUK oversaw the operation on a daily basis at the plant site, reviewed regular reports on operating activities and event reports, as well as performed three inspections of operations that focused on training and competence of control room operators, actions during annual outages and operating experience feedback. The results of the inspections are described in Appendix 5.

Six events classified as operational transients occurred at Olkiluoto NPP. One of the events caused a partial reactor trip at Olkiluoto 1: a malfunctioning valve during a bypass test of the LP heaters triggered a partial reactor trip due to high surface

Operation and operational events

On 7 April 2014, TVO observed at Olkiluoto 2 that a radiation measuring channel had been detached despite the requirements of the operational limits and conditions (OLC) in connection with calibration of the radiation measuring system. The calibration of the radiation measuring channel was erroneously started even though the parallel measuring channel had been detached shortly before to be sent out for calibration. This was an OLC non-conformance because the OLC requires that at least one of these parallel measuring channels must be operable at all times. When the OLC non-conformance was detected, TVO restored operability of one of the measuring channels. The deviation lasted for three minutes.

Soon after the annual outages, problems with the grounding carbon brushes of the main generator were detected in both units: the grounding carbon brushes had worn through clearly faster than normal. The purpose of a grounding carbon brush is to safely release the voltage generated by the rotation of the turbine shaft to prevent it reaching a harmful level. The grounding carbon brushes were replaced twice during the summer of 2014 at Olkiluoto 2. To replace the brushes, the unit was placed into turbine bypass operation and the grounding carbon brushes were replaced while the turbine was in hydraulic turning gear operation. On 30 September 2014, the plan was to inspect condition of the grounding carbon brushes at Olkiluoto 1. It had been observed in connection with an inspection that the carbon brushes could be replaced simultaneously. The unit's shift supervisor was not informed of the replacement of the carbon brushes. Some of the administrative procedures that guide the operation of the unit were not followed. There was no work permit for the replacement of the carbon brushes. Furthermore, the task took place in a room which, due to its radiation level, had been classified in the OLC as a room where work may only be performed with a radiation work permit, but no such permit for the task had been issued. The event did not have any direct impact on radiation safety, but it was still classified as an INES 1 event due to the related major defects in safety culture.

On 14 August 2014, STUK observed that TVO had lifted some of the covers that protect the pools in the storage facility from an airplane crash with an unapproved hoisting device. The lifting work was immediately discontinued. An unapproved safety class 3 hoisting device that had not undergone a construction inspection was being used. According to the OLC, all of the components of a crane must be operable before lifting work is started. The YVL Guides determine inspections of hoisting devices important to safety that had not been performed. The event did not compromise spent fuel storage safety. The lifting did not cause any fuel damage or any radiation hazard.

The events are described in more detail in Appendix 3.

level of a HP heater. The event decreased the reactor power to approximately 20%. Four operational transients in which one of the reactor coolant pumps dropped to its minimum rpm were caused by voltage disturbances of the external 400 kV power grid. In two of these events, the reactor coolant pump speed was not reduced fully according to plan. TVO noticed that a reactor coolant pump equipped with a key switch dropped to its minimum rpm even though the undervoltage of 1,000 ms that is required for this action did not occur during either of the events. TVO will check and adjust the undervoltage and ramp control of the reactor coolant pumps during the 2015 annual outage. A circulating water leak was detected in a condenser of Olkiluoto 1 in March. To repair the leak, the condenser was detached and the plant was dropped to 40% power.

The above-mentioned three events non-compliant with the OLC were events warranting a special report. The events are described in more detail in Appendix 3.

In 2014, risks caused by component malfunctions, preventive maintenance and other events causing unavailability of equipment were 7.9% and 6.4% of the expected value of the annual accident risk calculated using the plant's risk model for Olkiluoto 1 and Olkiluoto 2, respectively. The result is in line with those of previous years.

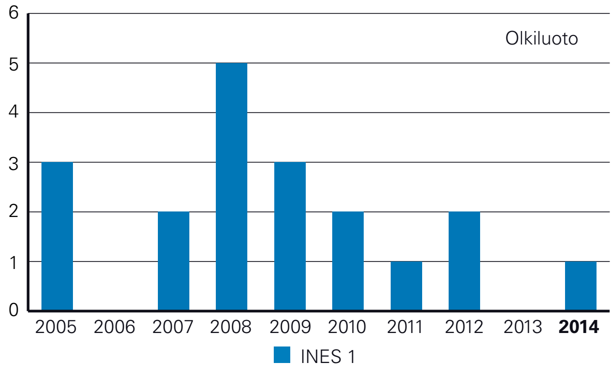


Figure 11. INES classified events at the Olkiluoto plant (INES Level 1 or higher).

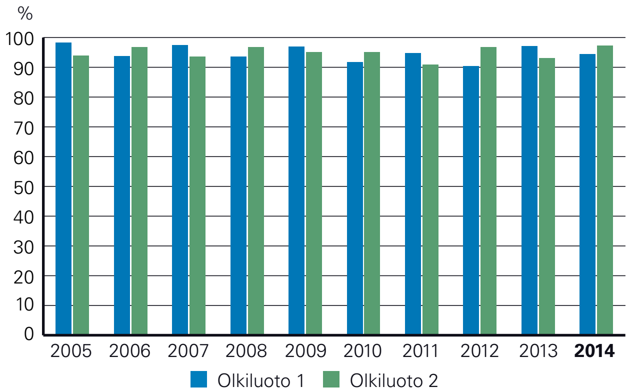


Figure 12. Load factors of the Olkiluoto plant units.

Annual outages

During an annual outage, equipment and structures important to plant safety are inspected, serviced, replaced or modified. These measures ensure the preconditions for operating the NPP safely during the following fuel cycles. Furthermore, some of the nuclear fuel is replaced with fresh fuel during an annual outage. STUK oversees that the licensee ensures the safe completion of the annual maintenance work and prevents radiation hazards to the plant employees and the environment. STUK performed an annual outage inspection in compliance with the inspection programme during the annual outage. The inspection is described in more detail in Appendix 5.

Several events caused by human errors occurred during the annual outages, but none of them warranted a special report. TVO drafted a joint event report for six human errors. In this report, TVO assesses the underlying causes of the

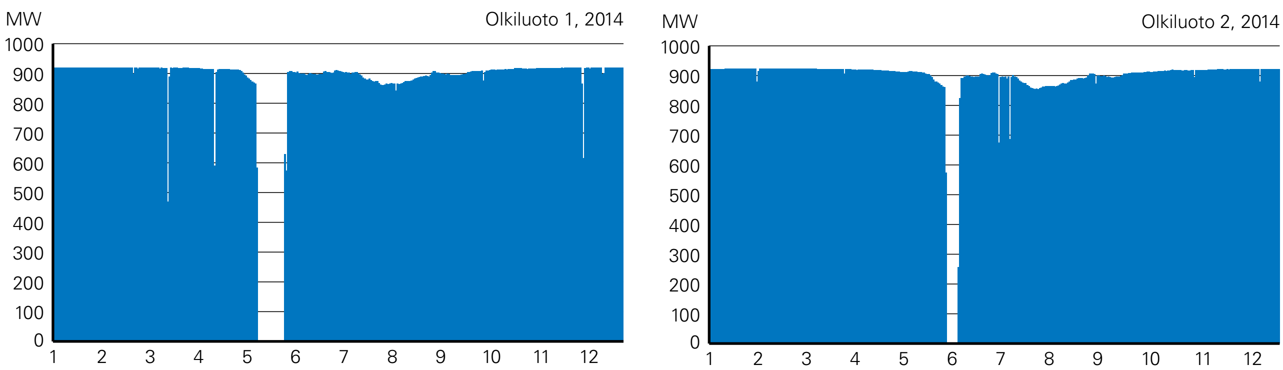


Figure 13. Daily average gross power of the Olkiluoto plant in 2014.

Annual outage of Olkiluoto 1 (11–29 May 2014)

The maintenance outage of Olkiluoto 1 lasted for a little more than 17 days, which was around two days longer than expected. The delay was caused by, for instance, the need to locate a fuel leak in connection with the refueling and the repair of a valve in the relief train. Issues that caused delays during the startup of the unit included a loose connector of a control rod actuator and the repairing of a leak in a steam line valve.

Around one fifth of the reactor fuel was replaced during the annual outage. The most major modifications implemented included replacing low voltage switchgears of two trains and modifying auxiliary feed water system recirculation lines of two trains where the recirculation lines drain into demineralised water storage pools that also act as the water source for the auxiliary feedwater system.

The auxiliary feedwater system modification will reduce the system's dependence on the sea water cooling. The modification will not influence the auxiliary feedwater system in any other operating mode apart from the recirculation mode. At present, the water that has flowed through the pump in recirculation mode is cooled using a separate cooler from where the heat is transferred via an intermediate circuit to the service water system. If the service water cooling is lost, the temperature of the recirculated water will quickly increase, which will eventually lead to a loss of the auxiliary feedwater system pumps. In addition to the modifications, a considerable number of inspections, maintenance work, repairs and tests were carried out on systems, equipment and structures.

An indication suggesting a fuel leak was observed in the plant unit at the end of the fuel cycle in May 2014. Attempts to locate the fuel leak were made prior to the start of the annual outage. Minor indications of the location of the fuel leak were found and a leaking fuel assembly was searched for during the annual outage. The leaking assembly was not detected, however. TVO has a guideline on the management of fuel leaks. It will be used if the leaking assembly is observed to be still in the reactor during the fuel cycle.

Annual outage of Olkiluoto 2 (1–9 June 2014)

The refueling outage of Olkiluoto 2 took a little less than eight days, as planned. During the annual outage, one fifth of the reactor fuel was replaced. No major modifications are carried out during a refueling outage; instead, the work mainly consists of inspections, maintenance, repairs and tests of systems, equipment and structures, such as fuel inspections and leak tests of containment isolation valves.

events and contributory factors, as well as lists measures to be performed in order to prevent their recurrence.

4.2.3 Ensuring plant safety functions

Deterministic safety analyses

An extensive evaluation of the transient and accident analyses (deterministic safety analyses) was carried out to verify that the safety functions of the plant have been performed in connection with the periodic safety review of 2009. Since then, TVO has further supplemented the analyses in connection with plant modifications in terms of expansion of postulated accidents and loss of coolant accidents. No updated deterministic safety analyses were submitted to STUK in 2014.

Probabilistic risk assessments

The risk of a severe nuclear accident is evaluated on the basis of a probabilistic risk assessment (PRA). As a rule, PRA calculations utilise regularly updated information on the occurrences of initiating events and the unavailability of equipment together with a logical model of the plant's systems and their interdependencies. The model is used to assess, for example, the annual risk of severe reactor fuel failures, which is also called the core damage frequency.

At the end of the year 2014, the calculated core damage frequency for Olkiluoto 1 was 0.84×10^{-5}/year, which is around 30% lower than in 2013 (1.21×10^{-5}/year). At the end of the year 2014, the calculated core damage frequency for Olkiluoto 2 was 1.41×10^{-5}/year, which is around 16% higher than in 2013 (1.21×10^{-5}/year).

TVO introduced separate risk models for Olkiluoto 1 and Olkiluoto 2 in 2013. The differences between the units are mainly caused by the fact that plant modifications that improve safety are not implemented at the same time. The key reason behind the decreased core damage frequency at Olkiluoto 1 from the level of 2013 was a change made in two trains of the auxiliary feedwater system that reduced the system's dependence on seawater cooling. The modification is described in Chapter 4.2.5, Auxiliary feedwater system recirculation line modification and trial run results.

The increased core damage frequency of Olkiluoto 2 is mainly due to changes in system separation implemented in order to be able to perform maintenance during the annual outage. The above-mentioned modification of the auxiliary feedwater system that will decrease the risk has not been implemented at Olkiluoto 2 yet, but the plan is to implement it in the near future.

The accident risk at the Olkiluoto power plant and its changes are discussed in more detail in Section A.II.4 of Appendix 1, Accident risk of nuclear power plants.

4.2.4 Integrity of structures and equipment

Reactor coolant system

At Olkiluoto 2, a crack in one of the welded joints of the reactor feedwater system has been monitored by means of ultrasound and eddy current examinations during inservice inspections since the indication was detected in 2003. The crack 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 with the new inspection techniques. 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. In an inspection by TVO during the 2013 annual outage, the depth of the internal crack was determined as 23 mm. The acceptable crack depth in terms of operation is max. 25 mm. The inspection was done using phased array ultrasonic testing from the outside of the nozzle. 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 2014 annual outage, the crack has not grown. The inspections were done using two techniques from the inside of the nozzle and using one technique from the outside. TVO installed a leak detection system that is based on temperature in the area during the annual outage. TVO has already made preparations for repairing the crack. The repair plan states that the crack will be removed by machining a groove that covers the entire circumference of the nozzle in the cracked area and then welding the groove shut.

In inspections done during the 2014 annual outages, several cracks were observed in feedwater line 1 and one crack in feedwater line 2 at Olkiluoto 2. Several cracks were observed in the same part of feedwater line 2 at Olkiluoto 1. The cracks are at a mixing point of pipelines from the feedwater system and the shutdown cooling system where flows at different temperatures mix. The mixing flows cause continuous temperature fluctuation of the structural material when the unit is in hot standby or low power feedwater control mode. This means that the mixing point is subjected to fatigue. These pipeline mixing points were replaced in 1986. STUK made a decision that required amendment of the operating method and replacement of the cracked pipe sections during the 2015 annual outages.

According to the decisions, only the mixing point with fewer cracks may be used during the above-mentioned operating modes that will stress the cracked mixing point at both units during the fuel cycle following the 2014 annual outage. Both mixing points at Olkiluoto 2 will be replaced during the 2015 annual outages. One of the mixing points at Olkiluoto 1 will be replaced during the 2015 annual outage and the other during the 2016 annual outage. STUK will oversee the planning of the replacement, manufacture and installation.

During the 2014 annual outage, TVO inspected supporting feet of the reactor moderator tank at Olkiluoto 1 based on operating experience from Sweden. In Sweden, two cracks were detected in welds between similar feet and the interior of the reactor pressure vessel in 2011. All of the eighteen supporting feet at Olkiluoto 1 were subjected to video camera and ultrasound inspections in 2014. No fault indications were detected. Based on video camera inspections done inside the reactor pressure vessel, there are no faults that can be seen on the surface in the supporting feet. Based on the ultrasound inspections done on the outside of the reactor pressure vessel, there are no internal faults in the pressure vessel wall material close to the supporting feet. Video camera inspections were started at Olkiluoto 2 in 2013 and will be concluded during the 2015 annual outage. No fault indications were detected in the inspections.

Fuel and control rods

In early 2014, TVO submitted to STUK for approval last parts of the construction plans for the fuel batches and test assemblies delivered to Olkiluoto 1 and Olkiluoto 2 in 2014, as well as commissioning applications for these batches, which STUK approved in March. TVO implemented a simultaneous fuel inspection at both units during the 2013–2014 fuel cycle, except for the condition monitoring assemblies because TVO applied an extension for their inspections while updating the inspection plan for the 2014–2015 fuel cycle. Implementation of the spent fuel condition monitoring programme has been delayed and the inspection scope has been decreased because the fuel inspection equipment at the interim storage facility for spent nuclear fuel was not applicable for fuel assembly channelling. Due to the installation schedule of the covers at the interim storage facility for spent nuclear fuel, there was not enough time to implement a modification of the system. TVO will submit an updated condition monitoring programme to STUK for information at a later date.

Fuel assemblies and channels were visually inspected during the 2014 annual outage. According to inspection reports submitted by TVO to STUK, no difference was observed in the reactor behaviour of channels that had been processed in an autoclave and channels that had not been processed in an autoclave. As in the previous years, some local flaky oxide particles were observed in the ZIRLO channel. TVO will pay special attention to this phenomenon in future inspections. Otherwise, the fuel behaved normally when taking into account the burn-up values. Control rod inspections and replacements were also implemented during the annual outages of Olkiluoto 1 and Olkiluoto 2 according to an approved plan. The control rods removed from the reactor were inspected after the annual outage, during the fuel cycle. Test batches of a new fuel assembly type were commissioned at both Olkiluoto units.

The manufacture of the 2015 fuel batches at Olkiluoto 1 and Olkiluoto 2 was completed in compliance with the approved construction plans, mainly by the end of 2014. TVO implemented the planned delivery batch specific manufacturing and supplier control inspections at the fuel supplier factories and for their suppliers.

In early 2014, TVO submitted a construction plan on a new control rod type that will be commissioned during the 2015 annual outages. During a manufacturing control inspection, TVO inspected the manufacturing and inspection methods of the rod type.

Maintenance and management of spare parts

Management of spare parts

STUK assessed the management of spare parts and supplies at the operating Olkiluoto plant units. The inspection, implemented in April 2014, covered procurement, reception, storage and handover from the warehouse of spare parts and supplies. Responsibilities, instructions, resources and data systems pertaining to these sectors of spare part management were studied. Furthermore, operation of the incoming goods unit and the storage facilities were verified. An increased risk of fake goods could not be excluded in the inspection, since the supply chains are longer than before and suppliers are changed often. A fake product cannot usually be detected using normal quality assurance procedures that are based on mutual trust. The risk of fake products can, however, be mitigated by adding more quality assurance measures at the spare part procurement and reception stage, as well as by providing more training. Measures pertaining to the prevention of fake products, in particular, was an issue that could not be verified during the inspection. STUK demanded that TVO study means it could use to identify forgeries. Based on the inspection results, TVO needs to add more precautionary measures to its spare part procurement and inspection instructions in order to avoid a situation where fake spare parts or supplies are used at the plant. This requirement applies in particular to mechanical, electrical and I&C components that are serially produced and of the commercial grade as well as commercial supplies that influence the operability of a safety classified system, structure or component.

Inservice inspections

TVO completed the inservice inspections of Olkiluoto 1 and Olkiluoto 2 in compliance with the inservice inspection programme approved by STUK. The programme included internal video camera inspections of the reactor pressure vessel, external ultrasound inspections of the reactor pressure vessel and internal inspections of the reactor pressure vessel nozzles, for example. Pipelines were subjected to inservice inspections and erosion measurements. The most significant observations were the above-mentioned cracks in the material at the feedwater line mixing points.

Emergency diesel generators

A voltage controller in the diesel generator of one train at Olkiluoto 2 has been exceptionally often replaced in the past due to malfunctions. The suspected cause of the malfunctions was too high mechanical vibration. The voltage controller is in a generator where it is susceptible to powerful vibrations from the diesel engine, similar to shock load. TVO conducted vibration measurements of the generator's voltage controller in late 2013. It was observed that the vibration is very strong. The fixing structures of the voltage controller were repaired to reduce the vibration to an acceptable level. Vibration of the voltage controllers in the other emergency diesel generators at Olkiluoto 1 and Olkiluoto 2 was measured in early 2014. It was noted that the vibration was fairly strong also at two other generators. The fixing structures between these voltage controllers and the generators were also repaired to rectify the situation. All of the above-mentioned measurements were taken from the cover of the voltage controller housing. In the summer of 2014, one of the voltage controllers was subjected to a test where, in addition to the vibration of the cover, the vibration and characteristic frequencies of the circuit boards inside the housing were measured. Based on these vibration measurements, TVO designed rubber spacers to be placed in between the voltage controller and the internals of the generator frame. The plan is to conduct preliminary testing of the new arrangement in early 2015. If the results seem promising, all of the voltage controllers will be subjected to the same modification.

Containment

The containments at Olkiluoto meet the design requirements. Based on leak tests implemented in 2014, three valves were repaired at Olkiluoto 1 and two valves at Olkiluoto 2.

4.2.5 Development of the plant and its safety

Replacement of reactor coolant pumps and their frequency converters

In 2014, STUK approved TVO's conceptual design plans on replacing the reactor coolant pumps and the frequency converters needed when controlling and supplying power to the pumps. The pumps are replaced because of their ageing. In connection with the replacement, a flywheel will be added to the reactor coolant pump shaft to ensure sufficient cooling of the nuclear fuel in case of a trip if the I&C and electric control systems are unavailable. The pump is currently shut down by means of electric control.

TVO decided to order the pumps from Westinghouse Electric Sweden AB. The company in charge of pump manufacturing is German KSB. The frequency converter supplier is ABB. TVO also submitted the first detailed documents regarding the design of the new pumps at the end of the year. The plan is to commission the first new reactor coolant pump at Olkiluoto 1 during the 2016 annual outage, all of the six pumps at Olkiluoto 1 during the 2017 annual outage and the remaining five pumps of Olkiluoto 1 in 2018.

High pressure coolant injection to the reactor

As part of the safety improvements following the Fukushima accident, TVO has proposed a turbine-driven high pressure coolant injection system to manage a situation where a total loss of AC power has occurred. The system will consist of a pump operated by the steam turbine: the steam will be taken from the main steam line and supplied through a dedicated line to the pump turbine. The water will be supplied to the reactor by the system via one auxiliary feedwater line.

Such a system is necessary because, based on studies conducted by TVO, it is apparent that the first proposed solution (a low pressure system with supply via the fire water system) alone would not be enough to guarantee integrity of the reactor core in case of a total loss of power. The high pressure system will offer more time to start the low pressure system.

TVO submitted a conceptual design plan of the new system for approval in 2014. Processing of the conceptual design plan and more detailed system design are currently ongoing.

Auxiliary feedwater system recirculation line modification and trial run results

In 2013, STUK approved TVO's plan on a modification of the auxiliary feedwater system recirculation line. The modification will not influence the auxiliary feedwater system in any other operating mode apart from the recirculation mode. During the modification, the recirculation lines will be connected to the demineralised water storage pools that are also the water source of the auxiliary feedwater system, and cooling of recirculated water with seawater will no longer be necessary. This means that the system will no longer be dependent on seawater.

The modification was implemented at Olkiluoto 1 in 2014. Abnormal vibration and sounds were observed in the new recirculation line and springs on the pressure side of the auxiliary feedwater system pump broke off during commissioning. This did not influence operation of the pump, however, and the fault would not have prevented the supply of water to the reactor in case of need. Studies to eliminate this problem are ongoing. The modification will not be implemented at Olkiluoto 2 until the studies are completed.

Construction of remote shutdown station at Olkiluoto

TVO is in the process of constructing remote shutdown stations for the Olkiluoto units currently in operation in compliance with decisions made in STUK's implementation decision regarding YVL Guide 5.5 and the periodic safety review of Olkiluoto. STUK reviewed and approved a conceptual design plan for the remote shutdown stations in 2012. Plans regarding the construction of the remote shutdown stations and their ventilation at Olkiluoto 2 were reviewed in 2014 and the construction work was completed in 2014. The plan is to install the electricity and I&C components and commission the remote shutdown stations at Olkiluoto 2 in 2015 and at Olkiluoto 1 in 2016.

Pressure equipment manufacturers and inspection and testing organisations

A total of 12 nuclear pressure equipment manufacturers were approved for the Olkiluoto plant (plant units Olkiluoto 1, 2 and 3). STUK approved 11 testing organisations to carry out tests related to the manufacture of mechanical equipment and structures. Testing operators from three testing organisations were approved to carry out periodic tests of mechanical equipment and structures pursuant to YVL 3.8.

Replacement of diesel generators

TVO has continued the preparation of the replacement of the emergency diesel generators at Olkiluoto 1 and Olkiluoto 2. STUK approved the conceptual design plan on the replacement of the diesel generators in early 2013, and TVO selected Wärtsilä Finland as the supplier of the new emergency diesel generators. There are a total of eight emergency diesel generators in the units operating at Olkiluoto. A ninth one, to be shared by both units, will be added. Cooling of the diesel engines of the generators will be improved by adding an air cooling system that is independent of the seawater cooling system. At present, TVO's goal is to start construction of the building for the ninth emergency diesel generator that will be shared by the units in the summer of 2015. According to the current estimated schedule, this emergency diesel generator, which will be used during the replacement project instead of the diesel generator that is currently being replaced at the units, will be installed and commissioned in the spring of 2017. The plan is to have the entire diesel generator replacement project completed by the spring of 2021.

Low-voltage switchgear replacement project

In 2010, TVO launched a low voltage switchgear replacement project at Olkiluoto 1 and Olkiluoto 2. The key reasons for replacing the switchgears are an increase in maintenance costs due to the ageing of the original equipment, and the need to modernise the switchgear to correspond to the current requirements regarding plant and personnel safety. The replacement mainly concerns the switchgears and associated transformers of electricity systems important to safety. TVO already replaced the medium voltage switchgears (6.6 kV) in 2005 and

2006. The voltage in the plant units' low voltage networks varies from 24 VDC to 660 VAC. The switchgears are used to supply the required electrical power to the plant units' I&C systems and components that are important to safety.

According to the current plan, the low voltage switchgears will be replaced during the plant units' annual outages between 2010 and 2016. TVO continued the work during the 2014 annual outage of Olkiluoto 1 by replacing the switchgears in two trains. STUK reviewed the documents for the switchgear project and oversaw the execution of the work onsite. TVO intends to continue the project at Olkiluoto 2 during the 2015 annual outage by replacing the switchgears of two trains.

Development of operational limits and conditions

The development plan of the operational limits and conditions (OLC) states that TVO improves the justification for requirements and clarifies the requirements as necessary. The OLC development project continued in 2014. Over the course of the year, TVO submitted four proposed amendments to STUK for approval. STUK approved two of the new chapters. The other two chapters were still being processed at the end of 2014. Also in 2014, STUK approved two chapters submitted in 2013 with the changes required by STUK implemented. The development project will be continued in 2014 and possibly also later.

Abnormal and emergency operating procedures

In 2014, TVO continued project on updating the abnormal and emergency operating procedures that was started based on the results of the periodic safety review. The goal of the project is to improve the procedures by describing the measures in more detail. Furthermore, the procedures will be improved by adding flowcharts to clarify the division of labour between operating personnel and the measures to be completed.

In 2014, the development project focused on abnormal operating procedures that apply to power operation. TVO submitted to STUK for information ten updated abnormal operating procedures in 2014. The renewed procedures deal with reactor and turbine trips, triggering of the boron chain, loss of cooling channel (three separate procedures) and shutdown of the plant from outside the control room. STUK processed the updated procedures as documents submitted to STUK for information. In 2015, development of the procedures will still focus on abnormal operating procedures that apply to power operation.

Development targets based on Fukushima accident

After the Fukushima accident in 2011, STUK sent a decision to the licensees concerning provisions and plans to be made by the power companies for natural phenomena and power supply disruptions. In 2013, TVO submitted to STUK reports on the opportunity to use a water supply system independent of existing plant systems to cool the reactors of Olkiluoto 1 and Olkiluoto 2. The proposed solution consists of supplying make-up water from the fire water system via the core spray system to the reactor after depressurisation. System design of this solution will be completed in 2014. The plan is to complete detailed design by the end of 2015 and the plant modification in 2016–2017. In addition to the low pressure system, an automatically starting high pressure make-up water system that will guarantee sufficient time for a transfer into the low pressure system is being designed. TVO submitted to STUK a conceptual design plan (see Chapter 4.2.5) for the high pressure make-up water system and additional reports in 2014. The plan is to commission the high pressure make-up water system by 2018.

In 2014, independence of the auxiliary feedwater system from seawater cooling was improved according to plan by implementing pipeline modifications at Olkiluoto 1. The plan is to implement the same modifications at Olkiluoto 2 in 2015. For more information on the modification, please see Chapter 4.2.5.

TVO acquired five portable electric generators for the plant area in 2014. Portable generators can be used, for instance, to recharge the uninterruptible power supply batteries during long-lasting accidents. Two portable fire water pumps were also acquired in 2014. The portable fire water pumps can be used to fill up the containment in case of a severe accident and supply make-up water to the fuel pools in the reactor building and the spent fuel storage facility. In 2014, TVO improved seismic resistance of the fire water systems by reinforcing pipe supports and the supports of electrical cubicles and relay cabinets in the relay rooms.

According to the plan to ensure residual heat removal from the spent fuel pools, TVO installed fixed pipelines from the fire water system dry risers to the fuel pools at Olkiluoto 1 in 2014. The plan is to implement the same modifications at Olkiluoto 2 in 2015. TVO submitted to STUK updated design documentation of the fuel pool temperature and level measuring monitoring system in 2014.

Radiation monitor upgrade

TVO has upgraded the fixed radiation measuring systems at Olkiluoto 1 and Olkiluoto 2 in stages. During the 2014 annual outages, the radionuclide specific activity measuring instruments used in fuel leak detection were replaced at both units. The new measuring instruments are easier to maintain than the old ones: the cooling system used for radionuclide analytics can be modernised so that it is electrically cooled.

The latest items to be upgraded are the radiation measuring instruments used to monitor releases during normal operation of the plant. TVO conducted factory acceptance tests of these measuring instruments at the equipment supplier's facility in late 2014.

The measuring instrument modernisation project will improve and standardise the plant's operating components.

4.2.6 Spent nuclear fuel storage and NPP operational waste

The processing, storage and final disposal of low- and intermediate-level waste (NPP operational waste) at Olkiluoto NPP 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 contributing factors include the high quality requirements for nuclear waste management and nuclear fuel, the planning of maintenance and repair operations, decontamination as well as component and process modifications. In addition, the NPP employs efficient procedures for reducing the volume of waste destined for final disposal. Because of waste monitoring and sorting, some waste types that contain very little radioactive materials can be released from control. Waste released from control included operational waste, scrap metal for recycling and non-radioactive hazardous waste to be further processed, such as waste oil and fluorescent tubes. STUK has approved the licensee's procedures on releasing waste from control. STUK will monitor the activities, the amount of waste exempted from control and its activity concentrations.

In 2014, STUK regulated operating waste management and final disposal of operating waste as well as the concrete and rock structures of the repository. STUK reviews and approves reports and other documents submitted to it, as well as performed regulatory inspections and inspections included in the periodic inspection programme. No significant deficiencies or development needs were observed during the inspections carried out in 2014. The inspections are described in more detail in Appendix 5.

Expansion of spent fuel storage facility

TVO is currently adding three pools to the interim storage facility for spent nuclear fuel at Olkiluoto. The structures of the storage facility will also be modified to comply with the current safety requirements. The original capacity of the interim storage facility for spent nuclear fuel at Olkiluoto would have been sufficient until 2014. The expansion will increase the capacity for the spent fuel coming from the Olkiluoto plant units 1, 2 and 3.

TVO submitted reports regarding expansion of the storage facility to STUK for approval at the end of 2009. The extension of the storage facility is designed to meet the current safety requirements, the most significant of which are its earthquake resistance and its ability to withstand a large airplane crash. The structures of the existing part of the storage facility will be simultaneously renovated to comply with the current requirements.

In 2014, system modifications pertaining to the expansion of the interim storage facility for spent nuclear fuel were completed and some systems were commissioned. Two commissioning inspections regarding the entire facility were arranged. In the first inspection, the work in the original part of the interim storage facility for spent nuclear fuel was found completed and commissioned. Furthermore, it was verified that spent fuel can be transferred to the pools in the original storage facility part. However, some issues about require-

Quantities of spent fuel and low-and intermediate-level waste in Olkiluoto

The volume of spent nuclear fuel on-site at the Olkiluoto plant at the end of 2014 was 8,304 assemblies 1,461 tU, tonnes of original uranium) with an increase of 208 assemblies (36 tU). The volume of low- and intermediate-level waste finally disposed of was 5,898 m³ at the end of 2014. The total increase of volume from 2013 is 217 m³. Approximately 95 % of the waste has been finally disposed of.

ments on the commissioning of the extension were not concluded during the first inspection. TVO was able to complete some works pertaining to the commissioning of the extension by the second commissioning inspection, and most of these open issues were concluded at that time.

Preparation of STUK's decision regarding the increasing of the capacity of the interim storage facility for spent nuclear fuel has been postponed to 2015. The decision will be made once the last works linked to the commissioning have been completed.

In 2014, one operational event warranting a special report took place at the interim storage facility for spent nuclear fuel: objects were lifted with an unapproved hoisting device. For more information on this operational event, please see Chapter 4.2.2 and Appendix 3.

Final disposal of radioactive waste managed by the Radiation and Nuclear Safety Authority

An approval of the operating license for the low- and intermediate-level waste repository located in the Olkiluoto plant area that was implemented on 22 November 2012 enables the final disposal of the radioactive waste managed by STUK's Environmental Monitoring Department that is stored at Olkiluoto in the silos for low- and intermediate-level waste. The waste consists of radioactive sources generated by the use of radiation that have been decommissioned as radioactive waste. By virtue of the Radiation Decree, the state is in charge of such waste.

STUK's Nuclear Waste and Nuclear Material Regulation Department demanded a separate plan on implementation of the final disposal of the waste. The plan, drafted by TVO, includes descriptions of, for instance, sorting of waste packages, records and final disposal. TVO submitted the plan and supplements to it to STUK in late 2014, and STUK processed and approved them. The sorting and final disposal of the waste packages in the Olkiluoto NPP repository will take place in early 2015.

Provisions for the costs of nuclear waste management

In compliance with section 88, subsection 2 of the Nuclear Energy Decree, TVO provided the Ministry of Employment and the Economy with information on the costs and prices of nuclear waste management measures by the end of June. A supplemented waste management scheme includes an updated cost estimate of the remaining waste management costs.

STUK reviewed the documents submitted in compliance with the Nuclear Energy Decree and submitted a statement regarding them to the Ministry of Employment and the Economy. In its statement, STUK assessed the cost estimates on which the financial provisions are based, considered them acceptable and stated that they can be used as the basis for the cost provisions. TVO's extent of liability was €1,349.1 million at the end of 2014.

According to the Nuclear Energy Decree, supplemented waste management schemes for technical and financial plans, as well as related calculations, must be prepared every three years. The next revision will take place in 2016.

4.2.7 Organisational operations and quality assurance

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.

Over the course of the year, STUK focused its oversight on TVO's management procedures, modifications, resources and procurement processes.

TVO will continue to invest in the development of its operations. As part of these investments, TVO has implemented changes that influenced its organisational structure. The organisational reform in the Nuclear Safety Department aimed at focusing the management of nuclear safety issues in a single department that is directly managed by the company's President and CEO. The reform also involved transferring the Operating Safety Office from the

Production Department to the Nuclear Safety Department. TVO implemented the organisational reform to better manage all of the Group's projects and to manage all demanding modification projects in a centralised manner.

As part of the development of its management processes, TVO has introduced new scorecards that comply with its new business model and measure changes. The development work has also involved training of supervisors. TVO is not using process indicators yet, but development of the indicators is underway.

A periodic self-assessment of the safety culture has been performed, and responsibilities and schedules for the changes to be implemented have been determined. The recommendations include studying the underlying cause for the low response rate to a personnel survey, paying attention in creating an atmosphere at work that does not include any laying of blame, as well as increasing the recognition, training and use of tools for managing human errors.

A resource management development project aimed at streamlining the operations, for example. TVO has introduced a competence centre model that can be used to standardise ways of working and evening out the workload. STUK has demanded that TVO determine the role of the competence centres in more detail and communicate the role to the personnel.

TVO has reformed its internal auditing programme to make it more comprehensive. The auditing programme was changed from a process-centred study to a study that mainly focuses on activities. The programme extends until the year 2020. During the first quarter of 2015, TVO must report to STUK how it plans to ensure that the internal auditing programme supports the assessment of the process-based management system.

Over the course of the year, TVO performed supplier audits. STUK also participated in some of them as an observer.

In 2014, STUK approved the following people required by the Nuclear Energy Act: a deputy of the person responsible for emergency preparedness, a deputy of the person responsible for nuclear security, two people responsible for the safeguards of nuclear materials, a person responsible for international transfers and a deputy of the responsible director in charge of operation. The people responsible for emergency preparedness and nuclear security will be the deputies during both construction and operation.

STUK oversaw the oral examinations of shift personnel where the shift managers, operators and trainee operators prove that they are competent in all key issues related to plant operation and safety. In 2014, STUK granted 34 licenses to shift managers and operators on application by the power company and following a successful oral examination, eight of them to new operators. In addition, an extension of four months without an oral examination was granted for one shift manager license. TVO applied for the extension because the person will retire soon after the expiration of the license and a new oral examination was thus deemed unnecessary. STUK granted the extension because the person's results in previous examinations have been good. All the participants passed their examinations in 2014. The new operators had good results in the examination, which is an indirect indication that the basic training programme is effective. The operators renewing their licenses also had good results in the examination, which, for its part, indicates that the power company's refresher and supplementary training is effective.

4.2.8 Fire safety

Fire safety at the Olkiluoto NPP was acceptable. No events classified as fires occurred in the Olkiluoto plant area in 2014. There was a minor fire outside the plant area at the Olkiluoto 3 construction site, but it petered out by itself before the plant fire brigade was able to respond. In 2014, STUK oversaw the maintenance and upkeep of the fire protection systems that ensure fire safety of the plant by means of regulatory inspections and by reviewing reports submitted by TVO. An inspection included in the periodic inspection programme and onsite inspections by the resident inspectors were performed onsite.

TVO continuously develops fire safety at Olkiluoto NPP. The plant's fire load was minimised in 2014. Extinguishing systems in a cable room below the control room at Olkiluoto 1 and in some tall cable channels were replaced. Due to the improvements demanded after the Fukushima accidents, portable fire water pumps that can be used in the containments and also to fill the fuel pools will be acquired for Olkiluoto 1 and Olkiluoto 2. The NPP has an appropriate fire safety training programme. The plant fire brigade's duties also include fire protection at the Olkiluoto 3 construction site and in the Posiva NPPs.

4.2.9 Operating experience feedback

STUK assessed the operating experience feedback activities and corrective measures on the basis of reports, regulatory inspections and inspections within the periodic inspection programme.

In 2014, a total of 63 reported events that included measures took place at Olkiluoto NPP. Regarding the events in 2014, fourteen transient and event reports were submitted to STUK for information and three special reports were submitted for approval. All of the events warranting a special report involved an event that was non-compliant with the OLC. The special reports were drafted and submitted to STUK in compliance with the requirements. The events warranting a special report are described in more detail in Appendix 3.

In 2014, one event classified as Level 1 on the International Nuclear Event Scale (INES) took place at Olkiluoto NPP (the replacing of generator carbon grounding brushes during power operation). The licensee has decided to draft a root cause analysis on the events involving hoisting devices.

In the operating experience feedback inspection, STUK verified methods, procedures and new practices related to the operations. There are development actions in progress in both the internal and external operating experience activities at Olkiluoto NPP. Despite personnel changes, operations were found to be well organised and instructed, and had adequate resources. The operating experience feedback team meets every two weeks. The team discusses experience feedback from Finland and from abroad, as well as the utilisation of the feedback in the improvement of operations.

Of all the recent events at Olkiluoto, STUK decided to draft one new report on problems with the cracks at the pipeline mixing points at Olkiluoto 1 and Olkiluoto 2 for the International Reporting System for Operating Experience (IRS) maintained by the International Atomic Energy Agency (IAEA). In addition, STUK saved in the IAEA database a report on the cracks of stator welds observed during periodic maintenance of the emergency diesel generators at Olkiluoto 1 and Olkiluoto 2 in 2013.

Olkiluoto NPP uses methods to assess and utilise operating experience from other plants. TVO has utilised Nordic cooperation in the preselection of reports from the World Association of Nuclear Operators (WANO), the IRS database maintained by the IAEA and reports from the plants in the United States. TVO continues to develop methods and procedures for operating experience feedback activities during construction and commissioning.

4.2.10 Radiation safety of the plant, personnel and the environment

Occupational radiation safety

STUK carried out a radiation protection inspection as part of the periodic inspection programme of Olkiluoto NPP, focusing on radiation measurements in particular. The scope of the inspection included the environmental radiation monitoring programme and the instruments intended for measuring radiation at the plant. Special attention was paid to the representativeness of radiation measuring and analyses, as well as the environmental monitoring programme. STUK required after the inspection that the power company update its final safety analysis report and its internal guidelines pertaining to environmental radiation protection.

The dosimeters used for measuring the occupational radiation doses underwent annual tests. The tests comprised irradiating a sample of dosimeters at STUK's measurement standard laboratory and reading the doses onsite. The test results showed that the plant's dosimeters are in working order.

STUK carried out targeted radiation protection inspections during the annual outages at the Olkiluoto plant units. Radiation protection activities of the plant's radiation protection personnel and employees within the controlled area were assessed during these inspections. Based on the inspection results, radiation protection at the NPP is good: no major defects were observed. Individual development targets were observed in the inspections, concerning the use of personal protective equipment in the controlled area, radiation protection markings and transfers related to the reactor's feedwater dividers.

Radiation doses

In 2014, Olkiluoto 1 underwent a maintenance outage and Olkiluoto 2 a refueling outage. The occupational radiation doses of nuclear power plant workers mostly accumulate during work carried out during annual outages. The radiation levels of both plant units' turbine islands continued to decrease due to new moisture separators that were installed in 2005–2007.

The highest individual radiation dose accumulated was 3.1 mSv at Olkiluoto 1 and 3.9 mSv at Olkiluoto 2. The highest individual dose incurred during the entire year was 7.7 mSv. This dose was caused by cleaning work. The highest individual radiation doses have been less than 10 mSv during the last eight years.

The radiation doses for plant employees remained below the individual dose limits. The effective dose for a worker from radiation work may not exceed the 20 manSv/year average over any period of five years, or 50 manSv during any single year.

The collective occupational dose of employees for the entire year was 0.40 manSv at Olkiluoto 1 and 0.24 manSv at Olkiluoto 2. Due to improvements in radiation safety, the collective occupational radiation dose of Olkiluoto employees was the lowest ever recorded during the operation of

Table 4. NPP originated radioactive nuclides found in the environmental samples of the Olkiluoto power plant in 2014.

Sample types containing detected radionuclides. Figures indicate the number of positive samples in a sample group. Several different nuclides may be found in the same sample..

Radionuclide / Type of sample	Mn-54	Co-60	Total
Air		2	2
Aquatic plants	2	6	8
Perifyton	2	4	6
Sedimenting materials		10	10
Sediment		4	4
Rainwater		1	1
Dumping ground ditch water		1	1
Total	4	27	31

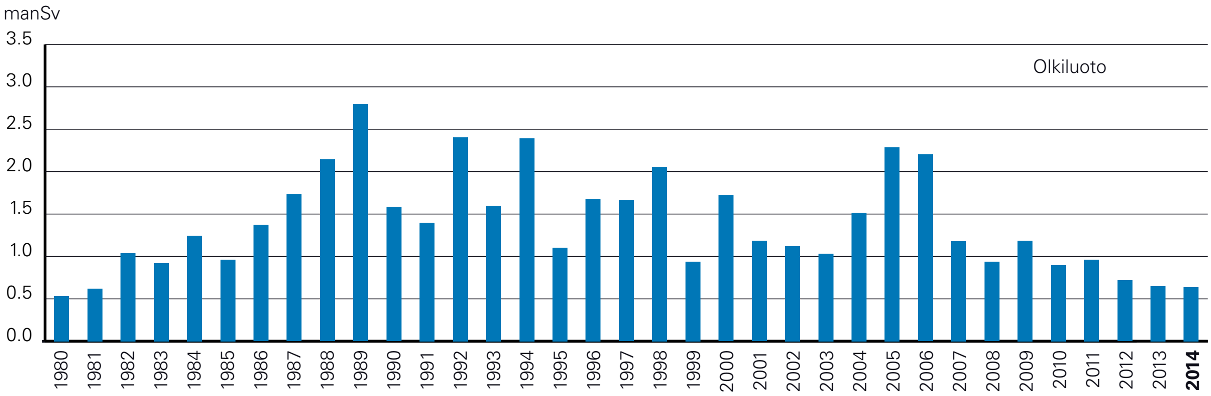


Figure 14. Collective occupational doses since the start of operation of the Olkiluoto units 1 and 2.

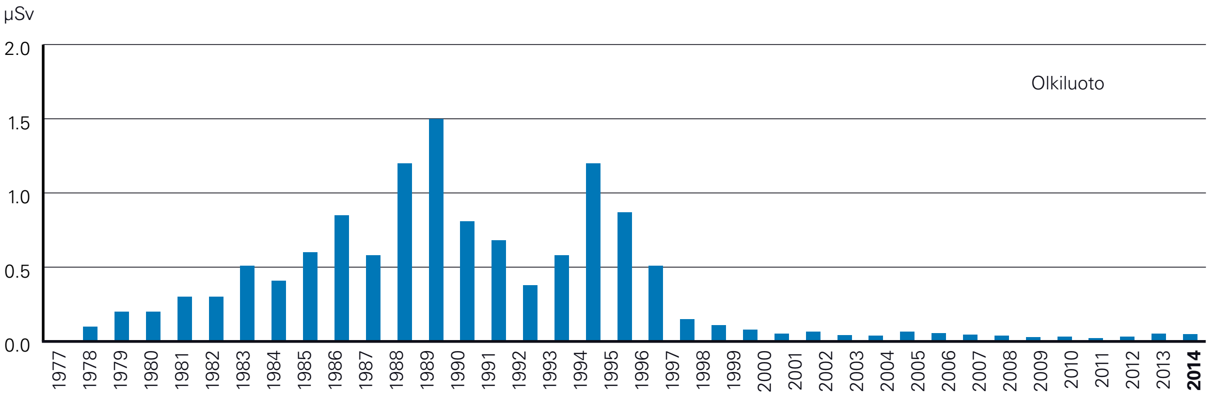


Figure 15. Annual radiation doses to the most exposed person of the public since the start of operation of the Olkiluoto units 1 and 2. Over the recent years, the doses calculated based on the radioactive discharges has remained below one percent of the set limit, 0.1 milliSv.

the NPP. The collective radiation dose of employees due to operations during the outage at Olkiluoto 1 was 0.33 manSv, and the collective radiation dose due to operations during the outage at Olkiluoto 2 was 0.19 manSv. The collective occupational radiation doses of employees in Olkiluoto were clearly lower than the average doses of employees working in boiling water reactors in OECD countries.

According to the YVL Guide issued by STUK, the threshold for one plant unit's collective dose averaged over two successive years is 2.5 manSv per one gigawatt of net electrical power. This means an average annual dose value of 2.20 manSv per Olkiluoto plant unit. This threshold was not exceeded at either of the units.

The radiation dose distribution of employees at the Olkiluoto and Loviisa NPPs in 2014 is given in Appendix 2.

Radioactive releases and environmental radiation monitoring

Radioactive releases into the environment from Olkiluoto NPP remained well below the authorised annual limits in 2014. No releases of radioactive noble gases into the environment were detected. Releases of iodine into the air were approximately 0.3 MBq (as I-131-equivalent activity), which is approximately 0.0002% of the set limit. Releases through the vent stack into the air also included radioactive particulate matter amounting to 7 MBq, tritium amounting to 0.7 TBq and carbon-14 amounting to approximately 0.8 TBq.

The tritium content of liquid effluents released into the sea, 1.6 TBq, was around 9% of the annual release limit. The total activity of other radionuclides released into the sea was 77 MBq, which is approximately 0.03% of the plant location-specific release limit.

The calculated radiation dose of the most exposed individual in the vicinity of the plant was around 0.05 µSv, i.e. less than 0.05% of the set limit (Appendix 1, indicator A.I.5c). An average person living in Finland receives the equivalent radiation dose from radiation sources in nature and in space in about 20 minutes.

A total of around 300 samples were collected and analysed from the land and marine environment surrounding the Olkiluoto power plant in 2014. External background radiation and the exposure to radioactivity of people in the vicinity of the NPP were also regularly measured. Minute amounts of radioactive substances originating from the nuclear power plant were observed in some of the analysed environmental samples. The amounts were so small that they are insignificant in terms of people's radiation exposure.

4.2.11 Emergency preparedness

STUK oversees the capability of the emergency preparedness organisations of nuclear power plants to act under abnormal conditions. No events requiring emergency response actions occurred at Olkiluoto NPP in 2013.

Emergency preparedness at Olkiluoto NPP complies with the key requirements. STUK's inspection of the emergency preparedness arrangements at Olkiluoto NPP, which is part of the periodic inspection programme, was implemented in April 2014. It focused on the emergency preparedness organisation, drills, alarm arrangements, the environmental monitoring system, meteorological measurements at the plant site, drafting of spreading forecasts and planning of emergency preparedness operations at Olkiluoto 3. STUK required after the inspection a test on how well the alarms that are used to alert the general population can be heard indoors in the accommodation village and an update of the materials used when assessing the size of accident releases due to the transfer of the environmental monitoring system stations. Some of the measures pertaining to emergency preparedness that were required after the Fukushima accident have been completed and others are being implemented. The amended Government Decree on Emergency Response Arrangements at Nuclear Power Plants (VNA 716/2013) entered into force in October 2013. Some of the new requirements of the Government Decree have been met, while the details of others will be specified in the implementation decision of Guide YVL C.5 in 2015.

The Olkiluoto 3 construction site did not influence TVO's emergency preparedness operations to any great extent.

In the autumn, an extensive two-part cooperation drill, OLKI 14, was arranged at Olkiluoto NPP. In addition to the NPP, around sixty private organisations, as well as central, regional and local administration organisations participated in the drill. The first part of the drill was arranged in September. It involved rehearsing the management of an accident with the help of maps. A release generated during the first part of the drill was used as the scenario for the second part of the drill. The second part was the first drill in Finland on extensive preparation for the management after an accident and the required measures.

4.2.12 Nuclear security

In 2014, STUK completed two inspections of nuclear security that were included in the scope of the periodic inspection programme. An inspection dubbed *Nuclear security as part of the management system* focused on procedures used to manage the risks caused by illegal activities as part of the company's comprehensive risk management process, the processing of nuclear security nonconformances and observations, as well as the processing of nuclear security issues in management reviews. The inspection covered both nuclear security and information security. TVO has developed its risk management in the past few years based on the inspection results, and risk management is now systematic. Non-conformances and observations are processed in an established manner and continuous development occurs in, for instance, processing nuclear security non-conformances as commensurably and systematically as possible in the organisation's normal system for processing non-conformances and observations while taking into account confidentiality issues. STUK demanded that TVO continue the development of the process used to identify risks pertaining to illegal activities in all of the organisation's operations as well as the management of non-conformances and observations pertaining to nuclear security and information security as a whole.

A second inspection focused on the technical implementation of nuclear security. The inspection covered all of the surveillance systems and procedures that are part of nuclear security at Olkiluoto NPP. During the inspection visit, STUK inspected access control arrangements of a new work permit office and monitored the on-call operations of the alarm centre. One issue that needs to be updated in the safety organisation's security instructions was observed during the inspection.

STUK also inspected nuclear security of the spent fuel storage facility as part of the commissioning inspection of the extension. TVO provided information on planned supplements to other arrangements. STUK deemed the plans good.

In an inspection of the transport of fresh fuel, STUK verified that the arrangements complied with the requirements.

4.2.13 Safeguards of nuclear materials

A total of 18 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. The amount of nuclear material in the spent nuclear fuel storage facility was separately verified because the verification could not be implemented simultaneously with the reactor units due to the construction of the extension. Furthermore, STUK inspected the locations of the fuel assemblies in the reactor prior to the closing of the reactor cover at Olkiluoto 1 and Olkiluoto 2. STUK also performed two safeguards of nuclear materials inservice inspections at Olkiluoto 1 and one at the spent fuel storage facility.

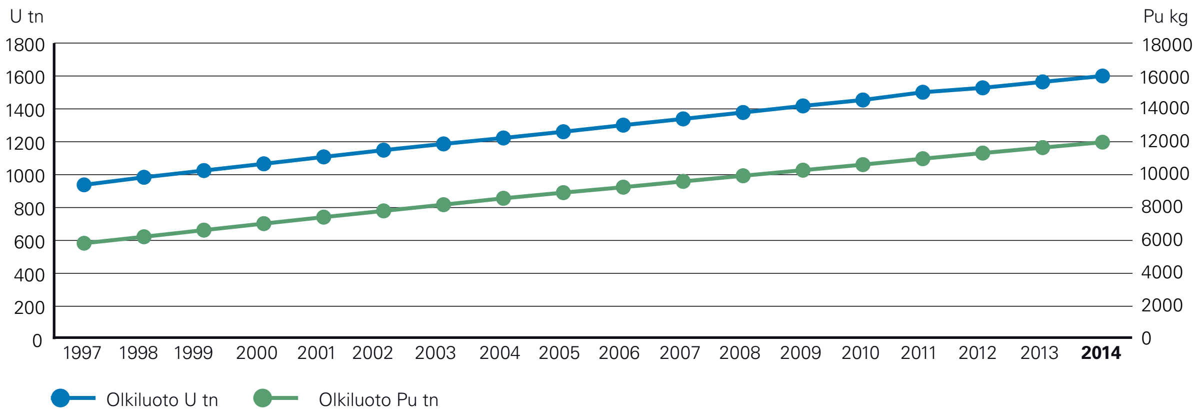


Figure 16. Amounts of uranium and plutonium at the Olkiluoto NPP.

STUK approved TVO's records of international transport of nuclear fuel and the nuclear material manual that provides instructions on regulatory activities. At the end of 2014, TVO submitted to STUK for approval a nuclear material manual on material balance areas of Olkiluoto 1, Olkiluoto 2 and the spent fuel storage facility as well as other operations by TVO pertaining to nuclear materials. It complies with the requirements of the new Guide YVL D.1, and its processing will be continued in 2015.

4.3 Regulatory oversight of the construction of Olkiluoto 3

4.3.1 Overall safety assessment of Olkiluoto 3

The overall safety assessment of Olkiluoto 3 discusses the observations made by STUK on the basis of a review of plans, the oversight of manufacturing, construction, installation and commissioning operations, results of the construction inspection programme during construction, oversight of the plant supplier and its subcontractors, and experience acquired as a result of interactions between STUK, TVO and the plant supplier.

The most important open issue regarding plant design is instrumentation and control (I&C). Over the course of the year, the licensing of I&C proceeded well as STUK approved the overall I&C plan, i.e. architecture , and found that the analyses of active failures were acceptable. STUK required some changes in the architecture but the required changes are so minor that the plan could be accepted.

STUK had already requested TVO take into account the possibility of failures in the I&C system software and possible consequences of such failures when assessing the implementation of the plant's general design bases. In 2014, STUK approved the method used for the analyses and reviewed the analyses themselves. STUK did not have any remarks concerning the scope or results of the analyses. Some modification needs in the control of components have been identified based on the analyses.

The plant supplier started test bay testing of the I&C systems in early April. STUK participated in some of the test kick-off meetings and visited the test bay to observe the tests. STUK reviewed and accepted the system testing plans.

The licensee submitted to STUK for approval several failure mode and effects analyses on process and electricity systems, as well as piping loading descriptions. Some updates and supplements to system and component plans were submitted. Most of the plans have been of a high quality. The licensee has also started to submit its own inspection memorandums in connection with key materials to demonstrate the scope of the licensee's inspections and the conclusions made.

Installation activity at the Olkiluoto 3 construction site slowed down starting in early 2014. Manufacture and installation of the emergency diesel generator auxiliary system pipelines was almost the only work that was still ongoing in 2014. Modifications of the already installed I&C and electrical cabling due to supplemented plans started in the autumn. The fact that the construction site is restarted will bring new organisations and employees to the construction site, which is why the plant supplier and TVO must make sure that they handle the project and its safety in a systematic manner. In connection with an inspection, STUK demanded a plan on preparation for the reopening of the construction site.

Pressure and leak tightness tests of the containment took place at the nuclear island in February. STUK closely monitored the preparation for the tests and conducted an inspection on meeting the prerequisites for the tests prior to the testing. STUK oversaw testing onsite with the help of experts from VTT Technical Research Centre of Finland. The tests were implemented according to plan and on schedule, and the test results clearly met the acceptance criteria. STUK has reviewed and approved some of the test reports but a final summary report of the test results was not submitted to STUK by the end of the year. STUK has expressed its concern regarding the long drafting times of test result reports in several connections.

In 2014, STUK ordered a preliminary report on the safety culture during commissioning of Olkiluoto 3. The report focused on potential threats and any operating methods of the organisation that could compromise safety at the commissioning stage. Challenges highlighted in the report included the highly complex stage during the lifecycle of the plant and the fact that open items and deviations from the construction stage tend to cumulate. Issues that were deemed especially challenging included potential slow processing of unexpected events and people focusing only on their own work in a very narrow sector. The results will assist STUK in targeting its regulatory oversight to the key issues and challenges during the commissioning stage.

To ease the workload at the operating license stage, STUK began at TVO's request a pre-review of the operating license application documents before the submittal of the actual application. The documents submitted for pre-review must form a logical entity, and represent the final plant design. In 2014, a chapter of the final safety analysis report on the reactor, parts of a chapter on accident analyses and the plant's operational limits and conditions were submitted to STUK for pre-review. STUK presented to TVO its observations regarding the chapter on the reactor. The other pre-review documents were still being reviewed at the end of the year. STUK ordered comparison analyses to verify correctness of the plant supplier's accident analyses. No major discrepancies were observed in the results of the analyses made. More comparison analyses will be made in 2015.

Based on the construction inspection programme and other oversight activities by STUK, the methods, operations and adequacy of TVO's organisation have mainly been found to be at a good level, for example as far as the commissioning of the plant is concerned. During construction, TVO and the plant supplier have taken into account modification needs that have emerged as design of the various areas of technology has become more detailed. Deficiencies detected in manufacturing and installation have either been corrected so that the original quality requirements are met, or it has been demonstrated by means of additional inspections or analyses that the requirements are met. 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.

4.3.2 Design

Plant and system design

STUK continued to review the detailed design of process systems, support systems and electricity systems. STUK has approved most of the process system, support system and electricity system designs, but some ventilation system plans still need to be updated before the operating license stage. Furthermore, TVO announced that the plant supplier will make some additional plant system modifications that may require STUK's approval.

The most important open point of plant design is the plant's I&C systems. In the spring of 2014, STUK approved the overall I&C plan or the I&C architecture. STUK issued requirements regarding the plan but they were so minor that the plan could be approved. The requirements concerned for example the independence of a system used in the management of severe accidents from other systems and alarms on I&C failures. After the approval, STUK started reviewing the technical I&C materials. The technical materials include system requirement specifications and system descriptions, as well as testing plans. STUK has processed some old versions of the technical materials in the past but now all the materials have been rewritten to comply with the processes approved by STUK.

The plant supplier started test bay testing of the I&C systems in early April. STUK participated in some of the test kick-off meetings and visited the test bay to observe the tests a couple of times. STUK approved TVO's application to test the priority management system directly onsite. The priority management system ensures that controls of a higher safety class will bypass controls of lower safety classes.

The qualification of I&C components continued to proceed slowly; STUK did not receive many applications. Qualification ensures that the components will operate as planned under all the conditions determined for them, including potential accidents. The components may not be installed before their qualification has been approved.

Fault analyses of plant and system design

The key issue regarding fault analyses in 2014 was the processing of active I&C faults. The term "active fault" refers to an I&C transient where unnecessary or erroneous control signals or messages are sent to process components, electrical devices or other I&C components. In 2013, STUK demanded that the possibility of such faults be surveyed and the consequences of such faults be analysed. In March 2014, TVO submitted to STUK a description of a method based on which the analyses will be conducted. STUK did not consider the method sufficient and demanded some supplements. STUK's requirements had been taken into account in the updated method description that was submitted to STUK in July. STUK received the analyses performed using this method for review in October. Some modification needs in the control of components, such as the control of the I&C rooms ventilation system, have been identified based on the analyses. STUK did not have any remarks concerning the scope or results of the analyses.

STUK approved all of the updated failure mode and effects analyses on electricity systems and components, and nearly all of the failure mode and effects analyses on process systems. However, STUK demanded that the process system analyses be supplemented with a review of vent and drain valve faults, as necessary. Before the operating license stage, TVO must submit analyses on systems whose design has been changed.

STUK reviewed an update of the plant's common-cause failure and diversity analysis regarding process and support systems. STUK approved the analysis but required some corrections and checks. Since the required corrections are minor, taking them into account in the operating license application documents will suffice.

STUK also inspected some flood analyses in 2014. No significant deficiencies were found in the analyses.

Transient and accident analyses

The transient and accident analyses included in the final safety analysis report of Olkiluoto 3 were submitted to STUK for a pre-review in late 2014. Most of the submitted analyses are the same as those already unofficially submitted in 2012 to assist in the review of analysis methodology reports. STUK ordered comparison analyses of the accident analyses to verify correctness of the plant supplier's accident analyses. No major discrepancies were observed in the results of the analyses made. More comparison analyses will be made in 2015.

Probabilistic risk assessments

An updated probabilistic risk assessment (PRA) for Olkiluoto 3 was not submitted to STUK in 2014. The review of the PRA and its reference materials focused on ensuring meeting of the key design principles in the detailed system and structure design materials and their updates. Furthermore, STUK pursued to ensure that the content and up-to-dateness of the materials regarding the PRA and its applications that are to be submitted as appendices to the operating license application, are in compliance with the requirement level laid down in the YVL Guides.

Radiation safety

A radiation protection inspection included in the construction inspection programme was carried out in 2014. The inspection focused on commissioning of the area that will be the plant unit's controlled area, TVO's experiences and observations regarding meeting of the radiation protection requirements and status of the radiation measuring system. STUK required after the inspection that the power company submit a plan which describes the procedures that will be used when commissioning the plant unit's controlled area and implementing the licensee's commissioning inspection.

In 2014, STUK approved a report by TVO on radiation protection of a fuel transfer tube in between the reactor building and the fuel building as well as a report on the impact of changed consistency of the high-density concrete used at Olkiluoto 3 on radiation safety. In connection with the suitability assessment of electrical and I&C equipment, STUK reviewed compliance with requirements regarding the radiation resistance of equipment in normal operation and during accidents. At the licensee's request, the deadlines for updating several radiation measurement system design documents were postponed in 2014.

Plant fire safety

STUK has demanded that the fire hazard analyses be updated to comply with the final plant design. In 2014, STUK demanded from TVO a report on cable types and the quantity of cables as laid down in final design. STUK will use the report when assessing whether cable fire tests and analyses by VTT Technical Research Centre of Finland, which were made to support a previous inspection by STUK, can still be used. The fire hazard analyses must be updated and representativeness of comparison analyses must be studied before submitting the operating license application.

Design of components and structures

In 2014, the plant supplier focused its resources in finalising plant and system design and reduced the resources allocated to detailed component design.

Thus, STUK received clearly fewer design documents than in the previous years. Most of the submitted component design documents were linked to updates of construction plans or pipeline design documents. Final loading descriptions of nuclear island piping systems were assessed in the autumn of 2014. Approved loading descriptions are required before final piping stress analyses.

STUK continued the review of design documents for steel platforms. In contrast to the original plans, the safety significance of the steel platforms has increased because process piping and equipment important to safety will be supported on them. The steel platforms have been approved for component installation purposes after construction inspections done in stages. Compliance with the requirements set by plant operation will be confirmed before the final commissioning of the steel platforms. STUK has implemented inspection visits to verify that TVO's inspections have progressed in line with the approved procedure. STUK will review the final design documents of steel platforms before starting its own commissioning inspections where compliance with the requirements will be ultimately verified.

4.3.3 Construction

Except for some final touches, construction work on the Olkiluoto 3 buildings is completed. In 2014, STUK oversaw the installation of the steel platforms.

In January 2014, STUK concluded the first stage of commissioning inspections on the containment base plate, the interior concrete structures, the concrete part of the containment wall and structural engineering monitoring systems of the containment.

The procedures to determine readiness to start commissioning inspections have proven functional. These procedures have served to ensure that the plant supplier and TVO have inspected and approved the structures and their testing plans before STUK is invited to complete its inspections.

4.3.4 Manufacture of components and piping

Some of the Olkiluoto 3 valves, pipeline flow measuring components and flow limiters had not been manufactured yet in 2014. STUK oversaw their manufacture by means of inspection visits to the manufacturers' facilities.

Furthermore, the manufacture of the emergency diesel generator auxiliary system pipelines also continued in 2014. In early 2014, manufacturing operations were interrupted to study quality problems detected in prefabricated pipes.

4.3.5 Installation

The plant supplier almost completely discontinued installation work at the Olkiluoto 3 construction site in 2014, except for the work on the diesel building pipings.

An extensive modification of cabling was started in the nuclear island in the autumn of 2014. In this modification, the I&C cables of the plant will be updated to comply with the current design status. In 2014, the cabling modification consisted of dismantling cables to be removed. The installation of new cables will start in 2015. STUK oversaw the dismantling of cables onsite in connection with its site visits. Implementation plans on the dismantling were also covered in construction inspection programme inspections on electricity systems. No major non-conformances were observed in the plans or implementation of the work.

STUK inspected TVO's installation supervision in several inspections carried out in accordance with the construction inspection programme and in connection with regulatory activities onsite to verify the sufficiency of TVO's supervision methods. During daily oversight, compliance with approved procedures was monitored, among other things.

4.3.6 Commissioning

Commissioning tests of equipment and systems

Pressure and leak tightness tests of the containment took place at the reactor island in February. STUK closely monitored the preparation for the tests and conducted an inspection on meeting the prerequisites for the tests prior to the testing. STUK oversaw the tests onsite. The tests were implemented according to plan and on schedule, and the test results clearly met the acceptance criteria. STUK has reviewed and approved some of the test reports but a final summary report of the test results was not submitted to STUK by the end of the year. STUK has expressed its concern regarding the long drafting times of test result reports in several connections.

In addition to the tests in the containment, testing of the building technology systems (such as telephone systems, fire detection systems and lighting systems) has also continued in the reactor island. The other parts of nuclear island commissioning will not be continued until the operational I&C has been installed.

Testing of equipment and systems in the turbine island continued. All the tests that can be completed without the nuclear island were completed over the course of the year. STUK monitored selected tests. Corrosion damage was observed in the circulating water piping and related components (such as heat exchangers) in the turbine island. Based on the observations made, the turbine island supplier, Siemens, conducted extensive inspections of the turbine island piping and repaired any damage observed. It is assumed that the damage was caused by the protective coating on the inside of the pipes being thinner than planned, damage incurred during installation and the fact that the electronic corrosion protection for the piping was not used when the piping was filled with water because it generates hydrogen and hydrogen cannot be vented from the piping if the water is not circulating. STUK has requested a report on the underlying causes of the damage. The damage in the turbine island is not significant in terms of the plant's nuclear or radiation safety, but the underlying causes must be studied in order to learn from the mistakes and prevent similar problems at any points that are important to safety.

Inspecting of commissioning test programmes is an important element of STUK's regulatory work. Only a few commissioning test programmes were submitted to STUK for review in 2014. Most of them were updated versions of programmes that had already been reviewed before. Only a few test programmes were submitted to STUK because most of the reactor island system test programmes will not be updated until the detailed I&C design has been completed. Furthermore, TVO has announced that most of the already approved test programmes will be revised, which means that they have to be resubmitted to STUK for approval.

Preparations for future operation of the plant unit

In addition to technical trial runs, commissioning also includes verification of the organisation's capability to operate the plant in a safe manner. The prerequisites of safe operation include an adequate number of licensed operators and the necessary plant documentation, such as procedures and the operational limits and conditions.

An inspection included in the construction inspection programme in November 2014 focused on operator training and status of plant procedures. Simulator training for trainee operators has not been started yet because the I&C design is still incomplete. A number of test cases must be run on the simulator before operator training can be started. The trial runs will be performed to assess whether the simulator describes the plant accurately enough for it to be used in training.

The preparation of plant procedures and the operational limits and conditions, as well as the validation of operating procedures, the control room and human-machine interfaces have also been delayed because the I&C design is still incomplete. Drafting of plant procedures is proceeding, however, and most draft versions have been completed. The operational limits and conditions, except for the I&C part, have been submitted to STUK for pre-review.

4.3.7 Reviewing documents related to operating license application

STUK has agreed with TVO that STUK may review parts of the operating license application documents before the delivery of the actual operating license application. The pre-review will balance the workload of the various parties as completed thematic sections can be reviewed in advance. The documents submitted for pre-review must form a logical entity, and represent the final plant design. As a result of the pre-review, STUK will present a decision including potential observations and requests for further clarifications. The pre-review also functions as practice for the review procedures planned for the operating license stage. All the documents that are delivered to STUK in connection with the operating license application will be reviewed by STUK at the operating license stage as a whole, and STUK will approve their key parts before delivering a safety assessment and a statement on the operating license application to the Ministry of Employment and the Economy.

The pre-review of the operating license application documents began in 2012 with the review of the methodology reports and radiological analyses presented in Chapter 15 of the final safety analysis report. In 2014, Chapter 4 of the FSAR (Reactor), parts of Chapter 15 (Accident analyses) and Chapter 16 (OLC) were submitted for pre-review. STUK completed the review of Chapter 4 in 2014 and submitted its comments to TVO. No significant remarks regarding the chapter were made. At the end of the year, Chapters 15 and 16 were still being reviewed.

4.3.8 Organisational operations

Organisation

The total number of personnel working at the Olkiluoto 3 construction site towards the end of 2014 was around 1,100, of whom around 290 were part of the plant supplier's construction site organisation and around 490 were employees of subcontractors. TVO's project organisation consisted of project personnel (around 50), TVO's line organisation personnel (around 95) and consultants, of whom some worked part-time (around 170). The number of plant supplier and subcontractor personnel at the construction site clearly decreased in 2014, but the plant supplier has estimated that more employees will be added again in early 2015. The fact that the construction site is restarted will bring new organisations and employees to the construction site, which is why the plant supplier and TVO must make sure that they handle the project and its safety in a systematic manner.

The project organisations of both the licensee and the plant supplier were changed over the course of the year. The organisational changes were caused by the schedule of the remaining work to be done by the plant supplier, for example. The organisations were changed in a manner that will make finding a "counterpart" in the other organisation easier. The plan is to increase the amount of cooperation between the plant supplier and TVO. TVO's organisational reform also aims at improving efficiency of the operations: responsibilities and roles have been clarified. STUK studied in an inspection included in the construction inspection programme how the organisational reform by TVO has influenced the project and thus safety. No issues that compromise safety were observed in the inspection or any other assessments of the organisational changes implemented by TVO. STUK will continue to monitor the sufficiency of personnel and the organisation's operations under the changing conditions.

Functionality of the management system

In accordance with the project agreement, instructions provided by the plant supplier are followed by the Olkiluoto 3 project. The parties have accepted these instructions. In addition to the plant supplier's instructions, a quality management system drafted for the Olkiluoto 3 project controls TVO's own operations. When operation of the plant starts, TVO will be in charge of the operation and safety, however. In 2014, STUK demanded from TVO reports on how the procedures applied to the Olkiluoto 3 project can be revised to correspond to the procedures required for an operating nuclear power plant. According to TVO, the separate management system for the Olkiluoto 3 project will be discontinued at the latest when applying for the operating license. At that time, the general part of TVO's management manual, which has been approved by STUK, will enter into force. It will also be supplemented with a quality plan for the Olkiluoto 3 project. It determines the functions and documentation that will be used during component and system installation and commissioning stages until the final handover of the plant unit. STUK has emphasised the fact that all documents pertaining to this change must be submitted to STUK well before the implementation of the change.

Quality assurance and supplier monitoring

TVO's independent quality assurance unit (QA) monitors quality issues of the Olkiluoto 3 project by processing any critical non-conformances observed in the operations of the plant supplier and its subcontractors, product non-conformances and audit results, as well as by recording statistics and analysing information pertaining to the underlying causes for the non-conformances. A continued concern regarding the Olkiluoto 3 project is the large number of open issues. Even though some issues were concluded over the course of the year, particularly towards the end of the year, there are still a large number of open issues. Fewer audits pertaining to the monitoring of suppliers than in the previous years were conducted in 2014. In connection with previous inspections, STUK has demanded that the adequacy of quality assurance resources must be verified when replacing personnel, and TVO has transferred some experienced employees to quality assurance positions.

Safety culture

In 2014, STUK ordered a preliminary study on the safety culture during commissioning of Olkiluoto 3. It focused on potential threats and any operating methods of the organisation that could compromise safety at the commissioning stage. The report studied the clarity of the division of roles between TVO and the plant supplier, the clarity of procedures and instructions, personnel turnover, planning of personnel resources, decision-making, language problems and the management of unexpected events. Challenges highlighted in the report included the highly complex stage during the lifecycle of the plant and the fact that problems from the construction stage tend to cumulate. Issues that were deemed especially challenging included slow processing of unexpected events and people focusing only on their own work in a very narrow sector. The fact that the project seems temporary but still drags on may lead to temporary solutions, several interfaces, delays and high personnel turnover. The research results suggest that TVO should take on a more active role of a vanguard. The results will assist STUK in targeting its regulatory oversight to the key issues and challenges during the commissioning stage.

4.3.9 Nuclear security

Over the course of the year, STUK processed information security plans and assessed the adequacy of technical and administrative information security control in connection with reviewing materials, site visits and inspections. Information security was also studied and assessed during a review of I&C materials and during I&C test field visits. STUK observed some development issues pertaining to information security and some deficiencies in documentation.

Taking into account security issues when assessing and developing the safety culture was studied in an inspection of quality assurance and the safety culture, which is part of the construction inspection programme. Some issues requiring development were observed.

4.3.10 Safeguards of nuclear materials

STUK performed a safeguards inspection of the Olkiluoto 3 design information (basic tecnical characteristics) with the IAEA and the European Commission. The review focused on locating the key issues in terms of the safeguards of nuclear materials, such as fuel storage locations and transfer routes. No remarks pertaining to the NPP were made during the inspection, but TVO was obligated to submit up-to-date basic technical characteristics document to the Commission and STUK.

4.4 New nuclear power plant projects

In 2014, STUK drafted preliminary safety reviews on supplementary applications for the decisions-in-principle on Fennovoima's Hanhikivi 1 and TVO's Olkiluoto 4 and submitted them to the Ministry of Employment and the Economy in compliance with the Nuclear Energy Act.

4.4.1 Olkiluoto 4

In its supplementary application, TVO applied for an extension of five years to the deadline for submitting a construction license application for the new nuclear power plant unit at Olkiluoto in compliance with the 2010 decision-in-principle. According to the decision-in-principle made in 2010, a construction license for the plant would have to be applied by the end of June 2015. The Ministry of Employment and the Economy requested from STUK a preliminary safety assessment in compliance with the Nuclear Energy Act on TVO's application. STUK stated that there are no nuclear safety issues that would prevent the extending of the deadline. STUK is of the opinion that the extension requested by TVO could be used to revise the design of the selected plant type to meet the new Finnish safety rules, as well as to develop TVO's expertise and management system.

4.4.2 Hanhikivi 1

In its preliminary safety assessment of the Hanhikivi 1 plant unit of Fennovoima, STUK assessed whether Fennovoima could build a NPP of the AES-2006 type by Rosatom in a manner that meets the Finnish safety requirements and whether Fennovoima would be able to ensure safety of the NPP. In its preliminary safety assessment, STUK focused on issues that have changed since the original decision-in-principle four years ago. The most major changes include the plant type having been changed to AES-2006 as well as E.ON withdrawing from the project and Rosatom entering the project as an owner. STUK is of the opinion that these changes have clearly influenced the progress of the project and the development of the Fennovoima organisation, Fennovoima's resources and Fennovoima's activities. STUK also assessed the Fennovoima management system, organisation and expertise also in terms of the preparation for the construction license stage.

In its preliminary safety assessment, STUK stated that an AES-2006 nuclear power plant can be constructed in a manner that meets the Finnish safety requirements at the location indicated by Fennovoima, Hanhikivi in Pyhäjoki. STUK paid attention in issues where compliance with the Finnish safety requirements would require changes in plant design, such as provisions for an airplane crash, internal floods, fires and severe accidents. Furthermore, STUK identified other technical details that would require further analyses or tests at the construction license stage. STUK also stated in the preliminary safety assessment that Fennovoima will need expertise and will have to take action already before the next license stage, i.e. the submitting of the construction license application, in order to change the design so that it meets the requirements and draft the documentation to be submitted to STUK. STUK is of the opinion that Fennovoima must improve its expertise and develop its management system in order to be capable to assess and ensure the safety of a new NPP, as well as to draft the construction license materials to be submitted to STUK. In its statement to the Ministry of Employment and the Economy, STUK questioned whether the company could submit comprehensive documentation to STUK simultaneously with submitting the construction license application to the Government. STUK stated that this issue must be taken into account when planning the creation of the materials to be submitted to STUK at the construction license stage and their schedule, as well as when assessing the duration of the construction license stage.

STUK and Fennovoima arranged several meetings on various themes, such as plant technology, the preliminary safety assessment, nuclear waste management, safeguards of nuclear materials, civil engineering, planning of licensing, management systems and seismology. The significance of thorough licensing planning was emphasised in both project meetings and the themed meetings. Fennovoima has faced some challenges in its licensing planning. Submission of the first version of the licensing plan to STUK was postponed from early autumn 2014 to 2015.

STUK monitored the development of Fennovoima's management system and quality assurance, and assessed the company's organisational resources to begin construction of a nuclear power plant. In the discussions, STUK aimed at improving the company's expertise. Furthermore, STUK's experts participated as observers in audits of the plant supplier and its subcontractors arranged by Fennovoima. The Fennovoima supplier audit programme was mostly completed in late 2014.

Unlike expected by STUK, Fennovoima did not send a large quantity of documents to STUK for advance approval. By virtue of an amendment of section 55 of the Nuclear Energy Act that entered into force in the autumn of 2012, STUK can launch the approval procedure of components and structures before a construction license decision has been made. STUK can also pre-review plant and system level documents.

STUK processed Fennovoima's nuclear security by means of reviewing documents and participated as an observer in the plant supplier audit. STUK processed documents pertaining to the processing and delivery methods of safety classified and confidential information, and approved a new status proposed by Fennovoima for the processing of safety classified information.

4.4.3 STUK's preparation for plant projects

In 2014, STUK started its preparations for the processing of the construction license applications for the new plants. The plan is to establish project-specific workgroups within STUK to coordinate and partially also process issues pertaining to their dedicated project. Some expert resources were tied up in the processing of supplements to the decisions-in-principle and related preliminary safety assessments, and these experts could not participate in the preparation. On the other hand, processing of the new plant type proposed by Fennovoima provided STUK with more understanding of the plant and how its design would meet the Finnish safety requirements at the time of the application being submitted.

STUK launched requirement management development projects VAHA-A and VAHA-B to create the prerequisites for proving compliance with requirements in the license procedures in compliance with the Nuclear Energy Act. VAHA-A includes the determination of attributes for each of the around 8,000 requirements in the YVL Guides. The attribute determination process is very extensive. In addition to the STUK experts, experts of the power companies participate in the work. The requirement attributes will allow STUK to specify interpretation of the requirements and achieve the prerequisites needed to utilise requirement management working methods. In VAHA-B, STUK will determine, acquire and commission a requirement management tool. Due to the high workload, the original deadline for the VAHA-A project's attributes was postponed from the autumn of 2014 to the spring of 2015.

4.4.4 Safeguards of nuclear materials

Including the safeguard requirements in the design and construction of new plants as early on as possible is important both in terms of the operator's own supervision activities and the safeguards of nuclear materials arranged by STUK and international parties. TVO submitted preliminary design information (i.e. the basic technical characteristics documents) for Olkiluoto 4 in November 2012 and Fennovoima submitted preliminary design data for Hanhikivi 1 in July 2013. The European Commission issued Material Balance Area codes for the plants and submitted the design information to the IAEA. Thus, international safeguards organisations have been able to start the planning of their regulatory actions and regulation of the projects. In 2014, STUK approved a handbook by Fennovoima on the safeguards of nuclear materials, which provides instructions on the safeguards of nuclear materials at this stage, i.e. mainly on procedures pertaining to data subject to license.

4.5 Research reactor

Decommissioning and waste management

The operating license for the research reactor FiR 1 is valid until the end of 2023. However, VTT Technical Research Centre of Finland has decided to shut down and decommission the reactor earlier due to financial reasons. VTT submitted an updated nuclear waste management plan for the research reactor to the Ministry of Employment and the Economy in June 2014. The document includes a preliminary plan on decommissioning the reactor, handling and intermediate storage of the decommissioning waste. By request of the Ministry of Employment and the Economy, STUK submitted a statement on the nuclear waste management plan on 28 November 2014. In this statement, STUK emphasised the importance of a systematic study on how the final disposal of the decommissioning waste should be managed.

VTT started an environmental impact assessment (EIA) procedure for the reactor's decommissioning by submitting an EIA programme to the Ministry of Employment and the Economy on 6 November 2013. STUK submitted a statement on the EIA programme to the Ministry of Employment and the Economy on 13 January 2014. Based on the EIA programme, VTT prepared an EIA report, and STUK issued its statement on the report on 18 December 2014. In its statements, in addition to the safe operation of the research reactor, STUK paid special attention to more specific planning of the demolition and more specific planning of nuclear waste management during the decommissioning stage.

There are safety requirements for decommissioning in the Nuclear Energy Act, acts and decrees on the use of radiation and the YVL Guides. A new YVL Guide, YVL D.4, deals with the decommissioning of nuclear facilities. It entered into force on 1 December 2013 for new nuclear facilities. The plan is to extend the Guide to cover FiR 1 based on a decision by STUK in 2015. The Guide states that the licensee must, for example, submit a final decommissioning plan to STUK for approval.

Safeguards of nuclear materials

In 2014, STUK conducted one inspection of nuclear material inventory together with the European Commission.

Nuclear security

STUK implemented an inspection of the research reactor that is included in the periodic inspection programme and oversaw the implementation of nuclear security. STUK approved a deputy of the person responsible for nuclear security.

4.6 Encapsulation plant and disposal facility for spent nuclear fuel

4.6.1 Processing of construction license application

At the end of 2012, Posiva submitted to the Government a construction license application for an encapsulation plant and disposal facility for spent nuclear fuel and submitted to STUK the construction license application documentation laid down in the Nuclear Energy Decree and Government Decree 736/2008.

Actual review of Posiva's construction license application documents continued in 2014. According to the original schedule, STUK's review work was to be completed in June 2014, but the processing took longer because the review of the application documents and the overall safety assessment took longer than expected. The key reasons for the delay were the following:

- Posiva was not able to submit all of the technical materials included in the construction license application in connection with the license application in late 2012. Since the materials were incomplete, STUK could not launch the review process in its entirety in early 2013.
- When reviewing the application documents, STUK observed some deficiencies due to which Posiva had to update and supplement the application. The key supplements required by STUK involved plant design materials, plant operation transient and accident analyses, proving performance of the final disposal system, long-term safety analyses and nuclear security plans.
- Encapsulation plant and disposal facility for spent nuclear fuel are facilities of a new type. There is only little previous experience on the design and construction of such facilities, as well as the assessment of their safety. Furthermore, STUK's new safety requirements (YVL Guides) on nuclear facilities that were published in late 2013 were applied for the first time in the construction license process of Posiva's nuclear facilities. For the above-mentioned reasons, special attention had to be paid in the safety assessment.

In June, STUK applied from the Ministry of Employment and the Economy an extension to the deadline for processing the construction license application and submitting a statement. STUK estimated that the work should be completed at the end of 2014. The plan was to submit STUK's statement and the safety assessment to the Ministry of Employment and the Economy in January 2015. This schedule could only be met if the supplements to the application submitted by Posiva in the autumn were sufficient. The Ministry of Employment and the Economy approved STUK's proposition on extending the processing period of the Posiva construction license application. In its decision, the Ministry of Employment and the Economy requested that STUK submit its statement and the safety assessment by the end of January 2015, if possible.

Of the key documents included in the license application, STUK approved in 2014 Posiva's management handbook, a preliminary emergency preparedness plan, a report on quality assurance during construction, a plan on arranging regulatory activities necessary to prevent the proliferation of nuclear weapons, general inspection plans and a plan on a study on radiological baseline in the environment. Furthermore, decisions on the preliminary safety analysis report, a safety case, a proposal on a classification document, a preliminary nuclear security plan, a preliminary report on ageing management principles to be applied to the facility and a probabilistic risk assessment for the design stage were prepared. These decisions will be issued in January and February 2015. Detailed review reports were also prepared to support the decisions on the preliminary safety analysis report and the safety case, as well as the presentation memorandums.

STUK used an international group of experts in various fields to support the review of the safety case on long-term safety. STUK used plenty of man-hours when planning, controlling and administering their work. This was necessary for STUK to benefit as much as possible from the independent review work of the external experts when reviewing all the documents.

Sweden is almost exactly at the same point as Finland in its license process for a spent nuclear fuel disposal project. The Swedish Radiation and Nuclear Safety Authority (SSM) is currently processing the license application. On 22–24 September 2014, STUK and SSM arranged a seminar on observations made during the license application review in Finland and Sweden, the background for these observations and lessons learned during the review processes in general.

In addition to the above-mentioned decisions, a statement and a safety analysis report to be submitted to the Ministry of Employment and the Economy were prepared at the end of the year. Furthermore, a statement on the construction license application based on STUK's statement and safety analysis report was requested from the Advisory Committee on Nuclear Safety. The Advisory Committee's statement will be enclosed with STUK's statement as laid down in section 37 of the Nuclear Energy Decree.

Plant design, plant construction, safety classification and operational safety

In 2014, Posiva supplemented the plant design documents included in the construction license application in terms of the general parts of the preliminary safety analysis report and system descriptions both at its own initiative and based on requests for supplementary information by STUK as a result of the review. STUK's review focused on reviewing plant design safety principles and the review of safety classified systems.

Of the general chapters of the preliminary safety analysis report, Posiva updated chapters on general safety and design principles, construction and operation, management of radioactive materials, as well as transients and accidents. The key supplements to the safety principles were implementation of the defence in depth principle in plant design, the definition of a controlled and safe state and behaviour of the plant in case of a loss of power. In the transient and accident analyses, selection criteria for transients and accidents selected for a more detailed study, details of analyses and radiation protection issues were supplemented.

In terms of system design, Posiva supplemented system descriptions, which cover most of the safety classified systems. System descriptions in the following fields were updated: hoisting and transfer devices, radiation measuring, ventilation, electricity and I&C, underground rooms, emergency power supply units and the supply of emergency power, fire safety and civil engineering. Requested system description supplements involved more details in design bases, analysis used to justify the design solutions and principles of safety classification. Major proposed changes to design given by Posiva included changing the safety classification of emergency power and changing the canister hoist into a single failure tolerant system. The change regarding the canister hoist meant that a shock absorber, which was to be placed at the bottom of the canister shaft, was no longer necessary to ensure safety. Thus, the shock absorber was changed into an option.

A plant design inspection report was prepared during the year. It included observations made based on a review of the preliminary safety analysis report and justification for these observations. Changes made in latest documentation updates were taken into account when finalising the report. Safety classification and seismic classification of systems were reviewed when inspecting the systems and reviewing the proposed classification document. A request for supplementary information was submitted to Posiva regarding the classification document and observations on classification made during the system description review, in which further information about basis of the classification, supplements to the documents, as well as standardising of system inspection and the classification document were requested. Posiva proposed changing the safety class of the emergency power supply to EYT (non-nuclear), since Posiva is of the opinion that the facility can meet the safety function requirements without external power supply with battery-backed systems. In terms of the seismic classification, the request stated that Posiva should provide further information on safety functions that will be retained after an earthquake. Based on the request for supplementary information, Posiva submitted an updated proposed classification document.

Long-term safety

STUK continued its review of long-term safety and prepared a report on the observations made when reviewing the performance of the engineered barriers and natural barrier and the safety analysis.

STUK used the independent expertise of around twenty Finnish and foreign consultants to support its review of the safety case in terms of the disposal facility location, engineered barriers and the safety analysis. The consultants met in a concluding workshop on 12–16 May 2014 to summarise their review findings. Based on results presented at the meeting, the consultants drafted separate summary reports that are independent of STUK's review of Posiva's safety case. The summary reports by the consultants on the disposal site, the engineered barriers and the safety analysis were completed by the end of 2014.

STUK's review of the Posiva safety case started in 2013. Most of the review work was done in 2014, however. The review was completed in late 2014. STUK drafted a safety case review report and a draft decision during the last quarter of the year. The review report includes justification for STUK's requirements on further studies to further ensure properties of the bedrock, performance and suitability as well as to develop the rock classification system to be used during layout planning of the facility and verifying acceptability of excavated rooms. In terms of engineered barriers, the review report includes e.g. justification for requirements on proving performance of the engineered barriers and uncertainties about performance. As part of the safety analysis, the review report includes justification for requirements on developing the safety case, developing the safety analysis methods, and combining the low- and intermediate-level waste disposal facility safety analysis with the safety analysis of the spent fuel disposal facility. The safety case review report includes background for and details of the requirements included in the decision on the safety case and plenty of review observations made. The safety case decision to be given in January or February 2015 will include the issues most important to safety as requirements.

Based on the safety case materials reviewed by STUK, long-term safety of the facility has been analysed to an extent that is sufficient for the construction license application stage. The results show that the facility will be safe in terms of the environment, people and other living organisms after the closing of the facility in the manner required by the Government Decree. Furthermore, Posiva has proven suitability of the disposal method and site in a manner sufficient for the construction license application stage. The review showed, however, that the safety case needs to be further developed by clarifying the safety arguments and related methods, and by eliminating some of the uncertainties regarding the performance of the barriers.

Engineered barriers and bedrock at the disposal site

Regarding the safety case for the disposal facility, STUK submitted to Posiva requests for supplementary information that requested that Posiva supplement the rock classification system criteria, the occurrence of natural resources, the selection criteria for the depth of the disposal facility and performance for the bedrock surrounding the disposal facility near-field. In terms of engineered barriers, the requests involved e.g. the performance of engineered barriers, the changing of the sealing method of the canisters, thermal properties of the engineered barriers, buffer saturation, montmorillonite in the buffer and tunnel filling material, as well as dimensioning of the buffer and tunnel filling material density.

Themed workshops on the disposal site that were launched in late 2013 were continued in 2014. A workshop on the hydrogeological discrete fracture network model used by Posiva was arranged on 24–26 February. In this workshop, sources of errors in characterisation measurements and hydrogeological flow models, the link between paleohydrogeochemistry and flow models, as well as the links between rock classification and flow models were discussed. A workshop on Posiva's seismic modelling was arranged on 19–21 March. This workshop focused on the initial data and model assumptions used, seismicity caused by thermal expansion, analysing the consequences of earthquakes and further development plans of Posiva's earthquake analyses. A workshop on interpretation and modelling of the rock structures in the Olkiluoto area was arranged on 31 March – 1 April. It focused on reconciling the collected geological data and model presentations into a comprehensive view.

Safety analysis

Review of the long-term safety analysis for the final disposal was completed in 2014. Posiva submitted responses to requests for supplementary information by STUK regarding Posiva's computational safety analysis, biosphere assessment, final disposal of low- and intermediate-level waste and long-term safety. STUK reviewed the results of the computational safety analysis by Posiva to verify that the issues included in the safety case are sufficient to prove compliance with the safety requirements. Posiva has presented annual doses and releases of radioactive materials calculated as a result of analyses on probable scenarios and analyses on weakening of the safety functions. Posiva has compared these results with the set dose and release limits. The results remain below the set limits.

Organisational operations and quality assurance

In 2014, Posiva continued to develop and improve its management system, procedures and instructions. One of Posiva's goals in this development work is creating a system that complies with the requirements set for a management system of a nuclear facility during the construction stage in the renewed YVL Guides by STUK. The improvements involve Posiva's management system as a whole. The management system comprises a management handbook, an organisation handbook, processes used to control the activities and procedures in the form of handbooks. To support the development, Posiva ordered an annual independent assessment of the management system's compliance with the requirements.

The procedures guiding Posiva's operations have been compiled into several handbooks covering a variety of areas, such as the R&D handbook, the procurement handbook, the design handbook, the manufacturing handbook and the construction handbook. In 2014, Posiva completed some of these handbooks and started using them. STUK reviewed the instructions included in the handbooks submitted by Posiva to STUK. Based on a request by STUK, Posiva created a schedule on preparation of the missing handbooks in such a manner that the handbooks will be approved and in use at the correct plant project stages.

Posiva developed its organisational structure in 2014 to better correspond to the needs of the preparation and construction stage after delivery of the construction license application. The project organisation in charge of the construction of the nuclear facilities was published in 2014. The line organisation will be in charge of the development of the final disposal concept and supporting functions at the company level for the construction project. The project organisation will be complemented later based on the construction requirements. In 2014, STUK continued evaluation of the Posiva organisation, personnel resources and competence as part of the construction license application process.

In 2014, STUK assessed Posiva's management system and organisation by conducting nine inspections of Posiva's operations as part of the processing of the construction license application. 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 8.

Emergency preparedness and nuclear security

Posiva submitted to STUK in connection with its construction license application a preliminary emergency response plan and an update to the plan, which STUK reviewed. STUK also took into account a statement by the Ministry of the Interior in its assessment. STUK approved the preliminary emergency response plan by Posiva on 3 April 2014. Planning of the Olkiluoto encapsulation plant and disposal facility in terms of emergency preparedness and plans of action for the site are sufficient.

STUK will continue to oversee the progress of emergency preparedness during construction of the encapsulation plant and disposal facility by, for example, reviewing Posiva's updated accident analyses and the estimated radiation doses and early stage protection activities based on them, as well as by monitoring how the division of labour between Posiva and TVO is specified and how resources are allocated in case of emergencies.

STUK processed the documents submitted in connection with the construction license application linked to nuclear security and prepared a decision that takes into account the requested statement by the Ministry of the Interior.

STUK has processed Posiva's proposed nuclear security for the construction period and will oversee the progress and development of Posiva's nuclear security issues during construction of the encapsulation plant and disposal facility.

Safeguards of nuclear materials

Since safeguards of nuclear materials is international, several technical meetings with the European Commission and the IAEA have been arranged on safeguards of nuclear materials at the Posiva's planned nuclear facilities. Based on these meetings, the Commission and the IAEA prepared in 2014 a plan on surveillance and monitoring instruments to be installed in the encapsulation plant. STUK reviewed a description of arrangements required for non-proliferation of nuclear weapons that was submitted by Posiva as laid down in section 35 of the Nuclear Energy Decree when submitting the construction license application. It was noted that the plan can be approved and Posiva must take into account during further planning the monitoring needs by the IAEA, the Commission and STUK.

4.6.2 Construction of research facility Onkalo

Excavation of underground facilities

The excavation of a vehicle tunnel to Onkalo started in 2004. Most of the excavation works were completed in 2012. Total length of the vehicle tunnel, shafts, research facilities, demonstration tunnels and other facilities is around 9,000 metres, extending from the ground level to a depth of 455 metres (Fig. 17). The excavated volume is around 365,000 m^3.

The Onkalo supply air shaft and personnel shaft were opened between levels –290…–455 by raise boring by early April. Before the raise boring of the personnel shaft and supply air shaft, water-conducting zones in the surrounding bedrock were sealed by injecting several times with grout-containing ultrafine silica.

Measuring of seepage water in the personnel shaft and supply air shaft started in July 2014. Based on the results obtained, sealing of the surrounding bedrock with ultrafine silica was successful: the amount of seepage water in the shafts varied between almost zero to around 1.8 litres per minute. The total seepage water volumes in Onkalo are discussed in the chapter *Monitoring and studies* below.

An extensive area of around 15–20 m^2 where the shotcrete used to reinforce the bedrock had come partially or wholly loose was observed during a seepage water survey in mid-November. According to Posiva, the shotcrete has come loose partially because the basis on which it was spread was uneven and partly because of the geology and tensions. Lowering the amount of shotcrete determined in the reinforcement plan may be needed.

Testing of bedrock suitability classification at Onkalo

The demonstration area on level –420 includes four demonstration tunnels: DT2 (105 metres in length), DT1 (52 m), DT3 (25 m) and DT4 (21 m). Posiva plans to use the demonstration area to test the final disposal methods and performance of engineered barriers as well as to conduct installation tests and trial runs of the machinery and equipment to be used during final disposal. Underground joint operating tests of several engineered barriers will also take place in the demonstration area.

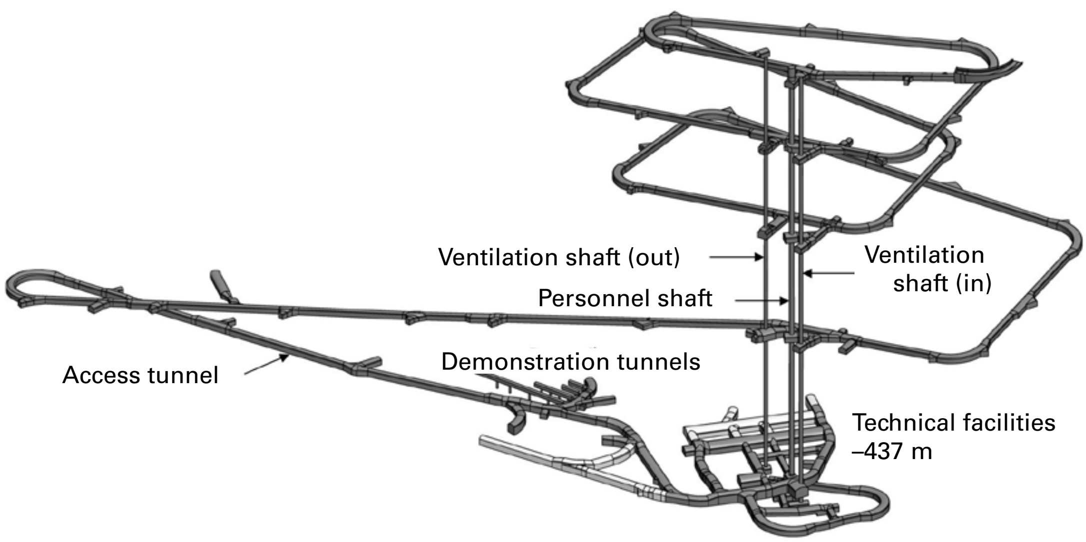


Figure 17. Status of the excavation of Onkalo in January 2015. Lightgray parts denote Posiva's excavation plans for 2015.

In 2014, pilot holes for test disposal holes were drilled in DT2. A probe hole drilled during construction of the demonstration tunnel DT2 penetrates two of the test disposal holes, which means that they might not be eligible for the intended studies. In terms of the excavation of the repository, Posiva clearly needs to develop its excavation methods, the supervision of excavation and its documentation on the final results. STUK will oversee the drilling of the test disposal holes because Posiva plans to use the same method when drilling the actual final disposal holes.

The main purpose of the demonstration tunnels, in addition to providing a location for testing, is to yield information for the development of the rock suitability classification (RSC), as well as information for the needs of characterisation and modelling of the Onkalo bedrock.

Posiva started construction of a testing hall at the Onkalo construction site in the autumn of 2013. The hall was completed in the spring of 2014. The plan is to use the testing hall to test the installation of canisters and buffer blocks as separate systems and together. A structure that is approximately eight metres in height and corresponds to a full-scale disposal hole was built under the testing hall's floor. It is made of transparent material so that the installation work can be seen at all times.

Posiva planned to test and prove the performance of the buffer installation vehicle as well as the canister transfer and installation vehicle in 2014. Due to a variety of delays, the buffer could not be fully assembled in 2014, even though single blocks could be installed. A successful canister installation test into the test disposal hole was completed. The testing will continue with installation of buffer blocks into the test hole in 2015. In 2014, STUK oversaw preliminary field testing of tunnel floor levelling materials. STUK will oversee the testing at Onkalo in 2015.

STUK oversaw factory acceptance testing and field testing of Posiva's installation equipment in 2014. Compliance of the equipment with requirements and feasibility of the installation work were assessed during inspection visits. STUK oversees all demonstrations to assess the feasibility of the systems and concepts as well as remaining uncertainties.

Monitoring and studies

In 2014, studies as part of Posiva's hydrogeology, hydrogeochemistry, rock mechanics and foreign material monitoring programmes took place in Onkalo. They were used to monitor the impact of the construction of Onkalo. The purpose was to obtain more reliable and representative data for geoscientific interpretations and modelling and the rock suitability classification (RSC) by means of surveys, measurements and studies.

The total amount of seepage water into Onkalo varied from 29 to 35 l/min in 2014. The total amount of seepage water remained clearly below the action limit set by Posiva, which is 80 l/min, and the seepage in single shafts remained below the action limit of 5 l/min.

Posiva obtained more information about the consistency of the groundwater at the planned final disposal depth with the help of hydrochemical measurements and sampling. Furthermore, Posiva obtained information about the impact of the construction of Onkalo with the help of its hydrogeochemistry monitoring programme. In the spring of 2014, Posiva detected faults in multi-packer devices installed in deep bore holes in the eastern part of Onkalo. The measuring results were correct but the results were linked to the wrong borehole sections during the automatic data collection. According to Posiva's studies, no erroneous hydrogeological data, modelling or conclusions were used in the background materials of the construction license application.

Exceeding of the hydrological and hydrogeochemical action limits set by Posiva may influence the long-term safety of the final disposal of nuclear waste because the exceeding of the limits suggests that the stable conditions of the bedrock at Olkiluoto (slow groundwater flow and favourable groundwater chemistry) have changed because of the construction of Onkalo.

In December 2014, the lowering of the groundwater pressure head due to seepage of groundwater into Onkalo exceeded the action limit set by Posiva at six research holes drilled from the ground level close to Onkalo. Posiva determined that the pressure head decreased because connections with low conductivity or local connections did not receive any water to substitute the water that is seeping into Onkalo.

Posiva set the action limits for the hydrogeochemical monitoring of Onkalo based on the normal state of the bedrock at Onkalo determined before the construction of Onkalo started. The action limits for different parameters vary according to depth because the hydrochemical conditions in the Olkiluoto bedrock clearly show that different water types are layered.

In 2014, Posiva detected exceeding of the hydrogeochemistry action limits at more than ten deep bore holes drilled from the ground level. The excesses varied from minor to tens of times the action limit. The following groundwater chemistry parameter values were exceeded: alkalinity, total salinity, chloride, ammonium, sulphate, sulphide, phosphate and organic carbon. Of these, ammonium and phosphate are likely residues from the explosives used during the construction of Onkalo.

The action limits were exceeded in four of the groundwater samples taken at the groundwater stations in Onkalo or from research holes. The organic carbon, sulphide or pH action limits were exceeded in these samples.

STUK will continue to monitor and assess the data reported by Posiva and Posiva's interpretations on the impact of Onkalo's construction on the bedrock of Olkiluoto. It is important to see whether the changes remain within the limits set in the safety case of Posiva's construction license application.

STUK's inspection activities

In 2014, STUK performed eight regulatory site inspections in Onkalo and at the Onkalo construction site above ground level. During these inspections, STUK focused on the planning and implementation of ongoing works and Posiva's own quality assurance and quality control. The raise boring of shafts and all the work conducted in the demonstration area were monitored with special care.

In 2014, the construction inspection programme of Onkalo included three inspections that focused on issues critical to long-term safety. The results of the inspections are described in Appendix 7 to this report.

In 2014, Posiva conducted five construction readiness inspections of Onkalo. STUK participated in these inspections as an observer or verified the readiness to start construction from records submitted by Posiva. In February 2014, STUK carried out one inspection on the readiness to start shotcreting in demonstration tunnels 3 and 4.

Reviewing Onkalo construction documents

In 2014, STUK processed 91 documents regarding the construction of Onkalo that were submitted to STUK for information or for approval. One of the most important documents was Posiva's application on updated Onkalo master drawings and a change in the scope of Onkalo. In the updated master drawings, the depth of the final disposal tunnels had been decreased by fifteen metres from the previously approved plan. Posiva also proposed the excavation of new vehicle tunnels 16 and 17 that would create the connecting tunnel to the first final disposal panel. Posiva justified the excavation of the new facilities by the development of bedrock characterisation, RSC demonstration, the suitability analysis method and excavation methods. STUK also processed excavation plans for a plug in DT4, as well as some plans pertaining to the supply air and personnel shafts and their raise boring.

4.6.3 Safeguards of nuclear materials

STUK has carried out safeguards of nuclear materials at Onkalo, which is currently under construction and which will become part of the repository. STUK's regulatory activities have been implemented in line with the national safeguards of nuclear materials 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 2013, Posiva drafted the first notices of the basic technical characteristics of the encapsulation plant and disposal facility included in the construction license application design documentation and submitted these to the European Commission and the IAEA. Posiva updated the documents in 2014. Posiva also updated the handbook on regulatory oversight of nuclear non-proliferation in this connection. It provides instructions on the safeguards of nuclear materials at the project's Onkalo stage.

In November 2014, STUK, the Commission and the IAEA reviewed the technical basic characteristics declaration of the repository at Onkalo to verify that Onkalo has been built in compliance with the declaration. The EU Joint Research Centre

(JRC/Ispra) assisted the IAEA and Commission by measuring and drafting an independent 3D model of Onkalo to use as the basis of future inspections by international organisations. The inspection and the related land surveying took seven days. A total of twelve people from the IAEA, the Commission and JRC participated in the work. Their combined workload was 65 man-days.

5 Other uses of nuclear energy

5.1 Talvivaara

In 2014, Talvivaara Mining Company Plc practiced mining operations at Talvivaara in Sotkamo. The mine's key products were nickel and zinc, and the ore also included smaller concentrations of other elements that can be utilised. The metals are separated from the ore at the mine by means of bioheapleaching. In this process, uranium is dissolved from the ore in addition to other heavy metals. The uranium concentration at the Talvivaara deposit is low (17 ppm on average), but Talvivaara used to consider the recovery of uranium to be profitable because of the large volumes. For this reason, Talvivaara submitted an application to the Finnish Government on the recovery of uranium in 2010. If not recovered, the uranium will end up in the gypsum waste pond and part of it will end up in the mine's nickel product. Talvivaara was granted a permit from the Government by virtue of the Nuclear Energy Act to start recovery on 1 March 2012. The permit stated that the recovery of uranium could be started once STUK had approved several documents pertaining to the recovery process.

Talvivaara started construction of a uranium recovery plant after granting of the permit. STUK monitored progress of the construction project and prepared to start regulation of the uranium recovery process. The poor financial status of Talvivaara postponed the completion of the recovery plant, and Talvivaara failed to submit the documents pertaining to the start of the recovery of uranium to STUK for processing. In the autumn of 2013, the Supreme Administrative Court returned, with its decision 3825/2013, the uranium recovery permit of Talvivaara to the Government for new round of processing. Talvivaara Sotkamo Oy filed for bankruptcy in November 2014.

Environmental impact of leaks from the Talvivaara mine in the winter 2012–2013 was continued in 2014 by virtue of the Radiation Act. Uranium contents in watercourses were monitored with special care in the mine area and in waterways close to the mine.

5.2 Others

Small amounts of uranium are being extracted in the production processes of Freeport Cobalt Oy in Kokkola and Norilsk Nickel Harjavalta Oy in Harjavalta. STUK has reviewed their inventory reports on the production of uranium. Other inspected nuclear material inventories include those of the Helsinki University Laboratory of Radiochemistry and the Radiation and Nuclear Safety Authority. No remarks were made in the inspections.

In late 2014, VTT Technical Research Centre of Finland submitted to the European Commission and STUK preliminary design information on VTT Centre for Nuclear Safety that is currently under construction. The plan is to transfer some laboratory functions from VTT's reactor building to the new building when it is completed in 2016.

The responsible manager for the nuclear safeguards at Aalto University and his debuty were approved in 2014.

STUK granted Fortum, Platom and VTT licenses to possess and transfer of nuclear information pertaining to the nuclear safeguards.

According to the new Guide YVL D.1, all operators must prepare a nuclear material handbook that includes instructions on the implementation of the nuclear safeguards. The producers of uranium, the parties in possession of small amounts of nuclear materials and the research facilities participating in the nuclear safeguards relevant research of the nuclear fuel cycle prepared these handbooks in 2014. They will be processed in 2015.

6 Safety research

The purpose of publicly funded safety research is to ascertain that the authorities have adequate expertise available, including a concern for unforeseeable issues affecting the safety of nuclear power plants. Since the beginning of the 1990s, Finnish safety research has typically taken the form of four-year research programmes. Safety research is divided into two research programmes: SAFIR2014 focuses on nuclear power plant safety and KYT2014 on the comparison of the practices and methods of nuclear waste management. The projects under the research programmes are selected annually on the basis of a public call for projects. The projects selected for the programmes must be of a high scientific standard, and their results must be available for publication. The results must have a broader scope of applicability than the NPP of a single licensee. Funding will not be granted for any research which is directly connected with projects that licensees, or parties representing them, carry out for their own needs, or for research which is directly provided by the regulatory oversight of nuclear energy.

STUK controls this research by contributing to the work of the programmes' steering and reference groups. The Ministry of Employment and the Economy annually verifies that the proposed set of projects meets the statutory requirements and

Nuclear safety research in Finland

In general terms, nuclear safety research comprises two distinct areas of research: nuclear power plant safety and nuclear waste management safety. In Finland, nuclear safety research is conducted by research institutions, universities and power companies operating nuclear power plants. In addition to the above-mentioned parties, research on the safety of nuclear waste management is conducted by Posiva Oy. Posiva's research programme is the most extensive of all the research programmes.

Research programmes SAFIR2014 and KYT2014 were launched in 2011. The purpose of these programmes is not only to provide scientific and technical results, but also to ensure the maintenance and development of Finnish competence. Further information on the projects is available on the websites of the research programmes at http://virtual.vtt.fi/virtual/safir2014/, http://www. ydinjatetutkimus.fi and http://kyt2014.vtt.fi/. Websites of the new research programmes SAFIR2018 and KYT2018 to be launched at the beginning of 2018 are http://virtual.vtt.fi/virtual/safir2018/ and http://virtual.vtt.fi/virtual/kyt2018/.

Pursuant to Finnish legislation, the parties with nuclear waste management obligations are unambiguously responsible for the design, implementation and costs of managing the waste they have produced, including the associated research and development work. The research and development work regarding final disposal is carried out by Posiva Oy. Posiva also conducts research in different sectors linked to the final disposal of nuclear fuel in cooperation with international parties.

The Finnish actors contribute extensively to international nuclear safety research within the framework of the following programmes and organisations: the European Union's framework research programmes (both fission and fusion research), the Nordic NKS safety research programme, the Nuclear Energy Agency (NEA) of the OECD, and the International Atomic Energy Agency (IAEA) within the UN family.

STUK's nuclear safety research needs. STUK issued statements on the SAFIR2014 and KYT2014 programmes in February 2014.

STUK participated in the preparation of a national research strategy on the use of nuclear energy, which was managed by the Ministry of Employment and the Economy. The strategy was published in April 2014. According to the strategy, nuclear safety research and nuclear waste management research will continue as separate programmes. After the completion of the strategy, the Ministry of Employment and the Economy launched the preparation of new four-year research programmes, SAFIR2018 and KYT2018.

The four-year research programme SAFIR2014 was a continuation to the previous programme, SAFIR2010. It was more extensive than the previous programme because of the decisions-in-principle on new nuclear power plant units that were made in the summer of 2010. Following the decisions, funds for the research programme were also collected according to the maximum outputs defined in the license conditions for the new plant units (funding from the National Nuclear Waste Management Fund). The annual volume of the SAFIR2014 programme was €9.9 million in 2014, of which the National Nuclear Waste Management Fund covered €5.4 million. The project programme launched at the beginning of 2014 provided funding for 45 projects. The organisation providing the largest amount of funding was VTT Technical Research Centre of Finland, whose share was €2.8 million.

The SAFIR2014 research programme was divided into nine competence areas, which mainly corresponded to the support group areas of the previous research programme. A new support group introduced at the beginning of 2011 was Support Group 9, Infrastructure, since the construction of significant arrays of test equipment was funded and guided at, for example, VTT and the Lappeenranta University of Technology. The areas of research under SAFIR2014 and their shares of the total funding are illustrated in Figure 18.

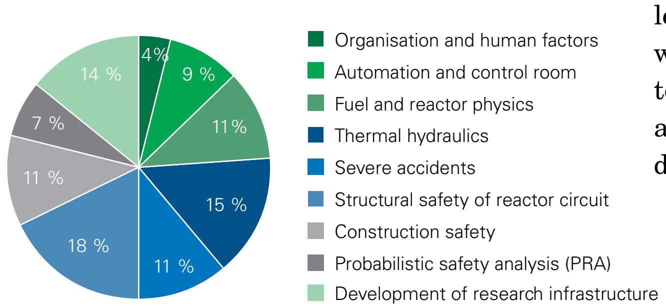


Figure 18. Research areas of SAFIR2014 programme and their shares of the total funding in 2014.

In the autumn of 2012, the call for projects for the 2014 project programme was updated with the additions to the SAFIR2014 framework plan considered necessary as a result of the Fukushima Daiichi nuclear accident that took place in March 2011. The 2014 research programme focuses on issues important to nuclear safety, such as reactor physics, accident analyses and material research. Accident management projects and expansions of earlier projects that dealt with the management of severe accidents and the provisions made for external threats that were launched in 2013 were continued. The call for projects for the 2014 project programme was updated with the additions of topical research needs on the regulatory oversight of nuclear safety, such as analyses used to prove compliance of new regulations with the requirements and nuclear power plant quality management in a networked operating environment. No new projects on these subject matters were launched within the SAFIR2014 research programme.

The research programme involved extensive development of Finnish expertise for defining the design basis of nuclear power plants and for producing safety analyses, as well as for managing expert work and organisations with a high standard of safety culture. A project on studying the coverage of the Finnish nuclear safety regulations by applying methods from the field of sociology that was launched in 2013 was continued. An issue that is still topical is the research on external threats where the potential impacts of climate change on the extreme weather conditions and seawater levels occurring in Finland were studied, along with the seismic requirements for NPPs. Another topical issue is the definition of the source term for an accident, and provisions for accidents of a long duration.

Content and management of the SAFIR2018 research programme were determined under the management of STUK. The Ministry of Employment and the Economy appointed a planning workgroup in April 2014. The planning workgroup named by the Ministry of Employment and the Economy, which consists of nineteen people, chairpersons of the SAFIR2014 programme support groups and other experts have actively participated in the drafting of the research programme framework plan. Representatives of the Ministry of Employment and the Economy, the Radiation and Nuclear Safety Authority (STUK), the Finnish Funding Agency for Innovation (Tekes), Fennovoima Oy, Fortum, Teollisuuden Voima Oyj (TVO), the Aalto University, Lappeenranta University of Technology and VTT Technical Research Centre of Finland were involved. The organisations that participated in the planning represent the end users of the final results and the parties participating in the research activities.

The SAFIR2018 research programme consists of three research areas: overall safety and management of planning, reactor safety, as well as structural safety and materials. Support groups that focus on scientific issues will be established to guide the research activities. The number of groups to be established and their focus areas will be determined based on the projects selected for the research programme. The SAFIR2018 framework plan introduces to the people drafting project proposals the subject matters on which the research programme projects should focus and the planning workgroup's views on key problems and research needs linked to these subject matters. The SAFIR2018 research programme will focus on issues important to nuclear safety, such as nuclear fuel, accident analyses and material research. Issues

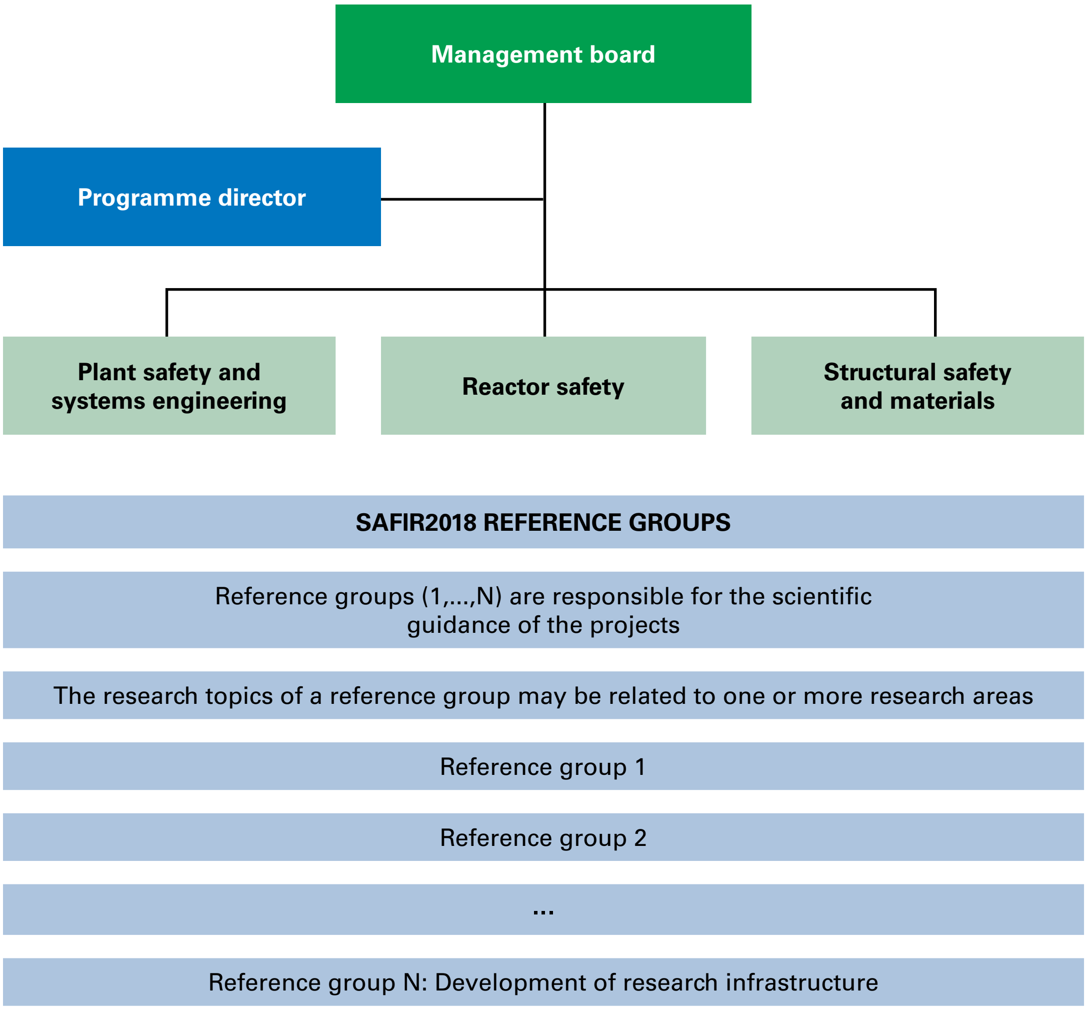


Figure 19. The administrative structure of SAFIR2018 research programme.

involving the assessment of overall safety and the management of planning are more prominent than before in the research programme framework plan.

The subject matters and research needs listed in the framework plan are based on issues of which the planning workgroup was aware in June 2014. The SAFIR2018 research programme will also take into account any changes that occur in the operating environment during the programme period: new projects that support the objectives of the programme may be launched during the programme period.

STUK participated in the assessment of the SAFIR2018 research programme projects and the preparation of the programme in the management group of the SAFIR2018 programme and in the steering groups of the research areas.

The four-year KYT2014 programme started in 2011 and ended in 2014. The programme consisted of research issues important to national expertise. It aimed at extensive coordinated research projects. Such coordinated projects were formed in the following research areas: performance of buffer and backfilling materials, and the long-term durability of final disposal canisters.

The KYT management group provided funding recommendations to the Ministry of Employment and the Economy based on assessments by the support groups, applicability of the subject matter and content of the research project. In 2014, the total funding of the programme was around €2.9 million, of which funding from the National Nuclear Waste Management Fund amounted to around €1.9 million. In 2014, the research programme provided funding for 31 research projects representing new and alternative technologies for nuclear waste management (three projects), safety research on nuclear waste management (28 projects of which 11 were combined into two coordinated projects) and social nuclear waste management research (one project). Figure 18 illustrates the relative shares of these projects of the total funding.

The KYT2018 research period will start in early 2015, and the new programme period will be four years. There are representatives of Fennovoima, Fortum Power and Heat, Posiva, the Ministry of Social Affairs and Health, TVO, the Ministry of Employment and the Economy, the Ministry of the Environment and STUK in the planning workgroup. STUK chairs the group.

46 research project proposals were submitted for the year 2015. The research programme according to the management group's funding recommendation includes 30 research projects.

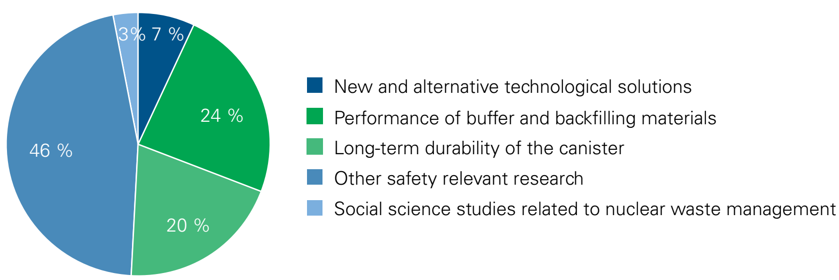


Figure 20. Research areas of KYT2014 programme and their shares of the total funding in 2014.

7 Oversight of nuclear power plants in figures

7.1 Processing of documents

A total of 3,045 documents were submitted to STUK for processing in 2014. Of these, 627 concerned the NPP unit under construction and 410 the repository for spent nuclear fuel. The reviewing process of a total of 2,930 documents was completed, including documents submitted in 2014, those submitted earlier and licenses granted by STUK by virtue of the Nuclear Energy Act, which are listed in Appendix 4. The average document review time

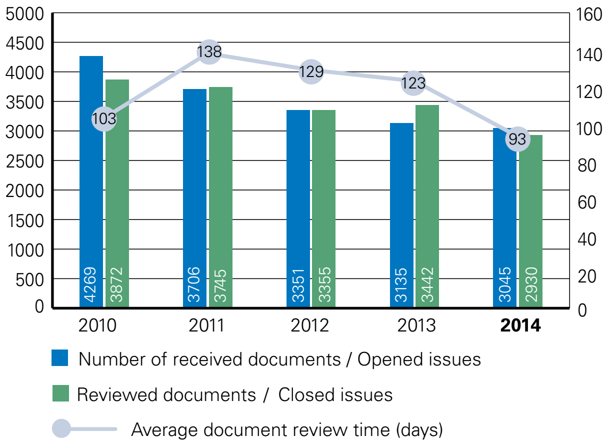


Figure 21. Number of documents received and reviewed as well as average document review time.

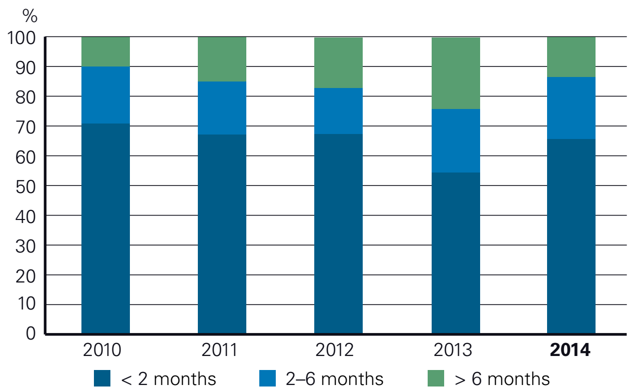


Figure 22. Distribution of time spent on preparing decisions on the Loviisa plant.

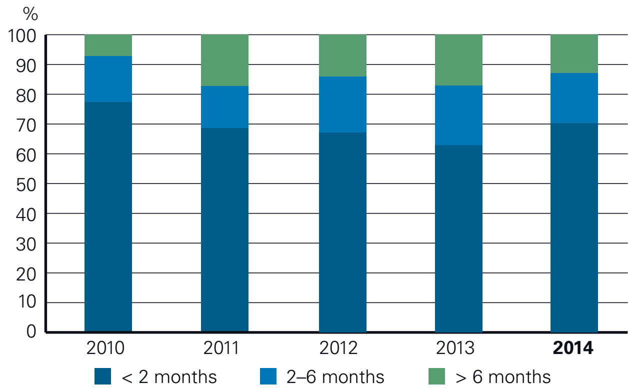


Figure 23. Distribution of time spent on preparing decisions on the operating plant units of Olkiluoto.

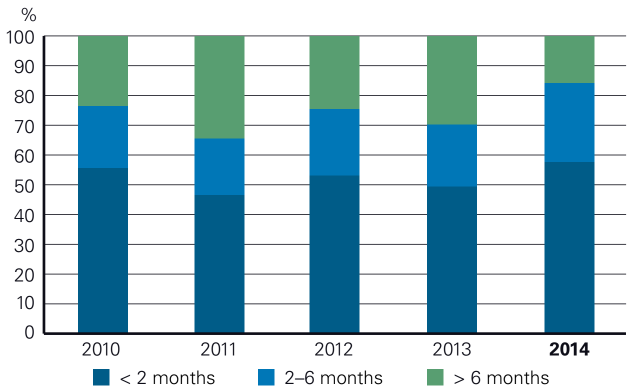


Figure 24. Distribution of time spent on preparing decisions on Olkiluoto plant unit 3.

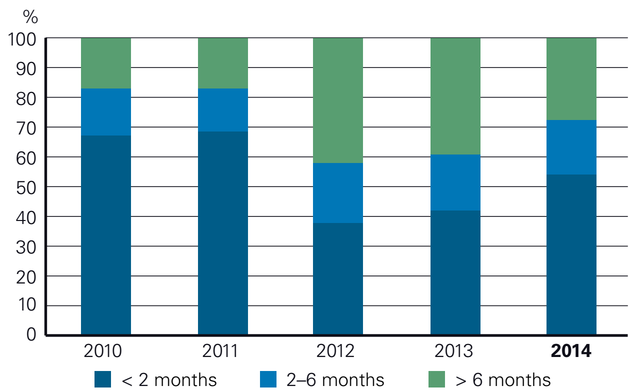


Figure 25. Distribution of time spent on preparing decisions on Posiva.

was 93 days. The number of documents and their average review times in 2010–2014 are illustrated in Figure 21. Figures 22–25 illustrate the review time distribution among documents from the various plant units and documents about Posiva.

7.2 Inspections at nuclear power plant sites and suppliers' premises

Periodic inspection programmes

A total of 24 inspections at the Loviisa plant and 23 at the Olkiluoto plant were carried out under the 2014 periodic inspection programme (Appendix 5). STUK carried out ten inspections within the Olkiluoto 3 construction inspection programme (Appendix 6) and three inspections within the Onkalo construction inspection programme (Appendix 7). Nine inspections of the repository's construction license application processing stage were conducted in 2014. 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 1,340 inspections onsite or at suppliers' premises were carried out in 2014 (other than inspections of the periodic or construction inspection programmes, of the nuclear non-proliferation control and of the construction inspection programme of the underground research facility at Olkiluoto, which are discussed separately). 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, 222 were related to the regulatory oversight of the plant under construction and 1,118 to that of the units in operation.

The number of inspection days on site and at component manufacturers' premises totalled 2,961. This number includes not only inspections pertaining to the safety of nuclear power plants but also those associated with nuclear waste management, nuclear non-proliferation control, audits and inspection of the underground research facility at Olkiluoto. Four resident inspectors worked at Olkiluoto NPP and three resident inspectors at Loviisa NPP. The numbers of onsite inspection days in 2010–2014 are illustrated in Figure 26.

7.3 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.

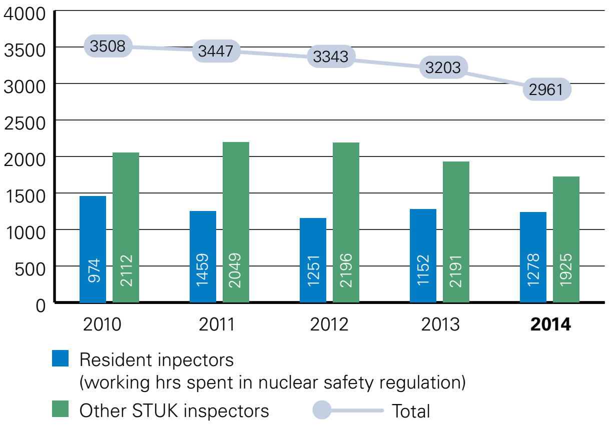


Figure 26. Number of inspection days onsite and at component manufacturers' premises. Luvut eivät sisällä tehtyjä ylitöitä.

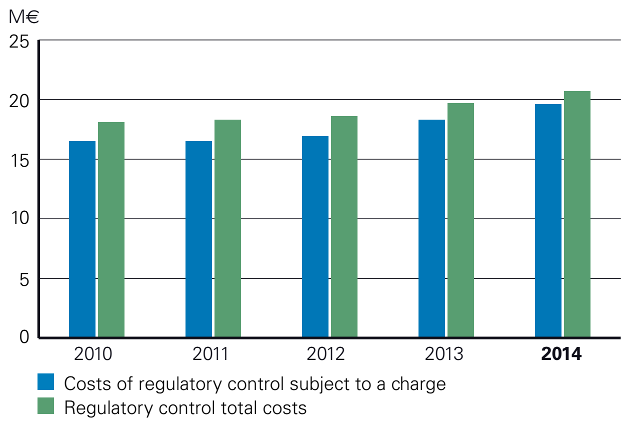


Figure 27. Income and costs of nuclear safety regulation.

In 2014, 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 20.7 million. Thus, the share of activities subject to a charge was 94.7%.

The income from nuclear safety regulation in 2014 was EUR 19.6 million. Of this, EUR 4.4 million and EUR 10.0 million came from the inspection and review of the Loviisa and Olkiluoto NPPs, 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. The income from the regulatory oversight also includes costs of the safety assessments of the new NPP projects of TVO and Fennovoima. The regulation of Posiva Oy's operations yielded EUR 4.2 million. Figure 27 shows the annual income and costs from nuclear safety regulation in 2010–2014.

The time spent on the inspection and review of Loviisa nuclear power plant was 17.5 man-years, i.e. 12.0% of the total working time of the regulatory personnel. The time spent on the operating units of Olkiluoto NPP was 15.3 man-years or 10.5% of the total working time. In addition to the monitoring of the operation of the NPPs, these figures include the safeguards of nuclear materials. The time spent on the inspection and review of Olkiluoto 3 was 21.4 man-years or 14.7% of the total working time. Work related to new NPP projects amounted to 2.1 man-years or 2.1% of the total working time. A total of 14.3 man-years or 9.8% 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 0.4 man-years. Figure 28 shows the division of working hours of the personnel engaged in nuclear safety oversight (in man-years) by subject of oversight during 2007–2014.

Where necessary, STUK commissions independent safety analyses and research in support of regulatory decision-making. Figures 29 and 30 illustrate the costs of such assignments in 2010–2014. Expenses in 2014 were mainly related to comparative analysis, independent assessments and third-party consultants' inspection work concerning the unit under construction, as well as to assessment work concerning the safety documentation for final disposal of nuclear waste. Appendix 8 lists assignments on the safety of nuclear power plants and the final disposal of nuclear fuel funded by STUK in 2014. Reviews of the safety documentation for the final disposal of nuclear energy are discussed in Chapter 4.6.1.

Distribution of the annual working time of the nuclear safety regulation personnel to the various duty areas is shown in Table 5.

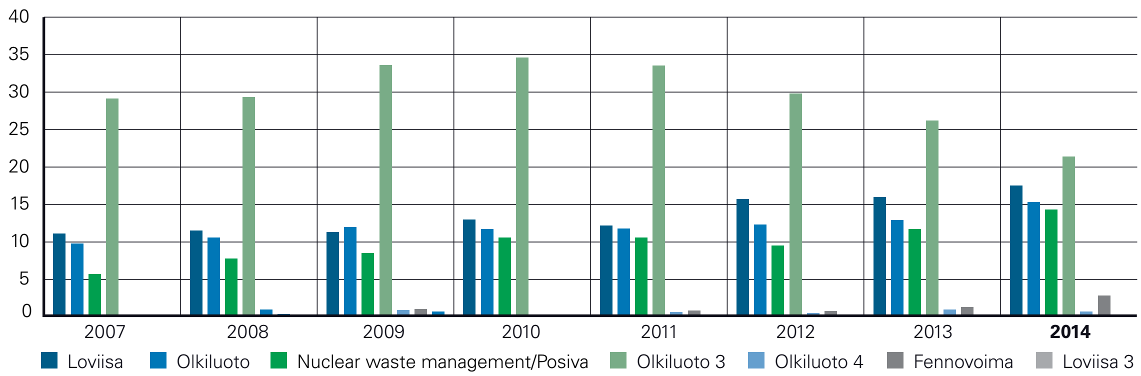


Figure 28. Distribution of working hours (person-years) of the regulatory personnel by subject of oversight in 2007–2014. Until 2011 the nuclear waste management includes both the oversight of the operating nuclear power plants' nuclear waste management as well as the oversight of Posiva, since 2012 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.

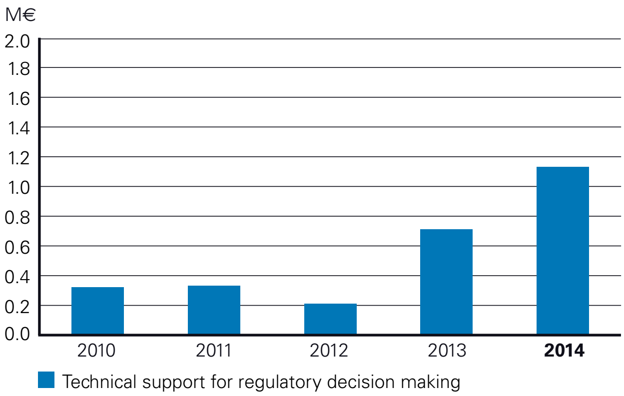


Figure 29. The costs of research and commissioned work pertaining to the safety of nuclear power plants.

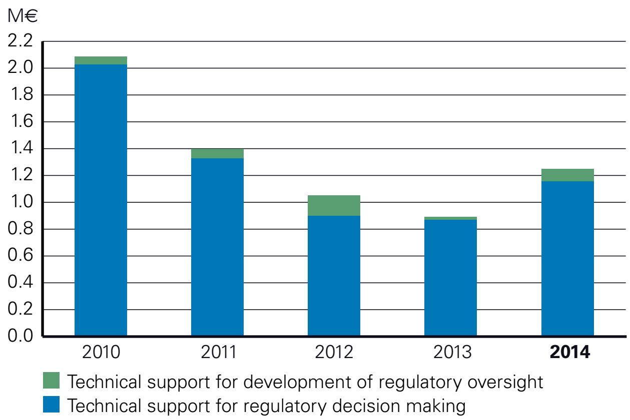


Figure 30. The costs of research and commissioned work pertaining to nuclear waste management and nuclear non-proliferation.

Table 5. Distribution of working hours (person-years) of the regulatory personnel in each duty area.

Duty area	2010	2011	2012	2013	2014
Basic operations subject to a charge	70.5	70.2	68.9	69.7	72.0
Basic operations not subject to a charge	7.8	8.8	5.6	5.0	3.5
Contracted services	1.9	1.7	2.2	1.6	2.9
Rule-making and support functions	38.2	43.0	46.3	45.3	41.8
Holidays and absences	24.3	24.7	24.7	25.1	25.3
Total	142.9	148.4	147.7	146.7	145.5

8 Development of regulation

8.1 STUK's own development projects

Changes in practices and organisation updated in quality manual

A total of 20 guides were updated in the quality manual for nuclear safety regulation, and 35 appendices to the guides were updated. The guides were updated following changes in procedures as well as changes in the personnel of the nuclear reactor regulation department and the nuclear waste and material regulation department.

Progress in development of requirement management

STUK continued the development of its requirement management procedures that was started in connection with the preparation of new YVL Guides. Definition of operating processes was continued and testing of the information system started in the summer of 2014. The system will be used when preparing YVL Guide implementation decisions.

Development of records management system and preparation for provision of electronic services

Planned development of workflows in the STUK records management system was delayed. The requirement specifications that had been prepared before were further supplemented in late autumn but the implementation was postponed to 2015.

STUK launched a project on an electronic service system that will offer licensees the opportunity to submit applications to STUK for processing in electronic format. The system will be introduced into production use in early 2015.

8.2 Renewing and working capacity

Training on issues such as nuclear power plant accidents, nuclear power plant systems, safety culture, document management and regulatory activities was arranged for inspectors. A clear majority of the training events focused on STUK's new YVL Guides. The training aims at ensuring consistent interpretation of the new Guides.

New STUK inspectors participated in a national training programme in the field of nuclear safety (the YK course), which STUK organises together with other actors in the industry. The YK course consists of six study modules provided over the course of 20 working days. The three last study modules of YK11 were arranged in the spring of 2014, and YK12 started in the autumn. Around a dozen STUK employees participated in both YK courses.

STUK was actively involved in the planning and execution of national nuclear waste management training, now organised for the fifth time. The course lasted for six days and had around twenty participants. Lecturers included representatives of all the organisations providing the training. The course focused on the main themes of nuclear waste management, covering the entire nuclear fuel cycle. The latest addition was environmental impact assessment procedures.

STUK's inspectors also participated in training provided by external companies, such as project operations and media training. Furthermore, STUK's inspectors participated in various Finnish and international training events of the industry, both as participants and lecturers.

In 2014, two Master's theses were completed in the nuclear reactor regulation department:

A method for reviewing structural systems relevant to nuclear safety and *Occupational radiation doses and contributing factors at Finnish nuclear power plants*.

On average, 11.5 days per inspector in the field of nuclear waste and materials regulation, and 7.9 days per inspector in the field of nuclear reactor regulation, were spent on developing the expertise of STUK's nuclear safety experts in 2014.

Five new employees were hired for nuclear reactor regulation in 2014. Their positions are in fields of water chemistry in nuclear power plants, radiation protection, development of competence, regulations and internal information management. In addition, two permanent posts were established. Some recruitments were postponed to 2015 because of new projects being delayed. One person was transferred to a position in safeguards of nuclear materials from another position within STUK.

9 Emergency preparedness

The NPPs, the police and STUK develop the planning of emergency drills in case of threats. The planning scope covers both physical and information security threats.

STUK actively participated in the work of the emergency response cooperation groups in both Eastern Uusimaa and Satakunta. Both groups include the most important operators of the early stages of an emergency: in addition to STUK, representatives from the power companies, the rescue services, the police and – as the latest addition – the Ministry of the Interior. The Satakunta group also includes the Finnish Border Guard; the Eastern Uusimaa group also involves the local emergency care organisation. Issues such as emergency response training, experiences gained from drills, the update status of external rescue plans, the organisations' development projects, and changes to legislation were discussed in meetings of the cooperation teams.

10 Communications

STUK's nuclear safety communications are based on active, immediate, open and honest communication and media services.

In addition to news about STUK's own regulatory oversight and the NPP license process, STUK provides, as quickly as possible, information about any deficiencies observed at the Finnish NPPs for which the licensee must submit a special report to STUK or that are otherwise considered matters of public interest.

In 2014, STUK gave information on its website about five observations made during the inspections and oversight of the operating NPPs and the Olkiluoto 3 plant unit, which is currently under construction. Even though the events did not put the safety of the NPPs or the environment at risk, STUK reported them without delay in accordance with its communications policy.

STUK published announcements about a total of 21 nuclear safety issues in 2014. Furthermore, nuclear safety experts gave several interviews to Finnish and foreign media.

In addition to its own website, STUK communicates with citizens via social media, such as Facebook and Twitter. STUK also answers questions that the public presents by telephone or e-mail, participates in public meetings and receives guest groups.

At the end of May and in the beginning of June, STUK's directors and experts told the public at Loviisa and Eurajoki about the results of the oversight operations at the NPPs and their environment, and about topical issues related to nuclear safety. The public events were organised in cooperation with the municipalities.

STUK provides reports on the operation, events and oversight of the operating NPPs as well as the oversight of Olkiluoto 3 and nuclear waste management, on a quarterly basis. In its annual report published in April 2014, STUK reported the regulatory oversight of nuclear safety and related observations in 2013.

Communications about nuclear safety with stakeholders are mainly handled in connection with the daily work of the management of STUK, inspectors and other STUK employees. In late 2014, STUK studied success of such stakeholder communications by surveying its reputation among its key stakeholders. One of the studied stakeholder groups consisted of nuclear power companies. According to the survey results, the power companies respect STUK and trust in it, and are satisfied with its ability to cooperate. The reputation could be further improved, however, by better sharing best practices with colleagues within STUK and thus standardising practices.

11 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's experts presented Finland's report at the statutory review meeting of the International Convention on Nuclear Safety in the spring of 2014. The most important issues that took place in Finland during the three-year reporting period included an overall safety requirement renewal process, a safety review of the Finnish NPPs due to the Fukushima accident and an evaluation of regulatory activities by the IAEA. The report was well received by the meeting. In the peer evaluation, good practices from Finland included procedures that aim at continuous improvement, a comprehensive national nuclear safety research programme, and instructions on action limits and practical operating methods in case of radiation danger drafted together with the other Nordic countries. Listed future challenges included the ageing of the NPPs, proving the reliability of digital I&C, as well as the management of competence and resources as the new NPP projects increase the workload and current employees start to retire.

The meeting also discussed the development of the International Convention on Nuclear Safety and the related evaluation process, and approved some amendments of the instructions. Furthermore, the meeting voted on a proposal by Switzerland on amending the actual International Convention on Nuclear Safety in terms of the management of severe accidents. Based on the voting results, the proposal will be discussed by a Diplomatic Conference to be arranged in early 2015. Preparations for the Diplomatic Conference started in 2014 and STUK participated in a work meeting on the amendment proposal by Switzerland, for example.

STUK coordinated the drafting of the national report for the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management, also called the Nuclear Waste Convention, and submitted the report to the IAEA in October 2014. Significant reporting themes included processing of the construction license application for the spent nuclear fuel repository, development of nuclear waste management competence and preparation of the final disposal of small amounts of radioactive waste. A similar review meeting will be arranged in May of next year. Finland also reviewed the reports of other countries, such as Sweden, the United States, France and Hungary, and submitted specifying questions to these countries.

Cooperation within international organisations and other countries

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 fourteen 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, Japan, Canada, China, Korea, France, Finland, Sweden, the United Kingdom, Russia and the United Arab Emirates. In 2014, Turkey also joined the programme. 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. 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. STUK has representatives in all of the above-mentioned working groups, except for the AP100 Working Group, because an EPR plant is under construction at Olkiluoto (the Olkiluoto 3 project), APR1400 and ABWR are considered as alternatives in the Olkiluoto 4 project and Fennovoima is planning the construction of a VVER plant.

The EPR Working Group's work was originally a continuation of cooperation between the Finnish and French authorities concerning safety assessment of EPR power plants. The other countries in the EPR Working Group are France, the United States, the United Kingdom, Canada, China, India and Sweden. The EPR Working Group has four subgroups dealing with I&C, accidents and transients, severe accidents and probabilistic risk assessment (PRAs). STUK's representative chairs the PRA subgroup.

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. The objective of the Working Group dealing with plant and equipment supplier inspections and reviews is to establish the procedures and requirements applied to inspections and reviews by the participating countries and to create the procedures and goals for joint inspections and reviews. In 2014, the Working Group implemented its first joint inspection at a company that manufactures mechanical pressure equipment. Jointly developed criteria on assessing manufacturer's operations were utilised in the inspection.

The objective of the Working Group dealing with pressure equipment is the harmonisation of requirements in different standards. The Working Group on programmable I&C aims to promote the coordinated development of the IEC and IEEE standards, among others. Some individual issues have also been selected, on which common positions have been drafted.

Co-operation 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 Nuclear Security Guidance Committee (NSGC) and the Transport Safety Standards Committee (TRANSSC). STUK issued statements on the IAEA regulatory guides under preparation. STUK also participated in the composition of regulatory guide drafts in small expert groups.

STUK's representatives participated in IAEA expert groups; the groups reviewed the operations of regulatory authorities in the France and Korea.

STUK is the Finnish contact organisation for the following nuclear energy information exchange systems maintained by the IAEA:

- International Reporting System for Operating Experience (IRS)
- Incident Reporting System for Research Reactors (IRSRR)
- International Nuclear Event Scale (INES)
- Power Reactor Information System (PRIS)
- Nuclear Fuel Cycle Information System (NFCIS)
- Net Enabled Waste Management Database (NEWMDB)
- Illicit Trafficking Database (ITDB)
- Database on Events that have arisen during Transport of Radioactive Material (EVTRAM)

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 co-operation 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

STUK actively participated in an update of the nuclear safety reference levels of the Western European Nuclear Regulators' Association (WENRA) where the Fukushima accident was taken into account. The updated reference levels were published in September 2014.

ENSREG

STUK participated in the activities of the EU member states' nuclear safety regulators' co-operation group (ENSREG, European Nuclear Safety Regulators Group) and in two of its subgroups (on nuclear safety and nuclear waste management). In July 2014, STUK submitted to the European Commission a report in compliance with the Nuclear Safety Directive on compliance with the Directive in Finland.

As a result of the Fukushima accident, the EU launched stress tests for existing nuclear power plants and for those under construction. The purpose of these tests was to establish how the NPPs would cope with exceptional external events and other situations associated with the simultaneous loss of operability of several safety systems. In late 2014, STUK updated the national action plan of Finland, which will be reviewed by a review meeting arranged by the ENSREG in Brussels in April 2015.

Other international cooperation

STUK participated in the cooperation between the regulatory authorities of countries with VVER power plants (such as the Loviisa power plant) via the VVER Forum. The annual meeting of the VVER Forum was arranged in June 2014 by STUK. STUK's representatives participated in the work of two VVER Forum working groups. The Probabilistic Risk Analyses Working Group (PRA) meet in Jerevan in June. Another working group of the VVER Forum, one that focuses on experiences on construction and commissioning of VVER plants, met at STUK's office in November 2014.

STUK's representative was a member of the supporting committee to the Swedish nuclear safety authority, and a reactor safety expert group called by the Swiss nuclear safety authority.

STUK participated in the work of the European Safeguards Research and Development Association (ESARDA). The purpose of ESARDA is to promote and harmonise the European research and development work on nuclear safeguards. In 2014, STUK participated in the Executive Board of ESARDA and was among the presiding officers of the NA/NT Working Group which develops new technologies and the VTM Working Group which develops verification methods.

International operating experience feedback

STUK's operations

STUK has a working group for monitoring and assessing international operating experience events and reports from nuclear power plants. The working group includes STUK experts from various fields of technology. In 2014 in its monthly meetings, the working group assessed a total of approximately a hundred reports received from the IAEA's operating experience database. Of the assessed reports, 92 required no measures at the Finnish NPPs. With regard to five events, the practices and arrangements in place at the Finnish NPPs were found to be adequate to prevent similar events. In the case of 15 event reports, the working group decided that the status of the Finnish NPPs should be assessed in more detail in connection with STUK's inspections or the issue should be studied in connection with other oversight activities.

Four new reports were drafted in the International Reporting System for Operating Experience (IRS) maintained by the IAEA regarding events at the Finnish NPPs. Furthermore, information on the current status or procedures of the Finnish NPPs was added as feedback to five events reported by other countries in the IRS.

APPENDIX 1 STUK's safety performance indicators for NPPs in 2014

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 NPPs. The power companies and STUK evaluate and oversee the safety and operation of the plants in many ways. Along with inspections and safety assessments, indicators are a method of acquiring information on the safety level of the NPPs and on any changes to the safety level.

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

In the indicator system, nuclear safety is divided into three sectors: 1) operation and maintenance, 2) operational events and 3) structural integrity. STUK began the development of its own indicator system in 1995. Since 2006, indicator information has been managed in STUK's INDI (INdicator DIsplay) information system. Nominated STUK representatives are responsible for the maintenance and analysis of the indicators. Individual indicators, their maintenance procedures and the interpretation of results are presented at the end of this summary. A brief summary of the safety status of each plant in 2014 is presented below, followed by the detailed results by indicator.

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

***Operation and maintenance of a nuclear facility** is 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 disturbance report must be prepared for any significant disturbances occurring at a plant unit. Such disturbances 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 the equipment's unavailability periods and the 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 primary and secondary circuit integrity. The monitoring is done by indices depicting water chemistry control and by following selected corrosive impurities and corrosion products. The 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 2014

Summary of indicator results for Loviisa NPP

In the indicator system, nuclear safety has been divided into three categories as illustrated below. The assessments given in the paragraphs below are based solely on conclusions made based on the indicators. An actual overall safety assessment is given in Chapter 4.1.1 of this annual report.

Operation and maintenance

There were no essential changes when compared to previous years in the total number of maintenance tasks on components subject to the OLC in 2014. However, the number of immediate operation restrictions due to faults in components subject to the OLC has constantly decreased over the past four years. The ratio of preventive maintenance to fault repairs was 7.2 in 2014, which is 25% higher than the average of the four previous years. The ratio means that the share of preventive maintenance of all maintenance work has remained high. The average repair times of faults that caused inoperability of components have also systematically decreased at Loviisa NPP since 2009. No faults with a significant impact on plant safety have occurred and zero common-cause failures were identified at Loviisa NPP in 2014.

The main purpose of the OLC exemption procedure is to enable modifications and maintenance that will improve safety and plant availability with the approval of STUK. In 2014, Loviisa NPP submitted six exemption applications to STUK for approval. This is a normal number of applications. Furthermore, the NPP was in a state that was non-compliant with the OLC six times in 2014. Fortum analysed all events and defined corrective measures to prevent similar events from recurring.

In the STUK indicator system, the functionality of safety systems is monitored on the basis of the unavailability of the high-pressure safety injection system, emergency feedwater system and emergency diesel generators. In 2014, the condition and availability of the former two were good and the availability of the emergency diesel generators remained acceptable. No changes in the availability of these three systems have occurred in the past few years.

The main part of the radiation doses is received during outages. Due to improvements in radiation safety, the collective occupational dose of employees at Loviisa 1 was the lowest ever recorded and the collective occupational dose at Loviisa 2 was low even though a four-year annual outage was implemented. The radiation doses for NPP employees at Loviisa remained below the individual dose limits. The average of the ten largest doses was slightly lower than the average even though a larger four-year annual outage was implemented at Loviisa 2. The doses during previous similar annual outages have been clearly higher than the doses in 2014. In 2014, the radioactive releases into the air and water from Loviisa NPP were of the same magnitude as in previous years. Releases into the environment remained clearly below the limits set. Releases of noble gases into the air from Loviisa NPP were of the same magnitude as in previous years while releases of particulate aerosols were clearly lower than normal.

Operational events

No reactor trips occurred at Loviisa NPP in 2014. The number of transient reports remained at the normal level and the number of events warranting a special report was around the same as during the previous year.

The indicator for risk-significance of component unavailability is an increase of the conditional core damage probability (CCDP) in connection with each event. In 2014, this indicator was of the same magnitude as in the previous year when taking into account events that are most or least significant in terms of the risk. The number of risks due to operational activities has continued to decrease over the past four years, however.

In 2014, a little over half (54%) of the core damage frequency originated from power operation: fires during power operation comprise one quarter, weather phenomena around one sixth, internal initiating events around 5%, floods 2% and seismic events 0.4% of the total risk. Less than half (42%) of the core damage frequency originates from cold shutdowns. One third of the risk assessments for standard cold operating modes are caused by oil spills and one quarter by drops of heavy loads. Primary leaks caused by human errors are also among the most significant risks. The Probabilistic Risk Assessment (PRA) model for the Loviisa NPP used to describe the plant unit Loviisa 1. In 2014, Fortum completed a separate PRA model for Loviisa 2. The key differences between the plant units involve loss of ventilation in the instrumentation facilities and fires. No events classified as fires occurred at Loviisa NPP or outside the plant area in 2014. The number of fire detection system faults at Loviisa NPP has remained at the same level for the past ten years.

Structural integrity

There was no leaking fuel in the reactors of the Loviisa units in 2014, which means that the maximum iodine (I-131) activity values associated with shutdowns have been restored to the level preceding leaks. In 2014, the impurity and corrosion product levels in the reactor coolant system and the secondary circuit, followed in STUK's indicator system, were in keeping with the OLC limits. In the past few years, the chemistry index has also remained at a good level at the Loviisa plant units. In 2014, the maximum Co-60 activity levels associated with shutdowns were around the same as in the previous years, which indicates successful compliance with the ALARA principle. All of the chemistry indicators show that the integrity of the reactor coolant systems at the Loviisa plant units was good in 2014.

Total leakage of the outer isolation valves at Loviisa 1 compared to the maximum allowed total leakage remained unchanged. The total leakage at Loviisa 2 clearly decreased from the previous year. The percentage of isolation valves that passed the leaktightness test at first attempt increased at both Loviisa 1 and Loviisa 2. The indicator describing the overall as-found leakage of the personnel airlock, material airlock, emergency personnel airlock, reactor pit, inward relief valves, cable penetrations and bellows seals is good for both plant units and remains clearly below the limit set.

Summary of indicator results for Olkiluoto NPP

Operation and maintenance

Functionality of safety systems is monitored on the basis of the unavailability of the containment spray system, the auxiliary feedwater system and the emergency diesel generators. The condition and availability of the systems and emergency diesel generators were good in 2014.

The indicators describing the condition of components subject to the OLC show that the maintenance of equipment important to safety and the repairing of faults occurring in them remain at an appropriate level.

Radiation doses received by employees and releases into the environment remained low and clearly below the limits set in official regulations. In 2014, the collective occupational radiation dose of Olkiluoto employees was the lowest ever recorded during the operation of the NPP. The previous record was from 2013. The radiation doses have clearly decreased after the installation of new moisture separators at the plant units in 2005–2007. The radiation level in the turbine buildings has continued to decrease after the installation of the moisture separators, which has also decreased the collective occupational dose. Furthermore, improvements aiming at reducing the employees' radiation doses have also been made in radiation protection of the NPP.

The releases of substances with gamma activity into the sea from Olkiluoto NPP have been decreasing in recent years, reaching their lowest value ever in 2014. In 2014, releases of radioactive materials into the air were of the same magnitude as in the preceding years. Releases into the environment were low, well below the set limits.

Operational events

No reactor trips occurred at Olkiluoto NPP in 2014. The number of events warranting a special report (ten in total) was around the average for the past ten years while the number of events warranting a transient report (seven in total) was slightly above the average. In all of the cases warranting a special report, the plant was non-compliant with the OLC without an advance safety analysis and STUK's permission. TVO analysed the events and defined corrective measures to prevent their reoccurrence.

At Olkiluoto NPP, 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). In 2014, the risk caused by operational activities remained at around the same level as in the past ten years. The annual probability of a severe reactor accident calculated for Olkiluoto 1 at the end of 2014 was 0.84×10^{-5} and for Olkiluoto 2 1.41×10^{-5}. The key reason behind the difference between the plant units and the decreased core damage frequency at Olkiluoto 1 from the level of 2013 was a modification made in the auxiliary feedwater system that reduced the system's dependence on seawater cooling. A similar modification has not been implemented at Olkiluoto 2 yet.

No events classified as fires occurred in the Olkiluoto plant area in 2014. One event classified as a fire occurred outside the plant area. The fire event was minor and no fire extinguishing measures were necessary. No fire detection system faults were observed at Olkiluoto NPP in 2014. There were slightly more actual fire detection system alarms in 2014 than in 2013. The number of alarms has continued to decrease over the past ten years, however.

Structural integrity

Based on water chemistry indicators, integrity of the reactor coolant systems at the Olkiluoto plant units was good in 2014. The impurity and corrosion product levels in reactor water and feedwater, monitored in the STUK indicator system, were in keeping with the guideline values set by the licensee at Olkiluoto 2. At Olkiluoto 1, the chloride content was momentarily high due to a condenser circulating water leak in April, and the limit value laid down in the operational limits and conditions (OLC) was exceeded. Fuel integrity of both plant units was good during the 2013–2014 fuel cycle, and no fuel leaks were detected. Several fuel leaks have occurred in the 2000s at the Olkiluoto plant units, particularly at Olkiluoto 2. The main reason for the leaks has been small foreign objects entering the reactor during maintenance operations. These objects can get caught in the fuel assembly structures. The coolant flow may cause the loose objects to vibrate and break the fuel cladding. To prevent this, fuel assemblies with new sieve structures for foreign objects were loaded into the reactor of Olkiluoto 2 in 2012. The sieve profiles were changed to make the grid denser.

The total as-found leakages of outer isolation valves at both plant units continued to remain clearly below the limit set in the OLC. The percentage of isolation valves that passed the leak test at first attempt has remained high for both plant units. 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, has remained small for 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 NPP lifecycle management and development of the condition of components.

Responsible units/persons

Resident inspectors
Pauli Kopiloff (Loviisa NPP)
Jukka Kallionpää (Olkiluoto NPP)

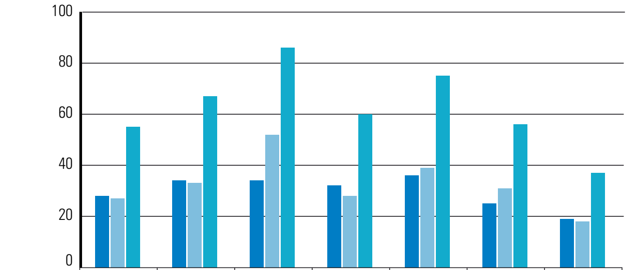
Interpretation of the indicator

Loviisa

The total number of faults causing an operation restriction of components subject to the OLC in 2014 was 154. The average number of faults during the four previous years was 180, which means that there was no significant change in the number of faults in 2014 or in the fault trend.

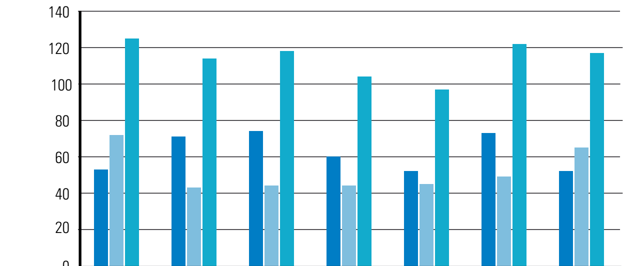
The number of faults per year remained stable. Any variation therein has been caused by the random occurrence of faults that occurs in any large number of components. Fault detection and anticipation have been continuously improved in plant maintenance operations at Loviisa, and components have been replaced. Due to these measures, there have been no faults with a significant impact

Number of failures of OLC components causing immediate operation restriction, Loviisa NPP



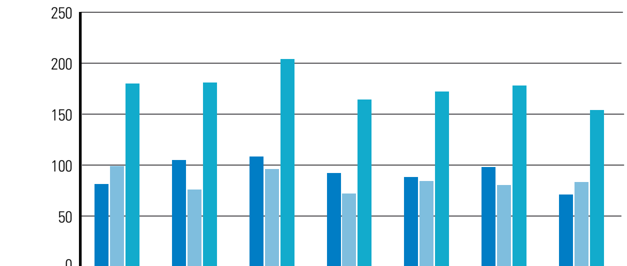
	2008	2009	2010	2011	2012	2013	2014
LO1	28	34	34	32	36	25	19
LO2	27	33	52	28	39	31	18
LO1,2	55	67	86	60	75	56	37

Number of failures of OLC components causing operation restriction from start of a repair work, Loviisa NPP



	2008	2009	2010	2011	2012	2013	2014
LO1	53	71	74	60	52	73	52
LO2	72	43	44	44	45	49	65
LO1,2	125	114	118	104	97	122	117

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



	2008	2009	2010	2011	2012	2013	2014
LO1	81	105	108	92	88	98	71
LO2	99	76	96	72	84	80	83
LO1,2	80	181	204	164	172	178	154

on plant safety, and the management of component availability has been successful.

Based on the above, it can be stated that the indicator or the underlying fault data do 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.

Interpretation of the indicator

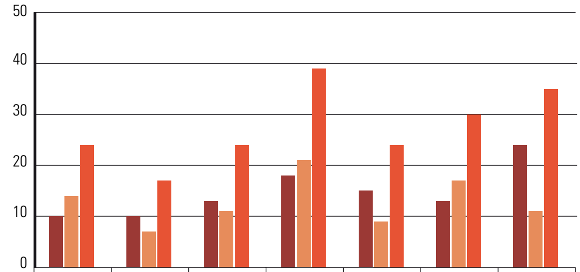
Olkiluoto

The number of faults occurring during load operation and causing the unavailability of components subject to the OLC has been increasing since 2009. In 2011, 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. The number of faults indicates that maintenance has been successful.

The unavailability times of OLC components in OL1 during all four quarters of 2014 were brief. The number of faults leading to an immediate operation restriction at OL1 somewhat increased from the previous years. Faults did not occur in a particular system alone, however.

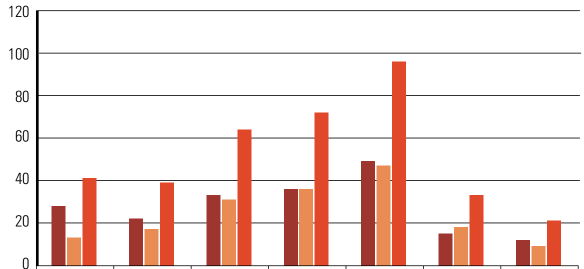
In OL2, most of the unavailability times of OLC components were brief in 2014. Most of the observed OLC component faults occurred in emergency diesel generators and related systems.

Number of failures of OLC components causing immediate operation restriction, Olkiluoto NPP



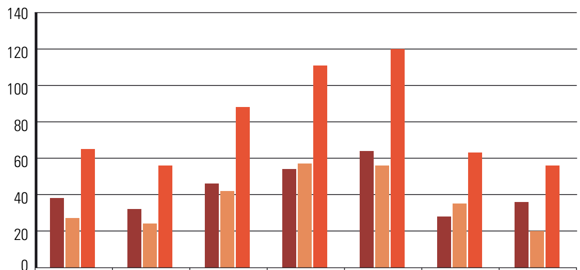
	2008	2009	2010	2011	2012	2013	2014
OL1	10	10	13	18	15	13	24
OL2	14	7	11	21	9	17	11
OL1,2	24	17	24	39	24	30	35

Number of failures of OLC components causing operation restriction from start of a repair work, Olkiluoto NPP



	2008	2009	2010	2011	2012	2013	2014
OL1	28	22	33	36	49	15	12
OL2	13	17	31	36	47	18	9
OL1,2	41	39	64	72	96	33	21

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



	2008	2009	2010	2011	2012	2013	2014
OL1	38	32	46	54	64	28	36
OL2	27	24	42	57	56	30	20
OL1,2	65	56	88	111	120	63	56

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 NPP 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 NPP and its maintenance strategy. The indicator is used to assess the maintenance strategy implemented at the NPP.

Responsible units/persons

Resident inspectors
Pauli Kopiloff (Loviisa NPP)
Jukka Kallionpää (Olkiluoto NPP)

Interpretation of the indicator

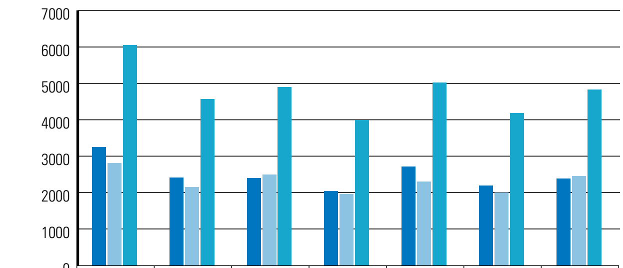
Loviisa

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 (refueling outage, short annual outage, four-year annual outage, eight-year annual outage) included in the maintenance strategy of Loviisa NPP during a four-year cycle should be considered, since it can have a significant impact on the annual figures. In 2014, a short annual outage was implemented in LO1 and a four-year annual outage in LO2.

According to the data on which the indicator is based, the year 2014 showed no major deviation from the average numbers of fault repairs and preventive maintenance volumes of the four previous years. In 2014, the number of maintenance tasks on components subject to the OLC was 9% higher than the average. Similarly, the volume of preventive maintenance was 11% higher than the average, and the number of fault repairs 14% lower.

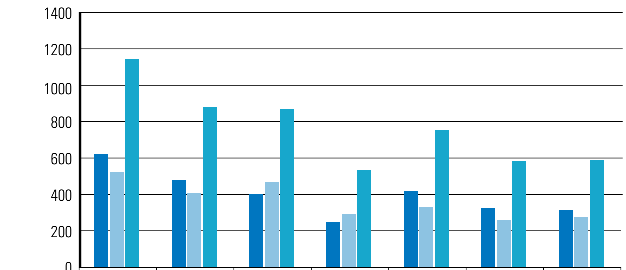
The ratio of preventive maintenance to fault repairs was 7.2. The ratio is 25% higher than the 5.8 average of the four previous years, which means that the share of preventive maintenance of all maintenance work has remained high.

Volume of annual maintenance works of OLC components, Loviisa NPP



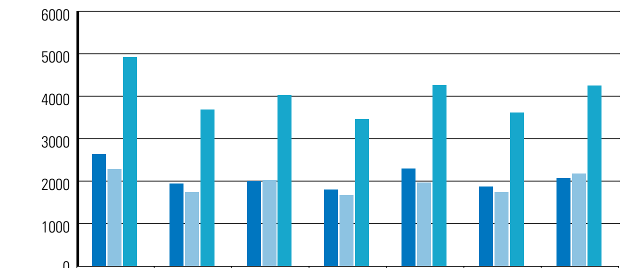
	2008	2009	2010	2011	2012	2013	2014
LO1	3250	2416	2403	2040	2717	2192	2388
LO2	2807	2148	2495	1952	2299	1997	2447
LO1,2	6057	4564	4898	3992	5016	4189	4835

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



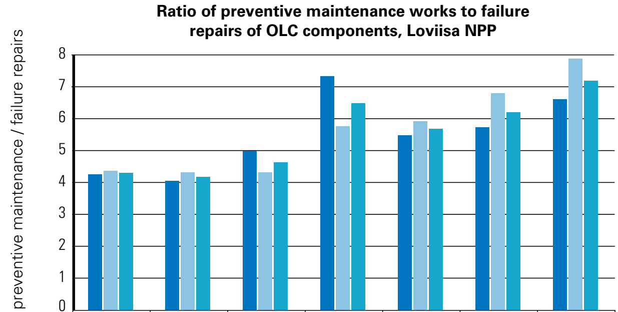
	2008	2009	2010	2011	2012	2013	2014
LO1	619	478	401	245	419	326	314
LO2	524	404	469	289	332	256	276
LO1,2	1143	882	870	534	751	582	590

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



	2008	2009	2010	2011	2012	2013	2014
LO1	2631	1938	2002	1795	2298	1866	2074
LO2	2283	1744	2026	1663	1967	1741	2171
LO1,2	4914	3682	4028	3458	4265	3607	4245

Ratio of preventive maintenance works to failure repairs of OLC components, Loviisa NPP



	02008	2009	2010	2011	2012	2013	2014
LO1	4.25	4.05	4.99	7.33	5.48	5.72	6.61
LO2	4.36	4.32	4.32	5.75	5.92	6.8	7.87
LO1,2	4.30	4.17	4.63	6.48	5.68	6.2	7.19

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

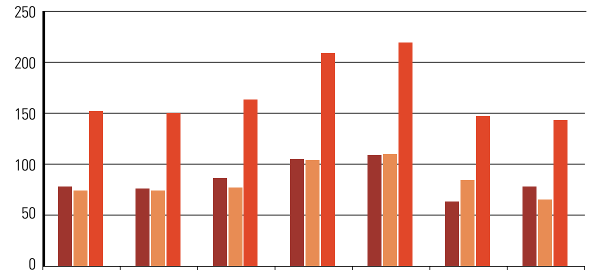
Olkiluoto

The number of maintenance works causing inoperability of components, included in the indicator, decreased in 2007–2009 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 2014, the number of fault repairs that caused inoperability of components remained at the level of 2011–2013. The number of preventive maintenance tasks slightly increased, improving the ratio of preventive maintenance and fault repairs from 2011. The number of faults repaired at OL2 decreased and the relative number of preventive maintenance tasks increased more than at OL1, and thus the maintenance ratio increased at OL2 to 2.25.

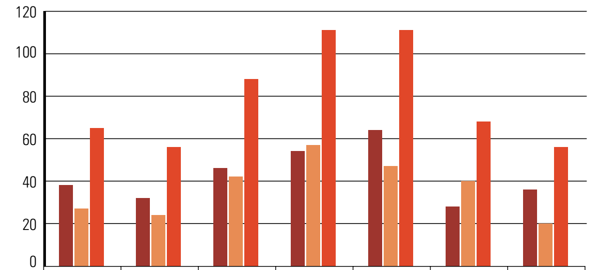
Based on the development of the ratio of preventive maintenance work to fault repairs and an assessment of the work on which the figures are based, the maintenance strategy can be considered successful.

Volume of annual maintenance works of OLC components, Olkiluoto NPP



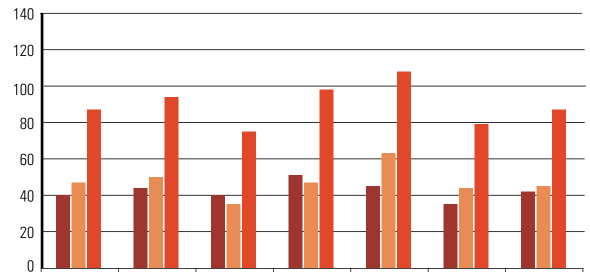
	2008	2009	2010	2011	2012	2013	2014
OL1	78	76	86	105	109	63	78
OL2	74	74	77	104	110	84	65
OL1,2	152	150	163	209	219	147	143

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



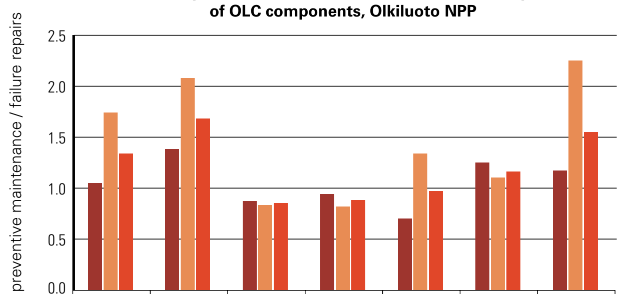
	2008	2009	2010	2011	2012	2013	2014
OL1	38	32	46	54	64	28	36
OL2	27	24	42	57	47	40	20
OL1,2	65	56	88	111	111	68	56

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



	2008	2009	2010	2011	2012	2013	2014
OL1	40	44	40	51	45	35	42
OL2	47	50	35	47	63	44	45
OL1,2	87	94	75	98	108	79	87

Ratio of preventive maintenance works to failure repairs of OLC components, Olkiluoto NPP



	2008	2009	2010	2011	2012	2013	2014
OL1	1.05	1.38	0.87	0.94	0.70	1.25	1.17
OL2	1.74	2.08	0.83	0.82	1.34	1.10	2.25
OL1,2	1.34	1.68	0.85	0.88	0.97	1.16	1.55

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. With each repair, the time recorded is the time of inoperability. In the case of a fault that causes an immediate operation restriction, it is calculated from the detection of the fault to the end of the repair work. If the component is operable until the beginning of repairs, only the time it takes to complete the repairs is taken into account.

Source of data

The data is obtained from the NPPs' 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.

Responsible units/persons

Resident inspectors
Pauli Kopiloff (Loviisa NPP)
Jukka Kallionpää (Olkiluoto NPP)

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 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 Loviisa NPP for several years. In 2008, the average repair time for the plant units was 20.4 hours, while the average of the four previous years was 24.6. In 2014, the average repair time of OLC component faults that had an allowed repair time of 72 hours or less was 12.7 hours at Loviisa 1 and 7.7 hours at Loviisa 2.

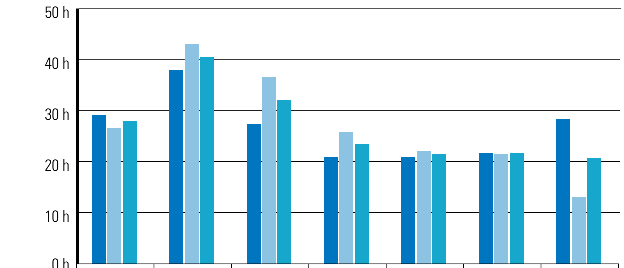
Based on the 2013 indicators and the underlying data, the plant's maintenance operations can be considered appropriate. Despite the positive development in repair times, attention still needs to be paid to the NPP's maintenance on having the necessary resources available for fault repairs, and for carrying out the repairs without unnecessary delays.

Interpretation of the indicator

Olkiluoto

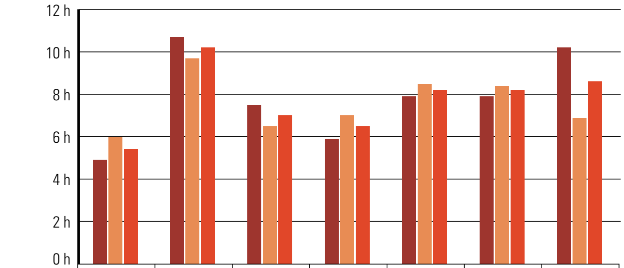
The indicator is used to monitor the repair times of components subject to the operational limits and conditions (OLC). The repair time allowed in the OLC is usually 30 days for faults concerning one train and three days for faults concerning two

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



	2008	2009	2010	2011	2012	2013	2014
LO1	29.1	38.0	27.3	20.9	20.9	21.7	28.4
LO2	26.6	43.1	36.6	25.9	22.1	21.4	13.0
LO1,2	27.9	40.6	32.0	23.4	21.5	21.6	20.7

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



	2008	2009	2010	2011	2012	2013	2014
OL1	4.9	10.7	7.5	5.9	7.9	7.9	10.2
OL2	6.0	9.7	6.5	7.0	8.5	8.4	6.9
OL1,2	5.4	10.2	7.0	6.5	8.2	8.2	8.6

trains. 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 2014, the average repair time of faults causing inoperability of components subject to the operational limits and conditions (OLC) at Olkiluoto 1 was around 10 h and at Olkiluoto 2 around 7 h. In the case of both plant units, the average repair time of faults causing inoperability of components subject to the OLC was at around the same level as in the previous years, except that the time increased to the level of 2009 at OL1.

On the basis of the 2014 indicators and the underlying data, the NPP's maintenance operations were appropriate.

A.I.1d Common-cause failure

Definition

As the indicator, the number of common-cause failures of components or systems defined in the operational limits and conditions (OLC) is followed.

Source of data

Data for the indicators is collected from the reports by the power companies of works causing an operation restriction.

Purpose

The indicator is used to follow the quality of maintenance.

Responsible unit/person

Operational safety (KÄY)
Suvi Ristonmaa (Loviisa)
Mikko Heinonen (Olkiluoto)

Interpretation of the indicator

Loviisa

When a fault is observed in a safety-critical system, component or structure in connection with maintenance, inservice testing or other monitoring operations, the corrective measures include an investigation of whether the fault is a single fault, or whether there might be other similar faults in the system. No common-cause failures were identified at Loviisa NPP in 2014.

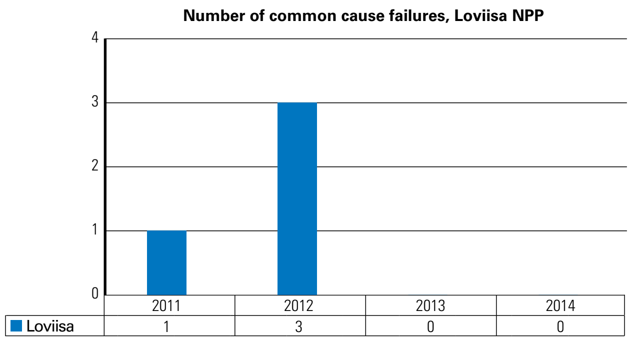
Olkiluoto

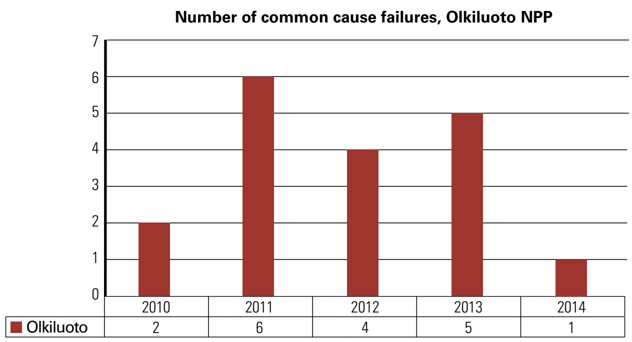
One fault that was identified as a common-cause failure occurred at Olkiluoto in 2014. It concerned a software fault detected in the Gardel system that is used in reactor monitoring.

The number of common-cause failures has varied a great deal over the years. There were only a few common-cause failures in 2005–2010 (six in total),

while there were plenty of common-cause failures in 2011–2013 (15 in total).

In the past few years, most common-cause failures have been detected in emergency diesel generators and the relief train. TVO has launched a project on replacing the emergency diesel generators. The new emergency diesel generators will be installed in 2017–2021.





A.I.1g Production losses due to faults

Definition

As the indicator, the loss of production caused by faults in relation to rated power (gross) is monitored.

Source of data

Data for the indicator is obtained from the annual and quarterly reports submitted by power companies.

Purpose

The indicator is used to follow the significance of faults from the point of view of NPP production.

Responsible unit/person

Operational safety (KÄY)
Suvi Ristonmaa (Loviisa)
Mikko Heinonen (Olkiluoto)

Interpretation of the indicator

Production losses due to faults have been small at both Loviisa and Olkiluoto, which is also indicated by the NPPs' high load factors.

Loviisa

In 2014, Loviisa 1 and Loviisa 2 experienced more faults resulting in production losses than in the previous year. The number of faults was restored to the level prior to 2012.

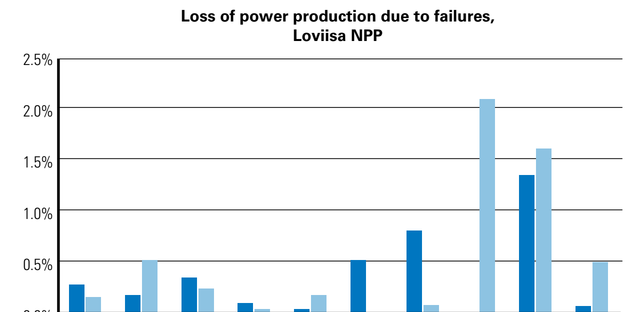
Most of the faults resulting in production losses (two out of three) at Loviisa 2 in 2014 were caused by observations made during the commissioning tests of the main steam line safety valves that were replaced during the annual outage and studying of these observations. A little less than one third were caused by the maximum allowed fuel element power that restricted the restoration into full power after the annual outage. The production losses at Loviisa 1 were caused by several faults of different types and their repairs; there was no single predominant cause.

Olkiluoto

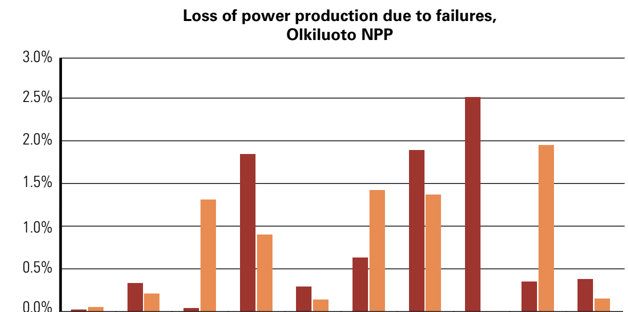
There were only a few faults resulting in production losses at both Olkiluoto plant units in 2014; the number of faults resulting in production losses has not been so low since 2009. There were no long-term repair outages caused by faults at neither of the plant units.

Most production losses at Olkiluoto 1 were caused by the replacement of a relief train control valve in March, the repair of a circulating water leak in a condenser in April and a partial reactor trip during a preheater bypass test in December.

Most production losses at Olkiluoto 2 were caused by the replacement of two generator carbon brushes in July.



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	0.27	0.17	0.34	0.09	0.03	0.51	0.8	0.004	1.34	0.06
LO2	0.15	0.51	0.23	0.03	0.17	0.00	0.07	2.08	1.60	0.49



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	0.02	0.33	0.04	1.84	0.29	0.63	1.89	2.51	0.35	0.38
OL2	0.05	0.21	1.31	0.90	0.14	1.42	1.37	0,00	1.95	0.15

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 indicators is collected from applications for exemption orders 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.

Responsible unit/person

Operational safety (KÄY)
Suvi Ristonmaa (Loviisa)
Mikko Heinonen (Olkiluoto)

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

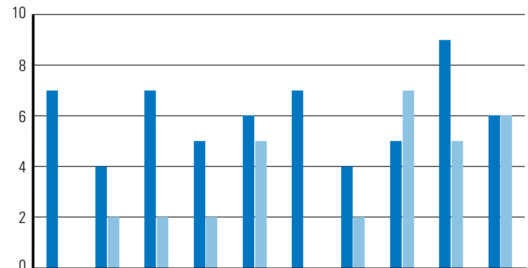
Based on the last ten years (2004–2013), Loviisa NPP applies for STUK's approval for exemptions from the OLC six times per year on average. The number of applications in 2014 (six applications) was in line with the average. Three of the applications concerned modifications and three concerned the enabling of the plant unit's startup after the annual outage. As the planned deviations had no significant safety implications, STUK approved the applications.

Non-conformance with the OLC

In 2014, six events during which the plant did not comply with the OLC without an advance safety analysis and approval were detected at Loviisa NPP. There have been more such events in the past three years than in the previous years. Such events have occurred three times per year on average during the past ten years (2004–2013). The increase may have been caused by the development of the event detection and reporting procedures or a decrease in operations. For more information on an assessment of this issue and a related improvement project, please see Chapter 4.1.7 of the 2013 and 2014 annual reports (a project started by a special reporting committee). All events that were non-compliant with the OLC in 2014 are described in Chapter 4.1.2 of this annual report and 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 deviations. 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 2012–2014 (observed in connection with seven events in total) was non-compliance with the OLC during the changing of a plant unit's operating mode, i.e. either when switching the unit

Number of deviations from the OLC, Loviisa NPP

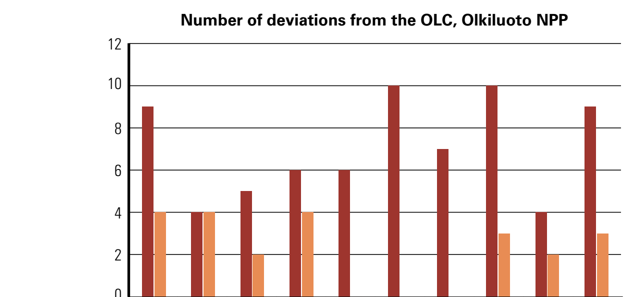


	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Exemptions	7	4	7	5	6	7	4	5	9	6
Deviations	0	2	2	2	5	0	2	7	5	6

from load operation to a shutdown or from a shutdown 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. Fortum studied the events at the turn of the year 2013/2014 and drafted a root cause analysis. All of the measures listed in the analysis report will be implemented by the 2015 annual outages. Effect of the measures can be verified during future annual outages and any other future outages. The applications for exemptions from the OLC concerning startup that were mentioned above are also an indication that attention has been paid to this issue and the changing of operating mode has been properly managed in these cases.

Olkiluoto

Based on data from the last ten years (2003–2014), Olkiluoto NPP applied for STUK's approval for exemptions from the OLC seven times per year on average. The number of applications in 2014 (nine applications in total) was slightly higher than the average. Three of the applications concerned installation of a recirculation line in the auxiliary feedwater system of Olkiluoto 1 and three concerned the expansion and modernisation of the interim storage facility for spent fuel. STUK approved all the applications, except for one. STUK refused TVO's application to increase the trip limit for high circulating water temperature that starts the cooling circuits of the condensate pool because



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Exemptions	9	4	5	6	6	10	7	10	4	9
Deviations	4	4	2	4	0	0	0	3	2	3

TVO did not provide sufficient justification on the operation of the unit being safe at the proposed condensate pool temperature.

In 2004 and 2005, the number of deviations was increased by work and installations related to the modernisation of OL1 and OL2 and the construction of OL3. Similarly, major modifications were carried out in 2010 and 2011.

Non-conformance with the OLC

In 2014, TVO reported three events during which the NPP was non-compliant with the OLC without an advance safety analysis and STUK's permission. This number of events complies with the average number of events during the past ten years (three). Both measuring channels of the radioactivity monitoring system were simultaneously detached at Olkiluoto 2 due to a human error during calibration of the system. Some of the covers that protect the pools in the interim storage facility from an airplane crash were lifted with an unapproved hoisting device. A generator grounding carbon brush was replaced at Olkiluoto 1 in a manner that violated the NPP's administrative procedures. Special reports on all three deviations from the OLC were submitted to STUK. In these reports, TVO analysed the causes of the events and determined corrective measures to prevent their reoccurrence.

A.I.3 Unavailability of safety systems

Definition

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

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

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

The unavailability hours of a train 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 period 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 person in charge 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.

Responsible units/persons

Resident inspectors
Pauli Kopiloff (Loviisa NPP)
Jukka Kallionpää (Olkiluoto NPP)

Interpretation of the indicator

Loviisa

TJ system

Analysis of the unavailability figures of the high pressure safety injection systems of the plant units in 2014 and their background information shows that two faults, the repairs for which caused the system to be unavailable for 8.25 hours, occurred at Loviisa 1. No faults causing unavailability occurred at Loviisa 2.

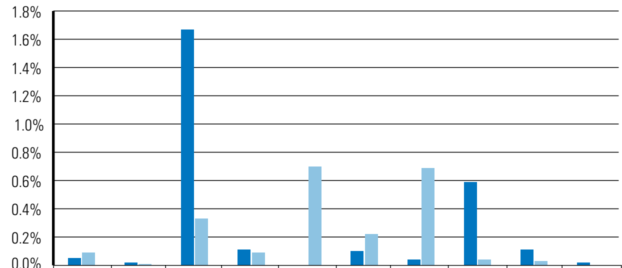
The unavailability of the high pressure safety injection systems was low in 2014, i.e. their condition and availability were good.

RL system

At Loviisa 1, the total unavailability time of the emergency feedwater systems was 474 hours, of which unavailability of 383 hours was caused by the repair of a seized bearing of a pump in the emergency feedwater system RL94. No other faults were repaired at Loviisa 1, and the rest of the unavailability (91 hours) was caused by the periodic maintenance of a diesel generator of the emergency feedwater system RL94 during the annual outage of Loviisa 1.

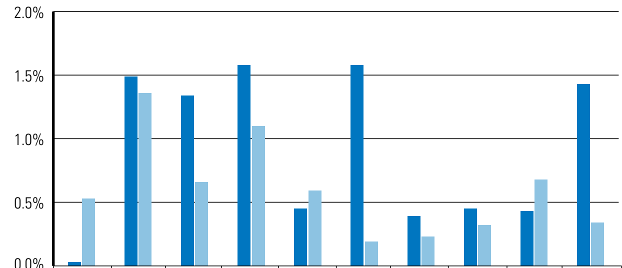
The total unavailability time at Loviisa 2 was 109 hours, which was caused in its entirety by periodic maintenance of the emergency feedwater system RL97 during the annual outage.

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



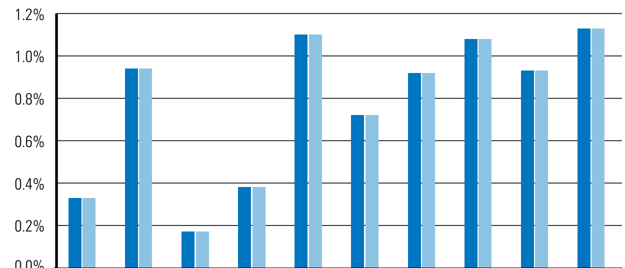
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	0.05	0.02	1.67	0.11	0.00	0.10	0.04	0.59	0.11	0.02
LO2	0.09	0.01	0.33	0.09	0.70	0.22	0.69	0.04	0.03	0.00

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



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	0.03	1.49	1.34	1.58	0.45	1.58	0.39	0.45	0.43	1.43
LO2	0.53	1.36	0.66	1.10	0.59	0.19	0.23	0.32	0.68	0.34

Unavailability of emergency diesel generators (EY), Loviisa NPP



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	0.33	0.94	0.17	0.38	1.10	0.72	0.92	1.08	0.93	1.13
LO2	0.33	0.94	0.17	0.38	1.10	0.72	0.92	1.08	0.93	1.13

The unavailability of the emergency feedwater systems was low in 2014, i.e. their condition and availability were good.

EY system

In 2014, the unavailability time of the eight emergency diesel generators was 723 hours, compared to 526 hours in 2013. The increase in the unavailability time was mostly caused by the replacing of auxiliary relays in the diesel generator control circuits: relays with a programming option were replaced with approved relay types. The fourteen separate relay replacements took 242 hours total. There were a total of 73 diesel generator faults causing unavailability of the generators. 15 of these caused immediate operation restrictions while 58 caused operation restrictions from the beginning of the repair work. Most of the faults were caused by the normal ageing of components and did not have any serious implications.

Unavailability of the emergency diesel generators was 1.13% in 2014, which is somewhat higher than the average for the past four years, 0.91%. Taking into account the impact of the above-mentioned replacement of relays, the unavailability of diesel generators remained low, i.e. availability of the emergency diesel generators was acceptable.

Interpretation of the indicator

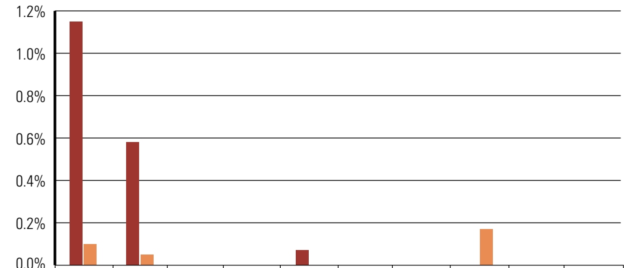
Olkiluoto

The unavailability times of the containment spray system have been decreasing since 2005. In 2007, 2008, 2010, 2011 and 2013, the unavailability was zero for both plant units, and almost zero in 2009 and 2012.

The unavailability of the auxiliary feedwater system increased significantly after 2004, when the unavailability was practically zero. 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 nearly zero in 2009 at both plant units. In 2010, unavailability of OL1 was still zero but unavailability of OL2 increased slightly from the previous year, mainly as a result of several new faults discovered during the outage. In 2011, the figure for OL1 was multiplied many times over as the result of a latent fault in one auxiliary feedwater system valve that remained inoperable for 504 hours (cf. Section A.II.3). In 2013, the unavailability of the auxiliary feedwater system was restored to the level prior to 2011, and the unavailability remained at this level in 2014.

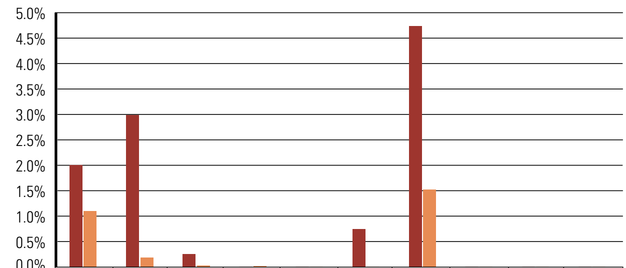
The unavailability of the diesel generators has decreased since 2005, and was very low in 2006 and 2007. In 2008, the value increased by nearly 95% compared to the previous year. The increase was due to latent faults in the compressed air mo-

Unavailability of containment spray system (322), Olkiluoto NPP



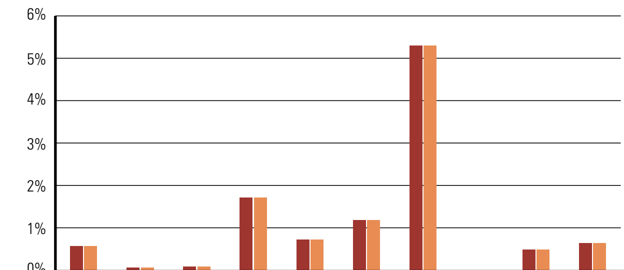
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	1.15	0.58	0.00	0.00	0.07	0.00	0.00	0.00	0.00	0.00
OL2	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00

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



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	2.00	2.98	0.25	0.00	0.00	0.74	4.73	0.00	0.00	0.00
OL2	1.10	0.18	0.02	0.01	0.00	0.00	1.52	0.00	0.00	0.00

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



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	0.57	0.06	0.09	1.71	0.72	1.18	5.30	0.00	0.48	0,64
OL2	0.57	0.06	0.09	1.71	0.72	1.18	5.30	0.00	0.48	0,64

tors of the diesels in both plant units. In 2009, the unavailability of the diesel generators decreased considerably from the 2008 figures. In 2010, unavailability increased somewhat from the previous year as a result of faults occurring in connection with inservice testing. At OL1, the stator winding of a diesel generator failed in connection with a periodic 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 while the parameter has been monitored. The reason for the increase was the above-mentioned 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 emergency diesel generators was zero. The unavailability of the diesel generators slightly increased in 2014 but still remained very low.

A.I.4 Radiation exposure

Definition

As the indicators, collective radiation exposure of NPP employees by plant site and plant unit is monitored, together with the annual average of the ten highest occupational doses.

Source of data

The data on the collective occupational dose is received from the quarterly and annual reports of the NPPs as well as the national dose register. The data on individual radiation doses is obtained from the national dose register.

Purpose

The indicators are used to control the radiation exposure of employees. In addition, compliance with the YVL Guide's calculated threshold for one plant unit's collective occupational dose averaged over two successive years is monitored. The threshold value, 2.5 manSv per one gigawatt of net electrical power, means a radiation dose of 1.24 manSv for one Loviisa plant unit and 2.20 manSv for one Olkiluoto plant unit. The collective occupational doses describe the success of the NPP's ALARA programme. The average of the ten highest doses indicates how close to the 20 manSv dose limit the individual occupational doses at the NPPs remain. It also indicates the effectiveness of the NPP's radiation protection unit.

Responsible unit/person

Radiation protection (SÄT)
Antti Tynkkynen

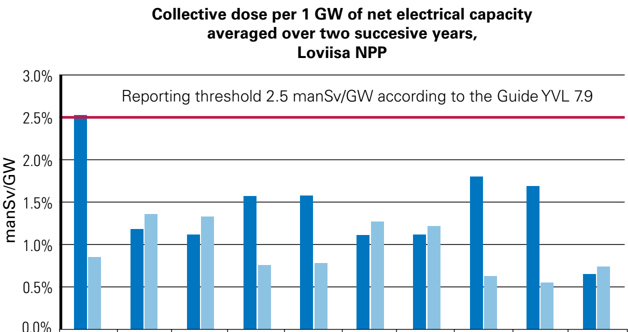
Interpretation of the indicator

Loviisa

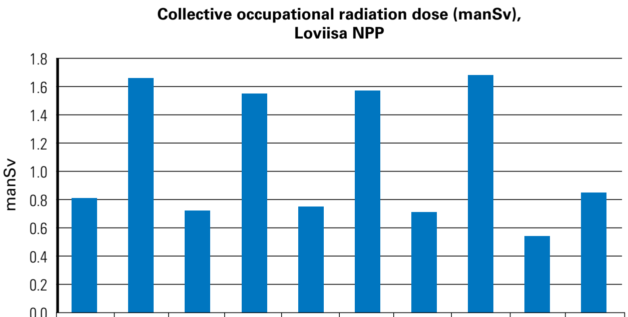
Most doses are incurred through work done during outages. Thus, the duration of the outage and the amount of work having significance on radiation protection affect the annual radiation doses. Both Loviisa plant units have more extensive annual outages every four and eight years (the four-year annual outage and the eight-year annual outage) so that both plant never have a major annual outage during the same year. Four-year and eight-year outages have been held in even years and normal annual outages in odd years. The effect of annual outages on collective occupational doses can be seen in the *Collective occupational dose, Loviisa* graph. In 2014, an eight-year annual outage took place at Loviisa 1 and a four-year annual outage at Loviisa 2. Due to improvements in radiation safety, the collective occupational dose of employees at Loviisa 1 was the lowest ever recorded and the collective occupational dose at Loviisa 2 was low even though a four-year annual outage was implemented.

The radiation doses for NPP workers at Loviisa remained below the individual dose limits. The average of the ten largest doses was slightly lower than the average even though a larger four-year annual outage was implemented at Loviisa 2. The doses during previous similar annual outages have been clearly higher than the doses in 2014. The Radiation Decree (1512/1991) stipulates that the effective dose for a worker from radiation work may not exceed the 20 manSv/year average over any period of five years, or 50 manSv during any one year.

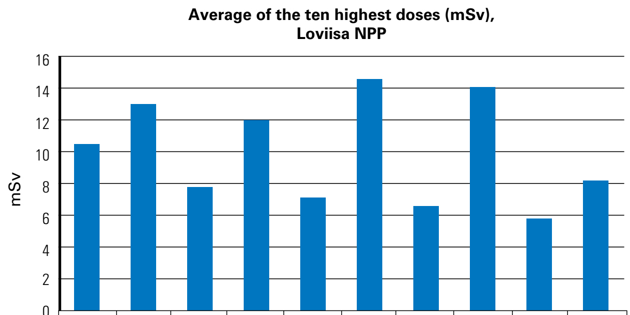
The threshold set for the collective occupational dose was not exceeded either in 2013. If, at one plant unit, the collective occupational radiation dose average over two successive years exceeds 2.5 manSv per one GW of net electrical power, the power company is to report to STUK the causes of



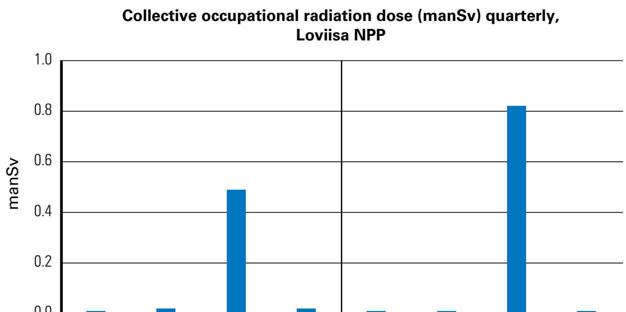
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	2.53	1.18	1.12	1.57	1.58	1.11	1.12	1.8	1.69	0.65
LO2	0.85	1.36	1.33	0.76	0.78	1.27	1.22	0.63	0.55	0.74



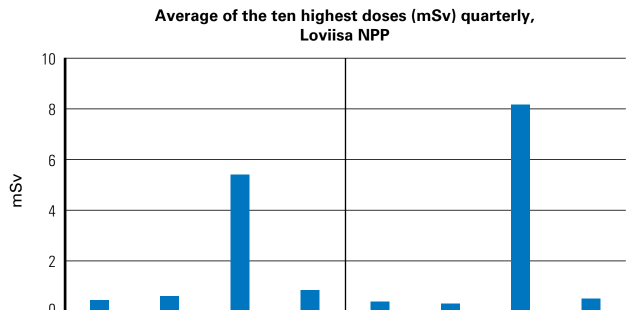
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO	0.81	1.66	0.72	1.55	0.75	1.57	0.71	1.68	0.54	0.85



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO	10.48	13.00	7.76	11.99	7.11	14.55	6.56	14.06	5.78	8.16



	I/13	II/13	III/13	IV/13	I/14	II/14	III/14	IV/14
LO	0.01	0.02	0.49	0.02	0.01	0.01	0.82	0.01



	I/13	II/13	III/13	IV/13	I/14	II/14	III/14	IV/14
LO	0.46	0.60	5.40	0.84	0.39	0.32	8.16	0.52

this and any measures required to improve radiation safety (Guide YVL 7.9).

Interpretation of the indicator

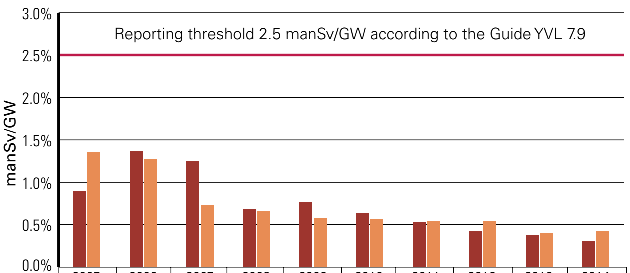
Olkiluoto

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 Olkiluoto plant units are divided into two groups: refueling outages and maintenance outages. The refueling 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 refueling outage. In 2014, Olkiluoto 1 underwent a maintenance outage and Olkiluoto 2 a refueling outage.

In 2014, the collective occupational radiation dose of Olkiluoto employees was the lowest ever recorded during the operation of the NPP. The previous record was from 2013. The radiation doses have clearly decreased after the installation of new moisture separators in 2005–2007. The radiation level in the turbine buildings has continued to decrease after the installation of the moisture separators, and this has also decreased the collective occupational dose. Furthermore, improvements aiming at reducing the employees' radiation doses have also been made at the NPP.

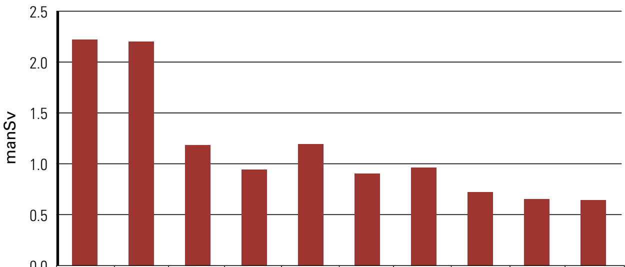
In 2014, the average of the ten largest doses was the lowest ever recorded during the operation of the NPP. The ten largest doses have continued to decrease during the past ten years. The prescribed dose limits (Radiation Decree 1512/1991) were not exceeded.

Collective dose per 1 GW of net electrical capacity averaged over two succesive years, Olkiluoto NPP



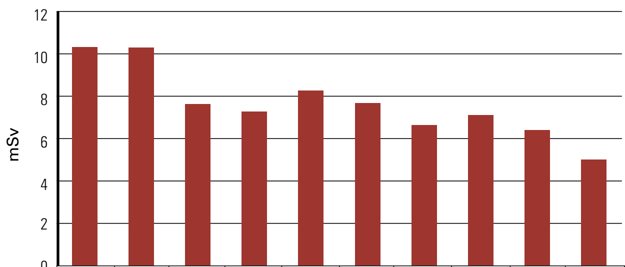
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	0.90	1.37	1.25	0.69	0.77	0.64	0.53	0.42	0.38	0.31
OL2	1.36	1.28	0.73	0.66	0.58	0.57	0.54	0.54	0.40	0.43

Collective occupational radiation dose (manSv), Olkiluoto NPP



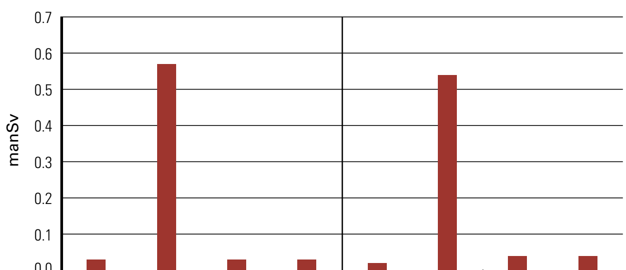
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL	2.22	2.20	1.18	0.94	1.19	0.90	0.96	0.72	0.65	0.64

Average of the ten highest doses (mSv), Olkiluoto NPP



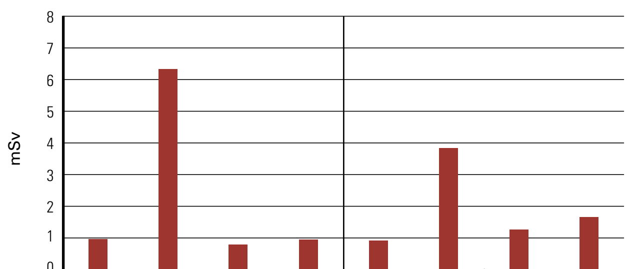
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL	10.32	10.30	7.63	7.28	8.27	7.68	6.65	7.12	6.41	5.02

Collective occupational radiation dose (manSv) quarterly, Olkiluoto NPP



	I/13	II/13	III/13	IV/13	I/14	II/14	III/14	IV/14
OL	0.03	0.57	0.03	0.03	0.02	0.54	0.04	0.04

Average of the ten highest doses (mSv) quarterly, Olkiluoto NPP



	I/13	II/13	III/13	IV/13	I/14	II/14	III/14	IV/14
OL	0.97	6.33	0.79	0.94	0.92	3.84	1.27	1.66

A.I.5 Releases

Definition

As the indicators, radioactive releases into the sea and the air from the NPPs are monitored, together with the calculated dose due to releases to the most exposed individual in the vicinity of the NPP.

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 NPP is defined.

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.

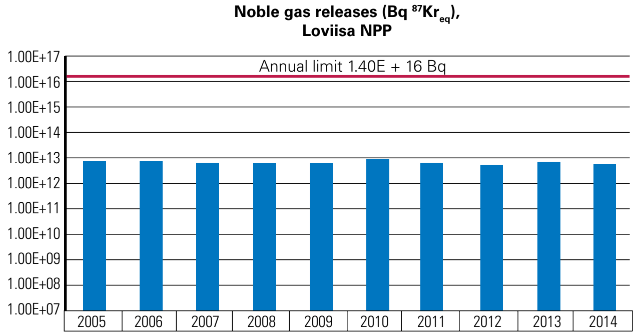
Responsible unit/person

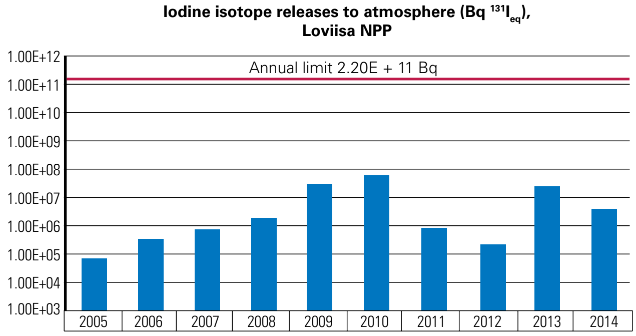
Radiation protection (SÄT), Antti Tynkkynen

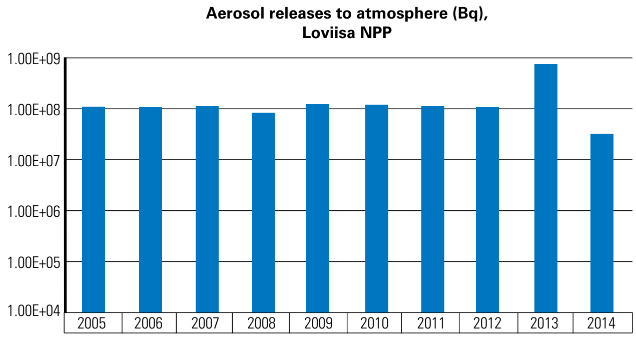
A.I.5a Releases into the air

Interpretation of the indicator

In 2014, the radioactive releases into the air from Loviisa NPP and Olkiluoto NPP were of the same magnitude as in previous years. Releases into the environment were low, well below the set limits.



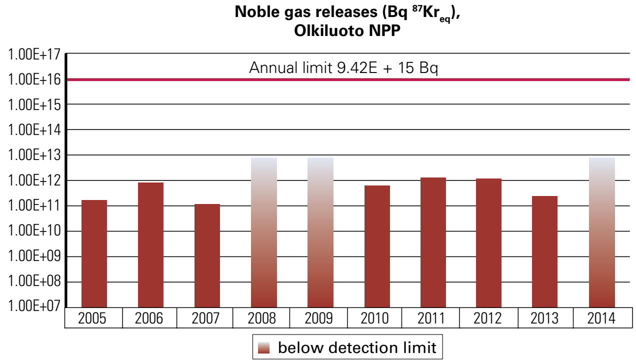


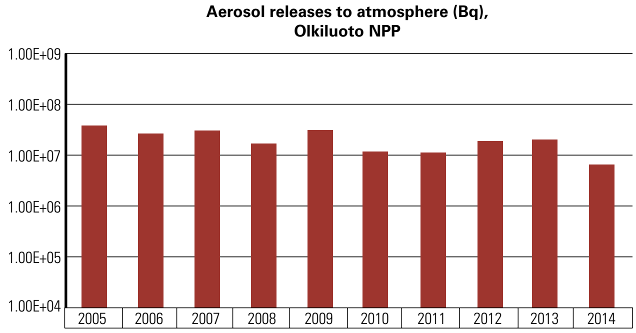


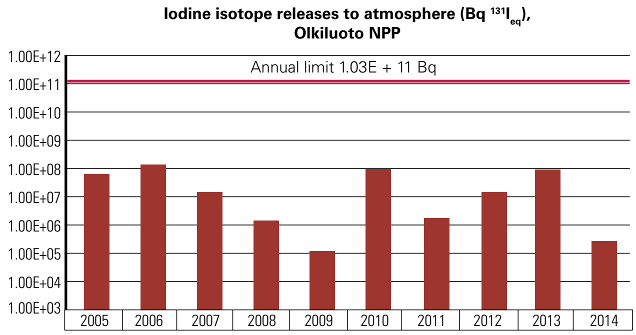
Releases of noble gases from Loviisa NPP were of the same magnitude as in previous years, while releases of particulate aerosols were clearly lower than normal. The releases of particulate aerosols were higher in 2013 because more rapidly decaying As-76 (arsenic) than normal was released over the course of the year from both plant units. Releases of iodine isotopes decreased from the previous year.

No releases of radioactive noble gases into the environment were detected at Olkiluoto NPP (meaning that the releases remained below the detection limit). Releases of iodine isotopes were very low because there were no fuel leaks during the fuel cycle. The releases of particulate aerosols were also very low.

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 from earlier fuel leaks. At both Loviisa and Olkiluoto, there have been very few leaking fuel rods and the leaks have been small. No fuel leaks were observed at the NPPs in 2014. The indicator A.III.1 describes fuel integrity. The releases of radioactive noble gases from Loviisa power plant are dominated by argon-41, the activation product of argon-40 originating in the air space between the reactor pressure vessel and the main radiation shield. Aerosol nuclides (including activated corrosion products) are released during maintenance work.



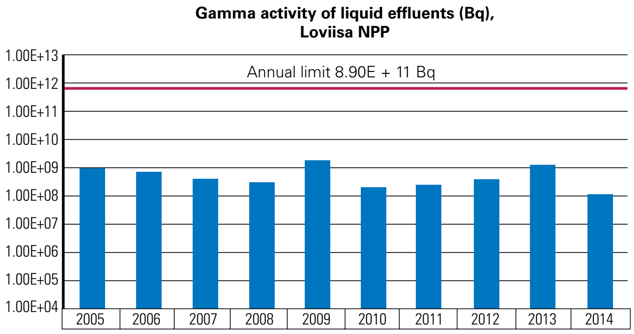


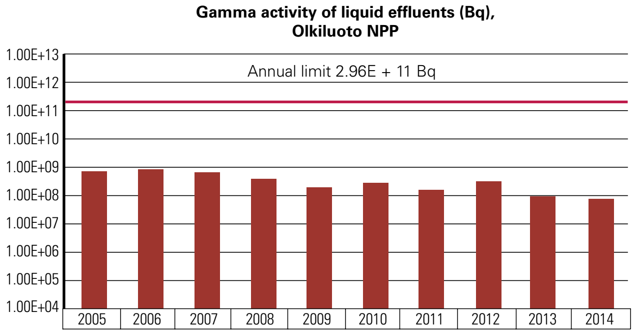


A.I.5b Releases into the sea

Interpretation of the indicator

Releases of radioactive substances emitting gamma radiation into the environment from Loviisa NPP and Olkiluoto NPP remained clearly below the set limits. In 2009 and 2013, Loviisa NPP released low-activity evaporation bottom into the sea as planned. Consequently, the releases of substances with gamma activity were larger than the average in those years. The releases of substances with gamma activity into the sea from Olkiluoto NPP have been decreasing in recent years, reaching their lowest value ever in 2014.



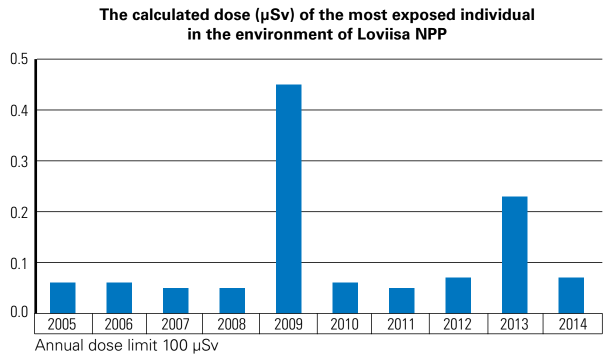


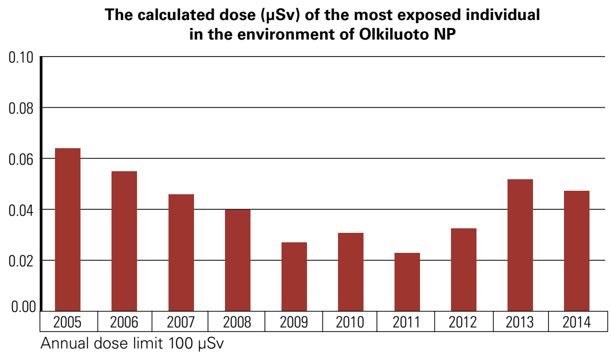
A.I.5c Population exposure

Interpretation of the indicator

The doses of the most exposed individual in the vicinity, calculated on the basis of the NPP's release data and meteorological measurement data, remained below the set limit at Loviisa and Olkiluoto. The calculated dose of the most exposed individual in the vicinity of Loviisa NPP was at the normal level in 2014. Larger radiation doses in 2004 and 2009 were caused by the discharge of evaporator bottom into the sea. The calculated dose of the most exposed individual in the vicinity of Olkiluoto NPP was also normal.

The radiation doses of both NPPs were less than 0.1% of the limit of 100 microsieverts that is established in the Government Decree (733/2008).





A.I.6 Investments in facilities

Definition

Investments in NPP maintenance and modifications in the current value of money adjusted by the building cost index.

Source of data

The licensee submits the necessary data directly to the person responsible for the indicator.

The indicator demonstrates the relative fluctuation of investments. The amounts given in euro are confidential information of the power companies involved, and not to be published here. Furthermore, the scales of the investment and modernisation graphs for Loviisa NPP and Olkiluoto NPP are not mutually comparable.

Purpose

The indicator is used to follow the amount of investments in plant maintenance and their fluctuations.

Responsible unit/person

Operational safety (KÄY)
Suvi Ristonmaa (Loviisa)
Mikko Heinonen (Olkiluoto)

Interpretation of the indicator

The variation of the indicator clearly shows the investments related to the power upgrades and modernisation projects of the NPPs. Both NPPs have paid great attention to lifecycle management, which also shows as continuous long-term investment plans. The renewal of the operating license of Loviisa NPP in 2007 and the intermediate assessment carried out at Olkiluoto in 2008 have also had an impact on the investment plans.

Loviisa

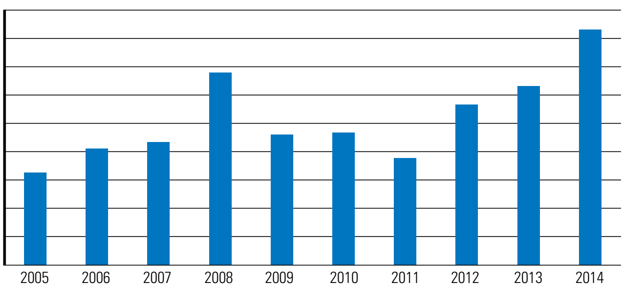
Many modification projects and other projects span over the course of several years, which means that their total costs are also divided between several years. For example, investments in the Loviisa I&C renewal started in 2007. Other major investments in 2014 included modernisation of the reactor coolant system pressure control system, a reheater upgrade, a turbine modernisation project, an upgrade of a maintenance data system and modernisation of the service water system piping.

Olkiluoto

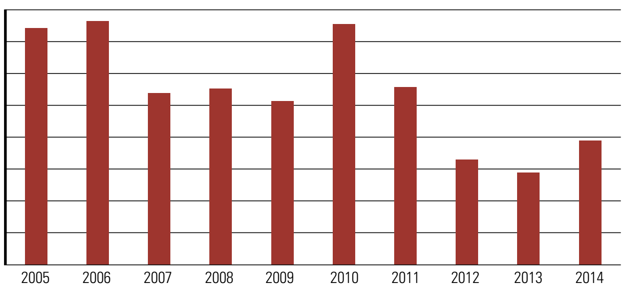
Slightly more investments and refurbishment projects than in the two previous years were implemented in 2014. Investments have clearly decreased from the level of 2010 and 2011, during which years the LP steam turbines of both units were replaced, for example.

Major investments in 2014 included expansion of the interim storage facility for spent nuclear fuel, replacement of low voltage switchgear and auxiliary transformers, and construction of a remote shutdown station. A major project started during the year was the replacement of reactor coolant pumps and their frequency converters. Another ongoing major investment is the replacement of the emergency diesel generators.

Maintenance investments and renovations, Loviisa NPP



Maintenance investments and renovations, Olkiluoto NPP



A.II Operational events

A.II.1 Number of events

Definition

As the indicators, the number of events reported in accordance with Guide YVL 1.5 is monitored (events warranting a special report, reactor trips and reports on operational events).

Source of data

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

Purpose

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

Responsible unit/person

Operational safety (KÄY)
Suvi Ristonmaa (Loviisa)
Mikko Heinonen (Olkiluoto)

Interpretation of the indicator

Loviisa

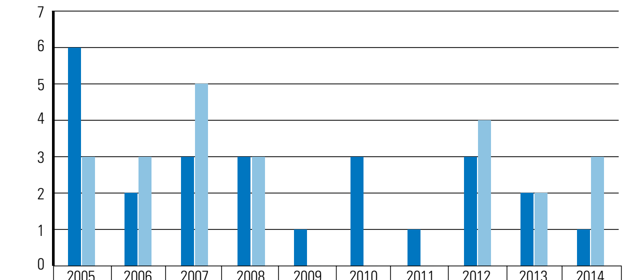
No reactor trips occurred at Loviisa NPP in 2014.

Based on data from the last ten years (2004–2013), the average number of annual events warranting a special report is three to four per year, while the average number of events warranting a transient report is five per year. The number of events warranting a special report was higher than the average in 2014 (six in total) and the number of events warranting a transient report (four in total) was slightly below the average. All of the events that warranted a special report in 2014 are described in Chapter 4.1.2 of this annual report and Appendix 3. Events classified as operational transients are described in brief in Chapter 4.1.2 of this annual report.

The number of events warranting a special report has increased over the past few years. STUK discussed the issue of the increased number of events with the management of Fortum Power and Heat Oy (hereinafter referred to as "Fortum") in the autumn of 2012. The licensee studied the underlying causes of the changed trend and specified corrective measures. Fortum submitted an action plan on this issue to STUK for information at the end of 2013. The improvement project and its progress are described in more detail in Chapter 4.1.7 of the annual reports for 2013 and 2014. Many of the events warranting a special report are deviations from the operational limits and conditions (OLC). The development of events non-compliant with the OLC is considered under indicator A.I.2.

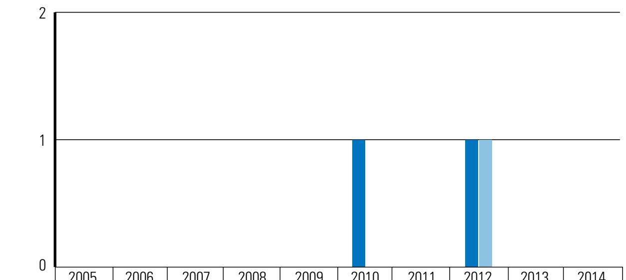
When considering the indicators concerning special and transient reports, it must be noted that the number of reports does not give a correct idea of the division of events by plant unit since, for technical reasons, the reports that concern both plant units have been entered for Loviisa 1 alone. In 2014, one event warranting a special report concerned both plant units.

Number of operational transient reports, Loviisa NPP



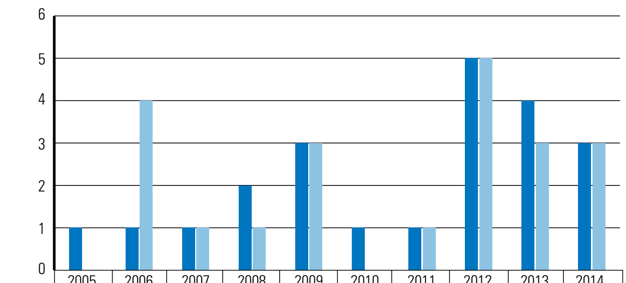
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	6	2	3	3	1	3	1	3	2	1
LO2	3	3	5	3	0	0	0	4	2	3

Number of reactor scrams, Loviisa NPP



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	0	0	0	0	0	1	0	1	0	0
LO2	0	0	0	0	0	0	0	1	0	0

Number of Special Reports, Loviisa NPP



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	1	1	1	2	3	1	1	5	4	3
LO2	0	4	1	1	3	0	1	5	3	3

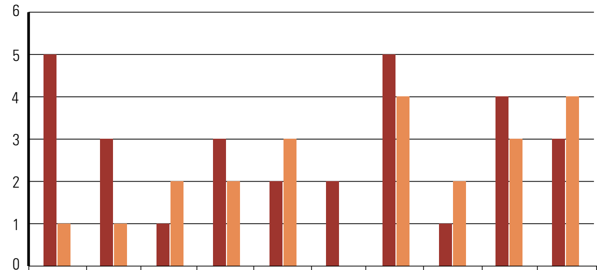
Olkiluoto

No reactor trips occurred at Olkiluoto NPP in 2014. Based on the data from the last ten years, an average of zero to one reactor trips per year occurs at Olkiluoto NPP. During the previous decade (1993–2001), an average of almost three to four reactor trips occurred each year. 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 last ten years, the average annual number of events warranting a special report or a transient report is five. The number of events warranting a special report (three in total) was slightly lower than the average in 2014, while the number of events warranting a transient report (seven in total) was slightly above the average. Events warranting a special report were replacement of generator grounding brushes at Olkiluoto 1 in a manner that violated the NPP's administrative procedures, erroneous detachment of radiation measuring systems at Olkiluoto 2 and the use of an unapproved hoisting device at the interim storage facility for spent nuclear fuel. Events warranting a transient report included, for instance, switching of a reactor coolant pump to its minimum rpm due to a grid fault; this fault occurred four times in 2014.

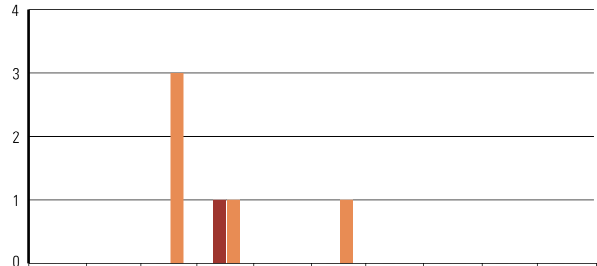
When considering the indicators concerning special and transient reports, it must be noted that the number of reports does not give the correct idea of the division of events by plant unit since, for technical reasons, reports that concern both plant units or the interim storage facility for spent nuclear fuel have been entered for Olkiluoto 1 alone.

Number of operational transient reports, Olkiluoto NPP



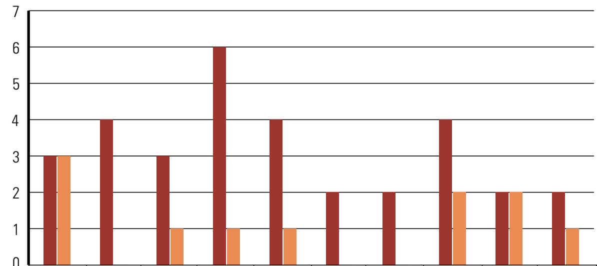
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	5	3	1	3	2	2	5	1	4	3
OL2	1	1	2	2	3	0	4	2	3	4

Number of reactor scrams, Olkiluoto NPP



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	0	0	0	1	0	0	0	0	0	0
OL2	0	0	3	1	0	1	0	0	0	0

Number of Special Reports, Olkiluoto NPP



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	3	4	3	6	4	2	2	4	2	2
OL2	3	0	1	1	1	0	0	2	2	1

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 faults, 2) planned unavailability and 3) initiating events. Furthermore, events are grouped into three categories according to their risk-significance (CCDP): the most risk-significant events (CCDP>1E–7), other significant events (1E-8 ≤ CCDP < 1E–7) and other events (CCDP < 1E–8). The indicator is the number of events in each category.

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-conformances with the OLC are also dealt with under indicator A.I.2.

Calculations concerning Olkiluoto NPP have been made with FinPSA software and those concerning Loviisa NPP with RiskSpectrum software. For Loviisa NPP, calculations of a simultaneous fault in several components are solely based 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 indicators 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.

Responsible unit/person

Risk assessment (RIS), Jorma Rantakivi
(PRA computation)
Operational safety (KÄY)
(fault data)

Interpretation of the indicator

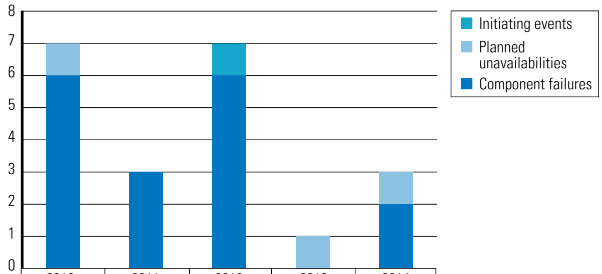
Loviisa

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

Loviisa 1:

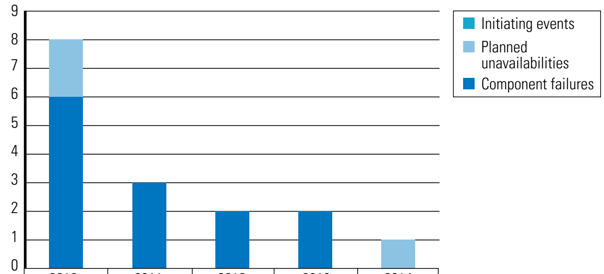
1. On 25 August 2014, the maintenance of the startup and shutdown pump system of LO2 took 108.9 hours during the annual outage of LO2. This caused a risk for the unit LO1 that was in power operation because the startup and shutdown pump system of LO2 can also be used to cool LO1. The calculated CCDP was 1.4E-7.
2. On 24 September 2014, it was observed during an inservice inspection that the startup and shutdown pump system RL94D001 was stuck. When the fault was studied, it was noted that the cause was a seized journal bearing. The fault had been hidden for 48 hours, and the pump's total unavailability time was 431 hours. The calculated CCDP was 6.34E-7.

Most risk-significant events
CCDP ≥ 1E-7
Loviisa 1 (total number of events)



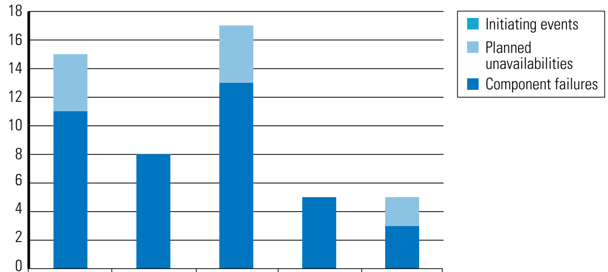
2010	2011	2012	2013	2014
0	0	1	0	0
1	0	0	1	1
6	3	6	0	2

Most risk-significant events
CCDP ≥ 1E-7
Loviisa 2 (total number of events)



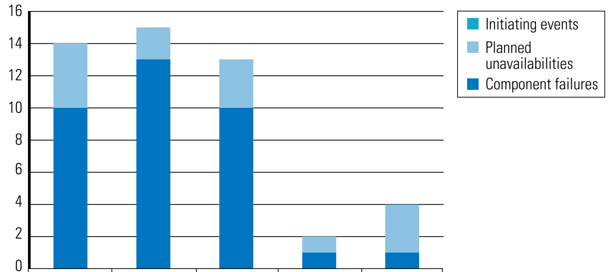
2010	2011	2012	2013	2014
0	0	0	0	0
2	0	0	0	1
6	3	2	2	0

Other significant events
1E-8 ≤ CCDP < 1E-7
Loviisa 1 (total number of events)



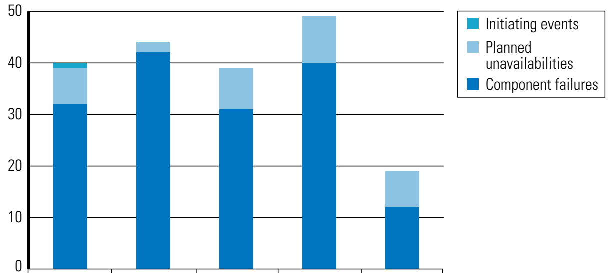
2010	2011	2012	2013	2014
0	0	0	0	0
4	0	4	0	2
11	8	13	5	3

Other significant events
1E-8 ≤ CCDP < 1E-7
Loviisa 2 (total number of events)



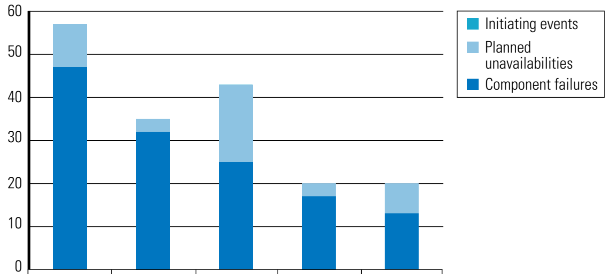
2010	2011	2012	2013	2014
0	0	0	0	0
4	2	3	1	3
10	13	10	1	1

Other events CCDP < 1E-8
Loviisa 1 (total number of events)



2010	2011	2012	2013	2014
1	0	0	0	0
7	2	8	9	7
32	42	31	40	12

Other events CCDP < 1E-8
Loviisa 2 (total number of events)



2010	2011	2012	2013	2014
0	0	0	0	0
10	3	18	3	7
47	32	25	17	13

3. On 6 October 2014, emergency diesel generator EY02 did not start during inservice testing. The fault was studied, and it was noted that it was caused by a defective solenoid valve in the starting system. The fault had been hidden for 321 hours and the total unavailability time was 351 hours. The calculated CCDP was 3.2E-7.
4. The unavailabilities caused by events 2 and 3 were simultaneously valid for 44.9 hours. The CCDP calculated for this simultaneous fault was 1.1E-7.

Loviisa 2:

1. On 31 July 2014, the maintenance of the startup and shutdown pump system of LO1 took 83.5 hours during the annual outage of LO1. This caused a risk for the unit LO2 that was in power operation because the startup and shutdown pump system of LO1 can also be used to cool LO2. The calculated CCDP was 1.1E-7.

Olkiluoto

A brief description of the significant events is given below.

Olkiluoto 1:

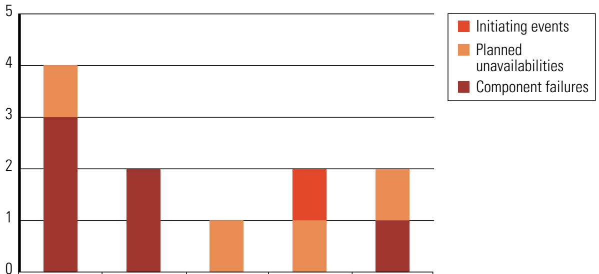
1. Preventive maintenance of a diesel generator in train C took 159 h. CCDP: 1.6E-07.
2. On 6 April 2014, switch 653G201 of a diesel generator in train B did not close. A hidden fault. Unavailability time 377 h. CCDP: 1.6E-7.

Olkiluoto 2:

1. Preventive maintenance of a diesel generator in train C took 107 h. CCDP: 1.1E-07.

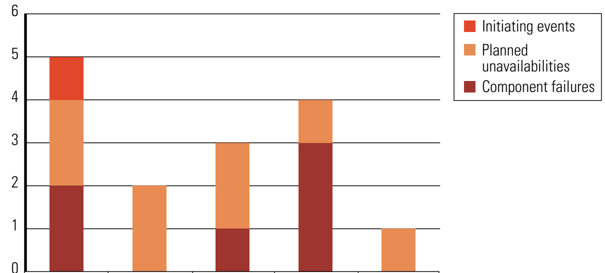
It should be mentioned that there were several faults in the ultrasound flow detection of several trains of the service water system 712, which cools the emergency heat transfer chain. Since the operation of the service water system can also be verified with the temperature measurements in

Most risk-significant events
CCDP ≥ 1E-7
Olkiluoto 1 (total number of events)



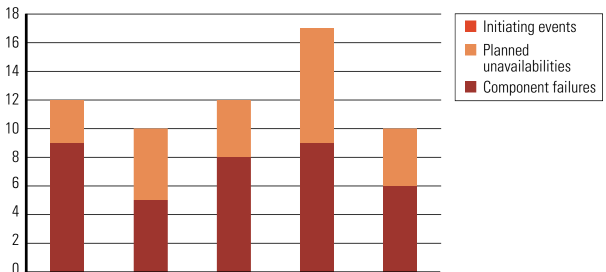
2010	2011	2012	2013	2014
0	0	0	1	0
1	0	1	1	1
3	2	0	0	1

Most risk-significant events
CCDP ≥ 1E-7
Olkiluoto 2 (total number of events)



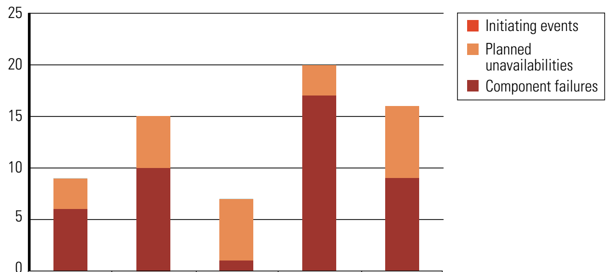
2010	2011	2012	2013	2014
1	0	0	0	0
2	2	2	1	1
2	0	1	3	0

Other significant events
1E-8 ≤ CCDP < 1E-7
Olkiluoto 1 (total number of events)



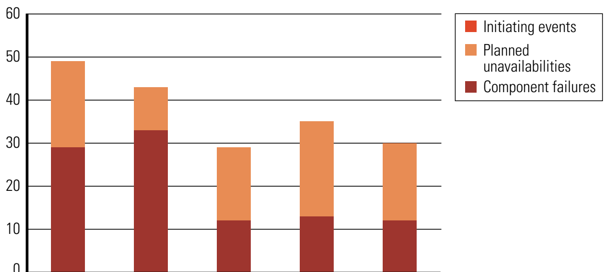
2010	2011	2012	2013	2014
0	0	0	0	0
3	5	4	8	4
9	5	8	9	6

Other significant events
1E-8 ≤ CCDP < 1E-7
Olkiluoto 2 (total number of events)



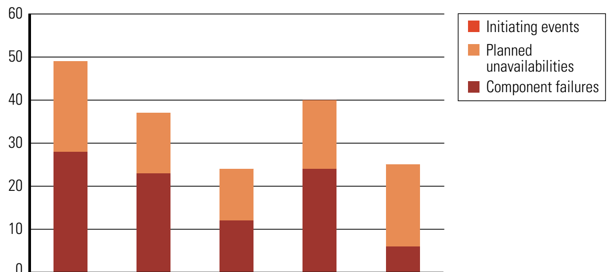
2010	2011	2012	2013	2014
0	0	0	0	0
3	5	6	3	7
6	10	1	17	9

Other events CCDP < 1E-8
Olkiluoto 1 (total number of events)



2010	2011	2012	2013	2014
0	0	0	0	0
20	10	17	22	18
29	33	12	13	12

Other events CCDP < 1E-8
Olkiluoto 2 (total number of events)



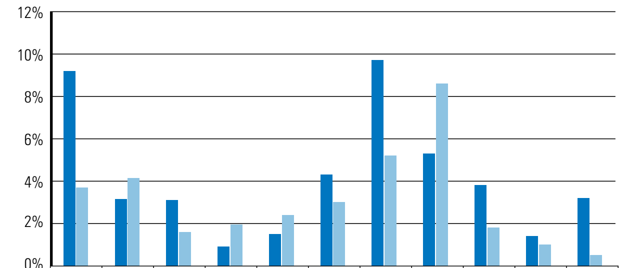
2010	2011	2012	2013	2014
0	0	0	0	0
21	14	12	16	19
28	23	12	24	6

the emergency heat transfer chain, it was considered that the service water systems were operable regardless of the flow detection faults.

The combined total CCDP of all three categories 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.

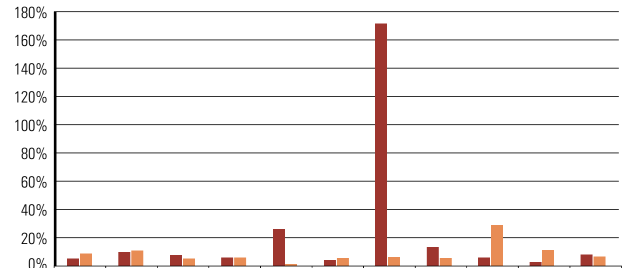
At both Loviisa and Olkiluoto, the risk caused by operational activities remained at around the same level as in the past years.

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



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	9.20	3.15	3.10	0.90	1.50	4.30	9.70	5.30	3.80	1.40	3.20
LO2	3.70	4.14	1.60	1.95	2.40	3.00	5.20	8.60	1.80	1.00	0.50

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



	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	5.10	9.64	7.60	6.00	26.10	4.00	171.40	13.10	5.90	2.80	7.90
OL2	8.60	10.95	5.00	6.00	1.30	5.40	6.30	5.40	29.00	11.00	6.40

A.II.4 Accident risk at nuclear facilities

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 NPPs. 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 Finnish NPPs.

Purpose

The indicator is used to follow the development of the NPP's accident risk. The objective is to operate and maintain the NPP 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 NPP or revise operating methods.

Responsible unit/person

Risk assessment (RIS), Jorma Rantakivi (PRA computation)
Operational safety (KÄY) (fault data)

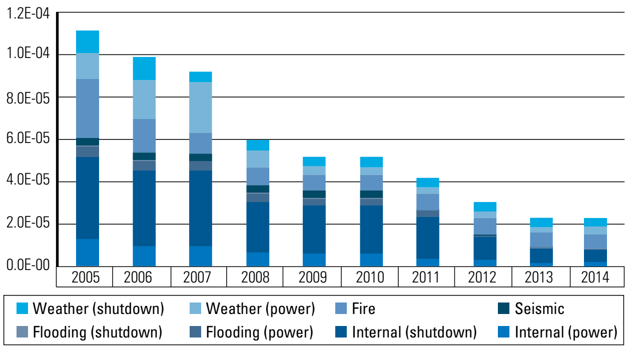
Interpretation of the indicator

When assessing the indicator, one must keep in mind that it is affected by both the development of the NPP 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 refueling outage. In the following year, the indicator value decreased, partly as a result of a more detailed analysis of these factors.

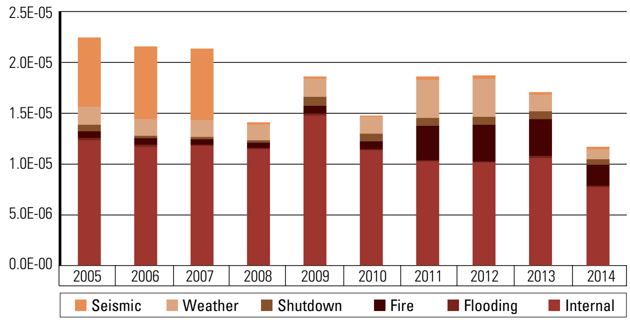
Loviisa NPP's accident risk has continued to decrease over the last ten years, and new risk factors, discovered as the scope of the PRA has been extended, have been efficiently removed. The indicator decreased in 2007 due to the new service water line completed during the period. The new line allows for the alternative intake of seawater from the outlet channel to cool the NPP when it is at a shutdown. The change decreases the risks in situations where algae, frazil ice or an oil spill endangers the availability of seawater via the conventional route. The decrease of the indicator in 2008 and in the following years result from more detailed assessments performed in conjunction with the renewal of the operating license, as well as changes at the NPP planned to be carried out earlier or in connection with the license renewal. Such changes include a decrease in the probability of a criticality accident using, for example, boron analysers, modernisation of a refueling machine and a decrease in the probability of an external leak.

In 2014, a little over half (54%) of the core damage frequency originated from power operation: 1.2

Fluctuation of the calculated annual core damage frequency for Loviisa plant units during 2005–2014



Fluctuation of the calculated annual core damage frequency for Olkiluoto plant units during 2005–2014



$\times 10^{-5}$/a. Fires during power operation comprise one quarter, weather phenomena around one sixth, internal initiating events around 5%, floods 2% and seismic events 0.4% of the total risk. Less than half (42%) of the core damage frequency originates from cold shutdowns. One third of the risk assessments for standard cold operating modes are caused by oil spills and one quarter by drops of heavy loads. Primary leaks caused by human error are also among the most significant risks. The risk assessment for standard cold annual maintenance outage operating modes is 9.7×10^{-6}.

The PRA model for the Loviisa NPP used to describe the plant unit Loviisa 1. In 2014, Fortum completed a separate PRA model for Loviisa 2. The key differences between the plant units involve loss of ventilation in the instrumentation facilities and fires. The instrumentation facility ventilation system of LO2 is inferior to that of LO1, and the spreading of fires via fire doors is more unlikely at LO1 than at LO2.

The indicator for Olkiluoto NPP 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 NPP to improve seismic qualification. The increase in 2009 was due to the fact that a heat exchanger in the screening system could not be used for residual heat removal after all, contrary to earlier assessments. The decrease of the risk in 2010 was due to changes in the modelling of DC systems 672 and 679 (inclusion of battery diversity), while the increase in 2011 resulted from reassessment of fire frequencies. At Olkiluoto NPP, 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).

TVO has introduced separate risk models for Olkiluoto 1 and Olkiluoto 2. The annual probability of a severe reactor accident calculated for Olkiluoto 1 at the end of 2014 was 0.84×10^{-5} and for Olkiluoto 2 1.41×10^{-5}. The key reason behind the decreased core damage frequency at Olkiluoto 1 from the level of 2013 was a change made in the auxiliary feedwater system that reduced the system's dependence on seawater cooling. A similar change has 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 indicator is used to follow the effectiveness of fire protection at the NPPs.

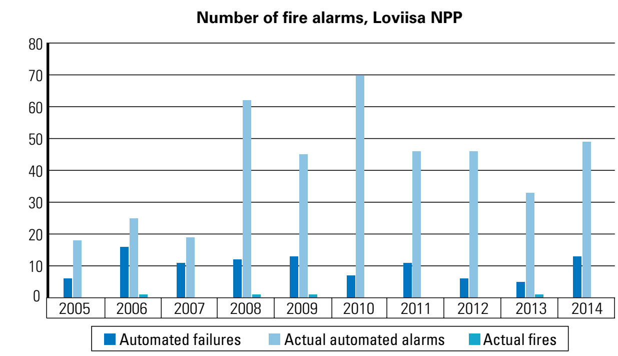
Responsible unit/person

Civil engineering and fire protection (RAK)
Pekka Välikangas

Interpretation of the indicator

No events classified as fires occurred at Loviisa NPP (LO1/LO2) or outside the plant area in 2014. The number of fire detection system faults and the number of actual alarms made by fire detectors at Loviisa NPP have remained stable for the past ten years. Alarms from the fire detection systems have also remained at a relatively low level. Most of the alarms were caused by dust, smoke or humidity.

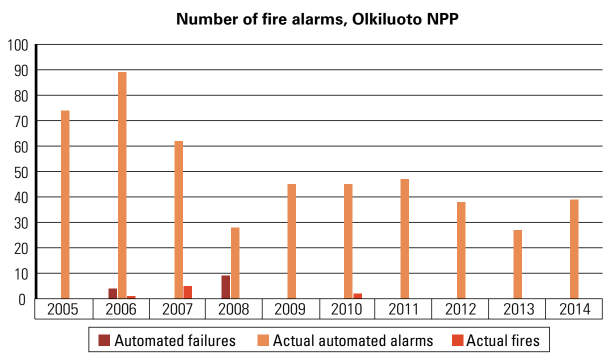
No events classified as fires occurred at Olkiluoto NPP (OL1/OL2) in 2014. One event classified as a fire occurred outside the plant area: an electric heater got overheated to an extent that its painted surface started to smoke at the OL3 construction



site. The employees detached the heater from the power grid and called the TVO fire brigade. The fire petered out by itself at this point, and no extinguishing measures were necessary. The fire brigade ventilated the premises. No fire detection system faults were observed at Olkiluoto NPP (OL1/OL2) in 2014. No faults were observed during the five past years, either. There were slightly more correct fire detection system alarms in 2014 than in 2013. The number of alarms has decreased over the past ten years, however.

The fire detection system of Loviisa NPP was renovated in 2000 and the fire detection system of Olkiluoto NPP in 2001. After the renovation of the fire alarm systems, the number of alarms increased at both NPPs due to more sensitive detectors. Advance alarms issued by the fire detection system are no longer included in these statistics.

Fire safety at Loviisa and Olkiluoto remained at around the same level as before. There have been four events classified as fires in the Loviisa plant area in the past ten years. The trend for Olkiluoto is slightly decreasing: the last event classified as a fire occurred four years ago.Fire detection systems are not always disconnected in a wide enough area during maintenance work. The number of alarms from the fire detection system is also affected by the amount of maintenance and repair work performed at the NPPs.



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, as well as the number of leaking fuel assemblies removed from the reactor, is also followed as an indicator.

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.

Responsible unit/person

Reactor and Safety Systems (REA),
Dina Solatie

A.III.1a Reactor coolant system activity

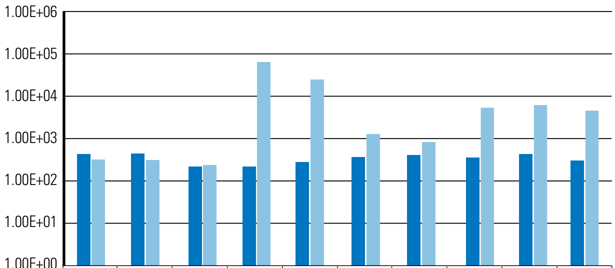
Interpretation of indicators (Loviisa)

There were no leaking fuel assemblies in the reactor of Loviisa 1 in 2014. 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 activity values associated with shutdowns also returned to the level before the leaks. The actual reason for the fuel leak in Loviisa 2 is still unknown, as examination of the damaged fuel assemblies has not been possible due to problems with the pool inspection equipment. All in all, the fuel integrity at both Loviisa plant units was good in 2014.

Interpretation of indicators (Olkiluoto)

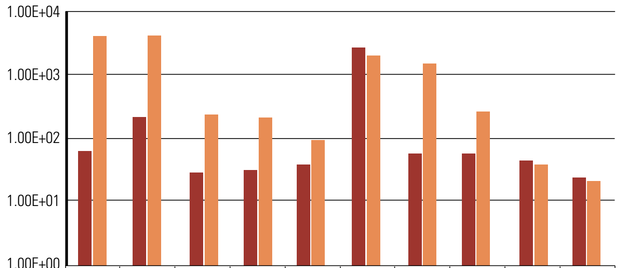
There were no leaking fuel assemblies in the reactor of Olkiluoto 1 in 2014. Thus, the primary coolant activity caused by iodine-131 at Olkiluoto 1 has continued to decrease since 2010. On the basis of other inspections carried out during the annual outage, the fuel types at both plant units have mostly behaved normally. Several fuel leaks have occurred in the 2000s at Olkiluoto 2. Most of the 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.

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



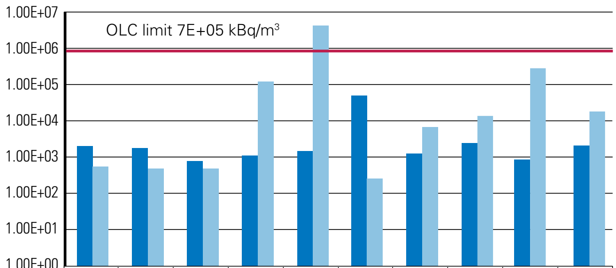
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	3.89E+02	3.91E+02	1.90E+02	2.00E+02	2.60E+02	3.80+02	3.90E+02	3.70E+02	4.00E+02	3.50E+02
LO2	2.91E+02	2.72E+02	2.10E+02	4.90E+04	2.40E+04	1.20+03	8.50E+02	4.71E+03	5.40E+03	4.60E+03

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



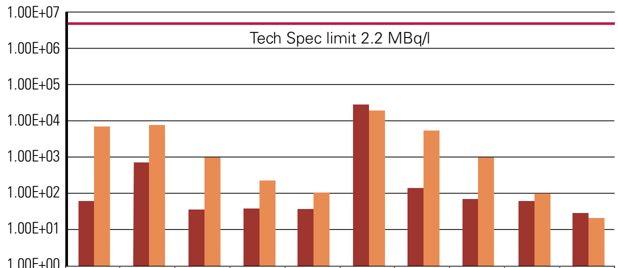
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	5.80E+01	2.00E+02	2.70E+01	3.00E+01	3.50E+01	2.45E+03	5.50E+01	5.58E+01	3.92E+01	2.55E+01
OL2	4.00E+03	4.00E+03	2.30E+02	2.10E+02	9.10E+01	1.87E+03	1.46E+03	3.03E+02	3.43E+01	2.13E+01

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



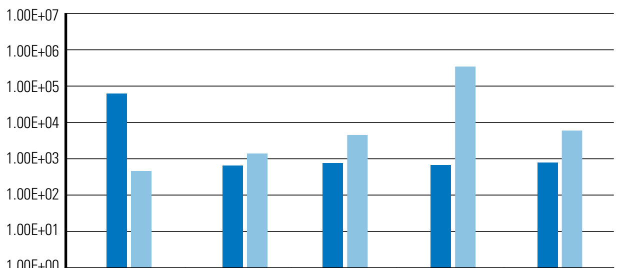
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	2.20E+03	1.90E+03	8.10E+02	1.20E+03	1.54E+03	4.97E+04	1.49E+03	2.80E+03	8.50E+02	2.43E+03
LO2	5.90E+02	5.20E+02	5.00E+02	1.30E+05	3.85E+06	3.20E+03	6.64E+03	1.27E+04	3.41E+05	1.58E+04

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



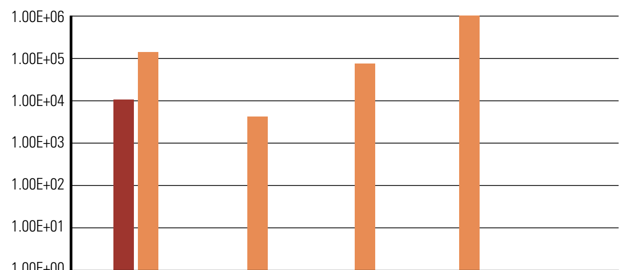
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	5.90E+01	6.90E+02	3.50E+01	3.70E+01	3.60E+01	3.12E+04	1.40E+02	6.76E+01	5.90E+01	3.16E+01
OL2	6.52E+03	7.03E+03	9.99E+02	2.30E+02	1.00E+02	2.01E+04	4.84E+03	9.45E+02	9.51E+01	2.53E+01

Fuel integrity:
Iodine (I-131) maximum activity concentration of primary coolant (kBq/m³) related to shutdowns, Loviisa NPP



	2010	2011	2012	2013	2014
LO1	5.60E+04	6.70E+02	7.06E+02	6.30E+02	7.60E+02
LO2	4.10E+02	1.40E+03	4.10E+03	3.41E+05	5.00E+03

Fuel integrity:
Iodine (I-131) maximum activity concentration of primary coolant (kBq/m³) related to shutdowns, Olkiluoto NPP

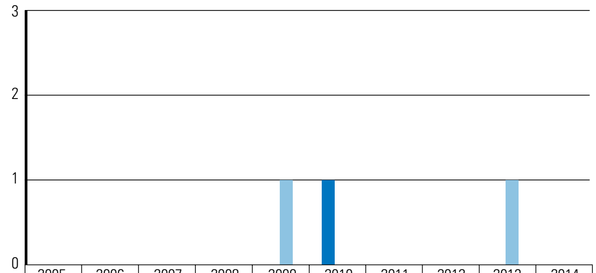


	2010	2011	2012	2013	2014
OL1	1.03E+04	0.00E+00	0.00E+00	0.00E+00	0.00E+00
OL2	1.61E+05	3.93E+03	6.19E+04	1.00E+06	0.00E+00

A.III.1b Number of leaking fuel assemblies

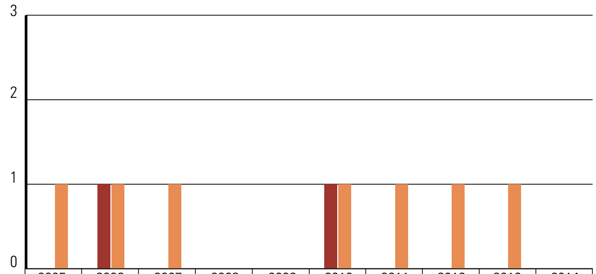
All leaking fuel assemblies are removed during annual outages. Both licensees use an external party when identifying leaking assemblies. This means that a subcontractor handles the actual equipment and provides the operators, but the NPP's own radiochemistry laboratory analyses the water samples from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

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



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	0	0	0	0	0	1	0	0	0	0
LO2	0	0	0	0	1	0	0	0	1	0

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



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	0	1	0	0	0	1	0	0	0	0
OL2	1	1	1	0	0	1	1	1	1	0

Interpretation of indicators (Loviisa)

There was no leaking fuel in the reactors of Loviisa 1 or Loviisa 2 during the period under review.

Interpretation of indicators (Olkiluoto)

There was no leaking fuel in the reactors of Olkiluoto 1 and Olkiluoto 2 during the period under review.

A.III.2 Reactor coolant system integrity

A.III.2a Water chemistry conditions

Definition

As indicators, the water chemistry conditions for each plant unit are followed.

The water chemistry indicators are:

- Chemistry performance indices used by the licensees, depicting the effectiveness of water chemistry control in the secondary circuits of PWRs and in the reactor circuits of BWRs. The chemical conditions in the secondary circuit of a pressurized water reactor affect the integrity of the interface between the reactor coolant system and the secondary circuit. The indicator for Loviisa is a new index developed at the NPP to be used together with the international index. The new index describes the water chemistry conditions in the secondary circuit at Loviisa with a higher degree of sensitivity than the corresponding international index for VVER plants. The indicator for Olkiluoto is the international index used by the NPP. The Loviisa index observes corrosive factors and the concentrations of corrosion products in the steam generator blowdown and the feedwater. For steam generator blowdown, the calculation includes the chloride, sulphate and sodium concentrations and acid conductivity. For feedwater, it includes the iron, copper and oxygen concentrations. The chemistry index of Olkiluoto consists of the chloride and sulphate concentrations of the reactor water and the iron concentration in the feedwater. The indices for both NPPs only cover the aforementioned parameter values during load operation.
- The maximum chloride concentration of the steam generator blowdown at the Loviisa plant units and the reactor water at the Olkiluoto plant units during operation compared with the OLC limit in the monitoring period. At Olkiluoto, the maximum sulphate content of reactor water during steady-state operation is also followed.
- Corrosion products released from the surfaces of the reactor coolant system and the secondary circuit into the coolant. For Loviisa NPP, the iron concentration of the reactor coolant and the secondary circuit feedwater (maximum values for the monitoring period) are followed. For Olkiluoto NPP, the iron concentration of feedwater (maximum value for the monitoring period) is followed. In addition, the maximum Co-60 activity concentration in the reactor coolant while bringing the plant to a cold shutdown or after a reactor trip is followed for both NPPs.

Source of data

The licensees submit indicators describing water chemistry control to the respective responsible person at STUK. The approximate concentration levels of corrosive substances and corrosion products can also be obtained from quarterly reports submitted by the licensees.

Purpose

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 water chemistry control and by following selected corrosive impurities and corrosion products. The water chemistry indices combine a number of water chemistry parameters and thus give a good overview of the water chemistry conditions. STUK's indicators are also used to monitor the fluctuation of certain parameters in more detail. The corrosive substances monitored include chloride and sulphate. The corrosive products followed are iron and radioactive Co-60. The activity concentration of Co-60 isotope while bringing the NPP to cold shutdown is used to describe the access of cobalt-containing structural materials into the reactor circuit and the success of the water chemistry control and the shutdown procedures. In addition to the parameters described here, the licensees use several other parameters to monitor the water chemistry conditions of the plant units.

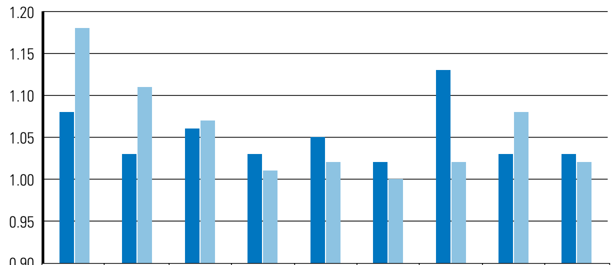
Responsible units/persons

Reactor and safety systems (REA),
Dina Solatie

Interpretation of indicators (Loviisa)

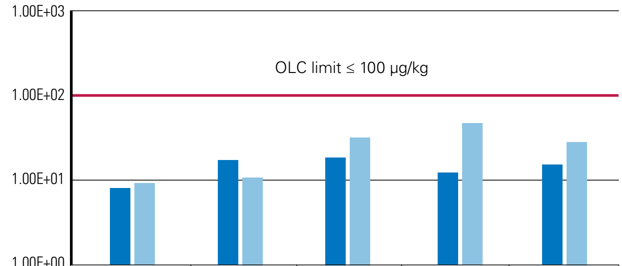
In 2014, the impurity and corrosion product levels in the reactor coolant system and the secondary circuit, followed in STUK's indicator scheme, were

Integrity of the secondary circuit: Chemistry index, Loviisa NPP



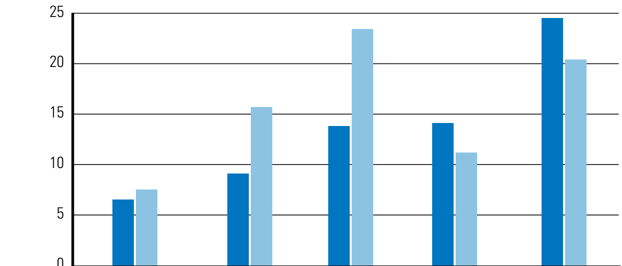
	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	1.08	1.03	1.06	1.03	1.05	1.02	1.13	1.03	1.03
LO2	1.18	1.11	1.07	1.01	1.02	1.00	1.02	1.08	1.02

Integrity of primary circuit: Corrosive impurities; Maximum chloride concentration of a steam generator blow-down (µg/kg) in power operation, Loviisa NPP



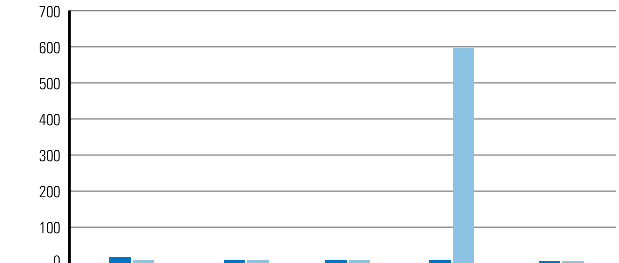
	2010	2011	2012	2013	2014
LO1	7.80E+00	1.93E+01	1.98E+01	1.36E+01	1.81E+01
LO2	9.10E+00	1.10E+01	3.19E+01	4.30E+01	3.00E+01

Integrity of primary circuit: Corrosion products; Maximum iron concentration in primary coolant (Fe-tot µg/l) in power operation, Loviisa NPP



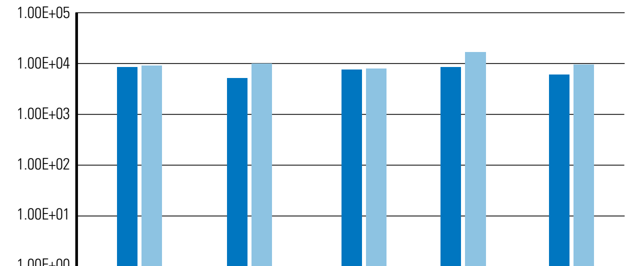
	2010	2011	2012	2013	2014
LO1	6.5	9.1	13.8	14.1	24.5
LO2	7.5	15.7	23.4	11.2	20.4

Integrity of primary circuit: Corrosion products; Maximum iron concentration in the feed water (µg/l) (RL30 / RL70) in power operation, Loviisa NPP



	2010	2011	2012	2013	2014
LO1	17.0	8.1	8.4	7.4	6.7
LO2	8.7	8.4	7.7	596.0	6.6

Integrity of primary circuit: Maximum cobalt-60 activity concentration (kBq/m³) in primary coolant related to shutdowns, Loviisa NPP



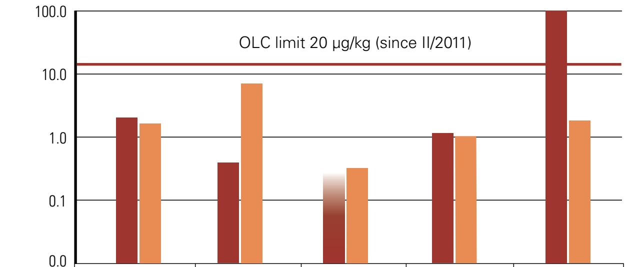
	2010	2011	2012	2013	2014
LO1	8.21E+03	5.26E+03	7.48E+03	8.10E+03	5.40E+03
LO2	8.60E+03	9.88E+03	7.90E+03	1.40E+04	9.10E+03

in keeping with the OLC limits. In the past few years, the chemistry index has remained at a good level at the Loviisa plant units. The Loviisa 1 index for 2014 was lower than in 2013 because of improved startup procedures introduced during the 2013 annual outage and more specific adherence to related procedures that aim to optimise the chemical parameters. The blowdown water chloride content and iron content of the secondary circuit feedwater were normal in 2014. The figures show that the most clearly discernible change from previous years is the high iron concentration in the secondary side feedwater at Loviisa 2. This was a brief transient (one measuring result) and thus it does not have a major impact on the corrosion behaviour of the steam generator pipes in the long term or the integrity of the reactor coolant system. The iron concentration in the secondary side feedwater returned to normal in 2014. The maximum Co-60 activity levels associated with shutdowns were measured during shutdowns for annual outages. In 2014, the concentrations were around the same as in the previous years, which indicates successful compliance with the ALARA principle. The indicator shows that the integrity of the reactor coolant systems of the Loviisa plant units was acceptable in 2014.

Interpretation of indicators (Olkiluoto)

The impurity and corrosion product levels in reactor water and feedwater, followed in STUK's indicator scheme, remained below the OLC limits at Olkiluoto 2. At Olkiluoto 1, the chloride content was momentarily high due to a condenser circulating water leak in April, and the OLC limit value was exceeded. The leak was located and repaired. In 2014, the chemistry index for Olkiluoto 2 was the best possible: 1. The chemistry index for Olkiluoto 1 was higher due to the condenser circulating water leak. In 2014 the iron, sulphate and chloride concentrations of reactor coolant did not deviate from their regular values, which is also shown by the achieved chemistry index value. The monitor-

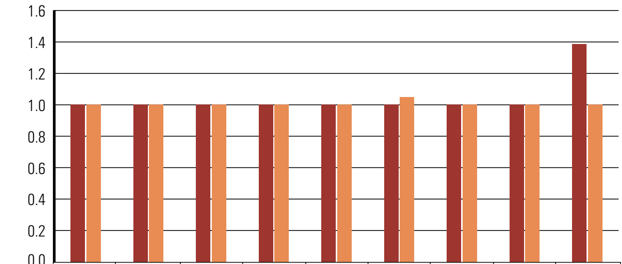
Integrity of primary circuit: Corrosive impurities; Maximum chloride concentration in primary coolant (µg/kg) in power operation. Olkiluoto NPP



	2010	2011	2012	2013	2014
OL1	3.0	0.7	0.5	1.1	102.0
OL2	2.1	7.8	0.6	1.0	2.5

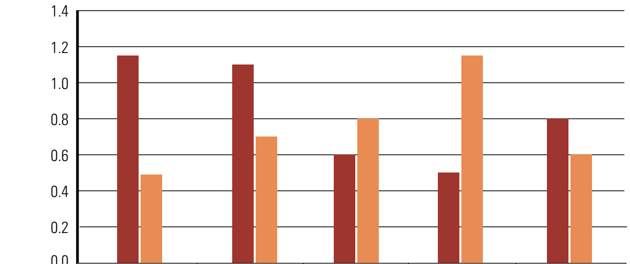
below detection limit

Integrity of primary circuit: Chemistry index, Olkiluoto NPP



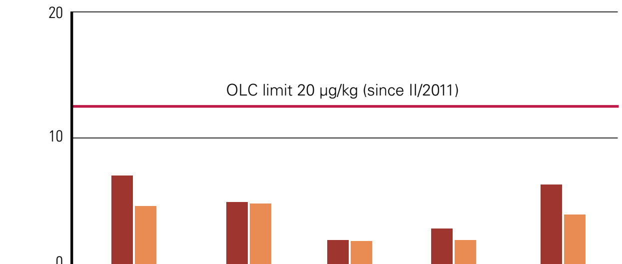
	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.39
OL2	1.00	1.00	1.00	1.00	1.00	1.05	1.00	1.00	1.00

Integrity of primary circuit: Corrosion products; Maximum iron concentration in reactor feed water (µg/l) in power operation, Olkiluoto NPP



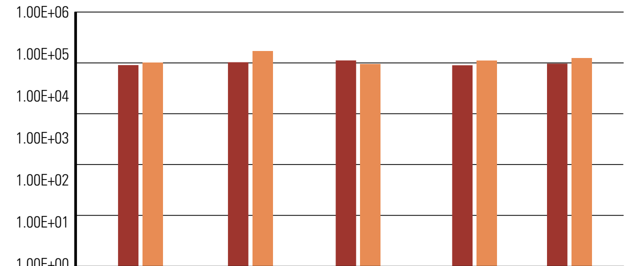
	2010	2011	2012	2013	2014
OL1	1.15	1.10	0.60	0.50	0.80
OL2	0.49	0.70	0.80	1.15	0.60

Integrity of primary circuit: Corrosion products; Maximum sulphate concentration in primary coolant (µg/l) in power operation, Olkiluoto NPP



	2010	2011	2012	2013	2014
OL1	7.0	4.9	1.9	2.8	6.3
OL2	4.6	4.8	1.8	1.9	3.9

Integrity of primary circuit: Corrosion products; Maximum cobalt-60 activity concentration (kBq/m³) in primary coolant related to shutdowns, Olkiluoto NPP



	2010	2011	2012	2013	2014
OL1	8.59E+04	1.10E+05	1.19E+05	8.65E+04	9.91E+04
OL2	1.01E+05	2.66E+05	9.05E+04	1.19E+05	1.34E+05

ing and optimisation of Olkiluoto 2 water chemistry was also successful in 2014. At both plant units, the shutdown-related maximum value of Co-60 activity content occurred during shutdowns for annual outages. There were no essential changes in the Co-60 activity content compared to previous years, which indicates successful compliance with the ALARA principle. The indicator shows that reactor coolant system integrity was good at the Olkiluoto plant units in 2014.

A.III.2b Reactor coolant system leakages (Olkiluoto)

Definition

The indicators below are used to follow identified and unidentified reactor coolant system leakages at the Olkiluoto plant units:

- Total volume (m³) of identified (from containment to collection tank 352 T1 of the controlled leakage drain system) and unidentified (total volume of leakages into the sump of the controlled floor drainage system, 345 T33) internal leakages in the containment during the fuel cycle.
- Highest daily internal leakage volume in the containment during the fuel cycle in relation to the leakage volume allowed in the OLC (outflow water volume of water condensing in the air coolers of the containment cooling system 725/ OLC limit).

Source of data

The licensee submits data on reactor coolant system leakages at Olkiluoto NPP to the person responsible at STUK.

Purpose

The indicator describing reactor coolant system leakages is used to follow and monitor the leak rate of the reactor coolant system within the containment.

Responsible units/persons

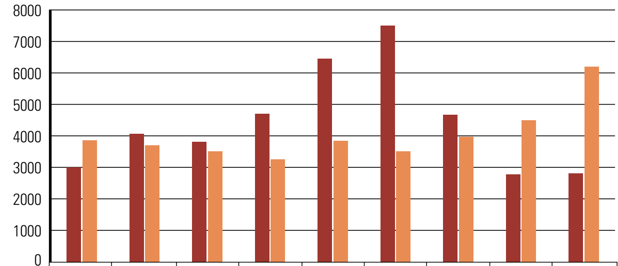
Operational safety (KÄY), Jukka Kallionpää

Interpretation of the indicator, fuel cycle 2013–2014

One of the purposes of controlled leakage K352 is to collect leakages from valves, pumps and other similar components. The drains from the seal boxes of the valves within the containment are equipped with temperature sensors to locate any leaks. Temperature sensors installed in the drains above the main lines will detect any leakage in the line. Other methods must then be used to locate the actual leaking object. Identified leaks within the containment increased to some extent at OL1 in 2009, 2010 and 2011. They decreased in 2012, continued to decrease in 2013 and remained at the 2013 level in 2014. The number of identified leaks at OL2 somewhat increased in 2014. The leakage volumes do not include the drainage of process systems during annual outages and other outages. The identified leaks include sampling flows of approximately 100–1,500 m³ from the reactor building.

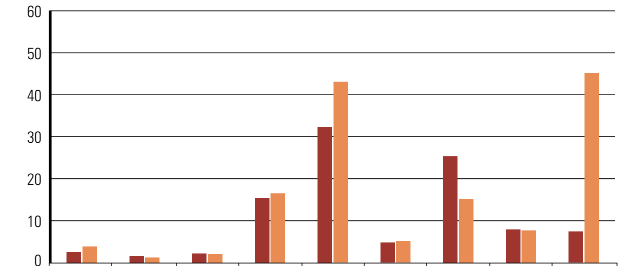
At the lowest point of the containment drywell, there is the drain water pit T33, which collects the drain water from the containment drywell floor

Identified leakages of primary circuit (352T1, m³), Olkiluoto NPP



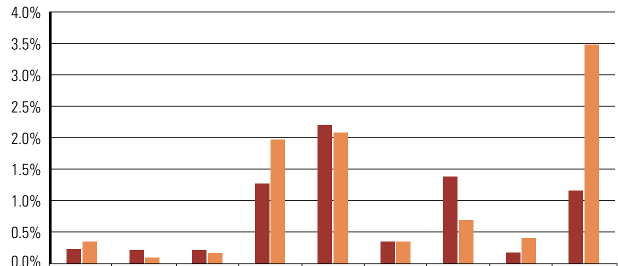
	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	3004	4058	3805	4697	6448	7496	4664	2773	2810
OL2	3862	3696	3502	3252	3847	3506	3973	4489	6195

Unidentified leakages of primary circuit (345T33, m³), Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	2.52	1.56	2.16	15.48	32.28	4.74	25.30	7.90	7.38
OL2	3.84	1.26	2.04	16.5	43.08	5.10	15.2	7.70	45.12

The maximum unidentified leakage in ratio to the OLC limit, Olkiluoto NPP



	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	0.23	0.21	0.21	1.27	2.20	0.35	1.38	0.17	1.16
OL2	0.35	0.09	0.16	1.97	2.08	0.35	0.69	0.40	3.48

drains and any leakage from the control rod actuator seals. The volumes of unidentified reactor coolant system leaks during the operating cycle 2010–2011 decreased at both plant units. In 2012, they increased slightly from the 2011 level at both plant units, only to fall back to the previous level in 2013. Unidentified leaks at OL1 remained at the 2013 level in 2014, but unidentified leaks at OL2 increased to the level of 2010.

One of the purposes of containment gas cooling system 725 is to remove moisture from the containment atmosphere. Moisture may originate from steam leaking from the reactor coolant system. During the fuel cycle of 2013–2014, the ratio of the containment's largest internal daily leak volume to the maximum allowable volume, as specified in the OLC, was low at both plant units.

The reactor coolant system was relatively leakproof during the 2013–2014 fuel cycle.

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' leaktightness 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, since 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

This indicator is used to monitor the integrity of containment isolation valves, penetrations and airlocks.

Responsible unit/person

Reactor and safety systems (REA),
Päivi Salo

Interpretation of the indicator

Loviisa

Total leakage of the outer isolation valves at Loviisa 1 compared to the maximum allowed total leakage remained unchanged. The total leakage at Loviisa 2 has clearly decreased. The as-found leakage of both units remains clearly below the set limit.

The percentage of isolation valves that passed the leaktightness test at first attempt has increased at both Loviisa 1 and Loviisa 2.

Overall as-found leakage rate of containment penetrations and airlocks is low at both plant units.

Olkiluoto

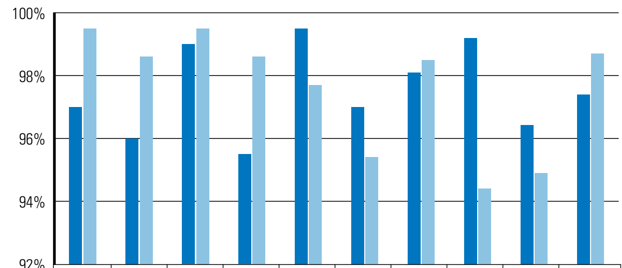
The total as-found leakages of outer isolation valves at Olkiluoto 1 have increased but are still low and remain clearly below the below the limit set for overall as-found leakage in the OLC.

The overall as-found leakage of the outer isolation valves at Olkiluoto 2 decreased from the previous year, and was below the limit set in the OLC.

The percentage of isolation valves that passed the leak test at first attempt remained high for both plant units.

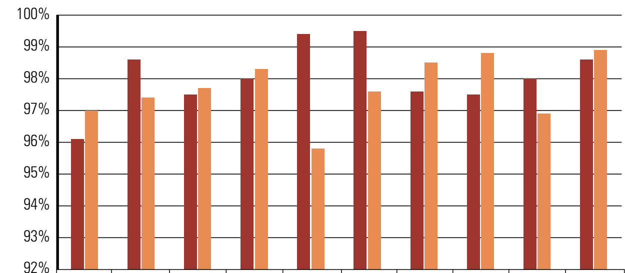
The total as-found leakage rate of containment penetrations, in which TVO includes leakages in the upper and lower personnel airlocks, the maintenance dome and the containment dome, remained small for both plant units.

Isolation valves passing the leakage test at the first attempt, Olkiluoto NPP



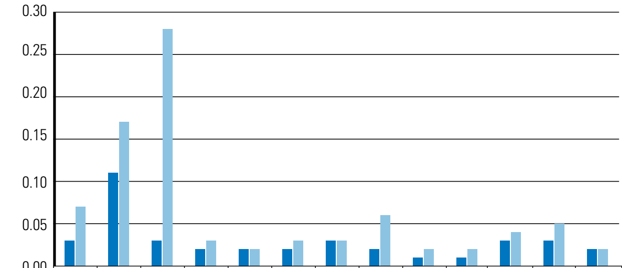
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	97.0	96.0	99.0	95.5	99.5	97.0	98.1	99.2	96.4	97.4
LO2	99.5	98.6	99.5	98.6	97.7	95.4	98.5	94.4	94.9	98.7

Isolation valves passing the leakage test at the first attempt, Olkiluoto NPP



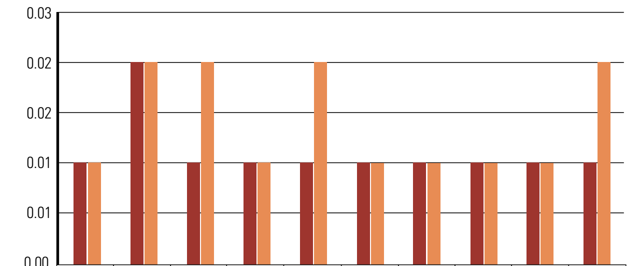
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	96.1	98.6	97.5	98,0	99.4	99.5	97.6	97.5	98.0	98.6
OL2	97.0	97.4	97.7	98.0	95.8	97.6	98.5	98.8	96.9	98.9

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



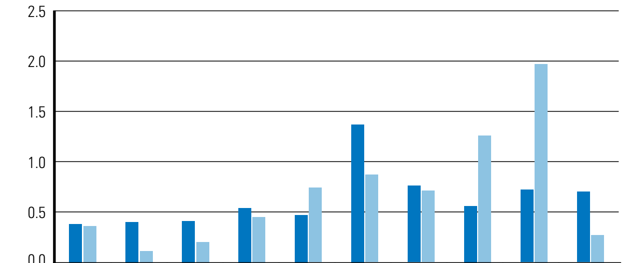
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	0.03	0.11	0.03	0.02	0.02	0.02	0.03	0.02	0.01	0.01	0.03	0.03	0.02
LO2	0.07	0.17	0.28	0.03	0.02	0.03	0.03	0.06	0.02	0.02	0.04	0.05	0.02

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



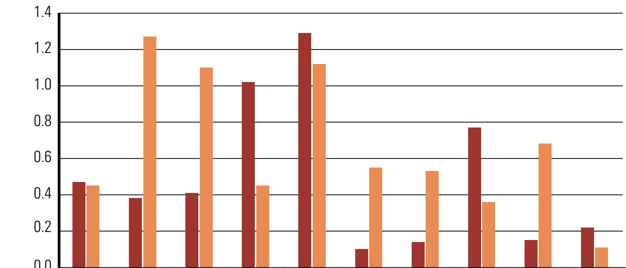
	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
OL2	0.03	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.01	0.02

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



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
LO1	0.38	0.40	0.41	0.54	0.47	1.37	0.76	0.56	0.72	0.70
LO2	0.36	0.11	0.20	0.45	0.74	0.87	0.71	1.26	1.97	0.27

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



	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
OL1	0.47	0.38	0.41	1.02	1.29	0.10	0.14	0.77	0.15	0.22
OL2	0.45	1.27	1.10	0.45	1.12	0.55	0.53	0.36	0.68	0.11

APPENDIX 2 Occupational radiation dose distribution at Loviisa and Olkiluoto nuclear power plants in 2014

According to the Radiation Decree, the annual effective dose from radiation work for a worker must not exceed 50 mSv while the average over any period of five years must remain below 20 mSv.

The highest individual dose incurred at Finnish nuclear power plants was 9,2 mSv. This dose was accumulated from work at the Loviisa nuclear power plant. The highest individual dose for a Finnish nuclear power plant worker in the five-year period from 2010–2014 oli 47,2 mSv. The dose was accumulated at the Loviisa nuclear power plant.

dose range (mSv)	number of persons by dose		
	Loviisa	Olkiluoto	total*
< 0,1	923	1364	2240
0.1–0.19	66	193	260
0.2–0.49	121	249	361
0.5–0.99	120	181	293
1.00–1.99	106	126	227
2.00–4.99	110	70	191
5.00–9.99	33	3	44
10.00–14.99	0	0	0
15.00–19.99	0	0	0
> 20	0	0	0

* The data in this column include Finnish workers who have received doses also at Swedish nuclear power plants. The same person may have worked at both Finnish nuclear power plants and in Sweden.

Source: STUK's dose register

APPENDIX 3 Exceptional operational events at nuclear power plants in 2014

Loviisa NPP

Relay faults in emergency diesel generators of Loviisa NPP

In December 2013, malfunctions of the control circuit relays of the emergency diesel generators were detected. The malfunctions were caused by deviations of relay quality. The relays that were causing problems were replaced by Loviisa NPP. When the relays had been replaced, it was observed that the new relays included programmable technology, which meant that the official approval for the relay types was no longer valid. The relay quality deviations caused unavailability of the emergency diesel generator control systems and the fact that unqualified programmable relays were used increased the risk of a common-cause failure caused by a software fault.

Both Loviisa plant units have four emergency diesel generators that start when necessary to supply power to the safety systems. The diesel generators are equipped with dedicated control, protection and monitoring systems that include, for instance, plenty of relays (electrically controlled electromechanical switches) of different types. Operability of the diesel generators is verified by means of inservice testing every four weeks. In addition to the emergency diesel generators, the NPP includes other emergency power sources to maintain the safety functions in case of the loss of the regular electric power supply.

The malfunctions of the relays in the diesel generator control circuits, which were observed during normal inservice testing of Loviisa NPP in December 2013, mostly caused jamming of the relays or slowness or relay functions. It was noted that the cause of the malfunctions was a mechanical manufacturing defect (a tolerance defect) of the relay types used. The relay manufacturer stated that such a quality deviation had only occurred in specific production batches. As a corrective measure, Loviisa NPP made a decision to replace all of the relays that were causing problems, which had been installed in 2011 and 2012 (15 relays per diesel generator or a total of around 120 relays). When the relays of one of the diesel generators at Loviisa 1 and one of the diesel generators at Loviisa 2 had been replaced, the replacement work was discontinued in January 2014 because the relay manufacturer announced that the new relays could also cause problems. At the turn of January and February, the relay manufacturer submitted new flawless relays to the NPP. They were installed in all of the diesel generators.

In late February, the relay manufacturer announced that relays of the types that had been installed in the diesel generators include programmable technology. The programmable technology is used to control the coil. Since it was not known that the relays include programmable technology when applicability and acceptability of the relay types were being assessed in 2011, the official approval (qualification) for the relay types was no longer valid. In early March, Fortum submitted a suitability analysis of a substitutive analog relay type (that does not include any programmable technology) and a plan of corrective measures to STUK for approval. Half of the programmable relays in both units of Loviisa NPP were replaced with the approved analog relay type by the end of March. The rest of the relays will be replaced at the latest during the annual outages in 2014. Similar relays (24 pcs) in the motor control circuits of the reactor coolant pumps will also be replaced during the annual outages, but the safety significance of these relays is not as high.

The relay quality deviations caused malfunctions in the diesel generator control circuits and thus led to unavailability of the diesel generators. The fact that unqualified programmable technology was used in the relays increased the risk of a common-cause failure in case of a software fault, which cannot be overruled. Such an event could have made the emergency power supply systems unavailable and thus compromised plant safety in case of a transient or accident.

The relay quality deviations mostly caused the control systems to function more slowly than normal. Furthermore, there were some temporary malfunctions. No errors have been detected in the software components of the programmable relay types that are currently in use in the control systems. The substitutive emergency power sources that are to be used instead of the emergency diesel generators at Loviisa NPP do not include any of the problematic relay types.

One can state that the root cause of the relay quality deviations was the lack of operating experience feedback from the malfunctioning relays. In addition, the procedures used by the NPP to identify relays that contain programmable technology have been proven defective.

In addition to replacing the relays, Fortum will update its guidelines on management of component ageing and the drafting of electrical/I&C suitability analyses.

Fortum has submitted information about the relay problems to Olkiluoto NPP and the Swedish NPPs.

On the International Nuclear Event Scale (INES), the event was rated as Level 1 due to the risk of a common-cause failure.

Out of date operational limits and conditions of Loviisa 2 with respect to thermal load of the spent fuel storage pool

In March 2014, it was observed that the operational limits and conditions (OLC) of Loviisa NPP are not up to date in all respects. The pool-specific maximum thermal load value for the spent fuel storage facility had not been updated when modifications were implemented in the 1990s and denser fuel racks were introduced in the early 2000s.

When the fact that the OLC had not been updated was observed, Loviisa NPP studied again the pool-specific thermal loads in the spent fuel storage facility and noticed that the thermal load of one of the storage pools at Loviisa 2 had exceeded the maximum thermal load limit laid down in the OLC by approximately 1% in December 2013. The thermal load remained above the limit for approximately two weeks. Spent fuel had recently been transferred to the storage pool from the refueling pool in the reactor building of Loviisa 2, and the new fuel introduced into the pool increased the thermal load. The exceeding of the limit value was not detected when transferring the fuel because a new limit value that had been determined after the modification was being followed. The new pool-specific thermal load limit value was approximately 20% higher than the limit value laid down in the OLC.

The event did not compromise the cooldown or integrity of spent nuclear fuel because the limit value was only exceeded by a small amount and for a short time. Furthermore, according to Loviisa NPP the new pool-specific maximum thermal load is higher than the old value that was not changed in the OLC.

The operational limits and conditions lay down prerequisites and limit values for safe operation of the NPP. The OLC must be kept up to date and followed at all times. Other information that is not up to date in the OLC has also been detected over the past few years at Loviisa NPP. Corrective measures to improve OLC maintenance procedures and keeping the OLC up to date have been determined. In addition, Loviisa NPP will update the OLC with the new pool-specific maximum thermal load.

On the INES scale, the event is rated at Level 0.

Non-compliance with the operational limits and conditions at Loviisa 1

The annual outage of Loviisa 1 started on 20 July 2014. During the shutdown of the unit on 21 July 2014, leak tests of the isolation valves of the fuel pool cooling system were performed. When the tests were still ongoing, the unit's operating mode was changed from hot shutdown to cold shutdown. Because the operating mode was changed, temperature and pressure of the reactor coolant system did not reach the set limits.

The operational limits and conditions state that both cooling circuits of the fuel pool cooling system must be operable when the operating mode is changed. One of the circuits was inoperable due to the isolation valve leak testing, however.

The unit is shut down in stages. The transfer to the next stage may not occur before it has been checked that all of the safety requirements for the next stage are met. In this case, one of the safety requirements was not met, i.e. the administrative procedures were not fully successful. The event did not compromise the cooldown of spent fuel, however, since the other cooling circuit was in operation. One circuit alone is capable of handling the cooling of the spent fuel pool. Furthermore, the unit reached the allowed state right after the change of operating mode: at that time, the operational limits and conditions require operability of one cooling circuit only.

Loviisa NPP determined corrective measures to prevent recurrence of the event. The corrective measures include further training on changing operating modes and reassessment of the related safety requirements.

On the INES scale, the event is rated at Level 0.

Brief malfunction of Loviisa 2 containment ventilation system during annual outage

The annual outage of Loviisa 2 was implemented from 16 August to 20 September 2014. Once the nuclear fuel had been replaced, the rest of the reactor pressure vessel internals were lifted back into place. During the lifting on 8 September 2014, control valves of the ventilation system of the containment, which surrounds the reactor pressure vessel, closed, which reduced the differential pressure between the interior of the containment and the outdoor air. The differential pressure no longer complied with the requirements laid down in the operational limits and conditions (OLC). The containment itself remained leak tight, however. According to the NPP, the valves closed because of maintenance work being carried out at a switchboard.

The containment must be kept leak tight and negative pressure ventilation must be maintained during heavy lifting because of the risk that the object being lifted drops on top of the spent nuclear fuel and damages it. A leak tight containment guarantees that any leaks from the containment will be minimal and negative pressure ventilation guarantees that any radioactive materials released into the air will not be able to leak in an uncontrolled manner from the containment due to minor faults in sealing. Integrity of the spent fuel was not compromised by the event, and thus there was no danger of a release of radioactive materials.

Loviisa NPP has determined corrective measures to prevent recurrence of the event. The corrective measures included assessing the scope of the containment monitoring system and related software as well as studying whether there is any need to further specify the duties of the people involved and job descriptions. All of the measures will be completed by the 2015 annual outage.

On the INES scale, the event is rated at Level 0.

Safety injection system valve erroneously closed at Loviisa 2

A modification of the reactor coolant system pressure control system was implemented during the 2014 annual outage of Loviisa 2 (16 August - 20 September 2014). When the modification was complete, the pressure control functions were tested and approved. However, an emergency cooling valve in a pressurizer spray line was accidentally closed after the testing. The valve is to be used after an accident. The valve is in a pipeline that was constructed in connection with the modification.

According to the operational limits and conditions (OLC), the valve must be left open. It having been erroneously closed was noticed during a normal inspection on 12 November 2014. The valve was opened immediately after this.

Since the valve was closed, one of the pressurizer spray lines, which should be used after an accident, was unavailable. The spraying system would have been operable regardless of this, however, since the other pipeline was normally available. The safety significance of the spraying function was decreased by the modifications made during the annual outage.

STUK rated the event as a Level 0 event on the International Nuclear Event Scale (INES), i.e. as an event that has no nuclear or radiation safety significance.

Some inservice inspections of Loviisa weather mast not performed

The four temperature sensors in the weather mast were not subjected to an inservice inspection in the manner laid down in the OLC in 2013. This was a deviation from the OLC because the OLC state that an inspection must be performed annually, and the maximum allowed excess of this inspection deadline is 30%. The weather mast temperature sensors had undergone a calibration inspection in September 2012 and they were inspected the next time in May 2014. The event was observed by STUK in November 2014 during an inspection included in the periodic inspection programme that covered operability of the weather mast.

Fortum submitted a special report of the event to STUK, describing the underlying reasons and corrective measures for the event. The calibration inspections of the temperature sensors were not implemented due to occupational safety reasons: first, the equipment needed when climbing the mast was not in order and later on climbing the mast was no longer possible because of the weather conditions. An exemption from the OLC was not applied because of a human error. The event was classified at INES Level 0.

Olkiluoto nuclear power plant

Repair outage of Olkiluoto 1

On Sunday 9 March 2014, a fault was observed in one of the reactor relief train control valves of Olkiluoto 1. To study the fault, the unit's power was decreased to 90% of full power for approximately one hour on 10 March 2014. TVO was able to locate the fault: it was in a position indication unit of the valve, which is inside the reactor containment. The unit was shut down to repair the fault. The unit's repair outage started on Saturday 15 March 2014 at 3:00 am. The work was performed according to plan. The position indication unit was replaced, operation of the valve was tested and approved, and startup of the unit was started. The unit was synchronized with the national grid by the following afternoon.

Simultaneous detaching of radiation measuring channels in the reactor building of Olkiluoto 2

On 7 April 2014, TVO observed at Olkiluoto 2 that a radiation measuring channel had been detached despite the requirements of the operational limits and conditions (OLC) in connection with calibration of the radiation measuring system. The calibration of the radiation measuring channel was erroneously started even though the parallel measuring channel had been detached a minute ago to be sent out for calibration. This was an OLC non-conformance because the OLC requires that at least one of these parallel measuring channels must be operable at all times. When the OLC non-conformance was detected, TVO restored operability of one of the measuring channels. The deviation lasted for three minutes.

The measuring channels of the radioactivity monitoring system monitor the general radiation level in the reactor building. No control commands to components are sent based on the measuring results; instead, the system issues a local alarm to warn people working in the hall of an abnormal radiation level. No work that could have increased the radiation level, such as fuel handling, was being carried out when the event occurred. The radiation measuring systems that monitor the exhaust air from the reactor building were operable.

The event caused no risk to the plant, people or the environment. On the International Nuclear Event Scale (INES), the event was rated as Level 0.

Crack in a feedwater nozzle 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 with the new inspection techniques. 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.

According to inspections made during the 2014 annual outage, the crack has not grown. TVO installed a leak detection system that is based on temperature in the area during the annual outage. TVO has already made preparations for repairing the crack. According to the submitted repair plan, the feedwater nozzle will be plugged from the reactor side and the feedwater piping will be cut at a pipe bend outside the biological shield before repairing the crack.

Cracks at pipeline mixing points

In an inspection implemented during the 2014 annual outage of Olkiluoto 2, several cracks were detected in feedwater line 1 and one crack in feedwater line 2. Several cracks at a similar mixing point were also observed during an inspection of feedwater line 2 at Olkiluoto 1. These pipeline mixing points were replaced in 1986.

The cracks are at points where pipelines connect and flows at different temperatures mix. The mixing flows cause continuous temperature fluctuation of the structural material when the unit is in hot standby or low power feedwater control mode. This means that the mixing point is subjected to fatigue. STUK made a decision that required amendment of the operating method and replacement of the cracked pipe sections during the 2015 annual outages.

Only the mixing point with fewer cracks may be used during operating modes that will stress the cracked mixing point (hot standby or low power feedwater control) at both units during the next fuel cycle. The mixing points with more cracks at both units (line 2 of Olkiluoto 1 and line 1 of Olkiluoto 2) must be replaced during the 2015 annual outages. A decision on whether the other T joints are to be replaced will be made annually based on the inspection results. STUK will oversee the planning of the replacement, manufacture and installation.

Using an unapproved hoisting device at the Olkiluoto spent fuel storage facility

A local STUK inspector observed on 13 August 2014 that a hoisting device that did not include the proper markings was being used to lift new protective covers of the fuel pools at the Olkiluoto interim storage facility for spent nuclear fuel. The inspector noted that the hoisting device had been safety classified but had not been subjected to a commissioning inspection by STUK. The hoisting device was decommissioned until a proper approval procedure has been completed.

Safety classified hoisting devices are governed by the Government Decree on Safety of Machines (VNA 400/2008), the Government Decree on the Safe Use and Inspection of Work Equipment (VNA 403/2008) and the YVL Guides. According to the Government Decree on the Safe Use and Inspection of Work Equipment, a hoisting device must include a marking showing the maximum allowed load and a CE marking as an indication of its compliance with personnel safety requirements. According to Guide YVL 5.8, a safety classified hoisting device must be subjected to a two-stage commissioning inspection by STUK.

TVO drafted a special report on the event, indicating defects in goods reception that occurred when the interim storage facility for spent nuclear fuel was expanded and defects in processing of the deviation. The event started when it was noted during a commissioning inspection by TVO that the dimensions of the first hoisting device to be used did not comply with the plan. The hoisting device was returned to the manufacturer. There was a material deviation in the manufacture of the new hoisting device and defects in processing this deviation led to the new hoisting device being manufactured, delivered and even taken into use incorrectly.

The hoisting device is part of the new protective cover system, and the entire system has been processed as a steel structure in compliance with Guide YVL 4.2. The construction plan was processed and approved in compliance with Guide YVL 4.2, which is why none of the involved parties (the client or the licensee TVO, the designing organisation, the manufacturer and STUK) identified the hoisting device at any point as a component that is also subject to the Government decrees mentioned above, the hoisting device design standard and Guide YVL 5.8. There are no references to legislation or norms on hoisting devices, nor any instructions on hoisting device markings in the design documentation. The special report by TVO does not mention this problem, even though it was the error that initiated the entire event. Had there been no dimension problems or material deviations, the original hoisting device could have been taken into use without the proper markings or the proper commissioning inspection.

By the end of the quarter, TVO had not submitted to STUK a plan on how the different regulatory requirements will be met, compliance will be proven and approval will be sought.

On the INES scale, the event is rated at Level 0.

Replacing carbon grounding brushes of the generator during power operation

After the annual outages of Olkiluoto NPP in May and June of 2014, it was observed that the main generator carbon grounding brushes were being worn through faster than normal. The worn out components of Olkiluoto 2 were replaced in the summer during an extra outage so that occupational safety and radiation protection issues could be taken into account.

The plan was to inspect the grounding brushes of Olkiluoto 1 on 30 September 2014 when the unit was in power operation. It had been observed in connection with an inspection that the carbon brushes could be simultaneously replaced. However, the shift supervisor of the unit (Olkiluoto 1) was not informed of the replacement of the carbon brushes and there was no work permit for the replacement of the brushes. The task took place in a room that has been classified in the OLC, based on the radiation level, as a room where work may not be performed without a radiation work permit but there was no such permit for the task.

The event did not influence the unit's nuclear security or nuclear safety but it was still classified as a Level 1 event on the International Nuclear Event Scale (INES) due to the fact that the OLC was not followed and the event indicated defects in the safety culture.

APPENDIX 4 Licenses and approvals in accordance with the Nuclear Energy Act by STUK in 2014

Teollisuuden Voima Oy

- 3/C42214/2014, 3 September 2014, import of nuclear fuel manufactured from uranium equipped with Euratom obligation code “S” from Germany (OL1 e 37). Last date of validity 31 December 2015.
- 4/C42214/2014, 12 September 2014, import of nuclear fuel manufactured from uranium equipped with Euratom obligation code “S” from Sweden (OL2 e 35, part of a batch). Last date of validity 31 December 2015.
- 5/C42214/2014, 12 September 2014, import of nuclear fuel manufactured from uranium equipped with Euratom obligation code “P” from Sweden (OL2 e 35, part of a batch). Last date of validity 31 December 2015.

Fortum Power and Heat Oy

- 1/Y42214/2014, 3 February 2014, possession and transfer of nuclear information concerning the Fennovoima NPP to Fennovoima Oy, Platom Oy and VTT Technical Research Centre of Finland. Last date of validity 31 December 2023.
- 3/A42214/2014, 26 September 2014, import from Sweden of radioactive waste generated when processing contaminated metal waste. Last date of validity 31 January 2015.

Fennovoima Oy

- 2/J42214/2014, 24 October 2014, import of nuclear information from JSC Rusatom Overseas from Russia and possession of said data. Last date of validity 31 December 2023.
- 3/J42214/2014, 24 October 2014, import of nuclear information from JSC TVEL or a legal person included in the same group of companies as JSC TVEL from Russia and possession of said data. Last date of validity 31 December 2023.
- 4/J42214/2014, 24 October 2014, possession and transfer of nuclear information submitted by JSC Rusatom Overseas to Platom Oy, Fortum Power and Heat Oy, VTT Technical Research Centre of Finland and ÅF-Consult Oy. Last date of validity 31 December 2023.
- 5/J42214/2014, 24 October 2014, possession and transfer of nuclear information submitted by JSC TVEL to Platom Oy, Fortum Power and Heat Oy, VTT Technical Research Centre of Finland and ÅF-Consult Oy. Last date of validity 31 December 2023.

Others

- 2/F42214/2014, 10 March 2014, VTT Technical Research Centre of Finland; possession and transfer of nuclear information submitted by JSC Rusatom Overseas to Fennovoima Oy, Fortum Power and Heat Oy and Platom Oy. Last date of validity 31 December 2023.
- 8/Y42214/2014, 27 June 2014, Aalto University; possession, processing, use and storage of a maximum of 5 g of nuclear fuel for a subcritical pile.
- 2/Y42214/2014, 3 July 2014, Platom Oy; possession and transfer of nuclear information concerning the Fennovoima NPP to Fennovoima Oy, Fortum Power and Heat Oy and VTT Technical Research Centre of Finland. Last date of validity 31 December 2023.
- 12/Y42214/2014, 19 December 2014, University of Jyväskylä Department of Physics; possession, processing, use and storage of nuclear materials. A maximum of 15 g of special fissionable materials and a maximum of 200 g of source materials.

APPENDIX 5 Periodic inspection programme of nuclear power plants 2014

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, operations, maintenance and protection activities (radiation protection, fire protection and security) with the requirements of nuclear safety regulations are verified by the inspections.

Periodic inspection programme 2014, Loviisa

Management, management system and personnel

A1 Management and safety culture (nuclear security), 8–9 October 2014

In the management and safety culture inspection, STUK studied how the security arrangements (both nuclear security and information security) and the safeguards of nuclear materials are linked to the Loviisa NPP management system and safety management. The inspection focused on how processes related to nuclear security and the safeguards of nuclear materials are described in the management system, how nuclear security and the safeguards of nuclear materials have been taken into account in the risk management process and how these issues influence duties of the involved employees. Furthermore, discussions on how nuclear security has been taken into account when assessing and developing the organisation's safety culture were conducted. In addition to management interviews, the inspection interviews focused on the employees' knowledge of their responsibilities and obligations regarding nuclear security, communication channels used for issues pertaining to nuclear security, adequacy of information and how the employees react to deviations.

A2 Personnel resources and competence, 14–15 May 2014

In the personnel resources and competence inspection, STUK assessed the management of competence at Loviisa NPP, refresher training provided to employees important to safety, training on the operational limits and conditions (OLC), personnel planning process, as well as goals and the role of the training team in the implementation of the strategy of Loviisa NPP. Based on an internal audit implemented at the NPP, the employees feel that issues such as their workload impede their personal development. Furthermore, the employees find identifying competence needs based on their job descriptions challenging. The NPP could not provide any proof of the management having assessed the key personnel competence areas as stated in the plant procedures. The management and the training team failed to react to an observation made during an internal audit on the strategy and training focus areas not being consistent. In addition, some of the employees important to safety had not attended all of the mandatory refresher training courses. STUK demanded that the NPP ensure that all employees important to safety perform their refresher training in compliance with the requirements and that the NPP improve its related monitoring procedures. Furthermore, the content of refresher training courses must be assessed in terms of overall safety and the refresher training plan must be updated based on the assessment results. The NPP must also study why the employees feel that they do not have enough time to attend training and improve their competence. The NPP must submit to STUK a report on how the management annually assesses the key personnel competence areas and justification for the management having determined in its self-assessment that management of competence is a key improvement opportunity of the NPP. Furthermore, underlying reasons for the deficiencies in implementation and monitoring of OLC training must be studied.

A3 Functionality of management system and quality assurance, 2–3 April 2014

The inspection of the functionality of the management system and quality assurance focused on updating of instructions for operation and maintenance units, implementation of a development action monitoring system, assessment of the impact of actions and the supplier audit process. The NPP has streamlined the updating of instructions for operation and maintenance units, which has better ensured that instructions are up to date. The NPP has developed the management of non-conformances and instructions on impact assessments. Furthermore, the NPP's supplier audit process as well as the required competence and tools have been updated in the past few years.

Plant safety and its improvement

B2 Plant safety functions, 13–14 November 2014

The plant safety functions inspection at Loviisa NPP focused on the management of severe reactor accidents (Severe Accident Management or SAM). The inspection included assessments of the measures and systems pertaining to the SAM strategy as well as Fortum's resources and the maintenance of competence. Fortum's SAM strategy is based on retaining and cooling melted fuel within the pressure vessel and ensuring the integrity of the containment by means of external cooling and the management of hydrogen. Based on the inspection results, Fortum's resources, SAM competence and SAM training are adequate. Fortum develops its measures and renews its systems in the long term but currently focuses on the reforms determined after the Fukushima accident. In the future, Loviisa NPP will improve residual heat removal from the fuel pools, fuel pool measurements and the management of severe accidents during outages. Furthermore, a future modification of diesel fuel containers and the distribution of diesel fuel will ensure that the emergency diesel generators, which are needed when managing severe accidents, can stay in operation for 72 hours without any fuel supplied from outside the NPP.

B3 PRA and safety management, 6 November 2014

The inspection concerning the use of probabilistic risk assessment (PRA) in safety management focused on current status of PRA updates, key changes and impact of improvements in the PRA. Other issues studied during the inspection included processes and operation of the organisation implementing the PRA and personnel planning. A PRA model for Loviisa 2 was drafted in 2014. There are differences in the PRAs of the Loviisa plant units in terms of the service water systems and the cooling systems of some rooms, for example. In addition to the plant's own reliability data, supporting analyses – such as service water level frequency estimates, damage caused by dropping heavy loads, spurious dilution of the boron content of the coolant, human error analyses and common-cause failure analyses – have been updated. Releases of the fuel in the reloading pool have been added to the scope of the analysis used when assessing the frequency of major releases. Based on the inspection results, Fortum's PRA operations are on a good level in general. The PRA resources have not changed much from the previous year. Component faults are efficiently processed and classified during the annual reliability data updates. The PRA is used as planned to support the management of safety, and no major deficiencies were observed in the inspected issues.

B4 Operating experience feedback, 28 May 2014

The operating experience feedback inspection focused on processes and their organisation as well as related software and procedures in internal operating experience feedback operations. The requirement on reliable monitoring of corrective measures as well as assessing the impact and reliability of measures that was made during previous inspections could not be fully removed yet. STUK demanded that Fortum ensure adequacy of its operating experience feedback resources to enable high-quality reporting and action on time without delay. Furthermore, STUK demanded that Fortum submit to STUK a report on the adequacy of the resources of the operating feedback organisation during annual outages.

Operational safety

C1 Operational activities, 11 March and 13 March 2014

The inspection of operational activities focused on training and competence of control room operators. Based on the inspection results, STUK found that adequately many competent employees are available for the training of operators and operator trainers as well as that the responsibilities and procedures used when planning, implementing, assessing and improving the training have been described in the NPP's instructions. No major deficiencies in the instructions or deviations from the instructions were observed in the inspection. Based on the inspection results, the development of operator competence has been ensured, the competence of operators is being monitored and training needs are identified with a variety of methods at Loviisa NPP.

C2 Plant maintenance, 21–22 October 2014

The plant maintenance inspection focused on the management of spare parts for components important to safety at Loviisa NPP. The NPP has started to draft inspection instructions to ensure operability of spare parts. The early stages of the development project will focus on spare parts for electrical and I&C components. Since warehouses may contain very old products, even ones dating back to the commissioning of the NPP, STUK demanded that the NPP assess the operability of all spare parts, and particularly those that are susceptible to ageing. The NPP will survey the spare part stock, consumption and fault history of each component to be able to assess the adequacy of spare parts and their quantities as well as the correct time to order spare parts. The survey will be done separately for each criticality class, which means that in addition to the probability of core damage, production issues will be studied. The plan is to focus this survey on components with a high criticality class. However, lower criticality classes include some higher safety class components that, based on their classification, are significant to nuclear safety and that may be left out of the survey if the proposed procedure is used. This is why STUK demanded that the licensee supplement the spare part survey by including all safety class 1 and 2 components that can be replaced.

C3 Electrical and I&C systems (electricity), 4–5 November 2014

The electrical inspection focused on battery bank loads and condition management, commissioning inspection activities of a notified body, maintenance of low-voltage unit transformers, monitoring of the ageing of electricity systems and components, maintenance of electricity systems in case of severe reactor accidents, as well as the spare part acquisition process. Based on an inspection of the maintenance of the emergency diesel generators, STUK demanded from Fortum a report on maintenance inspections and measurements of the diesel generators during the 2014 annual outage. STUK also issued a requirement concerning the improvement of battery bank load management.

C3 Electrical and I&C systems (I&C), 4–5 November 2014

The I&C system inspection focused on possible construction inspection of I&C components, renewal of I&C modification work process, development of qualification and the management of ageing, identifying of programmable devices in connection with acquisition, as well as the role of notified body during commissioning inspections. Fortum develops the modification work process of Loviisa NPP, the management of ageing at Loviisa and related instructions. This work is still underway, mostly because of changes to be made due to reformed YVL Guides. Fortum is also preparing instructions on the identification of programmable devices and Fortum's role in commissioning inspections.

C4 Mechanical engineering, 4–5 November 2014

In the mechanical engineering inspection, STUK assessed the reliability of the emergency diesel generators, which supply emergency power to important components. The diesel engines of the emergency diesel generators date back to their installation year, and Loviisa NPP no longer plans to replace them. Spare parts are still available and their operability has been ensured by means of maintenance and inspection programmes for which the NPP has the required competence. They are subjected to mechanical stress, particularly during sequence tests that are annually implemented at each unit. There are plans to arrange these tests less often or simulate them. Their mechanical components have required more repairs in the past few years, but reduced operability has never been determined as the cause for a failure of the unit to start during testing. STUK requested in the inspection that the licensee specify faults causing unavailability in more detail based on whether they were actual faults that caused inoperability or repair needs that caused minor deterioration of performance.

C5 Structures and buildings, 9–10 April 2014

The inspection on structures and buildings at Loviisa NPP focused on maintenance procedures for seawater cooling structures, the steel containment, spent fuel storage and handling pools, containers of the reactor safety injection system, steel cladding in container rooms, fuel racks and pipeline supports. The scope of the inspection also included the organisation of the power company, inspection procedures issued by the power company, inservice inspections by the power company, repairs and modifications, supplementary construction works onsite and other inspections within the area of responsibility. STUK issued three requirements during this inspection. They involved inspection instructions, reporting and the delivery of a repair plan.

C7 Chemistry, 8–9 May 2014

The chemistry inspection focused on chemical conditions at the NPP and migration of activity. The chemical laboratory has handled all of the obligations posed by STUK within the given deadlines. There is no official process description for the laboratory but its operation is being measured and assessed by various means and any non-conformances in its operations are addressed in a systematic and well-documented manner. The laboratory is currently assessing sampling during an accident: which samples would actually be needed and how they would be taken. The assessment also aims at creating estimated sample sizes for the sampler. Alternative sampling routes are annually tested.

In addition to the laboratory's own personnel, other people bring samples to the laboratory. In such cases, the laboratory must make sure that the samples have been correctly taken. In addition to theoretical training, training on sampling onsite should be provided. No requirements were imposed by STUK Based on the inspection results.

C8 Annual outage, 18 July - 1 October 2014

In the inspection during the annual outage, STUK studied whether Loviisa NPP has provided instructions on regularly repeated work on the steam generators and a one-time modification (the replacement of six safety valves in the Loviisa 2 fresh steam piping), whether plans and instructions are followed when implementing the work, and whether the instructions are up to date. Other inspection areas included monitoring by the licensee as well as general order and cleanliness of worksites.

STUK made several similar observations regarding both inspection objects. The observations involved activities that do not comply with the instructions and plans, defective orientation or instructions for the employees, communications, supervision of work or monitoring of measures, as well as defective documentation and decision-making. The significance of these observations must be assessed in more detail after the annual outage: were they isolated incidents or do the observations suggest a more extensive need to improve the operations? STUK considers important that Loviisa NPP complete this assessment of its own activities and organisation so that it will be able to determine whether any measures are needed and if so, which measures will be efficient and sufficient. STUK will monitor the progress of the development work based on the action plan required from Loviisa NPP and a status report on implementation of planned measures. STUK also issued detailed requirements based on four observations made. The improvement measures must be completed by the NPP's 2015 annual outage.

Personal and plant protection

D1 Radiation protection, 22–23 October 2014

The radiation protection inspection covered the nuclear power plant's radiation protection, radiation measurements, emission monitoring and environmental monitoring. Special attention was paid to radiation measuring. Inspection focus areas included the representativeness of radiation measurements and analyses, for example. The new YVL Guides by STUK require more specific descriptions of the locations of radiation measuring instruments. Based on the inspection results, STUK determined that the radiation measuring results are representative. However, STUK still demanded a detailed report from Fortum on the locations of the measuring probes used in radiation measuring. Fortum has identified a need to update descriptions as well as specify descriptions and instructions in connection with the periodic safety review of Loviisa NPP. The environmental monitoring programme has reached all of the goals set. STUK found during the inspection that a technical description of the equipment base should be included in the final safety analysis report on the NPP systems.

D2 Fire protection, 6–7 March 2014

The fire protection inspection assessed effectiveness of the Loviisa power plant's fire protection arrangements and the operations of the power plant, as well as inspecting the implementation of plans on modifying the fire protection arrangements. Focus areas included processes and operations. The inspection also included studying changes made in the protection unit organisation as well as a review of fire extinguishing and fire detection system inspections and the processing of non-conformances observed in these inspections. Requirements by STUK on updating maintenance instructions and a form on managing service life that were made in 2013 were closed in this inspection. A fire water system condition evaluation required by STUK in its previous inspection had not been performed yet. Fortum will arrange a competitive bidding on the condition evaluation project by the end of 2014.

D3 Emergency preparedness, 28–29 October 2014

The emergency preparedness inspection focused on emergency preparedness at Loviisa NPP, emergency preparedness instructions, emergency preparedness training and emergency preparedness equipment, particularly the renewed automatic environmental radiation monitoring system and the weather observation system that is currently being modified. An additional focus area was the drafting of spreading forecasts in case of an accident. Furthermore, STUK assessed in the inspection personnel planning, the processing of non-conformances and work processes. STUK found during the inspection that the calibration interval of the meteorological measurements exceeded the time limits laid down in the OLC and requested from Fortum a special report on this event. In terms of the drafting of spreading forecasts, STUK issued a requirement on assessing the adequacy of supporting materials included in the instructions. Furthermore, Fortum must test the audibility of population alarms in the accommodation village. During the inspection, STUK found that the emergency preparedness of Loviisa NPP is fine, the plant organisation has received the necessary training in compliance with the emergency response plan, and the plant's emergency response plan and related instructions are up to date. Even though emergency preparedness has not been determined as a process by Loviisa NPP, related quality assurance is fine. Any non-conformances and requirements are processed in compliance with agreed procedures.

D4 Nuclear security, 26 March 2014

The nuclear security inspection of Loviisa NPP verified the implementation of nuclear security particularly in the final disposal facility and also partially due to modified fences and modified reactor building access arrangements. A remark made during the inspection will have significance in the assessment of the application of the new YVL Guides and design basis threat.

Nuclear waste and its storage

E1 Operational waste, 10–11 June 2014

The operational waste inspection focused on waste management processes, personnel planning and the occupational radiation dose. The condition of facilities in which waste is processed and stored, radiation levels in these facilities, as well as their classification and their markings were inspected during the inspection visit. No major non-conformances or development needs were detected in the inspection. A good practice observed during the inspection was an indicator system that had been developed for the packaging of waste: it is used to assess activity measuring, cleanliness, order, etc. as well as to monitor and develop packaging operations. Nuclear waste management reporting of Loviisa NPP is being developed based on updated waste records in order to make it compatible with the reporting system of STUK. The occupational radiation dose is incurred when employees process waste during annual outages, transport waste, package waste and test the solidification facility for liquid radioactive waste. The radiation doses have remained low when compared to the NPP's total radiation doses. They have remained clearly below the individual dose limits set for employees doing radiation work.

Special issues

F1 Assessment of operating license and new YVL Guides, 13 October 2014

With its inspection, STUK verified some of the licensee's actions that are included in the scope of the implementation process of the YVL Guides. The new YVL Guides, published by STUK in November 2013, will be ratified for the operating NPPs with a separate implementation decision by STUK. For STUK to be able to make this decision, Fortum must submit an assessment on compliance with the all of the requirements of the new YVL Guides, references to verifying plant documentation and, if necessary, improvement measures and their justification, and submit the guide-specific assessments to STUK for approval. In the inspection, STUK verified Fortum's assessment process and its status. The information obtained in this inspection will assist STUK in the preparation for the processing of the assessments.

F2 Renewal of main control room ceiling, 5–6 June 2014

STUK implemented an extra periodic inspection programme inspection to verify that Fortum has properly designed and will properly implement haulage and installation work included in the main control room ceiling renewal project. The current ceilings of the main control rooms at Loviisa 1 and Loviisa 2 are not watertight. Fortum will construct new watertight ceilings to protect the main control rooms from any process leaks. The modification will be implemented first at Loviisa 1 and then at Loviisa 2. The work at Loviisa 1 started with the construction of a protective level. In the inspection, STUK verified that Fortum has studied the safety risks connected to the work, has determined procedures to eliminate or minimise the risks, and will follow these procedures in practice. STUK implemented the inspection before the starting of the haulage and installation of the main control room ceiling at Loviisa 1, but after construction of the protective level. Some development areas connected to possible bypassing of the safety ventilation system, the ability to detect an alarm related to discontinuation of the work, fire detectors in the main control room below the protective level, orientation for contractors, haulage and construction inspections were observed. Observed good practices included daily meetings between the contractor and the shift supervisor to discuss the current status and documentation of these meetings.

F3 Studying whether the OLC is up to date, 2 December 2014

In December, STUK implemented an unannounced inspection to verify with the help of spot tests the implementation of corrective measures and the development of operations after expiration of deadlines. The measures were connected to inspecting whether the currently valid OLC is up to date and development of OLC maintenance procedures. The operational limits and conditions (OLC) are an operating license document mentioned in the Nuclear Energy Decree. It must be kept up to date at all times. Based on the inspection results, STUK stated that Loviisa NPP has not started sufficiently extensive, speedy and effective measures based on the requirement posed by STUK in 2013. STUK demands that the director in charge of the NPP take action to perform these duties.

Periodic inspection programme 2014, Olkiluoto

Management, management system and personnel

A1 Management and safety culture, 4–5 March 2014

The inspection of the management and safety culture focused on TVO's processes and development projects, as well as self-assessment of the safety culture. In the inspection, STUK interviewed the process owners and people who drafted process descriptions, and TVO presented its safety culture self-assessment from 2013 and recommendations made based on the assessment. TVO presented the current status of its operating processes and the status of ongoing development projects on developing the management process and the management of resources. TVO has described the operating processes as charts and continues the development of process indicators. A business model development project involves the introduction of scorecard indicators that measure changes at the company and department level. The goals of the development of the management of resources include resource management rules, a competence centre model and a description of centralised resource management, and TVO states that the key results of the development measures will be completed by 30 June 2014. People in charge of the measures that were determined based on the safety culture self-assessment report have been named in the operative committee. A requirement made in the previous inspection on taking into account organisational changes in risk assessments when preparing for the operation of Olkiluoto 3 is still active. Based on the inspection results, STUK stated that TVO actively develops its operations and processes, and the development is systematic enough.

A2 Personnel resources and competence, 24–25 September 2014

The inspection on personnel resources and competence focused on TVO's personnel resource management process (REHA), duties and resources of the Personnel Development office and TVO's training. Furthermore, employees who work in the project office that was established in May 2014 were interviewed. The REHA project aims at streamlining operations by means of resource management at the Group level and a competence centre model. According to TVO, the project has ended and the final results determined in the project plan have been assessed. However, a final report on the resource management rules, the use of consultants and the competence centre model has not been drafted yet. According to TVO, development of resource management at the Group level is not possible because the ERP tool TVO uses is not well suited for this purpose. Based on the inspection results, the competence centre operations have been launched, but there are still some expectations and uncertainties regarding the competence centres in the TVO organisation. STUK demanded that TVO make an official decision about the competence centre's role as part of TVO's operations, update its management system accordingly and offer its employees more information on the competence centre model and its use. It was noted in a competence management audit in 2013 that external training is being monitored with the help of course feedback but separate systematic monitoring of the quality of training has not been arranged. TVO plans to arrange project training for project engineers and project managers. The preliminary training time is the beginning of 2015. Based on the inspection results, development of project activities and launching of a project office are still in the early stages. Assessing long-term effectiveness of training has been found challenging. In the future, TVO must submit an annual report on the training provided.

A3 Functionality of management system and quality assurance, 29–30 October 2014

The inspection of the functionality of the management system and quality assurance focused on assessments regarding TVO's operations (the internal audit programme in particular) as well as resources, job descriptions and development projects of the Quality and Environment Office. STUK assessed TVO's supplier audit procedures by interviewing people who implement the supplier audits. TVO's renewed internal audit programme aims at more comprehensive coverage of all operations. STUK demanded that TVO submit a report on how the renewed internal audit programme supports assessment of the process-based management system. Several parties within TVO are in charge of the development of processes, and it is unclear who carries the overall responsibility for the development. TVO must submit to STUK a status report on development of the management system processes and a report on who is in charge of the development of the processes.

Plant safety and its improvement

B2 Plant safety functions, 30–31 October 2014

The plant safety functions inspection at Olkiluoto NPP focused on the management of severe reactor accidents (Severe Accident Management or SAM). In the inspection, STUK assessed the measures and systems pertaining to the SAM strategy as well as TVO's resources and the maintenance of competence. TVO's SAM strategy is based on flooding of the lower plenum of the containment to cool melted fuel and thus ensure integrity of the containment. Based on the inspection results, TVO's resources, SAM competence and SAM training are adequate. TVO develops its operations and renews systems in the long term. At present, key plant modifications include the reforms determined after the Fukushima accident, such as ensuring fuel pool cooling.

B3 PRA and safety management, 9 September 2014

STUK assessed the use of the Probabilistic Risk Analysis (PRA) in the management of safety in an inspection that focused on the current update status of the PRA, the current status of planned improvements of seismic supports and the impact of these measures on the PRA. Processes and operations of the organisation in charge of the PRA and personnel planning were also assessed. The PRA update schedule has been speeded up from the previous plans: all parts of the PRA will be updated at least once before the operating license is renewed. TVO has sufficient resources to follow the update schedule. The PRA is used as planned and in a versatile manner to support the management of safety, and no major deficiencies were observed in the inspected issues. Potential development areas identified in training utilising the PRA included simulator training and the training of maintenance personnel.

B4 Operating experience feedback, 8–9 October 2014

The operating experience feedback inspection focused on the NPP's operating experience processes and activities, and verified with the help of example cases implementation of operating experience feedback activities and the processing of external operating events and experiences. STUK found that TVO's operating experience feedback operations are very well organised and the related instructions are excellent. The instructions and procedures are developed in compliance with the YVL Guides and organisational changes. High-quality event reports have been submitted at the right time. There is still some room for development in annual reporting and the assessment of the impact of corrective measures, however. Operating experience feedback during the construction of Olkiluoto 3 has been developed and standardised together with the operating plants.

Operational safety

C1 Operational activities, 19–20 March 2014

The inspection of operational activities focused on training and competence of control room operators. Based on the inspection, STUK issued two requirements, one of them about the updating of a couple of instructions and the other about the need for the licensee to clarify the process description on operator training. Based on the inspection results, STUK found that sufficiently many competent employees are available for operator and operator trainer training at Olkiluoto NPP, and that the development of operator competence is properly ensured. The competence of operators is being monitored and training needs are being identified with a variety of methods. The inspection results also show that the effectiveness of training is being monitored and further developed.

C2 Plant maintenance, 2–3 April 2014

The plant maintenance inspection focused on the management of spare parts and supplies at Olkiluoto 1 and Olkiluoto 2. The inspection covered procurement, reception, storage and handover from warehouse of spare parts and supplies. Responsibilities, instructions, resources and data systems pertaining to these sectors of spare part management were studied. Furthermore, operation of the incoming goods unit and the storage facilities were verified. An increased risk of fake goods could not be excluded in the inspection, since the supply chains are longer than before and suppliers are changed often. A fake product cannot usually be detected using normal quality assurance procedures that are based on mutual trust. The risk of fake products can, however, be mitigated by adding more quality assurance measures at the spare part procurement and reception stage, as well as by providing more training. Measures pertaining to the prevention of fake products, in particular, was an issue that could not be verified during the inspection. STUK demanded that TVO study means it could use to identify forgeries. Based on the inspection results, TVO needs to add more precautionary measures to its spare part procurement and inspection instructions in order to avoid a situation where fake spare parts or supplies are used at the plant. This requirement applies in particular to mechanical, electrical and I&C components that are serially produced and of the commercial grade as well as commercial supplies that influence the operability of a safety classified system, structure or component.

C3 Electrical and I&C systems (electricity), 19–20 March 2014

The electrical inspection focused on ensuring and monitoring power supply during annual outages, setting of the parameters of electrical components, maintenance and repairs of valve actuators, monitoring of the ageing of electrical components, battery banks and earth faults in DC systems. Based on the inspection results, STUK demanded from the power company reports on development of the procedures used when setting the parameters of electrical components, testing and settings of thermal relays, prevention of earth faults in DC systems and quality assurance during the maintenance of actuators.

C3 Electrical and I&C systems (I&C), 19–20 March 2014

The I&C system inspection focused on calibration requirements for measurements listed in the operational limits and conditions (OLC), compliance of the I&C design and implementation process with requirements, coverage of accident I&C qualification, correctness of the dimensioning of installed components and management of the ageing of I&C components. A requirement issued by STUK in its inspection in 2012 on updating I&C design and implementation instructions is still valid. STUK demanded further reports on the calibration of measurements and qualification of accident I&C.

C4 Mechanical engineering, 19–20 March 2014

The mechanical engineering inspection focused on operations pertaining to ensuring integrity of the reactor pressure vessels at Olkiluoto 1 and Olkiluoto 2 as well as operations pertaining to the management of ageing. Ensuring the sufficiency of expert resources at Olkiluoto NPP is challenging because the organisation is currently undergoing a transfer to the next generation simultaneously with ongoing construction projects and the drafting of reports pertaining to the extension of the operating license. STUK found in the inspection issues to be developed: the time needed to maintain the reactor pressure vessels, operation, condition monitoring and management of basic data during modifications. STUK required from the power company a more detailed report on the monitoring programme used to monitor the long-term effect of neutron radiation on the properties of the reactor pressure vessel materials. The ageing mechanism linked to the internals of the reactor and weld joints of pipe nozzles that causes the most concern is stress corrosion cracking. TVO has prepared for it by applying extended inspection programmes and ensuring the readiness to calculate the mechanics of failure. A deep crack in a feedwater nozzle at Olkiluoto 2 that has been monitored since 2003 may have been caused by this mechanism, and TVO has drafted a repair plan for it. STUK demanded more specific information from TVO on stresses to which the reactor pressure vessel cover is subjected because of temperature fluctuations of the flange connection and the screws in it at different speeds during transients.

C5 Structures and buildings, 29–30 October 2014

In the inspection of the structures and buildings at Olkiluoto NPP, STUK focused on the maintenance procedures and management of ageing of the structures, buildings, seawater channels and tunnels, spent fuel storage and handling pools, condensate pools, fuel racks and piping supports. The inspection covered the power company organisation, the power company's inspection instructions, the power company's inservice inspections, repairs and modifications, as well as other inspections within the area of responsibility. STUK verified the execution and results of the power company's own inspections and related reporting. STUK made remarks on requirement entries, specifying the requirement specification for steel and concrete structures, the delivery method of renewed instructions, the clarification of supplier classification and the reporting on ageing management in compliance with the new YVL Guide.

C6 Information security, 16–17 September 2014

The information security inspection focused on technical and administrative information security of the operating Olkiluoto units and TVO's preparations for the operation of Olkiluoto 3. In the inspection, deadlines for implementation of previous requirements were set, two requirements were closed and three new requirements were issued. TVO must draft a follow-up report on implementation of the requirements to monitor the status of all open requirements and observations from previous inspections as well as the implementation of information security inspection visits. Information security inspection visits are a new concept from the viewpoint of the continuous oversight of plants.

C7 Chemistry, 5–6 November 2014

The chemistry inspection focused on quality assurance at the laboratory, chemical conditions at the plant units and the migration of activity. According to an internal audit of the laboratory, the laboratory has properly performed regular self-assessments, drafted sufficient instructions on self-assessments and provided its employees with training on self-assessments. There is still some room for improvement in the updating of instructions and the implementation of supplier audit approvals, however. The laboratory's results in chemistry and radiochemistry reference measurements were fine, but the analyses of the reference measurement samples could also be used in identifying training needs. STUK demanded that TVO study how and how regularly radiochemistry reference measurements could be performed with known standards in the future.

C8 Annual outage, 11 May – 9 June 2014

The annual outages at Olkiluoto 1 and Olkiluoto 2 took place from 11 May to 9 June 2014. During the annual outage, STUK implemented an inspection on the operations of the NPP to maintain safety and manage operations during annual outages. Nearly twenty sectors and jobs were verified during the inspection. The inspection focused on shoe boundaries, monitoring and management of contamination, heavy lifting in the reactor building, shift change routines, maintenance of the reactor coolant pumps, nuclear security, supply of electric power during annual outages, processing of observed faults and modification of an auxiliary feedwater system recirculation line. During this inspection, STUK monitored the work done onsite, conducted inspection visits and interviewed employees. Good operations and examples of continuous improvement were observed during the inspection. Nothing or nothing major to remark was observed in most of the inspection objects. STUK's requirements based on the inspection mostly involved the updating of different instructions to develop the operations and documents. For example, clear instructions on what to do if the set test limits are exceeded must be added in the instructions on trip tests that are performed during the startup of a unit. One of the requirements involved commissioning inspections after modification of pressure equipment. TVO must draft clear instructions on the related procedures and offer the persons in charge of the trial runs proper training regarding the instructions.

Personal and plant protection

D1 Radiation protection, 18–19 March 2014

A radiation protection inspection covers the nuclear power plant's radiation protection, radiation measurements, emission monitoring and environmental monitoring. In 2014, special attention was paid to radiation measuring. Inspection focus areas included the representativeness of radiation measurements and analyses, for example. STUK found that the environmental monitoring programme has reached the set goals but there is still room for improvement in keeping instructions up to date.

STUK demanded that the power company supplement its description of the power company's role in acquisition of components and during reviews of subcontracted sampling. Furthermore, a description of the instruments used when collecting samples from the environment should be added, as a single entity, in the final safety review report of the NPP. STUK did not find anything to remark in the condition monitoring of fixed radiation measuring instruments. Many of the instruments have been replaced over the past few years, and the instruments have been fully functional.

D2 Fire protection, 18–19 September 2014

The organisational oversight of the fire protection at Olkiluoto focused on processes and operations. STUK demanded that TVO submit a survey report to STUK on the coverage of the VIRVE network that is used in communications between authorities once the report is completed. Furthermore, observations regarding the entering of inspections into the TEHA system and the acquisition of a boat to be used in oil prevention were made. These observations, as well as the status of TVO's active fire protection, are issues that will be monitored in future inspections.

D3 Emergency preparedness, 23–24 April 2014

The emergency preparedness inspection at Olkiluoto covered emergency preparedness of the NPP, instructions on emergency preparedness and emergency preparedness training. A special focus area was the drafting of spreading forecasts in case of an accident. Among emergency preparedness equipment, special attention was paid in the environmental monitoring system that is to be used in the case of an accident to assess the scope of releases, for example. Over the years, measuring stations have been moved due to construction activities, for instance. STUK demanded that TVO calculate new release assessment curves for the rearranged measuring stations. Furthermore, the NPP must test the audibility of population alarms indoors in the accommodation village. STUK also assessed in the inspection personnel planning, the processing of non-conformances and work processes.

D4 Nuclear security, 12–14 May 2014

The nuclear security inspection focused on nuclear security at the NPP in general and nuclear security during annual outages. Other issues covered in the inspection included the status of requirements from previous inspections, nuclear security events (special events) during the previous period, training for the safety organisation, drills, as well as access control management procedures for TVO's archiving facilities and electronic archives. During the inspection visit, STUK assessed access control arrangements of a new work permit office and on-call activities at the alarm centre, and interviewed the safety organisation shift supervisor. Based on the inspection, STUK demanded that a couple of details be updated in the safety organisation's security instructions.

D4 Nuclear security as part of the management system, 30 September – 1 October 2014

The inspection on nuclear security as part of the management system focused on the risk management process, procedures used to manage the risks caused by illegal activities as part of the company's comprehensive risk management process, the processing of nuclear security non-conformances and observations, as well as the processing of nuclear security issues in management reviews. The inspection covered both nuclear security and information security. TVO has developed its risk management in the past few years based on the inspection results, and risk management is now systematic. Non-conformances and observations are processed in an established manner and continuous development occurs. STUK demanded that TVO take into account the development areas in identifying risks pertaining to illegal activities in all of the organisation's operations and responsibility areas as well as the management of non-conformances and observations pertaining to nuclear security and information security as a whole that were identified during the inspection.

Nuclear waste and its storage

E1 Operational waste, 7–8 October 2014

The inspection on the processing and final disposal of radioactive operational waste at Olkiluoto NPP focused on waste management processes, personnel planning and occupational radiation doses. The condition of facilities in which waste is processed and stored, the condition of final disposal facilities, radiation levels in these facilities, as well as their classification and their markings were studied during the inspection visit by STUK. TVO is about to introduce a new system for measuring the activity of barrels and bales, and the development of a new bag monitor is underway. Nuclear waste management reporting of Olkiluoto NPP is being developed based on waste records in order to make it compatible with the reporting system of STUK. The occupational radiation dose is incurred when employees process waste during annual outages, transport waste, package waste and solidify liquid radioactive waste. The radiation doses have remained low when compared to the NPP's total radiation doses. They have remained clearly below the individual dose limits set for employees doing radiation work. No major non-conformances or development needs were detected in the inspection.

E2 Final disposal facilities, 25–26 September 2014

STUK assessed the final disposal of radioactive operational waste at Olkiluoto NPP in an inspection that focused on TVO's organisation, processes and operations of the low- and intermediate-level waste repository, condition of concrete and rock structures in the repository and monitoring of the bedrock. The monitoring scope covers hydrological and rock-mechanical monitoring measurements in the repository. Several long-term tests are also being performed at the repository. The inspection included a visit to the repository. TVO was unable to answer all the questions about rock monitoring posed by STUK, and TVO did not know how the subcontractor had processed or assessed some of the rock monitoring results. STUK's requirements involved the determination of criteria for assessing the monitoring results, collecting groundwater chemistry and hydrology measurement results, measured variables and measuring instruments, as well as competence of the people in charge of monitoring. STUK also encouraged TVO to pay attention in the monitoring of subcontractors' work.

Special issues

F1 Assessment of new YVL Guides, 30 October 2014

With its inspection, STUK verified some of the licensee's actions that are included in the scope of the implementation process of the YVL Guides. STUK published new YVL Guides (40 of them in total) in November 2013. The Guides will be ratified for the operating NPPs with a separate implementation decision by STUK. For STUK to be able to ratify the Guides, TVO must first submit its own assessment of compliance with the requirements of the new YVL Guides. STUK will then review TVO's guide-specific suitability analyses and make implementation decisions on ratifying the Guides. STUK has requested that the guide-specific suitability analyses be submitted by the end of December 2014. In the inspection, STUK verified TVO's assessment process and its status. The information obtained in this inspection will assist STUK in the preparation for the processing of the suitability analyses. TVO implemented the assessment as a separate project. Based on the inspection results, TVO's project was well planned and executed, and project management seems to have been successful. No requirements were imposed in the inspection.

APPENDIX 6 Construction inspection programme of Olkiluoto 3 in 2014

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 2014, ten inspections included in the construction inspection programme were implemented, three of which were targeted at the main operations of the Olkiluoto 3 project, and seven at practical work processes. Special focus areas of the construction inspection programme included quality assurance, commissioning procedures and activities at the construction site. Issues pertaining to Olkiluoto 3 are also covered in inspections included in the periodic inspection programme if this is appropriate due to the nature of the issue. Issues pertaining to Olkiluoto 3 covered in inspections of the periodic inspection programme in 2014 included personnel resources and competence, as well as chemistry operations. 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.

Subject of inspection	Inspection date
Main functions	
Quality management and safety culture	27–28 March 2014
Project management and management of safety	25–26 June 2014
Quality management – Restart of the construction site operations	19–20 November 2014
Work processes	
Commissioning – Readiness to start containment pressure and leak tightness tests	22–23 January 2014
Radiation protection	19 February 2014
I&C – Assessment of the protection system requirement specification	6–7 May 2014
Installation supervision – storage and maintenance	22–23 October 2014
Electrical engineering	30–31 October 2014
Commissioning – preparation for operation	19–21 November 2014
Utilisation of PRA	3 December 2014

The construction inspection programme inspections on **quality assurance** assessed TVO's procedures on maintaining and developing the safety culture of the Olkiluoto 3 project, taking into account nuclear security and information security as part of the safety culture, and the impact of TVO's organisational reform on ensuring safety. On the basis of the inspection, it is not self-evident that all observations on information security deviations will be communicated to all the parties involved in the assessment of the safety culture or saved into all the systems that will be used as the data sources during the assessment. Furthermore, the safety culture assessment has not taken into account the possible need to collect observations regarding special situations, such as the reduction of personnel from the construction site. Based on these observations, STUK required TVO to submit a plan on development measures.

The inspection on **management and processing of safety issues** focused on actions by project management in order to identify and monitor safety issues, risk management, and preparation for restarting operations at the construction site after a slower period. It was noted that TVO drafts inspection memorandums for all issues important to safety. This is a good practice, but the memorandums are not saved into the system that is used when commenting on the issue and monitoring its progress. STUK required during the inspection that tracking inspection memorandums in the system must be possible. On the basis of the inspection, it is not self-evident that TVO has a plan on restarting the construction site. STUK required that the plant supplier and TVO draft a plan that covers the orientation of all organisations and employees entering the construction site for the first time, supervision, risks involved in restarting the operations, and measures to be used to mitigate these risks.

The **quality assurance** inspection focused on starting of the construction site operations and related proactive measures to avoid problems, as well as impact of the organisational reform and the management system as the construction project is concluded and operation of the unit starts. In the inspections, it was not possible to fully determine the relationship between subprojects and the line organisation. The content and status of subprojects will be described in more detail in subproject plans that must be submitted to STUK for information.

During an inspection on the readiness tostart containment pressure and leak tightness tests, which are part of commissioning, it was observed that the prerequisites laid down for the containment pressure and leak tightness tests had been met and STUK was of the opinion that there were no open issues that would prevent successful testing. The readiness of TVO and the plant supplier to perform the tests was found good. STUK required during the inspection that the commissioning inspection of the containment instrumentation system would have to be completed before starting the testing in the containment.

The inspection on **radiation safety** focused on planning of the radiation protection organisation personnel, their training, commissioning inspections in the controlled area, experiences obtained by TVO during the construction stage on the unit's radiation protection solutions, and radiation measuring system licensing. STUK required that TVO draft a plan on commissioning of the controlled area of OL3 and implementation of the commissioning inspection by the licensee. The plan must include requirements on implementing radiation protection and the procedures that will be used to verify compliance with these requirements.

The **I&C** inspection focused on assessment of the protection system requirement specification. TVO is currently assessing the reactor protection system requirements in order to ensure that the protection system that will be implemented in compliance with the requirements will be able to perform the indicated tasks. Correctness, completeness and consistency of the requirements are assessed. In connection with this inspection, STUK required that the scope of the assessment be expanded and requested that TVO determine criteria it can use when ensuring that the requirements are correct, consistent and complete.

The inspection on **storage and maintenance** was an unannounced inspection. Compliance with plans and more detailed instructions on specific components, as well as documentation of maintenance measures were studied during the inspection. No cause for any remarks regarding the practices was found during the inspection.

The **electrical** inspection focused on the licensee's procedures and actions on ensuring compliance of the electricity systems during the systems' design, installation and commissioning stages. Following the inspection, STUK required that TVO continue the mapping of software-based components and draft a report on acceptability of cables that have been damaged on the outside. In addition, STUK demanded that TVO review and correct a document on the settings of protective relays.

The second **commissioning inspection focused on preparation for operation**, particularly in terms of the current status of unit procedures and operator training. No requirements were imposed by STUK following the inspection.

The **PRA inspection** focused on keeping the PRA model, documentation and applications up to date and taking them into account in plans drafted in order to conclude the project. TVO's own inspection and monitoring activities were also studied. No requirements were imposed by STUK following the inspection. However, STUK noted that the proposed schedule for updating the PRA model and the materials does not optimally support STUK's inspection activities.

APPENDIX 7 Construction inspection programme of Onkalo in 2014

The objective of the construction inspection programme is to verify that high-quality implementation of approved plans is ensured in the construction of the underground research facility, in compliance with official regulations and without compromising safe final disposal. The inspection programme includes assessment and monitoring of Posiva's operations when constructing Onkalo, the procedures applied to various parts of the construction work, the management research and monitoring in Onkalo, the management of safety and quality assurance during implementation. STUK prepares annual plans for Onkalo inspections.

An inspection of excavation and EDZ was implemented in early May. The inspection period was longer than normal based on a request by Posiva because there was plenty of new materials and interpretations on EDZ studies and related development work. A requirement on updating the management instructions for the excavation damage zone (EDZ) was issued in the inspection. In addition, Posiva was urged to study whether there is any need to draft separate excavation management instructions similar to Posiva's other management instructions for issues critical for long-term safety.

Five requirements were issued based on an inspection of seepage water and injecting in early October. The key requirements involved anticipating changes in the total salinity (total dissolved solids or TDS) content of the groundwater due to the construction of Onkalo, the impact of the observed exceeded action limits on the design and position of the repository, the development of silica injection and reliability of the method used when measuring seepage water in the shafts. In the inspection of foreign materials in early December, it was observed that the key issue to be developed in Posiva's own monitoring is still the monitoring of the amount of approved foreign materials used. Commissioning of TVO's new logistics centre in 2015 is expected to provide a solution to this problem. Three requirements were issued in this inspection. Posiva failed to follow its own instructions on entering environmental damage involving foreign materials into the KELPO system for STUK to view. Key definitions in the instructions on foreign materials must be standardised. Posiva must study the reference value of injection additives and provide justification for it.

Subject of inspection		Inspection date
Management system		
ONP-A1	Management system	–
Planning and management		
ONP-B1	Project management and control	–
ONP-B2	Safety management	–
ONP-B3	Project quality management	–
ONP-B4	Planning and management of the research and monitoring programme	–
ONP-B5	Design of Onkalo	–
Implementation		
ONP-C1	Site inspection and monitoring procedures	–
ONP-C2	Drilling and modelling	–
ONP-C3	Foreign materials	3–4 April 2014
ONP-C4	Excavation and EDZ	6–8 May 2014
ONP-C5	Seepage water and injecting	1–2 October 2014
ONP-C6	Monitoring and research methods	–

"–" denotes that the inspection was not carried out during the Onkalo construction inspection programme 2014 because the subject matter was included in the scope of Posiva's inspection programme during processing of the construction license.

APPENDIX 8 Inspection programme for the construction license application period of the disposal facility

In 2014, STUK continued the implementation of the inspection programme that was started in 2013 for the construction license application period of the disposal facility. The objective of the programme was to assess Posiva's procedures when constructing a safe and high-quality encapsulation plant and disposal facility. Furthermore, the programme was used as an aid when reviewing the application documentation. STUK drafted and submitted a bi-annual inspection plan to Posiva.

The inspection plan included nine inspections for 2014, which were implemented. 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 fifty requirements on correcting deficiencies or further developing its operations were submitted to Posiva during the inspections. As a result of the inspection programme, STUK has been able to get an overall view of Posiva's management procedures, Posiva's preparation for the construction stage, the management of design, quality assurance and Posiva's safety culture, for instance. In 2014, STUK drafted an overall assessment of Posiva's procedures and organisational preparedness as part of the processing of the construction license application.

Management

The management inspection focused on Posiva's management process and its practical implementation. Other inspected issues included safety culture in the Posiva organisation, training operations, personnel resources and management reviews as part of the assessment and continuous improvement of the management system. Furthermore, the inspection covered the status of corrective measures of the observations made in previous inspections by STUK.

Posiva's procedures in the handling of safety issues were verified in the inspection. Safety issues are processed by the technology and safety committees, as well as the operative committee. The Posiva management team acts as the project steering group. It also regularly discusses safety issues. According to Posiva, the procedures used when assessing the project, conducting safety assessments and managing safety are included in the project safety plan. STUK demanded that Posiva submit the safety plan to STUK for processing so that the management of safety can be assessed.

As a result of the inspection, STUK demanded that Posiva make sure that process indicators are regularly discussed in management reviews so that required decisions on effectiveness of the

Subject of inspection	Inspection date
Management	21–22 January 2014
Management of nuclear and radiation safety	4–5 March 2014
Management of documents and information security	25–26 March 2014
Management of design	7–8 April 2014
Safety arrangements and safeguards of nuclear materials	23–24 April 2014
Quality assurance and supervision	5–6 June 2014
Bedrock suitability analysis	17–18 June 2014
Safety culture	29–31 October 2014
Preparation for construction stage	19–20 November 2014

management system can be made and required measures can be implemented. Furthermore, the conclusions of a management system review must also include a comment on suitability and effectiveness of the system. The comment must also study whether the quality and safety policies are up to date.

Management of nuclear and radiation safety

The nuclear and radiation safety inspection focused on the procedures and instructions that guide Posiva's operations and with which Posiva plans to ensure that the safety requirements are met. It was noted in the inspection that Posiva has hired more nuclear and radiation safety experts. Furthermore, Posiva uses the competence of external experts in the management of nuclear and radiation safety. Regardless of the improvements already made, STUK demanded that Posiva make sure that it has sufficiently many competent employees to ensure nuclear and radiation safety of the NPP also in the future. Furthermore, Posiva must make sure that it has sufficient competence to take into account human factors and organisational factors in the design of the nuclear waste facility.

Management of documents and information security

The document management inspection aimed at assessing procedures pertaining to not only document management but also final documentation and information security. The inspection indicated that Posiva is still in the process of developing the structure of its management system documentation and the mutual relations of the documents. Based on the inspection results, it was noted that the development work will also require the updating of specific instructions on document management and the archiving process. The Posiva management system determines that documents must be reviewed to ensure that they are up to date and updated as necessary at least every four years. It was noted during the inspection that this requirement has not been met in the case of all the instructions. It was noted that it is apparent that Posiva's monitoring system does not enable reliable monitoring of the review requirement, which is why Posiva was requested to create a procedure that will reliably ensure that documents are monitored to ensure that they are up to date. It was also noted in the inspection that requirements and procedures for assessing and managing information security risks have not been described in the Posiva management system. Due to the observed deficiency, STUK demanded that the system be updated.

Management of design

The inspection included reviewing Posiva's procedures and instructions on management of plant design, implementation planning and plant configuration, as well as the guidance of suppliers in these sectors. Resources and competence of the Posiva design organisation were also assessed. On the inspection date, Posiva had not yet named the people in charge of the design of various sectors of the encapsulation plant and disposal facility, which is why their competence level and the adequacy of resources could not be assessed. Therefore, STUK stated after the inspection that Posiva's recruitment process and the allocation of personnel resources for the project are still unfinished and STUK was unable to verify the resources allocated to the control and supervision of design (such as people in charge of design sectors and control of schedules). Thus, Posiva did not, on the inspection date, have sufficient resources for the control and supervision of detailed design or the verification of compliance. STUK demanded that Posiva ensure that the design organisation personnel resources will comply with the plans as soon as possible.

STUK also reviewed instructions for Posiva's design operations. Some deficiencies in instructions on configuration management procedures were observed during the document review, such as undetermined responsibilities of implementation. Furthermore, the definition of basic configuration levels did not take into account the licensing stages laid down in the Nuclear Energy Act or the level of configuration required at each stage. The definition must be completed for the licensee to be able to manage supplements to the construction license application before starting detailed design. Thus, Posiva was requested to correct the deficiencies and submit updated procedure instructions to STUK for processing. Similar deficiencies were also detected in Posiva's detailed design handbook, and this handbook must also be updated.

Safety arrangements and safeguards of nuclear materials

In this inspection, it was assessed how safety arrangements (nuclear security and information security) and the safeguards of nuclear materials are linked to the Posiva management system and safety management. The inspection focused on ensuring the effectiveness of the safety arrangements and the safeguards of nuclear materials, descriptions of these operations in the management system, their implementation in the job descriptions of key personnel, as well as safety arrangements and the safeguards of nuclear materials in the risk management process. Safety arrangements and the safeguards of nuclear materials as part of the assessment and development of the organisation's safety culture were also assessed. Based on the inspection results, STUK demanded that Posiva supplement its management system in terms of the goals, tasks, responsibilities and procedures related to safety arrangements and the safeguards of nuclear materials.

Quality assurance and supervision

The quality assurance and supervision inspection aimed at assessing the readiness of Posiva to complete quality assurance and related operations during the construction project. The inspection also covered personnel resources of the organisational units in charge of the operations. The inspection covered both the Posiva line organisation and project quality assurance and supervision. A key observation made during the inspection was that Posiva's procedures and instructions on the management of non-conformances have not yet been developed to a level where the management of non-conformances during the construction project, including the implementation of corrective and preventative measures at the right time, could be efficient. Thus, STUK demanded that Posiva develop its non-conformance management methods to the level required from a party constructing a nuclear power plant. In terms of the organisation, STUK demanded that Posiva make sure that it has a QC inspector for electricity systems available at the right time in its organisation. Furthermore, Posiva must ensure that all the people handling quality assurance duties have the required quality competence, including competence on YVL Guides important to quality assurance.

Bedrock suitability analysis

The programme also included an inspection on the procedures Posiva applies to bedrock suitability analyses. Based on the observations made during the inspection, Posiva must submit instructions on rock classification and model description procedures, further development plan schedules and panel calculator to STUK for processing. Furthermore, three issues into which special attention must be paid were observed: deputies of employees, international cooperation and verifying the results produced by measuring methods.

Safety culture

The inspection covered Posiva's procedures in assessment and development of its organisational safety culture. Posiva's safety management procedures, internal communications about safety culture, safety culture of Posiva's suppliers and safety culture training materials were also studied. The inspection included interviewing eight employees of Posiva. Posiva selected the interviewees to represent various parts and levels of its organisation.

Based on the inspection results, Posiva must describe its safety culture principles in the management handbook in compliance with the requirements of the YVL Guide. Another issue observed in the inspection was the fact that Posiva does not have a safety culture programme; development of such a programme is still being planned. STUK demanded that Posiva draft and introduce a permanent safety culture programme by 30 April 2015. The programme must describe safety culture assessment and monitoring methods as well as procedures that will be used when utilising operating experience feedback in the monitoring and development of the safety culture. In addition, Posiva must ensure that the importance of safety culture will be regularly reasserted by means of internal communications. Based on observations made during the inspection, STUK's inspection team found that the management and personnel of Posiva are committed to ensuring a good level of safety.

Preparation for construction stage

In 2014, Posiva continued its preparations for the construction stage of the project. The inspection focused on the current status of Posiva's preparations, the current status of the project in terms of organisation, personnel resources, management of competence and training, as well as procedures used in the management of construction activities. It was found that Posiva has determined and described the operating processes to the extent necessary in order to proceed to the implementation planning stage. It was further found that the management plans for the different subprojects (quality, safety, risks and schedule) are complete. At the time of the inspection, implementation planning had been started or was being started in almost all of the technical sectors of the encapsulation plant.

Posiva is currently developing criteria to be used when assessing the readiness for a transfer to the construction project implementation stage. Posiva has launched a project on management of uncertainties. The assessment on the readiness to transfer to the implementation stage is linked to this management project. At the first stage of the management project, Posiva will draft a plan on the readiness to transfer to the implementation stage. The plan will include assessment criteria, a procedure to be used when assessing the meeting of the criteria and a description of the responsibilities for the assessment. The assessment on the readiness to transfer to the implementation stage will include an assessment of the development status of the disposal facility concept, i.e. it will cover Posiva's entire project. STUK demanded in the inspection that the plan, which is currently being prepared, must be taken into use well before Posiva is to assess its readiness for construction. The plan, including safety criteria, must be submitted to STUK for processing by 30 June 2015.

The inspection covered Posiva's updated instructions on the reporting and processing of observations. A non-conformance management procedure described in the instructions will be used to manage the reporting and processing of non-conformances by all of the organisations participating in the disposal facility project. STUK observed that the instructions are sophisticated and meet the YVL Guide requirements in terms of the classification and grouping of non-conformances, for example. Analysing and reporting of non-conformances were also covered in the inspection. STUK proposed that the reports on classification and grouping of non-conformances could be further developed to make them more visual.

It was noted that the disposal facility project does not possess all of the resources listed in the resource plan submitted to STUK and the organisation presented in the project plans. Therefore, Posiva must make sure that there will still be sufficient resources for the control and supervision of planning as the implementation planning scope is expanded. The current resources are not deemed sufficient for a larger volume of planning, since the resources do not comply with the resource plan. STUK demands that the disposal facility project resources must comply with the plans when Posiva assesses the transfer to the implementation stage. STUK will verify the resources in a separate inspection before construction starts.

The inspection covered the current status of Posiva's management system instructions and the instructions from the project's viewpoint. Posiva has started a survey of disposal facility project instructions. It aims at identifying which instructions need to be drafted and updated as well as planning the implementation, including related schedules. Posiva has already identified and listed in its handbooks instructions that are still missing from the handbooks. These instructions are not needed yet, but Posiva should have a clear plan on the schedule, i.e. by which project stage the instructions must be approved and taken into use. Based on the inspection results, STUK demanded that Posiva must submit to STUK a schedule on the drafting of the missing instructions. The schedule must ensure that the instructions will be approved and in use at the correct disposal facility project stage.

APPENDIX 9 Nuclear materials in Finland at 31 December 2014

Location	Natural uranium kg	Enriched uranium kg	Depleted uranium kg	Plutonium kg	Torium kg
Loviisa plant	–	635 920	–	5 752	–
Olkiluoto plant	–	1 563 865	–	11 313	–
VTT / FiR 1 research reactor	1 511	60	~0	~0	~0
Other facililties	5 384	< 1	1 568	~ 0	3.5

APPENDIX 10 Assignments funded by STUK in 2014

Safety of nuclear power plants

Most of the assignments in the 2014 plan for technical support assignments were inspection and assessment tasks regarding the regulatory oversight of Olkiluoto 3 as part of STUK's decision-making. Due to the delays in the Olkiluoto 3 construction project, some of the assignments proposed for 2014 were postponed until 2015.

Of the assignment proposals for 2014, twenty were related to the regulatory oversight of the construction of Olkiluoto 3, ten to the operating Olkiluoto plant units, eleven to the Loviisa plant units and four to new NPP projects. There were also four assignment proposals related to all plant units in general.

In 2014, total costs of the technical support assignments amounted to around EUR 1,255,000. The most important assignments pertaining to the construction of Olkiluoto 3 that were completed during the year were:

- Using the filtered containment relief train as an alternative residual heat removal system in the case of a severe accident
- Assessing the number of fuel rods that would burst in the case of a class 2 postulated accident
- Comparison analyses to be completed with the TRAB-3D/SMABRE model for EPR plants
- Comparison analyses of the accident analyses to be submitted in connection with the operating license application
- Assessing software-based electric and I&C components of NPPs and their manufacturers
- Expert assistance during the assessment of system level I&C materials
- Safety culture follow-up study

Safety of the final disposal of nuclear waste

Regulatory oversight of nuclear fuel by the Radiation and Nuclear Safety Authority involves the research, development and design of a repository for spent nuclear fuel, construction of waste facilities and waste management at the NPPs. As an aid for its decision-making and regulatory oversight, STUK uses external experts and projects on special issues. In 2014, the technical support programme for the oversight of nuclear waste management (VATU2014) included assignments to oversee the construction of the underground research facility (ONKALO) as well as assignments related to the review of the construction license for the repository to be built by Posiva. Separate framework contracts have been signed with several external experts (15 contracts in total). In 2014, total costs of the technical support assignments amounted to around EUR 1,104,000. The assignments involved the following subjects linked to the regulatory oversight of nuclear waste management:

- A consultant on rock construction to support regulatory oversight of the construction of Posiva's underground research facility and repository (ONKALO)
- A safety case
- Long-term safety analyses
- Engineered barriers
- Chemical and biological properties of buffer and backfilling materials
- Physical and mechanical properties of buffer and backfilling materials
- Design and mechanical strength of canisters
- Properties of spent nuclear fuel
- THMC modelling for the buffer material and evolution in the near field

- Repository site, performance of natural barriers
- Hydrogeology
- Hydrogeochemistry, geochemistry, paleohydrogeochemistry
- Rock mechanics
- Biosphere
- Assessment of resource and risk management plan
- Structural geology and 3D modelling
- Rock construction and rock construction projects
- Paleoseismology
- Seismic predictions
- Glaciology
- Assessment of sub project plans for the Posiva construction project
- Assessment of interaction between water and rock material, as well as retention and migration properties of the bedrock
- Assessment of Posiva's safety culture, organisation and training
- Assessment of the fire protection concept for the repository for spent nuclear fuel and survey of required comparative analyses

APPENDIX 11 Glossary and abbreviations

ALARA (as low as reasonably achievable)
radiation protection optimisation principle, according to which exposure must be limited to being as low as reasonably achievable

BWR
boiling water reactor

CBRN (chemical, biological, radiological and nuclear)
chemical, biological, radioactive and nuclear weapons or hazards, for example: ”protective measures taken against CBRN weapons or hazards”

Euratom
for nuclear material safeguards, Euratom refers to the European Commission units responsible for nuclear material safeguards: Directorate General for Energy and Transport, Directorates H and I

FSAR
Final Safety Analysis Report

IAEA
International Atomic Energy Agency

INSAG
International Nuclear Safety Group; organisation called by the Director General of IAEA

IRS
International Reporting System for Operating Experience operated jointly by the IAEA and OECD/NEA

ITDB
Illicit Trafficking Data Base, an IAEA database to which member states deliver data on deviations observed as regards nuclear substances and radiation sources.

KYT
Finnish nuclear waste management research programme

LARA
I&C renewal project at the Loviisa power plant

MDEP, Multinational Design Evaluation Programme
A multinational cooperation programme evaluating the practices and requirements of authorities related to the licensing of new nuclear power plants

NKS (Nordisk kärnsäkerhetsforskning)
Nordic safety research programme

OECD/NEA
Nuclear Energy Agency of the Organisation for Economic Co-operation and Development

OLC
Operational Limits and Conditions (previously Technical Specifications)

Onkalo
underground research facility for the final disposal of spent nuclear fue

PRA
Probabilistic Risk Analysis

PWR
pressurised water reactor

SAFIR, Safety of nuclear power plants
Finnish publicly funded national nuclear power plant research programme

SAGSI, Standing Advisory Group on Safeguards Implementation;
an international team of nuclear material safeguard experts called by the Director General of the IAEA

WANO, World Association of Nuclear Operators

WENRA, Western European Nuclear Regulators' Association

VVER (Vodo-Vodyanoi Energetichesky Reactor)
Russian pressurised water reactor; Loviisa 1 and Loviisa 2 are VVER-440 reactors

nuclear material
special fissionable material suitable for the creation of nuclear energy, such as uranium, thorium or plutonium

nuclear commodity (or: nuclear material)
nuclear material referred to above or another material referred to in Section 2, Paragraphs 4 and 5 of the Finnish Nuclear Energy Act (deuterium or graphite), device, system and information (Section 1, paragraph 8 of the Nuclear Energy Decree).

nuclear material accounting and control manual
manual to be used by an organisation in possession of nuclear commodities, describing the nuclear commodity safeguards and accounting system

nuclear non-proliferation manual
manual to be used by a future possessor of nuclear commodities, describing the measures to secure the requirements of nuclear safeguards

regulatory control of nuclear non-proliferation
monitoring operations to prevent the proliferation of nuclear weapons; operations consist of nuclear safeguards and the monitoring of the nuclear test ban

EIA procedure
Enviromental Safety Assessment

YVL Guides
STUK guides containing detailed requirements set for the safety of nuclear power plants. A comprehensive reform of the YVL guides was practically completed at the end of 2013 when 40 guides came into force on 1.12.2013 and will be applied as such to new nuclear facilities.