

Regulatory oversight of nuclear safety in Finland

Annual report 2012

Erja Kainulainen (ed.)

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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

MANAGEMENT REVIEW	3
INTRODUCTION	5
1 FUNDAMENTALS OF NUCLEAR SAFETY REGULATION	11
2 OBJECTS OF REGULATION	20
Loviisa NPP	20
Olkiluoto NPP	20
Onkalo	21
FiR 1 research reactor	21
3 DEVELOPMENT OF REGULATIONS	22
4 REGULATORY OVERSIGHT OF NUCLEAR FACILITIES AND ITS RESULTS IN 2012	24
4.1 Loviisa nuclear power plant	24
4.1.1 Overall safety assessment of the Loviisa power plant	24
4.1.2 Plant operation, events during operation and prerequisites of safe operation	28
4.1.3 Ensuring plant safety functions	29
4.1.4 Integrity of structures and equipment	30
4.1.5 Development of the plant and its safety	32
4.1.6 Spent nuclear fuel storage and operating waste	34
4.1.7 Organisational operations and quality management	35
4.1.8 Fire safety	36
4.1.9 Operating experience feedback	36
4.1.10 Radiation safety of the plant, personnel and the environment	37
4.1.11 Emergency preparedness	40
4.2 Olkiluoto nuclear power plant units 1 and 2	41
4.2.1 Overall safety assessment of Olkiluoto 1 and Olkiluoto 2	41
4.2.2 Plant operation, events during operation and prerequisites of safe operation	42
4.2.3 Ensuring plant safety functions	45
4.2.4 Integrity of structures and equipment	46
4.2.5 Development of the plant and its safety	48
4.2.6 Spent nuclear fuel storage and operating waste	50
4.2.7 Organisational operations and quality management	52
4.2.8 Fire safety	53
4.2.9 Operating experience feedback	53
4.2.10 Radiation safety of the plant, personnel and the environment	54
4.2.11 Emergency preparedness	56

4.3	Regulatory oversight of the construction of Olkiluoto 3	58
4.3.1	Overall safety assessment of Olkiluoto 3	58
4.3.2	Design	59
4.3.3	Construction	62
4.3.4	Manufacturing of components and pipes	62
4.3.5	Installation work	63
4.3.6	Commissioning	64
4.3.7	Review of documents related to the operating licence application	65
4.3.8	Organisational operations and quality management	66
4.4	Preparation for new projects	68
4.5	Research reactor	69
5	REGULATORY OVERSIGHT OF THE SPENT NUCLEAR FUEL DISPOSAL PROJECT	70
5.1	Spent nuclear fuel disposal project	70
5.1.1	Posiva's organisational operations and quality management	71
5.1.2	Oversight of the construction of research facility (Onkalo oversight)	71
5.1.3	Overseeing the research, development and design work for further specification of the Safety Case	74
6	REGULATORY OVERSIGHT OF NUCLEAR NON-PROLIFERATION	75
6.1	The basis, subjects and methods of regulatory control of nuclear materials	75
6.2	Nuclear safeguards, activities and results in 2012	78
6.3	The Comprehensive Nuclear Test Ban Treaty	80
7	NUCLEAR SECURITY	82
8	SAFETY RESEARCH	86
9	OVERSIGHT OF NUCLEAR FACILITIES IN FIGURES	89
9.1	Review of documents	89
9.2	Inspections on site and at suppliers' premises	90
9.3	Finances and resources	90
10	DEVELOPMENT OF REGULATORY OVERSIGHT	93
10.1	STUK's own development projects	93
10.2	Renewal and human resources	93
11	EMERGENCY PREPAREDNESS	95
12	COMMUNICATION	96
13	INTERNATIONAL COOPERATION	98

APPENDIX 1	STUK'S SAFETY PERFORMANCE INDICATORS FOR NPPs IN 2012	103
APPENDIX 2	OCCUPATIONAL RADIATION DOSE DISTRIBUTION AT LOVIISA AND OLKILUOTO NUCLEAR POWER PLANTS IN 2012	142
APPENDIX 3	SIGNIFICANT OPERATIONAL EVENTS AT NPPs IN 2012	143
APPENDIX 4	LICENCES AND APPROVALS IN ACCORDANCE WITH THE NUCLEAR ENERGY ACT IN 2012	152
APPENDIX 5	PERIODIC INSPECTION PROGRAMME OF NPPs IN 2012	153
APPENDIX 6	PERIODIC INSPECTION PROGRAMME DURING CONSTRUCTION OF OLKILUOTO 3 IN 2012	164
APPENDIX 7	INSPECTION PROGRAMME DURING THE CONSTRUCTION PHASE OF ONKALO IN 2012	168
APPENDIX 8	ASSIGNMENTS FUNDED BY STUK IN 2012	169
APPENDIX 9	GLOSSARY AND ABBREVIATIONS	170

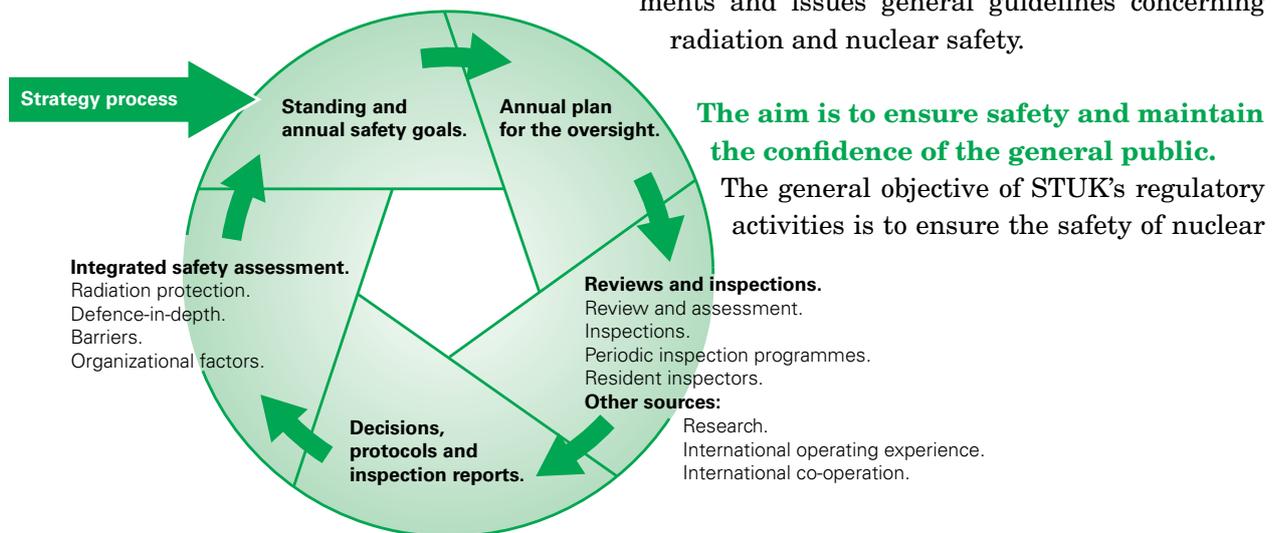
1 Fundamentals of nuclear safety regulation

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.



STUK functions for the oversight of nuclear power plants	
<p>Oversight of New Plant Projects and Plant Modifications Changes at the nuclear facility</p>	<p>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</p>
<p>Safety Assessments and Analysis Deterministic safety analysis Probabilistic risk analysis (PRA) Safety performance indicators; analysis and feedback</p>	
<p>Oversight of Operations Compliance with Technical Specifications Incidents Oversight of outage management Maintenance and ageing management Fire protection Radiation protection Emergency preparedness Physical protection</p>	<p>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</p>

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 ra-

diation 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 opera-

tions. 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 con-

trol 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 Feb 1977	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 Oct 1979	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.

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.

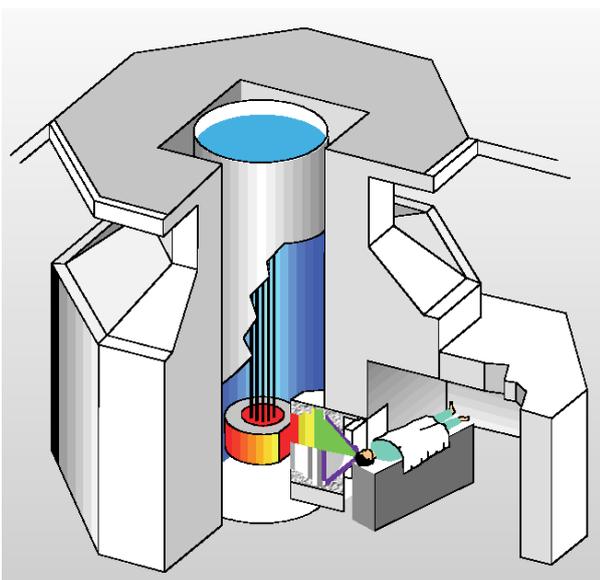


Figure 3. FiR 1 research reactor and the BNCT station.

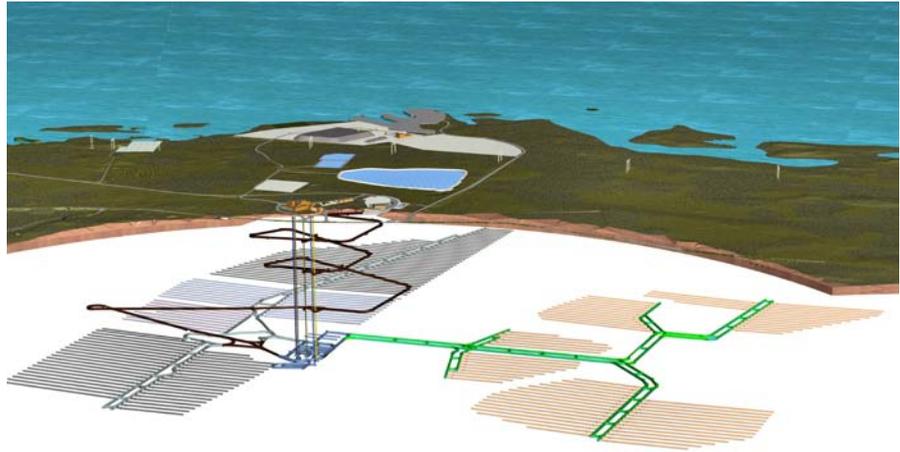


Figure 2. Diagram of the encapsulation and disposal facility in Olkiluoto (Posiva Oy).

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 assessments of the causes of the Fukushima Dai-ichi disaster and the lessons learned from it, as well as the new safety tar-

gets 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	
<p>A Safety management of a nuclear facility</p> <p>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</p>	<p>B Plant and system design</p> <p>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</p>
<p>C Radiation safety of a nuclear facility and environment</p> <p>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</p>	<p>D Nuclear materials and waste</p> <p>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</p>
<p>E Structures and equipment of a nuclear facility</p> <p>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</p>	<p>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</p>

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 operability 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

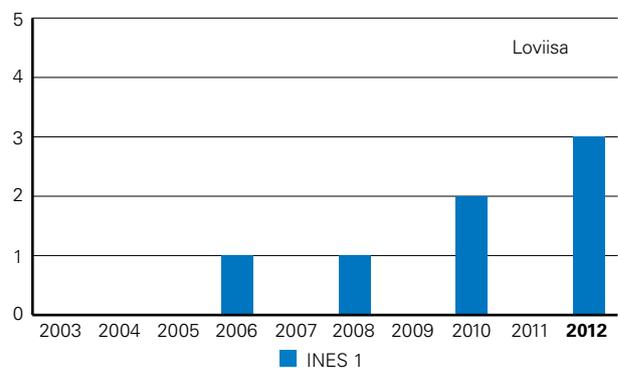


Figure 5. INES classified events at the Loviisa plant (INES Level 1 or higher).

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

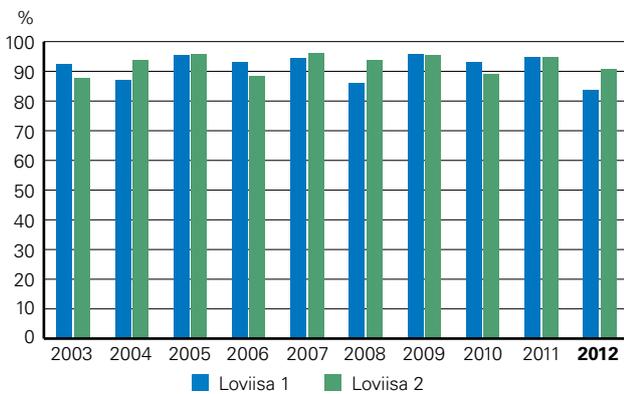


Figure 6. Load factors of the Loviisa plant units.

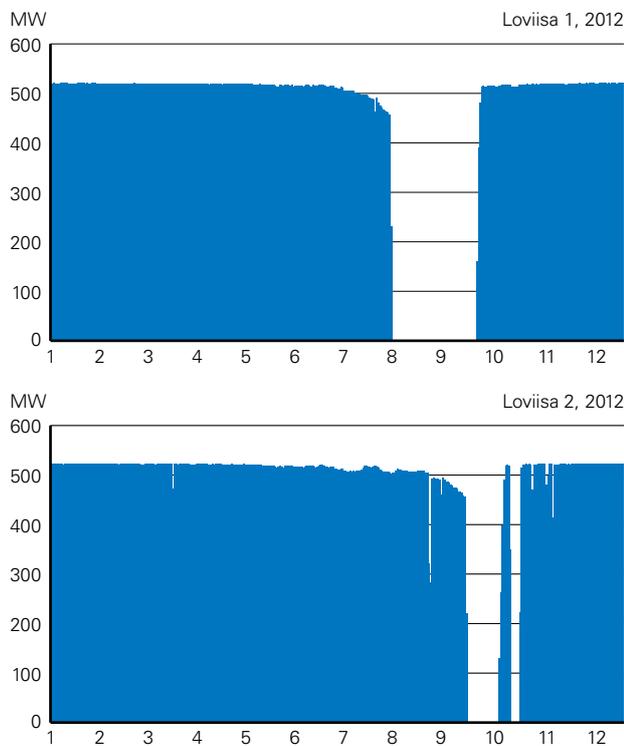


Figure 7. Daily average gross electrical power of the Loviisa plant in 2012.

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 ac-

ording 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 pres-

sure 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 execu-

tion 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 re-

quires 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 sub-

mitted 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 manage-

ment 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 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 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 occupa-

tional 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

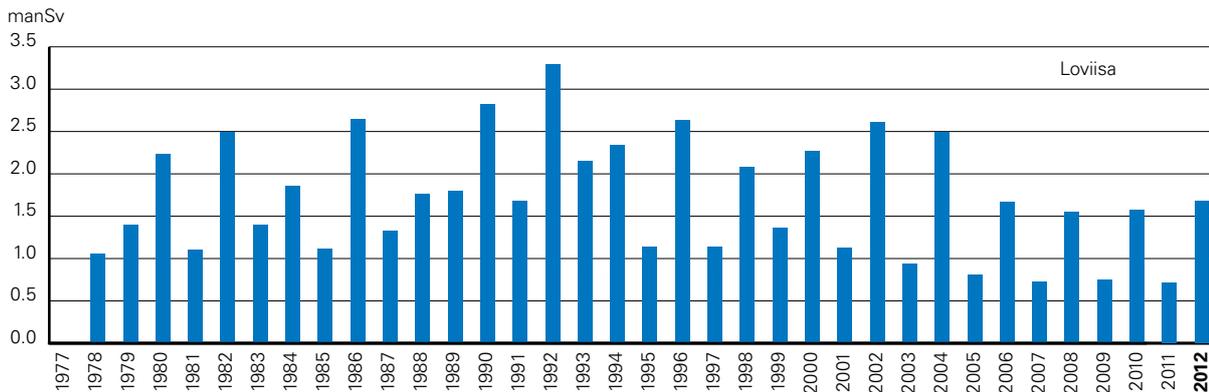


Figure 8. Collective occupational doses since the start of operation of the Loviisa nuclear power plant.

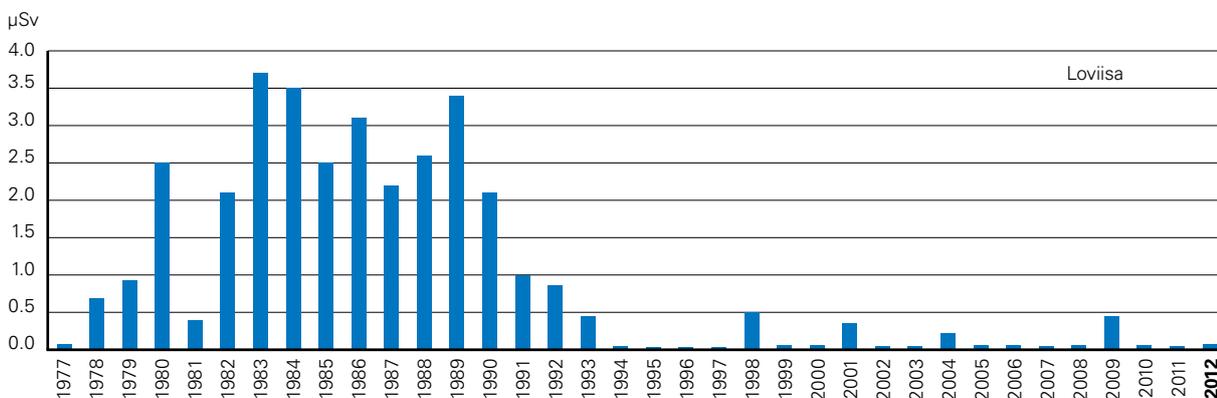


Figure 9. Annual radiation doses to the most exposed person of the public since the start of operation of the Loviisa nuclear power plant. Over the recent years, the doses calculated based on the radioactive discharges have remained below one percent of the set limit, 0.1 milliSv.

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
Periphyton	–	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 autho-

risied 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 μ Sv 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-

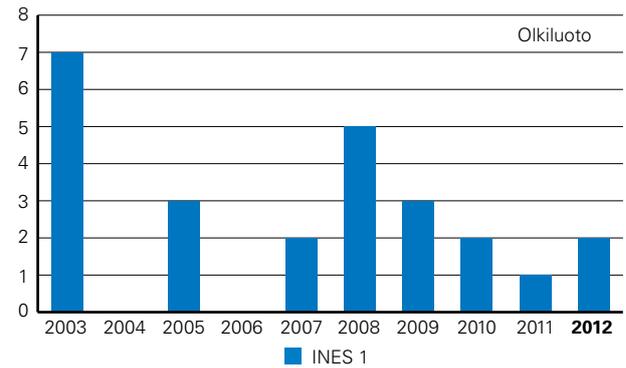


Figure 10. INES classified events at the Olkiluoto plant (INES Level 1 or higher).

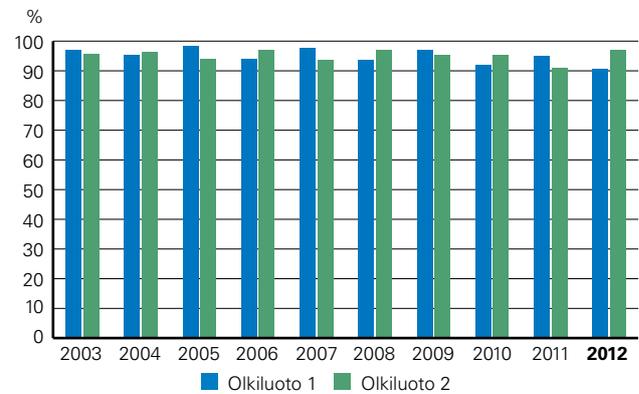


Figure 11. Load factors of the Olkiluoto plant units.

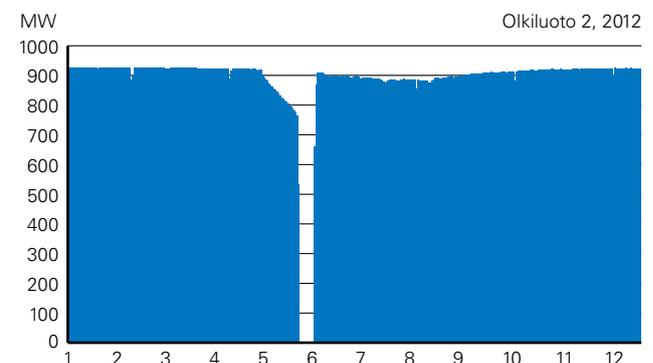
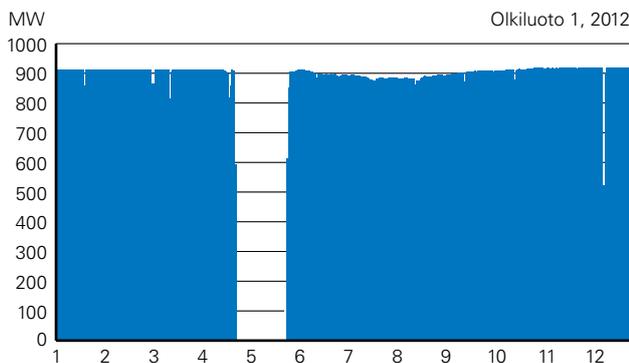


Figure 12. Daily average gross power of the Olkiluoto plant in 2012.

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.

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) car-

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.

ried 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

($1.33 \cdot 10^{-5}$ /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 de-

manding 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

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.

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.

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 uninterrupted 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 an 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

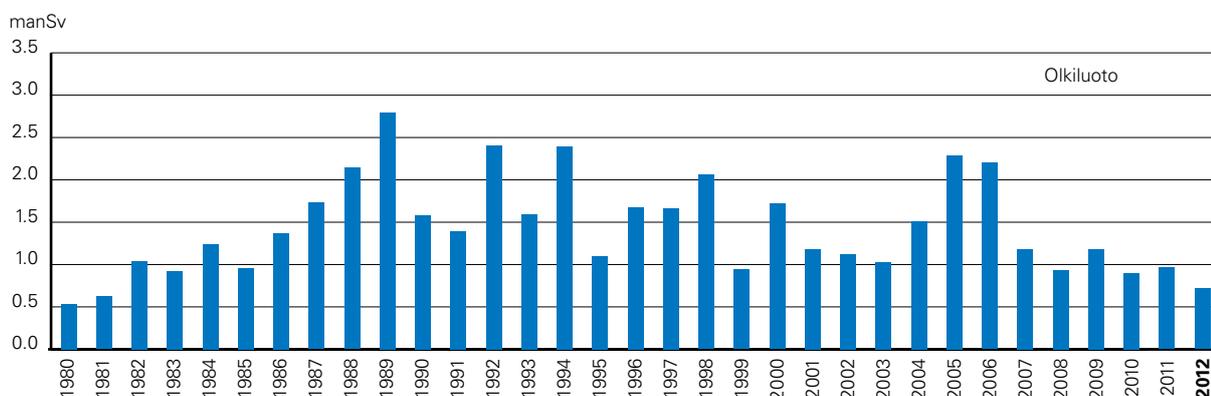


Figure 13. Collective occupational doses since the start of operation of the Olkiluoto units 1 and 2.

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-

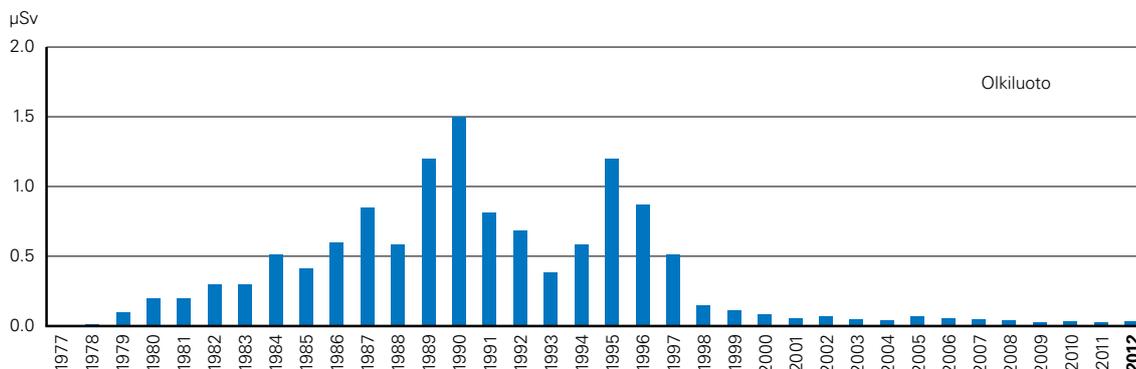


Figure 14. Annual radiation doses to the most exposed person of the public since the start of operation of the Olkiluoto units 1 and 2. Over the recent years, the doses calculated based on the radioactive discharges has remained below one percent of the set limit, 0.1 milliSv.

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
Periphyton	–	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

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.

from the nuclear power plant were observed in some of the analysed environmental samples. The amounts were so small that they are insignificant in terms of people's radiation exposure.

4.2.11 Emergency preparedness

STUK oversees the capability of the emergency 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 opera-

tion, 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 com-

pleted in 2012. In December 2012, TVO delivered to STUK an account of the acceptability of multi-layer 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 ad-

ditional 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 management 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 authori-

ties 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 re-

search 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,

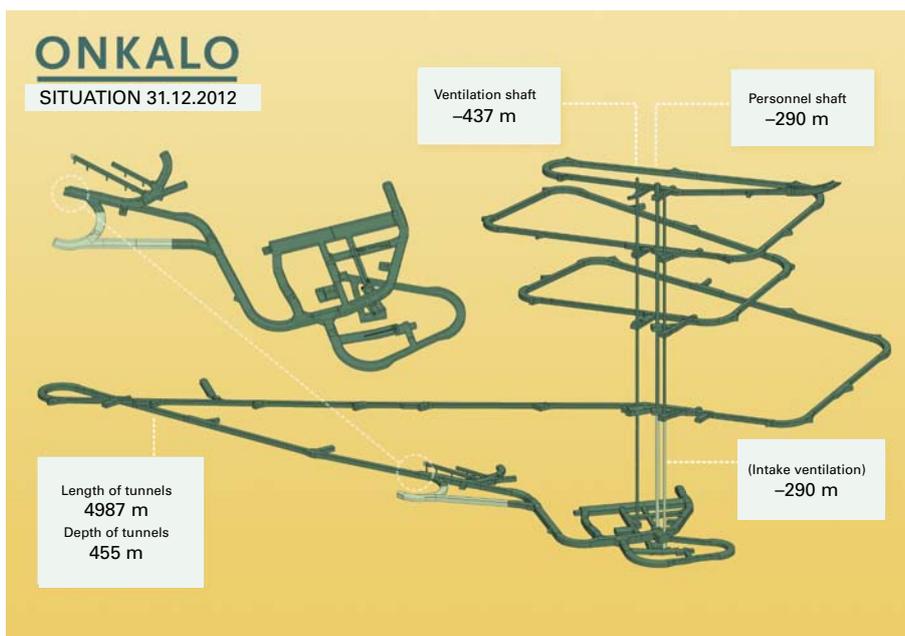


Figure 15. Status of the excavation of Onkalo in December 2012 (Posiva Oy).

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 mate-

rial 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 un-hurried 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

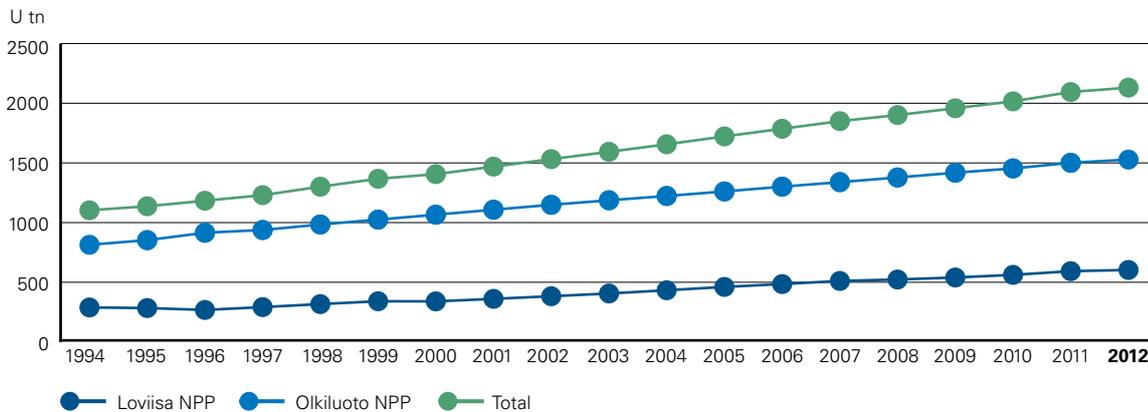


Figure 16. Uranium in nuclear fuel at the Finnish NPPs.

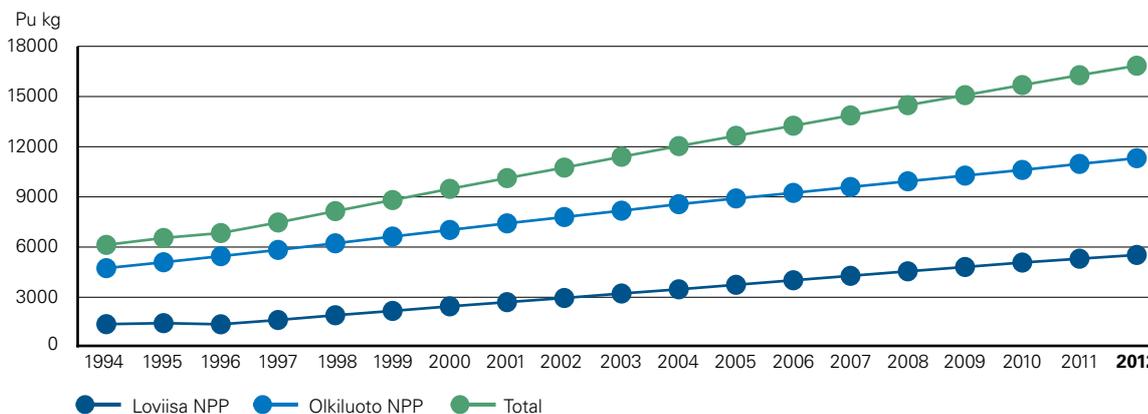


Figure 17. Plutonium in spent nuclear fuel at the Finnish NPPs.

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 facilities	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 declara-

tions 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 countries 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

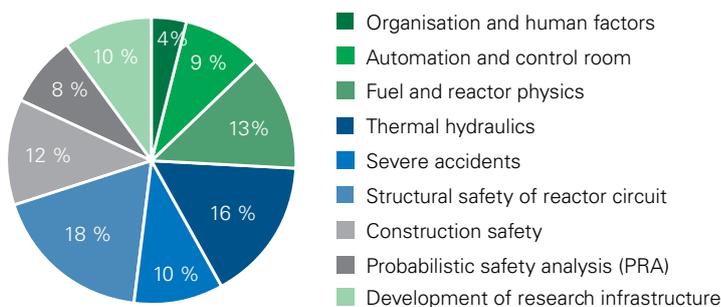


Figure 18. Research areas of SAFIR2014 programme and their shares of the total funding in 2012.

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.

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.

A total of 37 proposals for 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

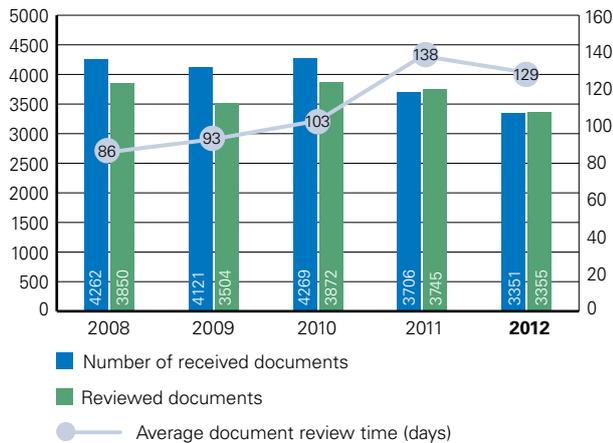


Figure 20. Number of documents received and reviewed as well as average document review time.

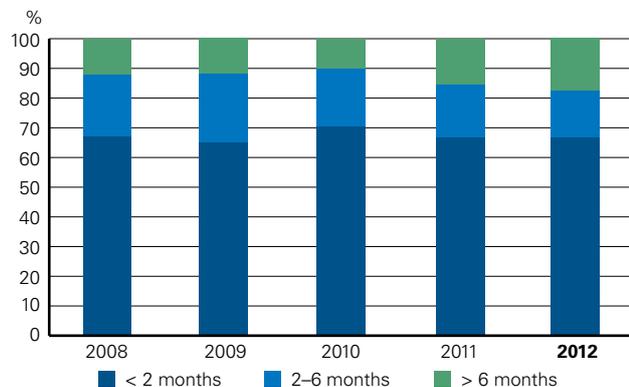


Figure 21. Distribution of time spent on preparing decisions on the Loviisa plant.

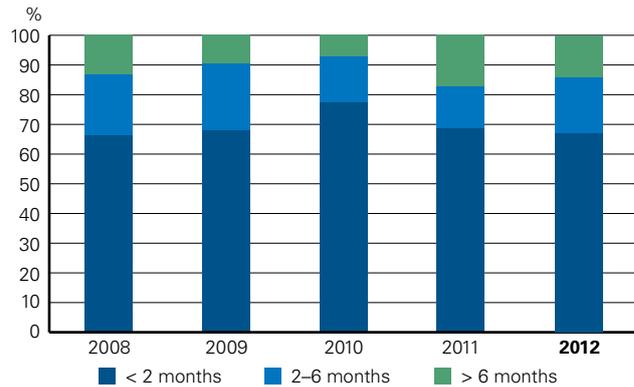


Figure 22. Distribution of time spent on preparing decisions on the operating plant units of Olkiluoto.

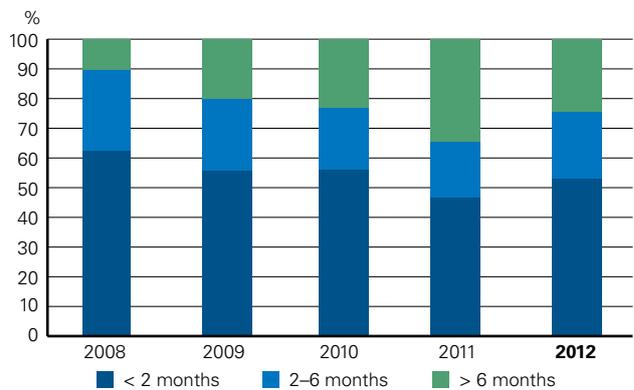


Figure 23. Distribution of time spent on preparing decisions on Olkiluoto plant unit 3.

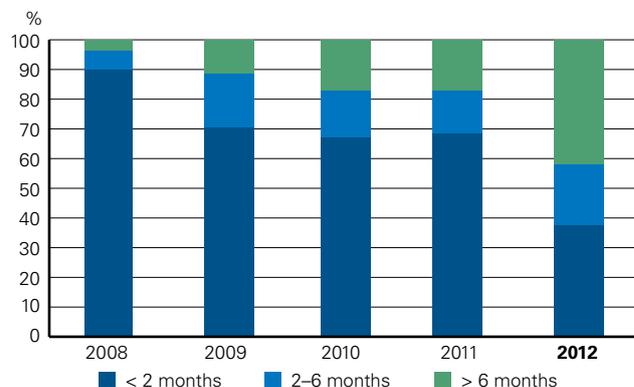


Figure 24. Distribution of time spent on preparing decisions on Posiva.

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 inspec-

tion. 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

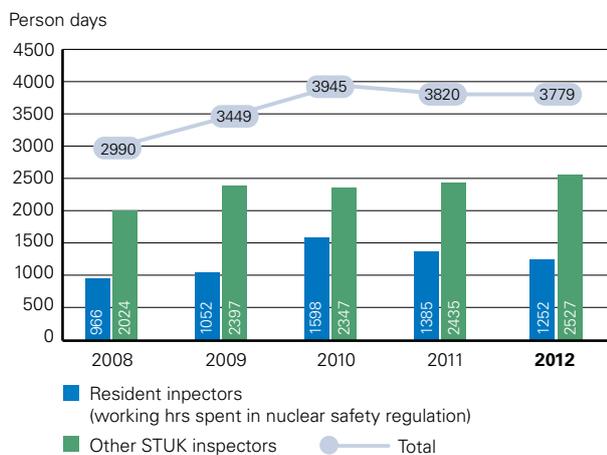


Figure 25. Number of inspection days onsite and at component manufacturers' premises.

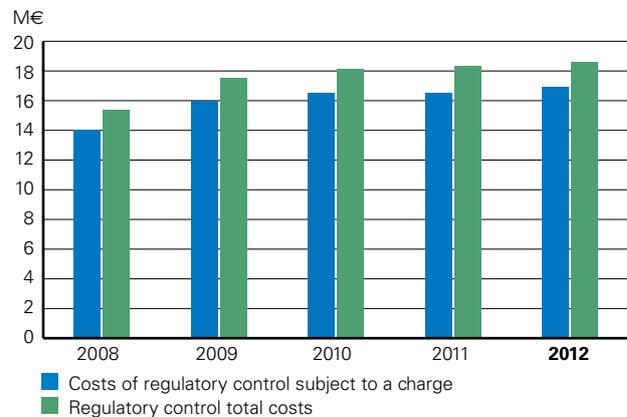


Figure 26. Income and costs of nuclear safety regulation.

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.

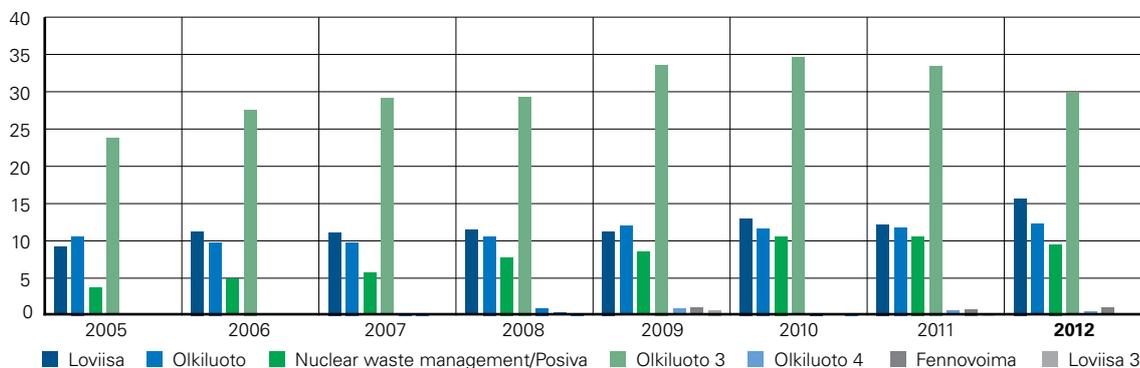


Figure 27. Distribution of working hours (person-years) of the regulatory personnel by subject of oversight in 2005–2012. Until 2011 the nuclear waste management includes both the oversight of the operating nuclear power plants' nuclear waste management as well as the oversight of Posiva, since 2012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

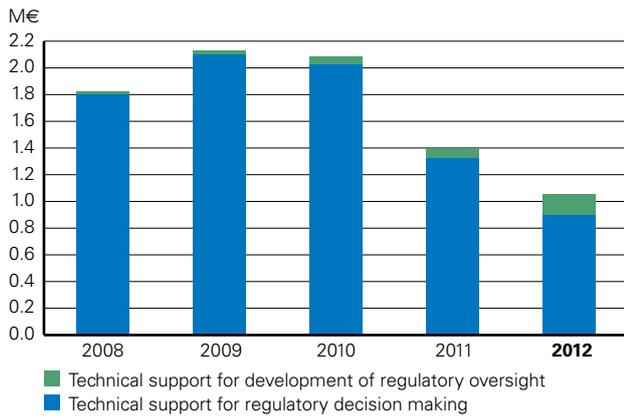


Figure 28. The costs of research and commissioned work pertaining to the safety of nuclear power plants.

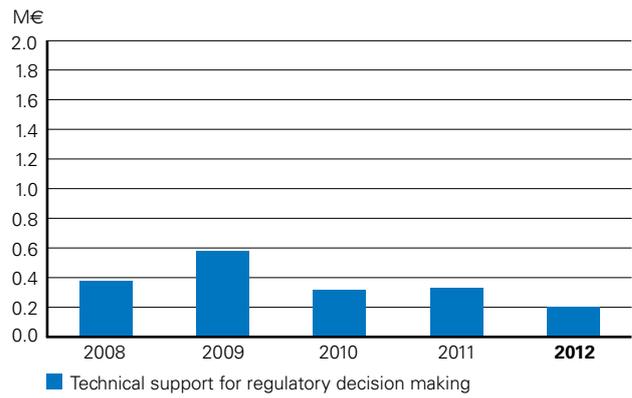


Figure 29. The costs of research and commissioned work pertaining to nuclear waste management and nuclear non-proliferation.

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 ac-

tivities. 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 prac-

tices 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 (NF-CIS)
- 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.