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Regulatory oversight of nuclear safety in Finland

Annual report 2012

Erja Kainulainen (ed.)

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Radiation and Nuclear Safety Authority

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STUK • SÄTEILYTURVAKESKUS
STRÅLSÄKERHETSCENTRALEN
RADIATION AND NUCLEAR SAFETY AUTHORITY

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

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Management review

In 2012, Finnish nuclear power plants operated safely and caused no danger to the plant environment or employees. The collective radiation doses of employees were low and the radioactive releases into the environment were very small. Radioactive waste generated in operational processes at the nuclear power plants accumulated as anticipated. Its processing and final disposal in underground facilities took place in a controlled manner.

The number of events at the Loviisa Nuclear Power Plant reported to STUK was higher than in previous years. Events were particularly frequent during the annual maintenance of the plant in autumn 2012. Several of the events were related to deficiencies in the plant's operating activities and procedures, resulting in deviations from the state required by the plant documentation. STUK discussed the issue of the increased number of events with the licensee's (Fortum Power and Heat Oy) management in autumn 2012. The licensee began the investigation of the causes behind the increased number of events. The work will continue in 2013. Based on the outcome of STUK's inspection and oversight activities, STUK found that the development of the Loviisa management system as well as the procurement operations and supplier control did not meet all the requirements set for them by the YVL Guides. The licensee launched measures to achieve compliance with the requirements.

Based on operating experience from the operating Olkiluoto plant units, Teollisuuden Voima Oy (TVO) will have to pay increased attention to the management of plant modification work. The reasons behind the events reported to STUK were related to deficient planning and execution of modification work, and testing carried out after the completion of modifications. STUK has paid additional attention to the modification process for a couple of years, and finds the completion of the development projects currently active in the area essential considering the need to ensure the safe implementation of the extensive modifications that are planned for the next few years.

At both Olkiluoto and Loviisa, modifications required for improving safety continued regarding plant systems, equipment and structures and operating practices. Engineering of modification to replace the emergency diesel generators was started at Olkiluoto to essentially improve the reliability of power supply in exceptional situations. At Loviisa, modifications were made to improve the reliability of safety functions. The modifications included changes in the primary circuit pressure control, replacement of seawater circuit pipes and the building up of the seawater channel dam to lower the risk of seawater flooding. After lessons learned from the Fukushima disaster, both nuclear power plants have prepared action plans to improve safety. STUK reviewed and approved the plans of both plants. Implementation of most of the improvements is scheduled for years 2013–2015.

Most of the detailed engineering of the Olkiluoto 3 plant unit has been approved by STUK, and the volumes of construction work and component manufacture are decreasing. The focus of STUK's supervisory operations has therefore transferred to the on-site installation and commissioning of components at Olkiluoto. For the plant's I&C systems, STUK approved with remarks the I&C platforms for use at the plant. STUK also approved with remarks the quality management procedures of the I&C engineering work. However, open issues still exist with regard to the independence of I&C systems and proving the safety impact of the potential failure of the I&C system. TVO and the plant supplier have continued the assessment of the safety culture at the construction site, and strived to create a positive safety atmosphere. However, continuous measures and exemplary activities are required of the project organisation management to be able to ensure and maintain the focus on safety and quality.

As part of the continual improvement of safety and preparation for new NPP projects, STUK continued the work to revise its own YVL Guides and also participated in the preparatory work for reforming the Finnish Nuclear Energy Act. The reform will entail harmonising the requirements, as far as possible, with the national regulations of EU countries and the requirements of the IAEA. STUK had intended to complete the YVL Guides by the end of 2012. The general workload, however, prevented the achievement of this objective.

Processing and storing nuclear waste and spent nuclear fuel proceeded in a safe manner, and no problems were detected at the Loviisa or Olkiluoto NPPs. Thanks to successful planning of operations, the plants accumulated clearly less nuclear waste than NPPs on average. At Loviisa, STUK supervised the commissioning of a liquid waste solidification facility, now delayed from the original schedule. The delay has no impact on the safety of nuclear waste management at the Loviisa NPP, but it is important that further delays are avoided as the plant's liquid waste storage is filling up. At the Olkiluoto NPP, STUK continued the supervision of the expansion of the interim storage for spent nuclear fuel. The length of the storage building will be extended, and additional pools will be constructed there to also accommodate the fuel coming from the Olkiluoto 3 plant unit. At the same time, protection against the crash of a large airplane will be added. The Government issued a decision on changing the operating licence conditions of the Olkiluoto repository for operating waste to allow the final disposal of low and intermediate level operating waste from Olkiluoto 3 in the same facility. The new conditions also allow the main part of waste that is the responsibility of the state and managed by STUK to be finally disposed of in the repository.

Posiva Oy (Posiva) continued its operations that aim at the final disposal of spent nuclear fuel. At the end of December, Posiva submitted to the Government a construction licence application for a final repository and delivered to STUK the safety documentation required by the Finnish Nuclear Energy Decree. The construction of an underground research facility was completed for the most part during 2012. STUK supervised the construction of the underground research facility, the operations of Posiva's organisation and the work carried out by Posiva to further specify the safety case for the final disposal. STUK also continued its preparations for the review of the construction licence by further specifying the review plans and by selecting members for an international team of experts from various fields of science and technology, assembled to assist STUK in the review of the construction permit application.

The implementation of nuclear safeguards functioned without problems in Finland, and no cause for remarks was found in the inspections carried out by the IAEA and the European Commission. Development of the nuclear safeguards regarding spent nuclear fuel continued in cooperation with the IAEA and the European Commission.

Introduction

This report constitutes the report on regulatory oversight in the field of nuclear energy which the Radiation and Nuclear Safety Authority (STUK) is required to submit once a year to the Ministry of 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 oversight of nuclear safety in 2012 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 basics of nuclear safety regulation included as part of STUK's responsibilities, 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 revision 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 operating 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, and the results of emission and environmental radiation monitoring. For the Olkiluoto 3 plant unit currently under construction, the report includes descriptions of the regulation of engineering, 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.

The section concerning nuclear non-proliferation describes the nuclear non-proliferation control for Finnish nuclear facilities and final disposal of spent nuclear fuel, as well as measures required by the Additional Protocol of the Safeguards Agreement. In addition, it describes the control of the transport of nuclear materials and the oversight of the nuclear test ban.

The chapter describing the oversight of security arrangements in the use of nuclear energy discusses oversight of the security arrangements in nuclear power plants and other plants, institutions and functions included within the scope of STUK's regulatory oversight. The chapter also discusses the national and international cooperation for developing the security arrangements and associated regulations.

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 licences granted by STUK pursuant to the Nuclear Energy Act in 2012. 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. The Onkalo construction inspection programme inspections are listed in a table in Appendix 7. Appendix 8 lists the most important assignments funded by STUK concerning the safety of nuclear power plants and final disposal. Appendix 9 contains definitions of terms and abbreviations used in the report.

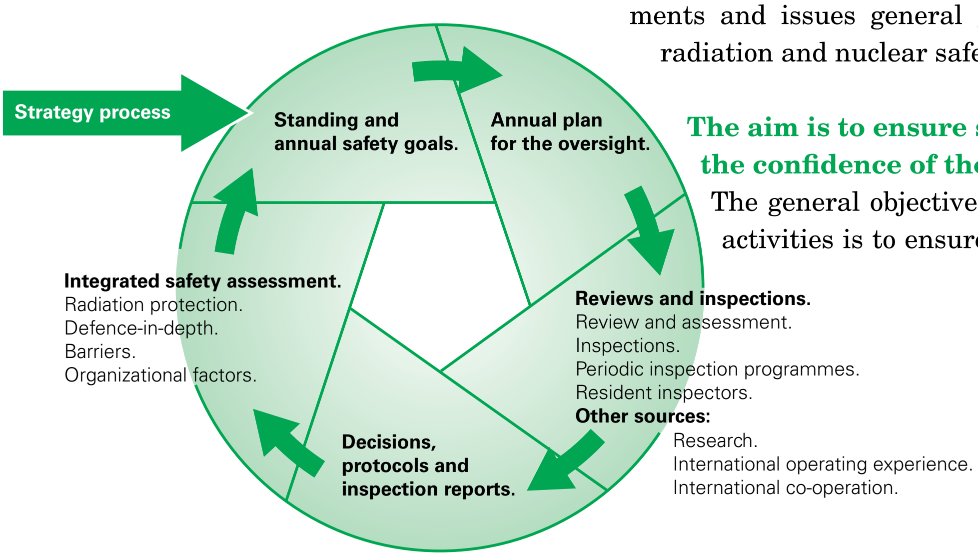
Contents

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 physical protection 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 licences under the Nuclear Energy Act, controls compliance with the licence 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	**Oversight of Management in Regulated Organizations** Safety management Management systems and QM Training and qualification of staff Use of operational experiences Event investigation Nuclear liability Inspection and testing organisations Manufacturers of nuclear pressure equipment
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 Oversight of outage management Maintenance and ageing management Fire protection Radiation protection Emergency preparedness Physical protection	**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 2009 and its term of office ended on 30 September 2012. A new Commission was appointed on 1 October 2012 and will remain in office until 30 September 2015.

In 2012, the Chairman of the Commission was Dr. Sc. (Tech.) Seppo Vuori, and the Vice-Chairman was senior inspector Miliza Malmelin (Ministry of the Environment). Members of the Commission were professor Riitta Kyrki-Rajamäki (LTY), customer director Rauno Rintamaa (VTT), country director Timo Okkonen (Inspecta Oy), customer manager Ilona Lindholm (VTT) and Dr. Sc. (Tech.) Antero Tamminen. Professor Tero Varjoranta, 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. The committees convene a few times each year. 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

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 licence 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 2012, 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 2012, the value of the SDR was about EUR 1.2.

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.

plans is verified through inspections carried out at the plant site or at subcontractors' premises. In 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 licence 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 licence 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 licence. 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 licence 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 licence 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 licence. Obtaining the operating licence is a prerequisite for loading the reactor with fuel.

Comprehensive safety assessment is a prerequisite for extending the operating licence

In Finland, operating licences are granted for a fixed term, typically 10 to 20 years. A comprehensive safety assessment is required to renew the operating licence. If the operating licence is granted for a period exceeding 10 years, an interim safety assessment is carried out during the licence period. The scope of the interim assessment is similar to that carried out in conjunction with renewing the operating licence. 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 licences, 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 licences 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, physical protection 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.

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.*

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.

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 licence 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 licences 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 licence 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.

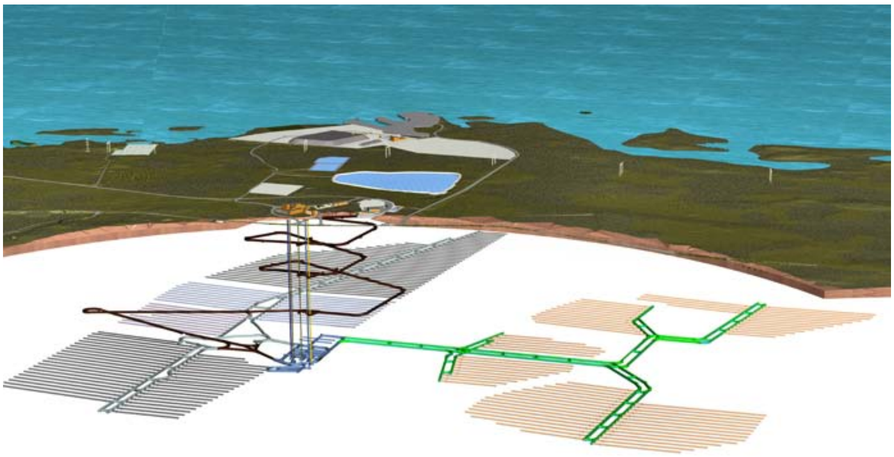


Figure 2. Diagram of the encapsulation and disposal facility in Olkiluoto (Posiva Oy).

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.

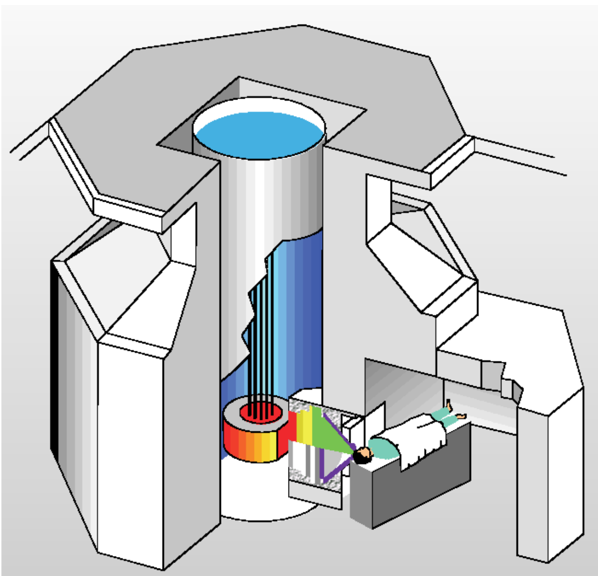


Figure 3. FiR 1 research reactor and the BNCT station.

FiR 1 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 began operations in March 1962, and its current operating licence will expire at the end of 2023. The reactor is used for the fabrication of radioactive tracers, activation analysis, student training and Boron Neutron Capture Therapy (BNCT) treatment of tumours, as well as the development of therapeutic methods.

- 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

3 Development of regulations

The reform of the Nuclear Energy Act, prepared in cooperation with the Ministry of Employment and the Economy, entered into force. The reform included a specification of STUK's regulatory rights for the time preceding the granting of a construction licence, and an extension of the use of inspection organisations for public administration duties with regard to inspections of nuclear facilities.

STUK prepared the reform of the Nuclear Energy Act and the Nuclear Energy Decree together with the Ministry of Employment and the Economy. The reforms include the changes necessary due to the EU directive for the responsible and safe management of spent fuel and radioactive waste (2011/70/Euratom).

STUK prepared drafts for the Ministry on changes to the Government Decree 733/2008 on the safety of nuclear power plants and the Government Decree 735/2008 on emergency response arrangements at nuclear power plants. These changes take into account the assesements of the causes of the Fukushima Dai-ichi disaster and the lessons learned from it, as well as the new safety targets and requirements of the IAEA and WENRA (Western European Regulators' Association).

STUK continued its long-term project of revising the YVL Guides. The objective was to complete the new guides during the year under review, but the work will continue in 2013. Delays in the schedule were caused by the discussion of the new safety requirements resulting from the Fukushima disaster, the new safety targets of WENRA, EU stress tests, the international nuclear waste conference and an extraordinary meeting concerning the IAEA's Convention on Nuclear Safety. These all required a considerable amount of work from STUK's experts.

The current YVL Guide set containing over 70 separate guides will be replaced by approximately 40 new guides. In addition to the comprehensive and demanding nature of the content, attention will be paid in the reform work to presenting the information in a uniform and user-friendly manner. By the end of the year, 29 final guide drafts had been completed.

Structure of the new YVL guides

A Safety management of a nuclear facility

A.1 Regulatory control of the safe use of nuclear energy
A.2 Siting of a nuclear facility
A.3 Management systems of a nuclear facility
A.4 Organisation and personnel of a nuclear facility
A.5 Construction of a NPP
A.6 Operation and accident management of a NPP
A.7 Risk management of a NPP
A.8 Ageing management of a nuclear facility
A.9 Reporting on the operation of a nuclear facility
A.10 Operating experience feedback of a nuclear facility
A.11 Security arrangements of a nuclear facility
A.12 Control of information security on a nuclear facility

B Plant and system design

B.1 Design of the safety systems of a nuclear facility
B.2 Classification of systems, structures and equipment of a nuclear facility
B.3 Safety assessment a NPP
B.4 Nuclear fuel and reactor
B.5 Reactor coolant circuit of a NPP
B.6 Containment of a NPP
B.7 Preparing for the internal and external threats to a nuclear facility
B.8 Fire protection of a nuclear facility

C Radiation safety of a nuclear facility and environment

C.1 Structural radiation safety and radiation monitoring of a nuclear facility
C.2 Radiation protection and dose control of the personnel of a nuclear facility
C.3 Control and measuring of radioactive releases to the environment of a nuclear facility
C.4 Radiological control of the environment of a nuclear facility
C.5 Emergency preparedness arrangements of a NPP

D Nuclear materials and waste

D.1 Regulatory control of nuclear non-proliferation
D.2 Transport of nuclear materials and nuclear waste
D.3 Handling and storage of nuclear fuel
D.4 Handling of low- and intermediate-level waste and decommissioning of a nuclear facility
D.5 Final disposal of nuclear waste
D.6 Production of uranium and torium

E Structures and equipment of a nuclear facility

E.1 Inspection, testing and certifying organisations
E.2 Manufacture and use of nuclear fuel
E.3 Pressure vessels and pipings of a nuclear facility
E.4 Verification of strength of pressure equipment of a nuclear facility
E.5 In-service inspections of pressure equipment of a nuclear facility
E.6 Buildings and structures of a nuclear facility
E.7 Electrical and I&C equipment of a nuclear facility
E.8 Valve units of a nuclear facility
E.9 Pump units of a nuclear facility
E.10 Emergency power supply of a nuclear facility
E.11 Hoisting and transfer equipment of a nuclear facility
E.12 Testing organisations in nuclear facilities

Figure 4. The structure of the new YVL guides at the end of 2012.

4 Regulatory oversight of nuclear facilities and its results in 2012

4.1 Loviisa nuclear power plant

4.1.1 Overall safety assessment of the Loviisa power plant

STUK oversaw the safety of the Loviisa power plant and assessed its organisation and personnel's competence in different areas by means of reviewing documents provided by the licensee, carrying out inspections in line with the periodic inspection programme, and by 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. The occupational radiation doses and radioactive releases into the environment were low and below the prescribed limits. The licensee has operated the Loviisa power plant in a safe manner and, for the most part, in compliance with YVL Guides. Emergency preparedness at the Loviisa power plant complies with the requirements. The processing, storage and final disposal of low and intermediate level waste (operating waste) at the power plant were carried out as planned.

According to the tests and inspections carried out, the condition of the containment and the reactor coolant system, which prevent the release of radioactive material into the environment, are in compliance with requirements. A leak was detected in the vent line of a protective pipe of the control rod mechanism in connection with a reactor coolant system pressure test carried out at Loviisa 1. Due to the damage, the corresponding welds of all the protective pipe vent lines of control rod mechanisms were welded again for both Loviisa 1 and Loviisa 2. STUK approved the application for renewing the operating permit of the Loviisa 1 reactor pressure vessel. The new permit is valid until the plant unit's operating licence expires on 31 December 2027.

A fuel leak was detected at Loviisa 2 late in 2012. Follow-up indicates that the leak has remained minor. The detected leakage is insignificant for the radiation safety of the environment, because the radioactivity is contained in the reactor coolant system and inside the containment. In recent years, problems with the pool inspection equipment have prevented Fortum from carrying out the inspections of spent fuel, control rods and protection elements to the planned extent (see section 4.1.4). Fortum has taken measures to rectify the situation.

Plant operation has been, for the most part, systematic and safe. Three events of INES class 1 were reported from the plant. In addition, seven other events were reported and rated as INES class 0. The number of events is significantly higher than in the previous years, which indicates deficiencies in the power company's procedures. The events included deficiencies in the periodic testing of components subject to operational limits and conditions (2 events), faulty isolations and repairs (4 events), excess fire load inside the containment, uncertainty of the operability of replaced valves of the pressure control system during start-up, erroneous settings of the thermal relays in the motors of pumps that are important to safety, and deficiencies of the scheduling of periodic preventive maintenance. The events had no impact on the safety of employees or the plant surroundings. Most of the events took place during annual maintenance. Some of the events have only received a superficial investigation by the power company. STUK has discussed the increased number and background of the events with the management of the licensee, and the management has begun measures to assess and remove any common causes behind the events. Loviisa power plant also had eight events classified as operational transients, two of which led to a reactor trip. System and equipment fail-

Table 1. Events at the Loviisa plant units subject to special reports or a root cause analysis and/or classified INES Level 1 or higher. All events subject to reporting are discussed in Appendix 1 (indicator A.II.1). Events with a special report are described in more detail in Appendix 3.

Event	Non-compliances with the OLC	Special report and/or root cause report	INES rating
Suction valve of the boron injection system erroneously closed at Loviisa 2	•	•	0
Deficiencies in the testing of radiation monitors at Loviisa 2	•	•	1
Deficient testing of recombiners at Loviisa 2	•	•	0
Stopping of cooling system pumps during Loviisa 1 annual outage	•	•	0
Excess fire load at Loviisa 1		•	1
Uncertainties in the operationality of replaced pressure equalisation system valves at Loviisa 1	•	•	0
Two serious accident management measurements unavailable at Loviisa 1	•	•	0
A residual heat removal subsystem briefly unavailable at Loviisa 2	•	•	0
Erroneous settings of protective relays of motors at Loviisa 2		•	1
Inconsistencies in testing procedures observed at the Loviisa power plant		•	0

ures had a minor safety implication for the plant. Annual maintenance was carried out as planned in terms of nuclear and radiation safety. The events are described in more detail in Appendix 3.

During the year, the power company implemented several modifications for improving radiation and nuclear safety. At Loviisa 1, some of the spraying and blowdown lines of the reactor coolant system's pressure equalisation system as well as their valves were replaced, the failure tolerance of the air cooling systems in the safety injection pump rooms was improved, service water system's discharge side pipes were modernised, modernisation of the dams in the discharge side of the seawater circuit was launched, and a mechanical seal containing resin instead of antimony was installed for one reactor coolant pump. Modernisation of the dams in the seawater circuit will improve the plant's flood protection during outages. The work will continue in the following annual maintenance outages. Replacement of the sealing material of the reactor coolant pumps will also continue in the following annual outages. The purpose is to reduce the radioactivity of the reactor coolant system and the resulting radiation doses. At Loviisa 2, switches of the 6 kV electrical system were replaced, and the replacement of the cooling units in the room of one of the emergency diesel generators was completed. The changes have been, for the most part, successful, except for the challenges met in the design and implementation of the reactor coolant system pressure control's modernisation project (see section 4.1.5).

In 2007, STUK issued a statement to the Ministry of Trade and Industry (now the Ministry of Employment and the Economy) regarding the renewal of the Loviisa power plant's operating licence and the plant's periodic safety review. The actions for improving plant safety in compliance with the action plan produced by Fortum Power and Heat Oy at that time have, on the whole, progressed according to plans. After the Fukushima nuclear accident in 2011, STUK sent a decision to the Loviisa power plant concerning the provisions against natural phenomena and disturbances in the power supply. The measures proposed by the power company have proceeded. STUK reviewed and approved the power company's plans for improving the plant safety with regard to extreme

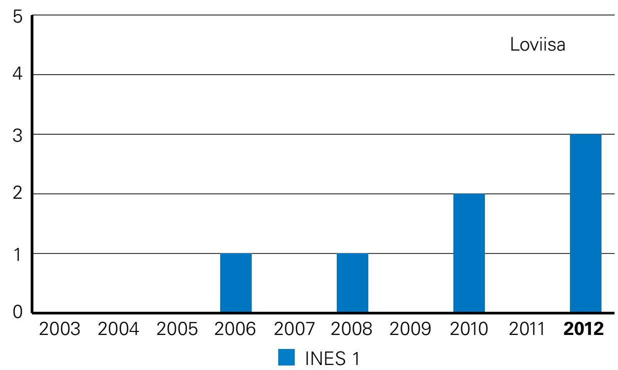


Figure 5. INES classified events at the Loviisa plant (INES Level 1 or higher).

external hazards. The plans include a conceptual design plan for cooling towers designed for securing the removal of residual heat of spent fuel, and an action plan to improve flood protection.

Implementation of the second phase of the Loviisa I&C renewal (LARA) has been postponed to 2015, as the qualification of the I&C equipment platform components is still in progress. The systems to be upgraded in the second phase include the nuclear island's I&C systems that have the greatest safety significance, as well as the I&C systems of most important safety functions, such as the emergency power supply. As the upgrade will be delayed and the plant components and systems

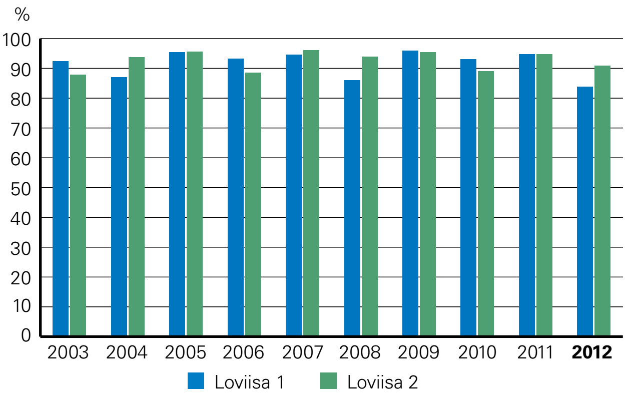


Figure 6. Load factors of the Loviisa plant units.

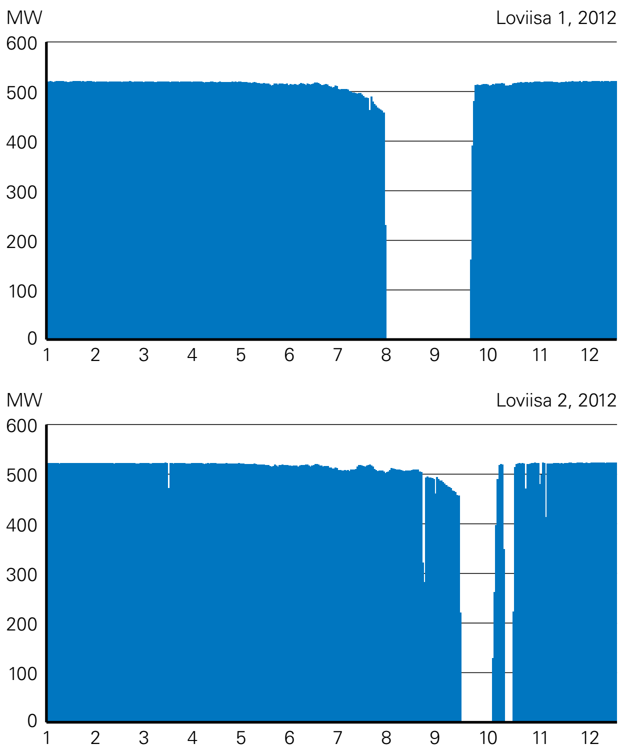


Figure 7. Daily average gross electrical power of the Loviisa plant in 2012.

Operation and operational events

The load factor of Loviisa 1 was 83.8%, while that of Loviisa 2 was 90.9%. The load factor is affected by the duration of the unit's annual maintenance outage. The outage lasted 54 days for Loviisa 1 and 20 days for Loviisa 2. The load factor is also affected by the losses in gross energy output due to operational transients and component failures. The losses in gross energy output were 0.004% at Loviisa 1 and 2.08% at Loviisa 2. Loviisa 2's production losses from component failures were higher than in the previous years. Most of the losses were due to a leaking seal water line in a reactor coolant pump. The plant was run down to a cold shutdown state for repairing this fault.

A reactor trip occurred at Loviisa 2 on 29 August 2012 *as a result of annual maintenance work carried out at Loviisa 1. Switchboard maintenance was carried out in the annual outage, and the switchboard was cut off for the purpose. This resulted in the power supply also being cut off from the control cubicle of the back-up excitation system of turbine generators. This caused faulty protection signals in the back-up excitation system, and resulted in the isolation of Loviisa 2 turbine generators from the power grid. The reactor operator of Loviisa 2 then shut down the reactor by initiating a reactor trip. During the event, the plant protections functioned as planned, and the event had no impact on the safety of the plant or its environment.*

Loviisa 2 was shut down for repair *on 20 October 2012 to fix a leaking seal water line of a reactor coolant pump. A minor leak in the seal water system of a reactor coolant pump was detected at the plant unit in October. In order to repair the leak, the plant had to be shut down and cooled down to a repair outage. The leak did not put the safety of people or the surrounding environment at risk.*

A reactor trip occurred at Loviisa 1 *during the start-up after annual outage on 24 September 2012, when the steam generator feed water pump stopped, and the feed water system could not be restarted despite the efforts due to a low input pressure. As a result, a reactor trip was performed while the reactor power was still at a low level. The event caused no risk to the plant, people or the environment. The plant's safety back-up systems functioned as planned.*

The events are described in more detail in Appendix 3.

Annual outage at Loviisa 1

The annual outage at Loviisa 1 comprised an extensive maintenance outage carried out every eight years. The outage began on 5 August and ended on 29 September. The length of the outage was 54 days, which was approximately 15 days longer than planned. The delay was caused by work such as the repair of leaking position transmitters observed during reactor assembly, and the testing of the reactor coolant system's pressure equalisation system, which took longer than expected.

In addition to refuelling, the annual outage included extensive inspection, repair and modification work. Periodic inspections were carried out for the pressure vessel and pipes. All fuel was removed from the reactor for the inspection of the pressure vessel and the reactor internals.

Eight-year pressure tests were carried out for the reactor coolant system and the secondary circuit. During the test, the strength and tightness of the structures is tested with 1.3 times the design pressure, 178 bar(abs) for the reactor coolant system and 73 bar(abs) for the secondary circuit. A four-year tightness test was carried out for the containment steel lining with acceptable results.

A leak was detected in the vent line of the protective tube of the control rod mechanism during the reactor coolant system pressure test. Due to the leak, all the similar welded joints in the vent lines of control rod mechanisms' protective tubes were renewed.

The secondary circuit pressure test had to be interrupted when a leak was detected in one of the six steam generators. The steam generator was isolated and the pressure test was completed. The isolated steam generator was subjected to a new pressure test during the plant start-up, after the leak had been repaired, and the scope of the original pressure testing plans for the secondary circuit was covered.

The major work carried out during the annual outage was the modification of the reactor coolant system's pressure equalisation system. The pressure equalisation system maintains the pressure of the reactor coolant system at setpoint during power operation, and limits or lowers the pressure during transients and accidents using the pressurizer spray and blowdown functions. The modification involved work such as replacement of spray and blowdown lines and their valves. During the modification, faults were detected in its planning and implementation as well as in the test operation of the system. In the commissioning tests carried out at the end of the annual outage, deficiencies were observed in the initial arrangement of the tests, and it was considered necessary to clarify the administrative decision-making process related to test operations.

Other modifications completed during the annual outage included the improvement of the fault tolerance of the air cooling systems of safety injection pump rooms, replacement of the discharge pipes of the service water system, and the modernisation of the system. In addition, a mechanical seal with a packing of resin instead of antimony was installed to one reactor coolant pump. Fortum has found that a large share of the dose rate from the reactor coolant system originates in antimony. The purpose of the packing material change is to lower the radioactivity of the reactor coolant system and the resulting radiation doses. The seals of other reactor coolant pumps will be replaced in future annual outages in accordance with plans.

The modernisation of the partition dams in the seawater circuit's discharge side began with the replacement of one of the two partition gates of Loviisa 1. The purpose of the dam is to prevent the access of the seawater into the plant facilities during outage, when the seawater circuit hatches are open for maintenance. The modernisation will include the improvement of outage flood protection by raising the top of the dam from +2.10 m to +2.45 m. Based on current investigations due to the Fukushima accident, it will be estimated whether the outage flood protection can be further improved by raising the top of the dam to ground level +3.0 m. The work will continue in future annual outages.

cannot be replaced with new ones as planned, the licensee is required to take measures to ensure the adequacy of the maintenance measures and spare part management of the existing I&C systems and components.

Fortum Power and Heat Oy and its Loviisa power plant organisation have operated mainly in a systematic and development-oriented way to ensure the safety of the plant. The Loviisa plant process development project has not proceeded according to the implementation of YVL Guide 1.4, and STUK required that the development work be continued with no delay. Due to the repeated deficiencies observed in the supplier control and procurement operations, STUK required that the licensee of the Loviisa power plant makes an independent evaluation of the power plant's procurement operations and supplier control. The observations made by STUK in the course of its oversight indicate that the organisation produces an abun-

Annual outage at Loviisa 2

The Loviisa 2 annual outage was a short maintenance outage started on 22 September 2012 and ended on 13 October 2012. The annual outage lasted 20 days. The outage was carried out in accordance with the planned schedule.

In addition to refuelling, the outage included inspections, repairs and modifications as planned by the power company. Periodic inspections were carried out for the pressure vessel and pipes. The operations important for safety included replacement of the plant unit's 6 kV electrical system switches and the 17-year maintenance of one of the emergency diesel generators, which involved replacing the engine with a completely overhauled unit. At the same time, the generator of the same emergency diesel generator was overhauled. The replacement of the cooling units in the room for the same emergency diesel generator, started in 2011, was completed with the replacement of the third fan bank. Due to a leak in the vent lines of control rod mechanisms' protective tubes at Loviisa 1, all the welded joints of the vent lines were also renewed at Loviisa 2.

dance of information regarding its operations, but this information is not fully and systematically utilised for developing the management system and for improving operations. The work for improving the operational processes of the organisation must be continued in order to ensure the safe operation of the plant, particularly with regard to developing the management system, ensuring the quality of procurement operations and developing the safety culture assessment methods.

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

Compliance with the operational limits and conditions (OLC)

The operational limits and conditions list the values within which nuclear power plant units must remain during operation. The Loviisa power plant has kept the power plant's operational limits and conditions document up to date. STUK has assessed the operational limits and conditions and their validity in connection with inspecting the modifications and analyses carried out at the plant as well as in connection with on-site oversight.

In 2012, Fortum submitted to STUK for approval ten amendment proposals for the operational limits and conditions. Amendments of the OLC were due to modifications carried out at the plant, such as the replacement of the reactor coolant system's pressure equalisation system, improvement of the fault tolerance of the air cooling system in the safety injection pump rooms, renewal of the service water system's discharge side, and the introduction of new fuel and changes to water chemistry conditions. One of the changes involved the addition of conditions related to the safety of the fuel transport cask. STUK approved nine of the applications on the grounds that the deviations had no significant implications for the safety of the plant or the environment. The conditions related to the fuel transport cask are still being processed by STUK.

In 2012, the power company applied for permissions from STUK for five planned deviations from the operational limits and conditions. Two of the applications were related to fault repair that exceeded the repair time allowed by the OLC, one to a change of the plant's operating condition while one of the emergency diesel generators was isolated, and one to a modification carried out at the 110 kV switchyard. The I&C upgrade (the LARA project) caused one planned deviation from the OLC. The application concerned a modification which involved the isolation of one of the two pumps of the fuel pool cooling system while work was being carried out. STUK approved the applications because the assessments carried out indicated that the deviations had no significant implications for the safety of the plant or the environment.

In 2012, seven events occurred at the plant in addition to the approved deviations during which the plant was non-compliant with the operational limits and conditions. The number of events is clearly higher than the average for the ten preceding years, which is two events per year. The situations were related to neglected periodic testing of components subject to OLC (2 events), faulty isolations and repairs (4 events) and uncertainty of the operability of replaced valves in the pressure control system during start-up. Most of the events took place during annual maintenance. The events had no significant implications for the plant's nuclear or radiation safety, but they indicate deficiencies in the power company's procedures. The power company has prepared special reports on the events containing a proposal for corrective measures to prevent similar events in the future. The events are described in more detail in Appendix 3.

Operation and operational events

In addition to the events for which special reports were filed, there were eight events that were classified as operational transients. Two of these led to a reactor trip. A leak in the reactor coolant pump seal water line at Loviisa 2 was a significant operational event. The plant unit was consequently shut down for a short repair outage.

In 2012, the risks caused by component malfunctions, preventive maintenance and other events causing unavailability of equipment were 3.8% (Loviisa 1) and 1.8% (Loviisa 2) of the expected value of the annual accident risk calculated using the plant's risk model. The results are in line with long-term averages.

Annual maintenance outages

Annual maintenance at the Loviisa power plant was carried out safely, and all maintenance work was completed in the planned scope. The power company paid particular attention to cleanliness and order during the outage, as well as to cleaning the reactor pit and level. As stated above, the number of officially reported events during annual maintenance was higher than in the previous years. STUK oversaw the annual outage in accordance with the oversight and inspection duties defined in YVL Guides, and performed an outage inspection according to the inspection programme.

STUK's inspection of outage operations, performed in accordance with the inspection programme, was targeted at the power plant operations that maintain safety and lead and manage actions during the annual outage. The inspection observations of various significance levels were mostly related to the work of the Loviisa power plant organisation. Among other things, STUK required that the Loviisa power plant update certain maintenance and radiation protection procedures and estimate whether current procedures are adequate to prevent the access of loose parts and impurities in opened reactor hall drains. The Loviisa power plant must also further develop its procedures in order to prevent items that contain activating substances from unnecessarily accessing the controlled area and to prevent such items and other loose parts from accessing the process systems of the reactor coolant system.

STUK used a total of 343 man-days on on-site oversight during the annual maintenance outages; these days were made up of equipment and system inspections and oversight work in various areas of expertise. In addition, two resident inspectors worked regularly on site.

4.1.3 Ensuring plant safety functions

Deterministic safety analyses

An extensive evaluation of the transient and accident analyses (deterministic safety analyses) carried out to verify the safety functions of the Loviisa power plant has been performed in connection with the renewal of the plant's operating licence. 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 updated analyses to STUK in 2012.

Probabilistic risk analyses

The risk of a severe nuclear accident is evaluated on the basis of a probabilistic risk analysis (PRA). As a rule, PRA calculations use regularly updated information of the occurrences of initiating events and the unavailability of equipment together with a logical model of the plant's systems and their interdependencies.

According to preliminary information, the annual probability of a severe reactor accident calculated for the Loviisa plant units was $3.6 \cdot 10^{-5}$/year at the end of 2012, which is 28% lower than in 2011 ($4.3 \cdot 10^{-5}$/year). The change was due to plant modifications, further specification of the model and updates to the reliability information.

The following is a list of some measures that were carried out in 2012 to lower the probability of risk:

- The dam used in the seawater channel discharge side was built up to lower the risk of seawater flooding during outage.
- Modifications to the seawater system that cools down safety systems improved the reliability of

residual heat removal and cooling of the reactor coolant pump sealing water.
- Modifications to the pressurizer spraying system used for reactor coolant system pressure control improved the reliability of the reactor coolant system pressure control.
- Qualification of the small relief valves in the reactor coolant system improved the reliability of the reactor coolant system pressure control.

The following changes in the modelling and the initial data also contributed to the reduction of risk:
- Modelling of the falling of heavy loads in connection with lifting work was further specified.
- Heavy load falling frequency was updated according to the accumulated operating experience.
- Pipe break frequencies were updated.
- Common cause failure frequencies of components were updated.

The addition of fuel pools into the model slightly increased the probability of risk.

The accident risk at the Loviisa power plant and its changes are discussed in greater detail in Section A.II.4 of Appendix 1, "Accident risk of nuclear facilities".

4.1.4 Integrity of structures and equipment

STUK confirmed the integrity of structures and equipment using periodic inspection programmes as well as oversight and inspections of the major repairs and modifications especially during the annual maintenance of autumn 2012. No deviations affecting the use of the inspection targets were observed in the monitoring and inspections of the primary circuit or other equipment and structures important to safety.

Reactor coolant system

The condition of the main components and other components of the reactor coolant system remains good at both Loviisa plant units. The power company monitors the condition of the reactor coolant system with procedures such as periodic inspections and by keeping records of the reactor coolant system load. STUK reviews the records within the inspection programme.

STUK approved the application for renewing the operating licence of the Loviisa 1 reactor pressure vessel. The new licence will be valid until the expiry of the plant unit's operating licence. Reactor safety must, however, be evaluated in two periodic safety evaluations taking place in 2015 and 2023. The operating licence of the Loviisa 2 reactor pressure vessel was similarly approved in 2011.

The main flange faces and sealing grooves of the Loviisa 2 reactor pressure vessel were refurbished in the 2012 annual outage. Build-up welding and machining were used in accordance with the repair plan approved by STUK. STUK oversaw the execution of the repair work and performed a construction inspection on the repaired flange face. Corresponding refurbishment had been carried out for the Loviisa 1 reactor pressure vessel in 2010.

A primary circuit pressure test was performed in accordance with the periodic testing programme at the beginning of the Loviisa 1 annual outage. At the beginning of the pressure test, a leak was detected in the weld joint between the collector and a vent line included in the control rod protective pipe structure. Based on non-destructive testing, similar weld repair needs were observed in a total of 36 joints. The licensee decided to repair all these weld joints. STUK approved the repair plans and carried out the appropriate construction inspections after the completion of the welding.

In the annual outage of 2012, fault indications were detected in the cover and shaft of one reactor coolant pump. These were repaired by grinding in accordance with a repair plan approved by STUK. A dent detected at the end of the shaft keyway was removed by grinding, and the surfaces were inspected using a liquid penetrant examination. Three indications were found at the interface between the inner sealing surface of the cover and the casting. These were repaired by grinding. It was concluded that the indications were old irregularities of the casting surface. All indications could not be entirely removed by grinding, but they were considered to remain unchanged during operation and to have no impact on the leak-tightness of the reactor coolant pump.

Fuel

During the past operating cycle, a fuel leak was observed at Loviisa 2 late in the year. As Fortum has been unable to return the functionality of the Loviisa power plant's pool inspection equipment, the plant has experienced problems in the execution of fuel, control rod and protection element inspections for several years.

Some of the Loviisa 1 protection element inspections planned for the 2012 annual outage were not executed. One of the protection elements was left out of the reactor to allow the completion of the measurements after the annual outage. Visual inspections of protection element spring packs were also carried out. Some wear was still observed in them, but no jamming or other major problems.

To assess the further use of control rods, mechanical wear of the six control rods subjected to long-term monitoring was examined. The surveys were carried out less extensively as was originally planned and revealed no indications that would have prevented the use of the control rods in the next fuel cycle of Loviisa 1.

The measurements to assess the mechanical strength of the test fuel assembly equipped with a new type of mixing spacer were also carried out less extensively as was originally planned. Based on the good mechanical behaviour of the test assembly that contained no fuel, 12 test assemblies with mixing spacers, complete with fuel, were loaded into the Loviisa 1 reactor in the annual outage.

The impact of a change in the water chemistry OLC on the oxidation of fuel components was assessed during the operating cycle in 2012. On the basis of a visual inspection carried out without removing the protective casing it was concluded that the change of water chemistry had no impact on the corrosion of the protective casing and thus also could not have an impact on the corrosion of the fuel rods. Another inspection, originally planned for 2010, aimed to reveal the cause behind the damage to a fuel assembly removed in 2009 due to a leak. The inspection was planned to be carried out after the annual outage, but was not possible due to the current condition of the pool inspection equipment. STUK has required immediate measures from Fortum to rectify the inspection situation. As an immediate corrective measure, a new information collection system will be temporarily installed to the existing pool inspection equipment. This will allow the execution of the necessary inspections required during the 2013 annual outage and operating cycles. At the same time, Fortum will allocate additional resources to the modernisation of the pool inspection equipment.

Maintenance, ageing management, spare parts management

Periodic inspections

Periodic in-service inspections must be carried out on pressure equipment and pipes important to nuclear safety as required by the YVL Guides. The inspection targets are selected in accordance with an annual periodic inspection programme defined by the power company and approved by STUK. In 2012, Loviisa 1 had a long annual outage and Loviisa 2 a short refuelling outage. Both included non-destructive periodic inspections in accordance with the plans. At Loviisa 1, inspections were carried out for the reactor pressure vessel, steam generators, reactor coolant pipes, and other pipes and equipment. At Loviisa 2, the same targets were inspected with the exception of the reactor pressure vessel that only received visual inspections of the internals following a limited inspection plan. No faults with nuclear safety implications were observed in the inspections. Other periodic inspections of registered pressure equipment were carried out during the annual maintenance outages according to plans for both plant units. A total of 66 inspections were carried out at Loviisa 1, and 24 at Loviisa 2. No observations restricting the use of pressure equipment were made in the inspections.

Emergency diesel generator

Several nuclear power plants in other countries have reported that the bearings at the bottom end of the connecting rod of diesel engines of the type also used at the Loviisa power plant wear faster than expected. Wear has been observed in one bearing type that is no longer used at the Loviisa power plant. The engine manufacturer has tested the new bearing and approved it for use. Bearings of this type were installed in 2012 to an overhauled diesel engine. STUK required that the new bearings are monitored and the results reported to STUK.

In the overhaul of the emergency diesel generator carried out in the 2012 annual outage an ultrasonic examination revealed looseness of the white metal coating of one slide bearing in relation to the bearing shell. According to the report submitted to STUK, the situation has existed since the generator was put into use, as a similar defect was detected in an unused spare part bearing examined for comparison. Previously, the bearings have received

Pressure equipment manufacturers and inspection and testing organisations

STUK approved, on application by Fortum Power and Heat Oy and pursuant to the Nuclear Energy Act, testing operators from three testing organisations for carrying out periodic tests of mechanical equipment and structures of the Loviisa power plant in accordance with YVL Guide 3.8.

a visual inspection at annual outages and have been found to meet the requirements. The deviation was observed now that ultrasonic inspections have begun. The Loviisa power plant submitted to STUK a report on the significance of the deviation and a plan for measures to ensure the compliance of the slide bearings in the plant units' emergency diesel generators. To secure the functionality of the bearings, they will be subjected to vibration and temperature measurements during test runs. Lubricant oil will also be analysed. The bearings will be inspected again in the 2013 annual outage and replaced if necessary.

Ageing management

Procurement operations are considered a part of ageing management, as securing the safety of a nuclear power plant requires continuous renewal of systems, structures and equipment as these age and become technologically obsolete. During inspections, STUK paid attention to the procurement procedures of equipment and services important to safety. The main focus was on the purchases related to demanding modifications and spare parts deliveries. Based on the inspections, STUK required that the power company submit an account of whether adequate attention is paid to tested or otherwise carefully researched design solutions in the procurement of functional equipment important to safety.

STUK evaluated the organisation and technical execution of the Loviisa maintenance and ageing management programmes by reviewing the steam generator operating and inspection history and the structural modifications carried out for the steam generators during their operational life. Trends significant for operational life, such as the increasing number of heat transfer tube pluggings, received detailed consideration. STUK required that Fortum establishes the necessary measures to allow the prevention and early detection of the potential fracturing of the weld between the steam generator shell and the primary collector's connector. Fractures have been detected in the bi-metal weld at other VVER-440 plants.

STUK approved the installation and commissioning plans of the two high-pressure safety injection pumps acquired from Slovakia. The pumps were installed and commissioned in the annual outage of 2012. The installation work required small structural changes to the fixing bolts and pipes to allow the connection of the components. Due to the vibration of electrical motors observed in the commissioning tests of the pump units, STUK required that Fortum carry out additional investigations by the end of 2012. In addition, STUK required that the power company regularly monitor the vibration levels of motors in connection with periodic testing and report observations made in 2013 to STUK.

4.1.5 Development of the plant and its safety

In 2007, STUK issued a statement to the Ministry of Trade and Industry (currently the Ministry of Employment and the Economy) regarding the renewal of the Loviisa power plant's operating licence and the plant's periodic safety review. In connection with a periodic safety review, Fortum Power and Heat Oy presented an action plan to reduce the plant's accident and release risks. The actions have, on the whole, progressed in line with the action plan. However, the intention is to implement certain safety improvements in connection with the I&C upgrade of the Loviisa power plant. The risk associated with lifting heavy loads will be reduced by modifications implemented in connection with the modernisation of the fuel transfer machine. The purpose of the modifications is to allow the use of safer lifting routes. Since the above projects have been delayed from their original schedule, the implementation of associated safety improvements has likewise been postponed.

Targets for development based on the Fukushima disaster

After the Fukushima nuclear disaster in 2011, STUK sent a decision to the licensees concerning provisions to be made for natural phenomena and disturbances in the power supply. STUK reviewed and approved Fortum's action plan with additional requirements. In 2012, Fortum submitted to STUK for approval the cooling tower design basis required in the decision; the purpose of the cooling towers was to secure the residual heat removal of the fuel present in the reactors and the fuel pools. STUK approved Fortum's action plan to improve flood protection, but required that the power company add further details to the plan. Fortum must submit an implementation plan for improving the fuel pool cooling to STUK for approval in 2013. Fortum must prepare a plan to extend the battery capacity of the special uninterrupted power supply with the aim of securing two hours of battery operation. The plan must pay particular attention to extending the operating time of the reactor coolant pump seal injection system. Fortum has delivered to STUK a report on the availability of raw water in accident situations. The report also covers situations in which both plant units as well as the fuel pools in the containments and in the interim storage for spent nuclear fuel need to be cooled down at the same time.

I&C upgrade at the Loviisa power plant

The LARA I&C upgrade of the Loviisa power plant was launched in 2005. The LARA project will modernise almost the entire I&C system of the plant to a digital equipment platform. At the same time, the plant's control room will be modernised. The original intention was to carry out the upgrade in four phases, but according to the current plan, all safety-classified modifications will be implemented during phase 2 of the implementation and phases 3 and 4, involving modernisation of the non-classified I&C, are to be combined. No new installation work was carried out for the LARA project in 2012. Instead, the work focused on basic engineering of the I&C systems and architecture and, for certain parts of the system, starting the manufacture of the I&C cubicles. STUK's oversight and inspection activities focused on the quality management methods and instructions related to the engineering processes mentioned above. The configuration management of the I&C system supplier was inspected in Offenbach in June. As the qualification of the selected I&C platform's components has not been completed, the second phase of the I&C upgrade has been postponed to 2015. The delay requires the licensee to take measures to ensure the adequacy of the maintenance measures and spare part management of the existing I&C systems and components that cannot be replaced with new ones as planned.

Modernisation of the reactor coolant system pressure control

Modernisation of the Loviisa 1 reactor coolant system pressure control was carried out according to plans during the annual outage. The modification comprised the replacement of the open-close spray valves and shut-off valves of the pressurizer spray system as well as their heating, by-pass and shutdown lines with two adjustable spray valves. The modification also involved the changes to the I&C, electrical systems and pipes required by the new pressure control system. STUK inspected the modification plans, oversaw the manufacture of the mechanical components, and carried out construction inspection of the components. After the completion of the installation work, STUK performed construction inspections of the mechanical installation as well as the commissioning inspection of the electrical and I&C systems. The plant start-up was delayed due to tightness problems that emerged during the commissioning tests of the system, and the plant had to be returned to the hot shutdown state (see the description of the event in Appendix 3). The preparation and implementation of the modification as well as the engineering, testing and commissioning of the I&C system were found to be challenging. Fortum has prepared a special report on the event and is currently in the process of preparing a root cause analysis. The acquired experience must be taken into account when the corresponding modification is carried out for Loviisa 2 in 2014.

Other safety improvements

In 2012, STUK approved changes to the wiring of the Loviisa 1 safety injection pump rooms' cooling system that cools down the rooms under accident conditions. After the modification completed in the 2012 annual outage, the system removes the heat load of the safety injection pump room under all conditions so that the temperature of the room remains below 50°C. Test runs have shown that the modified system functions as planned.

4.1.6 Spent nuclear fuel storage and operating waste

The processing, storage and final disposal of low and intermediate level waste (operating waste) at the Loviisa power plant were carried out as planned. The volume and activity of low and intermediate level waste in relation to generated electrical power remained low compared with most other countries. Contributing factors include the high quality requirements for nuclear waste management and nuclear fuel, the planning of maintenance and repair operations, decontamination, component and process modifications, as well as waste monitoring and sorting, which enable some of the waste with a very low radioactive substance content to be exempted from control. Waste below the set activity limits was exempted from control at the power plant with STUK's approval in 2012 to be processed elsewhere. Waste exempted from control included maintenance waste, scrap metal and hazardous waste to be processed further, such as waste oil. In addition, the power plant employs efficient procedures for reducing the volume of waste destined for final disposal.

STUK inspected, in accordance with the inspection programme, the management and final disposal of operating waste at the Loviisa power plant. The 2012 review focused on issues such as the organisation and resources, communications at the plant and with STUK, and the status of waste management projects. No significant deficiencies or needs for development were detected in the review. During the review, STUK requested that an account of the operating strategy of the operating waste repository currently being built be attached to the operating licence application for the maintenance waste tunnel 3 of Loviisa power plant's VLJ repository.

Construction and commissioning of a liquid waste solidification facility (LOKIT)

A solidification facility for liquid radioactive waste (LOKIT) has been constructed on the Loviisa plant site. The solidification facility processes the radioactive evaporation residues generated at the power plant and the radioactive ion exchange resins from the purification filters. Prior to commissioning the solidification facility, a test programme will be carried out and approved to ensure that the solidification facility systems function as planned. The tests are to ensure, among other things, the functioning of the I&C system, the correctness and adequacy of the information transmitted by the process measurement devices, and the correct determination of the radioactivity of waste packages. In 2012, STUK has approved test run programmes for the solidification facility as well as some plans for changes required for plant systems. The Loviisa power plant aims to complete the test runs and commission the facility in 2013. In 2012, STUK stated that the LOKIT project has not proceeded in accordance with the project and licensing plan. Work has not been carried out within the planned schedule, and equipment needed for modification work has not been available. Recruitment of the operating personnel is also still in progress. The construction and commissioning of the solidification facility should be completed as soon as possible and the licence obtained, because the liquid radioactive waste storage of the Loviisa power plant is filling up. Therefore, STUK will pay particular attention to the completion of the project according to plans in 2013.

The HARVALA sub-project of the LOKIT project, intended for increasing the resin storage capacity, has advanced in the liquid waste storage facility. In the sub-project, the storage capacity of intermediate level resin has been expanded by modifying one low level ion exchange resin storage tank for intermediate level resin. Radiation protection of the tank room has been built up. Installation of tank pipelines continues. In 2012, STUK approved the construction plans for the pipelines and the modification plans for the radiation protection constructions.

Expansion of the operating waste repository (VLJ repository)

An expansion of the VLJ repository was initiated at the Loviisa power plant in 2010. The expansion will comprise Operation waste tunnel 3 and a connecting tunnel. The new facility will be used for the sorting and temporary storage of maintenance waste.

According to the statement issued by the Ministry of Employment and the Economy, the expansion can be implemented subject to STUK's approval and oversight. The commissioning of Maintenance Waste Facility 3 will take place in the first quarter of 2013. The Loviisa power plant submitted the operating licence application to STUK for approval in 2012. STUK will issue a decision on the application at the beginning of 2013. A commissioning inspection by STUK will also be necessary before commissioning can take place.

Provisions for the costs of nuclear waste management

In compliance with section 88, subsection 2 of the Nuclear Energy Decree, Fortum provided the Ministry of Employment and the Economy with the revised and supplemented waste management schemes and information on the costs and prices of nuclear waste management measures. The update of the waste management scheme includes an index adjustment to the cost and price information as well as an estimate of the amount of nuclear waste at the end of 2012.

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 statements, STUK assessed the technical plans and cost estimates on which the financial provision is based and considered them to be appropriately updated. Fortum's extent of liability was €996.2 million at the end of 2012.

According to the Nuclear Energy Decree, supplemented waste management schemes for the technical and financial plans, as well as the related calculations, must be prepared every three years. The next revision will take place in 2013.

4.1.7 Organisational operations and quality management

Based on STUK's oversight and the results of operating activities, it can be stated that, with a view to ensuring safety, the organisation of Fortum Power and Heat Oy has operated in a systematic and development-oriented way. During the year, STUK has focused its oversight activities on the development of the management system, procurement operations, human resources planning, and the quality management competence of the procurement personnel.

No major organisational changes took place within Fortum's nuclear power operations in 2012. Fortum updated the licensee's quality management system description and supplemented it with the licensee's management review procedures. In summer 2012, STUK stated that the process development project for Fortum's Loviisa power plant has not proceeded according to the schedule that the licensee had committed to in connection with the implementation of YVL Guide 1.4 in 2008 and 2009. STUK required that the Loviisa power plant provides an account of how the plant's management system will achieve compliance with the management system's process requirements, and that the Loviisa power plant continues the process development with no delay.

During a review of the implementation of the management system, STUK stated that despite corrective measures already implemented, the supplier supervision and procurement procedures of the Loviisa power plant need to be developed further. STUK ordered an assessment of the Loviisa power plant's procurement operations and supplier evaluation procedures from a third party quality management specialist. The assessment confirmed the necessity of the requirements and measures already required by STUK, namely that the plant must further specify the instructions and procedures concerning the procurement operations and supplier evaluation, and ensure the adequacy of competencies and the development of procedures. Due to these results, STUK considered that the corrective measures have not had an adequate impact, and required that Fortum order an independent assessment of the procurement operations and supplier evaluation of the Loviisa power plant, and determine the causes behind the repeated deficiencies. The required account of these issues was completed at the beginning of 2013.

STUK also found that the information produced while processing deviations occurring at the Loviisa power plant was not being systematically utilised in the management of the plant and the related decision-making, as had been required. STUK required development measures to ensure the development of the deviation management and the management system.

Concerning the oversight of human resources and competence management, STUK required that the Loviisa power plant update the competence management procedures and define and maintain the personnel's competence requirements in more detail. Based on observations made in the course of the oversight, STUK particularly required that the Loviisa power plant increase its quality management and auditing expertise (QA personnel, the persons responsible for the quality management of projects and modifications). STUK stated that the Loviisa power plant has increased its human resources in the areas of operating experience feedback and safety culture. However, STUK required that the division of responsibilities in the area of safety culture evaluation and development shall be further clarified, and that the related procedures shall be updated to reflect the changes. The HR planning tool used at the Loviisa power plant takes into account changes to the number of personnel due to retirement, for example. The project management model adopted at the Loviisa power plant also aims to improve resource management. STUK also required that the deputy system of the persons responsible for physical protection and emergency preparedness arrangements at the Loviisa power plant shall be corrected to meet the requirements in accordance with the Nuclear Energy Act.

STUK oversaw the oral examinations of shift personnel where the shift managers, operators and trainee operators prove that they are conversant with all salient matters related to plant operation and safety. In 2012, STUK granted 26 licences to shift managers and operators on application by the power company and following a successful oral examination, five of them to new operators. All participants passed their examinations in 2012. The new operators achieved good results in the examination, which indicates that the basic training programme is effective. The operators renewing their licences also achieved good results in the examination, which indicates that the power company's refresher and supplementary training is effective.

4.1.8 Fire safety

In 2012, STUK reviewed reports, carried out onsite inspections, implemented a periodic inspection programme, and sent resident inspectors to their rounds to oversee the maintenance of the fire protection systems and arrangements that ensure fire safety at the Loviisa power plant.

During the oversight of the Loviisa 1 annual outage, STUK's inspectors observed that the volume of flammable liquids kept in the reactor coolant pump room within the containment exceeded the volume allowed by the plant's fire safety instructions. Other tools meant for the cleaning of the reactor pit, including cleaning cloths, were also stored at the same location. STUK also observed a similar situation at Loviisa 1 in the 2010 annual outage. Although the event had no direct impact on the safety of people, the plant or the environment, the increased risk of ignition increased the risk of potential fire. Due to the repeated nature of the event, STUK rated it a category 1 event on the seven-step radiation and nuclear safety scale. The power plant has further specified its annual outage procedures with the aim of preventing similar events in the future. STUK believes that the persons responsible for fire safety at the Loviisa power plant are well acquainted with fire safety requirements, but the knowledge is too focused. Increased attention must be paid to continuous improvement of fire safety at the plant through measures such as ensuring that information is passed on within the organisation.

4.1.9 Operating experience feedback

STUK assessed the operating experience feedback activities and corrective measures on the basis of reports, inspection visits and inspections within the periodic inspection programme. Three INES 1 events took place during the year: deficiencies observed in the testing of radiation monitors at Loviisa 2, the excess fire load at Loviisa 1, and the erroneous configuration of the thermal relays of the 0.4 kV pump motors at Loviisa 2.

One root cause analysis was performed at the Loviisa power plant in 2012. The analysis concerned an event that occurred in 2011, when a safety classified valve was replaced by a non-classified valve without the required official approval.

The Loviisa power plant delivered ten special reports to STUK on events that occurred in 2012. The number of events discussed in special reports was clearly higher than in the previous years. The number of events constituting non-compliance with operational limits and conditions (OLC) was considerably higher in 2012 than in the previous years. Other events warranting a special report included the excess fire load at Loviisa 1, the erroneous configuration of the thermal relays of the 0.4 kV pump motors at Loviisa 2, and the differences in the intervals of periodic preventive maintenance found between procedures and the OLC. For a more detailed description of the events discussed in special reports, see Appendix 3.

The special reports were prepared and delivered to STUK in accordance with the requirements, but the power company's investigation of some of the events remained superficial and incomplete.

A total of 72 unexpected operation-related events were recorded at the Loviisa power plant, and 19 event reports were delivered to STUK. The most significant events had been processed at the Loviisa power plant. The reports related, for example, to water and other leaks, component isolation problems, modification work, component failures, methods of operation, and erroneous requirements included in procedures.

In the operating experience feedback inspection, STUK verified instructions, procedures and practices related to the feedback operations. A new operating experience and safety culture team has been established at the safety unit of the Loviisa power plant, responsible for the maintenance and development of the power plant's operating experience feedback process. The new team has increased the resources available for operating experience feedback operations, and they were found to be well organised and instructed and to have adequate resources.

The inspection included verification of the implementation of corrective measures at Loviisa and in other power plants on the basis of example cases. STUK found that there was scope for improvement in the follow-up of corrective actions decided on the basis of operational events at the plant as well as in the assessment of the effectiveness of corrective actions.

The procedures for evaluating and utilising international operating experience feedback function well at the Loviisa power plant. International event reports are comprehensively analysed, and the corrective actions decided on their basis are justified and traceable. Fortum itself conducts pre-screening of the reports coming from various sources, mainly via the IRS system maintained by WANO and IAEA/NEA. The selection criterion for events to be taken to the International operating experience team is their safety significance for the Loviisa power plant.

The fire that took place during a containment leak test carried out at the 2011 annual outage of Ringhals 2, as well as the obstructions in the containment spray systems of Ringhals 2 and 4 observed during the cleaning and inspections carried out after the fire, were identified as issues relevant to the Loviisa power plant. A presentation of the event has been included in the induction training materials for self-study. It was observed at Loviisa that various electrical tools often remain in the electrical network during breaks in the work. The pressure test procedure has been supplemented with the requirement for removing superfluous electrical tools from the containment or cutting off their power. Fortum estimated the amount of plastic materials in the reactor hall and the necessity of replacement of the glass-fibre booth used as a social facility in the reactor hall during revision. The procurement surveys of pressure-resistant fire detectors are also unfinished. Loviisa has considered the possibilities of inspecting pipes with x-ray or endoscope procedures and decided to propose the inspection of a few pipes using an endoscope, which allows the visual inspection of several metres of pipe.

The IAEA report Highlights from the International Reporting System for Operating Experience (IRS) for Events 2010–2011 mentioned the IRS report of an event at the Loviisa power plant in which liquid resin escaped into a ventilation channel from a mixing tank of the liquid waste solidification plant. This event constituted one of the five reports that were found to include important lessons on the management of a project covering the field of several technologies.

4.1.10 Radiation safety of the plant, personnel and the environment

Occupational radiation safety

STUK carried out a radiation protection inspection according to the periodic inspection programme at the Loviisa plant, focusing on occupational dosimetric surveillance and radiation measurements. Based on the inspection, STUK required an account of the procedures used to take care of dosimetry in certain emergencies which prevent measurements at the plant. STUK required that the power company update the administrative procedures of radiation protection and further specify the criteria related to the basic calibration of the dosimetric reader equipment. STUK also remarked that the measurement periods of the dose information submitted for the dose register must correspond to actual measurement periods.

The dosimeters used for measuring the occupational radiation doses underwent the annual tests. The tests comprised irradiating a sample of dosimeters at STUK's measurement standard laboratory and reading the doses at the power plant. The test results were acceptable.

STUK carried out targeted radiation protection inspections during the annual maintenance outages. In the inspections, STUK assessed the radiation protection personnel's work and resources. At the same time, the activities of employees in radiation work within the controlled area were assessed. Radiation protection during the annual outage of the Loviisa power plant was found to be working well, and no significant deficiencies were observed. Based on the inspections, it was found that the plant's radiation protection unit has further improved the radiation protection reporting and management tools. Individual targets for development were revealed in the inspections concerning the arrangements of the protective equipment boundaries of the controlled area, and the use of the protective equipment.

The Loviisa power plant intends to reduce the releases of antimony (Sb-122 and Sb-124) to the reactor coolant system and to reduce the activity of the reactor coolant system and the resulting radiation exposure. The power company replaced one of the reactor coolant pump seals at Loviisa 1 with a seal that contains no antimony.

Radiation doses

The collective occupational radiation dose was 1.35 manSv at Loviisa 1 and 0.33 manSv at Loviisa 1. 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 gigawatt of net electrical power. This means a collective dose value of 1.22 manSv per Loviisa plant unit. This threshold was not exceeded at either plant unit.

The total duration of the annual maintenance outages in Loviisa was long, and the number of operations with significance for radiation protection was higher than on average, which resulted in the

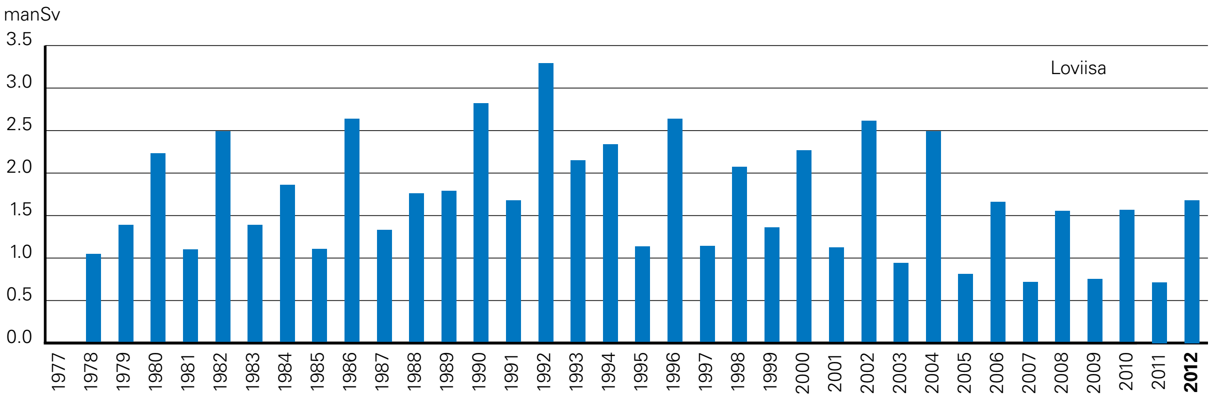


Figure 8. Collective occupational doses since the start of operation of the Loviisa nuclear power plant.

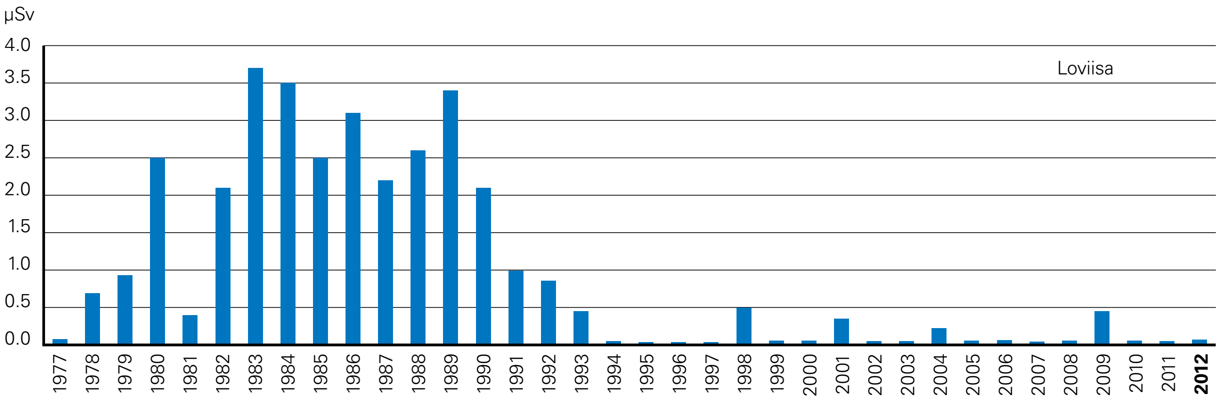


Figure 9. Annual radiation doses to the most exposed person of the public since the start of operation of the Loviisa nuclear power plant. Over the recent years, the doses calculated based on the radioactive discharges have remained below one percent of the set limit, 0.1 milliSv.

Table 2. Radioactive nuclides originating from the Loviisa NPP, found in the environmental samples.

Types of samples containing radionuclides originating from the NPP in 2012. Figures in the table indicate the number of samples of a certain sample type in which each radionuclide was detected. Several different nuclides may be found in the same sample.

Type of sample / radionuclide	H-3	Mn-54	Co-58	Co-60	Nb-95	Zr-95	Ag-110m	Te-123m	Sb-124	Sb-125	Ce-144	Total
Air	–	–	–	2	–	–	–	–	–	–	–	2
Fallout	–	1	–	2	–	–	1	–	–	–	–	4
Aquatic plants	–	2	2	5	1	1	5	1	3	1	–	22
Perifyton	–	2	2	3	1	1	2	1	2	1	1	15
Sedimenting materials	–	–	–	8	–	–	5	–	–	–	–	13
Sediment	–	–	–	3	–	–	–	–	–	–	–	3
Seawater	4	–	–	-	–	–	–	–	–	–	–	4
Sludge	–	2	1	3	–	1	3	1	2	1	–	14
Total	4	7	5	26	2	3	16	3	7	3	1	77

total collective dose being higher than that of the previous years. Compared to the collective doses at plants with pressurised water reactors (VVER) in OECD countries, the collective occupational dose at the Loviisa power plant was average even with the long annual outage of Loviisa 1.

The occupational radiation doses of nuclear power plant workers mostly accumulated in work carried out during annual maintenance outages. The collective occupational radiation dose caused by work carried out during the annual maintenance outages was 1.31 manSv at Loviisa 1 and 0.29 manSv at Loviisa 2. The highest individual radiation dose incurred amounted to 14.3 mSv at Loviisa 1 and to 5.5 mSv at Loviisa 2. The highest individual dose incurred at either plant unit during the entire year was 14.3 mSv. The radiation doses for nuclear power plant workers were below the individual dose limits. The effective dose for a worker from radiation work must not exceed the 20 manSv/year average over any period of five years, or 50 manSv in any one year.

The individual radiation dose distribution of workers at the Loviisa and Olkiluoto nuclear power plants in 2012 is given in Appendix 2.

Radioactive releases and environmental radiation monitoring

The radioactive releases into the environment from the Loviisa nuclear power plant were well below the authorised annual limits in 2012. The releases of radioactive noble gases into the air were approximately 5.6 TBq (as Kr-87-equivalent activity), which is approximately 0.04% of the authorised limit. The releases of radioactive noble gases were dominated by argon-41, i.e. the activation product of argon-40 present in the air space between the reactor pressure vessel and the main radiation shield. The releases of radioactive iodine

New limits for releases of radioactive substances adopted at the Loviisa power plant at the beginning of 2012

The limits for releases of radioactive substances from the Loviisa power plant are specified in the operational limits and conditions (OLC) approved by STUK. The limits have been defined at a level where the annual radiation dose incurred to a person living in the vicinity does not exceed 0.1 mSv, the limit specified in Government Decree 733/2008. The limits apply to releases of noble gases and iodine into the atmosphere during a calendar year, and releases of tritium and other substances into the sea during a calendar year. No release limits have been set for some released substances, as their volume remains low and steady during normal operation of the power plant, and their releases can be controlled based on the radiation dose limit mentioned above.

Loviisa power plant's noble gas release limit was lowered by approximately 40%. Other limits remained unchanged. The change was based on the observation by Fortum that according to the calculation method currently in use, some noble gas releases within the limit could in some cases have resulted in the radiation dose limit being slightly exceeded. The change has no great practical significance, as the noble gas releases from the plant have been considerably lower than the limit during the entire operating history of the plant.

isotopes into the air were about 0.2 MBq (as I-131-equivalent activity), i.e. approximately 0.0001% of the authorised limit. The emissions through the vent stack also included radioactive particulate matter amounting to 0.1 GBq, tritium amounting to 0.2 TBq and carbon-14 amounting to approximately 0.3 TBq.

The tritium content of liquid effluents released into the sea was 15 TBq, which is approximately 10% of the release limit. The total activity of other nuclides released into the sea was about 0.3 GBq, which is 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 about 0.07 µSv per annum, i.e. less than 0.1% 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 30 minutes.

STUK approved the environmental radiation monitoring programmes of the Loviisa power plant for 2012–2016.

A total of 300 samples were collected and analysed from the land and marine environment surrounding the Loviisa power plant during 2012. External background radiation and the exposure to radioactivity of people in the surroundings were also measured regularly. Extremely small 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 the radiation exposure of the environment or people.

4.1.11 Emergency preparedness

STUK oversees the capability of the emergency response organisations of nuclear power plants to act in abnormal situations. No situations requiring emergency response actions occurred at the Loviisa power plant in 2012.

Emergency preparedness at the Loviisa power plant complies with the main requirements set for emergency response. The emergency response organisation of the power plant consists of the organisation of the Loviisa power plant and of Fortum's technical support organisation in Keilaniemi. STUK's inspection of the emergency preparedness arrangements of the Loviisa power plant, included in the periodic inspection programme, included the inspection of preparedness training, drills, equipment and facilities, alarm arrangements, environmental radiation measurements and weather observations at the plant site. On the basis of the inspection, STUK required that emergency procedures be further developed and the Final Safety Analysis Report be updated for certain on-site radiation measurements required during emergencies. At the time of the inspection, the investigations that began following the Fukushima nuclear power plant accident were still in progress, and they had no immediate impact on the emergency preparedness activities during 2012.

The functions of the emergency information system were revised. The system is used to transfer key information on events at the plant to the emergency response centres at STUK and in Keilaniemi. The revision was necessary due to the discontinuation of the 2V network, used for data transfer, in September. The project proceeded at the equipment level and with tests carried out at supplier facilities, with the aim of commissioning the system at the end of September or the beginning of October. Data transfer to emergency response centres did, however, already begin in January 2013.

An internal emergency response drill was organised at the Loviisa power plant control centre in spring 2012. Planning of the extensive Loviisa 13 preparedness and rescue drill to be organised in 2013 began in a team of experts including representatives of authorities and from the power company.

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 the Olkiluoto power plant and assessed its organisation and personnel's competence in various areas by means of reviewing documents provided by the licensee, carrying out inspections in line with the periodic inspection programme and by 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. Occupational radiation doses and radioactive releases into the environment were low and clearly below the prescribed limits. The licensee has operated the Olkiluoto power plant in a safe manner and in compliance with the YVL Guides. Emergency preparedness at the Olkiluoto power plant is in compliance with requirements. The processing, storage and final disposal of low and intermediate level waste (operating waste) at the power plant were carried out as planned.

According to the tests and inspections carried out, the condition of the containment and the reactor coolant system, which prevent the release of radioactive material into the environment, are in compliance with requirements. A small fuel leak was detected at Olkiluoto 2 in 2011. The leak was located during the 2012 annual outage, and the leaking fuel assembly was removed from the reactor. The leak had no significance for the radiation safety of the plant environment.

Plant operation has been systematic and safe. Two events of INES class 1 were reported from the plant. Both events were related to the deficiencies observed in the main steam isolation valves at Olkiluoto 1 and Olkiluoto 2. The deficiencies were corrected immediately after detection, but TVO launched extensive investigation at both plant units to assess the comprehensiveness of the testing of systems important to safety. Three events occurred at the plant during which the plant was non-compliant with the operational limits and conditions (OLC). The events had no impact on the safety of employees or the plant surroundings. System and equipment failures had a minor safety implication for the plant. The annual maintenance outages of plant units were implemented as planned in terms of nuclear and radiation safety.

During the year, modifications were implemented for improving plant safety. The plant is in the middle of a modernisation project spanning many years, aimed at extending the service life of the plant and improving its availability. A generator and low-voltage switchgear were replaced in one subsystem at Olkiluoto 1 in 2012. At Olkiluoto 2, three devices that measure radiation levels of main steam lines during operation were replaced. TVO is also in the process of expanding the spent fuel storage at Olkiluoto. At the same time, the structures of the storage facility will be modified to comply with the current safety requirements. In 2012, STUK approved the conceptual design plan submitted by TVO concerning the renewal of emergency diesel generators.

In 2009, STUK approved the periodic safety review regarding Olkiluoto 1 and Olkiluoto 2, as well as TVO's action plan for developing plant safety. The agreed actions have mainly progressed in line with the plans. In 2012, STUK approved an action plan submitted by the power company concerning the improved application of the diversity principle in the plant units' safety systems, as well as an updated conceptual design plan to build an emergency control room. After the Fukushima nuclear accident in 2011, STUK sent a decision to the Olkiluoto power plant concerning the provisions against natural phenomena and disturbances in the power supply. The measures proposed by the power company have proceeded. STUK reviewed and approved the power company's plans for improving plant safety with regard to extreme external hazards. The plans include an action plan to improve the independence of the auxiliary feed water system from the sea-water cooling system.

In 2012, STUK provided the Ministry of Employment and the Economy with a favourable statement on TVO's application concerning a change of the operating licence conditions of the operating waste repository (VLJ repository). After the decision by the Government, the repository will be able to accept radioactive sources created by the use of radiation, and later, the low and intermediate level waste created during the operation of Olkiluoto 3.

Table 3. Events at the Olkiluoto plant units subject to special reports or a root cause analysis and/or classified INES Level 1 or higher. All events subject to reporting are discussed in Appendix 1 (indicator A.II.1).

Event	Non-compliances with the OLC	Special report and/ or root cause report	INES rating
Error in the calculation of control rod efficiency at Olkiluoto 1 and Olkiluoto 2	•	•	0
Deficiencies found in the operation of main steam isolation valves at Olkiluoto 1		•	1
Deficiencies found in the operation of main steam isolation valves at Olkiluoto 2		•	1
Human error in a job related to the Olkiluoto 1 reactor protection system	•	•	0
A failed control room emergency ventilation fan at Olkiluoto 2	•	•	0
Deficiencies in the testing of protection system at Olkiluoto 1 and Olkiluoto 2		•	

TVO's organisation has acted in a systematic and development-oriented way to improve the plant's safety. In 2012, STUK's oversight was particularly focused on TVO's preparations for the commissioning of Olkiluoto 3, as well as the integration of the project organisation and project management system with the procedures used at the operating plant units. STUK's inspections paid attention to TVO's HR planning and allocation of resources, which have ongoing procedure development that needs to be finished. TVO is still improving the description of the modification work process. The modification work procedures will be developed in particular with respect to quality management and procurement. TVO has developed its project management procedures and had its project operations evaluated by a third party in autumn 2012. TVO has continued the preparation of management system process descriptions in 2012.

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

Compliance with the operational limits and conditions (OLC)

The operational limits and conditions (OLC) list the values within which nuclear power plant units must remain during operation. STUK is responsible for verifying that TVO keeps the operational limits and conditions up to date and does not deviate from them without STUK's permission. TVO looks after the up-to-dateness of the OLC of the Olkiluoto plant, among other things, by assessing the need to update them in regular reviews and during the planning stages of modifications.

In 2012, TVO reported three events during which the plant was non-compliant with the OLC without an advance safety analysis and STUK's permission. All of these non-compliances were unintentional. In one of the cases, non-compliance with the OLC was due to a human error in the planning stage of a modification, and, in another case, a human error in the implementation stage of a modification. In the third case, an error in the calculation method used to assess the efficiency of control rods during plant start-up led to non-compliance with the OLC. The individual events did not put the plant or its surrounding environment at risk. There were, however, three events in total, which makes it important to ensure that there are no deficiencies in the knowledge of the OLC or the procedures to follow the OLC that would lead to unintentional non-compliance. TVO analysed all events and defined corrective measures to prevent similar events from occurring in the future. A more detailed description of these events is included in the section Operation and operational events below and in Appendix 3. STUK oversees the licensee's operations at the plant site and carries out random inspections to ensure compliance with the requirements and limits of the OLC. No non-compliances were observed in the 2012 inspections.

During the year, TVO submitted to STUK for approval 17 amendment proposals for the operational limits and conditions. The amendments were mainly due to modifications and equipment replacements carried out at the plant, as well as an OLC development project (see section 4.2.5). STUK approved 14 of the amendments as such or with minor modifications. Needs for further surveys or corrections were found during the processing of two applications, and STUK returned the applications to TVO for completion. One application was not approved, as there was no justification for the changes proposed by TVO. STUK observed in connection with two applications that changes to periodic testing, required by the replacement of equipment, could not be updated into the OLC when the replacement of the equipment was completed, because the processing was not yet completed at the time. It followed that the OLC was not up to date concerning these matters. STUK required that TVO process the non-compliance in accordance with its own procedures and define corrective measures to prevent similar occurrences.

TVO applied for permission from STUK for ten planned deviations from the operational limits and conditions (Appendix 1, indicator A.I.2). Six of the applications were related to modifications (for example, in five cases a single radiation measurement was disabled for a few days to allow the replacement of equipment or changing the structure at the equipment location), one to the replacement of equipment, two to a defect detected in the calculation method used for the assessment of control rod efficiency, and one to a periodic test. As the planned deviations had no significant safety implications, STUK approved the applications.

Operation and operational events

STUK oversaw the operation on a daily basis at the plant site, by inspecting the regular reports on operating activities as well as the event reports, and by making two inspections as part of the periodic inspection programme; one of these inspections was performed without prior notice. The results of the inspections are described in Appendix 5 of this report.

No events leading to a reactor trip occurred at the Olkiluoto nuclear power plant. The most significant events are described briefly in the following, and in more detail in Appendix 3. Two of these events revealed deficiencies in the planning and implementation of I&C modifications carried out in previous years. Both of these events are related to main steam isolation valves. A missing control logic wire would have prevented the valves from closing should that have been necessary. The deficiencies were not revealed when the modifications were first put into use, or in the periodic testing during the plant's operating cycles. The observa-

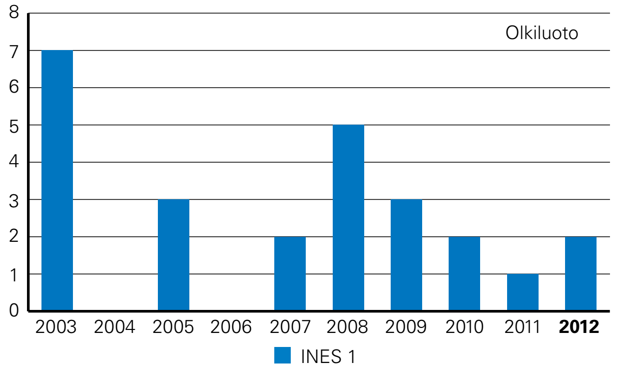


Figure 10. INES classified events at the Olkiluoto plant (INES Level 1 or higher).

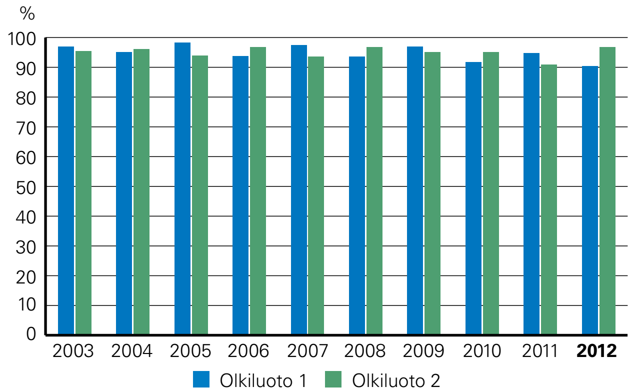


Figure 11. Load factors of the Olkiluoto plant units.

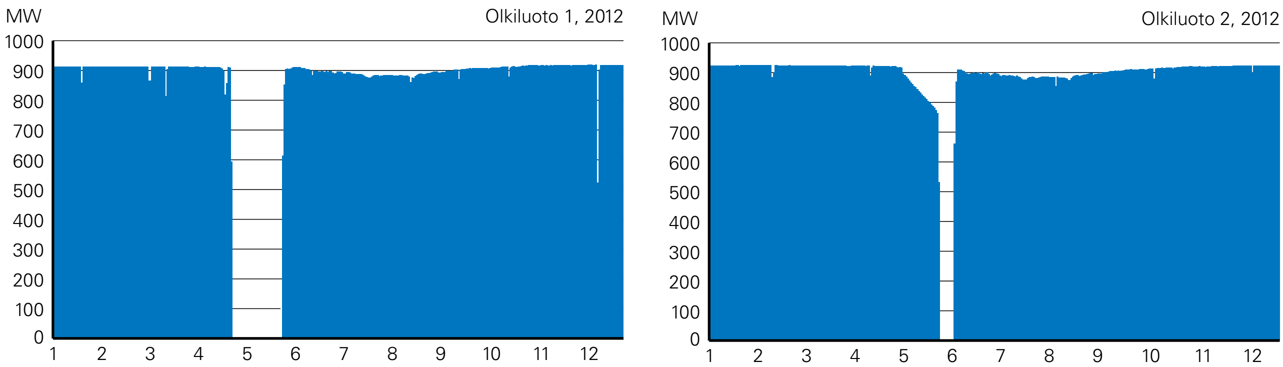


Figure 12. Daily average gross power of the Olkiluoto plant in 2012.

tion launched extensive investigations at both plant units to assess the comprehensiveness of the testing of systems important to safety. In this case, STUK required that TVO reveal the root causes that led to the deficiencies before the 2013 annual outage, and define corrective measures on the basis of the causes. The purpose of the investigations is to identify the causes that led to the deficiencies, to reveal any other similar deficiencies, and to develop the procedures so that the occurrence of similar deficiencies can be prevented in the future.

In 2012, the risks caused by component malfunctions, preventive maintenance and other events causing unavailability of equipment were 5.9% and 29.0% 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 was in line with those of previous years.

Annual maintenance outages

The Olkiluoto 1 annual maintenance outage took place from 24 April to 25 May 2012, and the Olkiluoto 2 refuelling outage from 27 May to 6 June 2012. At annual outage, equipment and structures important to plant safety are inspected, serviced, replaced or modified. These measures ensure the preconditions for operating the power plant safely during the following operating cycles. In addition, some of the nuclear fuel is replaced with fresh fuel during the annual outages. 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 used a total of 230 man-days on on-site oversight during the annual maintenance outages; these days were made up of inspections

Operation and operational events

The load factor of Olkiluoto 1 was 90.4%, while that of Olkiluoto 2 was 96.9%. The annual outages have a major effect on the load factors. The outage at Olkiluoto 1 lasted for 31 days, while that of Olkiluoto 2 lasted for 9 days. The losses in gross energy output due to operational transients and component malfunctions were 2.5% at Olkiluoto 1 and 0.003% at Olkiluoto 2.

TVO observed ***an error in the calculation method used to assess the efficiency of control rods during plant start-up****. Analyses show, however, that the error did not cause any risk to fuel integrity or plant safety.*

During the 2012 annual outage of Olkiluoto 1, TVO found that ***one of the reactor's main steam isolation valves would not have closed as planned when required****. A missing valve control conductor was revealed as the cause of the deficiency. The conductor had been removed when four inner main steam isolation valves had been replaced in the 2010 annual outage. The conductor had not been replaced due to a modification design error. The fault was repaired immediately after detection.*

TVO carried out additional checks and tests at both plant units after the observation, and ***found the same deficiency also at Olkiluoto 2****. In a turbine automation renewal carried out in 2005, a conductor had been unnecessarily removed. As a result, the same isolation valve as at Olkiluoto 1, and another isolation valve beside it, would not have closed automatically when required. The fault was repaired.*

During the annual outage of Olkiluoto 1, reactor protection system pushbuttons were replaced in the control room. ***Due to a human error****, the work was started in the wrong order. The necessary preparations had not yet been completed for the pushbuttons in question, and* ***the work triggered a plant protection function****. With the protection function activated, two pumps contributing to the cooling of the reactor core would not have started up when required.*

TVO modified the Olkiluoto 2 control room ventilation system in September. The preparation for the work included electrical isolation of equipment to ensure safety of the workers and the plant. During the planning of the work, it was not noted that a change in the position of one circuit breaker also affects the control room emergency ventilation fan, preventing it from starting when required. The error was detected in a test two weeks later when ***one of the two fans feeding overpressure into the control room in accident conditions failed to launch****.*

The events are described in more detail in Appendix 3.

Annual outage at Olkiluoto 1

The annual outage of Olkiluoto 1 took 31 days. TVO decided to launch the outage approximately one month earlier than planned due to a water leak observed in the generator. As this constituted an essential change to the original planning and execution of the annual outage, STUK required that TVO produces a safety assessment of moving the annual outage forward. The outage lasted more than 13 days longer than planned. TVO was able to carry out the annual outage in a controlled manner, and it has not reported any deviations that would have affected the safety of the plant or the personnel as a result of moving the annual outage forward.

During the annual outage, one fifth of the nuclear fuel was replaced. Major modifications included the replacement of the generator and the replacement of low voltage switchgear in one subsystem. In addition to the modifications, a considerable number of inspections, maintenance work, repairs and tests were carried out for systems, equipment and structures. Due to the annual outage being moved forward, some work planned for the annual outage could not be completed or their scope had to be changed. Most important of these included the replacement of the low voltage switchgear, mentioned above, in one subsystem instead of two, and the postponement of two battery bank replacements to power operation.

Olkiluoto 1 had a repair outage from 26 to 27 May 2012 immediately after the annual outage to repair a leaking valve in the steam extraction system of the turbine island.

Annual outage at Olkiluoto 2

The refuelling outage of Olkiluoto 2 lasted for nine days, which was more than a day longer than expected. The delay was caused by events such as a fault detected in a cable of the refuelling machine, and the repair of the fault.

Almost 25 per cent of the nuclear fuel in the reactor was replaced during the annual outage. Three measurement devices that monitor the radiation levels in the main steam pipes were also replaced. No major modifications are carried out during a refuelling 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.

A fuel leak was detected at the plant unit in August 2011. TVO monitored the development of the leak during the operating cycle. During the annual outage, the leaking fuel assembly was identified and removed from the reactor. The fuel leak had no significance to the radiation safety of the environment, as the released radioactivity was contained within the plant.

TVO observed similar main steam isolation valve control problems as those detected at Olkiluoto 1. The event is described in greater detail in Appendix 3.

and other oversight work on various areas of expertise, such as equipment and system inspections at the plant site, and inspection rounds. In addition, resident inspectors worked regularly on site, primarily responsible for overseeing the Olkiluoto 1 and Olkiluoto 2 plant units. For a more detailed account of the annual outage inspection, see Appendix 5.

4.2.3 Ensuring plant safety functions

Deterministic safety analyses

An extensive evaluation of the transient and accident analyses (deterministic safety analyses) carried out to verify the safety functions of the plant has been performed in connection with the periodic safety review of 2009. Since then, TVO has further supplemented the sections of the transient and accident analyses that concern an extension of postulated accidents and loss of coolant accidents. In 2012, no updated deterministic safety analyses were delivered to STUK.

Probabilistic risk analyses

The risk of a severe nuclear accident is evaluated on the basis of a probabilistic risk analysis (PRA). As a rule, PRA calculations use regularly updated information of the occurrences of initiating events and the unavailability of equipment together with a logical model of the plant's systems and their interdependencies.

The annual probability of a severe reactor accident calculated for the Olkiluoto plant was $1.35 \cdot 10^{-5}$, which is approximately the same as that of 2011

(1.33·10^{-5}/year). The increase of approximately 1.5% compared to 2011 was due to an update of the common cause failure information of the equipment, changes to some testing intervals, and small changes in modelling.

The accident risk at the Olkiluoto power plant and its changes are discussed in greater detail in Section A.II.4 of Appendix 1 entitled "Accident risk of nuclear facilities".

Operating condition of safety systems

STUK has approved TVO's action plan to improve the application of the diversity principle in the safety systems of Olkiluoto 1 and Olkiluoto 2. In connection with the periodic safety review, STUK presented the requirement to evaluate the adequacy of diversity and to develop a plan to improve the diversity. In its report, TVO has discussed the adequacy of the diversity at the levels of main safety functions, systems and equipment of the plant units, and found that the reactor level measurement and neutron flux measurement do not comply with the diversity principle. TVO has delivered to STUK plans for the diversification of the low and high reactor level trips and is looking into the improvement of the independence of the reactor trip conditions of neutron flux measurements.

4.2.4 Integrity of structures and equipment

STUK monitored the integrity of structures and equipment on the basis of periodic inspections and in connection with repairs and modifications. No observations restricting the use of pressure equipment or pipelines were made during the periodic inspections.

In 2012, leak tests of the containments and containment levels were completed during the annual outages of Olkiluoto 1 and Olkiluoto 2 in accordance with the testing programme. The tests included any openings and isolation valves. The results of the tests were acceptable.

Fuel and control rods

In August 2011, a fuel leak was detected at Olkiluoto 2, and the leaking fuel assembly was removed from the reactor in the 2012 annual outage. As the cause of the damage could not be revealed by inspections, TVO carried out additional inspections when repairing the fuel assembly after the annual outage. Control rods were also inspected and replaced during the annual outages in accordance with the approved plan. The control rods removed from the reactor were inspected after the annual outage, during the operating cycle.

Visual inspection in accordance with TVO's fuel inspection plan was carried out at Olkiluoto 1 during the 2012 operating cycle for six fuel assemblies and channels removed from the reactor after being exposed to radiation for four cycles. Visual inspections were also carried out for the channels of three fuel types, and fuel assemblies were inspected in accordance with the spent fuel condition monitoring programme. No deviations were detected in the inspection of the fuel assemblies currently being used or removed from use.

TVO has delivered the licensing materials for new fuel assembly types to STUK for approval. According to TVO's plans, the test assemblies will be loaded at Olkiluoto 1 and Olkiluoto 2 in the 2014 annual outage.

Reactor coolant system

The power company monitors the condition of the reactor coolant system with periodic inspections and reactor coolant system load monitoring, which STUK inspects in connection with the periodic inspection programme. The condition of the reactor coolant system remains good at both plant units.

An indication detected in a weld joint of a nozzle in the Olkiluoto 2 feed water system in 2003 has been monitored with periodic inspections. The size of the indication has remained the same from 2003 to 2012 based on the qualified inspection procedure used. The weld in question was also inspected using a new phased ultrasonic method in the 2011 annual outage. This unqualified method yielded a result based on which the indication was analysed to be 15.3 mm deep at the same place and orientation. This is approximately 5 mm deeper than the measurement yielded by the inspection methods previously used. The indication was inspected again in the 2012 annual outage using a qualified and phased method. The results were practically identical with the results of the 2011 inspection. Qualification of the phased method is currently in progress.

During the year under review, TVO surveyed the significance of the chloride content of the graphite gaskets used in the control rod actuators at Olkiluoto 1 and Olkiluoto 2. The chloride content of the new guide sleeve gaskets installed during the annual outage has been found to exceed the allowed value. The significance of this for the integrity of the reactor coolant system was studied. No increase of chloride content has been detected in the reactor coolant system's water chemistry. The results of the reactor trip tests carried out in recent years have also been acceptable. Risk of corrosion is considered to be low due to the structure of the control rod mechanisms. TVO will deliver the results of the surveys to STUK and inspect some guide sleeves and their gaskets again in the 2013 annual outage.

Periodic inspection programmes

Periodic in-service inspections must be carried out on pressure equipment and pipes important to nuclear safety as required by the YVL Guides. The inspection targets are selected in accordance with an annual periodic inspection programme defined by the power company and approved by STUK. In 2012, inspection of the reactor pressure vessel nozzles, cover, bolts, nuts and washers, as well as a visual inspection of the internals, was carried out at Olkiluoto 1. Some pipes and equipment were also inspected. At Olkiluoto 2, follow-up inspections of the reactor pressure vessel's feed water nozzle took place, together with a visual inspection of the internals. Pipes and equipment were also inspected. The Olkiluoto 1 and Olkiluoto 2 faults being monitored have remained unchanged, and the inspections did not reveal any new faults with nuclear safety implications.

A leak test was carried out for the Olkiluoto 1 containment during the annual outage. The leak test met the design requirements.

Maintenance, ageing management

STUK oversaw and inspected the use, maintenance and ageing management of valve and lifting equipment units as well as the organisation, HR resources and competence verification of these operations. The inspection revealed that the licensee was not able to give an adequate account of the periodic inspection practices for safety classified lifting aids at the Olkiluoto nuclear power plant. Therefore, STUK required that TVO deliver a separate account of the matter to STUK by the end of 2012.

As a part of ageing management, STUK also assessed TVO's procurement procedures for demanding spare part deliveries and modifications of Olkiluoto 1 and Olkiluoto 2. The inspection proved that TVO's operations are at an acceptable level. The technical and quality management requirement specifications for purchases comply with the YVL Guides that concern the procurement of equipment, and adequate resources and expertise are available for the preparation of purchases. However, STUK observed that the presentation of the failure trends of the plant units is not detailed enough where fault messages and operation restrictions are concerned. Therefore, STUK required that TVO develop its annual reporting so that safety system fault trends caused by actual inoperability would be easier to recognise. STUK has also required better prediction and traceability of various fault types in the ageing management programme.

The ageing management inspection of constructions and buildings was targeted at steel structures, HR planning, monitoring processes and inspection operations. At the inspection, requirements were issued on the further specification of procedures concerning the condensing pool equipment responsibilities. STUK also required that the fuel pool inspection and reporting practices be updated to the pool inspection procedures. STUK also required an account of safety inspections of the KPA storage.

Emergency diesel generators

Due to the bearing damage detected in the emergency diesel generators of the Loviisa power plant, STUK requested from TVO information on the bearing types used in the Olkiluoto diesel generators. The bearings of the Olkiluoto diesel generators were found to be of a different type from those used in Loviisa, but TVO was planning to use a new bearing type by the same manufacturer that supplied the bearings used in Loviisa. STUK required that TVO ensure that the new bearings do not have problems similar to those experienced at the Loviisa power plant.

Operation and condition monitoring of valves

A warranty inspection of an inner isolation valve of a main steam line installed in 2010, carried out during the 2012 annual outage of Olkiluoto 1, revealed small liquid penetrant indications that refer to pitting on the hard faced sealing surfaces of the slides.

STUK required that the power company also open and inspect three other valves and determine their operability. The three opened valves were in the same condition as the valve subjected to warranty inspection, and they had been found to be tight in the leak test performed before opening. One valve was inspected at Olkiluoto 2, and similar indications were observed on the slide. STUK granted test operation permission for the valve on the basis of TVO's reports. STUK required that TVO submit for approval a root cause analysis of the deviation report related to the observation, as well as a plan for measures that can be used to avoid corrosion of the sealing surfaces in the future.

The reactor overpressure protection system's control valves were opened for inspection, because their opening times exceeded the allowed limits. A new indication was observed on the sealing surface of one poppet seat. The indication was stated to have no significance for valve operation, and STUK granted test operation permission for it.

Repairs and modifications

TVO had a reactor coolant pump's stator core repaired without an approved plan contrary to the requirement of Guide YVL 5.7. A repair plan was submitted to STUK for approval after the completion of the work. STUK required that TVO deliver an account of the decision-making process related to the repair as well as the chain of events following it, and specify the corrective measures that will prevent similar situations in the future. TVO's account of the events states that the deputy who processed the repair plan was not familiar with the scope of the approval process, which is why permission was given to carry out the work. As a corrective measure, the power company has prepared a separate repair work procedure for electrical and I&C equipment, and the persons in question will be given training on the preparation and approval of repair plans.

4.2.5 Development of the plant and its safety

In 2009, STUK approved the periodic safety assessment regarding Olkiluoto 1 and Olkiluoto 2 as well as TVO's action plan for decreasing the risk of accidents and releases. The power company is assessing and developing the application of the diversity principle at the plant (see section 4.2.3), the operational limits and conditions, as well as abnormal and emergency operating procedures.

> ***Pressure equipment manufacturers and inspection and testing organisations***
>
> *A total of 25 nuclear pressure equipment manufacturers were approved for the Olkiluoto plant (plant units Olkiluoto 1, 2 and 3). STUK approved 20 testing organisations to carry out tests related to the manufacture of mechanical equipment and structures, plus one inspection organisation to review the construction plans of mechanical components and structures and to carry out their structural and commissioning inspections. Two testing organisations were approved to carry out periodic tests of mechanical equipment and structures pursuant to YVL 3.8.*

Targets for development based on the Fukushima accident

After the Fukushima nuclear accident in 2011, STUK sent a decision to the licensees concerning provisions to be made for natural phenomena and disturbances in the power supply. STUK reviewed and approved TVO's action plan with additional requirements. TVO is planning a separate water supply system independent of existing plant systems to cool the reactors of Olkiluoto 1 and Olkiluoto 2. STUK required addition of further details to the plan concerning situations such as loss of power supply. TVO is also planning measures to improve the independence of the auxiliary feed water system from the sea-water cooling system. TVO delivered to STUK an account of the adequate volume and availability of water for the simultaneous cooling of all reactors, fuel pools and spent fuel storage during long-lasting accidents which involve loss of the normal heat sink. TVO also delivered a status report on the need for portable generators, pumps and other equipment, and the measures to ensure their fast availability. Portable generators are to be used for purposes such as recharging the uninterruptible power supply batteries during long-lasting accidents.

Construction of an emergency control room at Olkiluoto

Pursuant to a Government Decree, a nuclear power plant shall have an emergency control room independent of the control room, and the necessary local control systems for shutting down and cooling the nuclear reactor, and for removing residual heat from the nuclear reactor and spent fuel stored at the plant in a situation where operations in the main control room are not possible.

TVO is in the process of constructing emergency control rooms for the operating Olkiluoto plant units in compliance with the requirements set out in STUK's implementation decision regarding Guide YVL 5.5 and in the periodic safety assessment of Olkiluoto. STUK reviewed and approved the updated conceptual design plan for the emergency control rooms in 2012. The update was based on STUK's earlier decision that required a more thorough assessment of the consequences of a loss of main control room as well as the adequacy and comprehensiveness of the measurement information and controls to be used at the emergency control room. Final design materials are expected to be completed in 2013.

Replacement of diesel generators

TVO submitted a conceptual design plan concerning the replacement of Olkiluoto 1 and Olkiluoto 2 emergency diesel generators to STUK for approval in late 2011. According to the plan, the EGDs will be replaced to meet the changed power need, including potential need for increased electrical power due to future plant modifications. The change will also improve the reliability of the emergency generators. Both operating plant units of the Olkiluoto power plant have four subsystems, and each subsystem has its own standby diesel generator.

The most significant difference in the operating principles of the new emergency diesel generators compared to the current ones is their cooling system. The new diesel motors are to have air cooling in addition to the sea-water cooling. The cooling arrangement will have two heat exchangers in the cooling circuit of each diesel generator, one for sea-water cooling and one for air cooling. The operating principle of the sea-water cooling will remain the same, and sea-water cooling will continue to be the primary cooling method. Cooling radiators will be installed for the air cooling on top of the diesel generator buildings. This cooling solution will provide two independent heat sinks, which is a significant improvement for nuclear safety.

TVO submitted an updated conceptual design plan for the diesel generator replacement to STUK for approval in late 2012. It has been estimated that the installation and commissioning of all the new diesel generators will be completed by 2020.

Low-voltage switchgear replacement project

TVO has initiated a project (the SIMO project) for replacing the switchgears of the low-voltage distribution systems at Olkiluoto 1 and Olkiluoto 2. The primary reason for replacing the switchgears is the increase in maintenance costs due to the ageing of original equipment, as well as 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 electrical systems important to safety. TVO has already replaced the medium-voltage switchgear (6.6 kV) in 2005 and 2006. The voltages in the low-voltage networks of the units vary from 24 V DC to 660 V AC. 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 for execution, the low-voltage switchgears will be replaced during plant units' annual outages of 2010–2016. TVO made the first switchgear installations of the project in the 2010 annual outage. They concerned an electrical system less important to safety. During the 2011 annual outage of Olkiluoto 2, TVO implemented the first switchgear replacement to systems important to safety so that the low-voltage switchgear and associated transformers in one of the plant unit's four subsystems was replaced. TVO continued the work in the 2012 annual outage of Olkiluoto 2 by replacing the switchgear of another subsystem. STUK reviewed the documents for the switchgear project and oversaw the execution of the work at the plant. TVO intends to continue the project at Olkiluoto 2 during the 2013 annual outage by replacing the switchgear of two subsystems.

Development of the operational limits and conditions (OLC)

The OLC development plan states that TVO improves the justification for requirements and clarifies the requirements when necessary. In 2011, TVO conducted internal discussions regarding the needs to amend the OLC and produced amendment proposals. TVO submitted the first four proposals to STUK for approval in 2012. The development project will continue at least for the years 2013 and 2014.

Further development of abnormal and emergency operating procedures

The periodic safety assessment required that TVO assess the development needs of all the abnormal and emergency operating procedures, and prepare background and justification materials for the procedures. STUK required that the strategy and justification documents and validation of the emergency operating procedures and outage procedures be completed during 2012.

During the year, TVO prepared the outage procedures together with their background and justification materials. The procedures cover the loss of reactor cooling systems necessary during the outage, as well as leaks through the bottom of the reactor. Some needs for changes were found at the review of the procedures, but changes were not yet made in 2012. All emergency operating procedures were updated and validated using a simulator. The work concerning the background materials is not yet complete. STUK has overseen the procedure development work and advised that TVO should pay particular attention to the comprehensiveness of the validation of the procedures.

4.2.6 Spent nuclear fuel storage and operating waste

STUK inspected, in accordance with the inspection programme, the management and final disposal of operating waste at the Olkiluoto power plant. The 2012 review focused on issues such as the organisation and resources, communications at the plant and to STUK, and the status of waste management projects. No significant deficiencies or needs for development were detected in the review. The processing, storage and final disposal of low and intermediate level waste (operating waste) at the Olkiluoto power plant were carried out as planned and no significant events in terms of plant or environmental safety were evident. The volume and activity of operating waste in relation to generated electrical power remained low compared with most other countries. Contributing factors include the high quality requirements for nuclear waste management and nuclear fuel, the planning of maintenance and repair operations, decontamination, component and process modifications, as well as waste monitoring and sorting, which enable some of the waste with a very low radioactive substance content to be exempted from control. Waste below the set activity limits was exempted from control at the power plant with STUK's approval in 2012 to be processed elsewhere. Waste exempted from control included maintenance waste, scrap metal and hazardous waste to be processed further, such as waste oil. In addition, the power plant employs efficient procedures for reducing the volume of waste destined for final disposal.

The review concerning the waste repositories covered the organisation, communications, procedures and ongoing research status of the operating waste repository (VLJ repository) as well as the maintenance procedures of the concrete and rock structures of the repository. An inspection visit to the VLJ repository was also included. No significant deficiencies were detected in the review. STUK presented suggestions for developing the content of the VLJ repository's bedrock monitoring research reports.

Expansion of the spent fuel storage

TVO is currently adding three pools to the spent fuel storage (KPA storage) at Olkiluoto. At the same time, the structures of the storage facility will be modified to comply with the current safety requirements. The current KPA storage capacity in Olkiluoto will be sufficient until 2014, and the expansion will increase the capacity for the spent fuel coming from the Olkiluoto plant units 1, 2 and 3.

TVO submitted the documentation regarding expansion of the storage to STUK for approval at the end of 2009. The extension of the storage is designed to fulfil the current safety requirements, the most significant of which are its seismic resistance and its ability to withstand the crash of a large aircraft. At the same time, the structures of the existing part of the storage will be modified with a view to the current requirements. In conjunction with assessing the safety of the expansion, STUK reviewed the needs to update the earlier design basis and safety analyses, the resources and operational methods of TVO's project organisation, the structural design basis of the storage, as well as the methods with which TVO will ensure the safety of the existing storage facilities. Following its reviews, STUK found that the storage expansion meets the safety requirements. During the construction work, STUK will assess, among other things, the design basis with regard to aircraft crash resistance and the plans regarding annexation of the expansion to the storage currently in use.

In 2012, the construction work of the new pools continued at the KPA storage expansion site. The outer walls and roof of the expansion are complete, and the lining of the pools has begun. STUK reviewed the dismantling plans for the end wall between the existing facility and the expansion as well as the plans for the protective structures to be used during the work. STUK has reviewed the design basis and implementation plans for airplane crash shield constructions. The design and construction of structures that fall into the scope of construction engineering are overseen by an inspection organisation approved by STUK. STUK has participated in the oversight and steering of the inspection organisation's work.

Amendment of the operating licence conditions for TVO's operating waste repository (VLJ repository)

On 21 September 2011, TVO submitted an application to the Government for a amendment of the operating licence of the VLJ repository to allow the final disposal of the low and intermediate level nuclear waste from the Olkiluoto 3 plant unit currently under construction, and that the repository could also be the final destination of radioactive sources created by the use of radiation, currently stored in underground facilities. These sources have been removed from use as radioactive waste. According to the Radiation Act and the Radiation Decree, such waste is under the responsibility of the state and the management of STUK. At STUK, operative responsibility for waste management and the regulatory operations concerning waste are clearly separated to different units of the organisation. The licence conditions were also revised with respect to nuclear materials.

STUK prepared a safety assessment for the modification of the operating licence of the VLJ repository and used the assessment as the basis of a favourable statement issued to the Ministry of Employment and the Economy on 28 June 2012 on the modification of the operating licence conditions of the Olkiluoto VLJ repository. In its statement, STUK stated that the prerequisites for a modification of the operating licence of the VLJ repository are met and that STUK will specify more detailed requirements concerning the management of the waste produced at Olkiluoto 3 and the final disposal of the radioactive waste under the responsibility of the state in separate decisions.

The Government made a decision on the modification of the operating licence conditions of the Olkiluoto VLJ repository on 22 November 2012.

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 the revised and supplemented waste management schemes and information on the costs and prices of nuclear waste management measures by the end of June. The update of the waste management scheme includes an index adjustment to the cost and price information as well as an estimate of the amount of nuclear waste at the end of 2012.

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 statements, STUK assessed the technical plans and cost estimates on which the financial provision is based and considered them to be appropriately updated. TVO's extent of liability is €1,242.3 million at the end of 2012.

According to the Nuclear Energy Decree, supplemented waste management schemes for the technical and financial plans, as well as the related calculations, must be prepared every three years. The next revision will take place in 2013.

4.2.7 Organisational operations and quality management

Based on STUK's oversight and the results of operating activities, it can be stated that, with a view to ensuring safety, TVO's organisation has operated in a systematic and development-oriented way. During the year, STUK has focused its oversight activities on TVO's human resources planning, development of the modification work process, and the quality management competence of the procurement personnel. One of the particular areas of focus has been TVO's preparations for the commissioning of Olkiluoto 3, including the integration of the project organisation and management system to the organisation and management system of the operating plant units.

TVO did not make any changes relevant to safety in its organisation during 2012. TVO has prepared office-specific HR plans that take the needs of Olkiluoto 3 and Olkiluoto 4 into account. Resource plans are based on estimates by supervisors and the plant supplier as well as on TVO's previous experience. STUK observed during the review that HR planning is the duty of the supervisors, but the organisation has no unified tools or methods for it. Some sections of the organisation have limited resources, and the work load of some individual employees is large. For example, there has been a temporary lack of resources due to personnel changes in the Quality and Environment Office in 2012. STUK required that the development of TVO's HR planning and resource allocation procedures be completed by the end of 2012. STUK will review the development of the procedures in 2013. The Nuclear Energy Act was changed in August 2012 with respect to the back-up personnel requirements, among other things. STUK required that TVO take immediate measures to meet the requirements of the reformed Nuclear Energy Act concerning the back-up personnel for persons responsible for emergency and security arrangements.

A functional, reliable and smooth modification work process has critical importance for nuclear safety. In 2011, STUK required TVO to define how the modification work process is measured and to particularly develop the quality management and procurement procedures as well as the human resourcing. TVO's development work has seen some progress during 2012, but is still incomplete. In autumn 2012, TVO had a third party evaluate its project operations. The modification work process has been described by a working group and in a student thesis. Modification work process measurements are being developed.

TVO has continued the preparation of management system process descriptions in 2012. STUK approved the general part of TVO's management system which contained a written definition and description of TVO's main processes. In spring 2012, TVO has established a business planning section with the purpose of supporting the description and development of TVO's operating processes, among other things. The objective is to unify the group's internal operating methods through the group-level development of enterprise resource planning.

In 2012, STUK ordered from a third party quality management specialist an assessment of TVO's procurement operations and supplier evaluation procedures. The evaluation results confirmed the necessity of the measures required from TVO by STUK in 2011, including the improvement and further specification of the assessment of suppliers' and subcontractors' compliance, the definition of requirements for the products being procured, communication of the requirements to suppliers, and the exchange of information between suppliers and their subcontractors. TVO must be able to make sure that TVO, the supplier of the product, and the subcontractors have an identical view of the product requirements and the necessary product quality management. STUK also required further specifications for the competence management of the personnel that conduct supplier audits.

STUK oversaw the oral examinations of shift personnel where the shift managers, operators and trainee operators prove that they are conversant with all salient matters related to plant operation and safety. In 2012, STUK granted 22 licences to shift managers and operators on application by the power company and following a successful oral examination, five of them to new operators. STUK granted a trainee licence to six trainees in the basic operator training programme. The licence entitles the holder to supervised practical training in the main control room. All participants passed their examinations in 2012. 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 licences 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

In 2012, STUK reviewed reports, carried out on-site inspections, implemented a periodic inspection programme, and sent resident inspectors to their rounds to oversee the maintenance of the fire protection systems and arrangements that ensure fire safety at the Olkiluoto power plant.

STUK carried out an inspection of the Olkiluoto 1 and Olkiluoto 2 fire protection systems in line with the periodic inspection programme and required that the type of cable penetrations in the intermediate floor of the relay room and cable compartments be confirmed against the requirements of the plant's original fire compartment concept. TVO delivered to STUK a report that shows that the original requirements set for the penetrations are met. TVO has, however, launched the replacement of penetrations of this type in accordance with its continuous plant unit safety improvement programme. STUK also required that the observations made at TVO's own internal fire inspections and by third parties (inspection organisations and insurance companies) be recorded in a unified manner. This requires supplementing the plant procedures.

4.2.9 Operating experience feedback

STUK assessed the operating experience feedback activities and corrective measures on the basis of reports, inspection visits and inspections within the periodic inspection programme. There are development actions in progress in both the internal and external operating experience activities at the Olkiluoto power plant.

During the year under review, two INES 1 classified events took place at the Olkiluoto plant units as deficiencies were detected in the functionality of main steam isolation valves at both Olkiluoto 1 and Olkiluoto 2 during the 2012 annual outage. For a more detailed description of the events, see Appendix 3. During the year, the power company prepared one root cause analysis concerning the events related to isolations during the annual outage. The root cause analysis discusses seven events that took place during annual outages 2008–2011. The analysis systematically presents the causes and corrective measures for individual events, considers potential root causes and defines additional measures based on them. The root cause analysis has been proven useful. The analysis presents several causes that had not been identified in the original event reports but had a role in the events. The analysis is based on repeated isolation-related events, and the effectiveness of the proposed corrective measures will be followed up in future annual outages.

TVO produced five special reports regarding the unexpected operational events that occurred in 2012. For a more detailed description of the events discussed in special reports, see Appendix 3. In addition, TVO produced 13 event reports and three operational transient reports, of which eight and three were submitted to STUK, respectively.

In the operating experience feedback review, STUK verified instructions, procedures and new practices related to the feedback operations. Despite personnel changes, operations were found to be well organised and instructed, and had adequate resources. The operating experience feedback team gathers 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. Twice a year, the team meets together with the representatives of the management. Expertise has been added to the team by including a simulator trainer from Olkiluoto 3 and the project's safety engineer. A new procedure has been issued in 2012 on the reporting of Olkiluoto 3 events to STUK. Operating experience feedback utilises several information systems, such as the quality management system KELPO and the operating experience system OPEX. Operating experience feedback personnel have been trained and appointed for the various organisational units. They are responsible for making sure that the operating experience feedback received by the office or unit from the operating experience feedback team is processed and that measures are taken forward and reported.

The fire that took place during a containment leak test carried out at the 2011 annual outage of Ringhals 2, as well as the obstructions in the containment spray systems of Ringhals 2 and 4 observed during the cleaning and inspections carried out after the fire, were identified as issues relevant to Olkiluoto power plant. Five suggestions for measures have been recorded in KELPO concerning the fire, two of which have been implemented. The implemented measures are an update to the tightness test procedure (inspection of the removal of flammable materials) and the installation of portable fire detectors during annual outages. Work in progress includes an update to the hot work plan, further specification of the hot work instructions, and the measures aimed at the reduction of fire load. Instructions to remove flammable materials and sources during pressure tests have been added to the pressure test procedure for Olkiluoto 3. Guarding and records of materials taken into the containment will also be organised. Inspections of the containment spray systems of Olkiluoto 1 and 2 have been completed, and no debris was found in the pipelines or spray nozzles that could have caused potential failure of the spray system when needed.

Concerning the events at Olkiluoto plant units, STUK saved one new report, one supplement to an earlier report and one follow-up report into the operating experience feedback database maintained by the IAEA. The new report concerned the fractures found in the valves of the overpressure protection and residual heat removal system of the reactor coolant systems of Olkiluoto 1 and Olkiluoto 2. The supplementing report was prepared on the outer steam line isolation valves' disturbances detected at Olkiluoto 1 in 2009, and the follow-up report on the repairs and modifications carried out for the pipe penetrations of the emergency cooling system pump rooms of the Olkiluoto plant units to repair the deficiencies reported in 2009.

The IAEA report 'Highlights from the International Reporting System for Operating Experience (IRS) for Events 2010–2011' summarises the IRS report produced for the faults in the control valves of the Olkiluoto 314 valves as an example of the challenges of modification management.

4.2.10 Radiation safety of the plant, personnel and the environment

Occupational radiation safety

STUK carried out a radiation protection inspection according to the periodic inspection programme at the Olkiluoto power plant, focusing on occupational dosimetric surveillance and radiation measurements. Based on the inspection, STUK required an account of the procedures used to take care of dosimetry in certain emergencies which prevent measurements at the plant and required updates to the power company's administrative procedures related to personal dosimetry. STUK also required that the power company deliver in 2014 to STUK for approval a conceptual design plan that discusses the corrective measures to improve the spare part situation of the fixed radiation monitors of the interim storage for spent fuel.

The dosimeters used for measuring the occupational radiation doses underwent the annual tests. The tests comprised irradiating a sample of dosimeters at STUK's measurement standard laboratory and reading the doses at the power plant. The test results were acceptable.

STUK carried out targeted radiation protection inspections during the annual maintenance at the Olkiluoto plant units. In the inspections, STUK

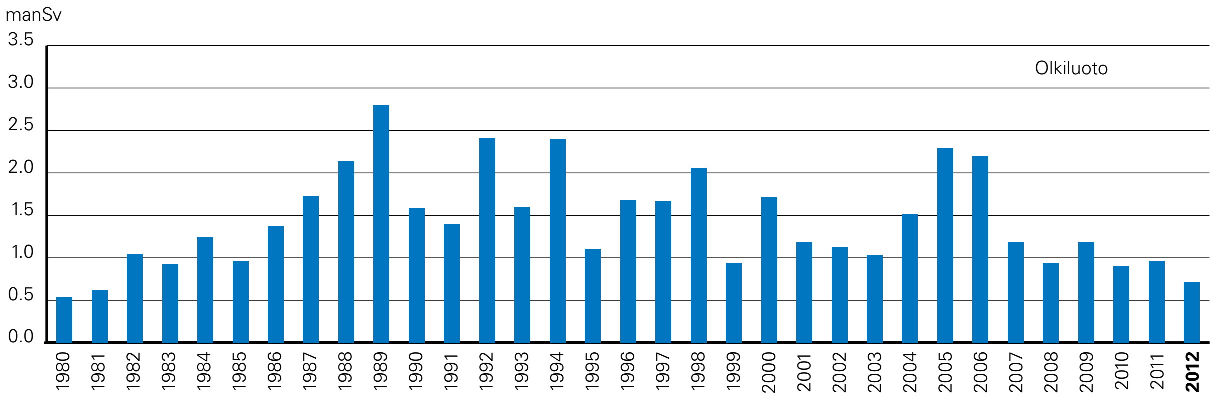


Figure 13. Collective occupational doses since the start of operation of the Olkiluoto units 1 and 2.

assessed the radiation protection personnel's work and resources. At the same time, the activities of employees in radiation work within the controlled area were assessed. Based on the inspections, radiation protection at the plant was found to be at a good overall level, and to have adequate resources. No significant deficiencies in the employees' work and use of protective equipment were observed during the annual outages. The inspections only revealed a few deficiencies related to unnecessary presence of employees in a radiation work environment.

Radiation doses

In 2012, the collective occupational radiation dose was 0.53 manSv at Olkiluoto 1 and 0.19 manSv at Olkiluoto 2. 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 gigawatt of net electrical power. This means a dose value of 2.20 manSv per Olkiluoto plant unit. This threshold was not exceeded at either plant unit.

The collective occupational radiation dose at Olkiluoto was the lowest of any annual outage since the first years after the commissioning of the plant units. The collective occupational radiation doses of employees at the Olkiluoto power plant were smaller than the average doses of employees working in boiling water reactors in the OECD countries.

The occupational radiation doses of nuclear power plant workers mostly accumulate in work carried out during annual maintenance outages. The collective radiation dose of employees due to operations during the outage at Olkiluoto 1 was 0.43 manSv, and the collective radiation dose due to operations during the outage at Olkiluoto 2 was 0.14 manSv. The annual outage of Olkiluoto 1 was brought forward, but this caused no radiation protection problems or higher radiation doses. The radiation levels at the turbine plants continued to decrease thanks to the new steam dryers that were installed in 2005 and 2006.

The highest individual radiation dose accumulated was 6.3 mSv at Olkiluoto 1 and 3.9 mSv at Olkiluoto 2. The highest individual dose incurred during the annual maintenance outages of both plant units was 7.9 mSv. The highest individual dose incurred during the year was 9.0 mSv. The highest individual radiation doses have been less than 10 mSv during the last six years. The radiation doses for nuclear power plant workers were below the individual dose limits. The effective dose for a worker from radiation work must not exceed the 20 manSv/year average over any period of five years, or 50 manSv in any one year.

The individual radiation dose distribution of workers at the Olkiluoto and Loviisa nuclear power plants in 2012 is given in Appendix 2.

Radioactive releases and environmental radiation monitoring

Radioactive releases into the environment from the Olkiluoto nuclear power plant were well below authorised annual limits in 2012. The releases of noble gases into the air were approximately 1.2 TBq (as Kr-87-equivalent activity), which is approxi-

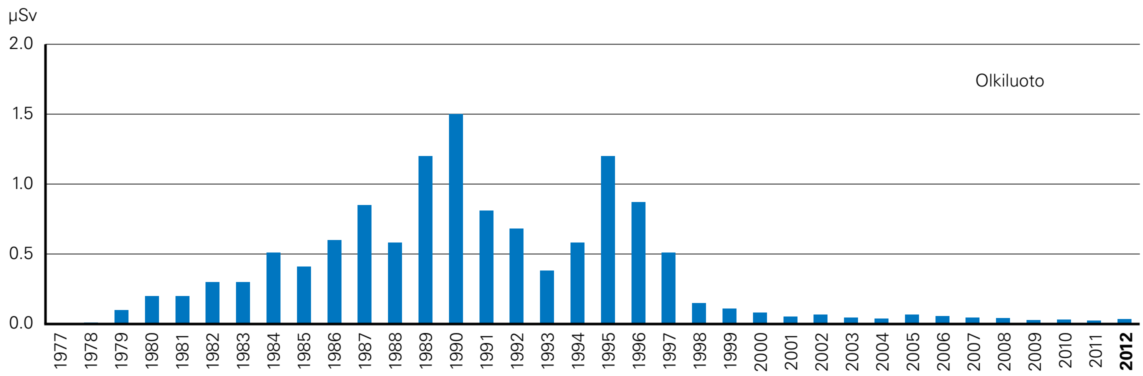


Figure 14. Annual radiation doses to the most exposed person of the public since the start of operation of the Olkiluoto units 1 and 2. Over the recent years, the doses calculated based on the radioactive discharges has remained below one percent of the set limit, 0.1 milliSv.

Table 4. Radioactive nuclides originating from the Olkiluoto power plant, found in the environmental samples.

Number of environmental samples containing radionuclides originating from the NPP in 2012. Figures indicate the number of positive samples in a sample group. Several different nuclides may be found in the same sample.

Type of sample	H-3	Mn-54	Co-60	Total
Air	–	2	2	4
Fallout	–	–	1	1
Seawater	1	–	–	1
Aquatic plants	–	2	7	9
Perifyton	–	2	5	7
Sedimenting materials	–	2	15	17
Sediment	–	–	3	3
Clams	–	–	1	1
Rainwater	1	–	–	1
Dumping ground ditch water	–	–	1	1
Total	2	8	35	45

mately 0.01% of the authorised limit. The releases of iodine into the air were approximately 17 MBq (as I-131-equivalent activity), which is approximately 0.02% of the authorised limit. The emissions through the vent stack also included radioactive particulate matter amounting to 16 MBq, tritium amounting to 0.4 TBq and carbon-14 amounting to approximately 0.9 TBq. The tritium content of liquid effluents released into the sea, 1.3 TBq, is approximately 7% of the annual release limit. The total activity of other radionuclides released into the sea was 0.2 GBq, which is approximately 0.07% of the plant location-specific release limit.

The calculated radiation dose of the most exposed individual in the vicinity of the plant was about 0.03 microSv, i.e. less than 0.03% 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 10 minutes.

STUK approved the environmental radiation monitoring programmes of the Olkiluoto nuclear power plant for 2012–2016.

A total of 300 samples were collected and analysed from the terrestrial and aquatic environment surrounding the Olkiluoto power plant during 2012. External background radiation and the exposure to radioactivity of people in the surroundings were also measured regularly. Extremely small 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.

New limits for releases of radioactive substances adopted at the Olkiluoto power plant at the beginning of 2012

The limits for releases of radioactive substances from the Olkiluoto power plant are specified in the operational limits and conditions (OLC) approved by STUK. The limits have been defined at a level where the annual radiation dose incurred to a person living in the vicinity does not exceed 0.1 mSv, the limit specified in Government Decree 733/2008. The limits apply to releases of noble gases and iodine into the atmosphere during a calendar year, and releases of tritium and other substances into the sea during a calendar year. No release limits have been set for some released substances, as their volume remains low and steady during normal operation of the power plants, and their releases can be controlled based on the radiation dose limit mentioned above.

Provisions were made for the commissioning of the new Olkiluoto 3 (OL3) plant unit by lowering the release limits of the operating OL1 and OL2 plant units by approximately 50% for noble gases and 10% for iodine. Due to the calculation method currently in use, the noble gas limit had to be lowered more than the iodine limit. The limits for releases into the sea from OL1 and OL2 could be kept unchanged. Lowering of the limits created no difficulty since the noble gas and iodine emissions from the plant have been considerably lower than the limits for the entire operating history of the plant.

4.2.11 Emergency preparedness

STUK oversees the capability of the emergency response organisations of nuclear power plants, formed of their operating personnel, to act in abnormal situations. No situations requiring emergency response actions occurred at the Olkiluoto power plant in 2012.

The preparedness arrangements at the Olkiluoto power plant meet the essential requirements set for emergency preparedness, but the efficiency of the arrangements must be improved in the future. STUK's inspection of the emergency preparedness arrangements of the Olkiluoto nuclear power plant included the inspection of preparedness training, drills, equipment and facilities, alarm arrangements, environmental radiation measurements, weather observations at the plant site, and the status of emergency preparedness procedures. Based on the inspection, STUK presented requirements concerning the planning of the preparedness training, availability of the personnel who participate in repairs, resources of TVO's preparedness arrangement organisation, development and maintenance of preparedness procedures, and the development of the emergency log. At the time of the inspection, the investigations that began following the Fukushima nuclear power plant accident were still in progress, and they had no immediate impact on the emergency preparedness activities during 2012. The preparedness operations required during the operation of Olkiluoto 3 will essentially increase the work load related to the planning and development of preparedness activities.

The communications between the power plant and STUK have been reorganised; the new system was tested alongside the old one for a considerable time, and taken into use in April. The old system was dismantled at the same time. The communication system was used for contact tests and during drills, for example.

An emergency preparedness exercise to test the forming of the preparedness organisation, launch of operations, and assessment of situations was organised at the Olkiluoto power plant in October 2012. STUK oversaw the exercise at the control centre and in the support group. Observations were made on matters such as the communication of these groups and the recording of status information, and the communication between the leaders of the emergency operations, the leaders of rescue operations, and STUK's emergency personnel. TVO develops its preparedness plan on the basis of feedback from the participants of the Olkiluoto exercise.

The power plant's fire brigade conducts fire training in cooperation with the Regional Rescue Service of Satakunta. An evacuation drill of the entire Olkiluoto 3 construction site was organised in January 2012. The drill also involved the rescue service and the police. STUK participated in the drill as an observer.

The preparedness plan for the power plant was updated in the autumn, and the plant delivered it to STUK for approval.

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 and installation 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.

Detailed design of the plant systems continued in 2012. The licensee delivered to STUK for approval the nuclear island process system plans which need to be approved again after modifications. Some of the modifications have been made as a result of the requirements STUK has imposed on systems design, but the majority of modifications have arisen from the licensee's and the plant supplier's own change requests. Several updates and additions have also been submitted for the equipment plans. The quality level of the plans has improved from the early years, but some of the plans delivered to STUK still lack the necessary finishing touches and revisions by the licensee or the plant supplier. This conclusion is supported by the observations made in connection with the inspections carried out as part of the inspection programme during construction that unfinished plans had been submitted to STUK for approval.

There are open questions regarding the overall architecture of I&C design, such as implementation of the defence-in-depth principle throughout the I&C system, the independence of different I&C systems from each other, and compliance with the failure tolerance criteria. STUK has emphasised to the licensee and the plant supplier how important it is to settle the open principal questions before starting the review of the detailed system design of the I&C system.

Construction work at the plant site, excepting finalisation work, was already completed in 2011. This allowed the launch of extensive equipment installation work at the nuclear island, and the installation of the reactor coolant system with related equipment was completed during the same year. Grinding of the butt welds of the reactor coolant system did not meet the appropriate quality requirements, and the plant supplier has to develop the method used in the periodic inspection of welds. The installation of components and pipes of the nuclear island did not proceed as expected due to challenges such as the surface indications found in the formed parts of small bore pipes. All fittings not yet installed were inspected, and indications removed. The plant supplier is launching a programme to replace similar parts that have already been installed. STUK oversaw the installation of components and pipes and performed inspections. STUK made a remark to the plant supplier on the scarcity of welding supervision resources and required that a detailed welding supervision plan be produced for the replacement of the fittings of small bore pipes. Based on the experience received from construction inspections, STUK has also emphasised to the licensee that it must ensure inspectability and acceptability of the objects before STUK performs an inspection at the plant site or at a component manufacturer's premises.

Most of the electrical equipment and cable installations of the nuclear island are completed. As plant engineering has proceeded, the number of electrical and I&C cables has increased considerably, and the cable trays are extremely full in many locations. TVO's report on the acceptability of multi-layer installation of cables is currently being reviewed by STUK.

Test operation of the components and systems of the turbine island began in 2012. The absence of operational I&C at the nuclear island prevented test operation except for the commissioning of individual equipment independent of the plant I&C. Installation of equipment and pipes of the nuclear island is also incomplete, which also prevents the commissioning of process systems. Test runs of electrical systems, on the other hand, began with the help of temporary control automation. STUK reviewed the ability of AREVA and TVO to launch the commissioning of the nuclear island, and found it adequate from an organisational point of view. Besides technical trial runs, commissioning also includes verification of the organisational capabilities to operate the plant in a safe manner. Safe operation requires, for example, the availability of a sufficient number of licensed operators and maintenance personnel familiar with the plant. The required operating manuals must also be available for the plant. The unfinished state of system design has prevented the training simulator at the plant from being finalised and the simulator training of operators from being started. The production and validation of operating manuals has also been delayed due to the unfinished state of system design.

At TVO's request, STUK began the preliminary processing of the operating licence application documents before the delivery of the actual application. The documents submitted for review must form a unified whole, and be descriptions of the final plant design. The adopted procedure balances the work load of the various parties to the process as completed thematic sections are processed in advance. All the documents that are delivered to STUK in connection with an operating licence application will be processed by STUK at the operating licence stage as a whole, and STUK will approve their essential parts before delivering a safety assessment and a statement on the operating licence application to the Ministry of Employment and the Economy.

Based on the construction-time inspection programme and other oversight activities by STUK, the methods, operations and adequacy of TVO's organisation has been found to be at a good overall level where the commissioning of the plant, for example, is concerned. STUK required that TVO further specify how it manages the issues that still remain open in the various stages of the project, and how the causes behind the deviations could be analysed in more depth to prevent repeated occurrences. STUK also required that TVO establish how the efficiency of the processing of functional deviations could be improved within the project, and which criteria are used to open deviations in the audits of the suppliers.

STUK also participated in subcontractor audits carried out by the plant supplier and TVO. At the beginning of 2012, these auditing operations of the contractors active at the plant site was nearly halted due to the plant supplier's inadequate resources, and TVO had not steered the plant supplier's operations in this respect. To investigate the matter, STUK targeted an additional construction-time inspection at the plant supplier's auditing resources, and required on the basis of the inspection that corrective measures be taken to restore the on-site auditing of contractors back to the appropriate level. TVO and the plant supplier immediately prepared a comprehensive subcontractor auditing plan for 2012 and began audits.

During construction, TVO and the plant supplier have taken into account modification needs which have emerged as design of the various areas of technology has become more detailed. Defects detected in manufacturing and installation have either been corrected so that the original quality requirements are fulfilled, or it has been demonstrated by means of additional inspections or analyses that the requirements are fulfilled. The flaws in the work of various parties and in product quality have resulted in additional work to assess and rectify the problems. This has had an impact on the progress of the project but not on the fulfilment of its quality requirements. 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, support and electrical systems. The system descriptions of the final process and ventilation systems were reviewed during the year. Most of the system descriptions were approved, but some must still be updated in accordance with the requirements of STUK's decisions before moving on to the operating licence stage. TVO also announced that the plant supplier is in the process of making additional plant system modifications that will require STUK's approval.

STUK continued to review the overall architecture of I&C systems. STUK has required that TVO and the plant vendor specify unambiguous requirements for the design of the overall architecture of I&C systems, and that the I&C architecture created on the basis of the requirements is described. The descriptions of architecture presented to STUK will still need to be supplemented with respect to the presentation regarding the defence-in-depth principle as well as with respect to the presentation and analysis of connections between the I&C systems. In terms of safety, it is important to specify unambiguous requirements for the independence of the various I&C systems involved in the architecture, because the I&C systems back each other up.

The qualification of the I&C system platforms proceeded during the year. During 2011, STUK reviewed the documentation regarding the system platform intended for self standing systems. The processing of the preliminary materials of the system platform intended for safety class 2 I&C systems began in 2011 and was completed in 2012. The materials that prove the final suitability will be delivered during the commissioning stage. The materials regarding the system platform intended for operational I&C and certain safety class 3 I&C systems was reviewed in 2012. With regard to the latter system platform, STUK worked together with the IRSN (Institut de radioprotection et de sûreté nucléaire), which had performed similar inspection work for the French authorities.

In 2012, STUK has continued to review the design processes of I&C architecture and systems and required further specifications and changes to these, particularly with regard to the test field and commissioning stages and the documents to be delivered to STUK.

Failure analyses of the plant and system design

In 2011, STUK reviewed the updated common mode failure analysis concerning the mutual independence of the plant's systems and equipment. In its decision, STUK required that the analysis be further specified so that implementation of the diversity principle in the plant's safety functions can be verified. Updated analyses were not delivered to STUK for review in 2012.

In 2011, STUK required TVO to investigate further and account for the impacts of the failures and malfunctions of I&C systems of lower safety classes on the electrical systems and other functions of higher safety classes. These accounts were not submitted to STUK by the end of 2012.

The definition of I&C system failure criteria, particularly for software failures, has constituted a third safety-critical matter concerning failure analyses. STUK has required that the realisation of the requirements for independence and failure criteria be demonstrated by means of analyses. Accounts of the analysis methods or actual analyses were not delivered to STUK in 2012.

In 2012, STUK received the failure mode and effect analyses of the process and electrical systems for processing. Several deficiencies were found in the process system analysis reports; as a result, only a few of them were reviewed, and the processing of the rest was interrupted until updated versions are received.

Transient and accident analyses

The review of the methodology reports of the transient and accident analyses for the Olkiluoto 3 final safety analysis report began in autumn 2012. Preliminary findings were processed together with TVO and AREVA in work meetings at the end of the year. The actual analyses have also been delivered to STUK unofficially.

In 2011, documents submitted for review included an updated analysis of overpressure protection during power operation and an updated analysis of the behaviour of the plant unit in the case of an interruption of the regular power supply from the national grid, with power supplied through an external emergency connection. The review was completed early in 2012, and STUK found no cause for remarks in the analysis reports.

Probabilistic risk analyses

The review of the probabilistic risk analyses (PRA) of Olkiluoto 3 focused in 2012 on ensuring the actualisation of the fundamental design principles in the detailed design materials of systems and constructions (including I&C architecture, system descriptions, topical reports and failure analyses). In addition, the aim has been to ensure that sufficient precautions are in place regarding localised events (internal fires and flooding) and external events. Updates are expected for the materials delivered for information purposes, as detailed design, particularly that of I&C systems, is still in progress.

Due to the unfinished state of the I&C design, the assessment of the overall reliability of I&C requested by STUK has not yet been submitted.

Radiation safety

A radiation protection inspection included in the construction-time inspection programme was carried out in 2012. The inspection paid attention to the radiation safety of the upcoming test operation of the plant unit, the licensee's radiation protection functions and purchases, radiation protection training of the personnel, the radiation protection procedures required of the licensee, radiation level measurements of the plant unit during test operation, and the status of radiological safety analyses. Three requirements were issued on the basis of the inspection; these concerned supplementing the system descriptions with information of the radiation measurement instruments which are the licensee's responsibility, planning of training and induction for the temporary radiation protection personnel that will be involved in the commissioning of the plant unit, and an assessment of the updating and development needs of the licensee's radiation protection procedures with regard to the processing of the operating licence application.

In connection with the suitability assessment of electrical and I&C equipment, STUK also reviewed fulfilment of the requirements regarding the radiation resistance of equipment in normal use and during accident situations. STUK also took part in the factory testing of the components of the Olkiluoto 3 radiation measurement systems in 2012. At the licensee's request, the deadlines for updating several radiation measurement system materials were postponed in 2012.

Fire safety at the plant

STUK reviewed the updated structural fire hazard analyses (FHA) of the plant with the purpose of demonstrating the adequacy of the fire compartment structures and penetration seals. In addition to the structural fire hazard analyses, STUK reviewed updated fire hazard functional analyses (FHFA) showing the potential impact of fires on the safety functions of the plant. After cable routes are confirmed for the final plant design, STUK will verify that the corresponding analyses are up to date and requires that the plant's defence-in-depth be confirmed with appropriate sensitivity analyses which assume the deterioration of fire protection measures, including the inoperability of the fire dampers installed at the plant.

VTT completed its fire safety investigations regarding the fire-retardant power and I&C cables to be installed at Olkiluoto 3, and produced a summary report in 2011. The properties of the cable types presented by the plant supplier were assessed from the point of view of fire safety and found to be appropriate regarding the general fire protection arrangements of the plant. STUK is still waiting for the licensee's account regarding demonstration of the sufficiency of fire protection in certain cable rooms and routes. As the cable types and volumes of the nuclear power plant are confirmed, the comprehensiveness of VTT's investigations will be verified. STUK will then require further investigations and accounts for those cable types that were not investigated by VTT, if necessary. Following these additional investigations, STUK will make an overall assessment of the acceptability of the fire risk carried by cables.

STUK continued the assessment of the flood risk arising from a potential rupture in the fire water pipeline in the annulus space between the inner and outer containment walls. To be able to confirm the adequacy of the by-pass line and valve arrangement planned for the fire water pipeline to limit leakages in order to reduce the risk of flood, risk assessment must be updated and adequate first-aid fire extinguishing capacity confirmed. STUK will perform an overall assessment of the acceptability of the annulus flooding risk on the basis of PRA level 1 and 2 risk assessments.

Design of components and structures

STUK continued the review of detailed plans for safety class 2 components and structures in 2012. The key objects of this review were the construction and work plans of steel structures, as well as the construction plans of mechanical equipment and their updates. STUK has also reviewed and approved containment testing plans related to the commissioning of the nuclear power plant unit.

STUK has reviewed and approved nearly all construction plans of safety-classified concrete structures. The plans for steel linings of the fuel pools have been approved for the most part. A major part of the planning documentation of steel platforms, originally only intended for use as maintenance platforms, has also been reviewed. The safety importance of the steel platforms has increased because process pipelines and equipment important to safety will be supported on them in deviation from the original plans. This applies to about 150 different steel platforms. In accordance with a procedure approved by STUK, steel platforms have been used for component installation purposes after construction inspections done in stages. The fulfilment of the requirements set by plant operation will be confirmed before the final commissioning of the steel platforms. STUK has paid inspection visits to the site and verified that TVO's inspections have progressed in line with the approved procedure. STUK will review the final design documentation of steel platforms before starting its own commissioning inspections where fulfilment of the requirements will be finally verified.

During 2012, STUK continued the review of final strength analyses of the main components of the reactor coolant system. STUK was provided with supplementary and modification documentation on the strength analyses where the modifications made during manufacture had been taken into account. The basic inspection plans of periodic inspections, periodic inspection programmes and qualification documentation concerning inspection systems compliant with Guide YVL 3.8 regarding pressure vessels, heat exchangers, pumps, valves and pipelines continued in 2012.

Design of the nuclear island pipelines also continued in 2012. Calculations of pipeline support structures and pipeline stress analyses as well as construction plans and construction plan updates concerning Safety Class 1 and 2 components were submitted to STUK for review. The amount of review work carried out by STUK in 2012 remained high due to the large amount of design modification documentation.

The design of the I&C of the fuel handling systems and safety class 3 cranes continued in 2012. Example materials of one lifting device in accordance with the requirements was submitted to STUK for review and approved with minor changes. The design documentation of electrical and I&C systems of safety class 3 equipment must be approved and the equipment tested before use, but some of the cranes have been used for installation work at the Olkiluoto 3 site before these measures. However, approval of the design and tests is a prerequisite for the final commissioning of lifting and transfer equipment before fuel is loaded in the reactor.

4.3.3 Construction

Except for some final touches, the construction work of the Olkiluoto 3 buildings is completed. STUK oversaw and inspected grouting, anchoring and injection work related to component installations, as well as the installation of steel platforms.

The procedures to determine readiness to start concrete casting, post-tensioning and grouting have proven to function well. These procedures have served to ensure that the plant supplier and TVO have reviewed and approved the plans for the structures and the work to be carried out before STUK is requested to give permission to start the work.

4.3.4 Manufacturing of components and pipes

Manufacturing of Olkiluoto 3 components and pipes continued in 2012. STUK oversaw and inspected the manufacture of safety class 1 and 2 pipelines, tanks, heat exchangers, pumps, valves and steel structures. STUK also oversaw and inspected the manufacture of fuel handling equipment as well as the emergency diesel generators and their auxiliary equipment.

With regard to the reactor coolant system components, the factory testing of the control rod drive

In autumn 2011, Areva carried out examinations of the formed parts of small pipes. The examination was targeted at formed parts that were manufactured from one nozzle material batch and in which surface indications had been observed. Based on the examinations, it was stated that surface indications are possible in the entire batch. It was also found that the manufacturer's process produces faulty T pieces. The problems concerned a total of 10,612 formed pieces, of which 7,411 were already installed.

When the extent of the problems was revealed, Areva halted pipe installations that involved formed pieces from the batch in question or other T pieces from the same manufacturer in February. More detailed surveys showed that the high inclusion rate in the material batch in question, together with the cold-moulding method used by the manufacturer, led to the creation of surface indications. All uninstalled formed pieces were inspected and indications removed, after which the pieces were inspected again. The installed pipe parts' impact on nuclear safety, operability, the dispersion of radioactive materials, safety of pressure equipment and fire safety was analysed. Replacement needs for each target were assessed on the basis of the analysis. The deviation reports and replacement plans were delivered to STUK for approval at the end of 2012, and were approved. It was found that 1,560 installed pipe parts, approximately 25 per cent of installed formed pieces, had to be replaced.

mechanisms revealed scratching on the inner surfaces of the guide tubes. Two mechanisms were subjected to additional testing required by STUK. In the additional testing, the scratching was assessed to be insignificant.

STUK's construction inspections, intended to ensure that the manufacture of components complies with requirements, still revealed issues preventing the inspections from being carried out as planned. The most serious of these issues concerned the equipment's readiness for inspection and open issues related to construction plans. As early as 2008, STUK required TVO and the plant supplier to ensure before the inspections that the prerequisites for construction inspection exist. TVO and the plant supplier have changed their supervision and inspection procedures with the aim of ensuring readiness for inspection prior to STUK's inspections.

The manufacture of auxiliary equipment for the emergency diesel generators continued in 2012. Changes to the piping design delayed the manufacture and installation of prefabricated pipes of the diesel facility. Problems of the design and manufacture of the auxiliary equipment have continued to delay the installation work in the diesel buildings in 2012.

4.3.5 Installation work

The main components of the plant unit's reactor coolant system were installed in 2011. The installation of the reactor pressure vessel internals continued in 2012. The reactor's control rod drive mechanisms were delivered to Olkiluoto at the end of 2011, and the installation of their pressure frames began in early 2012. During installation, problems were detected with the seals of the pressure frames, and the installation work had to be interrupted. After a change made to the tolerance range of the seal dimensions, the seals functioned as required.

Appropriate quality requirements were not complied with when grinding the butt welds of the reactor coolant system pipes, which means that the roughness of the surface profile will, among other things, make future periodic inspections more difficult. The suitability of the joints for periodic inspections will be verified during 2013 after the qualification of an appropriate inspection method.

Welding work on the lining sheets of the reactor building and fuel building pools continued throughout the year. Some of the pools were completed and filled with water for leak testing. STUK oversaw the tests and found the results acceptable. The installation of sump filters in the in-containment refuelling water storage tank began in the spring and continued for the rest of the year. Repairs of factory welds and inspections were also carried out on the filters.

Installation of pipes and supports in the nuclear island continued with reduced capacity due to problems observed in the formed parts of small bore pipes. STUK has followed the progress of pipe installations and the adequacy and level of supervisory activities by the licensee, plant supplier and the plant supplier's subcontractors. In 2012, STUK paid attention to issues such as the plant supplier's HR resources in the supervision of welding, and required that the supervision plan that had been presented to STUK be complied with.

STUK has discovered many different deficiencies in the construction inspections and pressure tests of the installed pipelines. The repairs of these deficiencies have slowed down the inspections and, as a whole, STUK has spent a lot of oversight resources on the inspection when compared to the results achieved. The plant supplier and the licensee have changed their testing procedures based on feedback from STUK.

Installation work on the electrical equipment and cabling continued at the nuclear island throughout 2012. Approximately 85% of the nuclear island cables had been installed by the end of 2012. Almost all low and medium voltage switchgears and distribution and regulating transformers have been installed. Most of the other electrical equipment (rectifiers, batteries, inverters and converters) have been installed. Cable connection work has also been in progress throughout 2012. STUK has overseen the installation of the electrical equipment.

The installation of containment cable penetrations continued in 2012, and a total of 60 penetrations had been installed by the end of October 2012. The total number of containment cable penetrations at Olkiluoto 3 is 83.

The low-voltage cable trays in the plant's main cable routes are rather full, which is why it has been necessary to make the trays wider or install parallel trays, and reconsider the dimensioning of certain cables. Most of this work has been completed in 2012. In December 2012, TVO delivered to STUK an account of the acceptability of multilayer cable installations. The report supplements the cable dimensioning report already approved by STUK. STUK will decide the matter in early 2013.

STUK inspected TVO's installation supervision in several inspections carried out in accordance with the inspection programme during construction in order to ensure the adequacy of TVO's supervision procedures. Adherence to the approved instructions and procedures was monitored during daily inspection rounds. STUK also participated in quality audits of subcontractors carried out by the plant supplier and TVO at the plant site. No significant deviations were observed.

4.3.6 Commissioning

Commissioning of buildings and structures

Commissioning inspections of the building structures began in 2011, and continued in accordance with the procedures approved by STUK. STUK made on-site inspection visits to oversee the commissioning inspections carried out by TVO and the plant supplier. After this, STUK has carried out its own commissioning inspection of structural entities to verify the quality assurance records made by the licensee and to close the potential deviations in structures inspected during construction. STUK performed, among other inspections, the commissioning inspection of cooling water inlet and discharge tunnels. After the approval of the inspections, the tunnels were flooded. STUK has not yet begun building-specific commissioning inspections.

Test operation of equipment and systems

Test operation of the components and systems of the turbine island began in 2012. The absence of operational I&C of the nuclear island prevents test operations on any large scale. Installation of equipment and pipes of the nuclear island is also incomplete, which also prevents the commissioning of process systems. In other respects, TVO and the plant supplier would be prepared to begin the test operation of the nuclear island (the necessary personnel, information management systems, procedures, etc.). In February, STUK reviewed the organisational capacity of TVO and the plant supplier to begin test operation of the nuclear island, and found no obstacles.

Commissioning tests have been performed on some self standing systems of the nuclear island that do not require the plant's operational I&C, such as some filter changing equipment. To allow the launch of test operation of electrical systems, the plant supplier has brought temporary I&C cubicles to the plant site for controlling the nuclear island's electrical systems. Test operation of the electrical systems has begun.

STUK has performed several dozens of commissioning inspections for the pressure equipment of the turbine island and opened commissioning records for them. The pressure equipment will be later added to the pressure equipment register.

STUK oversaw the commissioning tests at the plant site, including the testing of circulating water pumps at the turbine island and the commissioning of the temporary I&C cubicles used for controlling the electrical systems of the nuclear island. Commissioning operations were found appropriate, but there has been some delay in the completion of the test operation result reports. STUK has advised TVO to pay attention to the matter and to emphasise to the plant supplier that reports must be produced without delay after the test.

Due to the delay of operational I&C, the plant supplier has developed a temporary control system that allows the commissioning testing of systems needed for the containment pressure and tightness test. Some of the tests will be repeated after the installation of the final operational I&C. In a meeting held in December 2012, TVO and the plant supplier explained to STUK the use of the temporary control system for the pressure and tightness test and for the preparation of testing. STUK saw no obstacles to proceeding according to the plan.

Review of test operation plans is an important element of STUK's oversight work. STUK has approved all the turbine island test plans that need STUK's approval. Some of the nuclear island test operation programmes are yet to be approved, and changes may be necessary to the ones already approved due to open I&C issues. STUK received from TVO an account of the role of the process system testing programmes in the testing of I&C functions. The account described well the testing of plant control functions, but the relation of the process system testing programmes to the testing of I&C interfaces or fault situations remained unclear. STUK required that TVO submit an additional account of the matter. No account was received in 2012.

The joint operating organisation of TVO and the plant supplier, used during commissioning, has been strengthened during the year. Each shift includes TVO's operator trainees and plant supplier's personnel. The work of the shifts is supported by operating information releases and a list of targets to be regularly inspected at the plant. TVO has adopted an electronic operating log. The controls required by the turbine island test operation are performed from the temporary control room of the turbine island. At the nuclear island, the control of the I&C cubicles is arranged at the main control room. The work permit office is also located in the main control room. STUK inspected control room operations in the construction-time inspection programme's I&C inspection in April. Control room operations were found to be competent and well organised.

Regular weekly reporting of the progress of test operations to STUK began in February. The reports list all the commissioning tests and inspections performed during the week as well as any significant events, fault observations and deviations. Exact test operations schedules for the following two weeks are attached to each report.

Preparations for future operation of the plant unit

Besides technical test 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.

Operator trainees have not yet been able to receive the required simulator training, as the simulator does not yet correspond to the final plant design because I&C design is not complete. STUK reviewed the training of operators in a construction-time inspection in March 2012. Based on the inspection, STUK required that TVO produce a plan on how TVO will approve the simulator for training while the current situation prevails. TVO has applied for postponement of the deadline for the plan until the end of March 2013.

The construction-time inspection carried out in March also considered TVO's preparations for the operating phase. The organisation of the preparations was considered at a general level, and more detailed accounts were made of the preparation of plant procedures, planning of outage operations, and the status of the information systems needed during production operations. As a result of the inspection, STUK required that TVO ensure that the administration of the preparations for the operating phase meet the objectives set for it. TVO assessed the situation and added more detail to the project plan to be used when preparing for the operating phase.

The preparation of plant procedures and the operational limits and conditions, as well as the validation of the procedures, the control room and the operating interfaces, has been delayed due to the delays in the I&C design. During the year, STUK received hardly any materials concerning these subject areas. STUK has already required that more detail be added to the operating procedure validation plan and that detailed validation plans be produced for certain areas of the procedures, and for the main control room and interfaces. The plans were not delivered to STUK during the year.

4.3.7 Review of documents related to the operating licence application

STUK has agreed with TVO that STUK may review parts of the operating licence application documents before the delivery of the actual operating licence application. The adopted procedure balances the work load of the various parties to the process as completed thematic sections are processed in advance. The documents submitted for advance processing must form a unified whole, and be descriptions of the final plant design. As a result of the advance inspection, STUK presents a decision including potential observations and requests for further accounts. The advance review also functions as practice to the review procedures planned for the operating licensing stage. All the documents that are delivered to STUK in connection with an operating licence application will be reviewed by STUK at the operating licence stage as a whole, and STUK will approve their essential parts before delivering a safety assessment and a statement on the operating licence application to the Ministry of Employment and the Economy.

The advance processing of the operating licence application documents began with the review of the methodology reports and radiological analyses presented in chapter 15 of the final safety analysis report. The materials were delivered to STUK in late summer, and three working meetings were organised at STUK in November and December with AREVA presenting the contents of the documents. At the meetings, review observations presented by STUK in advance were discussed, together with open comments to the preliminary safety analysis report. Tables for the follow-up of STUK's inspection comments were produced at the meetings and will be officially delivered to TVO in a letter.

4.3.8 Organisational operations and quality management

Functionality of the management system

The management system of the OL3 project is a part of TVO's management system, which means that a considerable part of it concerns the OL3 project. In 2011, TVO carried out an independent assessment of the menegement system's conformity, performance and effectiveness targeted at the OL3 project management system. Operations improved in 2012 on the basis of the assessment; for example, the OL3 project synchronised its annual planning with the operating plant units. The management system of the OL3 project has been comprehensively defined and works with adequate efficiency according to the assessment. The transfer to the operating organisation and management system will constitute a challenge. At the final stages of the project, the division of authorisations and responsibilities between the responsible manager of the nuclear facility and the project management must be clear.

STUK inspected the measures carried out on the basis of the assessment and paid attention to the fact that many sections of the assessment report have not yet been acted upon. The report states that it is not clear in all cases which procedure or system should be implemented, and that the structure of the procedures is not clear to the users. Responsibility for familiarisation of the employees with the procedures has been given to supervisors, who should see to proper training, but no measures have been taken to clarify the procedures.

Quality management

TVO's independent quality assurance (QA) unit monitors the quality of the Olkiluoto 3 project and its management by processing any product deviations, audit results, and critical or significant deviations observed in the operations of the plant supplier and its subcontractors, as well as by recording into statistics and analysing information pertaining to the causes of the deviations. STUK approves the closing of significant deviations based on applications by the licensee, and appropriate closure of all deviations pertaining to the inspection target is confirmed during commissioning inspections. In 2012, TVO carried out internal audits of the OL3 project according to plans. Operations of the subcontractors active on the site were also systematically audited after STUK targeted an additional inspection at the operation and resources of the Areva OL3 project quality management at the beginning of the year based on observations made in earlier inspections.

STUK found that the OL3 audit procedures contained contradictory requirements concerning the processing of recommendations. Generally only significant observations that are clearly non-compliant with requirements are classified as deviations. Observations that are classified as recommendations are more problematic, as these do not require immediate corrective measures. Each case is assessed individually, and no clear procedure exists for them.

Another concern in the OL3 project was the high number of open issues, and the postponement of their solving to the commissioning and operating licence phases. STUK has emphasised in several connections that TVO should develop the management of open issues as a whole, taking the different phases of the project into account.

Safety culture

TVO has been systematically developing and introducing procedures related to the development and monitoring of safety culture at the OL3 site since 2008. The safety culture report is published twice a year, most recently in July 2012. Based on the report, all areas show improvement since 2009. The only report indicator that has gone down is compliance with regulations and instructions.

In the construction-time inspection of project management and the management of safety carried out in 2012 STUK interviewed the management of TVO for their views of the safety culture and its development within the OL3 project. The safety culture of the OL3 project was generally considered to have developed in a good direction, even though no existing models were available for it; instead, new procedures had been created for the development and measurement of the safety culture. As an example of the improvements, it was pointed out in the interviews that general orderliness and tidiness of the employees has improved. The plant supplier has also worked to improve the safety culture of its subcontractors. The biggest threat in the development of safety culture was considered to be the performance of token measures that use up resources and may deteriorate the credibility of the safety culture but do not actually improve safety. A wide and unified understanding of what is important for safety was considered the most important factor in the promotion of safety culture.

Leadership and project management

The OL3 project does not include the distinctive features of a project in all respects. The scheduling, resourcing and organisation of the operations has been difficult to manage. STUK believes that contractual difficulties have been reflected in decision-making. Challenges also include the combining of the project's and line organisation's resources. STUK has paid attention to the need for strong management and decision-making based on key indicators. The management should go through the assessments and reports concerning the operations and learn from them.

Personnel, competence and the adequacy of resources

The total number of personnel working at the Olkiluoto 3 project site towards the end of 2012 was about 3,400, of which about 3,100 were in the plant supplier's site organisation and about 350 in TVO's project organisation. TVO's project organisation consists of in-house project personnel (about 65), TVO's line organisation personnel (about 80) and consultants (about 200).

During the year, STUK reviewed the planning and targeting of the TVO's human resources, maintenance and development of the personnel's competence, and supervisory procedures. Concerns included the maintenance of motivation during the prolonged project and the feasibility of the HR management considering the controlled disassembly of the OL3 project organisation.

Procurement

When the problems with products and materials have been investigated, deficiencies in the management of procurement chains and networks have been revealed. For example, the quality issues related to the delivery of pipe sections concerned the management of the delivery chain and the relaying of requirements in the long delivery chain, as well as the supervision and inspection of deliveries. STUK has required that TVO develop its supplier supervision and control procedures. TVO must ensure that the delivery chain complies with the YVL Guides, the latest approved project specifications, and the quality plans.

4.4 Preparation for new projects

In 2008 and 2009, Teollisuuden Voima (TVO), Fortum and Fennovoima (FV) applied for the Government's decisions-in-principle regarding the construction of new nuclear power plant units in Finland. The decision-in-principle process includes STUK's preliminary safety assessment in compliance with the Nuclear Energy Act. STUK completed this assessment in October 2009 when the preliminary safety assessment concerning Fennovoima was submitted to the Ministry of Employment and the Economy. The Government rejected Fortum's application and made on 6 May 2010 positive decisions-in-principle regarding TVO's and Fennovoima's new plant units. In its decision regarding Fennovoima, the Government reduced the number of possible plant units from two to one. At the same time, the Government issued a positive decision-in-principle to Posiva regarding the final disposal of spent fuel from TVO's new nuclear power plant unit. The Parliament ratified the Government's decisions-in-principle before its summer recess on 1 July 2010. Following the Government's decision-in-principle process, Fortum ended its Loviisa 3 project.

The next licensing phase prescribed in the Nuclear Energy Act for new nuclear power plant units will be the construction licence phase. In its decision-in-principle, the Government ordered that the power companies must apply for the permit prescribed in the Nuclear Energy Act for initiating the construction of the nuclear power plant unit (construction licence) within five years from Parliament's decision to uphold the decision-in-principle (2015). However, before the construction licence phase, STUK assessed the safety-related sections of TVO's and Fennovoima's invitations to tender in compliance with Section 2.2 of Guide YVL 1.1 during 2011.

STUK has established an oversight project (VALVE) in preparation for the construction licence application processing phase of Olkiluoto 4 and Fennovoima's Hanhikivi 1 nuclear power plant units. In its preparatory project, STUK collected, classified and analysed experience from the Olkiluoto 3 oversight project in 2011. In addition to analysing written documentation, the managers of projects and sub-projects participating in the oversight project were interviewed. The experience gained will be utilised when preparing for new projects. Requirements management meetings with power companies have also been launched within the VALVE project in 2012 to discuss the requirements management processes and requirements set for the management of the requirements of the companies and STUK.

STUK continued to work closely with the power companies regarding the design capabilities, suitability and locations of plant alternatives. In these meetings, STUK was presented with the preparations of power companies for the projects, and STUK presented observations regarding the organisational capabilities of the power companies. STUK also participated in the power companies' meetings assessing the suitability of plant alternatives, where the impact of Finnish nuclear safety requirements on the planning for plant alternatives was discussed.

STUK continued the examination of the design basis concerning the Fennovoima plant site, Hanhikivi, and participated in the second, larger public assembly organised at the invitation of the municipality of Pyhäjoki and the local press. At the assembly, STUK discussed radiation and nuclear safety. STUK has also participated in various seminars for the authorities concerning the permit processes of regional authorities and the Centre for Economic Development, Transport and the Environment (ELY Centre) as well as the launch of safety and preparedness planning with local authorities.

Fennovoima's preliminary plans for meteorological measurements at the plant site, surveys of the basic radiation in the environment, and the environmental radiation safety analyses to be carried out at the project's construction licence phase were discussed in subject-specific meetings.

As a part of international cooperation of the authorities, STUK has participated in an OECD/NEA working group for the exchange of experiences of new nuclear power plant projects between the authorities of different countries. The working group has also produced comparative surveys of the various official operations within the construction projects. In 2012, STUK participated in the gathering of information for a survey concerning evaluation operations in the construction licence phase by reporting to the working group the scope and resourcing of the safety assessment carried out in the construction licence phase of the Olkiluoto 3 project.

4.5 Research reactor

VTT's FiR 1 research reactor was commissioned in 1962. The reactor was built for research and educational purposes and for producing isotopes. The reactor underwent considerable modifications in the 1990s, and in 1999, the use of the reactor for the boron neutron capture therapy (BNCT) of cancers in the head and neck area began. BNCT treatment and the related research became the reactor's most important use in the 2000s.

The Government renewed the reactor's operating licence in 2011, and the new licence period of the FiR 1 research reactor, extending to 2023, began at the beginning of 2012. The operation of the reactor was greatly affected by the bankruptcy of Boneca Oy, which had been responsible for the organisation of the BNCT operations. Only a few radiotherapy sessions could be organised in the first part of the year. The production of isotopes continued as usual, and basic training was provided to Finnish and Swedish university students. The number of operating days remained under 100.

VTT decided to end the reactor operation and to decommission it for financial reasons. The reactor is still to be operated while decommissioning plans are being detailed and approval of authorities is applied for. The environmental impact of the decommissioning must be assessed in accordance with the environmental impact assessment regulations before approval can be obtained.

STUK's safety assessment prepared in connection with the renewal of the operating licence included some issues that required immediate follow-up; these were reviewed in 2012. In addition to the safe operation of the reactor, STUK paid particular attention to safety management, more specific planning of decommissioning with respect to nuclear waste management, and to the development of physical protection.

During the year under review, STUK carried out inspections on the operational safety, physical protection, nuclear safeguards, nuclear waste management and radiation protection in accordance with the oversight plan for the FiR 1 reactor. The inspection of emergency preparedness operations was postponed to 2013.

STUK approved the reactor's new responsible manager and the deputy. In November, an examination of operators was organised at the FiR 1 reactor. STUK issued an approval for 2013–2016 to two operators on the basis of the results of the examination.

5 Regulatory oversight of the spent nuclear fuel disposal project

In 2001, Parliament ratified the decision-in-principle issued by the Government the year before to the effect that the final disposal of spent nuclear fuel from the Loviisa and Olkiluoto NPPs in the bedrock at Olkiluoto is in line with the overall good of society. The decision-in-principle states that the spent nuclear fuel disposal project may proceed to the construction of an underground research facility and more detailed investigation. With this statement, the Government indicated how far the implementation of the final disposal project may proceed pursuant to the decision-in-principle, taking into account that the underground research facility, Onkalo, referred to in the decision-in-principle is designed to form a part of the final disposal facility to be constructed later. The decision-in-principle regarding final disposal of spent fuel was later extended to serve the Olkiluoto 3 and 4 plant units.

After receiving the decision-in-principle, Posiva began investigations regarding the suitability of the final disposal site at Olkiluoto. Construction of the underground research facility began in 2004. Since the research facility is designed to form part of the final disposal facility to be constructed later, it has been constructed in accordance with the requirements concerning nuclear facilities with the corresponding regulatory oversight.

The companies with nuclear waste management obligations have taken the final disposal project forward in accordance with the policies and schedules defined by the Government. Major areas of focus include research of the intended disposal location, the construction of the underground research facility, design and development of the final disposal system and the repository, and safety assessment.

5.1 Spent nuclear fuel disposal project

In 2012, both the construction of Onkalo and the preparation of the licence application proceeded. In December, Posiva submitted a construction licence application concerning the Olkiluoto encapsulation and final disposal facility to the Ministry of Employment and the Economy, and delivered the materials required by the Nuclear Energy Decree to STUK. The materials delivered by Posiva were supplemented at the beginning of 2013, particularly in the sections concerning long-term safety.

Oversight of the construction of Onkalo proceeded according to plan in 2012. Oversight by STUK was particularly targeted at the review of construction and quality assurance documentation, as well as monitoring the construction of demonstration tunnels and holes.

Companies with nuclear waste management obligations submitted a three-year waste management programme to the Ministry of Employment and the Economy for review in autumn 2012. The programme mainly focuses on the spent nuclear fuel final disposal project. The Ministry has requested a statement from STUK concerning the programme in accordance with the Nuclear Energy Decree in January 2013. STUK's review is mainly targeted at the functionality of the final disposal system and proving its feasibility, but STUK is only able to give a detailed estimation of the additional work required when the construction licence application is being processed.

With regard to the final disposal project, STUK's major duties in 2012 included planning the processing of the construction licence and organisation of regulatory oversight. STUK has prepared a plan for the oversight operations, provided further detail to the criteria to be used in the processing of the application, and ensured the availability of external resources through measures such as extensive competitive tendering.

5.1.1 Posiva's organisational operations and quality management

During the years 2009–2011, Posiva has planned and implemented changes in the quality and safety management procedures. The most important of these changes include transfer from a line organisation to a matrix organisation, and the definition of the organisation's processes and their functions. In 2011, Posiva assessed the changes and their impact via a safety assessment, a self-assessment of the system, and management planning days. From time to time, Posiva has ordered third-party management system assessments to complement the certification audits. Starting from 2013, Posiva also intends to complement the certification audits with independent third-party evaluations that focus on the assessments of the management system. The evaluations will pay particular attention to the special nature of the requirements in the nuclear field. Posiva has made a preliminary decision on targeting the 2013 evaluation at the whole of the management system, with an emphasis on the encapsulation and final disposal facility design process.

STUK evaluated Posiva's management system and its functionality in 2012 by a review of the management of the Onkalo project. As a result of the review, STUK stated that needs for improvements still exist in Posiva's quality management and assurance procedures. STUK required, among other things, that Posiva defines the responsibilities concerning the control and inspection actions that aim to ensure the conformity of the end product. An unambiguous definition of responsibilities also serves to ensure the independence of operations. Furthermore, STUK required that Posiva provide a plan of the procedures to be used in the future to systematically continue the improvement of the management system and procedures. No essential changes were made to the organisation and structures of Posiva in 2012. Posiva is currently making preparations for the construction phase of the project and planning the organisational changes required by this phase, including the development of the project organisations for the encapsulation plant and the final disposal facility construction projects.

5.1.2 Oversight of the construction of research facility (Onkalo oversight)

Overview

The excavation of the Onkalo access tunnel was mostly completed in 2012. The combined length of the access tunnel and other tunnels is 4,987 m, and the deepest part is 455 m deep (Figure 15). The Onkalo sections excavated in 2012 include a large parking area (the southern parking hall), back parts of the personnel and canister shafts, connection tunnels, a pumping facility and a precipitation tank. Concrete casting for building systems was carried out in these sections at the end of 2012.

The addition of new support structures to the arch of the first part of the access tunnel began in the latter half of 2012. The need for additional support arose from the excavation work for the ventilation and hoist building of the final disposal facility to be built above ground level.

RSC demonstration

Posiva has excavated in Onkalo two demonstration tunnels, located slightly to the north from the access tunnel crossing section that begins at chainage 4,399 at level –420 m. The main purpose of the demonstration tunnels 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. Various testing of technical barriers, installation and operation procedures and simultaneous application of several technical barriers is also carried out in the demonstration tunnels.

Posiva has completed the RSC description and detailed model description of demonstration tunnel 1 as well as the suitability analyses of four experimental deposition holes. Posiva estimated that three of the deposition holes met the requirements. Inflow water measurements were also developed in demonstration tunnel 1.

Demonstration tunnel 2 was excavated to 105 metres during 2012. A geological survey and various geophysical surveys to reveal fractures, fracture zones and water-conducting structures, among others, were carried out. Six pilot holes were drilled in the floor of demonstration tunnel 2 with the purpose of obtaining geological and hydro-geological information for the drilling of experimental deposition holes in 2013. STUK closely monitors Posiva's RSC development work.

Rock falls

STUK received information on one incident of loose rock in Onkalo during 2012. On 13 September 2012, a large rock fell in demonstration tunnel 2 into a net bolted to the roof in an area which had already been reinforced. The area had been cleared as safe for working and inspecting. As a result of the incident, the communication and reporting practices between Posiva and STUK have been re-evaluated to ensure that STUK receives adequate information and is able to assess the safety significance of events.

Grouting of Onkalo shafts to manage inflow water

So far, only the ventilation shaft (ONK-KU2) is open all through. In 2012, Posiva performed grouting of leaks in the Onkalo personnel shaft (ONK-KU1) and inlet air shaft (ONK-KU3) at a level of –290 m in six to seven phases, but the leaks still exceeded the grouting threshold set by Posiva. In December 2012, Posiva announced that a decision on upward drilling of the personnel shaft and inlet air shaft will be made early in 2013. STUK has monitored the progress of shaft grouting in on-site inspections and Onkalo follow-up meetings.

Research activities

In 2012, Posiva conducted studies on the long-term safety of nuclear waste disposal in the Onkalo research facility. The studies were targeted at the following themes:

- the properties of bentonite in the conditions of the final disposal facility
- rock mechanical properties of Onkalo, such as the direction of tension stress in the rock, or its thermal properties
- the extent of the excavation damage zone (EDZ) and its impact on the water conductivity of the bedrock
- surveys of water conductivity between water-conducting fractures
- migration and retention of radioactive substances in the Olkiluoto bedrock
- survey of the groundwater's sulphate/sulphide balance and oxidation-reduction reactions through groundwater chemistry and geo-microbiological sampling and laboratory tests.

Surveys of Onkalo also include the survey of incoming inflow water and measuring the total volume of inflow water. The total volume varied between 34.0–40.5 l/min in 2012. In 2012, the measured total volumes of inflow water in Onkalo remained clearly below the first measure threshold of 80 l/min set by Posiva.

The expansion of the Olkiluoto micro-seismic network at levels –290 m and –437 m was completed during 2012. The measurement system can be used to monitor the excavation of Onkalo and,

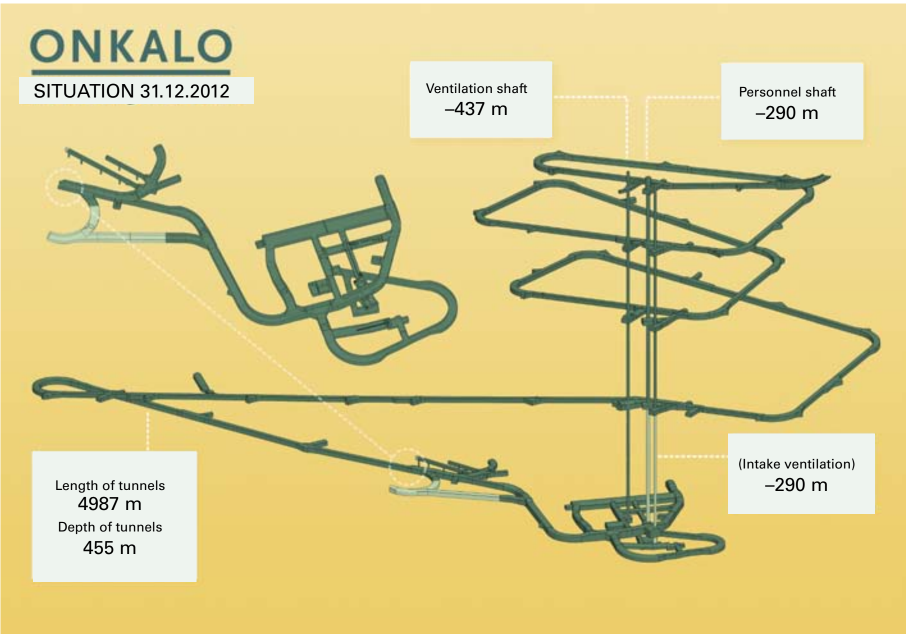


Figure 15. Status of the excavation of Onkalo in December 2012 (Posiva Oy).

later, the final repository, as well as the potential micro-seismic events induced by explosions, such as rock faults.

Construction inspection programme of Onkalo

Onkalo's construction-time inspection programme for 2012 included four inspections. These focused on project management, the development of the rock suitability classification, seepage water management in Onkalo, and the management of foreign materials. STUK set requirements for Posiva and paid special attention to the following issues:

- The requirements issued for the development of the rock classification system concerned the publication schedule of the instructions for Onkalo's tunnel survey phases and pilot hole surveys, and the significant delay observed in the pilot hole reporting.
- STUK required improved seepage water management, including more precise monitoring of seepage water and consideration of sources of error, as well as a survey of grouting alternatives.
- The requirements issued on the management of foreign materials concerned delays in the reporting of foreign substances, instruction updates, the production of a task description for the person responsible for foreign materials, conducting an internal audit of Posiva's foreign material management and supervision, surveys of the root causes of foreign material deviations and environmental damage, as well as the planning of corrective measures.

Construction document reviews

In August 2012, STUK reviewed the additional reinforcement plans for the TU1 phase (PLV 0000–1011) of Onkalo. The reinforcement plans were found adequate and consistent, which supports the launch of the work. During the review, attention was paid to the planned service life of the reinforcement bolts in the access tunnels and the shafts. The required service life stated in the Onkalo planning documentation varies, and in STUK's view the technical solution and the selected steel material are in line with the planned service life. STUK will continue investigations in 2013.

Inspection of the readiness to start construction work

STUK inspected the readiness to start construction work in area 5 of the TU5A phase of Onkalo (ONK-TT-4366, chainage 22–55) in August 2012. A new excavation contractor received permission to begin work. The resources of the contractor are limited, but adequate considering the small scale and unhurried schedule. At the inspection, requirements concerning the grouting work and the recording of information were presented. After a report submitted by Posiva, STUK issued a decision in December 2012 to the effect that the rock excavation work in area 5 of the TU5 phase may continue. STUK will oversee the development of the practices and as-built documentation of double plug measurement of grouting in connection with the approval of future work phases.

In 2012, STUK carried out a total of seven inspections of the readiness to start construction work for shotcreting. During the inspections, the rock surfaces of the Onkalo area in question were compared against the survey documentation; the results of laser beam measurements and the structures reaching across Onkalo were also considered. Inspections also included a visit to the area. In all shotcreting readiness inspections, Posiva was granted permission to begin work, and no additional requirements were issued.

Commissioning inspections

In September and December 2012, Posiva inspected the as-built documentation concerning the construction of the TU4 phase of Onkalo (PLV 3116–4340). Posiva was not able to present all the results of the grout and bolt tests required by the excavation work report and quality control procedure. STUK required that Posiva provide an account of the quality deviations and their causes. In the account, Posiva had to assess the significance of the quality deviations and to define corrective measures to prevent similar deviations in the future. STUK will continue the processing of the as-built documentation of Onkalo in 2013.

Follow-up meetings on the construction of Onkalo

STUK regularly conducted follow-up meetings on the construction of Onkalo together with Posiva to discuss the work in progress. The discussions included overviews of the general status of the construction work, the site, design and engineering, the rock facility process and surveys, the development of the rock suitability classification, QA matters, exchange of letters between STUK and Posiva, Onkalo construction inspections, non-proliferation control, deviations, and potential environmental damage caused by foreign materials.

5.1.3 Overseeing the research, development and design work for further specification of the Safety Case

In 2012, oversight of the research, development and design work was carried out in accordance with the procedure adopted in the previous year and the plan made at the beginning of the year. In the final part of the year, STUK consciously limited the amount of planned oversight to allow Posiva to allocate adequate resources for the preparation of the construction licence application.

STUK reviewed Posiva's materials concerning the design of the disposal canister and delivered a statement to Posiva in February. As a conclusion of the review, it could be stated that the design and descriptions of the disposal canister were considerably more detailed compared to the design materials presented on earlier occasions. However, the canister design and its design basis still include open issues which Posiva needs to investigate further, such as proving that the performance of the canister meets the requirements set by Posiva. STUK also reviewed documentation concerning the corrosion of the canister's copper material, and issued a statement to Posiva in September. As a conclusion to the review, it could be stated that major progress had taken place in the development of the disposal canister for spent nuclear fuel as well as in the evaluation of the canister's corrosion risk. Deficiencies were observed in the assessment of corrosion risks, and these areas need further investigation to reduce the uncertainties related to the evaluation of the long-term safety of the disposal operations. Both the design of the canister and the corrosion of copper were discussed in the meetings of STUK and Posiva.

In the second half of the year, STUK carried out a preliminary review of the draft documentation of Posiva's final disposal system. The results of the review are utilised in the review of the design requirements attached to the submitted construction licence application. No actual safety assessment reports on the long-term safety of final disposal were delivered to STUK in 2012. Nuclide migration analyses include a simplified model of the final disposal facility barriers, considered a complementary report. The model may be reviewed in connection with the review of the construction licence documentation.

Companies with nuclear waste management obligations submitted a nuclear waste management programme (YJH-2012) produced by Posiva to the Ministry of Employment and the Economy in September. STUK reviewed the plans for the next period and delivered a statement to the Ministry at the beginning of 2013. STUK's assessment focused on the research and development concerning the feasibility of final disposal, and on long-term safety at a preliminary level. Due to the programme review schedule's relation to that of Posiva's construction licence application, safety-related materials were not available to STUK, and STUK was therefore not able to assess the need for additional research in this area.

STUK followed Posiva's research, development and design work as projects progressed. STUK's oversight operations were targeted at areas such as canister fall tests and analyses, the design and manufacture experiments of canisters and the buffer, analysis of the feasibility and scenarios of the final disposal system, properties of the final disposal location, and the monitoring programme.

6 Regulatory oversight of nuclear non-proliferation

6.1 The basis, subjects and methods of regulatory control of nuclear materials

Regulatory control of nuclear materials and activities is based on the Nuclear Energy Act, Nuclear Energy Decree and international treaties.

Safeguarding nuclear materials and nuclear activities constitutes a requirement for the peaceful use of nuclear energy. In Finland, the national system for nuclear material control is maintained by STUK. Provisions on the control system are laid down in section 118 of the Nuclear Energy Decree, and its purpose is to carry out the safeguards for the use of nuclear energy that are necessary for the non-proliferation of nuclear weapons and to ensure that the operations are compliant with the obligations of international nuclear energy treaties.

International safeguards are implemented by the International Atomic Energy Agency (IAEA) and the European Commission's Directorate General for Energy, Directorates D and E, "Euratom". IAEA safeguards are based on the Non-Proliferation Treaty and the Safeguards Agreement signed by non-nuclear weapon EU Member States, the European Atomic Energy Agency and the IAEA, as well as the Additional Protocol of the Safeguards Agreement. EU safeguards are based on the Euratom Treaty and Commission Regulation EURATOM 302/2005. According to section 63 of the Nuclear Energy Act, STUK participates in the inspections performed by the IAEA and the European Commission in Finland.

The IAEA must be able to satisfy itself that the member country has no undisclosed activities related to the nuclear fuel cycle, and that the member country honours its obligations under the Nuclear Non-Proliferation Treaty. In addition to the nuclear material records, states must notify the IAEA of nuclear facility sites, research and development projects related to the nuclear fuel cycle, as well as of the manufacture of certain, separately defined, components in the nuclear field as well as their export, including the export of enriched uranium. The operators in the industry report nuclear materials to the Commission and STUK in compliance with the Commission Regulation. STUK submits to the IAEA and the Commission the declarations concerning Finland and Finnish facilities required by the Additional Protocol. In support of its controls, the IAEA gathers information from open sources, uses satellite imagery and collects environmental samples. The Additional Protocol also allows the IAEA more extensive access rights to inspect activities related to the nuclear fuel cycle in the whole country.

In the IAEA's integrated safeguards, the control under the Safeguards Agreement and that under the Additional Protocol have been matched together so that the IAEA carries out fewer routine inspections, but it has the possibility to make inspections unannounced or at very short notice at plants or of activities related to the nuclear fuel cycle. The IAEA's integrated control began in Finland on 15 October 2008. The efficient enforcement of the IAEA's Integrated Safeguards in Finland is made possible by the national control system maintained by STUK. STUK has enhanced its inspectors' capabilities for participating in the IAEA's Unannounced Inspections (UI) or Short Notice Random Inspections (SNRI).

In parallel with the expansion of the IAEA's regulatory control, the Commission also developed its inspection activities. The number of inspections carried out by the IAEA and the Commission has been decreasing since 2009. The number of inspections carried out by STUK has increased. The increase is due to new projects such as Posiva's Onkalo project, TVO's Olkiluoto 3 and 4, Fennovoima's Hanhikivi 1 and the uranium production operations of the Talvivaara mine.

STUK reports all nuclear material inspections to the Commission. The inspections of the IAEA or the Commission in Finland can only be carried out by inspectors authorised for Finland. In addition, STUK is responsible for the approval process of international inspectors.

Regulatory control is targeted at facilities and operators in the nuclear fuel cycle

STUK's nuclear safeguards apply to all nuclear fuel cycle activities in Finland as well as to nuclear commodity accounting and control systems, import, use, transport, storage, transfers, removal from use and final disposal. Nuclear items include nuclear materials (uranium, plutonium and thorium), deuterium and graphite, as well as nuclear devices, equipment, software and technology. Most nuclear materials in Finland (99.8%) are contained in nuclear power plants. A few consignments of fresh nuclear fuel are imported to Finland and transported within Finland annually.

STUK inspects the holders of nuclear items and stakeholders in the nuclear industry through facility and transport inspections and document reviews. At the facilities, STUK verifies that the quantity of nuclear items and their physical location comply with the accounting records. STUK reviews the documents on the facilities' nuclear items management: reports, notifications and nuclear safeguards manuals, and grants licences required by legislation.

The technical analysis methods applied to nuclear items ensure that nuclear materials and operations are in accordance with the reports and that all operations are reported. STUK applies non-destructive methods and environmental sample analyses to verify that the information reported by the facilities regarding nuclear materials and their use – for example, the degree of uranium

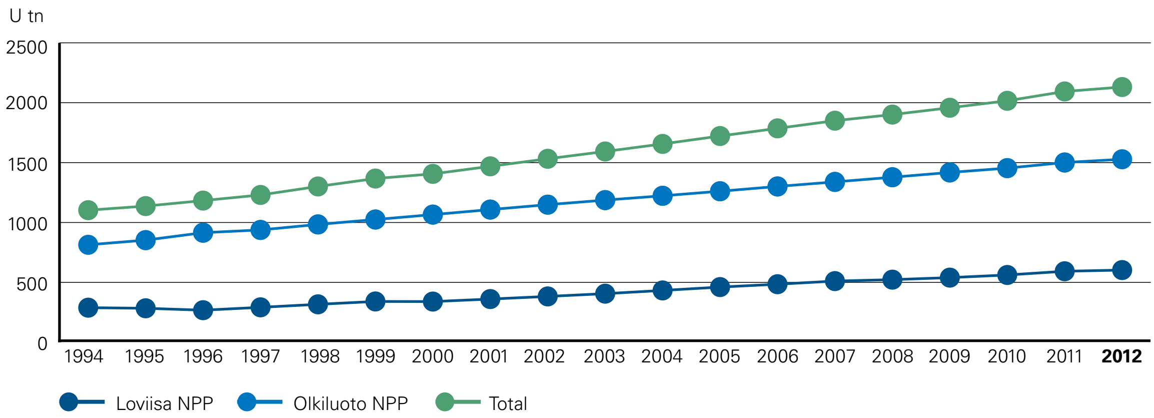


Figure 16. Uranium in nuclear fuel at the Finnish NPPs.

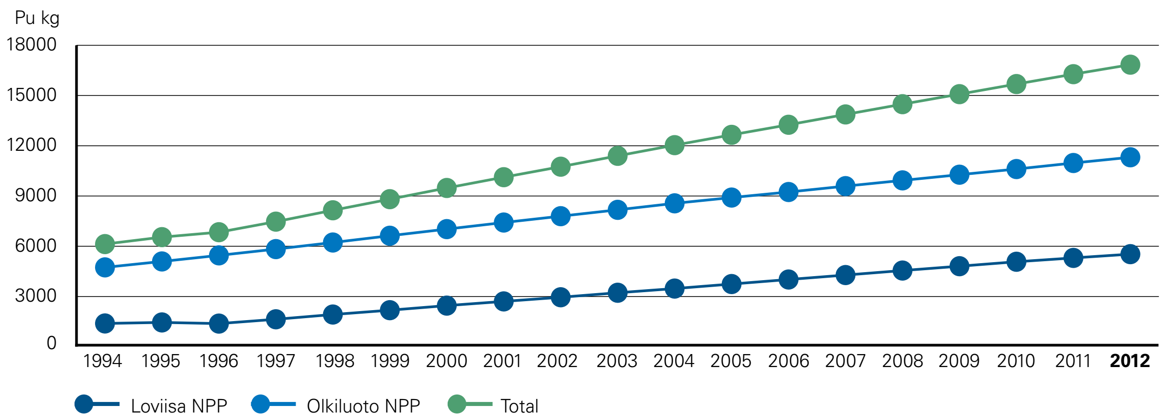


Figure 17. Plutonium in spent nuclear fuel at the Finnish NPPs.

Table 5. Nuclear materials in Finland on December 31 2012.

Location	Natural uranium kg	Enriched uranium kg	Depleted uranium kg	Plutonium kg	Torium kg
Loviisa plant	–	603 178	–	5 529	–
Olkiluoto plant	–	1 528 383	–	11 313	–
VTT / FiR 1 research reactor	1 511	60	~0	~0	~0
Other facililties	4 402	< 1	1 353	~0	~3

enrichment as well as fuel burn-up and the cooling period – is correct and complete.

Figures 16 and 17 contain information on the nuclear fuel assemblies located in Finland, as well as the quantities of uranium and plutonium contained in them. Table 5 presents the quantities of nuclear materials in Finland by facility and category.

Control of transfers of nuclear products

In order to prevent the proliferation of nuclear materials and sensitive nuclear technology, STUK controls the transfer of nuclear products and co-operates with Finnish Customs, the police and other public authorities. A licence granted by either STUK or the Ministry for Foreign Affairs is required for the import and export of nuclear products. Licence from STUK, as well as a transport plan and transport security plan approved by STUK, are required for the transport of nuclear materials. Customs and STUK co-operate in preventing illegal imports and exports at Finnish borders.

Nuclear security and cooperation between authorities

Another objective of the oversight of non-proliferation is to ensure that appropriate security arrangements are in place for nuclear items. ‘Security arrangements’ here refers to the deterrence, prevention and detection of and response to illegal activities related to nuclear and other radioactive materials, as defined by the IAEA under the heading ‘Nuclear Security’. In addition, the security arrangements of the oversight of non-proliferation include acting as a liaison authority for Customs in actions required by irregularities observed in radiation monitoring at the borders, and also as an expert when developing these radiation monitoring operations.

Oversight of non-proliferation in final disposal of nuclear fuel

Final disposal of nuclear fuel in inaccessible underground facilities sets new kinds of requirements for nuclear safeguards. After encapsulation, it is no longer possible to verify nuclear material in the same way as in traditional facilities or in long-term storage. STUK has obligated Posiva Oy, the company in charge of the disposal project, to ensure the implementation of nuclear safeguards during the construction of Onkalo, the underground research facility, as it is designed to become part of the final disposal facility. The aim of the obligation is to ensure that all necessary information on the final disposal facility will be available in due course, and that it will be possible to show that no undeclared facilities or operations relevant to nuclear safeguards exist in the final repository area.

Implementation of nuclear safeguards at the final disposal facility must be ensured so that appropriate international oversight is possible. The IAEA must be able to satisfy itself that there are no undeclared nuclear activities in Finland during the construction or use of the final disposal facility or after its closure; the Commission, on the other hand, will verify that the operator’s actions are sufficient for implementing nuclear safeguards at the final disposal facility. The development of nuclear safeguards for the final disposal facility is a demanding task because there is no experience of controlling a similar facility anywhere in the world. Both the IAEA and the Commission plan and implement their own regulation and inspection procedures on the basis of declarations made by the operator and the Government.

The IAEA finalised the control criteria for the final disposal facility and encapsulation plant in 2009 and 2010. On their basis and on the basis of experience from overseeing Onkalo, STUK has participated in the development of international requirements for nuclear safeguards in the IAEA's ASTOR support group for control activities.

STUK has prepared the actual oversight operations together with the IAEA, the Commission and Posiva with workshops, discussions conducted in connection with inspections, and at Safeguards by Design meetings. In early 2012, STUK organised an internal brainstorming session on the verification of the fuel destined for final disposal. STUK has also proposed a final disposal nuclear safeguards development project that would focus on the development of fuel assembly verification equipment (tomography) and the continuity management of control information. The conceptual plan for the project has also been presented to the Swedish nuclear authority who is an important partner in the development of safeguards operations. The project has not been launched yet.

STUK has organised the review of Posiva's construction licence application into a project that covers nuclear safety, security arrangements and nuclear safeguards at the Olkiluoto encapsulation and final disposal facilities.

6.2 Nuclear safeguards, activities and results in 2012

Licences and approvals

During 2012, STUK received 36 licence applications concerning nuclear items and 314 nuclear safeguards reports, notifications or other applications. All licence applications were approved. No significant deviations were detected in document reviews. In 2012, STUK granted three import licences for nuclear materials and seven for nuclear equipment or components, as well as one modified licence for the possession of equipment. STUK also granted a total of 16 licences for the import, possession or assignment of nuclear technology and two licences for the export of waste, and approved a modification for one licence concerning the import and transportation of waste.

Posiva and Fortum (the Loviisa power plant) submitted updates of nuclear safeguards manuals, compliant with Guide YVL 6.9, for approval. STUK reviewed the manuals and required improvements to both of them. STUK then approved both updated manuals with the improvements.

Ten transportation-related approvals were granted in 2012. These included approvals of transport package designs, transportations with special arrangements, and transportation plans for nuclear fuel.

Two applications for the approval of responsible managers and persons responsible for nuclear safeguards, referred to in the Nuclear Energy Act, were received for processing. In 2012, approvals were granted for the person responsible for nuclear safeguards at the Loviisa power plant as well as his deputy (approval of task rotation), and the deputy for the person responsible for nuclear safeguards at the Olkiluoto power plant. In addition, the replacements of the person responsible for nuclear safeguards at Posiva, as well as the deputy, were processed as received for information.

The qualification requirements of the responsible persons include sufficient knowledge of the legislation and other regulations governing nuclear safeguards. STUK is responsible for assessing the fulfilment of these qualification requirements before approval. Competence was assessed by written questions and an oral examination. This provided a good indication of the person's competence. When necessary, additional familiarisation may be required of the person in connection with the approval. In such a case, fulfilment of the requirement is also monitored and the person's level of competence is re-assessed later.

During 2012, the IAEA and the European Commission sent a total of 27 applications regarding the appointment of new inspectors. STUK asked the major holders of nuclear materials and the Finnish Security Intelligence Service to provide statements regarding the inspectors and approved all the proposed inspectors, 15 IAEA inspectors and 12 European Commission inspectors.

Declarations and inspection visits pursuant to the Additional Protocol to the Safeguards Agreement

STUK submitted all declarations pursuant to the Additional Protocol to the Nuclear Safeguards Agreement within the set time limits. STUK was also able to verify that the Commission had submitted the declarations regarding Finland under its responsibility within the time limits. The IAEA did not request any additional accounts on the basis of the declarations sent from Finland, and it has been able to verify on the basis of the declarations sent that activities in Finland have been in line with the notifications. Two short notice inspections were carried out in Finland for the Olkiluoto facilities in 2012, one for the OL1 plant unit and one for the interim storage for spent nuclear fuel. No cause for remarks was found in the inspections.

Inspections as part of nuclear safeguards

In 2012, STUK carried out a total of 41 inspections. Two of the planned inspections were postponed to 2013 due to reasons related to plant operations. Of minor holders of nuclear materials, the Tornio steel mill of Outokumpu Oy was inspected. In addition, STUK performed an inspection of three uranium producers: Norilsk Nickel Harjavalta Oy, OMG Kokkola Chemicals Oy and Talvivaara Sotkamo Oy. No cause for remarks was found in the inspections. The inspection reports by the IAEA and the European Commission (Statement 90a) indicate that the Finnish nuclear operators have met the obligations of international control. No significant deviations were detected in document reviews. In December 2012, STUK submitted a preliminary safeguards inspection plan for 2013 to the IAEA and the European Commission for information.

STUK carried out nuclear fuel verification measurement campaigns, one at the Olkiluoto plant and one at the Loviisa plant. STUK took environmental samples at the facilities of two uranium producers, in Harjavalta and Kokkola.

Inspections as part of nuclear safeguards regarding the disposal facility

STUK has carried out nuclear safeguards control at the Onkalo facility constructed by Posiva, intended as part of the disposal facility. STUK's control activities have been implemented in line with the national nuclear safeguards plan. Finland is the first country in the world to implement nuclear safeguards regarding disposal facilities, which is why STUK holds a key position in the development and implementation of international nuclear safeguards regarding disposal facilities. The implementation of international safeguards has been complicated by the fact that Posiva was not a licensee referred to in the Nuclear Energy Act. International safeguards operations are targeted at the nuclear facility already being planned. The IAEA and the Commission carried out the inspections under their inspection programme at the Onkalo construction site and at the plant area referred to in the Additional Protocol.

Control meetings with licensees

STUK usually organises oversight meetings with major operators twice a year. In 2012, 12 oversight meetings were organised with TVO, Fortum, Fennovoima, Posiva and VTT. One joint oversight meeting of operators was held in Vienna together with the IAEA.

Results and conclusions of inspection activities

STUK delivered protocols of all nuclear material inspections to the IAEA and the European Commission for information within three days of the inspection, even in cases where the IAEA or the EC did not participate in the inspection.

The IAEA and the Commission sent 18 reports to STUK on the results and conclusions of inspection activities. The reports did not contain inconclusive results. STUK compared the inspection results in the IAEA's and the Commission's reports to the results of its own inspections and found the information to be very coherent. STUK sent the inspection results to the inspected plants for information.

Regulatory control of nuclear materials begins at the design stage of a new plant

It is important that nuclear safeguards are included in the design and construction of new plants. This saves costs and additional work required, for example, in the installation of surveillance cameras in the reactor hall when the plant is otherwise complete. In March 2012, STUK organised the second Safeguards by Design training event at TVO's training facilities in Helmiranta in cooperation with the IAEA and the European Commission. At the training event, operators received an overall picture of the basics of nuclear safeguards and the principles of safeguards operations during the design and construction of a new facility. An exercise on how the safeguards could be taken into account at the participants' own plants was also included. In addition to the training events, STUK has actively ensured that safeguards operations will be taken into account in TVO's OL4 project and Fennovoima's FH-1 project as well as in the construction of Posiva's encapsulation and final disposal plant. STUK has participated in the development of IAEA standards in order to inform plant suppliers and licensees of the needs of safeguards operations as early as possible.

It was observed during the Safeguards by Design training events of 2011 and 2012 that operators need more real information on the supervision of technology exports. Technologies are an essential part of the design of a new power plant unit, and export supervision becomes an extremely topical issue when invitations for tenders are sent out. A better shared understanding of the matter between the authorities and operators was achieved as a result of the meetings concerning technologies, and it was agreed that in cases of individual questions, operators should always contact the proper authorities directly; open and proactive communications are the best option. It was also agreed that, in future, meetings concerning technologies will be organised when changes are made to the nuclear energy legislation and when new YVL Guides enter into force.

Remote surveillance of nuclear facilities

The IAEA and European Commission use surveillance cameras for control. The cameras are located in the reactor halls and spent fuel storage facilities at the Olkiluoto and Loviisa plants. The camera surveillance of the IAEA and the Commission has been in use at both plant units for about twenty years. The IAEA and the Commission have replaced the video tapes or hard disks during inspections. Current technology also allows the sending of surveillance data from nuclear power plants directly to the IAEA and the Commission. The remote use of surveillance systems has proceeded so that reports on the safety impact of the implementation of new systems have been requested from power companies, STUK has produced the necessary assessments, and more information on the technical implementation has been requested from the IAEA and the Commission to ensure the information security of the systems. Remote use of surveillance equipment also allows the reduction of the number of inspection visits by the IAEA and the Commission, and better planning of inspections in Finland.

Regulatory control of transport of nuclear material

STUK inspected transports in line with the inspection plan for 2012. Nuclear materials and nuclear security experts participated in the inspections. One of the inspections concerned TVO's transports and one those of Fortum's.

Cooperation with the police continued as in previous years. Transportation-related practices were discussed with the police before transports and inspections. STUK performed the inspections of transports in good cooperation with the police. During the last inspection, police provided particularly useful assistance in the interpretation of the transport regulations concerning dangerous goods. STUK included a remark on the matter in the inspection records.

STUK participated in a tabletop preparedness exercise concerning the transport of natural uranium, organised by Talvivaara Sotkamo Oy and Cameco Corporation. The exercise dealt with the operations of the various parties in exceptional situations.

Enhancement of radiation control at borders

Finnish Customs and STUK launched a joint project for revising radiation control at borders. The project is called RADAR. The project will be implemented during 2009–2014, and it includes equipment purchases, an update of common operational methods and instructions, as well as a training plan and provision of training together with the Customs School.

The purchases necessary to establish radiation control at the Kotka–Hamina ports began in 2012. Installations at the Helsinki Airport were supplemented by neutron moderation of the detectors.

6.3 The Comprehensive Nuclear Test Ban Treaty

The Comprehensive Nuclear Test Ban Treaty (CTBT) prohibits all nuclear testing. The Treaty was opened for signing in 1996. It will enter into force after ratification by 44 separately designated states. Of these, eight are yet to sign the Treaty. Finland ratified the Treaty in 1999, and a total of 183 countries had signed and 158 counties had ratified the Treaty by the end of 2012. Adherence to the Treaty is monitored by a global network of 321 observation stations. Of these, 80 stations detect radioactive particles in the atmosphere and 40 are also capable of detecting radioactive xenon gas. The other stations measure seismic, hydro-acoustic or infrasound waves. The measurement results of the monitoring system are available to all Member States.

A special Preparatory Commission, convening in Vienna, is preparing for the Treaty's entry into force. All signatory states are represented in the Commission. The Provisional Technical Secretariat, whose tasks include constructing and maintaining the international monitoring system, also operates in Vienna.

The National Data Centre, based on the CTBT and operating in conjunction with STUK, 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.

Activities of the National Data Centre in 2012

The data systems of the National Data Centre have operated without interruption for the whole year, apart from a few maintenance breaks lasting a few minutes. The automatic analysis software used for the NDC's own routine monitoring analysed on average more than 1,000 spectra per day towards the end of 2012. Routine monitoring is facilitated by an alarm system transmitting data on unusual observations to NDC personnel. The planned development and testing of noble gas analysis software was not carried out due to the slowness of the international community and the resource changes taking place in STUK's internal organisation. This software still needs further development, but the lack of resources prevents the work from being completed in Finland at the moment; instead, the results of international cooperation are utilised as efficiently as possible. During the year under review, STUK has participated in WGB meetings and acted as one of the chairs of the radionuclide expert group.

7 Nuclear security

Loviisa nuclear power plant

An inspection within the periodic inspection programme was carried out on 2 May 2012. An extensive inspection of security arrangements was included in accordance with the inspection plan. Examples include the security systems' maintenance and fault reporting procedures which now have improved work order practices. The training processes of the security organisation together with job-specific and personal training plans were discussed during the inspection, as well as issues concerning the practical security arrangements and the exercises of the security organisations, including those conducted in cooperation with the authorities. No 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.

The security arrangements of the power plant were inspected during the annual outage, on 21 August 2012. The inspection focused on the resources needed for the maintenance of adequate security arrangements during an annual outage, development measures and their status during the outage, and the surveillance of the refuelling area. The power plant has improved the security arrangements in accordance with the principle of continuous improvement. The TUVA project concerning the security surveillance operations will implement further improvements of the technical security systems.

An information security inspection was carried out with a focus on the I&C systems of the Loviisa power plant. Based on the inspection, it was stated that continuous improvement of information security takes place at the Loviisa power plant, but further investments by the power plant are still required. The Loviisa power plant had conducted an extensive risk assessment concerning the I&C system upgrade on the basis of a requirement issued in an earlier inspection. According to STUK's estimate, the risk assessment was carried out using the best information security practices.

Olkiluoto nuclear power plant

STUK inspected the security arrangements at the plant during the annual outage on 8 May 2012. The inspection focused on the resources needed for the maintenance of adequate security arrangements during an annual outage, development measures and their status during the outage, and the preparedness of the security organisation.

The security arrangement inspection on 8 October 2012 focused on matters such as the improvement measures implemented on the basis of an extensive third-party evaluation of the security arrangements carried out in 2010. The operative response of the licensee's security organisation and the related details were also assessed during the inspection. In 2012, TVO increased the number of drug and alcohol tests carried out by the security personnel. Structural improvements of the security arrangements have also been implemented.

The information security of the Olkiluoto power plant was inspected in two parts in 2012 (from 31 May to 1 June and from 9 October to 10 October). The first part, carried out at the turn of May to June, focused on the technical information security solutions of the operating plant units. The second part, carried out in October, focused on the organisation of information security, competence development, and administration. Concerning the OL3 project, STUK inspected the construction inspection programme and inspections of the information security of subsystems. STUK participated as an observer in the audits of potential OL4 plant suppliers using the KATAKRI criteria.

As a part of the spent fuel storage expansion project, STUK inspected the security arrangements of the KPA storage during expansion work.

Fennovoima's nuclear power plant project

In October 2011, Fennovoima Oy decided to concentrate its efforts on the preparation of the construction licence application solely on the Hanhikivi plant site, located in the Pyhäjoki municipality in North Ostrobothnia. In 2012, Fennovoima asked STUK to review certain plans and documents it had prepared and to provide preliminary instructions concerning, among other issues, security arrangements at the plant and the plant site. STUK complied with these wishes and also reviewed the design basis for the security arrangements. At the request of Fennovoima, STUK participated as an observer in the plant supplier audits carried out using the KATAKRI criteria.

Otaniemi research reactor

STUK requested statements from the Ministry of the Interior and the Advisory Commission on Nuclear Security concerning the updated security regulations for the FiR1 research reactor. When the statements had been received, STUK requested that VTT implement into the security regulations the changes proposed in the statements as a condition to the qualification of the regulations.

A third-party evaluation of the structures and organisation of security arrangements for the research reactor was carried out in 2011. The evaluation team proposed several targets for development. VTT prepared an action plan to remove the deficiencies observed in the safety arrangements of the research reactor, and implemented certain improvements. Due to the changed situation of the research reactor (plans to end operations), the action plan to develop security arrangements, prepared on the basis of an evaluation, was updated as a part of the overall security plan of the research reactor. STUK inspected the state of the research reactor's security arrangements in November 2012, after which VTT submitted an updated action plan and overall security plan to STUK for approval. The changes will continue in 2013 after the approval of the action plan.

Spent nuclear fuel disposal project

STUK has processed the security arrangements concerning the IV and lifting equipment buildings included in Posiva's final disposal project. At the end of 2012, Posiva submitted the safety-classified security arrangement documentation to STUK for processing together with the construction licence application.

Talvivaara uranium recovery project

Planning and construction of a uranium recovery plant in Talvivaara began in 2011. After requesting a statement from the Kainuu Police Department, STUK approved the security arrangement documentation of the Talvivaara uranium recovery plant. The practical security arrangements will be inspected in 2013 in accordance with the decision.

Transport of nuclear material and nuclear waste

STUK ensured that transport of nuclear fuel took place according to approved transport security plans. STUK inspected on site the implementation of the security arrangements of one transport by Fortum and one by TVO.

Security regulations, their development and Design Basis Threat

On 22 December 2011, the Government presented Parliament with a proposal concerning an amendment to the Nuclear Energy Act. The latest update to the Nuclear Energy Act entered into force on 1 October 2012 (410/2012). A modification of the Government Decree 734/2008 concerning security arrangements entered into force on 1 May 2012. YVL Guides concerning security arrangements will be produced in connection with the overall revision of the guides.

Design Basis Threat (DBT) is one of the tools for setting regulatory requirements on nuclear security. It defines the threat to be used as the basis for planning and evaluating security arrangements. Design Basis Threat is based on the threat assessment of unlawful acts related to use of nuclear energy and radiation, and the potential consequences of such unlawful acts. The threat assessment has been prepared under the leadership of the Finnish Security Intelligence Service and in cooperation with the relevant authorities, and it has been updated on an annual basis. The 2012 update focused on information security threats. STUK has prepared the DBT during 2009–2012. During the preparations, STUK has consulted the operators of nuclear facilities and received statements from the Ministry of the Interior, the National Police Board and organisations under it – the police departments who participated in the preparations of the threat assessment or have regional responsibility in the areas where nuclear facilities are located – as well as the Advisory Commission on Nuclear Security. In 2012, STUK discussed the application of the DBT with nuclear facility operators. The DBT was completed at the end of 2012, and is to be approved at the beginning of 2013.

A pilot project was organised on the use of PRA in the planning of security arrangements; parties to the project included TVO, Fortum and STUK. STUK will compile a report of the results in the first half of 2013. According to the new Guide YVL A.11, nuclear facilities must utilise PRA in the planning of security.

Emergency preparedness instructions, emergency response training and exercises

STUK's emergency preparedness (contingency) instructions for scenarios involving unlawful operations were updated.

STUK participated in a joint preparedness exercise of various authorities (CBRNE 2012) to practise operations in scenarios of unlawful acts related to radioactive materials. In an emergency, STUK adopts the role of an expert organisation within the joint organisation of the authorities, headed by the police in situations where unlawful acts are involved. STUK continues the development of integrated operations for various situations together with other authorities, using the results of the exercises.

STUK participated in a tabletop preparedness exercise concerning the transport of natural uranium, organised by Talvivaara Sotkamo Oy and Cameco Corporation. The exercise dealt with the operations of the various parties in exceptional situations.

STUK's internal cooperation group and nuclear security programme

STUK has a cross-department cooperation group on security, responsible for ensuring that in STUK, tasks related to nuclear security are carried out in close cooperation, employing the resources of the various departments and units. In 2012, the group met regularly, followed the implementation of STUK's security tasks and exchanged information related to internal, national and international nuclear security collaboration.

National and international cooperation for developing nuclear security

The Advisory Commission on Nuclear Security, appointed by the Government and operating under STUK, met three times in 2012. The Commission discussed, among other things, the operations and security regulations of the research reactor, changes to the nuclear energy legislation, security assessment procedures of nuclear facilities, and the international peer evaluation of security arrangements (IPPAS).

STUK participated in the national cooperation group for the prevention of terrorism, operating under the auspices of the National Police Board, and in the CBRNE cooperation forum led by the police. STUK also participated in Satakunta Police Department's OL3 project steering group during the year.

In 2011, STUK launched tests on the structural endurance of nuclear facilities in cooperation with Defence Forces Technical Research Centre. The work continued in 2012.

STUK was the Finnish representative of the Ad Hoc Group on Nuclear Security (AHGNS) of the Council of the European Union. The final report of the Group was published on 6 June 2012. In 2012, STUK also participated in international nuclear security cooperation within the IAEA and ENSRA.

International assessment of nuclear security

The international IPPAS assessment group performed a follow-up assessment of Finland's nuclear security and security arrangements on 16–27 April 2012 at the request of the Ministry of Employment and the Economy. The first IPPAS assessment was completed in summer 2009. The group stated that the recommendations issued during the first evaluation have been implemented to a very good degree. Finland also received some new recommendations to further improve nuclear security. IPPAS (International Physical Protection Advisory Service) is an assessment programme organised by the International Atomic Energy Agency (IAEA).

The most important recommendations given to Finland in the 2009 assessment concerned the development of nuclear energy legislation to better protect confidential information, the definition of the design basis threat used as a basis of the security arrangements in the use of nuclear energy and the use of radiation, and the increase of security-related resources at STUK. Legislation has been revised to protect information, the definition of the design basis threat is completed and human resources at STUK have been increased.

The follow-up assessment resulted in only a few new recommendations. These mainly concerned matters that were introduced into the follow-up assessment as new subjects, such as information security procedures. One of the recommendations was that the legislation should be changed to define a fixed term of validity for the safety assessments of people working in the nuclear industry.

The oversight of the security arrangements of the future Talvivaara uranium recovery plant was found to be a good practice. Good feedback was also received for the radioactive materials detection and analysis system developed by STUK and used to provide expert support to the operations of other authorities.

8 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 facilities. 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, of which 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 nuclear facility of a particular licensee. Funding is not granted for 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 nuclear energy regulatory oversight.

STUK controls this research by contributing to the work of the programmes' steering and reference groups. Every year, the Ministry of Employment and the Economy ascertains that the proposed set of projects meets the statutory requirements and STUK's nuclear safety research needs. In February 2012, STUK issued statements on the SAFIR2014 research programme and the KYT2014 programme.

Nuclear safety research in Finland

In Finland, nuclear safety research is conducted by research institutions, universities and utilities operating nuclear power plants. In general terms, nuclear safety research comprises two distinct areas of research: nuclear power plant safety and nuclear waste management safety.

The new research programmes, which started at the beginning of 2011, are SAFIR2014 and KYT2014. The purpose of these programmes is not only to provide scientific and technical results, but also to ensure the maintenance and development of Finnish expertise. Further information on the projects is available on the websites of the research programmes at http://virtual.vtt.fi/virtual/safir2010/, http://virtual.vtt.fi/virtual/safir2014/, http://www.ydinjatetutkimus.fi and http://kyt2014.vtt.fi/.

Pursuant to Finnish legislation, the parties with nuclear waste management obligations are unambiguously responsible for the design, implementation and cost of managing the waste they have produced, including the associated research and development work. Regarding final disposal, this research and development work is carried out by Posiva Oy with its extensive research programme. 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.

Finnish actors have also preliminarily charted issues related to the technology, safety and economy of new-generation GEN4 reactors. GEN4 research is financed within the four-year Sustainable Energy (SusEn) research programme of the Finnish Academy of Science and Letters, launched at the beginning of 2008. Research into fourth-generation reactors is part of energy technology research.

In 2011, a new four-year safety research programme, SAFIR2014, was initiated as a continuation of the previous SAFIR2010 programme. The new programme is more extensive than the previous one due to the decisions-in-principle issued in the summer 2010 regarding new plant units. Following the decisions, additional funds for the research programme were collected according to the maximum outputs defined in the licence conditions for the new plant units (funding from the National Nuclear Waste Management Fund). The annual volume of the SAFIR2014 programme was EUR 9.9 million in 2012, of which the National Nuclear Waste Management Fund covered EUR 5.6 million. The project programme initiated at the beginning of the year provided funding for 47 projects. The organisation providing the largest amount of funding was VTT whose share was EUR 2.7 million.

The SAFIR2014 research programme is divided into nine competence areas, which mainly correspond to the support group areas of the previous research programme. The new support group introduced at the beginning of 2011 is Support Group 9, Infrastructure, since the construction of significant arrays of test equipment is 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 shown in Figure 18.

In autumn 2012, the call for projects for the 2013 project programme was updated with the additions to the SAFIR2014 framework plan considered necessary as a result of the Fukushima Dai-ichi nuclear disaster that took place in March 2011. The call for projects resulted in new accident management proposals and expansion of earlier projects that dealt with the management of severe accidents and the provisions made for external threats.

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. One topical detail is the research on external threats where the potential impacts of climate change on the extreme weather conditions and sea water levels occurring in Finland were studied, along with the seismic requirements for nuclear facilities. Another topical issue is the definition of the source term for an accident, and provisions for accidents of a long duration.

The new four-year research programme KYT2014 covering the period 2011–2014 was also initiated in 2011. The programme framework consists of research targets important to national competence, organised into coordinated projects. The Ministry of Employment and the Economy ordered an international assessment of the programme, including an evaluation of the targets, practical execution and effectiveness of the programme. Results will be available in 2014. The KYT steering group gave its funding recommendations to the Ministry of Employment and the Economy, relying on the assessments of support groups. In 2012, the research programme provided funding for 31 research projects representing new and alternative technologies for nuclear waste management (3 projects), safety research on nuclear waste management (27 projects), and social nuclear waste management research (1 project).

The safety research included three extensive and coordinated projects: safety case, the performance of the buffer and backfilling materials, and the long-term durability of the canister. The other safety studies represented approximately 36% of the total volume of the programme. In 2012, the

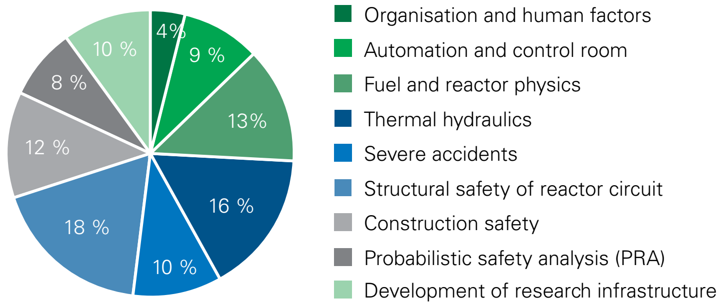


Figure 18. Research areas of SAFIR2014 programme and their shares of the total funding in 2012.

total funding of the KYT2014 programme was about EUR 2.7 million, of which funding from the National Nuclear Waste Management Fund makes up about EUR 1.7 million. Figure 19 shows the relative shares of these areas of the total funding.

A total of 37 proposals for research projects were submitted for the KYT2014 programme for 2013. These have been evaluated using the same criteria as in the previous year, listed in the call for projects. The research programme according to the management group's funding recommendation includes 32 research projects.

Figure 19. Research areas of KYT2014 programme and their shares of the total funding in 2012.

9 Oversight of nuclear facilities in figures

9.1 Review of documents

In all, 3,351 documents were submitted to STUK for review in 2012. Of these, 1,163 concerned the nuclear power plant unit under construction, and 241 were related to the final disposal facility for spent nuclear fuel. 3,355 document reviews were completed, including documents submitted in 2012, those submitted earlier and licences granted by STUK in accordance with the Nuclear Energy Act, which are listed in Appendix 4. The average

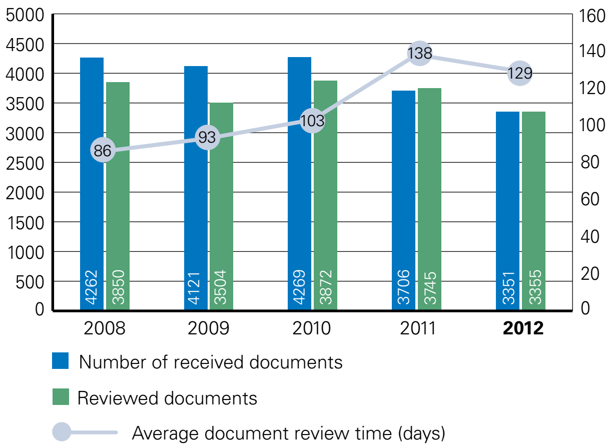


Figure 20. Number of documents received and reviewed as well as average document review time.

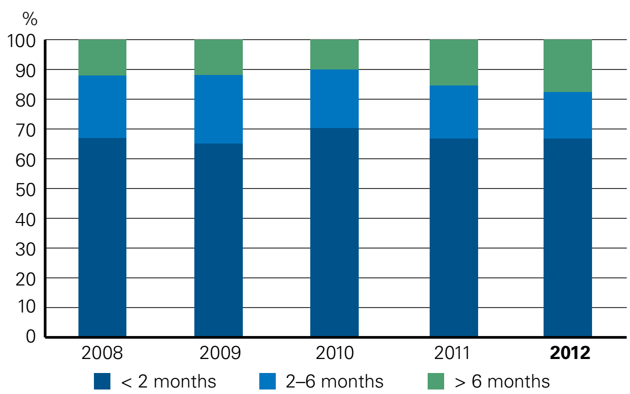


Figure 21. Distribution of time spent on preparing decisions on the Loviisa plant.

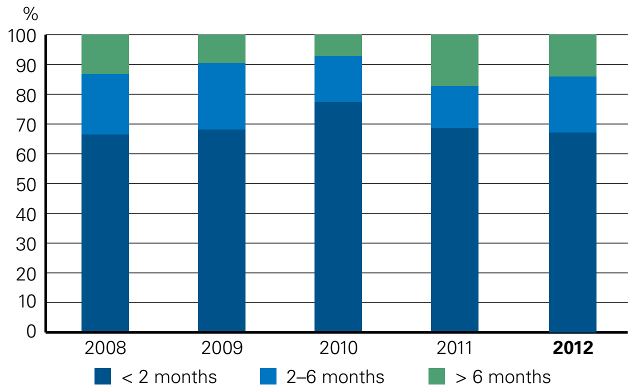


Figure 22. Distribution of time spent on preparing decisions on the operating plant units of Olkiluoto.

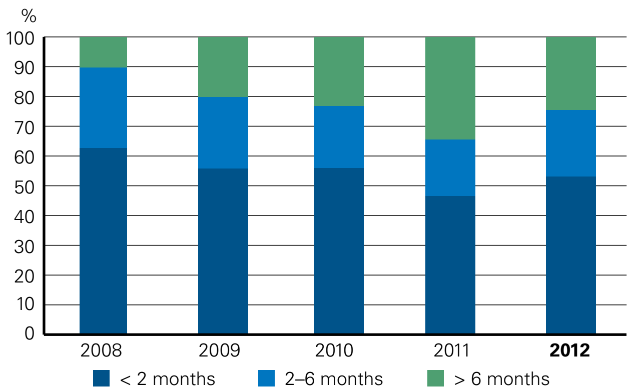


Figure 23. Distribution of time spent on preparing decisions on Olkiluoto plant unit 3.

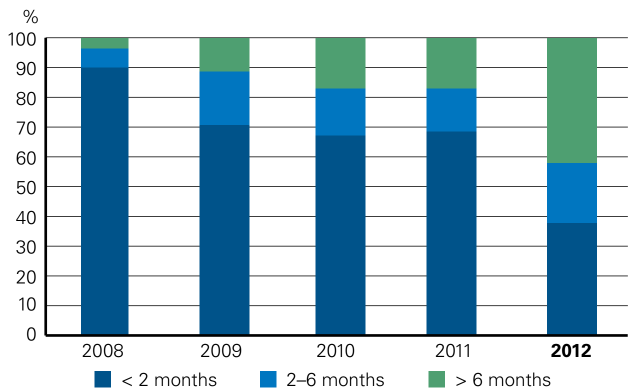


Figure 24. Distribution of time spent on preparing decisions on Posiva.

document review time was 129 days. The number of documents and their average review times in 2008–2012 are shown in Figure 20. Figures 21–24 present the distribution of review times for the document concerning the different plant units and Posiva.

9.2 Inspections on site and at suppliers' premises

Periodic inspection programmes

A total of 20 inspections at the Loviisa plant and 24 at the Olkiluoto plant were carried out under the 2012 periodic inspection programme (Appendix 5). STUK carried out 14 inspections within the Olkiluoto 3 construction inspection programme (Appendix 6) and four inspections within the Onkalo construction inspection programme (Appendix 7). The main findings of the inspections are presented in the chapters on regulatory oversight.

Other inspections at plant sites

A total of 1,030 inspections on site or at suppliers' premises were carried out in 2012 (other than inspections of the periodic or construction inspection programmes, of the safeguards of nuclear materials and of the construction inspection programme of the underground research facility at Olkiluoto, which are discussed separately). An inspection comprises one or more partial inspections, such as a review of results documentation, an inspection of a component or a structure, a pressure or leakage test, a functional test or a commissioning inspection. Of the inspections, 105 were related to the regulatory oversight of the plant under construction and 925 to that of the plants in operation.

The number of inspection days on site and at component manufacturers' premises totalled 3,779. This number includes not only inspections pertaining to the safety of nuclear power plants, but also those associated with nuclear waste management and safeguards, and audits and inspection of the underground research facility at Olkiluoto. A total of 294 inspection days outside normal working hours were spent at operating plant units, mostly during annual outages, as well as 96 inspection days at the plant unit under construction. Six resident inspectors worked at the Olkiluoto power plant and two resident inspectors at the Loviisa power plant. The numbers of on-site inspection days in 2008–2012 are shown in Figure 25.

9.3 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 facilities, with their costs charged to those subject to oversight. Those 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

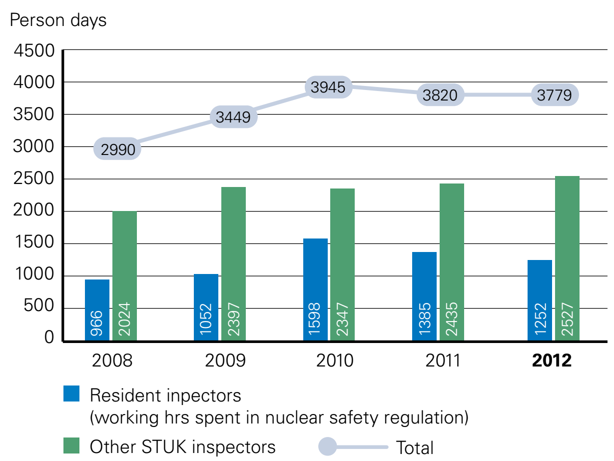


Figure 25. Number of inspection days onsite and at component manufacturers' premises.

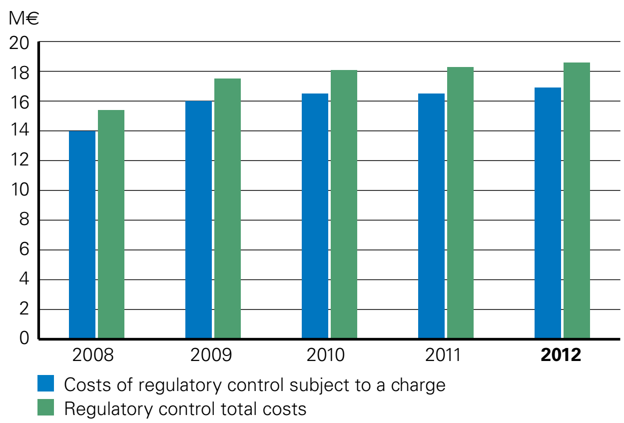


Figure 26. Income and costs of nuclear safety regulation.

of expertise, and reporting, as well as participation in nuclear safety research) were carried forward into the costs of both types of basic operation and of contracted services in relation to the number of working hours spent on each function.

In 2012, the total cost of the regulatory oversight of nuclear safety subject to a charge was EUR 17.0 million. The total cost of nuclear safety regulation was EUR 18.6 million. The share of activities subject to a charge was thus 91.4%.

The income from nuclear safety regulation in 2012 was EUR 17.0 million. Of this, EUR 3.7 million and EUR 10.7 million came from the inspection and review of the Loviisa and Olkiluoto nuclear power plants, respectively. In addition to the operating plant units, the income from the Olkiluoto plant includes that derived from the regulatory oversight of the Olkiluoto 3 construction project. The income from the regulatory oversight of the Olkiluoto nuclear power plant also includes the costs invoiced for the safety assessment of the new plant unit projects. The income from the inspection and review of Posiva Oy's operations was EUR 2.2 million. Figure 26 shows the annual income and costs from nuclear safety regulation in 2008–2012.

The time spent on the inspection and review of the Loviisa nuclear power plant was 15.7 person-years, i.e. 10.7% of the total working time of the nuclear safety regulation personnel. For the Olkiluoto nuclear power plant's operating units it was 12.3 person-years, which accounts for 8.4% of the total working time. In addition to the oversight of the operation of nuclear power plants, the figure includes nuclear material control. The time spent on the inspection and review of Olkiluoto 3 was 29.8 person-years, i.e. 20.2% of the total working time. Work related to the new power plant units amounted to 1.3 person-years, i.e. 0.9 % of the total working time. A total of 9.5 person-years, 6.4% of the total working time, were spent on inspection and review of Posiva's operations. The time spent on international co-operation regarding regulatory oversight of nuclear safety was 4.0 person-years, and that spent on the FiR 1 research reactor was 0.2 person-years. The working time spent on small-scale users of nuclear material was 0.4 person-years. Figure 27 shows the division of working hours of the personnel engaged in nuclear safety oversight (in person-years) by subject of oversight during 2005–2012.

Where necessary, STUK commissions independent safety analyses and research in support of regulatory decision making. Figures 28 and 29 show the costs incurred by orders during 2005–2012. The costs in 2012 were mainly related to comparative analysis, independent assessments and third-party consultants' inspection work concerning the plant unit under construction, as well as to assessment work concerning the safety documentation for final disposal of nuclear waste. Appendix 8 shows the assignments financed by STUK in 2012 regarding the safety of nuclear power plants and final disposal of nuclear waste. Assessment of the safety documentation for final disposal of nuclear waste is discussed in section 5.1.3.

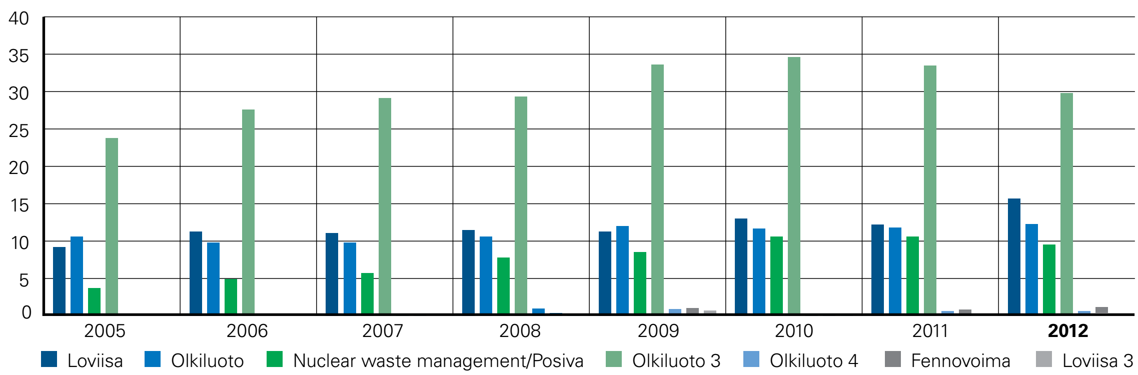


Figure 27. Distribution of working hours (person-years) of the regulatory personnel by subject of oversight in 2005–2012. Until 2011 the nuclear waste management includes both the oversight of the operating nuclear power plants' nuclear waste management as well as the oversight of Posiva, since 2012 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.

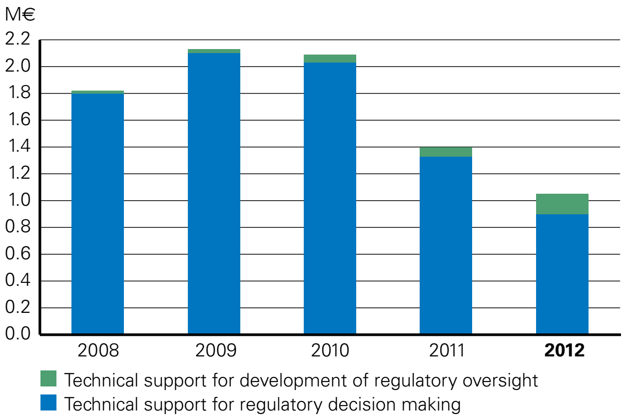


Figure 28. The costs of research and commissioned work pertaining to the safety of nuclear power plants.

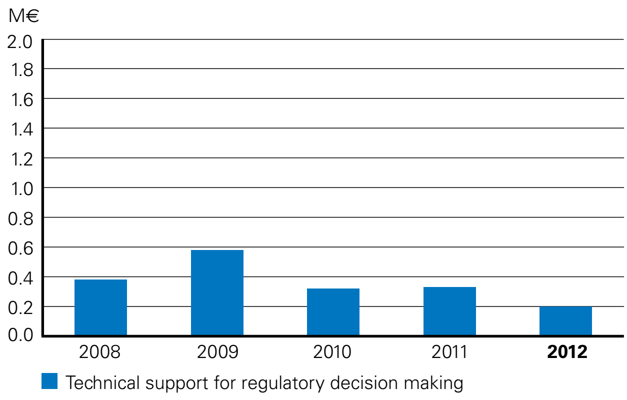


Figure 29. The costs of research and commissioned work pertaining to nuclear waste management and nuclear non-proliferation.

Table 6. Distribution of working hours (person-years) of the regulatory personnel in each duty area.

Duty area	2008	2009	2010	2011	2012
Basic operations subject to a charge	60.7	68.0	70.5	70.2	68.9
Basic operations not subject to a charge	6.3	6.6	7.8	8.8	5.6
Contracted services	2.2	1.7	1.9	1.7	2.2
Rule-making and support functions	31.5	33.6	38.2	43.0	46.3
Holidays and absences	21.1	23.5	24.3	24.7	24.7
Total	121.8	133.5	142.9	148.4	147.7

The distribution of the annual working time of the nuclear safety regulation personnel to the various duty areas is shown in Table 6.

10 Development of regulatory oversight

10.1 STUK's own development projects

Changes in practices and the organisation updated into the quality manual

A total of 36 guides were updated in the nuclear safety regulation quality manual, and 37 appendices to the guides were updated. Two new guides were completed, together with a total of three appendices to different guides. The new guides concerned the management of the access rights to the TARKKA system, used in the preparation of inspection records, and the oversight of the final disposal of radioactive materials. 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.

International assessment of STUK's regulatory oversight operations

A team of more than 20 experts headed by the IAEA carried out an extensive evaluation of STUK's oversight operations in October 2012. The final report of the evaluation team was completed in November, and STUK used the recommendations to produce an action plan. On the whole, STUK's nuclear energy oversight operations were assessed to be of a high quality. Recommendations were given on the independence of STUK, on the development of inspection and review procedures, and competence management.

The assessment results were also utilised in the development of STUK's strategy. The agreed development measures will be implemented during 2013–2015.

Development project for the periodic inspection programme

The operational model developed within the periodic inspection programme development project (KOTKA) was adopted. The new model includes a systematic assessment of the organisation's operations in all the inspections of the periodic inspection programme; the observations will be summed up in quarterly briefings. The new model allows easier assessment of overall safety.

Development of the oversight of nuclear waste management

In 2012, the development of nuclear waste management focused on the planning of oversight practices for the final disposal facility for spent nuclear fuel, and the further development of inspection criteria for the construction licence application. Since this is the first application of the plant type, oversight must be planned in stages as the project proceeds.

Development of the records management system

A version upgrade to the records management system adopted in 2009 was prepared in 2012. However, the adoption of a shared system for several state agencies was postponed to 2013.

Electronic inspection protocols were adopted in new areas

The electronic inspection protocol system (TARKKA) introduced in 2011 was expanded to the periodic inspection programme protocols. The functionality and availability of the system was also improved on the basis of feedback gathered when the system was first taken into use.

10.2 Renewal and human resources

Training for inspectors was organised, for example, concerning nuclear power plant systems and regulatory activities. 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 field.

The total duration of the ninth YK course was 20 days in six periods. Three of the periods took place in spring 2012. Eight STUK employees participated in the YK9 course. In the autumn 2012, the YK10 course began with eight STUK inspectors participating. The total number of participants in the YK10 course was 75.

STUK was actively involved in the planning and execution of nuclear waste management training, now organised for the third time as a course of a little over a week's duration. The course gathered together 24 students, and the lecturers were experts from the Ministry of Employment and the Economy, STUK, Posiva, Fortum, Fennovoima, TVO, Aalto University, the Laboratory of Radiochemistry at the University of Helsinki, and Saanio & Riekkola. The course focused on the main themes of nuclear waste management, covering the entire nuclear fuel cycle. In addition to lectures, the course involved an exercise on safety argumentation.

STUK's inspectors also participated in training provided by external enterprises, such as lead auditor training, project operations training and audit training. STUK's inspectors also participated in various domestic and international training events in the sector, both as participants and lecturers. In addition, supervisors in the field of nuclear safety participated in management and leadership skills coaching programmes.

Two Master's theses were completed in the Nuclear Reactor Regulation department in 2012, one concerning the assessment of the adequacy of Olkiluoto 3 test operation on the basis of accident analyses, and one concerning the generation of cross section data files in the Serpent-ARES calculation chain. In addition to these, two Master's theses were prepared for completion in 2013.

On average, 9.8 days per inspector in the field of nuclear waste and materials regulation and 8.2 days per inspector in the field of nuclear reactor regulation were spent on developing the expertise of STUK's nuclear safety experts in 2012.

Five new employees were hired for nuclear reactor regulation in 2012. Their position are in the oversight of operation, water chemistry, regulations and competence development. Three new inspectors were recruited for the regulatory oversight of nuclear waste management in the areas of management system and quality assurance, assessment of the bedrock in the final disposal facility, and oversight of the design and engineering of nuclear waste facilities.

11 Emergency preparedness

In 2012, Finnish nuclear power plants reported 14 events of failures to the Radiation and Nuclear Safety Authority. The nuclear power plant control rooms tested regularly the secured telephone connections built for emergency situations and real-time data transfer from power plant process computers to STUK's emergency response centre.

STUK organised emergency training and exercises related to nuclear power plant and radiation emergencies. The exercises test the operation of the emergency response organisation, the feasibility of the emergency response procedures and the usability of the emergency response premises in practice. Operations, procedures and tools are revised on the basis of the feedback received from the exercises. The exercises also serve to familiarise new personnel with their duties in the emergency response organisation.

The Olkiluoto exercise was organised on 18 October 2012 as an annual drill by the power plant and STUK, with the Finnish Meteorological Institute and the Regional Rescue Service of Satakunta also involved. Other participants included the on-call personnel from the Ministry of the Interior, the Ministry of Social Affairs and Health, and the Government Situation Centre. Other parties required in the situation were simulated by STUK. The date of the exercise had been provided in advance, but not the exact time. The actual weather conditions were used in the exercise.

STUK tested the initial stage operations and the generation of status information as well as cooperation with other organisations. STUK launched the necessary measures with no delay. STUK produced status reports, recommendations for the protection activities required by the hypothetical situation, and press releases. The exercise was the first time that STUK tested the use of an information officer of the Ministry of Social Affairs and Health for the preparation of press releases in Swedish. The practice proved successful. Information was transmitted in STUK's protected Finri site. The exercise was also the first time that the relay of status information using the IAEA's USIE website, especially built for exercises, was tested.

The exercise was a part of the international IRRS evaluation of nuclear safety, nuclear materials and preparedness. International reviewers gave positive feedback on the competence and motivation of STUK personnel and the work, procedures and tools of the emergency response organisation. STUK also had its own reviewers in all action groups. A total of 65 persons from STUK participated in the exercise.

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 and the police. The Satakunta group also includes the Finnish Border Guard; the Eastern Uusimaa group also involves the emergency care organisation. Meetings of the cooperation teams discussed issues such as emergency response training, experiences gained from drills, the update status of external rescue plans, organisations' development projects, and changes to legislation.

12 Communication

STUK's nuclear safety communications are based on active, immediate, open and honest communication and media services. In 2012, STUK published approximately 30 pieces of news on nuclear safety. Nuclear safety specialists also gave numerous interviews to domestic and international media on subjects such as the stress tests of the nuclear power plants and the final disposal of spent nuclear fuel.

Direct communications to the public via STUK's website and social media, such as Facebook and Twitter, are an important part of the communications. STUK also answers questions that the public presents by telephone or e-mail, participates in public meetings and receives guest groups.

In 2012, STUK's nuclear safety communications were focused on the improvement of the safety of nuclear power plants as a result of the Fukushima nuclear power plant accident. In this context, STUK provided information on the progress and results of national assessments and the EU's stress tests throughout the year. A total of seven press releases were published. The ability of the Olkiluoto power plant to deal with a long power outage was a particular topic of public discussion.

The European Nuclear Safety Regulators Group (ENSREG) published a summary of the stress tests of European nuclear power plants on 26 April and organised a public event in Brussels at the beginning of May to let nuclear safety regulators, power companies, civic organisations, the media, and the interested public discuss the stress tests. STUK provided information on the ENSREG report and invited the representatives of Finnish civic organisations and media to the event in Brussels.

STUK also organised its own event in Finland, directed at stakeholders and the public, on 16 May. The event was broadcasted live via the STUK website.

On 11 March, the anniversary of the Fukushima disaster, STUK's experts answered questions about Fukushima on STUK's Facebook page. The information from Fukushima investigations has been gathered under its own section on STUK's Finnish website.

During the year, STUK provided information for two international assessments organised by the IAEA. The international IPPAS group performed a follow-up assessment of Finnish nuclear security and security arrangements in April. An international IRRS peer evaluation of Finnish oversight of nuclear energy and the use of radiation took place in October.

STUK also organised a briefing about the IRRS evaluation together with the International Atomic Energy Agency IAEA as soon as the first evaluation results were available. The briefing was broadcast live via the website; a recording of it is still available.

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

STUK provided information as quickly as possible on all deficiencies observed at Finnish nuclear power plants that require a special report from the licensee or that are otherwise considered matters of public interest.

In 2012, STUK gave information on its website about observations made in the inspections and oversight of the Olkiluoto 3 plant unit, currently under construction, on 15 separate occasions. Even though the events did not put the safety of the plant or the environment at risk, STUK reported them with no delay in accordance with its communications policy.

STUK reports the operation, events and oversight of the operating power plant units as well as the oversight of Olkiluoto 3 and nuclear waste management on a quarterly basis. In the annual report published in April 2012, STUK reported the regulatory oversight of nuclear safety and the related observations in 2011. The annual report included, among other things, the overall safety assessments of nuclear power plants, produced on the basis of the observations made during oversight activities. The reports were published in printed form and as electronic versions on the STUK website.

With regard to international cooperation, STUK provided information on a cooperation agreement being signed with the regulatory authority of South Korea, on the appointment of Director General Tero Varjoranta as the head of the European Nuclear Safety Regulators Group ENSREG, and on a nuclear safety conference organised by the IAEA in August.

13 International cooperation

International evaluation of the measures launched as a result of the Fukushima accident

EU stress tests

As a result of the Fukushima accident, the EU launched stress tests for operating nuclear power plants and for those under construction. The purpose of these tests was to establish how the plants would cope with exceptional external events and other situations associated with the simultaneous loss of operability of several safety systems. The national stress test reports were prepared by nuclear safety authorities by the end of 2011, and an international peer evaluation of the national measures was carried out at the beginning of 2012.

The peer evaluation of national reports took place in a two-week event held in Luxembourg in February. The evaluation was carried out by three parallel groups that examined the reports by subject area: external threats, loss of safety functions, and serious accident management. One expert from STUK participated in the work of each evaluation group. Before the two-week event, the evaluation groups had presented additional questions on the basis of the national reports; these questions were answered within each group in a two-hour discussion session. Finland only sent STUK specialists to the peer evaluation, but many other countries also sent representatives of power companies to answer questions. Country-specific draft evaluation reports were prepared based on the Luxembourg event.

Evaluations were continued in March during country visits, including discussions with each country's authorities and visit to one plant. During the country visit, questions that had remained open in Luxembourg were answered, and the situation of the plants was verified as far as possible during the short visit. Two STUK experts participated in country visits to other countries. STUK acted as host to the visit to Finland, and the plant visit took place at the Loviisa power plant. At the power plant, STUK managed the discussions with the evaluation group, and the representatives of the licensee guided the guests around the plant. Country-specific evaluation reports were finalised during the visits, and comments from STUK were requested for the report concerning Finland to avoid any misunderstandings.

ENSREG (European Nuclear Safety Regulator's Group) used the peer evaluations as a basis for recommendations that should be taken into account when making safety improvements to nuclear power plants. The recommendations and the country-specific evaluations were published at the end of April. The Finnish country report did not reveal any major issues that STUK had not already included in its requirements to the power companies or in planned revisions to regulatory guidelines.

In December 2011, power companies had presented their own plans and estimates for the safety improvements to be implemented following the Fukushima disaster. STUK wanted to see the results of the stress test peer evaluation before commenting on these plans. After publication of the peer evaluation results, STUK issued decisions and additional requirements for the licensee's plans in July 2012. Some issues were still left to wait for the final requirements of the nuclear safety regulations currently being revised.

In September 2012, additional visits to some nuclear power plants in selected countries were made within the stress tests. Finland was not a target of these visits, but one representative of STUK participated in plant visits in other countries.

Second extraordinary meeting of the Convention on Nuclear Safety

The second extraordinary meeting of the Convention on Nuclear Safety (CNS) was held in Vienna at the end of August to discuss the safety improvements implemented following the Fukushima disaster. Unlike the EU stress tests, the CNS meeting also discussed implemented measures and the prerequisites of the maintenance of safety on a national level. STUK had delivered a report on Finland's status to the meeting in May 2012. The CNS meeting discussed nuclear safety issues in groups in accordance with the subjects included in the report: external threats, design basis, serious accident management, national organisations, emergency response operations, and international cooperation. Several STUK experts participated in the meeting to ensure representation in all groups. The director general of STUK chaired the design basis group in the meeting. Of the power companies, TVO had also sent a representative to the meeting.

Further plans

ENSREG will organise an evaluation of the national plans to be executed on the basis of the stress tests. National plans were delivered to ENSREG by the end of 2012. The plans aimed to demonstrate that ENSREG's recommendations had been followed. National plans will be evaluated similarly to the national stress test reports in April 2013 in a one-week meeting held in Brussels. In Finland, many of the recommended measures were already in place before the Fukushima disaster.

International operating experience feedback

STUK's activities

STUK has a working group for follow-up and review of international operating experience events and reports from nuclear power plants. The working group includes STUK experts from various fields of technology. In 2012, the working group assessed in its monthly meetings a total of approximately 100 reports received from the IAEA's operating experience database. Of 81 assessed reports, 60 required no measures at Finnish nuclear power plants. With regard to five events, the practices and arrangements in place at Finnish nuclear power plants were found to be adequate to prevent similar events. In the cases of 14 event reports, it was decided that the situation at Finnish nuclear power plants should be subjected to closer assessment in connection with the periodic inspection programme or the inspections carried out during the annual outage. Two reports, one of which was an event at Olkiluoto 1 reported by STUK, were considered to require measures at Finnish nuclear power plants or in future nuclear power projects.

One new report, one addition to an earlier report and one follow-up report of events at Finnish nuclear power plants were added to the IAEA's operating experience database (International Reporting System for Operating Experience, IRS). The new report concerned fractures observed in the valves of an overpressure protection and residual heat removal system of the reactor coolant system at Olkiluoto 1 and Olkiluoto 2; the addition to an earlier report concerned the outer steam line isolation valves' disturbances detected at Olkiluoto 1 in 2009; and the follow-up report concerned the repairs and modifications carried out for the pipe penetrations of the emergency cooling system pump rooms of the Olkiluoto plant units to repair the deficiencies reported in 2009. In addition, STUK submitted four feedback reports to the IAEA's IRS system on measures required on the basis of these reports in Finland.

STUK's expert acted as a national specialist at the EU OEF Clearinghouse, Petten, for the entire year preparing a report on the events of digital I&C systems.

Major events

The inspections carried out on Doel 3 in Belgium in July revealed indications in the pressure vessel material, believed to have been created during manufacturing due to deficient hydrogen removal heat treatment. Doel 3 is a pressurised water unit first commissioned in the first half of the 1980s, with a pressure vessel manufactured at a Dutch shipyard. The shipyard has manufactured pressure vessels during the period for several plants in Europe and the U.S. There are no pressure vessels from this manufacturer in Finland. The Belgian nuclear safety authority published a preliminary

IRS report on the observations, and asked at the same time the authorities of other countries about the kinds of inspections that had been carried out at other plants. European countries which have pressure vessels from the same manufacturer also reported their measures at the meetings of the IAEA's IRS coordinators and the operating experience group (WGOE) of the OECD/NEA.

Another event that had launched measures at Finnish power plants already a year earlier was a fire in the containment of Ringhals 2 during an annual outage. As a result of the fire, it was observed that the containment spray system could potentially be blocked (plugs and welding residue from modification work carried out in 1988). The investigations and resulting measures of Finnish nuclear power plants remain unfinished.

International conventions

STUK prepared a national report for the extraordinary meeting of the Convention on Nuclear Safety and delivered it to the IAEA according to the agreed schedule. The meeting considered the safety improvement and preparedness measures deemed necessary following the Fukushima disaster, as well as the need to modify the Convention on Nuclear Safety and the related evaluation process.

It was decided that the Convention shall not be modified at this stage, but detail was added to the evaluation procedure. In addition, it was decided that a new working group would be established to discuss the needs for modifications in the Convention and the related practices. The results will be reported in the sixth review meeting of the Convention on Nuclear Safety in spring 2014.

STUK experts presented Finland's report in the review meeting of the international nuclear waste management convention. The report and Finland's practices were well received. The meeting stated that Finland's long-term strategy for the final disposal of spent nuclear fuel, as well as the definition of strict dose limits for both the employees and the general population, were good practices. It was also stated that future challenges include the schedule of the final disposal project, the management of national competence, the nuclear waste management of the new operator, and the safety improvements required following the Fukushima disaster.

Cooperation within international organisations and with 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 ten 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 U.S., the following countries participate in the programme: South Africa, India, South Korea, France, Finland, the United Kingdom, Russia, and the United Arab Emirates. Participants in the programme include only those countries with new nuclear power plants at some stage of assessment by the regulatory authorities. The OECD Nuclear Energy Agency functions as the secretariat for the programme.

The MDEP's work is organised in design-specific and issue-specific working groups. In addition, the MDEP has a management group and a steering group. STUK is represented in all these groups. There are three plant type-specific working groups: the EPR group, the AP 1000 group and the APR1400 group. Finland is involved in the work of the EPR and APR1400 groups. An EPR unit is currently under construction in Olkiluoto, and APR1400 is one of the alternatives for the OL4 plant unit. The other countries in the EPR group include France, the United States, the United Kingdom, Canada and China. The participants in the APR1400 group include, in addition to Finland, the United Arab Emirates, South Korea, and the United States. The EPR working group is chaired by the Finnish representative; the working group has four subgroups dealing with plant automation, accidents and transients, severe accidents and probabilistic risk analyses (PRAs). STUK's representative chairs the PRA subgroup. The EPR group's work was originally a continuation of cooperation between the Finnish and French authorities concerning safety assessment of EPR power plants. The APR1400 group held its first meeting in late 2012. Finland will be involved in the work of the group for as long as the plant type is one of the alternatives for the OL4 unit.

The MDEP working groups independent of plant design dealt with the following three subjects:
- Inspections of plant and equipment suppliers
- Pressure equipment standards
- 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 is to establish the procedures and requirements applied to inspections by the participating countries and to create the procedures and goals for joint inspections. The objective of the working group dealing with pressure equipment is the harmonisation of requirements in different standards. The Digital I&C working group aims to promote coordinated development of the IEC and IEEE standards, among others. In addition, some individual issues have been chosen, 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 in 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) 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 were included in expert groups assembled by the IAEA to assess the operations of Swedish, Greek and Slovakian safety authorities, and in the IAEA group to assess the safety of the injection-based final disposal of liquid waste in Russia.

STUK is the Finnish contact organisation for the following nuclear energy information exchange systems maintained by the IAEA:
- Incident Reporting System (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)
- Directory for Radioactively Contaminated Sites (DRCS)
- Illicit Trafficking Database (ITDB)
- Database on Events that have arisen during Transport of Radioactive Material (EVTRAM).

Cooperation within the EU

STUK participated in the activities of the EU Member States' nuclear safety regulators' cooperation group (ENSREG, European Nuclear Safety Regulators Group) and in two of its subgroups (nuclear safety and nuclear waste management). The cooperation group took part in the preparation of the nuclear waste management directive and coordinated the implementation of the directive, as well as that of the nuclear safety directive, in the member countries. The director general of STUK chaired ENSREG starting from July.

STUK participated in the nuclear safety, nuclear waste and decommissioning work carried out by WENRA (Western European Regulators' Association) and its working groups. The groups have developed common safety reference levels on the basis of the IAEA standards, and an agreement regarding their implementation in all member countries has been concluded between the members of WENRA. WENRA continued the earlier work for defining the safety objectives of new plants and for establishing the differences and common features of inspection operations in different countries.

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).

Other international cooperation

STUK organised a meeting of the Network of Regulators of Small Nuclear Programs (NERS). The aim of the NERS cooperation is to promote cooperation between the authorities of small nuclear power countries in issues typical of these countries. In addition to Finland, the following countries participate in NERS: Argentina, Belgium, South Africa, the Netherlands, Pakistan, Slovakia, Switzerland and the Czech Republic. Finland chaired the NERS.

STUK participated in the cooperation between the regulatory authorities of countries with VVER power plants (such as the Loviisa NPP) via the VVER Forum. STUK's representative chairs the safety oversight working group. The working group's focused on the assessment and oversight of management systems.

STUK's representatives were members 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.

APPENDIX 1 STUK's safety performance indicators for NPPs in 2012

Summary of the safety performance indicators for nuclear power plants

Background and objectives of the indicator system

Safety is a primary prerequisite for the operation of nuclear power plants. The power companies and STUK evaluate and oversee the safety and operation of the plants in many ways. Along with inspections and safety reviews, indicators are a method of acquiring information on the safety level of the plant and on any changes to the safety level. The STUK indicator system consists of two main groups: 1) plant safety indicators, and 2) indicators describing the efficiency of the authorities. This summary covers the indicators describing plant safety.

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

In the indicator system, nuclear safety is divided into three sectors: 1) safety and quality culture, 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 situation in each plant in 2012 is presented below, followed by the detailed results by indicator.

<table>
<tr><th colspan="3">Nuclear safety</th></tr>
<tr><th>A.I Safety and quality culture</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>

Safety and quality culture 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. When assessing the safety and quality culture, 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 2012

Summary of indicator results for the Loviisa power plant

Structural integrity

In 2012, the reactor of Loviisa 1 had no leaking fuel. A minor fuel leak was observed at Loviisa 2 in December 2012. The leaking fuel assembly will be removed in the 2013 annual outage. Based on indicator values, the integrity of the reactor coolant system of both plant units remained good in 2012.

The overall as-found leakage of the outer isolation valves of Loviisa 1 has decreased. At Loviisa 2, the overall as-found leakage increased, and based on the first tests, exceeded the limit set for overall leakage. Two outer isolation valves with plenty of leakage formed 85% of the overall as-found leakage. Both lines also have inner isolation valves. After the repair of the valves, the overall as-found leakage was again below the set limit.

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 (RA, RL, TL23), is good at both plant units.

Radiation doses and releases

In 2012, the eight-year annual outage took place at Loviisa 1, and a short annual outage at Loviisa 2. The time used for annual outages was long, and there was a high amount of work with significance for radiation protection, which resulted in a total collective dose that was higher than that of the previous years. Radiation protection measures were carried out in the appropriate manner, and the occupational radiation doses at the nuclear power plant were below the personal dose limits. Releases into the environment were small in 2012, well below the set limits.

Operational events at the plant

Two reactor trips took place at the Loviisa power plant in 2012. The number of reactor trips has always been low at the power plant. The previous reactor trips happened in 2004 and 2010. The number of reported operational transients increased from the previous years, but remained reasonable when long-term data is considered. Seven operational transients occurred during the year. A leak in the reactor coolant pump seal water line at Loviisa 2 was a significant operational event. The plant unit was consequently shut down for a short outage. The number of events discussed in special reports was clearly higher than in the previous years. The number of events constituting noncompliance with operational limits and conditions (OLC) was considerably higher in 2012 than in the previous years. The events had no impact on the safety of the plant or its environment.

For the Loviisa power plant, the most significant factors affecting the overall accident risk include internal plant events during outages (such as falling heavy loads in the reactor hall), fire, a high level of seawater during power operation and oil spills during a refuelling outage. The annual probability of a severe reactor accident calculated for the Loviisa plant units has decreased by about 27% from the previous year. Several minor plant modifications, improvements of computational modelling and verification of reliability data have contributed to the reduction of the risk. Loviisa power plant's accident risk has continued to decrease over the last 10 years, and new risk factors discovered as the scope of the risk analysis has been extended, have been systematically removed.

The functionality of safety systems is monitored at the Loviisa power plant on the basis of the unavailability of the high-pressure safety injection system, the emergency feed water system and the emergency diesel generators. As in previous years, safety systems remained in good condition in 2012. The indicators show that the maintenance of and fault repairs to components important to safety was appropriate.

There were no events classified as fires at the Loviisa power plant or in its immediate vicinity in 2012. The power plant's fire detection system had a similar number of faults as in the previous year. The average fire safety of the Loviisa plant has remained at the same level.

The number of common cause failures has increased slightly from the previous years. In 2012, three safety-significant common cause failures were identified at the Loviisa power plant. These included the neglect of the testing of recombiners in the reactor building's annular space in accordance with the operational limits and conditions, faulty settings of the thermal relays in the motors of 0.4 kV pumps, and the programmable technology found in the voltage relays installed into safety classified switchgear. The common cause failure with the most safety significance was the faulty setting of the thermal relays in the motors of the 0.4 kV pumps. Human factors were behind the observed common cause failures.

Summary of indicator results for the Olkiluoto power plant

Structural integrity

Based on water chemistry indicators, the integrity of the reactor coolant circuits of the Olkiluoto plant units was good in 2012. The impurity and corrosion product levels in reactor water and feed water, followed in STUK's indicator scheme, were in keeping with the guide values set by the licensee at both plant units.

Fuel integrity of Olkiluoto 1 was good in the 2011–2012 operating cycle, and no leaks were detected.

One leaking fuel assembly was removed from the reactor of Olkiluoto 2 during the annual outage. The leak started in 2011. 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, which can get caught in the fuel assembly structures. The coolant flow may make the loose objects vibrate and break the fuel cladding. To prevent this, fuel assemblies with new sieve structures for foreign objects have been loaded into the reactor of Olkiluoto 2 in 2012. The sieve profiling has been changed to make the grid denser.

The overall as-found leakage of the outer isolation valves of Olkiluoto 1 increased when compared to the previous year, but remained clearly below the limit set in the operating limits and conditions (OLC). The overall as-found leakage of the outer isolation valves of 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 tightness test at first attempt has remained high for both plant units. The overall 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.

Radiation doses and releases

The radiation doses received by employees and the releases into the environment remained small and clearly below the limits set in official regulations. At Olkiluoto, the occupational radiation dose was the lowest in the power plant's operational history. The new steam driers, installed to the reactors in 2005 and 2006, have further lowered the radiation levels in the turbine island and thus the collective dose.

The releases of substances with gamma activity into the sea from the Olkiluoto power plant have been decreasing in recent years. In 2012, the atmospheric releases of radioactive substances were of the same magnitude as in previous years.

Operational events at the plant

For the Olkiluoto power plant, 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). The annual probability of a severe reactor accident calculated for the Olkiluoto plant units remained roughly the same as in the previous year.

No reactor trips took place at the Olkiluoto nuclear power plant in 2012. The number of events warranting a special report (five) follows the average of the last ten years. The number of events warranting a transient report (three) was below the average. Three of the events discussed in special reports included non-compliance with the operational limits and conditions without an advance safety analysis and STUK's permission. Such events did not occur in the three previous years. All of these non-compliances were unintentional. TVO analysed the events and defined corrective measures to prevent similar events from occurring in the future.

The production losses at Olkiluoto 1 due to failures were higher than in the previous years. This is mainly explained by the generator failure that occurred in the spring and led to TVO deciding to begin the annual outage of Olkiluoto 1 nearly a month earlier than planned. TVO replaced the generator during the annual outage. The production losses resulting from failures at Olkiluoto 2 were virtually nonexistent.

Two of the shut-down secondary cooling systems of Olkiluoto 2 were unavailable at the same time for little less than eight hours due to failures at the end of July. This increased the annual risk for Olkiluoto 2 by 29%. Such an increase due to a double common cause failure proves the importance of the secondary cooling system for plant safety. The dependence of safety of the secondary cooling circuit will decrease in future when the 327 auxiliary feed water system will be modified to function independently of the secondary cooling circuit. The project has been active for years, and is not a result of the event described above.

No events classified as fires occurred in the Olkiluoto power plant area in 2012. Five events classified as fires occurred outside the plant area. The fires were minor and could be put out using first aid extinguishers. No defects were found in the fire detector system.

The number of common cause failures has increased in recent years. In the three previous years, the total number of common cause failures has been 12. Most of these have occurred in the emergency diesel generators (six failures) and the relief system (three failures). TVO has initiated a planning process for replacing the emergency diesel generators.

Safety performance indicators

A.I Safety and quality culture

A.I.1 Failures and their repairs

A.I.1a Failures of components subject to the operational limits and conditions

Definition

The number of failures causing the unavailability of components defined in the operational limits and conditions (OLC) during power operation is monitored as an indicator. The failures are divided by plant unit into two groups: failures causing an immediate operation restriction and failures 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 the power plants.

Purpose of the indicator

The indicator is used to assess the plant life-cycle management and the development of the condition of components.

Responsible units/persons

Resident inspectors
Petri Vastamäki (Loviisa nuclear power plant)
Jukka Kallionpää (Olkiluoto nuclear power plant)

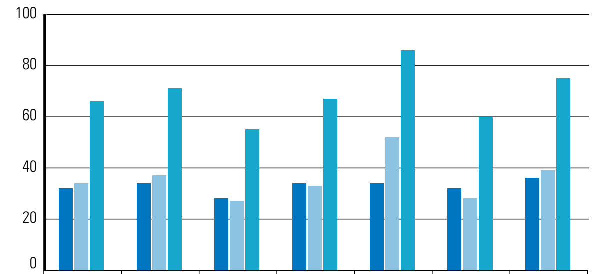
Interpretation of the indicator

Loviisa

The total number of failures causing an operation restriction of components subject to the OLC in 2012 was 172. The average of failures in the four previous years was 182, which means that there was no significant change in the number of failures in 2012 or in the failure trend.

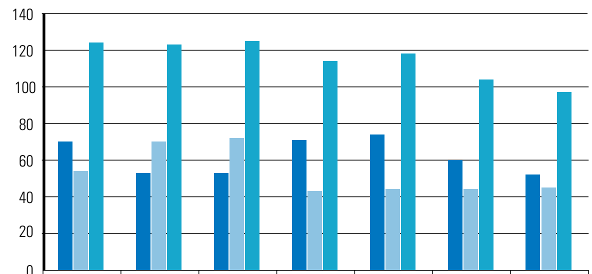
The number of failures per year has remained stable. Any variation therein has been caused by the random occurrences of failures that occur in any large number of components. Failure detection and anticipation have been continuously improved in plant maintenance operations at Loviisa, and components have been replaced. Due to these mea-

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



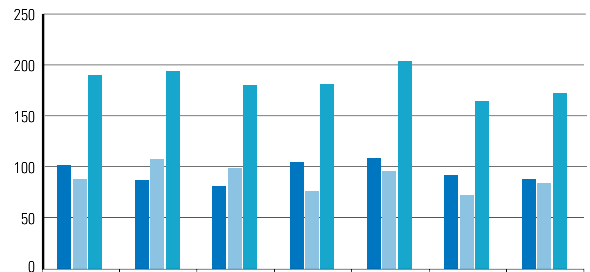
	2006	2007	2008	2009	2010	2011	2012
LO1	32	34	28	34	34	32	36
LO2	34	37	27	33	52	28	39
LO1,2	66	71	55	67	86	60	75

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



	2006	2007	2008	2009	2010	2011	2012
LO1	70	53	53	71	74	60	52
LO2	54	70	72	43	44	44	45
LO1,2	124	123	125	114	118	104	97

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



	2006	2007	2008	2009	2010	2011	2012
LO1	102	87	81	105	108	92	88
LO2	88	107	99	76	96	72	84
LO1,2	190	194	180	181	204	164	172

sures, there have been no failures with a significant impact 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 failure data behind it does not show any significant negative effects associated with the ageing of the facilities, which is an indication of well-functioning component life-cycle management and component maintenance.

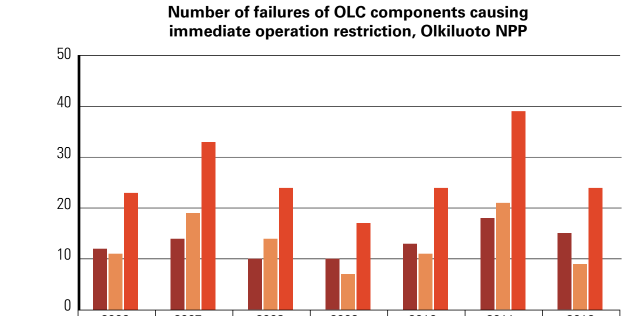
Interpretation of the indicator

Olkiluoto

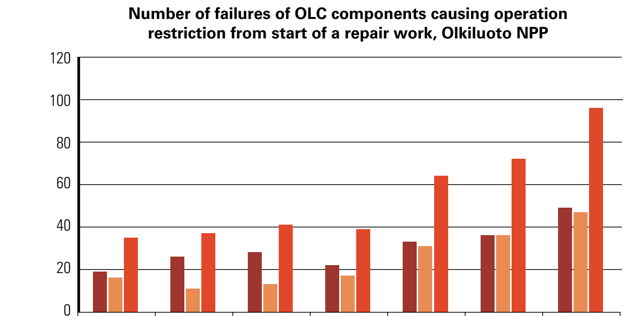
The number of failures occurring during power operation and causing the unavailability of components subject to the OLC has been increasing since 2009. In 2011, the number of failures was nearly double the number of failures in 2009. In 2012, the number of failures went down to the level of 2010. The number of failures indicates that maintenance work has been successful.

The unavailability times of OLC components occurring at OL1 during all four quarters of 2012 were brief.

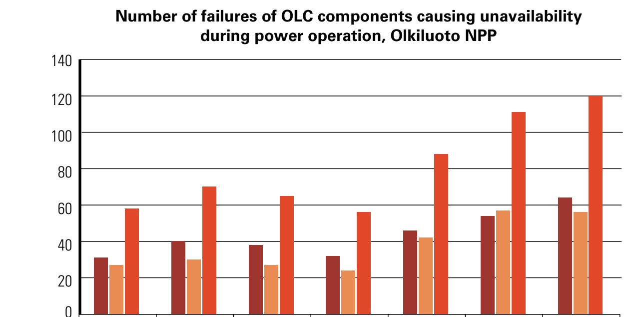
At OL2, most of the unavailability times of OLC components were brief in 2012. The number of operating restrictions was increased by the washing of the heat exchangers in the cooling systems.



	2006	2007	2008	2009	2010	2011	2012
OL1	12	14	10	10	13	18	15
OL2	11	19	14	7	11	21	9
OL1,2	23	33	24	17	24	39	24



	2006	2007	2008	2009	2010	2011	2012
OL1	19	26	28	22	33	36	49
OL2	16	11	13	17	31	36	47
OL1,2	35	37	41	39	64	72	96



	2006	2007	2008	2009	2010	2011	2012
OL1	31	40	38	32	46	54	64
OL2	31	40	38	32	46	54	64
OL1,2	58	70	65	56	88	111	120

A.I.1b Maintenance of components subject to the operational limits and conditions

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 plant work order systems, from which all preventive maintenance operations and fault repairs are retrieved.

Purpose of the indicator

The indicator describes the volumes of fault repairs and preventive maintenance and illustrates the condition of the plant and its maintenance strategy. The indicator is used to assess the maintenance strategy executed at the plant.

Responsible units/persons

Resident inspectors
Petri Vastamäki (Loviisa nuclear power plant)
Jukka Kallionpää (Olkiluoto nuclear power plant)

Interpretation of the indicator

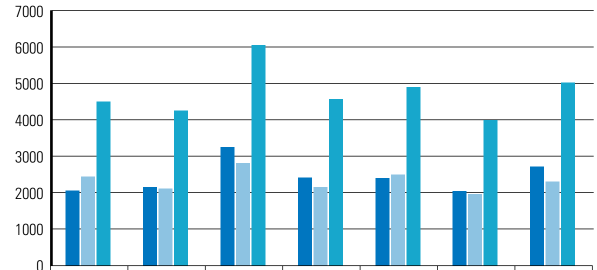
Loviisa

When considering the annual variation in the volume of fault repairs and particularly in the number of preventive maintenance works, the scheduling of various annual outages (refuelling outage, short annual maintenance, four-year annual maintenance, eight-year annual maintenance) included in the maintenance strategy of the Loviisa power plant during a four-year cycle should be considered as this can have a significant impact on the annual figures. In 2012, Loviisa 1 had an eight-year annual outage, and Loviisa 2 a short annual outage.

Based on the data behind the indicator, 2012 showed no major deviation from the average numbers of fault repairs and preventive maintenance volumes of the four previous years. In 2012, the number of maintenance tasks on components subject to the OLC was 3% higher than the average. Similarly, the volume of preventive maintenance was 5% higher than the average, and the number of fault repairs 14% lower.

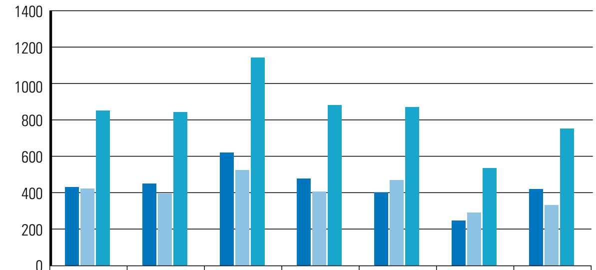
The ratio of preventive maintenance and failure repairs was 5.7. This is 16% higher than the 4.9

Volume of annual maintenance works of OLC components, Loviisa NPP



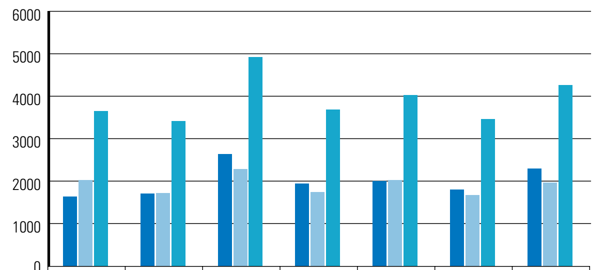
	2006	2007	2008	2009	2010	2011	2012
LO1	2057	2148	3250	2416	2403	2040	2717
LO2	2444	2105	2807	2148	2495	1952	2299
LO1,2	4501	4253	6057	4564	4898	3992	5016

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



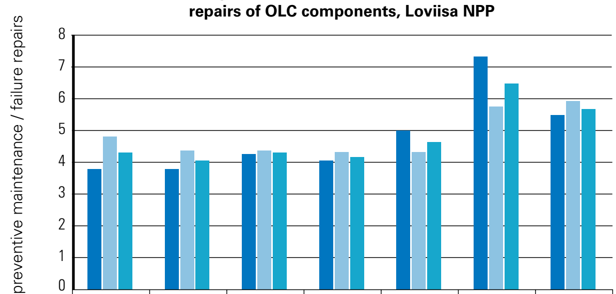
	2006	2007	2008	2009	2010	2011	2012
LO1	429	448	619	478	401	245	419
LO2	421	393	524	404	469	289	332
LO1,2	850	841	1143	882	870	534	751

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



	2006	2007	2008	2009	2010	2011	2012
LO1	1628	1700	2631	1938	2002	1795	2298
LO2	2023	1712	2283	1744	2026	1663	1967
LO1,2	3651	3412	4914	3682	4028	3458	4265

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



	2006	2007	2008	2009	2010	2011	2012
LO1	3.79	3.79	4.25	4.05	4.99	7.33	5.48
LO2	4.81	4.36	4.36	4.32	4.32	5.75	5.92
LO1,2	4.30	4.06	4.3	4.17	4.63	6.48	5.68

average of the four previous years, which means that the share of preventive maintenance of all maintenance work has remained high.

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

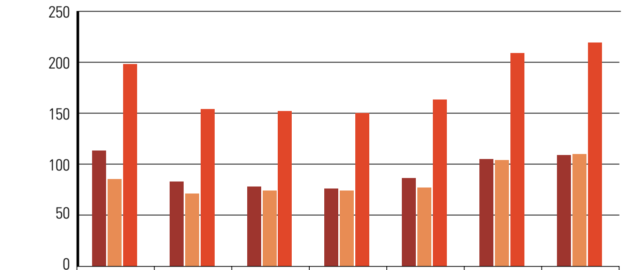
Olkiluoto

The number of maintenance works causing inoperability of components, included in the indicator, decreased during 2006–2009 due to the lower number of fault repairs. In 2010, the number of fault repairs increased while the number of preventive maintenance operations decreased.

In 2012, the number of fault repairs that caused inoperability of components remained at the 2011 level. The number of preventive maintenance tasks increased slightly, improving the ratio of preventive maintenance and fault repairs from 2011.

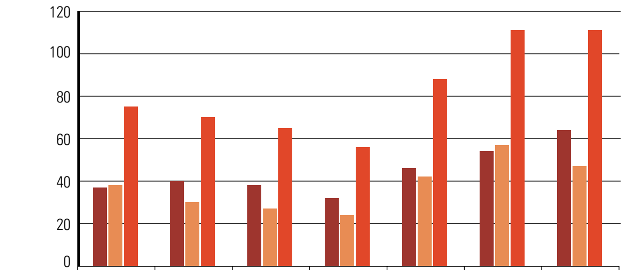
Based on the development of the ratio of preventive maintenance work to fault repairs and the assessment of the work behind the figures, the maintenance strategy can be considered successful.

Volume of annual maintenance works of OLC components, Olkiluoto NPP



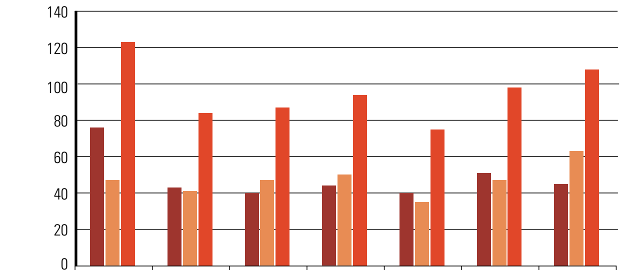
	2006	2007	2008	2009	2010	2011	2012
OL1	113	83	78	76	86	105	109
OL2	85	71	74	74	77	104	110
OL1,2	198	154	152	150	163	209	219

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



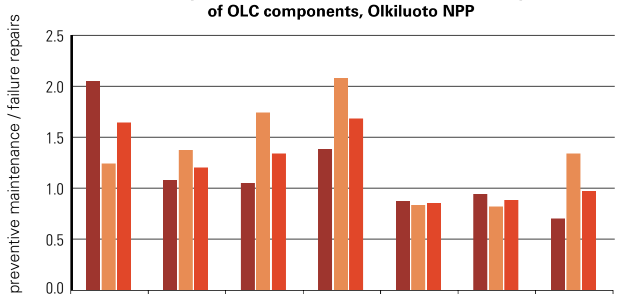
	2006	2007	2008	2009	2010	2011	2012
OL1	37	40	38	32	46	54	64
OL2	38	30	27	24	42	57	47
OL1,2	75	70	65	56	88	111	111

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



	2006	2007	2008	2009	2010	2011	2012
OL1	76	43	40	44	40	51	45
OL2	47	41	47	50	35	47	63
OL1,2	123	84	87	94	75	98	108

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



	2006	2007	2008	2009	2010	2011	2012
OL1	2.05	1.08	1.05	1.38	0.87	0.94	0.70
OL2	1.24	1.37	1.74	2.08	0.83	0.82	1.34
OL1,2	1.64	1.20	1.34	1.68	0.85	0.88	0.97

A.I.1c Repair time for components subject to the operational limits and conditions

Definition

As an indicator, the average repair time of failures 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. It is calculated from the detection of the failure to the end of the repair work, if the failure causes an immediate operation restriction. If the component is operable until the beginning of repair, only the time of the repair work is taken into account.

Source of data

The data is obtained from the power plant's work order systems and maintenance and operation documentation.

Purpose of the indicator

The indicator shows how quickly failed components subject to the operational limits and conditions (OLC) are repaired in relation to the repair time allowed in the OLC. The indicator is used to assess the strategy, resources and effectiveness of plant maintenance.

Responsible units/persons

Operational safety (KÄY), resident inspectors
Pauli Kopiloff (Loviisa nuclear power plant)
Jukka Kallionpää (Olkiluoto nuclear power plant)

Interpretation of the indicator

Loviisa

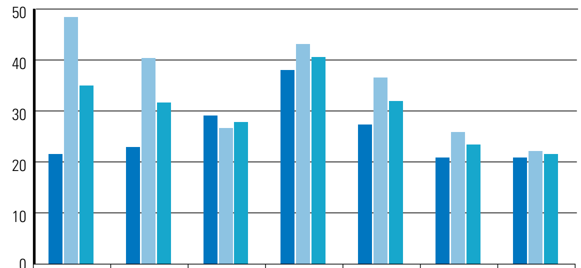
The operational limits and conditions define the maximum allowed repair times for components based on the components' safety significance. The times vary between four hours and 21 days. Failures in OLC components are to be repaired within the allotted time without undue delay.

Due to the small amount of work requiring operation restrictions and the varying allowable repair times, an individual operation may have a significant effect on the indicator value even when it is performed 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 failure repairs in terms of maintenance strategy, resources and efficiency of operations.

The average repair times for failures causing unavailability of components have remained stable at the Loviisa plant for several years; in addition, a decreasing trend can be traced over the last three years. In 2012, the average repair time at the plant units was 21.6 hours while the average for the four preceding years was 31.0 hours. The average repair time of OLC component failures that had an allowed repair time of 72 hours or less was 11.3 hours at LO1 and 14.8 hours at LO2 in 2012.

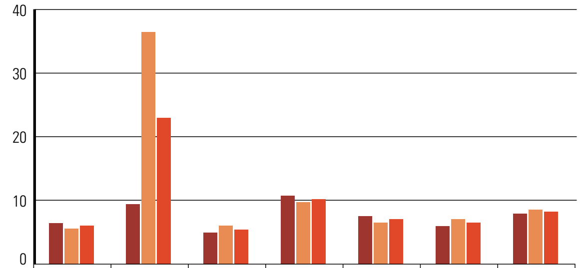
Based on the 2012 indicators and the data behind them, the plant's maintenance operations can be considered appropriate. In spite of the positive development in repair times, attention still needs to be paid to the power plant's maintenance on having the necessary resources available for fault repairs and on carrying out the repairs without unnecessary delays.

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



	2006	2007	2008	2009	2010	2011	2012
LO1	21.5	22.9	29.1	38.0	27.3	20.9	20.9
LO2	48.4	40.4	26.6	43.1	36.6	25.9	22.1
LO1,2	35.0	31.7	27.9	40.6	32.0	23.4	21.5

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



	2006	2007	2008	2009	2010	2011	2012
OL1	6.4	9.4	4.9	10.7	7.5	5.9	7.9
OL2	5.5	36.5	6.0	9.7	6.5	7.0	8.5
OL1,2	6.0	23.0	5.4	10.2	7.0	6.5	8.2

Interpretation of the indicator

Olkiluoto

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

Over a longer period, the average repair time has varied from six to ten hours with the exception of 2007. In that year, repair times increased strongly for both plant units to 1.5 times the previous year's figure at OL1 and to more than six times the previous year's figure at OL2. For both plant units, the increase was due to a failure in a single device. In 2012, the average repair time of failures causing the unavailability of components defined in the OLC was about 8 hours at OL1 and about 8.5 hours at OL2. At both plant units, the average repair time of failures causing the unavailability of components defined in the OLC was of the same order of magnitude as in 2010 and 2011.

On the basis of the 2012 indicators and the data behind them, the plant's maintenance operations were appropriate.

A.I.1d Common cause failures

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 utilities of works causing an operation restriction.

Purpose of the indicator

The indicator is used to follow the quality of maintenance.

Responsible unit/person

Operational safety (KÄY)
Niko Mononen (Loviisa)
Suvi Ristonmaa (Olkiluoto)

Interpretation of the indicator

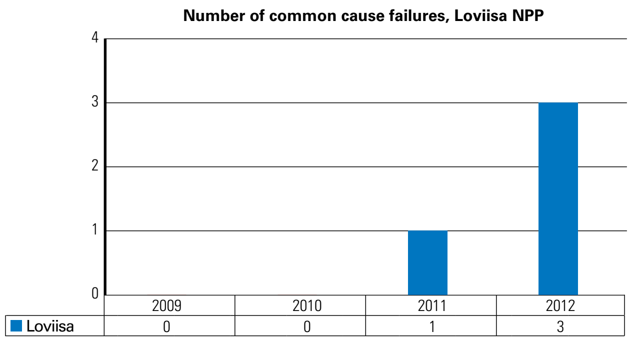
Loviisa

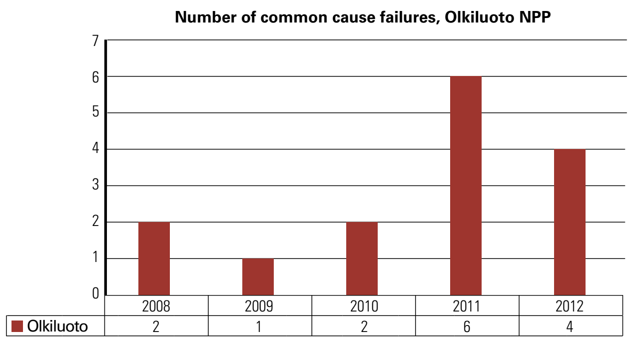
In 2012, three safety-significant common cause failures were identified at the Loviisa power plant. These included the neglect of the testing of recombiners in the reactor building's upper space in accordance with the operational limits and conditions, faulty settings of the thermal relays in the motors of 0.4 kV pumps, and the programmable technology found in the voltage relays installed into safety classified switchgear. The common cause failure with the most safety significance was the faulty setting of the thermal relays in the motors of the 0.4 kV pumps. Human factors were behind the observed common cause failures.

Olkiluoto

The number of common cause failures has increased in recent years. In the three previous years, the total number of common cause failures has been 12. Most of these have occurred in the emergency diesel generators (six failures) and the relief system (three failures). TVO has initiated a planning process for replacing the emergency diesel generators.

When a fault is observed in a safety-critical





system, component or structure in connection with maintenance, periodic testing or other monitoring operation, 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. Four common cause failures were found in the safety systems of Olkiluoto 1 and Olkiluoto 2 in 2012. These included the loosening and breaking off of the fixtures of the blowdown system pipes, an earth fault due to a failed core winding insulation in the rotor of an emergency diesel generator, dirty water and sedimentation in the emergency diesel cooling circuit due to the excess solvent content of the manufacturer's anti-corrosion agent, and fractures and damage in the shut-down secondary cooling system's pressure measurement nozzles.

A.I.1g Production loss due to failures

Definition

As the indicator, the loss of power production caused by failures 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 of the indicator

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

Responsible unit/person

Operational safety (KÄY)
Niko Mononen (Loviisa)
Suvi Ristonmaa (Olkiluoto)

Interpretation of the indicator

Production losses due to failures have been small at both Loviisa and Olkiluoto, as is also indicated by the plants' high load factors.

Loviisa

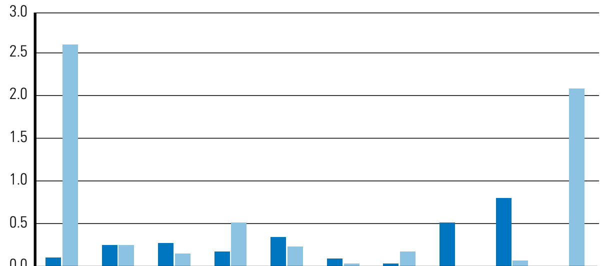
Loviisa 1 experienced less-than-average production losses from component failures. Loviisa 2's production losses from component failures were higher than in the previous years. Most of the losses were due to a leaking seal water line in a reactor coolant pump. The plant was run down to a cold shutdown state for repairing this fault.

Olkiluoto

In 2012, Olkiluoto 1 experienced a higher number of faults resulting in production losses than in the previous years. This is mainly explained by the generator failure that occurred in the spring and led to TVO deciding to begin the annual outage at the plant unit nearly a month earlier than planned. TVO replaced the generator during the annual outage. The production losses resulting from failures at Olkiluoto 2 were virtually nonexistent.

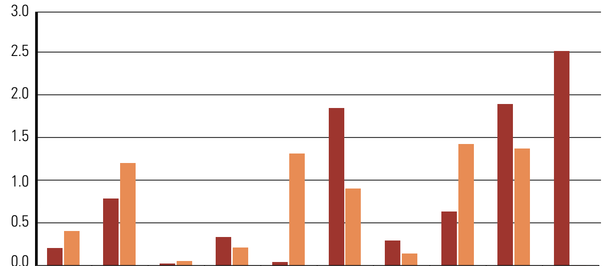
Most of the production losses at Olkiluoto 1 (91%) were due to the generator failure mentioned above. Other production losses were mostly caused by the identification and repair of turbine island faults during power operation. Reactor power was decreased during fault repairs. Such work included the repair of a leaking flange in the reheater drains cooler level measurement, replacement of a leaking rubbing-face seal of a feed water pump, and repair of a leak detected in the steam extraction system.

Loss of power production due to failures, Loviisa NPP



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	0.10	0.25	0.27	0.17	0.34	0.09	0.03	0.51	0.80	0.00
LO2	2.60	0.25	0.15	0.51	0.23	0.03	0.17	0.00	0.07	2.08

Loss of power production due to failures, Olkiluoto NPP



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	0.20	0.78	0.02	0.33	0.04	1.84	0.29	0.63	1.89	2.51
OL2	0.40	1.20	0.05	0.21	1.31	0.90	0.14	1.42	1.37	0.00

A.I.2 Exemptions and deviations from the operational limits and conditions

Definition

As indicators, the number of non-compliances 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 and from event reports.

Purpose of the indicator

The indicator is used to follow the utilities' activities in accordance with the OLC: compliance with the OLC and identified situations during which it is necessary to deviate from them; of which conclusions can be made as regards the appropriateness of the OLC.

Responsible unit/person

Operational safety (KÄY)
Niko Mononen (Loviisa)
Suvi Ristonmaa (Olkiluoto)

Interpretation of the indicator

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

Non-compliance with the OLC refers to a situation where the plant or a system or component of the plant is not in a safe state as required by the operational limits and conditions. The objective is that no events with non-compliance to the OLC occur at the plants. The licensee always prepares a special report on the non-compliance and any corrective action, and submits it to STUK for approval.

Loviisa

Exemptions

The Loviisa power plant applied for permissions from STUK for five planned deviations from the Operationl Limits and Conditions during 2012. The number of applications was slightly lower than the average of previous years (6). Two of the applications were related to failure repairs, one to a change of the plant's operating mode while an emergency diesel generator was isolated, one to the I&C upgrade, and one to a modification carried out at the 110 kV switchyard. STUK approved the applications because the assessments carried out indicated that the deviations had no significant implications for the safety of the plant or the environment.

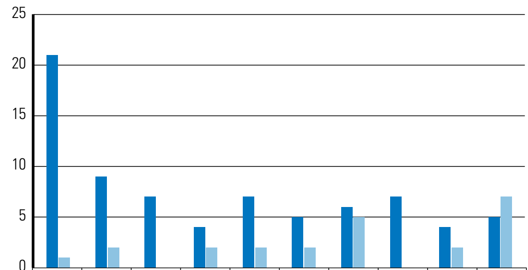
Events non-compliant with the OLC

In 2012, the number of events non-compliant with the OLC clearly exceeded the average of recent years (2). The Loviisa plant had seven events during the year when the plant was not in a state compliant with the OLC. The situations were related to neglected periodic testing of components subject to OLC (2 events), faulty isolations and repairs (4 events) and uncertainty of the operability of replaced valves in the pressure control system during start-up. Most of the events took place during annual maintenance. The events did not put nuclear or personal safety at risk.

Olkiluoto

Based on the results of the last 10 years, the Olkiluoto nuclear power plant applies for STUK's approval for non-compliance with the OLC seven times per year on average. Hence, the number of applications in 2012 (ten) was slightly higher than the average. Six of the applications were related to modifications, one to replaced equipment, two to an error detected in the control rod efficiency calculation method, and one to a periodic test. Half of the applications were related to the ongoing replacement of the plant's radiation measurement systems. Individual measurements had to be disabled for a few days during the replacement of equipment or the structure of the equipment location. As the planned deviations had no significant safety

Number of deviations from the OLC, Loviisa NPP



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Exemptions	21	9	7	4	7	5	6	7	4	5
Deviations	1	2	0	2	2	2	5	0	2	7

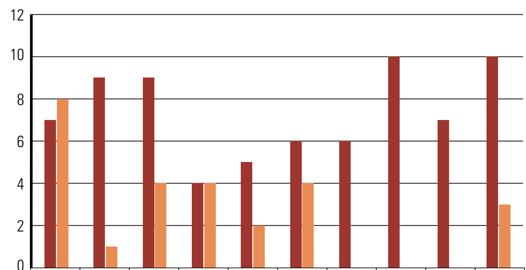
implications, STUK approved all applications. In 2004 and 2005, the number of deviations was increased by work and installations related to the modernisation of OL1 and OL2 and the construction of OL3. Similarly, major modifications were carried out during 2010 and 2011.

Events non-compliant with the OLC

In 2012, TVO reported three events during which the plant was non-compliant with the OLC without an advance safety analysis and STUK's permission. Such events did not occur in the three previous years.

All of these non-compliances were unintentional. In one of the cases, non-compliance with the OLC was due to a human error in the planning stage of a modification, and in another case, a human error in the implementation stage of a modification. In the third case, an error in the calculation method used to assess the efficiency of control rods during plant start-up led to non-compliance with the OLC. The individual events did not put the plant or its environment at risk. There were, however, three events in total, which makes it important to ensure that there are no deficiencies in the knowledge of the OLC or the procedures to follow the OLC that would lead to unintentional non-compliance. TVO analysed all events and defined corrective measures to prevent similar events from occurring in the future.

Number of deviations from the OLC, Olkiluoto NPP



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Exemptions	7	9	9	4	5	6	6	10	7	10
Deviations	8	1	4	4	2	4	0	0	0	3

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 vessel spray system (322), the auxiliary feed water system (327) and the emergency diesel generators (651…656). Those followed at Loviisa nuclear power plant are the high-pressure safety injection system (TJ), auxiliary feed water 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 calculated as the indicator. Unavailability hours are the combined unavailability of redundant subsystems divided by the number of subsystems.

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

Subsystem unavailability hours include the time required for the planned maintenance of components and unavailability due to failures. The latter includes, in addition to the time spent on repairs, the estimated unavailability time prior to failure detection. If a failure is estimated to have occurred in a previous successful test, but to have escaped detection, the time between periodic tests is added to the unavailability time. If a failure has occurred between tests so that its date of occurrence is unknown, half of the time period between tests is added to the unavailability time. Whenever the occurrence of the failure can be identified as an operational, maintenance, testing or other event, the time between the event and the fault detection is added to the unavailability time.

Source of data

Data for the indicators is collected from the power companies. Licensee representatives submit the necessary data to the relevant person in charge at STUK.

Purpose of the indicator

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

Operational safety (KÄY), resident inspectors
Petri Vastamäki (Loviisa nuclear power plant)
Jukka Kallionpää (Olkiluoto nuclear power plant)

Interpretation of the indicator

Loviisa

TJ system

Analysis of the unavailability figures of the high pressure safety injection systems (TJ) of the plant units and their background information shows that the LO1 plant unit had three faults that caused system unavailability amounting to 178.1 hours. Of this time, 167.0 hours were spent on the replacement of a switch based on observations of vibration in pump 12TJ52D0001. Two faults occurred at LO2, resulting in 12.7 hours of unavailability.

The failures of TJ systems were not serious. Apart from one job, the repairs were completed within the repair times allowed in the OLC. The three-week repair time allowed for the replacement of TJ52D0001 switch was deviated from on the basis of STUK exemption order 6/A42272/2012.

The significant unavailability of the high pressure safety injection systems was caused by a single fault at LO1. When that is taken into account, it can be stated that the unavailability of TJ systems was low in 2012, i.e. their condition and availability were good.

RL system

At LO1, the total unavailability time was 136.0 hours, of which 33.4 hours were attributable to a single fault occurring during power operation. At LO1, the rest of the unavailability was caused by the 102.6-hour annual outage work carried out on the RL94 system.

Similarly, the total unavailability time for LO2 was 104.7 hours. Of this time, 39.3 hours were due to three failures during power operation, and 65.4 hours resulted from the annual maintenance of RL97.

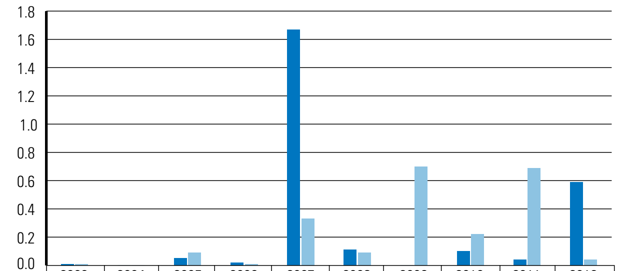
The unavailability of the auxiliary feed water systems was low in 2012, i.e. their condition and availability were good.

EY system

In 2012, the total unavailability time for all eight diesel generators was 734 hours. The 17-year periodic maintenance of the diesel generator 21EY02 amounted to 244 hours of the total. The maintenance of 21EY02 began as planned before the shutdown of LO2 for annual maintenance. While availability requirement based on the OLC existed, connection to the Ahvenkoski hydropower plant was used as a replacement of 21EY02.

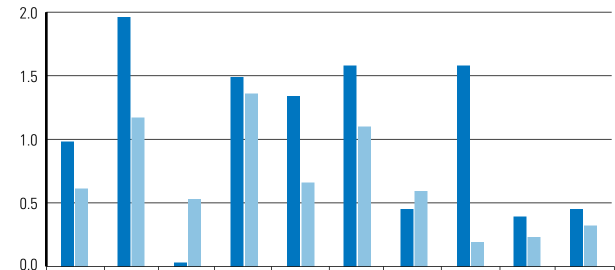
There were a total of 23 diesel generator faults in 2012, of which nine caused immediate operation restrictions while 15 caused operating restrictions

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



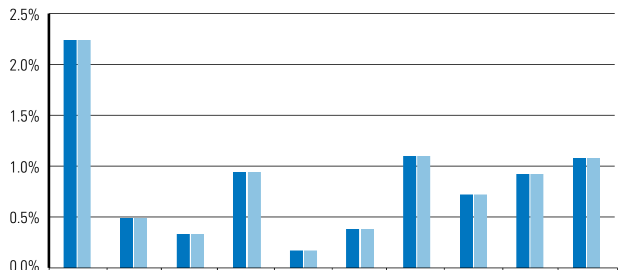
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	0.01	0.00	0.05	0.02	1.67	0.11	0.00	0.10	0.04	0.59
LO2	0.01	0.00	0.09	0.01	0.33	0.09	0.70	0.22	0.69	0.04

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



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	0.98	1.96	0.03	1.49	1.34	1.58	0.45	1.58	0.39	0.45
LO2	0.61	1.17	0.53	1.36	0.66	1.10	0.59	0.19	0.23	0.32

Unavailability of emergency diesel generators (EY), Loviisa NPP



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	2.24	0.49	0.33	0.94	0.17	0.38	1.10	0.72	0.92	1.08
LO2	2.24	0.49	0.33	0.94	0.17	0.38	1.10	0.72	0.92	1.08

from the beginning of the repair work. The failures detected were mainly caused by the normal ageing of components and did not have any serious implications.

The unavailability of the emergency diesel generators (EY) increased slightly from the previous year, but when the impact of the planned periodic maintenance of 21EY02 is taken into account, the total unavailability still remains low, i.e. availability was satisfactory.

Interpretation of the indicator

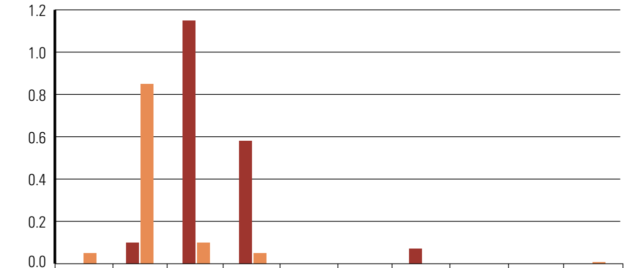
Olkiluoto

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

The unavailability of the auxiliary feed water system increased after 2004, at which point the unavailability was in practice zero. The higher unavailability of Olkiluoto 1 in 2006 was due to faults in the recirculation and safety valves of system 327. There were no significant failures in 2007, 2008 or 2009, and the unavailability of the auxiliary feed water system decreased to nearly zero in 2009 at both plant units. In 2010, unavailability at OL1 was still zero but increased slightly at OL2 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 feed water system valve that remained faulty for 504 hours. See section A.II.3. In 2012, the unavailability of the auxiliary feed water system returned to the level prior to 2011.

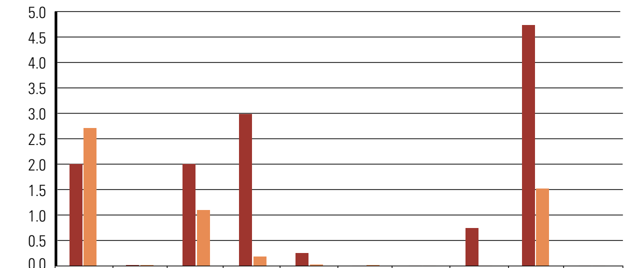
The unavailability of the diesel generators has decreased since 2004, and was very low in 2006 and 2007. In 2008, the value increased by nearly 95% compared to the previous year. The increase was due to latent faults in the compressed air motors of the diesels in both plant units. In 2009, the unavailability of diesel engines decreased considerably from the 2008 figures. In 2010, unavailability increased somewhat from the previous year as a result of failures occurring in connection with periodic tests. 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 EDGs was over four times higher than in 2010, the highest figure ever recorded while the parameter has been monitored. The reason for the increase was the generator fault discussed above, 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, unavailability of emergency diesel generators was zero.

Unavailability of containment spray system (322), Olkiluoto NPP



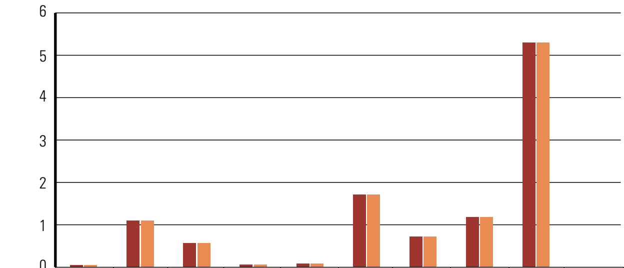
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	0.00	0.10	1.15	0.58	0.00	0.00	0.07	0.00	0.00	0.00
OL2	0.05	0.85	0.10	0.05	0.00	0.00	0.00	0.00	0.00	0.01

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



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	2.00	0.01	2.00	2.98	0.25	0.00	0.00	0.74	4.73	0.00
OL2	2.71	0.01	1.10	0.18	0.02	0.01	0.00	0.00	1.52	0.00

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



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	0.05	1.10	0.57	0.06	0.09	1.71	0.72	1.18	5.30	0.00
OL2	0.05	1.10	0.57	0.06	0.09	1.71	0.72	1.18	5.30	0.00

A.I.4 Occupational radiation doses

Definition

As the indicators, collective radiation exposure of nuclear power plant employees by plant site and plant unit is monitored, together with the annual average of the 10 highest occupational doses.

Source of data

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

Purpose of the indicator

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 dose averaged over two successive years is followed. The threshold value, 2.5 manSv per one gigawatt of net electrical power, means a radiation dose of 1.22 manSv for one Loviisa plant unit and 2.15 manSv for one Olkiluoto plant unit. The collective radiation doses describe the success of the plant's ALARA programme. The average of the 10 highest doses indicates how close to the 20 manSv dose limit the individual occupational doses at the plants are, at the same time indicating the effectiveness of the plant's radiation protection unit.

Responsible unit/person

Radiation protection (SÄT)
Antti Tynkkynen

Interpretation of the indicator

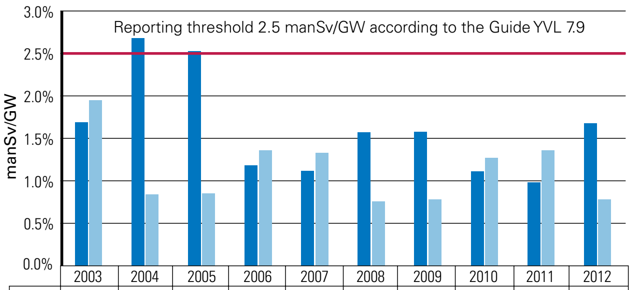
Loviisa

Most doses are incurred through work done during outages. Thus outage duration and the amount of work having significance on radiation protection affect the annual radiation doses. Both Loviisa plant units have more extensive annual outages every four and eight years (the four-year annual outage and the eight-year annual outage) so that both plant units never have a major annual maintenance outage in the same year. The 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 doses can be seen in the Collective radiation dose, Loviisa graph. In 2012, the eight-year annual outage took place at Loviisa 1, and a short annual outage at Loviisa 2. The time used for annual outages was long, and there was a high amount of work with significance for radiation protection, which resulted in a total collective dose that was higher than that of the previous years. Still, the collective doses during annual outages were the lowest ever achieved during annual outages of a similar type.

The radiation doses for nuclear power plant workers were below the individual dose limits. The increase in the average of the ten highest doses was due to the extensive eight-year outage with plenty of work, which resulted in some workers being exposed to a higher amount of radiation. The dose average was slightly lower than in 2010, which was the year when such extensive outages last took place. The Radiation Decree (1512/1991) stipulates that the effective dose for a worker from radiation work must not exceed the 20 manSv/year average over any period of five years, or 50 manSv in any one year.

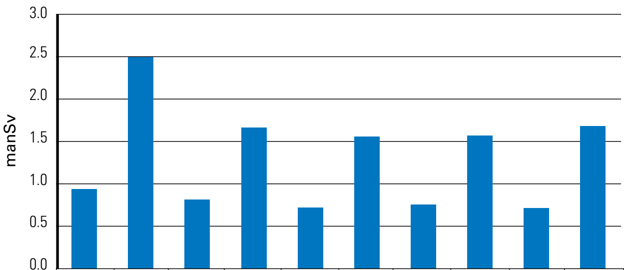
Furthermore, the threshold set for the collective occupational dose was not exceeded in 2012. If, at one plant unit, the collective occupational radiation dose average over two successive years exceeds 2.5 manSv per one GW of net electrical power, the power company is to report the causes of this to STUK, together with any measures possibly required to improve radiation safety (Guide YVL 7.9).

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



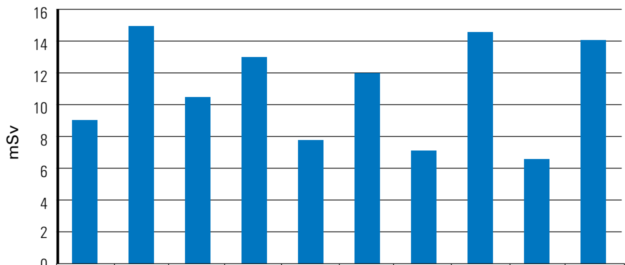
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	1.69	2.68	2.53	1.18	1.12	1.57	1.58	1.11	0.98	1.68
LO2	1.95	0.84	0.85	1.36	1.33	0.76	0.78	1.27	1.36	0.78

Collective occupational radiation dose (manSv), Loviisa NPP



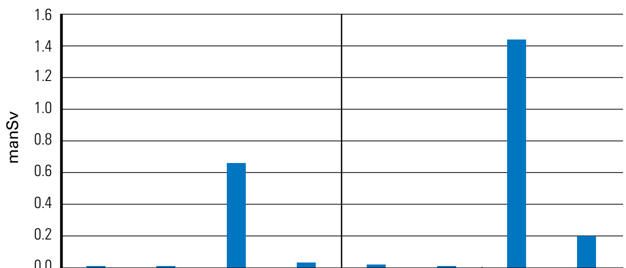
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO	0.94	2.49	0.81	1.66	0.72	1.55	0.75	1.57	0.71	1.68

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



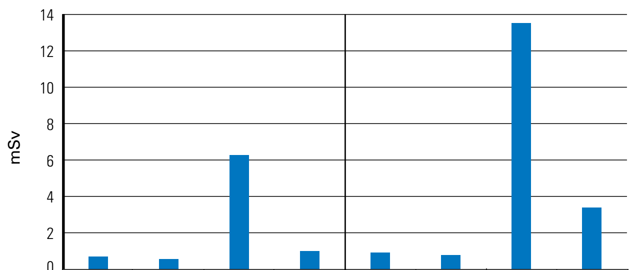
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO	9.01	14.93	10.48	13.00	7.76	11.99	7.11	14.55	6.56	14.06

Collective occupational radiation dose (manSv) quarterly, Loviisa NPP



	I/11	II/11	III/11	IV/11	I/12	II/12	III/12	IV/12
LO	0.01	0.01	0.66	0.03	0.02	0.01	1.44	0.20

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



	I/11	II/11	III/11	IV/11	I/12	II/12	III/12	IV/12
LO	0.70	0.54	6.27	1.00	0.91	0.76	13.53	3.39

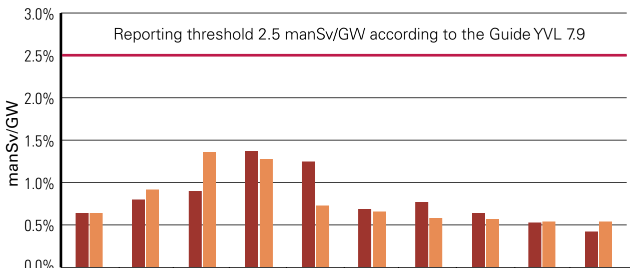
Interpretation of the indicator

Olkiluoto

Most doses are incurred through work done during outages. Thus outage duration and the amount of work having significance on radiation protection affect the annual radiation doses. The annual outages for the Olkiluoto power plant units are divided into two groups: refuelling outage and maintenance outage. The refuelling outage is shorter in duration (approximately 7 days). The length of the maintenance outage depends on the amount of work (2–3 weeks). Annual outages are scheduled so that in the same year, one plant unit has a maintenance outage and the other a refuelling outage. In 2012, the Olkiluoto nuclear power plant achieved its lowest radiation doses since the plant's first years of operation. The previous lowest-ever collective radiation dose was recorded at the power plant in 2010. The new steam dryers installed at the plant units in 2005–2006 have further reduced the radiation levels and collective doses at the turbine plant.

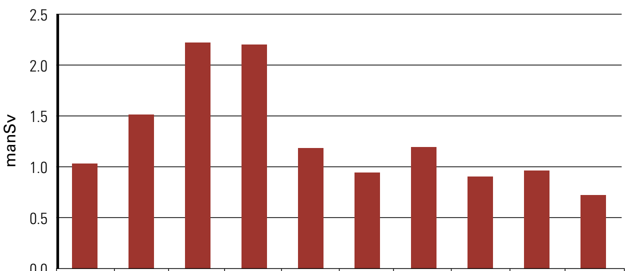
In 2012, the average of the 10 highest radiation doses was lower than average. The prescribed dose limits (Radiation Decree 1512/1991) were not exceeded.

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



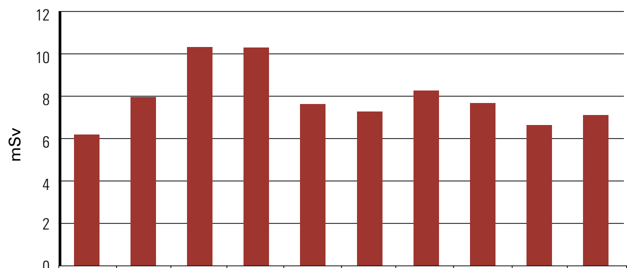
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	0.64	0.80	0.90	1.37	1.25	0.69	0.77	0.64	0.53	0.42
OL2	0.64	0.92	1.36	1.28	0.73	0.66	0.58	0.57	0.54	0.54

Collective occupational radiation dose (manSv), Olkiluoto NPP



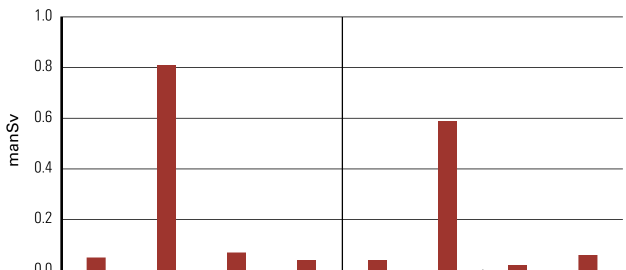
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL	1.03	1.51	2.22	2.20	1.18	0.94	1.19	0.90	0.96	0.72

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



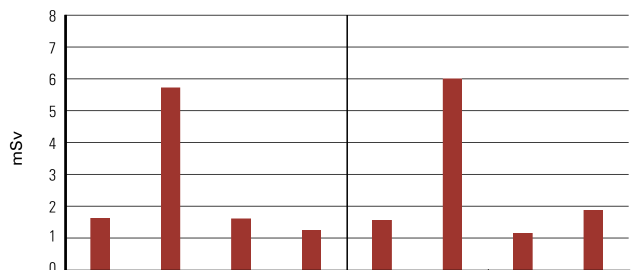
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL	6.20	7.96	10.32	10.30	7.63	7.28	8.27	7.68	6.65	7.12

Collective occupational radiation dose (manSv) quarterly, Olkiluoto NPP



	I/11	II/11	III/11	IV/11	I/12	II/12	III/12	IV/12
OL	0.05	0.81	0.07	0.04	0.04	0.59	0.02	0.06

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



	I/11	II/11	III/11	IV/11	I/12	II/12	III/12	IV/12
OL	1.63	5.73	1.61	1.25	1.56	6.01	1.15	1.87

A.I.5 Radioactive releases

Definition

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

Source of data

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

Purpose of the indicator

The indicator is used to follow the amount and trend of radioactive releases and to assess the causes of any changes.

Responsible unit/person

Radiation protection (SÄT), Antti Tynkkynen

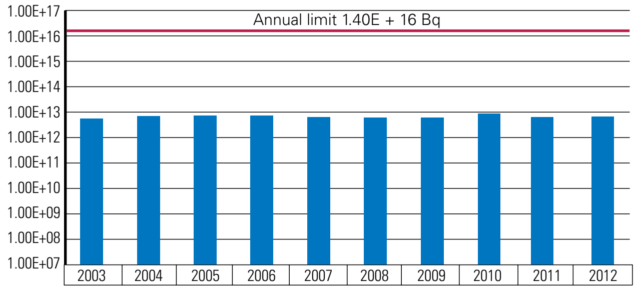
A.I.5a Releases into the atmosphere

Interpretation of the indicator

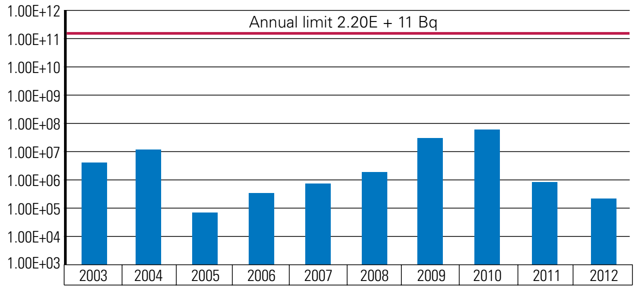
In 2012, the radioactive releases into the atmosphere from the Loviisa and Olkiluoto nuclear power plants were of the same magnitude as in previous years. The releases into the environment were small, well below the set limits.

The releases of noble gases and particulate aerosols from the Loviisa power plant were of the same magnitude as in previous years. The releases of iodine isotopes continued to decrease and were lower than average despite the fuel leak at Loviisa 2 that began in the final part of 2012.

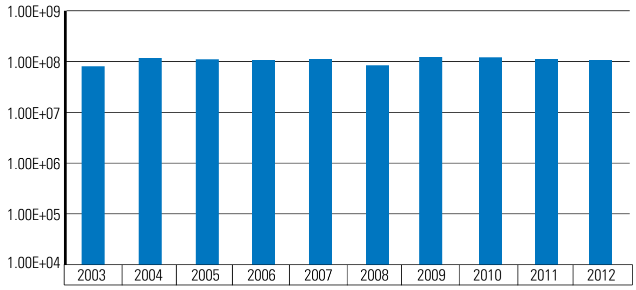
Noble gas releases (Bq $^{87}Kr_{eq}$), Loviisa NPP



Iodine isotope releases to atmosphere (Bq $^{131}I_{eq}$), Loviisa NPP

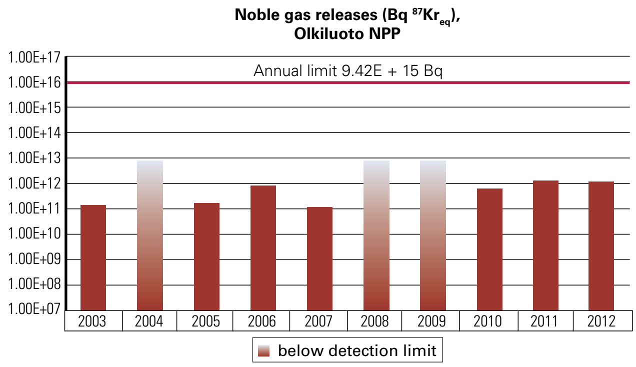


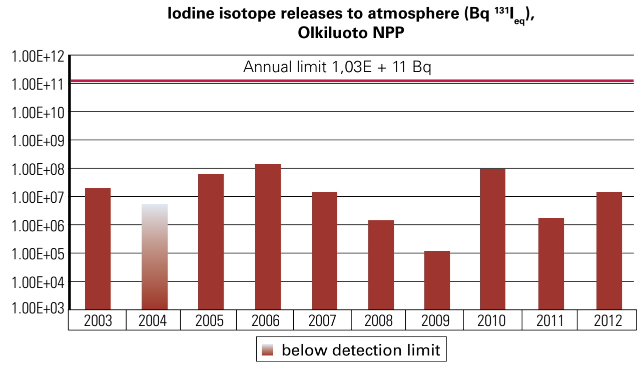
Aerosol releases to atmosphere (Bq), Loviisa NPP

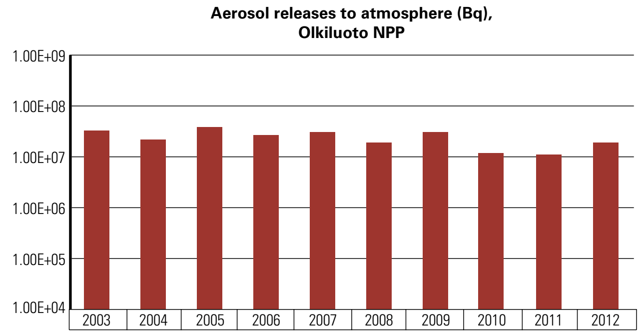


At Olkiluoto, the releases of noble gases and particulate aerosols into the atmosphere were on the same approximate level as in the previous years. The releases of iodine isotopes increased compared to 2011 due to a minor fuel leak at Olkiluoto 2. The fuel leak also had an effect on the released volume of noble gases.

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. A leak was detected in one fuel rod at Loviisa 2 late in 2012. At Olkiluoto, the leaking fuel assembly was replaced with a new one at annual outage. The indicator A.III.1 describes fuel integrity. The noble gas releases from the Loviisa plant are dominated by argon-41, an activation product of argon-40, found in the airspace between the reactor pressure vessel and the main radiation shield. Aerosol nuclides (including activated corrosion products) are released during maintenance work.



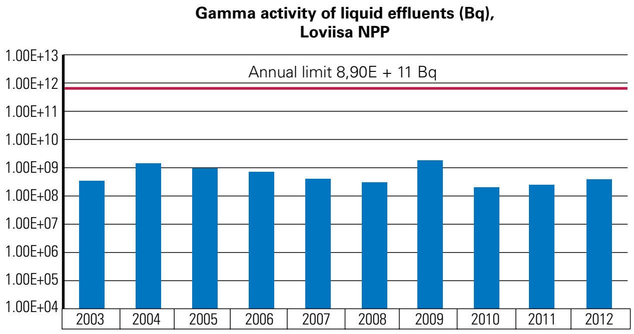


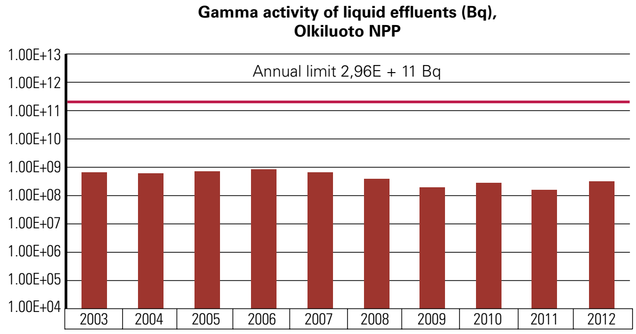


A.I.5b Releases into the sea

Interpretation of the indicator

Releases of radioactive substances emitting gamma radiation into the environment from the Loviisa and Olkiluoto nuclear power plants were clearly below the set limits. During 2001, 2004 and 2009, the Loviisa power plant discharged low-activity evaporation residues into the sea as planned. Consequently, the releases of substances with gamma activity were larger than average in those years. The releases of substances with gamma activity into the sea from Olkiluoto have decreased in recent years.



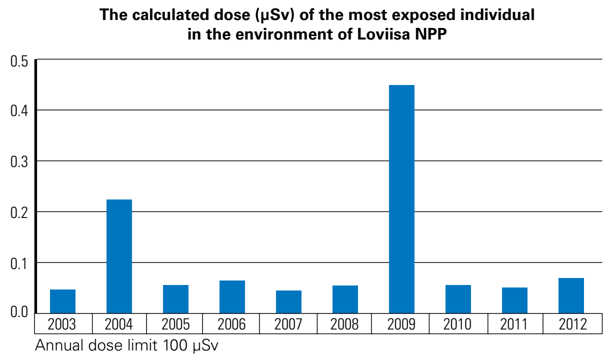


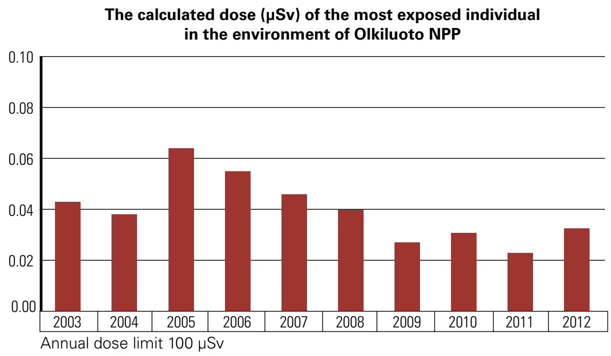
A.I.5c Population exposure

Interpretation of the indicator

In 2012, the doses of the most exposed individual in the vicinity, calculated on the basis of releases from the plant, were below the set limit both at Loviisa and Olkiluoto. At Loviisa, the dose of the most exposed individual in the vicinity was average. At Olkiluoto, it was lower than average. As a result of the planned release of low-level evaporation waste into the sea at Loviisa, the dose of the most exposed individual in the vicinity of the Loviisa power plant was higher than usual in 2009.

For both plants, the calculated doses of the most exposed individual in the vicinity were less than 0.1% of the 100-microsievert limit established in the Government Decree (733/2008).





A.I.6 Investments in facilities

Definition

Investments in plant 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 the confidential information of the utilities involved, and not to be published here. Furthermore, the scales of the Loviisa and Olkiluoto power plants' investment and modernisation diagrams are not mutually comparable.

Purpose of the indicator

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

Responsible unit/person

Operational safety (KÄY)
Suvi Ristonmaa

Interpretation of the indicator

The variation in the indicator distinctly shows the investments related to the power upgrades and modernisation projects of the plants. Both plants have paid great attention to life-cycle management, which also shows as continuous long-term investment plans. The renewal of the operating licence of the Loviisa plant in 2007 and the intermediate assessment carried out at Olkiluoto in 2008 have also had an effect on the investment plans.

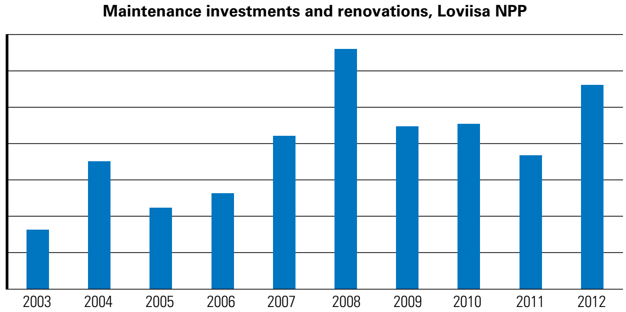
Loviisa

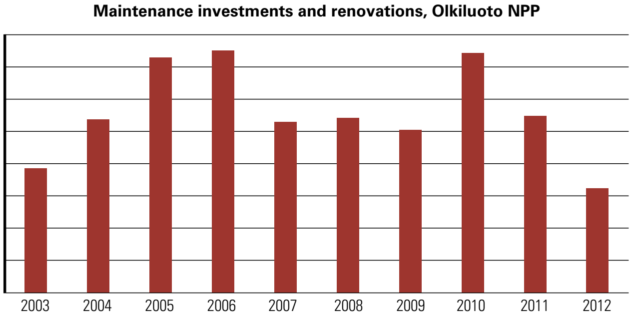
The increase in investments, starting from 2007, is caused by the modernisation of I&C systems at Loviisa. Other major investments in 2012 include the construction of a new emergency diesel power plant, a modification of the pressure equalisation system, replacement of service water system pipes, modernisation of turbines and the development of a maintenance information system. Many modification projects span over many years, which means that their total cost is also divided between several years.

Olkiluoto

Fewer investments took place in 2012 than in the previous years.

TVO has carried out extensive modifications in periods, which becomes evident in the trend. For example, the major modifications mainly implemented during the 2010 annual outage of Olkiluoto 1 and the 2011 annual outage of Olkiluoto 2 show in the investment figures for 2010 and 2011. These modifications included the replacement of inner isolation valves of the main steam lines, the replacement of low-pressure turbines and the replacement of main seawater pumps. Some of the work included in the project continued in 2012 and showed in the investment figures for the year. These included the replacement of low voltage switchgear, upgrading the condensate processing I&C, and the replacement of the main generators. Other major investments in 2012 included the purchases related to the new radiation measurement system, and the replacement and overhaul of the plant transformers.





A.II Operational events

A.II.1 Number of events

Definition

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

Source of data

Data for the indicators is obtained from STUK's document administration system (SAHA).

Purpose of the indicator

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

Responsible unit/person

Operational safety (KÄY)
Niko Mononen (Loviisa)
Suvi Ristonmaa (Olkiluoto)

Interpretation of the indicator

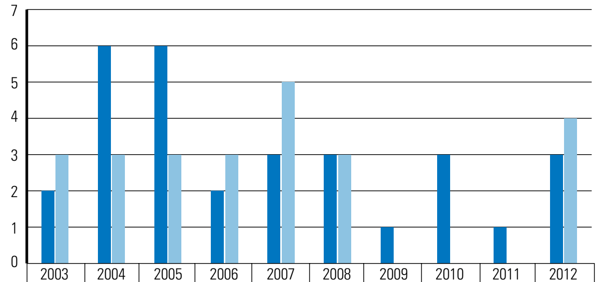
Loviisa

Two reactor trips occurred at the Loviisa power plant. Loviisa 1 operators shut down the reactor by initiating a reactor trip during the start-up after annual outage as a feed water pump stopped. At Loviisa 2, operators initiated a reactor trip as a result of a turbine trip that occurred at both turbines. The turbine trips were due to a faulty protection signal. During the events, the plant operated in the planned manner, and the events had no impact on the safety of the plant or its environment. The number of reactor trips has always been low at Loviisa. The previous reactor trips took place in 2004 and 2010.

The number of reported operational transients increased from the previous years, but remained reasonably good over the long term. Seven operational transients occurred during the year. The transients of Loviisa 1 concerned the drop of one control rod due to damage, the spurious opening of a relief valve, and the halting of a main feed water pump during start-up. At Loviisa 2, the transients concerned faulty operation of a feed water pump, spurious protective trip of a steam line isolation valve, as well as turbine trips due to a controller error and a faulty protection signal.

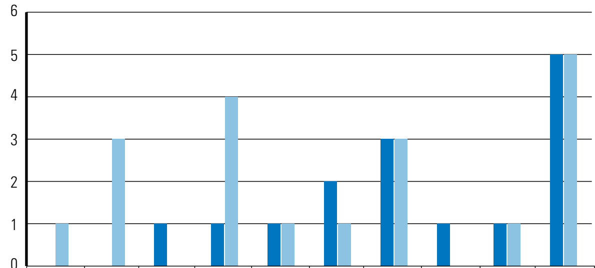
Based on the results of the last ten years, events warranting a special report occur three times a year on average. In 2012, the number of events warranting a special report (ten) was clearly above the average. The number is explained by the fact that the power company must produce a special report on all events involving a non-compliance with the OLC. The frequency of such events was considerably higher in 2012 than in the previous years (see section A.I.2). Other events warranting a special report included the excess fire load at Loviisa 1, the erroneous configuration of the thermal relays of the 0.4 kV pump motors at Loviisa 2, and the inconsistencies found in the periodic

Number of operational transient reports, Loviisa NPP



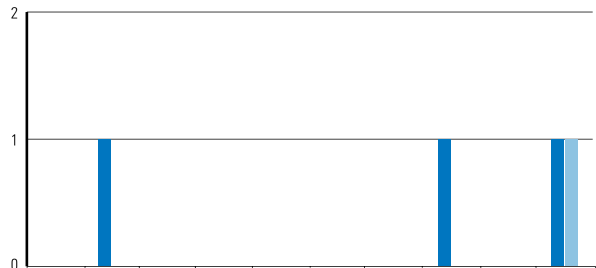
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	2	6	6	2	3	3	1	3	1	3
LO2	3	3	3	3	5	3	0	0	0	4

Number of Special Reports, Loviisa NPP



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	0	0	1	1	1	2	3	1	1	5
LO2	1	3	0	4	1	1	3	0	1	5

Number of reactor scrams, Loviisa NPP



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	0	1	0	0	0	0	0	1	0	1
LO2	0	0	0	0	0	0	0	0	0	1

preventive maintenance intervals specified in the procedures and the OLC.

When considering the indicators, it must be noted that the number of reports does not give the correct picture of the division of events by plant unit, since, for system technical reasons, the reports that concern both plant units have been entered for Loviisa 1.

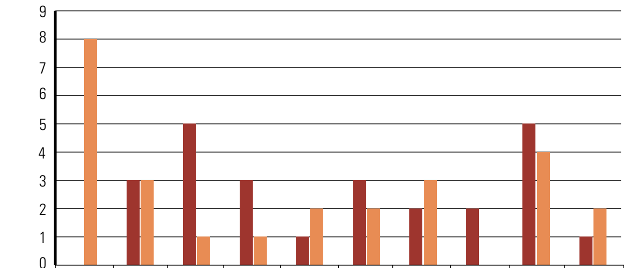
Olkiluoto

No reactor trips took place at the Olkiluoto nuclear power plant in 2012. Based on the results of the last ten years, an average of zero to one reactor trips take place each year. During the previous decade (1993–2001), an average of almost three to four reactor trips occurred per year. The number is explained by the fact that it also includes reactor trips during annual outages that occurred, for example, in connection with testing 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. In 2012, the number of events warranting a special report (six) was nearly at the average. The number of events warranting a transient report (three) was below the average. Four events for which special reports were produced concerned an error during the design or implementation of a modification. In one case, an error was observed in the calculation method used to assess the efficiency of control rods during plant start-up. All the events are described in more detail in Appendix 3 to the report. One transient report concerns the planned dropping of one Olkiluoto 2 main coolant pump to lower revolutions due to a disturbance in the external power supply. Another report describes a generator failure at Olkiluoto 1. As a result of the failure, TVO decided to launch the annual outage nearly a month earlier than planned. The third transient report describes a failure of the protective relay of a switch in the Olkiluoto 2 electrical system (660 V network).

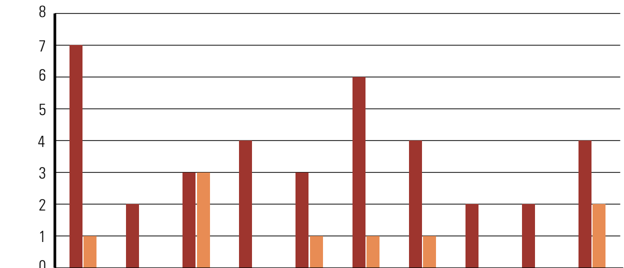
When considering the indicators concerning special and transient reports, it must be noted that the number of reports does not give the correct picture of the division of events by plant unit, since, for system technical reasons, the reports that concern both plant units have been entered for Olkiluoto 1. In 2012, two events warranting a special report concerned both plant units. It must also be noted for 2012 that a joint special report was produced for two separate events in Olkiluoto 1 and Olkiluoto 2, as this was sensible considering the similarity of the events and, therefore, the clarification of events and the definition of corrective measures. Because the events were separate, here they are considered as two events warranting a special report.

Number of operational transient reports, Olkiluoto NPP



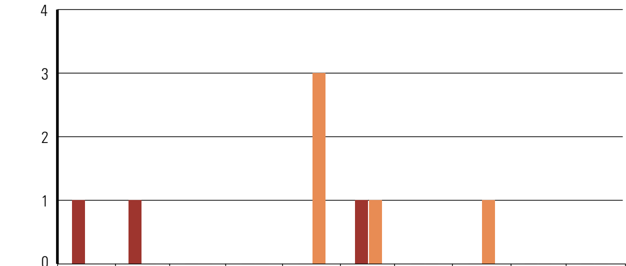
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	0	3	5	3	1	3	2	2	5	1
OL2	8	3	1	1	2	2	3	0	4	2

Number of Special Reports, Olkiluoto NPP



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	7	2	3	4	3	6	4	2	2	4
OL2	1	0	3	0	1	1	1	0	0	2

Number of reactor scrams, Olkiluoto NPP



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	1	1	0	0	0	1	0	0	0	0
OL2	0	0	0	0	3	1	0	1	0	0

A.II.3 Risk-significance of events

Definition

As the indicator, the risk-significance of events caused by component unavailability is monitored. As the measure of risk, an increase in the conditional core damage probability (CCDP) associated with each event is employed. CCDP takes the duration of each event into consideration. Events are divided into three categories: 1) unavailability due to component failures, 2) planned unavailability, and 3) initiating events. In addition, 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. Possible non-compliances with the operational limits and conditions (OLC) are in category 1, if they can be utilised for this indicator. Non-compliances with the OLC are also dealt with under indicator A.I.2.

N.B.! The calculations concerning the Olkiluoto plant were performed using FinPSA software and those concerning the Loviisa plant using RiskSpectrum software. For the Loviisa power plant, calculations of simultaneous failure of several components are solely based on the power operation model, meaning that the results are not as exact as for single failures which have been calculated for all operating modes. The modelling of simultaneous failures across all operating modes (17 of them) would be possible, but the calculation time would be too long compared to the benefits. This year, no simultaneous failures of several components with the highest risk-significance occurred.

Source of data

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

Purpose of the indicator

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 failures, simultaneously occurring failures 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)
(failure data)

Interpretation of the indicator

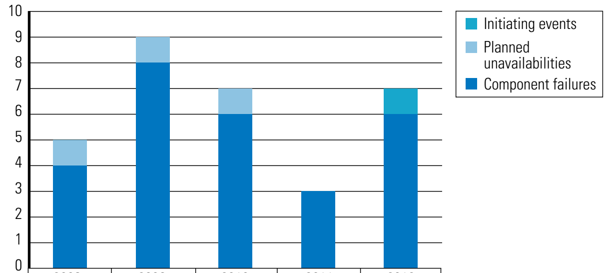
Loviisa

A brief description of the most significant events regarding risk is given below:

Loviisa 1:

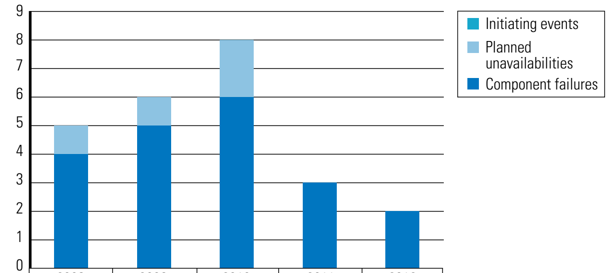
1. 12 May 2012. Generator excitation fault in emergency diesel EY01. Unavailable for 114.6 h. CCDP: 1.111E-07.
2. 30 May 2012. Generator excitation fault in emergency diesel EY01. Unavailable for 158.3 h. CCDP: 1.535E-07.
3. 30 July 2012. Abnormal operation of emergency diesel EY01. Unavailable for 83.18 h. CCDP: 1.001E-07.
4. 16 November 2012. Repair of a safety injection pump 12TJ52D0001 due to vibration. Unavailable for 165.0 h. CCDP: 1.08E-07
5. 16 July 2012. Generator excitation fault in emergency diesel EY01. Unavailable for 432 h. CCDP: 5.194E-07.
6. 29 September 2012. Leaking coolant in auxiliary emergency feed water pump RL94D001. Unavailable for 472 h. CCDP: 3.237E-07.
7. 24 September 2012. Initial event: loss of main feed water in part-load operation (17%) during start-up. CCDP: 1.297E-07.

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



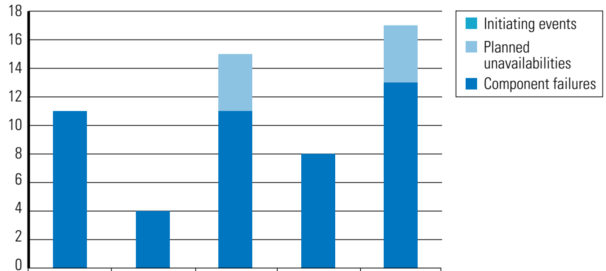
2008	2009	2010	2011	2012
0	0	0	0	1
1	1	1	0	0
4	8	6	3	6

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



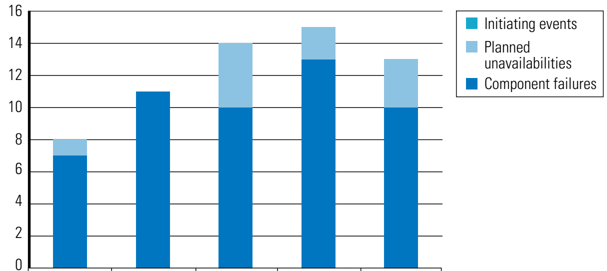
2008	2009	2010	2011	2012
0	0	0	0	0
1	1	2	0	0
4	5	6	3	2

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



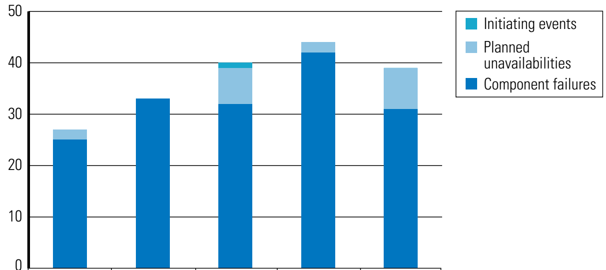
2008	2009	2010	2011	2012
0	0	0	0	0
0	0	4	0	4
11	4	11	8	13

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



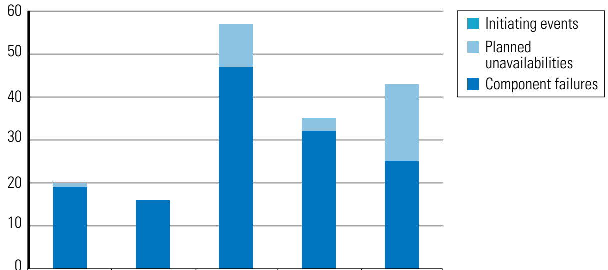
2008	2009	2010	2011	2012
0	0	0	0	0
1	0	4	2	3
7	11	10	13	10

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



2008	2009	2010	2011	2012
0	0	1	0	0
2	0	7	2	8
25	33	32	42	31

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



2008	2009	2010	2011	2012
0	0	0	0	0
1	0	10	3	18
19	16	47	32	25

Loviisa 2:

1. 3 August 2012. Failure and replacement of the oil pump in the second A circuit compressor of the special air conditioning system's water cooling equipment 22UV46B0002 (Eltie circuit). Unavailable for 170 h. CCDP: 1.641E-07.
2. 15 November 2012. Erroneous configuration of the thermal relays of 0.4 kV pump motors in several emergency systems. Unavailable for 37 days. CCDP: 1.80E-07.

Of these faults, the four faults of the LO1 diesel generator EY01 had the highest safety significance. STUK required that Fortum produce an account of the diesel generator's excitation and voltage control problems by 28 February 2013.

Olkiluoto

A brief description of the significant events is given below:

Olkiluoto 1:

1. Preventive maintenance of a diesel generator in subsystem C took 110 h. CCDP: 1.09E-07.

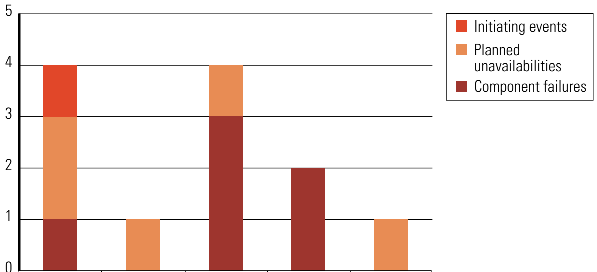
Olkiluoto 2:

1. Preventive maintenance of a diesel generator in subsystem A took 115 h. CCDP: 1.02E-07.
2. Preventive maintenance of a diesel generator in subsystem C took 104 h. CCDP: 1.02E-07.
3. 29–31 July 2012. Pumps 721P4 and 721 P2 isolated due to a leak in a suction line measurement nozzle. Pump P4 was unavailable for 48 hours. During this time, pump P2 was in a failed state for 8 hours. CCDP: 3.3E-06.

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.

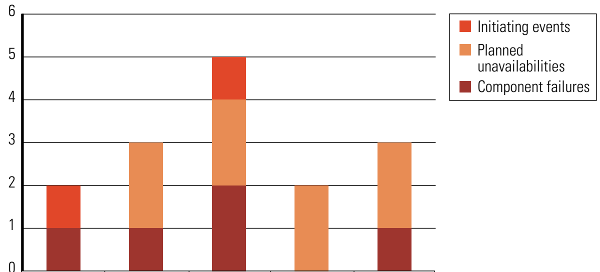
In 2012, the risk arising from operational ac-

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



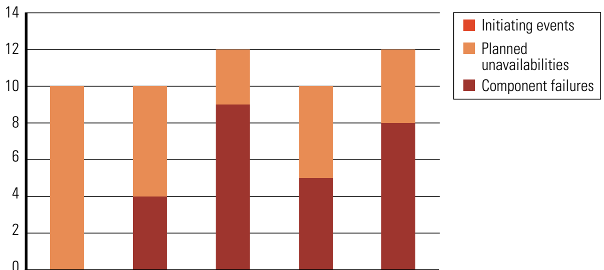
2008	2009	2010	2011	2012
1	0	0	0	0
2	1	1	0	1
1	0	2	2	0

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



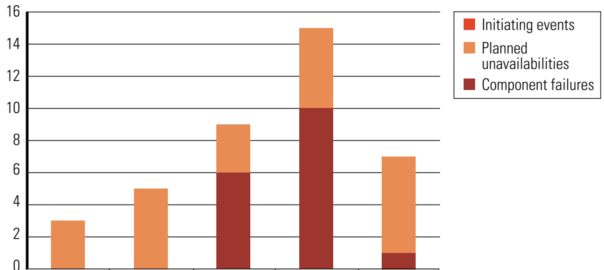
2008	2009	2010	2011	2012
1	0	1	0	0
0	2	2	2	2
1	1	2	0	1

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



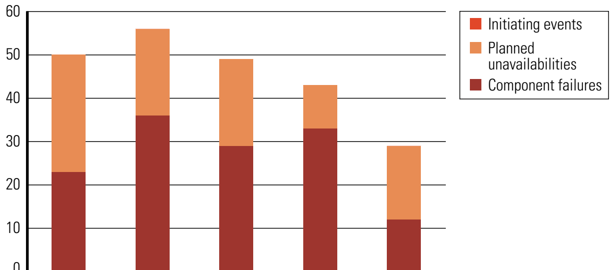
2008	2009	2010	2011	2012
0	0	0	0	0
10	6	3	5	4
0	4	9	5	8

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



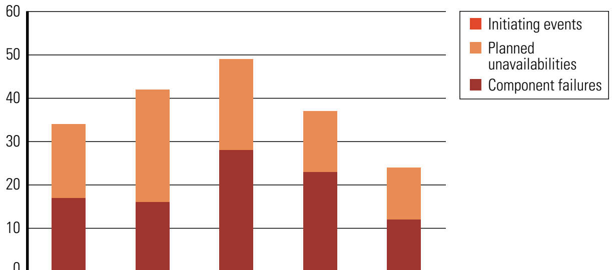
2008	2009	2010	2011	2012
0	0	0	0	0
3	5	3	5	6
0	0	6	10	1

Other events CCDP < 1E-8
Olkiluoto 1 (total number of events)



2008	2009	2010	2011	2012
0	0	0	0	0
27	20	20	10	17
23	36	29	33	12

Other events CCDP < 1E-8
Olkiluoto 2 (total number of events)



2008	2009	2010	2011	2012
0	0	0	0	0
17	26	21	14	12
17	16	28	23	12

tivities decreased slightly at the Loviisa plant compared to previous years. The simultaneous unavailability of two secondary cooling system pumps (721 P4 and P2) increased the annual risk for Olkiluoto 2 by 29%. Such an increase proves the importance of the secondary cooling system for plant safety. The dependence of safety of the secondary cooling circuit will be decreased in the next annual outage, when the 327 auxiliary feed water system will be modified to function independently of the secondary cooling circuit. (The project has been active for years, and is not a result of the event described above.)

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 followed. The accident risk is presented per nuclear power plant unit.

Source of data

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

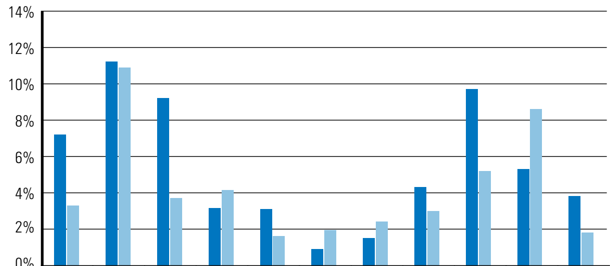
Purpose of the indicator

The indicator is used to follow the development of the nuclear power plant's accident risk. The objective is to operate and maintain the nuclear power plant so that the accident risk decreases or remains stable. Risk analyses can help detect a need to make modifications to the plant or change operating methods.

Responsible unit/person

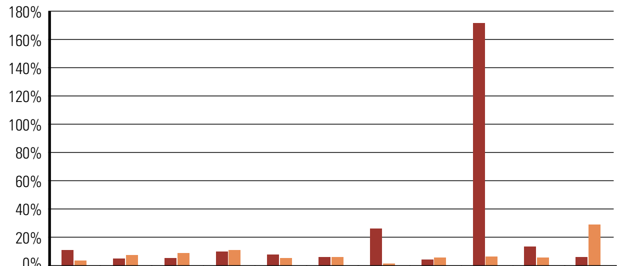
Risk assessment (RIS), Jorma Rantakivi (PRA computation)
Operational safety (KÄY) (failure data)

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



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	7.20	11.21	9.20	3.15	3.10	0.90	1.50	4.30	9.70	5.30	3.80
LO2	3.30	10.90	3.70	4.14	1.60	1.95	2.40	3.00	5.20	8.60	1.80

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



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	10.90	4.68	5.10	9.64	7.60	6.00	26.10	4.00	171.4	13.10	5.90
OL2	3.50	7.39	8.60	10.95	5.00	6.00	1.30	5.40	6.30	5.40	29.00

Interpretation of the indicator

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

Loviisa power plant's accident risk has continued to decrease over the last ten years, and new risk factors, discovered as the scope of the risk analysis has been extended, have been efficiently removed. The indicator decreased in 2007 due to the new seawater line completed during the period. The new line allows for the alternative intake of seawater from the outlet channel to cool the plant in shutdown operation. The change will decrease risks in situations where algae, frazil ice or an oil release endanger the availability of seawater through the conventional route. The decrease of the indicator in 2008 and in the following years results from more detailed analyses performed in conjunction with the renewal of the operating licence, as well as changes at the plant planned to be carried out earlier or in connection with the licence renewal. Such changes include: the I&C upgrade LARA; the decrease in the probability of a criticality accident using, for example, boron analysers; modernisation of the refuelling machine and the decrease in the probability of an external leak.

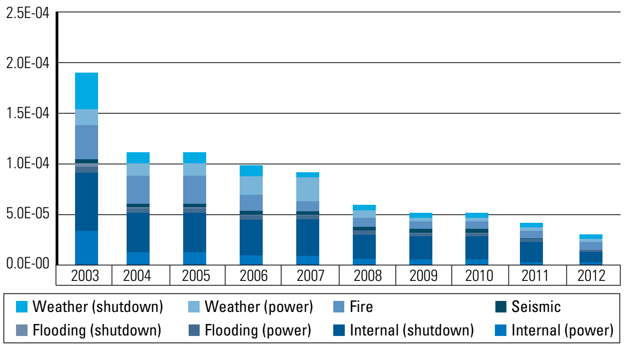
For the Loviisa power plant, the most important factors affecting the overall accident risk include internal plant events during outages (such as the falling of heavy loads or a power surge caused by the sudden dilution of the boron used to adjust reactor operation), fire, a high level of seawater during power operation and oil releases during a refuelling outage.

The annual probability of a severe reactor accident calculated for the Loviisa plant units was approximately 3.05 × 10^{-5} in 2012. The value has decreased by about 27% from the previous year. The decrease of the risk was a result of several small plant changes, changes in the model, and the revision of reliability data.

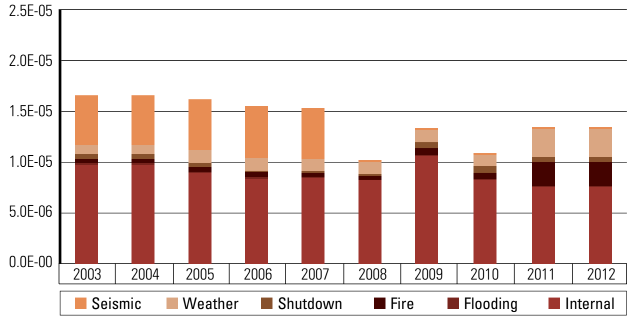
The indicator for the Olkiluoto plant decreased approximately 30% in 2008 compared to previous years' relatively stable value. The decrease was mainly due to the more detailed modelling of earthquake events and the plant changes carried out to improve seismic qualification. The increase in 2009 was due to the fact that the heat exchanger of the screening system cannot be used for residual heat removal after all, contrary to earlier assessments. The decrease of 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. For the Olkiluoto power plant, internal events during power operation (component failures and pipe ruptures leading to an operational transient) are the most important factors affecting the overall accident risk.

The annual probability of a severe reactor accident calculated for the Olkiluoto plant units was approximately 1.34 × 10^{-5} in 2012. The value has remained at the same level compared to the previous year.

Fluctuation of the calculated annual core damage frequency for Loviisa plant units during 2003–2012



Fluctuation of the calculated annual core damage frequency for Olkiluoto plant units during 2003–2012



A.II.5 Number of fire alarms

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

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 of the indicator
The indicator is used to follow the effectiveness of fire protection at the nuclear power plants.

Responsible unit/person
Civil Engineering and Fire Protection (RAK)
Pekka Välikangas

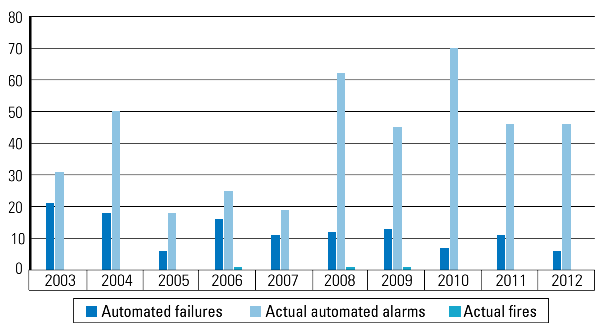
Interpretation of the indicator
There were no events classified as fires at the Loviisa power plant or outside the plant area in 2012. In 2012, the number of faults in the Loviisa power plant's fire detection system remained at the same level compared to the previous years. Actual alarms of the detectors continued at the 2011 level.

No events classified as fires occurred in the Olkiluoto plant area (OL1/2) in 2012. Five events classified as fires occurred outside the plant area: three at the OL3 site (an outdoor power transformer burned, and insulation sheets and protective plastic sheets ignited); smoking oil in a broken gearbox in Posiva's Onkalo facilities; and an outdoor fire starting from a barbecue in the accommodation village. The fires were minor and could be put out using first aid extinguishers. No fire detection system failures were observed at the Olkiluoto power plant (OL1/2) in 2012. The situation was the same in 2011. The number of correct fire alarms was of the same order in 2012 as in 2011.

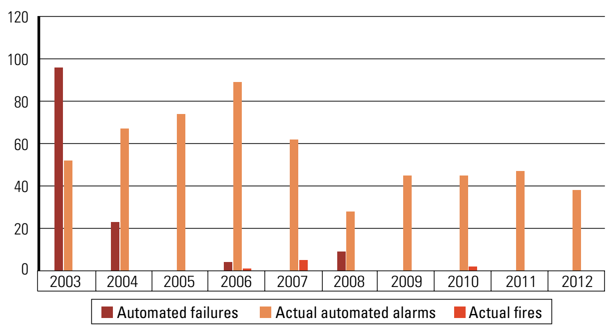
The automatic fire detectors were upgraded at the Loviisa power plant in 2000 and at Olkiluoto in 2001. The number of alarms increased at both units after that because of the more sensitive detectors. The distinct reduction in alarms at the Loviisa plant since 2003 and at the Olkiluoto plant since 2004 is due to pre-alarms no longer being included in the calculations.

On average, fire safety at the Loviisa and Olkiluoto plants has remained at the earlier level, as no events classified as fires have occurred in the plant area. Alarms from fire alarm systems have also been at a relatively low level. Most of the alarms were caused by dust, smoke or humidity. Fire alarm systems are not always disconnected in a wide enough area for maintenance work. The number of alarms from the fire alarm system is also affected by the amount of maintenance and repair work performed at the plants.

Number of fire alarms, Loviisa NPP



Number of fire alarms, Olkiluoto NPP



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 (start-up operation or power operation for Loviisa and power operation for Olkiluoto) are followed. The change in activity concentration of I-131 in primary coolant due to depressurisation during shutdowns or reactor trips, as well as the number of leaking fuel bundles removed from the reactor, are followed as indicators.

Source of data

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

Purpose of the indicator

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

Responsible unit/person

Reactor and Safety Systems (REA),
Kari Mäkelä

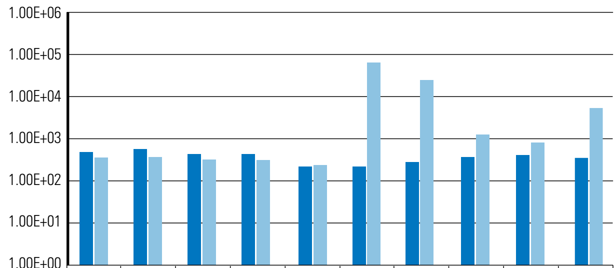
A.III.1a Primary coolant activity

Interpretation of indicators (Loviisa)

In 2012, the reactor of Loviisa 1 had no leaking fuel. The previous leaking fuel assembly was removed from the Loviisa 1 reactor in 2010, which reduced the maximum activity (I-131) of the primary coolant. After removal of the leaking fuel assemblies, the maximum activity values associated with shutdowns have also returned to the level before the leaks. Increased iodine content at Loviisa 2 was detected in a routine laboratory test in December. Noble gas measurements of the primary coolant confirmed that a fuel leak existed. The leak was, however, minor and the fuel assembly will be removed in the next annual outage. The number of minor fuel leaks has increased in Loviisa in recent years. The actual reason for this is unknown, as examination of the damaged fuel assemblies has not been possible due to problems with the pool inspection equipment.

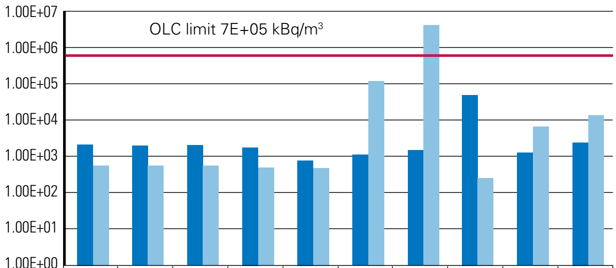
In 2012, fuel integrity at both Loviisa plant units was good.

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



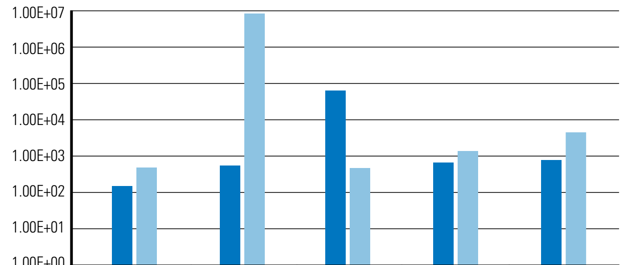
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	4.32E+02	5.01E+02	3.89E+02	3.91E+02	1.90E+02	2.00E+02	2.60E+02	3.80+02	3.90E+02	3.70E+02
LO2	3.22E+02	3.39E+02	2.91E+02	2.72E+02	2.10E+02	4.90E+04	2.40E+04	1.20+03	8.50E+02	4.71E+03

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



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	2.30E+03	2.10E+03	2.20E+03	1.90E+03	8.10E+02	1.20E+03	1.54E+03	4.97E+04	1.49E+03	2.80E+03
LO2	6.00E+02	5.80E+02	5.90E+02	5.20E+02	5.00E+02	1.30E+05	3.85E+06	3.20E+03	6.64E+03	1.27E+04

Fuel integrity:
Iodine (I-131) maximum activity concentration of primary coolant (kBq/m³) related to shutdowns, Loviisa NPP

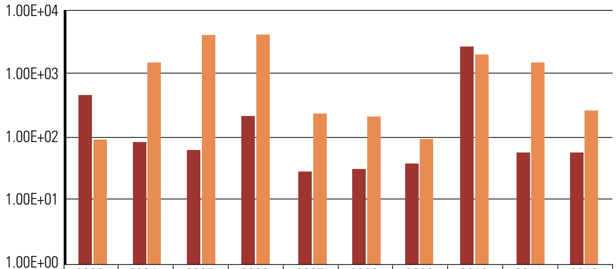


	2008	2009	2010	2011	2012
LO1	1.40E+02	4.80E+02	5.60E+04	6.70E+02	7.06E+02
LO2	4.30E+02	6.40E+06	4.10E+02	1.40E+03	4.10E+03

Interpretation of indicators (Olkiluoto)

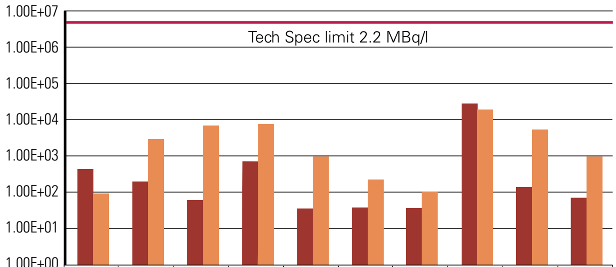
Olkiluoto 1 did not have any leaking fuel in 2012, which decreased the iodine-131 activity of the plant unit's primary coolant. A fuel leak in the Olkiluoto 2 reactor began in 2011 and continued until the leaking fuel assembly was removed in the 2012 annual outage. The impact of the leak showed in the maximum activity (I-131) of Olkiluoto 2 primary coolant associated with shutdown. The reason for the damage could not be revealed in preliminary inspections, which is why further investigations will take place when the fuel assembly will be repaired. On the basis of inspections carried out during annual outage, the fuel types at both plant units have behaved in the normal manner. 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 and getting caught in the fuel assembly structures. The coolant flow may make the loose objects vibrate and break the fuel cladding. To minimise the problem, new Triple Wave+ foreign object sieves have been adopted for the fuel at Olkiluoto 2 in 2012. The sieve profiling has been changed to make the grid denser.

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



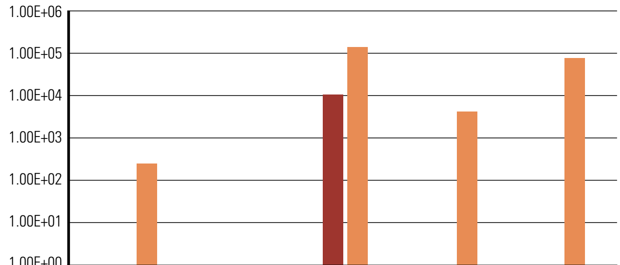
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	4.30E+02	8.20E+01	5.80E+01	2.00E+02	2.70E+01	3.00E+01	3.50E+01	2.45E+03	5.50E+01	5.58E+01
OL2	9.00E+01	1.49E+03	4.00E+03	4.00E+03	2.30E+02	2.10E+02	9.10E+01	1.87E+03	1.46E+03	3.03E+02

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



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	4.30E+02	1.90E+02	5.90E+01	6.90E+02	3.50E+01	3.70E+01	3.60E+01	3.12E+04	1.40E+02	6.76E+01
OL2	9.10E+01	3.12E+03	6.52E+03	7.03E+03	9.99E+02	2.30E+02	1.00E+02	2.01+04	4.84E+03	9.45E+02

Fuel integrity:
Iodine (I-131) maximum activity concentration of primary coolant (kBq/m³) related to shutdowns, Olkiluoto NPP



	2008	2009	2010	2011	2012
OL1	0.00E+00	0.00E+00	1.03E+04	0.00E+00	0.00E+00
OL2	2.52E+02	0.00E+00	1.61E+05	3.93E+03	6.19E+04

A.III.1b Number of leaking fuel assemblies

Interpretation of indicators (Loviisa)

Loviisa 1 had no leaking fuel during the period under review. A minor fuel leak was observed at Loviisa 2 in December 2012. The leaking fuel assembly will be removed in the annual outage 2013.

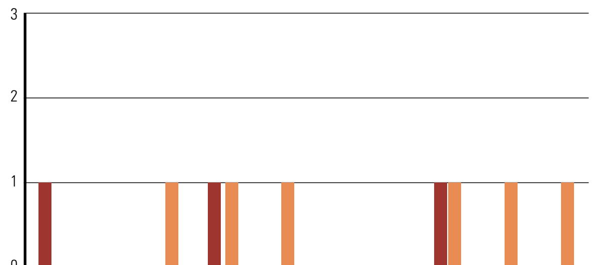
Interpretation of indicators (Olkiluoto)

Olkiluoto 1 had no leaking fuel in 2012. A fuel assembly that had been leaking since 2011 was removed from Olkiluoto 2 during the annual outage.

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

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	0	0	0	0	0	0	0	1	0	0
LO2	0	0	0	0	0	0	1	0	0	0

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



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	1	0	0	1	0	0	0	1	0	0
OL2	0	0	1	1	1	0	0	1	1	1

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 current 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. This index observes corrosive factors and the concentrations of corrosion products in the steam generator blowdown and the feed water. For steam generator blowdown, the calculation includes the chloride, sulphate and sodium concentrations and acid conductivity. For feed water, it includes the iron, copper and oxygen concentrations. The indicator for Olkiluoto is the international index used by the plant. It consists of the chloride and sulphate concentrations of the reactor water and the iron concentration in the feed water. The indices for both plants only cover the aforementioned parameter values during power 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 the Olkiluoto plant, 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 the Loviisa plant, the iron concentration of the reactor coolant and the secondary circuit feed water (maximum values for the monitoring period) are followed. For the Olkiluoto plant, the iron concentration of feed water (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 plants.

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 of the indicator

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 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 plant to cold shutdown is used to describe the access of cobalt-containing structural materials into the reactor coolant system, 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 plant units' water chemistry conditions.

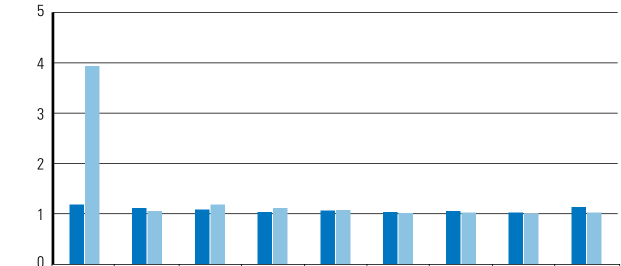
Responsible units/persons

Reactor and Safety Systems (REA)
Kari Mäkelä

Interpretation of indicators (Loviisa)

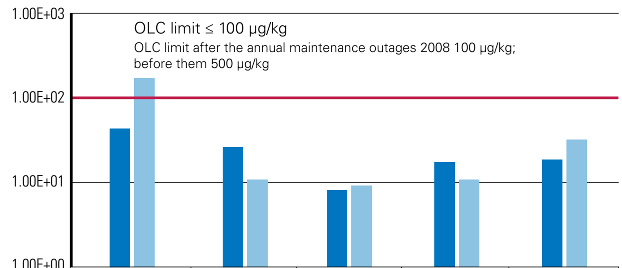
In 2012, the impurity and corrosion product levels in the reactor coolant system and the secondary circuit, followed in STUK's indicator scheme, were within the OLC limits. In recent years, the chemistry index of both Loviisa plant units has remained at almost the best possible value. The higher-than-normal value for Loviisa 2 in 2012 was due to impurities in steam generators. The impurities resulted from the inability to purify the secondary circuit water efficiently enough after start-up. To lower the impurity content, an exceptionally high quantity of water was let out from the bottom of the steam generators throughout the autumn. In addition, the secondary circuit powder resin coating was carried out more frequently, water was changed with increased efficiency, and ion exchange resins were regenerated and used for water purification. Despite these measures, the chemistry index was clearly higher than in the previous years. The water chemistry of the Loviisa 2 secondary circuit remained at the good level of the previous years. The exceptional value of the index for Loviisa 2 in 2004 was caused by a seawater leak in the condenser, which had caused the chloride concentration of the steam generator blowdown, affecting the index, to become greater than normal. The maximum Co-60 activity levels associated with shutdowns were measured during shutdowns for annual outages. In 2012, the concentrations did not deviate from previous years' values. The indicator shows that the integrity of the reactor coolant system has been good at the Loviisa plant units in 2012.

Integrity of the secondary circuit: Chemistry index, Loviisa NPP



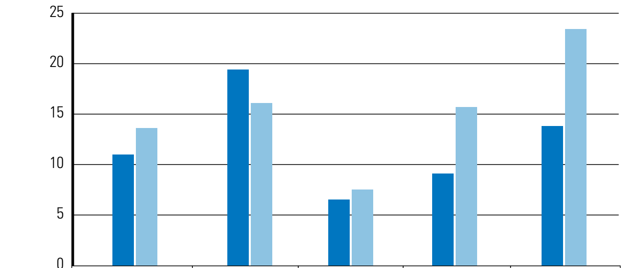
	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	1.18	1.11	1.08	1.03	1.06	1.03	1.05	1.02	1.13
LO2	3.93	1.05	1.18	1.11	1.07	1.01	1.02	1.00	1.02

Integrity of primary circuit: Corrosive impurities; Maximum chloride concentration of a steam generator blow-down (µg/kg) in power operation, Loviisa NPP



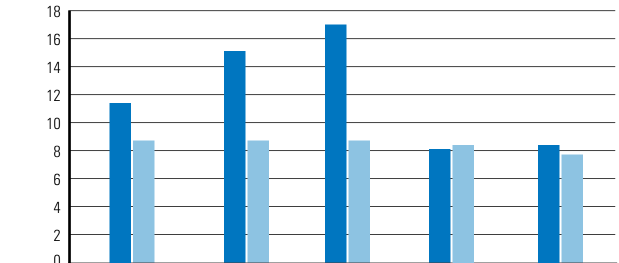
	2008	2009	2010	2011	2012
LO1	3.64E+01	2.90E+01	7.80E+00	1.93E+01	1.98E+01
LO2	2.10E+02	1.14E+01	9.10E+00	1.10E+01	3.19E+01

Integrity of primary circuit: Corrosion products; Maximum iron concentration in primary coolant (Fe-tot µg/l) in power operation, Loviisa NPP



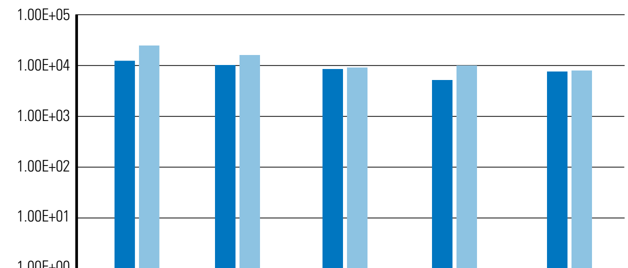
	2008	2009	2010	2011	2012
LO1	11.0	19.4	6.5	9.1	13.8
LO2	13.6	16.1	7.5	15.7	23.4

Integrity of primary circuit: Corrosion products; Maximum iron concentration in the feed water (µg/l) (RL30 / RL70) in power operation, Loviisa NPP



	2008	2009	2010	2011	2012
LO1	11.4	15.1	17.0	8.1	8.4
LO2	8.7	8.7	8.7	8.4	7.7

Integrity of primary circuit: Maximum cobalt-60 activity concentration (kBq/m³) in primary coolant related to shutdowns, Loviisa NPP

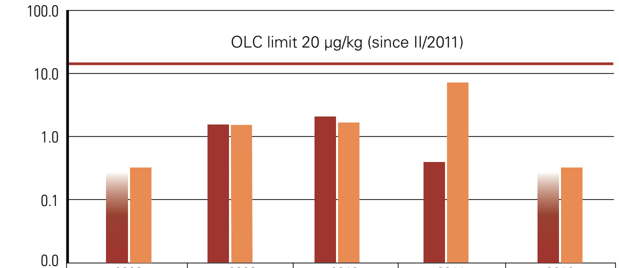


	2008	2009	2010	2011	2012
LO1	1.29E+04	1.03E+04	8.21E+03	5.26E+03	7.48E+03
LO2	2.40E+04	1.71E+04	8.60E+03	9.88E+03	7.90E+03

Interpretation of indicators (Olkiluoto)

The impurity and corrosion product levels in reactor water and feed water, followed in STUK's indicator scheme, were below the OLC limits at both plant units. The chemistry index was the best possible, 1, at both plant units in 2012. Iron, sulphate and chloride concentrations of the reactor coolant did not deviate from their regular values, which is also shown by the achieved chemistry index value. The monitoring and optimisation of Olkiluoto 2 water chemistry was successful in 2012. All the results presented in this report are at a normal good level. The higher-than-usual chloride content in 2011 was caused by a seawater leak in the condenser. The leak was rectified within two weeks of detecting it, after which the chloride content has been in line with the target value. Similar leaks did not take place in 2012. At both plant units, the Co-60 activity content maximum associated with shutdown occurred during shutdown for annual outage. There were no essential changes in the Co-60 activity content compared to previous years. The indicator shows that reactor coolant system integrity has been good at the Olkiluoto plant units in 2012.

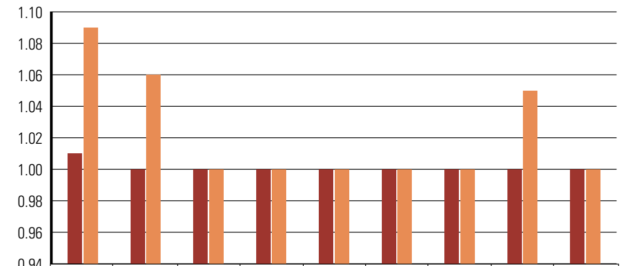
Integrity of primary circuit: Corrosive impurities; Maximum chloride concentration in primary coolant (µg/kg) in power operation, Olkiluoto NPP



	2008	2009	2010	2011	2012
OL1	0.5	2.1	3.0	0.7	0.5
OL2	0.6	2.0	2.1	7.8	0.6

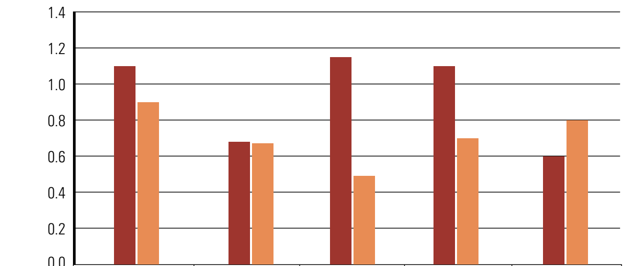
below detection limit

Integrity of primary circuit: Chemistry index, Olkiluoto NPP



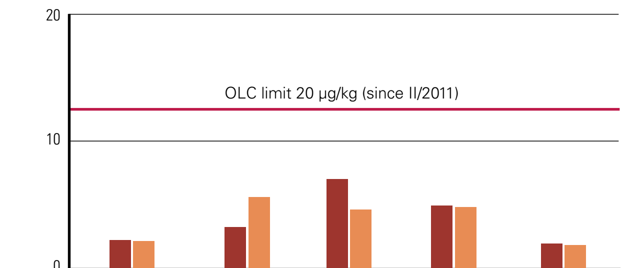
	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	1.01	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
OL2	1.09	1.06	1.00	1.00	1.00	1.00	1.00	1.05	1.00

Integrity of primary circuit: Corrosion products; Maximum iron concentration in reactor feed water (µg/l) in power operation, Olkiluoto NPP



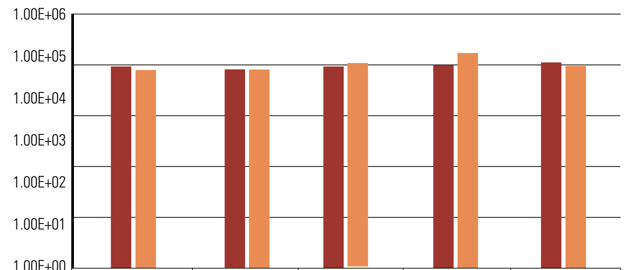
	2008	2009	2010	2011	2012
OL1	1.10	0.68	1.15	1.10	0.60
OL2	0.90	0.67	0.49	0.70	0.80

Integrity of primary circuit: Corrosion products; Maximum sulphate concentration in primary coolant (µg/l) in power operation, Olkiluoto NPP



	2008	2009	2010	2011	2012
OL1	2.2	3.2	7.0	4.9	1.9
OL2	2.1	5.6	4.6	4.8	1.8

Integrity of primary circuit: Corrosion products; Maximum cobalt-60 activity concentration (kBq/m³) in primary coolant related to shutdowns, Olkiluoto NPP



	2008	2009	2010	2011	2012
OL1	8.34E+04	7.83E+04	8.59E+04	1.10E+05	1.19E+05
OL2	7.01E+04	7.54E+04	1.01E+05	2.66E+05	9.05E+04

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 operating cycle.
- Highest daily internal leakage volume in the containment during the operating 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 the Olkiluoto power plant to the responsible person at STUK.

Purpose of the indicator

The indicators describing reactor coolant system leakages are used to follow and monitor the leak rate of the reactor coolant system within the containment.

Responsible units/persons

Projects (PRO), Jukka Kallionpää

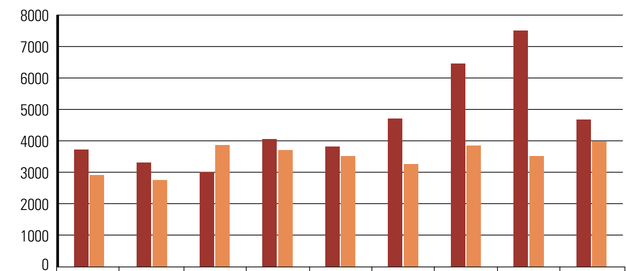
Interpretation of the indicator, operating cycle 2011–2012

One of the purposes of controlled leakage k352 is to collect leakages from valves, pumps and other such 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 on the drains above the main lines will detect any leakage in the specific line. Other methods must then be used to locate the actual leaking object. Identified leakages within the containment increased to some extent at OL1 in 2009, 2010 and 2011. In 2012, they went down. At OL2, the identified leakages have remained almost constant. The leakage volumes do not include the drainage of process systems during annual outages and other outages. The identified leakages 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 drains and any leakage from the control rod actuator seals. The volumes of unidentified reactor coolant system leakages during the operating cycle 2010–2011 decreased at both plant units. In 2012, they went slightly up from the 2011 level at both plant units.

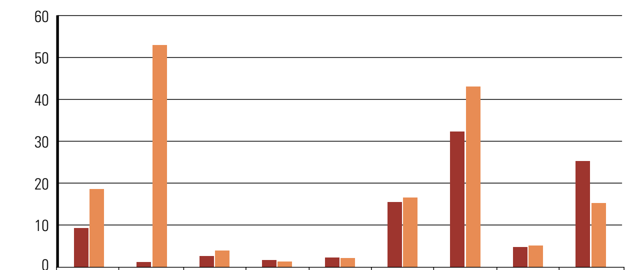
One of the purposes of containment gas cooling system 725 is to remove moisture from the containment atmosphere. Moisture may originate from steam leaking from the reactor coolant system. In the operating cycle of 2010–2011, the containment's largest internal daily leak volume's ratio to the maximum allowable volume, as specified in the

Identified leakages of primary circuit (352T1, m³), Olkiluoto NPP



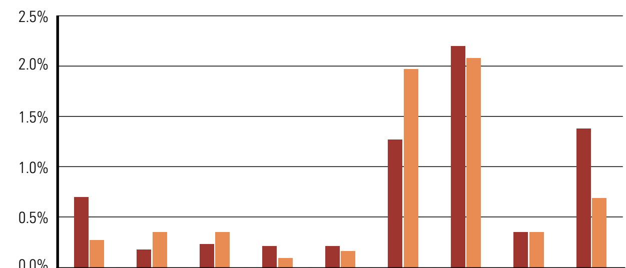
	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	3716	3300	3004	4058	3805	4697	6448	7496	4664
OL2	2908	2741	3862	3696	3502	3252	3847	3505	3973

Unidentified leakages of primary circuit (345T33, m³), Olkiluoto NPP



	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	9.20	1.14	2.52	1.56	2.16	15.48	32.28	4.74	25.3
OL2	18.60	53.00	3.84	1.26	2.04	16.5	43.08	5.10	15.2

The maximum unidentified leakage in ratio to the OLC limit, Olkiluoto NPP



	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	0.70	0.18	0.23	0.21	0.21	1.27	2.20	0.35	1.38
OL2	0.27	0.35	0.35	0.09	0.16	1.97	2.08	0.35	0.69

operational limits and conditions, was low for both plant units.

The reactor coolant system has been relatively leak-proof in the 2011–2012 operating cycle.

A.III.3 Containment integrity

Definition

As indicators, the parameters below are followed: the total as-found leakage of outer isolation valves following the first integrity tests, compared with the highest allowed total leakage from the outer isolation valves; the percentage of isolation valves tested during the year in question at each plant unit that passed the leakage test on the first attempt (i.e. as-found leakage smaller than the acceptance criteria of a valve and no exceeding of the so-called attention criteria of a valve without repair in consecutive years) and the combined as-found leakage rate of containment penetrations and airlocks in relation to their highest allowed total leakage. The combined leakage rate at Olkiluoto includes leakages from personnel airlocks, the maintenance dome and the containment dome. At Loviisa, the combined leakage rate is comprised of the leakage test results from personnel airlocks, the material airlock, the cable penetrations of inspection equipment, the containment maintenance ventilation systems (TL23), the main steam piping (RA) and the feed water system (RL) penetrations; the seals of blind-flanged penetrations of ice-filling pipes are also included.

Source of data

Data is extracted from the utilities' leak-tightness test reports submitted by the licensee to STUK for information within three months of the completion of annual maintenance. 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 of the indicator

This indicator is used to follow the integrity of the containment isolation valves, penetrations and airlocks.

Responsible unit/person

Reactor and Safety Systems (REA)
Päivi Salo

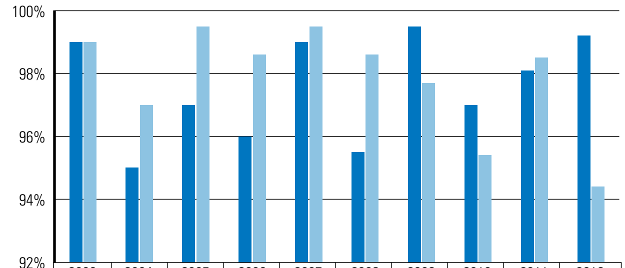
Interpretation of the indicator

Loviisa

The overall as-found leakage of the outer isolation valves of Loviisa 1 has decreased. At Loviisa 2, the overall as-found leakage increased, and based on the first tests, exceeded the limit set for overall leakage. Two outer isolation valves with plenty of leakage formed 85% of the overall as-found leakage. Both lines also have inner isolation valves. After the repair of the valves, the overall as-found leakage was again below the set limit.

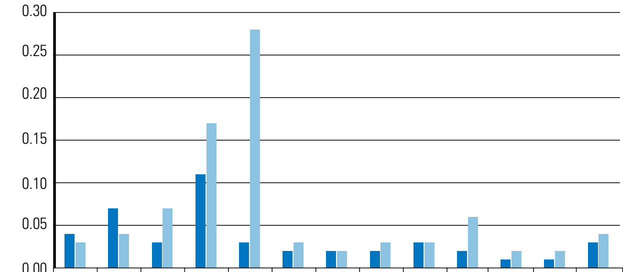
The percentage of isolation valves that passed the leak test at the first attempt has remained high.

Isolation valves passing the leakage test at the first attempt, Olkiluoto NPP



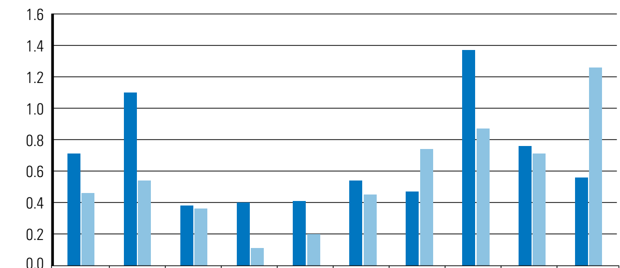
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	99.0	95.0	97.0	96.0	99.0	95.5	99.5	97.0	98.1	99.2
LO2	99.0	97.0	99.5	98.6	99.5	98.6	97.7	95.4	98.5	94.4

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



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	0.04	0.07	0.03	0.11	0.03	0.02	0.02	0.02	0.03	0.02	0.01	0.01	0.03
LO2	0.03	0.04	0.07	0.17	0.28	0.03	0.02	0.03	0.03	0.06	0.02	0.02	0.04

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



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
LO1	0.71	1.10	0.38	0.40	0.41	0.54	0.47	1.37	0.76	0.56
LO2	0.46	0.54	0.36	0.11	0.20	0.45	0.74	0.87	0.71	1.26

The overall as-found leakage of containment penetrations, which at Loviisa includes the leakage test results for the personnel airlock, the emergency personnel airlock, the material airlock, the reactor pit, inward relief valves, cable penetrations and bellow seals (RA, RL, TL23), was small at 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.

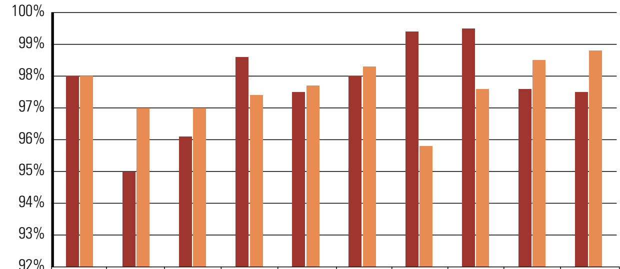
Olkiluoto

The overall as-found leakage of the outer isolation valves of Olkiluoto 1 increased when compared to the previous year, but remained clearly below the limit set in the operating limits and conditions (OLC).

The overall as-found leakage of the outer isolation valves of Olkiluoto 2 decreased from the previous year, and was below the limit set in the OLC.

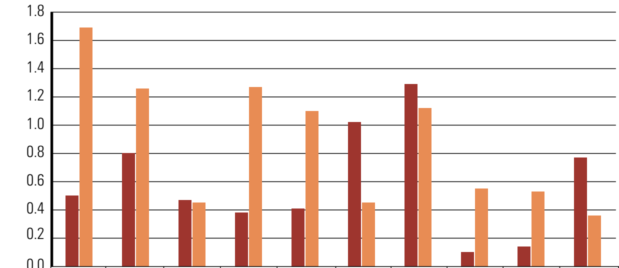
The percentage of isolation valves that passed the leak test at first attempt has remained high for both plant units.

Isolation valves passing the leakage test at the first attempt, Olkiluoto NPP



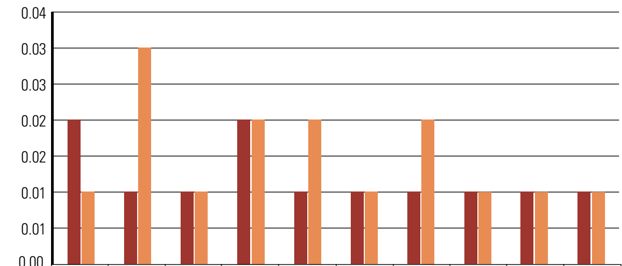
	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	98.0	95.0	96.1	98.6	97.5	98.0	99.4	99.5	97.6	97.5
OL2	98.0	97.0	97.0	97.4	97.7	98.3	95.8	97.6	98.5	98.8

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



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	0.50	0.80	0.47	0.38	0.41	1.02	1.29	0.10	0.14	0.77
OL2	1.69	1.26	0.45	1.27	1.10	0.45	1.12	0.55	0.53	0.36

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



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
OL1	0.02	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01
OL2	0.01	0.03	0.01	0.02	0.02	0.01	0.02	0.01	0.01	0.01

APPENDIX 2 Occupational radiation dose distribution at Loviisa and Olkiluoto nuclear power plants in 2012

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 14.3 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 2008 to 2012 was 54.5 mSv. The dose was accumulated at Swedish nuclear power plants.

dose range (mSv)	number of persons by dose		
	Loviisa	Olkiluoto	total*
< 0,1	817	1512	2229
0.1–0.49	194	397	555
0.5–0.99	129	186	288
1.00–1.99	132	131	253
2.00–2.99	84	39	113
3.00–3.99	38	22	62
4.00–4.99	37	3	40
5.00–5.99	29	12	41
6.00–6.99	10	3	20
7.00–7.99	19	0	17
8.00–8.99	13	3	19
9.00–9.99	8	1	9
10.00–10.99	5	0	8
11.00–11.99	3	0	6
12.00–12.99	2	0	2
13.00–13.99	6	0	7
14.00–14.99	7	0	7
15.00–20	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 Significant operational events at nuclear power plants in 2012

Loviisa NPP

Suction valve of the boron injection system erroneously closed at Loviisa 2

It was observed at Loviisa 2 on 10 April 2012 that the suction line valve of one of the boron tanks of the plant unit was erroneously in the closed position. The boron injection system includes two boron tanks from which water with high boron content can be pumped into the reactor in various operational, transient and emergency situations using six pumps. The function most important to safety is the injection of boron into the reactor to shut it down when shutdown with control rods fails. When repair of the boron injection system began at the plant unit, the suction line valve was found to be closed.

The closed position of the hand-operated suction valve prevented the use of three boron injection pumps. In addition, a fourth pump was disconnected for repairs. If the boron injection system had been required to shut down the reactor, only two pumps would have been available: one high-pressure pump and one low-pressure pump with low capacity. On the basis of analyses, one high-pressure pump is adequate in situations where the reactor shutdown by control rods fails.

The closed suction valve was opened immediately after the error was found, and the three pumps served by it were operational again. The closed valve was noticed due to an alarm that activated in the control room. The alarm would also have functioned in an emergency, and adequate boron injection into the reactor could have been speedily restored. It is also possible to change the pump suction to another tank using valves.

The boron injection system had been used approximately one week prior to the event, at which time the valve now erroneously closed had been open. According to the Loviisa power plant, the boron tank suction valve was most likely closed due to a human error occurring in connection with the testing of the boron pump. Due to the event, the Loviisa power plant will add further details to the boron pump periodic testing procedure to include checking and acknowledging the state of the boron tank suction valves at the end of the tests.

For the safe shutdown of the plant, it was essential that the control rod system was operational at the time of the event. The event was classified as category 0 on the INES scale, and it caused no risk to the environment or the personnel.

Deficiencies in the testing of radiation monitors at Loviisa 2

In May 2012, the Loviisa power plant informed STUK that it had found deficiencies in the testing procedure of certain radiation monitors at the plant. The monitors in question are used to measure the radioactivity of the water let out of the secondary circuit and discharged into the sea. The procedures had not been fully observed when testing the monitors, resulting in the process control function being left untested in some tests. In addition, some periodic tests had been completely ignored.

The testing requirements of radiation monitors are recorded in the operational limits and conditions (OLC) that the power plant must comply with. According to the OLC, a general inspection of the monitors must be performed every two weeks, a functional test every month, and a calibration check every six months. Based on the investigations of Fortum, there have been deficiencies in all these.

After the detection of the deficiencies, the radiation monitors and the related process control functions were tested in accordance with the procedures. The tests showed that the equipment functioned in the normal manner. Radiation monitors have a self-diagnostics function in case of failures and, in addition to periodic testing, the operation of the monitors is followed in the process computer trend displays. As the equipment functions in the normal manner, deficient testing had no immediate importance to the safety of the plant or the environment.

The preliminary classification of the event on the INES scale is 0. Fortum delivered a special report of the event to STUK, describing the reasons and corrective measures for the event. As the event involved deficient quality management and unjustified ignoring of procedures, STUK rated the event as an anomaly belonging to INES category 1.

Deficient testing of recombiners at Loviisa 2

It was observed at Loviisa 2 on 16 May 2012 that the containment recombiner test required by the plant procedures had not been carried out in March 2012.

Hydrogen is released from the reactor into the containment in a potential severe reactor accident. The recombiners remove the hydrogen by means of a catalytic reaction to prevent the creation of high hydrogen concentrations. If the recombiners are unavailable, hydrogen can be removed using ignition plugs.

The normal testing interval of recombiners is two months, but if testing shows that one third of the recombiners do not meet the operability requirements set for them, the testing interval must be reduced to one month. According to the procedures, the normal testing interval can be restored if the results of two consecutive tests are acceptable.

New recombiner sheets that met the criteria in the performed tests have been installed at both plant units in January and February 2012. These tests were interpreted as two accepted tests at Loviisa 2. Due to the erroneous interpretation, the plant unit restored the two-month testing interval after one accepted test. The following testing of the Loviisa 2 recombiners took place in April 2012. The equipment met the testing criteria. A similar erroneous interpretation was not made at Loviisa 1.

The event is classified as 0 on the INES scale, i.e. it has no significance for radiation or nuclear safety.

Stopping of cooling system pumps during Loviisa 1 annual outage

An annual outage was in progress at Loviisa 1 on 8 August 2012 when two secondary cooling system pumps stopped due to a human error. The situation constituted non-compliance with the operational limits and conditions (OLC), as both pumps of the secondary cooling system train should have been operational. The other train and its pumps had been isolated for maintenance.

The secondary cooling system cools seal water and feeds it into the auxiliary systems of the reactor coolant system, including the fuel pool cooling system and the related heat exchangers and pumps.

The events were initiated when an isolation valve included in the system to separate the subsystems was tested. The other isolation valve should be closed during the test, but due to a human error, the valve was open and let water through to the empty side of the system. As the water volume decreased, two pumps of the available clean secondary cooling system train stopped. Flow in the system stopped, and a moment later, two fuel pool cooling pumps also stopped.

Fuel pool cooling was only disconnected for 12 minutes, and it had no effect on the pool temperature. This was also due to the large water volume in the tanks and the fact that the fuel from the reactor had not yet been transferred into the pools, and only little residual heat was being generated as a result. The reactor and its fuel were being cooled by the residual heat removal system independent from the secondary cooling system.

The event did not put radiation or nuclear safety at risk. Operators noticed the event quickly based on alarms activating in the control room, and normal operation of the pumps could be speedily restored.

Reactor trip at Loviisa 2

Switchboard maintenance was carried out in the Loviisa 1 annual outage, and the switchboard was cut off for the purpose. This resulted in power supply being also cut off from the control cubicle of the back-up excitation system of turbine generators. This caused faulty protection signals in the back-up excitation system, and resulted in the isolation of Loviisa 2 turbine generators from the power grid. At this point, the reactor operator of Loviisa 2 initiated a reactor trip.

During the announcements given in the plant area during the event, an 'all clear' signal was erroneously sounded. This created confusion not only at the plant, but also in the vicinity of it.

As an immediate measure, the protections from the back-up excitation machine were disconnected and will only be reconnected when back-up excitation is taken into use. Similarly, the alarm and announcement procedures concerning transients were further specified.

Excess fire load at Loviisa 1

On STUK's oversight rounds during the annual outage on 7 September 2012, ten one-litre plastic bottles containing flammable solvent were found in a plastic bag at the shoe boundary of a reactor pit access opening located in the containment's reactor coolant pump room. The solvent was intended for the washing of the reactor pit's steel lining. According to the plant procedure, three litres of flammable solvents may be kept in the open at once. Other tools meant for the cleaning of the reactor pit, including cleaning cloths, were also stored at the same location.

The reactor coolant pump room has plenty of fixed fire load, such as 5,000 kg of cable insulation. Washing agents do not essentially increase the fire load but together with flammable materials, they create the preconditions for a rapidly progressing fire that ignites cables. When PVC cables burn, the temperature in the containment can increase to 200 times the normal value, and high quantities of hydrogen chloride would be released.

The fire safety of the Loviisa power plant's containment is partially based on keeping fire loads as low as possible and minimising the ignition potential. This is particularly important in spaces which have no fixed fire extinguishing systems, such as the containment's reactor coolant pump room, and where the success of first aid extinguishing is uncertain.

STUK also observed a similar event at Loviisa 1 during the 2010 annual outage, with a considerably higher quantity of connectors being stored. Since the 2010 event, the power plant has improved the procedures and supervision of the work.

Due to the repeated nature of the event, STUK rated it as a category 1 event on the seven-step radiation and nuclear safety scale (INES).

Reactor trip at Loviisa 1

During the start-up of Loviisa 1 after the annual outage, one feed water pump was feeding water into the steam generators. The pump stopped, and the feed water system could not be started up despite the efforts due to low pressure on the supply side. As a result, a manual reactor trip was performed while the reactor power was still at a low level.

The event caused no risk to the plant, people or the environment. The plant's safety back-up systems functioned as planned. The event was caused by inadequate feed water pumping capacity considering the operating mode. After the event, confirmation of adequate pumping capacity had been added to the updated start-up procedure of the plant units.

Uncertainties in the operationality of replaced pressure equalisation system valves at Loviisa 1

The start-up of Loviisa 1 after annual outage was interrupted on 20 September 2012 due to uncertainties found in the commissioning testing of a pressurizer blowdown line valve and the pressurizer spray valves.

Modifications were made to the reactor pressure equalisation system during the annual outage of Loviisa 1. According to the operational limits and conditions (OLC) updated due to the modifications, the valves must be operational when the plant is taken into the hot standby state during start-up. STUK estimates that there was no basis for confirming the operationality of the valves, as no certainty existed of the success of tests included in the test operation programme.

At STUK's request, the plant was cooled down to hot shutdown, as no operationality requirement existed for the valves in that state. The power company performed the necessary testing again, and after acceptable testing results, the valves could be confirmed as operational.

The event caused no risk to the plant, people or the environment. On the International Nuclear Event Scale (INES), the event was rated as category 0.

Two serious accident management measurements unavailable at Loviisa 1

After the annual outage on 4 October 2012, it was observed at Loviisa 1 that two measurements related to serious accident management would not have functioned reliably in an emergency. The measurements in question are used during serious reactor accidents to provide plant operators with information on whether the water volume used for external cooling of the reactor pressure vessel is adequate. Two other similar measurements were available and would have provided information on the water volume.

The reason behind the event was a valve left in the wrong position during annual outage. After installation, the valve had been left on the line in a closed position, which was why the measurements did not work. According to the OLC, the measurements must be available during plant start-up. As the valve had been left in the wrong position already during the annual outage, the plant had been non-compliant with the OLC during start-up.

The Loviisa nuclear power plant has identified the inspection procedure after valve installation and deficiencies in the verification of availability as the causes of the event. Due to the event, the Loviisa power plant will identify the valves which have an impact on the measurements and which have deficient inspection procedures, and will make the necessary changes to the procedures.

The event caused no risk to the plant, people or the environment. On the International Nuclear Event Scale (INES), the event was rated as category 0.

A residual heat removal subsystem briefly unavailable at Loviisa 2

One subsystem of the residual heat removal system of the Loviisa 2 reactor coolant system was unavailable for a brief time after the annual outage, creating non-compliance with the OLC. The power plant observed the fault on 8 October 2012 when the start-up of Loviisa 2 after annual outage had begun. The subsystem should have been operational before the beginning of start-up.

The purpose of the residual heat removal system is to cool down the reactor and to transfer the residual heat from the reactor to seawater. The system has two subsystems, each of which is capable of managing the residual heat removal alone. The other subsystem and the independent back-up system were operational.

According to the OLC, both subsystems must be operational when the plant unit is taken into cold shutdown during start-up. Before going into cold shutdown, repairs had been started in one of the subsystems. The repair work was not known to cause inoperability that prevents the change of the operating mode. As a result, the plant unit was non-compliant with the OLC during the change of the operating condition.

The Loviisa nuclear power plant has identified flawed awareness of the situation at the beginning of plant start-up as the cause of the event, and is assessing its potential to develop its operating mode change procedures before the 2013 annual outage.

The event caused no risk to the plant, people or the environment. On the International Nuclear Event Scale (INES), the event was rated as category 0.

Erroneous settings of protective relays of motors at Loviisa 2

At Loviisa 2, thermal relays (overload protections) were replaced in the electrical motors of pumps important to safety in the annual outage in autumn 2012. Approximately one month after the completion of the annual outage, Fortum observed that wrong settings had been entered for the relays, potentially resulting in the pumps stopping in the case of low motor supply voltage. The thermal relays are used as overload protection for the electrical motor, meant to protect the motor and to cut the motor's power supply if the motor overheats.

STUK's inspection in November revealed irregularities in the protections of the electrical motors of certain pumps important to safety. Further investigations by Fortum showed that erroneous settings existed in the new thermal relays installed into motors during the 2012 annual outage at Loviisa 2. There were erroneous thermal relay settings in a total of ten different pump motors in the emergency cooling and feed water circuits, with the normal supply voltage values used instead of undervoltage values. The erroneous relay settings could have led to stopping of the pumps in undervoltage situations.

The safety significance of the event was low, and the event caused no immediate risk for the safety of the plant unit or the personnel. The pumps were operational in normal voltage conditions, but could have stopped in undervoltage situations. Undervoltages and pump malfunctions are indicated in the control room, which allows operators to take the necessary measures following the procedures. The plant unit is designed to cope with undervoltage of the external 400/110 kV power grids using its four emergency diesel generators.

According to Fortum, the root cause behind the event was a design error in the definition of thermal relay settings. The plant documentation used as a basis of design work does not include undervoltage information for the pump motors in question. The design error was not observed in connection with the modification work or the inspection.

After the erroneous thermal relay settings had been detected, Fortum informed the control room personnel of the proper procedures in undervoltage situations. As an immediate corrective measure, Fortum implemented the appropriate thermal relay settings. The power company will also add further details to the setting and testing procedure, develop the plant information system and documentation, and make additional checks to ensure that the thermal relay settings used in the plant unit's electrical motors are correct. Fortum also inspected the corresponding thermal relays of pump motors at Loviisa 1, and no erroneous settings were found.

The event was rated as category 1 on the international INES scale, because the erroneous relay settings simultaneously affected the reliable undervoltage operation of several systems important to safety.

Inconsistencies in testing procedures observed at the Loviisa power plant

The Loviisa nuclear power plant has changed the periodic testing intervals of some systems and equipment so that the practice has become non-compliant with the operational limits and conditions (OLC) that guide the plant operations. The matter was revealed in an extensive review of procedures at the Loviisa power plant.

The power plant started the review of procedures after the events that took place early in 2012. At the time, some periodic testing defined in the OLC was not carried out at the correct time, because the testing interval specified in the procedure was different from that in the OLC. In the extensive review, new differences in testing intervals were found between certain procedures and the OLC.

The condition of safety-significant systems and equipment is monitored with periodic testing and inspections. The requirements for the periodic testing intervals are defined in the OLC. Differences between procedures and the OLC have been caused by reasons such as modifications being carried out at the nuclear power plant, resulting in changed testing intervals. The testing intervals presented in the OLC should also have been updated and subjected to STUK for approval after the modifications.

According to the Loviisa power plant, the observed differences in testing intervals were minor, and no safety-critical tests would have been neglected. The causes of the event were identified as the procedure update process being in conflict with the plant's own procedures, and the fact that the role of the OLC in the procedure and regulation hierarchy had not been recognised to the adequate extent. The Loviisa power plant will continue the comparisons between OLC and the procedures and make the necessary changes to the procedures or the OLC to remove any conflicting information.

The event belongs to category 0 of the International Nuclear Event Scale (INES), meaning that it had no impact on nuclear safety.

Problems with the Loviisa emergency diesel generators' connecting rod bearings

An overhauled emergency diesel generator was installed at Loviisa 2 in the 2012 annual outage. During the overhaul, the motor received a new type of bearing at the lower end of the connecting rod. Deficiencies had been observed in the reliability of the same manufacturer's previous bearing type when used in similar emergency diesel generators in other countries. The unreliable bearing type is not being used at the Loviisa power plant at the moment. The manufacture of the original bearing type ended in 2001.

The motor manufacturer tested the new bearing type, and the preliminary testing report states that it functions well. As there is no operating experience in addition to type testing, STUK approved the new bearing type for use, but presented requirements of visual inspections of the bearings during test operation, and analysis of lubrication oil at fixed intervals. At the end of 2012, the Loviisa power plant delivered to STUK the inspection records, analysis results, final type testing report and proposal for further measures to ensure the availability and reliability of the diesel motor. STUK will decide on the required long-term measures based on Fortum's proposal.

Olkiluoto NPP

Error in the calculation of control rod efficiency at Olkiluoto 1 and Olkiluoto 2

TVO reported that during the spring it had found an error in the calculation method used to assess the efficiency of control rods during plant start-up. According to STUK's assessment, the error found in the calculation method has no significance for the safety of the plant or the plant environment.

The reactors of Olkiluoto 1 and Olkiluoto 2 both have 121 control rods that can be moved inside the reactor core to adjust the reactor power, and that can be used to shut down the reactor when necessary. A control rod drop accident is a postulated accident used in nuclear power plant design with the probability of less than one for every thousand years of operation.

The error in the calculation method is associated with a situation where the reactor is operated at only a few per cent of full power during start-up after an annual outage. At the beginning of the start-up procedure, the control rods are inserted into the reactor core and are gradually pulled out according to the procedure to increase reactor power. Due to the error in the calculation, control rod efficiency was considered much too low at low reactor power. If a control rod had become stuck when being pulled out, and later dropped out of the core all at once, the resulting power increase in the reactor would have been higher than the estimated increase. Preliminary estimates show, however, that the error did not cause any risk to fuel integrity or plant safety.

The temperature of the fuel in the reactor must not increase so high that fuel integrity is lost. Therefore, safety analyses will be carried out for a control rod drop accident to confirm that the drop of any control rod at any stage of start-up cannot put safety at risk. Data of control rod efficiency is required for the analyses.

The event was rated as INES category 0.

Deficiencies found in the operation of main steam isolation valves at Olkiluoto 1 and Olkiluoto 2

During the 2012 annual outage of Olkiluoto 1, TVO found that one of the reactor's main steam isolation valves would not have closed as planned when required. A missing valve control conductor was revealed as the cause of the deficiency. The conductor had been removed when four inner main steam isolation valves had been replaced in the 2010 annual outage. The conductor had not been replaced due to a modification design error. TVO carried out additional checks and tests at both plant units after the observation, and found the same deficiency also at Olkiluoto 2. In a turbine automation renewal carried out in 2005, a conductor had been unnecessarily removed. As a result, the same isolation valve as at Olkiluoto 1, and another isolation valve beside it, would not have closed automatically when required.

Olkiluoto 1 and Olkiluoto 2 both have four steam lines for conveying the steam generated in the reactor to the turbine plant. Each steam line has two isolation valves, one inside the containment wall and one on the outside. Their purpose is to close the steam lines in certain transient and accident situations, thus isolating the reactor and its containment in order to retain radioactivity within the containment. The missing control conductors did not belong to these main valves. Instead, the concerned isolation valves were located side by side outside the containment on a pipeline that is used to let the steam released from under the valve piston of closing pressure-operated isolation valves into the containment condensation pool. These two external isolation valves are located on a closed circuit, which means that steam and radioactive substances carried by the steam could not have been released outside the containment even if the valves had been left open.

The events did not put the safety of the plant or the environment at risk, but revealed deficiencies in modification planning and the coverage of testing. TVO installed the missing conductors immediately after the events were detected. TVO will also investigate the coverage of testing more extensively and improve the process used to ensure that modifications are ready to be implemented.

The events of both plant units were rated as INES category 1. The classification is based on a modification error.

Corrosion indications in Olkiluoto 1 main steam isolation valves

During the annual outage, TVO carried out a warranty inspection on an inner main steam isolation valve of Olkiluoto 1 replaced two years earlier. Small pitting or selective corrosion indications were found in the valve's sealing surfaces. The size of the pits found in the sealing surface one centimetre wide was approximately one tenth of a millimetre, and TVO stated that they were not considered to affect the valve's tightness or operability. However, STUK required that three other similar valves be inspected at Olkiluoto 1 and that an account be given of the root cause and corrective measures used to avoid corrosion of the sealing surfaces in the future. In additional inspections, similar indications were found in the other three valves. According to the immediate assessment of TVO and the valve manufacturer, the root cause is the imperfect melting of filler material during surfacing. The condition of the sealing surfaces is followed by surface inspections in accordance with the preventive maintenance programme.

Human error in a job related to the Olkiluoto 1 reactor protection system

During the annual outage of Olkiluoto 1, some of the control room pushbuttons belonging to the reactor protection system were replaced. Due to a human error, the replacement of pushbuttons was started in the wrong order. The necessary preparations had not yet been completed for the pushbuttons in question, and the work triggered a plant protection function. When the protection function had activated, two pumps contributing to the cooling of the reactor core would not have started up when required.

At the same time, a pump impeller of a reactor coolant pump at the bottom of the reactor pressure vessel was being installed in place. At this stage of the work, precautions are taken for a situation where the plugging of the pump connection fails and water leaks out of the reactor pressure vessel. The precautions include keeping at least four pumps that contribute to the cooling of the reactor core in working order and ready to be started up quickly to pump more water into the reactor pressure vessel. The protection function triggered due to the human error reduced the number of available pumps to two. This created a non-compliance with the operational limits and conditions (OLC).

TVO interrupted the replacement of the pushbuttons and restored the disabled pumps in less than half an hour. The event did not create a risk to the safety of the plant or the environment, because two pumps could have kept the water level in the reactor core above the fuel assemblies even if water had leaked out of the reactor pressure vessel through the reactor coolant pump connection.

The event was rated as INES category 0.

Failed protective relay in the electrical system of Olkiluoto 2

A protective relay of a breaker in the Olkiluoto 2 electrical system failed on 3 September 2012. This resulted in the loss of power to one subsystem's 6.6 kV busbar and the busbars belonging to it. One of the six reactor coolant pumps lost its power supply and stopped. Reactor power went down to 91 per cent. As a result, the emergency diesel generator for the subsystem in question started up. This ensured steady power supply to equipment important to safety. The failure of the protective relay did not affect the power of the three other 6.6 kV busbars or the busbars belonging to them, and the equipment connected to these received uninterrupted power.

The cause of the failure has not yet been found, and investigations are ongoing. Olkiluoto 1 and Olkiluoto 2 also have other protective relays of the same type in various installations. TVO will define new corrective measures if required by the results of the investigation.

A failed control room emergency ventilation fan at Olkiluoto 2

In testing carried out on 18 September 2012, TVO observed that the Olkiluoto 2 control room emergency ventilation system did not function as planned. One of the two fans feeding overpressure into the control room in accident conditions failed to launch. TVO investigated the issue and found that the fan had been unavailable for two weeks. The fan was immediately restored to working order.

TVO carried out modifications to the control room ventilation at the beginning of September. The preparations included electrical isolation of equipment. These ensure safety of the workers and the plant during the work. During the planning of the work, it was not observed that a change in the position of one circuit breaker also affects the control room emergency ventilation fan, preventing it from starting when required.

The control room emergency ventilation system maintains safe working conditions in the control room during accidents. The system creates overpressure to the control room to prevent any radioactive releases into the air from entering the room. TVO conducted measurements to confirm that the other fan that remained operational was able to produce an adequate pressure difference, and that the system thus met the functional requirements set for it throughout the event. The situation involved non-compliance with the operational limits and conditions (OLC), as the OLC requires that both fans be available.

The event belongs to category 0 of the International Nuclear Event Scale (INES), meaning that it had no impact on nuclear safety.

Deficiencies in the testing of protection system at Olkiluoto 1 and Olkiluoto 2

During the annual outage, TVO found deficiencies in the Olkiluoto 1 and Olkiluoto 2 main steam isolation valves. The deficiencies had not been revealed during valve testing. As a result of the event, TVO launched more extensive investigations into the scope of the testing of reactor protection systems.

The purpose of the tests, carried out at fixed intervals, is to confirm the correct operation of the reactor protection function when required, and to make sure that the operators of the plant unit receive the necessary alarms. The investigation revealed that the scope of the tests has not been adequate. The electrical circuits between the measuring equipment and the protection system have had untested contactors, meaning that their possible problems would not have been revealed in the tests carried out. As a result, tests have not managed to produce certainty of the progress of the protection signal throughout the chain, or the correct operation of the protection function in an emergency. However, certainty has been achieved for the forwarding of alarms. The operators would have received the appropriate alarms and could have carried out the necessary measures manually.

TVO immediately launched the testing of the functions that had remained untested. All contactors were found to function appropriately in the tests completed by the end of 2012. The last of the tests will be carried out in the annual outage in spring 2013.

The event caused no risk to the plant, people or the environment. On the INES scale, the event is rated at level 0.

APPENDIX 4 Licences and approvals in accordance with the Nuclear Energy Act in 2012

Teollisuuden Voima Oy

- 2/C42214/2012, 23 February 2012. Amendment to import and transport licence and transport plan for radioactive waste created during the scrapping process of decommissioned reheaters. Last date of validity 31 December 2015.
- 3/C42214/2012, 23 February 2012. Import of CR99 control rods from Sweden. Last date of validity 30 June 2012.
- 9/C42214/2012, 27 August 2012. Import and possession of a model fuel assembly and its channel from the United States. Last date of validity for import 28 February 2013 and for possession 31 December 2022.
- 10/C42214/2012, 27 August 2012. Import and possession of a model fuel assembly and its channel from Sweden. Last date of validity for import 28 February 2013 and for possession 31 December 2022.
- 11/C42214/2012, 14 November 2012. Import of nuclear fuel with Euratom obligation code "C" from Germany (OL1 E34). Last date of validity 31 December 2013.
- 12/C42214/2012, 14 November 2012. Import of nuclear fuel with Euratom obligation code "C" from Sweden (OL2 E33). Last date of validity 31 December 2013.
- 13/C42214/2012, 14 November 2012. Import of nuclear fuel with Euratom obligation code "P" from Sweden (OL2 E33). Last date of validity 31 December 2013.
- 14/C42214/2012, 14 November 2012. Import of rods made of zirconium alloy from Sweden. Last date of validity 31 March 2013.
- 16/C42214/2012, 18/C42214/2012, 16 November 2012. Export of decommissioned turbines and heat exchangers to Sweden for scrapping. Last date of validity 31 December 2012.
- 19/C42214/2012, 18 December 2012, OL1/2. Import and possession of nuclear information concerning HGNE reactor coolant pumps from the United States and Sweden. Last date of validity 31 December 2013.
- 1/G42214/2012, 23 February 2012, OL3. Import of a boron concentration measuring system from Germany and import of neutron source elements from France. Last date of validity 31 December 2014.
- 2/G42214/2012, 23 February 2012, OL3. Possession of components for spent nuclear fuel handling equipment at Olkiluoto harbour. Last date of validity 30 June 2012.
- 3/G42214/2012, 14 November 2012, OL3. Import of a thermal shield from France. Last date of validity 31 December 2014.
- 1/M42214/2012, 26.4.2012, OL4. Import and possession of nuclear information concerning the EU-ABWR plant type from Sweden. Last date of validity 31 December 2030.
- 2/M42214/2012, 5 July 2012, OL4. Transfer of nuclear information concerning the EU-ABWR plant type to Fortum Power and Heat Oy. Last date of validity 31 December 2030.
- 4/M42214/2012, 27 August 2012, OL4. Import and possession of nuclear information concerning the EU-ABWR plant type from Japan. Last date of validity 31 December 2030.
- 5/M42214/2012, 27 August 2012, OL4. Import and possession of nuclear information concerning the EU-APWR plant type from Japan. Last date of validity 31 December 2030.
- 7/M42214/2012, 5 October 2012, OL4. Transfer of nuclear information concerning the ABWR plant type to Fortum Power and Heat Oy, VTT, ETU-Consult Oy and Kvaerner Finland Oy. Last date of validity 31 December 2030.

- 8/M42214/2012, 5 October 2012, OL4. Transfer of nuclear information concerning the APWR plant type to Fortum Power and Heat Oy. Last date of validity 31 December 2030.

Fortum Power and Heat Oy

- 2/A42214/2012, 24 February 2012. Import of a boron measurement device from the Czech Republic. Last date of validity 31 December 2012.
- 4/A42214/2012, 5 July 2012, OL4. Possession and transfer of nuclear information concerning the EU-ABWR plant type to Teollisuuden Voima Oy. Last date of validity 31 December 2030.
- 9/A42214/2012, 5 October 2012, OL4. Possession and transfer of nuclear information concerning the EU-ABWR plant type to Teollisuuden Voima Oy. Last date of validity 31 December 2030.
- 10/A42214/2012, 5 October 2012, OL4. Possession and transfer of nuclear information concerning the APWR plant type to Teollisuuden Voima Oy. Last date of validity 31 December 2030.
- 12/A42214/2012, 21 November 2012. Export of contaminated scrap metal to Sweden for scrapping. Last date of validity 31 March 2013.

Fennovoima Oy

- 1/J42214/2012, 12 June 2012. Import and possession of nuclear information from Japan. Last date of validity 31 December 2022.
- 2/J42214/2012, 12 June 2012. Import and possession of nuclear information from Sweden. Last date of validity 31 December 2022.

Others

- 3/Y4214/2012, 15 July 2012, Studsvik Nuclear AB. Transport of radioactive waste from Sweden to Spain via Finland. Last date of validity 31 May 2015.
- 7/Y42214/2012, 5 October 2012, Kvaerner Finland Oy. OL4. Possession and transfer of nuclear information concerning the EU-ABWR plant type to Teollisuuden Voima Oy. Last date of validity 31 December 2030.
- 8/Y42214/2012, 5 October 2012, ETU-Consult Oy. OL4. Possession and transfer of nuclear information concerning the EU-ABWR plant type to Teollisuuden Voima Oy. Last date of validity 31 December 2030.
- 9/Y42214/2012, 5 October 2012, Platom Oy. Transfer of nuclear information for the design of sampling autoclaves to GAV-Group Oy. Last date of validity 31 December 2021.
- 10/Y42214/2012, 5 October 2012, GAV-Group Oy. Possession of nuclear information for the design of sampling autoclaves. Last date of validity 31 December 2022.

APPENDIX 5 Periodic inspection programme of NPPs in 2012

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 2012, Loviisa

Management, management system and personnel

A1 Management and safety culture, 21–22 November 2012

The management and safety culture inspection focused on the assessment of safety culture at the Loviisa nuclear power plant, utilisation of measurements in decision-making, allocation of HR resources from the management's point of view, and the periodic assessment of the functionality and scope of the management system carried out by the licensee. Based on the inspection, it was stated that the Loviisa power plant has improved its safety culture assessment operations, but that the procedure still needs to be further specified and updated. The power plant has no unified methods or tools for HR resourcing, and it could not be verified during the inspection that HR planning was systematically carried out in all units. The licensee is currently evaluating the functionality and scope of the management system, and will deliver the results of the analysis to STUK by 15 August 2013. STUK also stated that the requirements issued in the 2011 inspection on procurement operations and the related management system and quality management competence remain valid, as the corrective measures at the plant are still incomplete.

A2 Personnel resources and competence, 6 and 8 June 2012

In the personnel resources and competence inspection, STUK evaluated the management and development of competencies. Particular attention was paid to the definition of the required competence of personnel working in positions important to safety, and to the verification of their competencies. The inspection also concerned the organisational change in the power plant's safety unit, and the related safety assessment delivered to STUK. STUK required that the Loviisa power plant update the safety assessment of the organisational change with the information concerning the period during which certain tasks and responsibilities are being transferred, and to ensure that the related procedures and management code are unambiguous. STUK also required that the power plant's training procedure shall be updated. Competence management at the Loviisa power plant mainly meets the requirements of the regulations, but there is still room for improvement in matters such as the definition of the required competencies and the monitoring of actual training and its effectiveness.

A3 Functionality of the management system, 30 March and 3 April 2012

At the management system inspection, STUK evaluated the functionality and continuous improvement of the Loviisa power plant management system. STUK has previously found deficiencies with the procurement operations and supplier evaluation of the power plant, and now paid particular attention to these issues. The inspection also dealt with the procedures used in the assessment of the effectiveness of deviation management and corrective measures, as well as document management. Based on the inspection, STUK required that the Loviisa power plant produce a summary of the measures used to ensure the fulfilment of all the requirements of Guide YVL 1.4 in procurement operations and supplier evaluation. The power plant must also deliver an account of how the qualifications of the persons involved in audits are verified, as well as of any further training and refresher programmes. The Loviisa power plant must develop procedures to ensure the fulfilment of requirements concerning deviation management, the assessment of the effectiveness of corrective measures, and continuous improvement of the management system. The Loviisa power plant must also manage the validity of procedures in a systematic manner, and identify the related YVL guides in the documents.

Plant safety and its improvement

B1 Assessment and improvement of safety, 3 May 2012

The safety assessment and improvement inspection was targeted at the Loviisa power plant's nuclear safety team and its tasks as well as the maintenance and documentation of the plant's design basis. The inspection also concerned a minor pipe modification of the secondary circuit, which had revealed deficiencies in the operations of the Loviisa power plant. A change of the pipework's safety classification, made during the design of the modification, had not been subjected to advance approval by STUK as required by YVL Guide 2.1. Based on the inspection, it was stated that the documentation of the design basis of the plant's systems in the final safety analysis report does not fully meet the requirements set out in YVL Guide 2.0. For example, the analyses used to define the capacity of the shutdown safety valve of the pressurizer are not included in the final safety analysis report. STUK required that the Loviisa power plant update the final safety analysis report to comply with the YVL Guide 2.0 before the next periodic safety review in 2015. It was also stated during the inspection that, at the moment, the procedure concerning the preparation of modification documentation leaves too much room for interpretations of the necessary scope of the materials sent for approval. STUK required that the Loviisa power plant add further detail to the procedures concerning the matter.

B2 Plant safety functions 6 and 20 November 2012

In 2012, the plant safety function inspection was targeted at the emergency cooling and residual heat removal systems. The inspection included an assessment of the methods and resources that the power company uses to manage the state, operability and availability of systems over the short and long term. Based on the inspection, Fortum manages the operability and state of emergency cooling and residual heat removal systems with well-functioning procedures that meet the requirements. The power plant is operated in a systematic manner based on appropriate procedures, and the responsibilities have been clearly defined. The power plant systematically develops the procedures and the safety systems being inspected also over the long term, and no lack of available resources was observed. The power plant has improved the management of the operability of systems and also appointed persons in charge for non-safety classified ventilation systems. The development of the final safety analysis report (FSAR) update process will continue due to delays in the update process observed in the previous years.

B3 PRA and safety management

The main subjects of the inspection concerning the use of Probabilistic Risk Analysis (PRA) in safety management were the available resources, up-to-dateness of the procedures, monitoring and analysis of critical faults in emergency generators, and the HR plan and deviation processing associated with the PRA production and application organisation. Fortum's PRA resources decreased slightly during 2012. Fortum has updated the critical fault analysis of emergency generators, proving that unavailability has remained at the same level. STUK required that, in future, Fortum must add to the PRA report's covering letter a statement concerning the compliance of the report and proposed measures with YVL Guide 1.2. Fortum must also plan the licensee's PRA model acceptance procedures, and update the written procedures with the new plan. Fortum must include further utilisation of PRA to the training contents of various personnel groups.

B4 International operating experience feedback, 22 November 2012

In the operating experience feedback review, STUK verified instructions, procedures and practices related to the feedback operations. A new operating experience and safety culture team has been established at the safety unit of the Loviisa power plant, responsible for the maintenance and development of the power plant's operating experience feedback process. The new team has increased the resources available for operating experience feedback operations, and they were found to be well organised and instructed and to have adequate resources. The implementation of corrective measures for the plant's own operating events was verified based on example cases. STUK found that there was room for improvement in the follow-up of corrective actions decided on the basis of operational events at the plant as well as in the assessment of the effectiveness of corrective actions.

Operational safety

C1 Operation, 28 March 2012

The inspection of the operation of the Loviisa power plant focused on the long-term resources and HR planning of the operating organisation support group. The inspection targets also included the practicality and results of the evaluations carried out by the operating organisation for testing programmes and procedures at fixed intervals. The inspection revealed no deviations. The corrective measures resulting from requirements issued in the course of STUK's earlier inspections were also considered to be appropriately implemented.

C2 Plant maintenance, 23–25 October 2012

The plant maintenance inspection contained a review of the ageing management and maintenance development project launched at the Loviisa power plant due to the inspection observations made in 2011. Based on the inspection, increased attention is now paid at the Loviisa power plant to the equipment that is important to safety but has no crucial significance for the plant's operating life. Effectiveness is assessed by equipment type, and the requirements of the new Guide YVL A.8 of STUK can be fulfilled. Several component replacements, post-Fukushima improvements, and research projects on subjects such as the impact of radiation on materials are in progress. The technical procurement procedures of components and services were reviewed in more detail, focusing on examples such as the replacement of the pressurizer safety valves and the motor of an emergency cooling pump. STUK required an additional account of whether adequate attention is paid to tested or otherwise carefully researched design solutions in the procurement of functional equipment important to safety.

C3 Electrical and I&C systems, 13–14 November 2012

In the electrical and I&C system inspection, the first part focused on issues such as the HR planning for electrical engineering and maintenance, relay protections, cabling principles, monitoring of the ageing of electrical devices, and periodic inspections. Based on the inspection, STUK issued requirements concerning, for example, the delivery of documentation required from the power companies, and the implementation and reporting of inspection and modification measures. STUK also required that the power company deliver an account of the excitation and voltage control problems of the emergency diesel generators, and the lubrication grease used in the valve actuators needed in accident conditions.

The I&C inspection focused on the repair of I&C equipment to be used as spare parts, competence development required by the new I&C technology, the development of the I&C engineering and installation process, confirmation of the consistency of the changes with the related plant documentation, ageing management, the scope of periodic testing, and the construction inspection requirements set for I&C equipment. As a result of the inspection, the power company must, for example, survey the construction inspection procedures of load-bearing I&C equipment, produce a description of the scope of periodic testing, and improve the verification of circuit diagrams against the actual installations.

C4 Mechanical engineering

In the Loviisa power plant's mechanical engineering inspection, the maintenance and ageing management of steam generators during the plant's entire operating history were assessed. The most important inspection targets were the heat exchanger tubes located inside the steam generator. The tubes belong to the reactor coolant system, and their outer surface is exposed to corrosion. Fractures on the outer surface of the tubes have been detected using special inspection techniques, and the tubes have then been disabled by plugging. At Loviisa, pluggings have been considerably less common than in other VVER 440 plants, but their number increased significantly in 2012. Stress corrosion cracking of certain dissimilar material joints of the steam generator, which has been a serious ageing mechanism in other VVER 440 plants, has not yet been observed at the Loviisa plant. This is most likely due to successful water chemistry control. STUK did, however, require that the power company assess the safety risk caused by this mechanism, as it was not included in the original design basis. STUK also stated that the power company has produced an acceptable account of interrupted start-ups which should have been recorded for the reactor coolant system fatigue monitoring but have been neglected throughout the entire operating life of the plant units.

C5 Structures and buildings, 31 October–1 November 2012

In the construction engineering inspection of the Loviisa power plant, STUK assessed the maintenance procedures for the steel constructions, steel containment, spent fuel storage and processing pools, emergency water tanks, fuel racks and pipe supports. The inspection included a review of procedures and reports related to the power company's organisation, periodic inspections, investigations and surveys, repair, modification and maintenance measures, operating experience feedback and ageing management. Personnel were also interviewed. The execution and results of the power company's own inspections were also verified. Based on the inspection, STUK issued a requirement concerning the reporting of pipe support maintenance.

C6 Information management and security, 7–8 June 2012

The information security inspection mainly focused on the I&C systems of the Loviisa power plant. The power plant has conducted a cyber risk assessment with external experts. This assessment reflects a good security practice. Inspection identified need for development on asset management, updates for information security plan and for information security training.

C7 Chemistry, 8–9 February 2012

The chemistry inspection was mainly targeted at the organisational change carried out in the task area, HR planning, ageing management associated with the chemical conditions, and the maintenance of continuously operated analysers and continuously operated radionuclide specific activity measurement equipment. The evaluation of the activity measurement uncertainty budget continued. Plant visits concerned the continuously operated analysers of the reactor coolant and the radioactive source storage. The requirements issued based on the inspection applied to the production of an uncertainty budget for alpha and beta measurements, the completion of the organisation's administrative procedure update, and the confirmation of competence requirements and appropriate qualifications in the chemistry organisation. The maintenance responsibilities of the continuously operated chemistry analysers have been rearranged, and the production of the related written procedures is being started. STUK required that the plan and schedule for the production of procedures be delivered to STUK for information. New continuously operated analysers are being procured for the analysis of the reactor coolant's water chemistry. To ensure the adequacy of their operation and maintenance training, the licensee was required to deliver the training plan to STUK for information.

C8 Annual outage, 5 August – 13 October 2012

STUK's inspection of outage operations, performed in accordance with the periodic inspection programme, was targeted at the power plant operations that maintain safety and lead and manage actions during the annual outage. The inspection observations of various significance levels were mostly related to the work of the Loviisa power plant organisation. Among other things, STUK required that the Loviisa power plant update certain maintenance and radiation protection procedures and assess whether current procedures are adequate to prevent the access of loose parts and impurities into the opened drains in the reactor hall. The Loviisa power plant must also further develop its procedures in order to prevent items that contain activating substances from unnecessarily accessing the controlled area and to prevent such items and other loose parts from accessing the process systems of the reactor coolant system.

Personal and plant protection

D1 Radiation protection, 27–28 November 2012

The radiation protection inspection was targeted at the Loviisa power plant's radiation protection, radiation measurements and the environmental and emission monitoring. Personal dosimetry was a particular area of focus. Based on the inspection, STUK required that the power plant prepare a detailed summary of how the practical determination of radiation exposure is carried out in various exceptional conditions. Such conditions could include, for example, long-term loss of power supply to the equipment used to measure radiation exposure, or the contamination of facilities and equipment used to measure radiation exposure. The power company needs to add some further detail to the dosimetry procedures and practices. New reactor water boron content measurement devices including a neutron source have been acquired by the Loviisa power plant. The power company must carry out additional measurements to ensure that the methods used to determine the employees' neutron dose are also appropriate for use around these measurement devices. The Loviisa power plant has ongoing development projects to ensure that the methods used to measure emissions into the air function in an optimal manner in various conditions.

D2 Fire protection, 20 March 2012

The fire protection inspection focused on structural fire protection, fire detection and extinguishing systems, and operative fire protection. The plant visit included the Loviisa power plant's new diesel-operated back-up power plant, the turbine island's sprinkler triggering centres and smoke vents, and one emergency diesel room. STUK's inspection observations and issued requirements applied to the entering of fire detection system's functional test records into the power plant's work management system, deficient testing of smoke vents during the winter, and the postponement of the extinguishing system inspection by an inspection institute by a year. The planning of training was found to be good.

D3 Emergency response, 25 October – 6 November 2012

Loviisa power plant's emergency response inspection concerned all the areas of the emergency response operations. Particular areas of focus were HR planning and communications. Emergency response-related HR planning concerns both the regular organisation and the emergency response organisation. After the inspection of 2011, more people have been added to the emergency response organisation, particularly to the technical support team based in Keilaniemi. STUK required that the power company improve the communications concerning the updated emergency response procedures. The 2V telephone network dismantled in September has been replaced with a satellite telephone connection, and a communication solution based on the 3G mobile network and satellite data transmission is currently being built. The plant's emergency information system was planned to be completed by the end of September, but during the inspection, the equipment was still being tested. STUK issued a requirement of the completion of the information system.

D4 Security, 2 May 2012

STUK inspected the Loviisa power plant's security arrangements, which are deemed to include structural, technical, operational and organisational arrangements for detecting, delaying and preventing illegal activities in the nuclear power plant. The inspection was targeted at the training processes of the security organisation as well as personal and position-specific training plans. The maintenance and fault reporting procedures of security surveillance systems, which now have improved work order practices, were assessed. Other targets of assessments included the implementation of security arrangements and the drills conducted within the security organisation and in cooperation with various authorities.

Nuclear waste and its storage

E1 Operating waste, 4–5 June 2012

The operating waste inspection included a review of the targets for development in waste management, status and schedules of projects, waste records and reporting, HR planning and communications. No significant deficiencies or needs for development were detected in the review. During the review, STUK requested that an account of the operating strategy of the operating waste repository currently being built be attached to the operating licence application for the maintenance waste tunnel 3 of the Loviisa power plant's VLJ repository.

E2 Final disposal facilities

Not performed in 2012.

Special items

F1 LARA, 3 October 2012

The inspection of the Loviisa power plant I&C upgrade project (LARA) included the assessment of the training and resourcing of personnel during project implementation, installations and the monitoring of installations. Based on the inspection, STUK stated that matters have been carefully considered and that planning is at a good stage. No approved plans or documents exist at this stage of the project, but a considerable amount of preparations have been completed. The content of the unofficial documents and plans presented for review was quite good. Task descriptions have been prepared and training and competence requirements identified based on them. Preliminary appointment of members of the organisation into the positions has also begun. The organisation will be complemented with external workforce when necessary. The resources have been defined based on the installation and implementation resources established by the system supplier. Key personnel mainly include persons working in the LARA project full time. In addition to the project manager, there are six persons responsible for the I&C systems, and their appointed back-ups. The persons responsible for the systems begin their training at the test field stage, and continue with the training and practice during installation and commissioning of the systems. The persons responsible for the systems will also train their own personnel at the Loviisa power plant. Since some procedure updates, for example, did not have all the required content, the requests issued at the previous inspection largely remained valid.

F2 Inspection with no advance notification / plant operation, 4 December 2012

In the inspection carried out for the Loviisa power plant without an advance notification, STUK verified the power plant's operating processes. STUK found that shift changes, the work of the on-call safety engineer, and the procedures for the work observed during the inspection met the requirements. A few deviations from the power plant's own instructions were observed during the inspection. STUK's requirements applied to the operating personnel's shift change procedures, the training requirement of the on-call safety engineer, and the cleanliness and maintenance of the plant.

Periodic inspection programme 2012, Olkiluoto

Management, management system and personnel

A1 Management and safety culture, 13 and 20 August 2012

The management and safety culture inspection particularly focused on the management's responsibilities and work concerning the integration of the Olkiluoto 3 project to the organisation of the existing plant units, the functionality of the modification work process, and the planning of personnel resources. Based on the inspection, STUK required that TVO assess the safety implications of the organisational change associated with the integration of the Olkiluoto 3 project, and also evaluate the procedures and practices related to organisational changes. Several good development measures are currently in progress concerning the modification work processes, but TVO must also ensure that the effectiveness of the development measures is assessed. STUK also required that TVO take immediate measures to fulfil the new requirements of the Nuclear Energy Act, valid since August 2012, concerning the back-up personnel for emergency response and security arrangements.

A2 Personnel resources and competence, 5–7 September 2012

In 2012, the personnel resources and competence inspection focused on resource assessment and planning concerning the preparations for the operating phase of the Olkiluoto 3 project. Particular areas of interest included the functionality of TVO›s HR management process and its sub-processes, with attention on the operating phase of Olkiluoto 3 and the controlled disassembly of the project organisation. General verbal descriptions exist of the HR processes. The descriptions do not, however, list the process stages, interfaces or all of the operators, and the processes are not repeated in a systematic manner throughout the organisation. A more detailed description of HR processes only began in summer 2012, and the work will continue assisted with the newly established business planning section. The development of the HR planning procedure thus remains unfinished. The competence management process seems to have advanced most at the moment. TVO has not carried out a separate process functionality assessment concerning the operating phase of Olkiluoto 3. Preparations for the Olkiluoto 3 operating phase have, however, been made by producing organisation charts and by defining the necessary competence resources by office.

A3 Functionality of the management system, 7–9 November 2012

The inspection of the functionality of the management system was targeted at the modifications' quality management, quality management competencies, audit operations, and the creation and evaluation of a joint management system of the existing plant units and Olkiluoto 3. During the inspection, STUK verified the modification work process descriptions produced by TVO. TVO has not included the requirements of YVL Guide 1.4 into the modification quality management training. STUK required that TVO present the development of the modification work process and the related training to STUK in March 2013. TVO must also review and update its logistics and procurement procedures to comply with YVL Guide 1.4, detail its instructions concerning the supplier auditor qualification requirements and the maintenance of the qualification, and deliver an account of the completed audits of suppliers of safety class 1 and 2 equipment in 2011 and 2012. TVO must also deliver the project plan for the management system integration to STUK for information.

Plant safety and its improvement

B1 Assessment and improvement of safety, 24 October 2012

The inspection of the assessment and improvement of safety was targeted at the tasks and resources of the reactor safety department, and the documentation and maintenance of the design basis for the Olkiluoto 1 and Olkiluoto 2 plant units and their systems and equipment. Based on the inspection, the reactor safety department seems to have adequate personnel resources considering the department›s tasks, and instructions have been prepared for the training and induction of new team members. The design basis of the plant units is documented in the final safety analysis report (FSAR). Instructions exist for the maintenance of the report. For a few years, TVO has used a design basis database for storing design basis documents when modifications, for example, are being carried out. STUK proposed that TVO consider the systematic processing of old modification work materials to complement the design basis database.

B2 Plant safety functions, 14–15 November 2012

In 2012, the safety function inspection was targeted at the emergency cooling and residual heat removal systems. The inspection included an assessment of the methods and resources (including information systems and human resources) that the power company uses to manage the state, operability and availability of systems over the short and long term. Based on the inspection, TVO manages the operability and state of emergency cooling and residual heat removal systems with well-functioning procedures that meet the requirements. The power plant is operated in a systematic manner based on appropriate procedures, and the responsibilities have been clearly defined. The power plant systematically develops the procedures and the safety systems being inspected over the long term, and no lack of available resources was observed. TVO continues to develop the roles of the persons responsible for the systems and plant functions and, in particular, the reporting included in the tasks of these persons.

B3 PRA and safety management, 13 September 2012

The inspection concerning the use of probabilistic risk analyses (PRA) in safety management was targeted at issues such as the PRA update status and the following applications of the PRA: risk-informed development of the operational limits and conditions (OLC), risk-informed testing programmes, and risk-informed planning of preventive maintenance programmes. HR planning and deviation processing of the PRA team were also processed. Based on the inspection, it was stated that the PRA is used in many different ways to support safety, and that no deviations were observed in the inspected area. HR planning documentation was found to require further development in the area of recruitment planning.

B4 International operating experience feedback 26–27 September 2012

In the operating experience feedback review, STUK verified instructions, procedures and new practices related to the feedback operations. Despite personnel changes, operations were found to be well organised and instructed, and had adequate resources. Twice a year, the team meets together with the representatives of the management. Expertise has been added to the team by including a simulator trainer from Olkiluoto 3 and the project's safety engineer.

Operational safety

C1 Operation, 15–16 February 2012

The inspection of plant operation focused on the periodic testing performed by the Operations Office, the reactions of the main control room operators to alarms during annual outages, and the HR planning of the operating engineering department. The plant rounds were targeted at the fire fighting pump stations. No significant needs for development were detected in the inspection. Based on the inspection, STUK issued requirements related to the periodic test result acceptance procedures and minor update needs found in the periodic testing procedures.

C2 Plant maintenance, 30–31 August 2012

The plant maintenance inspection continued the investigation of the increasing failure trends observed at the plant in 2011. The trend for failures that caused an immediate operating restriction has been stable until 2011, but has then started to increase. The power plant has revised the preventive maintenance programmes of its components within a development project carried out at STUK's request. However, the diesel motors planned to be replaced have not been included in the project, for which STUK expects to receive justification. The extended inspections during annual outages did not reveal new problems. STUK required that annual reporting of equipment responsibilities be developed so that the causes of fault messages and operating restrictions are classified according to whether an actual fault exists or whether the unavailability is a result of a planned preventive maintenance measure. STUK has also required better prediction and traceability of various fault types in the ageing management programme. TVO's technical procedures in the procurement of important components and services were also reviewed. STUK found no cause for remarks in these.

C3 Electrical and I&C systems / electricity, 13–14 March 2012

The inspection of electrical engineering was targeted at the HR planning in the electrical engineering office, electro-technical servicing of spare parts, evaluation and approval of suppliers of electrical components, and ageing monitoring and management of electrical devices and cables. No significant needs for development were detected in the inspection. Based on the inspection, STUK issued requirements related to the fault history of the gas turbine plant, intermediate assessment of suppliers of electro-technical equipment, and minor update needs in the annual electrical equipment ageing report.

C3 Electrical and I&C systems / I&C, 13–14 March 2012

In the I&C section of the electrical and I&C system inspection, STUK evaluated the maintenance of measuring accuracy, the I&C design and implementation process, qualification monitoring, ageing management, the HR management in the I&C office, and participation in processes and operations. Needs for development were found in the I&C modification planning and implementation process, and in the scope of qualification management.

C4 Mechanical engineering, 28–29 February 2012

The mechanical engineering inspection was targeted at the operation, maintenance and ageing management of Olkiluoto 1 and Olkiluoto 2 isolation and safety valves and lifting equipment. The adequate allocation of personnel resources and competencies was also verified. During the inspection, a systematic procedure to identify the most typical failure mechanisms of valves and to learn from this information for ageing management purposes could not be found. The maintenance interval of some valves is unnecessarily long, and the early stages of a failure may therefore be left unobserved. STUK found that there was scope for improvement in the division of responsibility for the work carried out for lifting devices, as well as in the use of operating experience and fault histories in the definition of maintenance programmes. The power company must also clarify the responsibilities for safety classified lifting aids used to fix loads, and establish a clear periodic inspection practice.

C5 Structures and buildings, 5–6 September 2012

The construction engineering inspection at the Olkiluoto power plant comprised a review of the maintenance procedures of the spent fuel storage and processing pools, condensation pools, fuel racks and pipe supports. The inspection also included interviews and a review of procedures and reports related to the organisation of the power company, periodic inspections carried out by the power company, surveys, repairs, modifications, maintenance operations, operating experience feedback and ageing management. The execution and results of the power company's own inspections were also verified. STUK required that the responsibility for the containment condenser pools be defined in more detail, that the pool inspection procedure be updated and that an account be given of the execution of periodic inspections of the fuel pools.

C6 Information management and security, 31 May–1 June 2012, 9–10 October 2012

The information security inspection at Olkiluoto was carried out in two parts in 2012. The first part, carried out at the turn of May to June, focused on the technical information security solutions of the existing plant units. The second part, carried out in October, focused on the organisation of information security, competence development, and administration. Inspections identified a need for development on continuity management, network security and related documentation.

C7 Chemistry, 21–22 November 2012

The chemistry inspection mainly focused on the personnel changes in the chemistry and radiochemistry organisation, HR planning and communications, the impact of chemical conditions on ageing management, possible deviations from chemistry target values, and the quality management of technical laboratory operations. The inspection also included a visit to the laboratories and the spent fuel storage. Based on the inspection, STUK required that conflicting information be removed from the procedures that concern the reporting of restrictions in measurements subject to the operational limits and conditions (OLC) and the launch of further corrective measures. TVO must also develop procedures to more efficiently ensure compliance with the maximum impurity levels specified in the procedures. TVO must possess proper procedures to ensure the effectiveness of the corrective measure in case of a situation where the values are exceeded. The production of an uncertainty budget for all gamma detectors was also required.

C8 Annual outage, 28 April–5 June 2012

The annual outages for Olkiluoto 1 and Olkiluoto 2 took place from 24 April to 6 June 2012. During the annual outages, STUK carried out an inspection to verify TVO's procedures in 13 areas. The inspection was targeted at hot work locations, shoe boundaries, fuel transfers, security arrangements, maintenance procedures and the training of employees, among other things. TVO›s operations in these areas were for the most part appropriate, and there was little cause for remarks. The requirements that STUK issues based on the inspection mainly concerned the further specification of procedures.

Personal and plant protection

D1 Radiation protection, 20–21 March 2012

The radiation protection inspection was mainly targeted at dosimetry. The inspection also dealt with the training of employees involved in radiation protection operations. The radiation protection procedures of the Olkiluoto nuclear power plant have been developed in recent years to cover practically all measures associated with radiation protection. The spare part situation of the fixed radiation measurement equipment installed in the spent nuclear fuel storage must be improved. STUK required that TVO deliver a conceptual design plan of the corrective measures for approval. TVO must also produce a detailed summary of how radiation exposure is to be determined in various exceptional conditions. Such conditions may involve the long-term loss of power supply to dose monitoring devices, or the contamination of the facilities and equipment that are used for dose monitoring.

D2 Fire protection, 23 August 2012

The fire protection inspection focused on structural fire protection, fire detection and extinguishing systems, and operative fire protection. The main emphasis was on the organisation and HR planning, as well as deviations and their processing. The plant visit carried out in connection with the inspection included fire water pump stations, the control room and relay rooms of Olkiluoto 1, the cable space below the relay rooms, and the workshop above the control room of Olkiluoto 1. During the inspection, STUK found that there is no certainty of the regulatory compliance of the cable penetration type (gypsum board, rock wool, gunning) between the relay rooms and the cable spaces. STUK required an account of whether the penetrations meet the one-hour fire compartmentalisation requirement. In its response dated on 25 September 2012, TVO stated that according to its interpretation, the penetration meets the requirement. TVO has, however, initiated a project to replace the penetrations of this type. It was also stated during the inspection that there are deficiencies in the recording and monitoring of the observations made in fire inspections carried out by TVO or a third party. Records are kept using many methods for which no instructions exist. STUK required that the power company produce a unified recording and monitoring method together with instructions. Of fire technical modifications, targets such as the operability of fire water pumps and system as well as the observed leaks were inspected. No preventive maintenance is carried out for fire water pumping station valves, and the oldest valves are from 1975. TVO has established a valve replacement project that is to be completed in 2013.

D3 Emergency response, 5–6 June 2012

In the Olkiluoto emergency response inspection, STUK reviewed the updating procedure of the emergency response plan, resources of the operations, and the necessary information transfer. Based on the inspection, STUK required that TVO manage better the updating of procedures included in the emergency response plan and their timely delivery to STUK to make sure that both parties use the same procedures. STUK required that TVO add the necessary personnel to ensure adequate resources for the emergency response planning, organisation and training operations. TVO must also ensure that the technical personnel who carry out repairs are included in the emergency response organisation and participate in the necessary training, including alarm drills.

D4 Security, 8 October 2012

STUK inspected the Olkiluoto nuclear power plant's security arrangements, which are deemed to include structural, technical, operational and organisational arrangements for detecting, delaying and preventing illegal activities in the nuclear power plant. The inspection included verification of security arrangement development measures, which TVO has carried out based on an extensive assessment of security arrangements carried out by a third party evaluation team in 2010. The operative response of the licensee's security organisation and the related details were also assessed during the inspection. In 2012, TVO increased the number of drug and alcohol tests carried out by the security personnel, and implemented structural improvements to security arrangements.

Nuclear waste and its storage

E1 Operating waste, 15–16 October 2012

The operating waste inspection included a review of the targets for development in waste management, status and schedules of projects, exemption of operating waste from monitoring, HR planning and communications. No significant deficiencies or needs for development were detected in the review.

E2 Final disposal facilities, 10–11 October 2012

The inspection of the final disposal facilities was targeted at the organisation, communications and procedures of the Olkiluoto power plant's operating waste repository (VLJ repository), as well as the inspections carried out in the repository by TVO, the status of ongoing research, and the maintenance procedures of the VLJ repository's concrete and rock structures. An inspection visit to the VLJ repository was also included. No deficiencies were detected in the inspection. STUK recorded suggestions for developing the content of the VLJ repository's monitoring research reports.

Special items

F1 Inspection with no advance notification / plant operation, 27 March 2012

During the period under review, STUK carried out one inspection without prior notification to verify operating procedures. STUK found that the procedures concerning shift changes, the on-call system and monitored work were in compliance with the regulations and written procedures. Major needs for development were not found. The requirements issued in connection with the inspection applied to cleanliness, proper marking practices and archiving procedures.

B2 Additional inspection / the procurement and monitoring of nuclear fuel, 11 December 2012

STUK performed an additional inspection of the power company's nuclear fuel procurement and monitoring processes, as well as the procedures and resources. Based on the inspection, STUK stated that TVO's fuel procurement and monitoring practices are functional and fulfil the requirements. Operations are systematic and they are based on appropriate procedures, and the responsibilities have been clearly defined. Monitoring of the behaviour of the fuel is systematic, and produces valuable operating experience information. International operating experience feedback is also widely utilised. No deficiencies were observed in the resources and induction training. Based on the inspection, STUK required that minor updates be made to the procedures.

APPENDIX 6 Periodic inspection programme during the construction of Olkiluoto 3, 2012

The objective of the Olkiluoto 3 construction-time inspection programme is to verify that the operations required by the construction of the plant ensure a high quality implementation according to the approved plans and are compliant with official regulations, without endangering the plant units already operational within the plant site. The inspection programme assesses and oversees the licensee's operations in building the plant unit, implementation procedures in various technical areas, the licensee's expertise and use of that expertise, the handling of safety issues and the quality management and control. The Olkiluoto 3 inspection programme was launched in 2005 when the construction of the plant began, and the milestone of one hundred inspections was reached in autumn 2012. The annual number of inspections has varied between 10 and 15.

In 2012, 14 inspections included in the periodic inspection programme during construction were carried out, four of which were targeted at the main operations of the Olkiluoto 3 project, and ten at practical work processes (Table 1). Areas of focus included the quality management of the Olkiluoto 3 project, monitoring and inspections in various technical fields carried out by TVO and the plant supplier, commissioning procedures and TVO's commissioning inspection procedures, and, at the end of the Olkiluoto 3 project, TVO's operating organisation's preparations for the long-term operation of the plant. The following is a brief description of inspection findings for which STUK required improvements from TVO. On the whole, the inspections have led to the conclusion that the procedures, practical operations and resources of TVO's organisation are adequate.

Table 1. Period inspections during construction in 2012.

Subject of inspection	Time of inspection
Main functions	
Inspection of the nuclear island's readiness for commissioning	7–9 February 2012
EDG investigation	14–15 May 2012
Project management and the management of safety	29–30 May 2012
Personnel and resources (combined A2 – reported as periodic inspection during operation)	5–7 September 2012
Quality management	1–2 November 2012
Work processes	
Additional quality management review: Areva's on-site quality management	18 January 2012
Commissioning: training of operators and preparations for operation	7–8 March 2012
TVO's mechanical equipment commissioning procedures	11 April 2012
Radiation safety	11–12 April 2012
I&C	25–26 April 2012
Commissioning inspection procedures for structures, buildings and fire protection	31 August 2012
Equipment installation control process, electrical systems	4–5 October 2012
Processing of deterministic safety analyses at TVO	17 October 2012
Installation inspections and pressure tests of mechanical equipment and pipes	27–28 November 2012
Utilisation of PRA	4 December 2012

Additional quality management review: Areva's on-site quality management

In the management system review in 2011, STUK stated that the plant supplier did not have on-site lead auditors required for the auditing of quality management systems, which meant that the plant supplier had not been able to audit the contractors working at the plant site after summer 2011. In January 2012, STUK carried out an inspection of the plant supplier's on-site project organisation with no prior notice with the purpose of identifying the plant supplier's quality management organisation's resources and tasks, as well as the situation and plans of supplier auditors. As a result of the inspection, it was stated that the plant supplier was in the process of building stronger quality management resources for the particular purpose of carrying out supplier audits in early 2012. STUK required that TVO ensures that the plant supplier's plans to increase resources are realised and that the 2012 auditing programme is finalised. The plant supplier and TVO finalised the auditing programme during January, and launched the audits of the organisations active at the plant site accordingly. AREVA has increased its supplier audit personnel resources.

Inspection of the nuclear island's readiness for commissioning

In the inspection of the nuclear island's readiness for commissioning, STUK evaluated the readiness of TVO and the plant supplier to begin pre-operational test runs at the nuclear island. As a result of the inspection, STUK stated that the parties have adequate organisational resources to begin pre-operational tests. STUK issued some detailed requirements concerning the commissioning procedures and reporting, but these did not prevent the beginning of pre-operational testing.

Commissioning: training of operators and preparations for operation

STUK continued commissioning inspections by inspecting TVO's procedures related to operator training and preparations for the operating phase. Based on the inspection, TVO's production preparation sub-project (TUVA) is not working according to its task definitions included in the sub-project plan. STUK required that TVO evaluate the functioning of the TUVA sub-project and make sure that the monitoring, control and coordination tasks set for the sub-project are carried out as documented. TVO must also assess the practical Olkiluoto 3 operator training process planned and executed by the plant supplier to ensure that the training complies with the plans. TVO must also prepare a plan for how TVO will approve the plant simulator for operator training.

TVO's mechanical equipment commissioning procedures

The inspection concerning the commissioning organisation of mechanical equipment evaluated TVO's readiness to start inspections. Commissioning inspections are carried out by STUK or an inspection institution authorised by it, but before the inspection by authority, TVO must ensure that the target complies with the requirements and is ready to be inspected, and present the target to STUK at the inspection. At the inspection, ten detailed requirements concerning the inspection process were issued, but the licensee's overall preparations for the launch of commissioning inspections were considered adequate.

Radiation safety

The radiation safety inspection focused on commissioning and test operation issues. STUK required that TVO prepare a technical description of portable radiation measurement equipment. TVO must also prepare a plan for the training and task-specific induction of the temporary radiation protection personnel needed during commissioning. In addition, TVO needs to identify the additions into the radiation protection manual required due to the commissioning of Olkiluoto 3.

I&C

In the I&C inspection, STUK surveyed the I&C installation supervision practices, arrangements in the temporary control rooms, monitoring of open issues, and TVO's audits that concern the I&C supplier and subcontractors. STUK found no cause for remarks in TVO's installation supervision of the first I&C cubicles of the nuclear island. The arrangements in temporary control rooms were also appropriate. However, STUK required that TVO define the procedures for the estimation of deadlines for open issues presented by the plant supplier. The procedures must take into account the open issue's potential impact on nuclear and radiation safety, and on the performance of official inspections. The inspection revealed that TVO had not performed sufficient audits of safety class 2 I&C device suppliers despite the fact that the suppliers have been known. STUK issued a requirement concerning the matter, and required that audits be performed in time so that they can be used as a basis for controlling the device supplier's operations when necessary.

EDG investigation

In 2011, STUK investigated the procurement of emergency diesel generators and their auxiliary systems and equipment. The investigation team issued a report with observations and recommendations, on the basis of which STUK required that TVO produces a plan of the necessary measures. STUK assessed the adequacy of the completed measures in an inspection. At the inspection, it was observed that TVO had carried out measures based on the investigation, but the results of the investigation had not been efficiently utilised in the development of the project's processes and procedures. STUK required that TVO produces a new assessment of the matter.

Project management and the management of safety

The project and safety management inspection was comprised of individual interviews on the management's procedures to lead the organisation in a safety-oriented manner. The inspection targets included the project management's measures to assess and utilise the investigation results concerning Olkiluoto 3 emergency diesel generators. Based on the inspection, STUK required that TVO produces a deeper analysis of significant deviations to prevent the reoccurrence of similar events, and communicates and discusses interdisciplinary safety-related matters more extensively within the project organisation. TVO must also investigate how to make the processing of functional deviations within the Olkiluoto 3 project more efficient.

Commissioning inspection procedures for structures, buildings and fire protection

The inspection aimed to assess TVO's ability to perform the commissioning inspections of the structures, buildings and fire protection systems of the Olkiluoto 3 plant unit. Based on the inspection, TVO needs to investigate which fire protection arrangements required by YVL guides are to be inspected at the building's commissioning inspection, and which after the commissioning inspection. The approval procedures for potential changes to be made after the commissioning inspections must also be defined. TVO must audit the plant supplier's construction engineering and fire protection commissioning inspection methods to assess their appropriateness.

Personnel and resources

The project's personnel and resource inspection focused on TVO's measures to operate the Olkiluoto 3 plant unit using an operating organisation shared by all plant units. The inspection covered the Olkiluoto 1 and 2 plant units currently in operation, and the Olkiluoto 3 unit under construction. No requirements concerning Olkiluoto 3 were issued at the inspection. Inspection findings have been discussed in detail in Appendix 5.

Equipment installation control process, electrical systems

The inspection was targeted at the licensee's procedures and measures to ensure the compliance of the electrical systems with the requirements at the system installation stage. The inspection focused on TVO's installation inspection procedures, the management of modifications during installations and commissioning, and the modifications required by the update of the plant's cabling concept. Based on the inspection, STUK issued four requirements to TVO. A description of the licensee's installation inspection process must be delivered to STUK, including the inspection procedure for post-installation modifications as well as a description of the site modification handling process. The approved cabling concept has not been fully observed in the installation of cable trays, and some cable trays have been installed too close to pipes. TVO must ensure that the distance requirements are complied with. In addition, TVO must ensure the adequate scope of the processing of cabling division separation structures within the TVO organisation to ensure that the various threats receive the proper attention.

Processing of deterministic safety analyses at TVO

The inspection was targeted at the processing of deterministic transient and accident analyses as well as emission and radiation dose analyses at TVO. TVO's procedures and personnel resources within the inspected area were verified. As a result, it was stated that TVO has evaluated the initial analysis data and ordered comparative analyses to confirm the analysis results. TVO has also assessed the impact of plant design modifications on the analyses. No requirements were imposed following the inspections.

Quality management

The quality management inspection included a review of the management system's functionality and scope assessment produced by TVO as well as the utilisation of the assessment, TVO's and the plant supplier's supplier auditor operations, and the procedures that TVO uses to review design materials. The inspection also included a section for which no prior notice had been given. This section concerned AREVA's resources to supervise pipe installations and welding. STUK found AREVA's supervisory resources to be very limited. According to STUK's opinion, the operations did not comply with the welding supervision plan delivered to STUK in 2011, and STUK required that an account of the matter be produced. In the same connection, STUK required that AREVA produce a plan of the supervision and inspections of the replacement of formed parts of small bore pipes being started at the time. Concerning the assessment report of the management system's conformity, performance and effectiveness, it was stated that the scope of the report is limited in places despite STUK's earlier requirements to supplement the report. TVO must analyse the report in more detail and define measures with schedules and responsible parties to ensure proper supervision. Concerning the reviewing of documents, STUK had stated in the construction-time quality management inspection carried out at the end of 2011 that TVO had knowingly delivered to STUK materials with deficiencies that prevented STUK from granting them official approval. At the time, STUK required that the materials' compliance with requirements be clearly stated in the covering letters and materials delivered to STUK, and that incomplete materials must not be delivered to STUK for review. As TVO has not changed its procedures, STUK repeated the requirements.

Installation inspections and pressure tests of mechanical equipment and pipes

The construction-time inspection of the installation inspections and pressure tests of mechanical equipment and pipes was targeted at TVO's measures, supervision and control in the area in question. The inspection particularly focused on the confirmation of the equipment and pipes' compliance with requirements, TVO's personnel resources available for the work, welding supervision procedures, tracking of open issues, and the processing of changes to work plans. Based on the inspection, it was stated that during the construction inspection of pipes, TVO does not systematically present the quality assurance materials for the valves installed to the pipes. STUK required that, in future, the quality assurance materials must be presented to be reviewed by STUK or an inspection organisation approved by STUK. An account of these inspection procedures must be delivered to STUK for information. TVO must also produce an account of how non-standard piping supports are taken into account in construction inspections, and of the replacement of missing piping components with dummies at pressure testing.

Utilisation of PRA

The inspection of PRA utilisation was targeted at the status of the probabilistic risk analyses that were being prepared, TVO's methods to ensure the correctness of the analyses, and TVO's and the plant supplier's personnel resources for the production and review of the analyses. Current issues processed at the inspection also included how the plant supplier and TVO intend to assess the overall reliability of the I&C systems or utilise PRA for the changes to be made into the design of the Olkiluoto 3 plant unit. As a result of the inspection, STUK stated that TVO has the proper procedures in place to review PRA and its reference materials and to document the work, and no requirements for improvements were issued to TVO.

APPENDIX 7 Inspection programme during the construction phase of Onkalo in 2012

The objective of the construction-time inspection programme is to verify that high-quality implementation of approved plans is ensured in the construction of the underground research facility, with compliance with official regulations and without jeopardizing safe final disposal. The inspection programme includes assessment and monitoring of Posiva's operations in building Onkalo, the procedures applied to various parts of the construction work, the management of Onkalo research and monitoring, the management of safety and the quality assurance of the implementation. STUK prepares annual plans for Onkalo inspections.

Subject of inspection		Time of inspection
Management system		
ONP-A1	Johtamisjärjestelmä	–
Planning and management		
ONP-B1	Project management and control	20–21 September 2012
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	6–7 June 2012
ONP-C3	Foreign substances	20–21 December 2012
ONP-C4	Excavation and EDZ	–
ONP-C5	Onkalo in-flows	28–29 November 2012
ONP-C6	Monitoring and research methods	–

"–" means that the inpection was not carried out in 2012, as planned in ONP programme

APPENDIX 8 Assignments funded by STUK in 2012

Safety of nuclear power plants

The subjects of assignments presented in the 2012 plan for technical support assignments were mainly 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 2012 were postponed to 2013.

Of the assignment proposals for 2012, 33 were related to the project of overseeing the construction of Olkiluoto 3 (FIN5/OL3), six to the existing Olkiluoto plant units, nine to Loviisa plant units and two to new NPP projects. The most significant framework agreements related to overseeing the construction of Olkiluoto 3 in 2012 were:

- FIN5/OL3, Oversight and inspection of the manufacture of pipeline prefabricates of safety classes 1 and 2 (Quality Factory Oy, EUR 260,700)
- FIN5/OL3, Strength analyses of nuclear pressure vessels (VTT, EUR 49,500)
- FIN5/OL3, Strength analyses of construction plans (Inspecta Nuclear AB, EUR 120,000)

Safety of nuclear waste disposal

In 2012, the technical support programme for the oversight of nuclear waste management (VATU) included assignments to oversee the construction of the underground research facility (Onkalo) as well as assignments related to the preliminary review of the construction licence for the final disposal facility. In 2012, the total cost for the VATU assignments amounted to EUR 165,000. The assignments included:

- Third party specialist consultation concerning the Onkalo excavation and rock construction.
- Spent fuel safety analyses concerning the sorption properties of the bedrock and the migration of radionuclides.
- An overview of the microbe models being used by Posiva.
- The ”Prospects for coupled modelling of the buffer and backfill” presentation in an international buffer material convention in Montpellier.
- Production of an analysis tool for the impact matrix needed in the evaluation of scenarios, with the purpose of identifying key factors.
- Comparison of the Olkiluoto and Forsmark (Sweden) plant sites and the related presentation in the autumn convention of the American Geophysical Union in San Francisco in December 2012.
- Possibilities for site-scale hydrogeological modelling – a state-of-the-art overview.
- Evaluation of Posiva's rock mechanical background reports.
- Final reporting of the “Replaceability of bentonite” and ”The potential of coupled models” projects.
- State-of-the-art overview of microbe activity in the buffer and backfill.
- Safety analysis consultation including uncertainty management training directed at STUK's inspectors.

APPENDIX 9 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
Incident Reporting System; nuclear power plant operating experience reporting system maintained by the IAEA and 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
OECD Nuclear Energy Association

OLC
Operational Limits and Conditions (previously Technical Specifications)

Onkalo
underground research facility for the final disposal of spent nuclear fuel

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

STUK-YVL Guides
Working title for the new restructured regulatory guides on nuclear safety during the renewing process in 2006–2009

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. There's a large restructuring project going on, the new YVL Guides should replace old ones by the end of 2012. The last old style YVL Guides with number-only id's were issued in 2008.