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REGULATORY CONTROL OF NUCLEAR SAFETY IN FINLAND

Annual report 2004

Kirsti Tossavainen (ed.)

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Abstract

This report covers regulatory control of nuclear safety in 2004. Its submission to the Ministry of Trade and Industry by the Radiation and Nuclear Safety Authority (STUK) is stipulated in section 121 of the Nuclear Energy Decree. Nuclear safety regulation focused on the design and operation of Finnish nuclear facilities as well as on nuclear waste management and nuclear materials.

No events endangering the safe use of nuclear safety occurred at the nuclear power plants. The doses of all nuclear power plant workers were below the individual dose limit. The collective occupational dose at the Olkiluoto plant units was low internationally. At Loviisa 1, the collective dose threshold per one gigawatt of net electrical power, calculated according to STUK's guidelines, was slightly exceeded. Radioactive releases were low and the dose calculated on their basis for the most exposed individual in the vicinity of Loviisa and Olkiluoto nuclear power plants was well below the limit established by Government Resolution.

The operating licence of the reactor pressure vessel of Loviisa 1 was extended in accordance with the licensee's application until the 2012 refuelling outage. The Loviisa plant units are undergoing extensive I&C upgrading the conceptual design plan of which STUK has reviewed.

STUK's safety performance indicators for nuclear power plants, which describe the effectiveness of STUK's activities, did not indicate changes that would have warranted STUK's immediate reaction.

STUK assessed the safety of the Olkiluoto 3 nuclear power plant unit when preparing its statement to the Ministry of Trade and Industry on the construction licence application of Teollisuuden Voima Oy. In addition to safety assessment, oversight focused on the manufacturing of the plant unit's main components and earth-moving work onsite. In addition, STUK assessed the activities of the licence applicant, vendor and subcontractors.

No events endangering safety occurred at the FiR 1 research reactor. The radiation doses of those working at the research reactor and radioactive releases into the environment were clearly below set limits as well.

No events endangering safety occurred in nuclear waste management. In the field of nuclear material safeguards, the use of nuclear materials in accordance with current regulations and the completeness and correctness of nuclear material accounting were verified.

STUK verified that nuclear liability in the event of nuclear damage has been taken care of according to legislation.

The total costs of nuclear safety regulation in 2004 were 10.2 M€. The total costs of operations subject to a charge were 9.2 M€, the full amount of which was charged to the licensees and licence-applicants.

Contents

1 Preface

The Radiation and Nuclear Safety Authority (STUK) regulates the use of nuclear energy in Finland, as prescribed in the Nuclear Energy Act (990/1987). STUK's responsibilities also include control of physical protection and emergency planning as well as control of the use of nuclear energy necessary to prevent nuclear proliferation. This is a report on regulatory control in the field of nuclear energy submitted by STUK to the Ministry of Trade and Industry as stipulated in section 121 of the Nuclear Energy Decree.

It covers the regulatory control of nuclear facilities, nuclear waste management and nuclear materials, which is the task of two STUK departments: Nuclear Reactor Regulation and Nuclear Waste and Materials Regulation.

Nuclear safety regulation mostly focused on the Loviisa 1 and 2 nuclear power plant units owned by Fortum Power and Heat Oy and the Olkiluoto 1 and 2 units owned by Teollisuuden Voima Oy as well as their nuclear waste management and nuclear materials. The Olkiluoto 3 plant unit of Teollisuuden Voima Oy, which is in the planning stages, was also subject to control. The planning and later implementation of the final disposal of nuclear fuel is taken care of by Posiva Oy. Subject to regulatory control were also the research reactor operated by the VTT Technical Research Centre of Finland, small-scale users of nuclear materials as well as the transport of radioactive materials.

Loviisa 1 began generating electricity to the national grid in 1977 and Loviisa 2 in 1981. Their operating licences were renewed in 1998 and will expire at the end of 2007. The Loviisa plant units are light-water PWRs. The highest allowable reactor nominal thermal power for each unit, according to a permit granted by the Government, is 1500 MW. The nominal values for electrical power 510 MW (gross) and 488 MW (net) correspond to this reactor power.

Olkiluoto 1 began generating electricity to the national grid in 1979 and Olkiluoto 2 in 1982. Olkiluoto 1 and 2 are light-water BWRs. The operating licences of the Olkiluoto 1 and 2 plant units were renewed in 1998. They will expire at the end of 2018 and cover also spent fuel intermediate storage as well as low and intermediate level reactor waste storage. According to the licences, the highest allowable reactor nominal thermal power for Olkiluoto 1 and 2 is 2500 MW. A corresponding nominal gross electrical power is 870 MW and net electrical power 840 MW. The licence conditions require that the licensee makes, by the end of 2008, an extensive intermediate safety assessment for the Olkiluoto nuclear power plant. Requirements for the contents of the assessment are set by STUK.

On 8 January 2004 Teollisuuden Voima Oy applied to the Government for a construction licence for Olkiluoto 3 in accordance with the Nuclear Energy Act. The licence was granted by the Government on 17 February 2005. The new plant unit is a light-water PWR with net electrical power of approx. 1600 MW and reactor thermal power of 4300 MW.

This report's section on nuclear reactor regulation describes the assessment of safety analyses for the Loviisa plant units and the operating units of the Olkiluoto plant; control of plant modifications, of availability of the plant units and of the operation of organisations. The implementation of new or revised YVL guides on operating nuclear power plants is described. The efficiency and effectiveness of nuclear safety regulation is analysed using STUK's Safety Performance Indicator System. The report's supplements include a detailed explanation of the Safety Performance Indicators (Appendix 1), of completed safety improvements (Appendix 2) and of significant operational events (Appendix 3). Radiation safety at the plants is analysed by looking at occupational and collective doses at the facilities as well as the outcome of monitoring for radiation in releases and the environment.

This report's section on Olkiluoto 3, which is in the design phase, discusses review of documents relating to the application for a construction licence, assessment of the operations of the licence applicant and vendor, and regulatory control of the manufacturing of main components.

The chapter on nuclear waste management deals with spent nuclear fuel intermediate storage, preparation for final disposal and treatment of low and intermediate level waste. The volumes of nuclear fuel as well as low and intermediate level waste stored onsite at the end of the year are given.

The chapter on nuclear non-proliferation describes nuclear material control at the Finnish nuclear facilities and plans for the safeguarding of final disposal of spent fuel as well as regulation of radioactive materials transport. Strengthening of nuclear material safeguards and implementation of the CTBT are included.

The report discusses the development of regulatory guides and nuclear safety regulation as well as functions in support of nuclear safety regulation such as safety research, emergency response, communications, and development projects. Participation in international co-operation in the field of nuclear safety is described.

2 Legislation and regulations

Pekka Salminen

Revision and updating of YVL guides continued. The guides are detailed safety regulations for nuclear facilities issued by STUK on the basis of the Nuclear Energy Act (990/1987) and the Government Resolution (395/1991) on the general safety regulations for nuclear power plants. The guides describe STUK's regulatory procedures as well. STUK decides, case by case, how new guides apply to facilities already in operation. Such decisions made in 2004 are discussed in subsections 3.1.1 and 3.2.1.

A total of about 34 guides were being prepared or reviewed in YVL guide working groups, with five guides completed by the end of the year. The number of Finnish language YVL guides published in 2000–2004 is given in Fig. 1. Five guides were published in English and three in Swedish. The guides were available in print and on STUK's web site (*www.stuk.fi*) and the Finlex portal (*www.finlex.fi*). Swedish language translations were published as electronic versions only.

The Additional Protocol to the nuclear material safeguards of the IAEA, Euratom and non-nuclear EU member states as well as the relevant amendment to the Nuclear Energy Act were carried into effect by presidential decree on 7 May 2004. On 27 May 2004 an amendment to the Nuclear Energy Decree was passed, into the preparation of which STUK participated. The preparation of an YVL guide on the Additional Protocol was started.

A new Commission Regulation (2002(99)) on safeguards, approved by the Council of the European Union in April 2004, partly pertained to the aforementioned Additonal Protocol. The Regulation came into force in 2005. STUK's representative contributed to the handling of the draft regulation in the Atomic Questions Group (AQG) of the Council of the European Union.

No amendments were prepared to the general regulations on nuclear safety issued in the form of Government resolutions in 2004.

The Commission of the European Communities prepared directives on the arrangement of nuclear waste management in Member Countries and on fundamental nuclear safety requirements. STUK has followed the status of this work and assessed for its part the contents of the drafts.

Towards the end of 2004 the Commission submitted a draft proposal for a Commission directive on the control and supervision of radioactive waste and spent fuel transfers, which is intended to replace Directive 92/3. The draft directive will be further discussed in the Atomic Questions Group in 2005.

Nuclear safety recommendations are also given by international organisations, such as the EU, the IAEA and the OECD/NEA. On various forums of co-operation STUK follows the work of other countries' national authorities in the field of rule-making. This did not result in any need to update the Finnish nuclear legislation. STUK prepared to the IAEA statements on two draft safety guides.

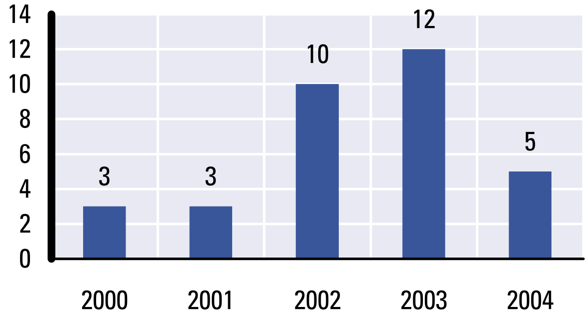

Figure 1. Number of yearly published YVL guides.

3 Nuclear facilities regulation

Kirsi Alm-Lytz, Timo Eurasto, Juhani Hinttala, Tarja K. Ikäheimonen, Marja-Leena Järvinen, Seppo Klemola, Tapani Koljander, Jouko Mononen, Matti Ojanen, Rainer Rantala, Suvi Ristonmaa, Pekka Salminen, Seija Suksi, Heimo Takala, Petteri Tiippana, Keijo Valtonen, Vesa-Pekka Vartti, Olli Vilkamo, Reino Virolainen, Tapani Virolainen

3.1 Loviisa 1 and 2

3.1.1 Implementation of regulations

STUK has introduced a procedure for application of new or revised YVL guides to operating nuclear facilities. According to it, the publication of a YVL guide does not, as such, change STUK's previous decisions. It is only after having heard those concerned that STUK will give a separate decision on the application of a new or revised YVL guide to an operating nuclear facility, or to one under construction as well as to a licensee's operation. The guides apply as such to new nuclear power plants.

In considering the application of new safety requirements given in YVL guides to operating nuclear facilities, or those under construction, STUK takes into account a principle stipulated in section 27 of the Government Resolution (395/1991). It prescribes that, to further improve safety, measures shall be implemented that are justifiable considering operating experience, safety research and development of science and technology.

Decisions to implement the below YVL guides were made in accordance with the new procedure

- YVL 1.5, Reporting nuclear facility operation to the Radiation and Nuclear Safety Authority, 8 September 2003
- YVL 2.2, Transient and accident analyses for justification of technical solutions at nuclear power plants, 26 August 2003
- YVL 2.5, Pre-operational and start-up testing of nuclear power plants, 29 September 2003
- YVL 2.8, Probabilistic safety analyses in safety management of nuclear power plants, 28 May 2003
- YVL 3.8, Nuclear power plant pressure equipment. In-service inspection with non-destructive testing methods, 22 September 2003
- YVL 6.3, Regulatory control of nuclear fuel and control rods, 28 May 2003
- YVL 6.8, Handling and storage of nuclear fuel, 27 October 2003
- YVL 7.5, Meteorological measurements of a nuclear power plant, 28 May 2003
- YVL 7.11, Radiation monitoring systems and equipment in nuclear power plants, 13 July 2004
- YVL 7.18, Radiation safety aspects in the design of a nuclear power plant, 26 September 2003.

Before the decisions to implement the guides were made, Fortum Power and Heat Oy gave an assessment of the fulfilment of the safety requiremens of each guide. The Loviisa plant units meet all requirements of guides YVL 1.5, YVL 2.5, YVL 6.3 and YVL 6.8 and they came into force as such at the Loviisa power plant.

Fortum Power and Heat Oy assessed that Loviisa nuclear power plant meets the safety requirements of Guide YVL 2.2. The transient and accident analyses made for the Loviisa plant units meet the requirements of the new guide for the most part. The sole shortcoming found was that the number of fuel rods sustaining damage in an accident was not analysed as required in the new guide. The licensee will see to this when analyses are updated in connection with the updating of emergency procedures and I&C upgrading projects at Loviisa nuclear power plant. STUK made no remarks on the licensee's assessment and actions.

In its assessement of Guide YVL 2.8, the licensee proposed to draw up in-service piping inspection programmes for the next ten years using risk-informed methods. On STUK's request the licensee further defined its report on the use of risk analyses to develop the Technical Specifications, safety classification and preventive maintenance during operation. The licensee's schedules for application of the new requirements were confirmed by STUK's decision. As a non-conformance to the higher-than-before requirement level established for nuclear power plant design, it was approved that the core melt frequency, which is set as the design basis for new nuclear power plants, is not attained at Loviisa nuclear power plant. Licensee analysis states approx. $1.5 \cdot 10^{-4}$/year as the core melt frequency of the Loviisa plant units, whereas the target value given in Guide YVL 2.8 is 10^{-5}/year.

As regards Guide YVL 3.8, the licensee presented a plan for fulfilment of the new qualification requirements. STUK approved the assessed fulfilment of safety requirements and the plan for inspection qualification with remarks. The qualification schedule extends until the year 2010.

STUK found the clarification given about Guide YVL 7.5 insufficient and required that the onsite weather measurement system has to be developed and the number of observation stations on the plant's protective zone to be increased. The licensee has submitted a more detailed plan to STUK. As regards Guide YVL 7.11, STUK was able to establish, based on the licensee's assessment, that the plant fulfils the requirements of the new guide, particularly owing to its recently renewed fixed radiation measurement system. The licensee's clarification about Guide YVL 7.18 mainly corresponds to STUK's view of the fulfilment of requirements. However, STUK called for further clarification as regards requirements concerning provision for radiation conditions during certain severe accidents.

3.1.2 Assessment of safety analyses

Deterministic safety analyses

The licensees update the nuclear power plants' deterministic safety analyses in connection with the renewal of operating licences. The analyses are updated also in connection with plant modifications, or whenever operational events warrant it. STUK reviews the licensee's analyses and conducts, or contracts out where necessary, its own reference analyses. In 2004, no deterministic safety analyses on the Loviisa plant were submitted to STUK for review.

Probabilistic safety analyses

STUK made a general review of the weather risk analysis for Loviisa plant's shutdown states. The licensee's analysis assessed the risks of a normal month-long annual maintenance outage. According to the analysis, weather and other environmental phenomena during a shutdown constitute a large part of the core melt probability for the Loviisa plant. The most risk-important environmental phenomena include simultaneously high air and sea water temperatures, oil spills or chemicals releases, and the occurrence of algae, which could be transported to the sea water channel and prevent the plant's sea water intake.

The licensee assessed the core melt probability from weather phenomena as $9.6 \cdot 10^{-5}$ per annual maintenance outage. The risk from simultaneously high sea water (above 25 °C) and air temperatures (above 31 °C) is assessed at approx. $6 \cdot 10^{-5}$. The core melt risk was attributed to the possibility of the cooling unit of the air conditioning of the instrumentation area tripping from refrigerant pressure during high temperatures (air 31 °C, sea water 25 °C) at a time when the other cooling unit is out of service for maintenance.

The outage risk analysis looked at oil or other sticky chemicals ending up with sea water to the plant's sea water systems where they could cause clogging and endager normal decay heat removal. The probability of an accident caused by an oil spill is based on global oil spill data. During the last 25 years, nine oil spills involving thousands of tonnes of oil have occurred. The frequency of oil spills in excess of 700 tonnes over the the past ten years is 7.3/year. Based on these data, the frequency of a large accident on the Gulf of Finland, which would affect the Loviisa plant, has been assessd at 0.002/year. Considering the timeshare of outage states in a year and the likelihood of a failed intervention, the licensee assessed the probability of a core melt from oil or other chemicals at $2 \cdot 10^{-5}$ per annual maintenance outage.

The licensee assessed the probability of a core melt caused by algae, or by simultaneously occurring storm winds and algae, at $1.5 \cdot 10^{-5}$/annual maintenance outage. Sea water cooling systems important for the plant's safety could get clogged up by algae. Storm winds could bring about the loss of the offsite electricity grid and, at the same time, detach algae, which could end up in the cooling system of the emergency diesel generators; in the worst-case scenario this would prevent their operation and cause total electricity loss.

The share of other initiating events in total is approx. $1 \cdot 10^{-6}$/annual maintenance outage.

Based on a general review by STUK, it was required that the licensee submits to STUK a plan for measures to reduce weather risks during shutdown states. The licensee gave a more detailed assessment of the frequency of the loss of air conditioning in the instrumentation area from high temperatures of sea water and air, made on the basis of systems states follow-up. The new clarification showed that the cooling units operate even if the temperature of outside air and that of the sea water would rise up to approx. 35 °C. This is a clearly higher temperature than had been assessed earlier based on design documents. Based on the new assessment, the risk posed by the loss of air conditioning is considered low.

In its clarification the licensee presented also a new assessment of the probability of a core melt caused by oil spills. It is reduced to a half of the previous estimate (from approx. $2 \cdot 10^{-5}$/year to $9.9 \cdot 10^{-6}$/year), which is mainly due to the commissioning of a back-up decay heat removal system in the annual maintenance outage of 2004. The licensee continues to find out about the frequencies, consequences and prevention of oil spills on the Gulf of Finland. The probability of an oil spill ending up to the Loviisa plant as a consequence of a tanker accident on the Gulf of Finland will be analysed in more detail in the future. The licensee is looking for ways to prevent the access of oil to the plant's sea water channel.

Based on the new data given in the clarification and safety improvements implemented in 2004, the probability of a core melt caused by weather risks (oil spills included) during an annual maintenance outage has decreased from approx. $9.6 \cdot 10^{-5}$ to approx. $1.3 \cdot 10^{-5}$.

STUK will separately review in detail the weather risk analysis for plant outage states.

Safety analysis of the Loviisa 1 reactor pressure vessel

The operating permits of the reactor pressure vessels of Loviisa nuclear power plant are are evaluated periodically. The licence extending the operation of the Loviisa 1 reactor pressure vessel, granted in 1996, was valid until the 2004 refuelling outage. Towards the end of 2003, Fortum Power and Heat Oy submitted to STUK an application for an extension of the permit until the 2012 refuelling outage.

Neutron radiation negatively affects the materials of the reactor pressure vessel. It changes the microstructure of steel and increases the ductile-brittle transition temperature representing the cleavage behaviour of ferritic steel. In lower temperatures the plastic deformation capability of steel decreases and it becomes brittle. If, under such a temperature, the structure is exposed to high stress, and if a sufficiently large crack exists in the location in question, crack growth becomes quick and the structure breaks. High stresses in a low temperature could occur for example during emergency cooling. Steel's impurities increase the susceptibility to shift of transition temperatures caused by neutron radiation. The core welds of the reactor pressure vessel of Loviisa 1 in particular contain such impurities (phosphorus and copper).

The material samples tested in 1980, which had been inside the Loviisa 1 reactor pressure vessel, showed that embrittlement had taken place considerably quicker than indicated in the vendor's forecast. Since then, several modifications have been made at both plant units to slow down embrittlement and reduce loading.

The ductility of steel can be restored to almost pre-irradiation level by annealing in a temperature higher than the irradiation temperature. In the 1996 refuelling outage a brittle weld nearest to the Loviisa 1 reactor core was heated up to 475–500 ºC for 100 hrs. After annealing, the microstructure of material is not the same as before the first irradiation, however, and re-embrittlement mechanisms differ somewhat from pre-annealing mechanisms. In a safety analysis conducted in connection with the 1996 licensing procedure, the rate of re-embrittlement was evaluated more conservatively than normally.

The irradiation of new samples inside the reactor pressure vessel was begun in 1996 after the vessel's annealing. The test pieces were cut from the sample weld, which very closely corresponds to the brittle weld of the Loviisa 1 reactor pressure vessel. After three years' irradiation the samples had incurred a dose almost as high as the pressure vessel wall prior to the annealing, and then they were annealed. The test pieces were further subjected to irradiation from one to four years prior to testing.

The reactor pressure vessel weld transition temperature used in the analysis is based on the test results (annealing and re-irradiation) of both old and new irradiation surveillance samples. From the test results, a model for the transition temperature has been derived as a function of dose and phosphorus concentration, which is conservative as regards the test results. To define the transition temperatures of the samples and to calculate the value of fracture toughness depicting the quantitative value of toughness, VTT State Technical Research Centre's "Master curve" method has been used, which helps reduce uncertainties relating to the definition of fracture toughness. The "Master curve" method is about to be launched in several countries.

The reactor pressure vessels of the Loviisa plant are inspected at least every eight years for potential defects. The immediate area of the Loviisa 1 pressure vessel core was inspected by nondestructive methods (ultrasound and eddy current) in the 2004 outage.

Fortum Power and Heat Oy submitted a new safety analysis to support its application. Loading-related thermohydraulic analyses and fracture mechanical analyses have been completely updated. The biggest change, however, is a re-assessment of the aforementioned ductile-brittle transition temperature.

STUK reviewed and assessed the results and analyses of an irradiation programme for the annealed reactor pressure vessel as well as other justification for the licence extension submitted by Fortum Power and Heat Oy. STUK made a safety assessment the essential conclusions of which are as follows:

- The rate of re-embrittlement is defined sufficiently conservatively.
- A deterministic analysis shows that the reactor pressure vessel maintains it's integrity in all postulated loading situations.
- The failure risk derived by probabilistic analysis only accounts for a minor part of severe accident total risk.

In accordance with the application of Fortum Power and Heat Oy, STUK approved the continued operation of the Loviisa 1 reactor pressure vessel until the 2012 refuelling outage.

3.1.3 Oversight of plant modifications

The most significant safety improvement under way at the Loviisa plant is the upgrading of the I&C systems of the plant units, which reached implementation stage towards the end of 2004. The project started with the construction of a new I&C building and is due for completion in 2014. The upgrading takes place phase by phase such that upgraded system sections are available for commissioning during annual maintenances. At the beginning of 2004 an overview project was set up at STUK to co-ordinate document review and control pertaining to the I&C upgrading. STUK approved the I&C conceptual design plan submitted by the licensee with certain supplementary requirements, which are to be observed in a later phase of the project. Towards the end of 2004 the licensee submitted to STUK for review detailed plans for Loviisa 1's new I&C buildings. Based on the approved plans, the licensee began construction of the buildings. STUK oversaw the progressing of the work.

During the 2004 annual maintenance outage, modifications were completed at the plant units relating to, among others, the new back-up decay heat removal system, a detailed description of which can be found in Appendix 2. STUK oversaw the implementation of component and structural modifications by inspections onsite and at the component manufacturers' premises as well as by reviewing reports submitted by the licensee. Modifications oversight included STUK/licensee meetings and STUK internal meetings.

In consequence of the plant modifications, several documents changed describing the plants' operation and structure – such as the Technical

Specifications, the Final Safety Analysis Report and the operating and maintenance instructions. STUK supervised the document revisions and generally followed the updating of plant documentation after the modifications. The results are given in Appendix 1 (indicator A.I.6).

3.1.4 Oversight of plant operability

Compliance with the Technical Specifications

Compliance with the Technical Specifications at the Loviisa power plant was controlled by witnessing operations onsite. Subject to oversight were in particular the testing and repair of components subject to the Technical Specifications. After completion of the annual maintenance outages, the plant unit's compliance with the Technical Specifications was established before startup. The licensee is obliged to immediately report to STUK all plant situations in non-compliance with the Technical Specifications.

Two situations occurred at the Loviisa plant units during which a plant unit was in non-compliance with the Technical Specifications (Appendix 1, indicator A.I.2). Both situations occurred at Loviisa 2 and they were the inoperability of the off-gas activity measurements in the secodary circuit and a brief disturbance in decay heat removal during annual maintenance. The events are looked into in more detail in Appendix 3. The licensee has planned and carried out actions to prevent recurrence.

The Technical Specifications were deviated from also by applying in advance for STUK's approval of non-compliances. In 2004, the licensee applied for approval of nine deviations from the Technical Specifications (Appendix 1, indicator A.I.2). After an analysis of the deviations' safety significance, STUK approved the applications. Five exemptions pertained to deviations from the Technical Specifications caused by plant modifications.

Operation and operational events

The Loviisa plant units operated reliably in 2004. The load factor of Loviisa 1 was 87.1 % and that of Loviisa 2 was 93.8 %. Fig. 2 gives the plant units' load factors for 1995–2004. The duration of the annual maintenance outage at Loviisa 1 was 47 days and 22.5 days at Loviisa 2. In addition, one brief production break occurred at both plant units. At Loviisa 1 it was due to a scram caused by a protection system malfuction (see Appendix 3) and at Loviisa 2 to the repair of a leaking check valve.

Production losses in nominal output caused by component malfunctions were 0.25 % at both plant units. Production losses from component malfunctions in a longer time period are depicted by indicators in Appendix 1 (indicator A.I.1g). Figure 3 gives the daily average gross powers of the plant units in 2004.

At the Loviisa plant units, three events warranted a special report, and one reactor scram and nine operational transients to be reported to STUK occurred (Appendix 1, indicator A.II.1). The events subject to a special report were as follows:

- Fuel handling error at the Loviisa plant spent fuel storage (INES Level 0)
- Inoperability of activity measurements at Loviisa 2 (INES Level 0)
- Disturbance in decay heat removal at Loviisa 2 (INES Level 0)

The reactor scram and the events subject to a special report are explained in more detail in Appendix 3. Figure 4 gives the number of INES Level 1 events in 1995–2004. During this time period, no events exceeding INES Level 1 occurred at the Loviisa plant.

In addition to event reports, the Loviisa power

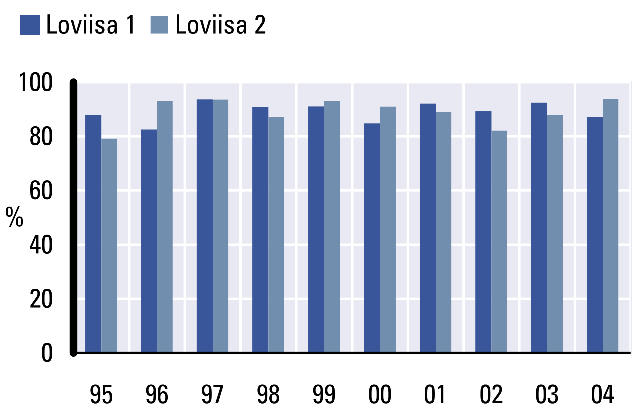

Figure 2. Load factors of the Loviisa plant units.

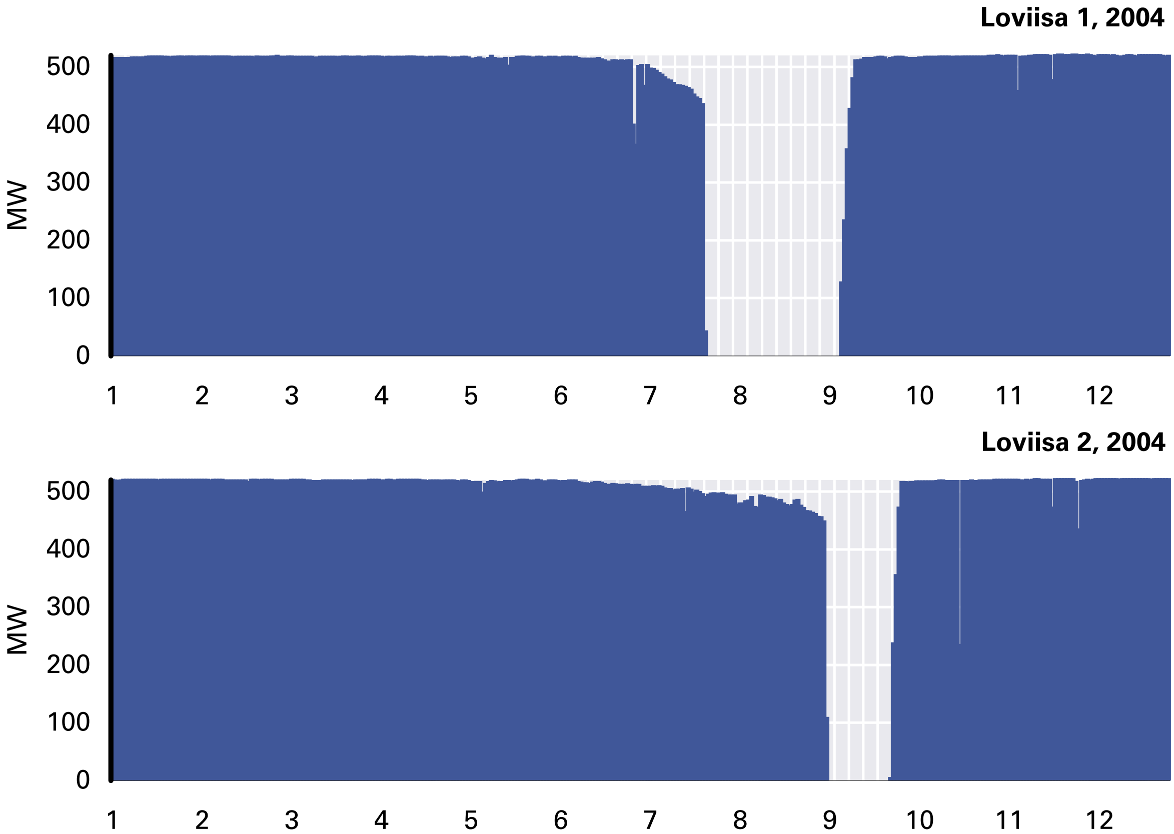

Figure 3. Daily average gross power of the Loviisa plant units in 2004.

plant submitted to STUK daily reports, monthly reports, annual reports, outage reports, annual environmental safety reports, monthly individual dose reports, annual operational feed back reports and nuclear safeguards reports.

Annual maintenance outages

The annual maintenance outage of Loviisa 1 was an extensive maintenance performed every eight years, which included time-consuming primary and secondary circuit pressure testing. These extensive annual maintenances always include other extensive inspections, maintenance and modifications. The Loviisa 1 annual maintenance was on 24 July to 8 September 2004. Its overall duration, 47 days, was about five days longer than planned. The extension of the outage was due, among others, to a longer-than-planned inspection of the reactor pressure vessel, the installation of flow limiters to the reactor instrument line, the replacement of pipe and end flanges of make-up water heat exchangers, time-consuming steam generator room cleaning and the repair of a leaking pressuriser spray valve.

The Loviisa 2 annual maintenance was a refuelling outage and took place on 4 to 26 September 2004. Its duration was 22.5 days, i.e. almost according to plan.

During the Loviisa 1 annual maintenance, the first fatal accident at work during the plant's operating life occurred at the 6 kV switchgear on 29 July 2004. A brief disturbance in decay heat removal occurred at Loviisa 2 on 16 September 2004. The events are separately described in Appendix 3.

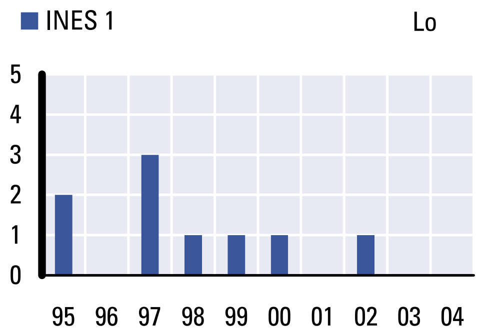

Figure 4. Loviisa plant's INES classified events (INES Level 1 and higher).

During the annual maintenance outage of Loviisa 1, a safety improvement was made to ascertain the plant units' decay heat removal. It is described in Appendix 2. Repairs and maintenance during the annual maintenances are described under "Repairs and maintenance ".

The collective radiation dose incurred in outage work was 1.93 manSv at Loviisa 1 and 0.44 manSv at Loviisa 2. Occupational radiation doses are examined in more detail under "Radiation Safety" and in Appendix 1 (indicator A.I.4).

STUK's oversight activities focused, among others, on the administrative arrangements of outage work, the work of the operating and maintenance personnel, refuelling as well as inspections and tests by the licensee and contractors. Attention was paid to the implementation of radiation protection, control room operations and housekeeping. Prior to the start of the new fuel cycle, safety analyses of a new fuel charge were reviewed. The loading of the fuel assemblies into the reactor according to plan was ascertained. The nuclear material inventory was verified prior to the closing of the reactor pressure vessel. STUK controlled the placement of the plant units into shutdown state and their post-outage start-up.

As regards Loviisa 1, STUK paid attention to an insufficient clarification of the safety implications of installation work relating to service water system piping modifications and the disorder and uncleanliness of certain plant areas. The level of housekeeping during the Loviisa 2 annual maintenance gave no cause to remarks. During the annual maintenance outages, shortcomings in personnel resources were mostly observed in supervision of work.

The regulatory oversight of the Loviisa facility's annual maintenance outages onsite took 172 working days. One resident inspector worked regularly on the site.

Repairs and maintenance

During the Loviisa 1 extended annual maintenance, the licensee performed primary and secondary circuit pressure tests. Inspections of the reactor pressure vessel and reactor internals, one high pressure turbine and the corresponding diesel generator were carried out as well, among others. Inspections of the reactor pressure vessel internals were made using STUK-approved, qualified inspection methods. No indications exceeding the threshold of approval were observed in them or any other inspections in accordance with a pre-approved programme.

Based on the results of the monitoring of the Loviisa 1 service water system piping, the licensee had decided to renew the piping from pumps to heat exchangers. Replacement piping is of carbon steel with hard rubber applied on its inner surface. Piping diameter was reduced due to installation engineering. Due to erosion-corrosion wear, piping replacements in the feed water system continued both in the steam generator compartment and outside it.

The licensee continued inspection of areas around the temperature measurement devices of the protection pipes of control rod drive mechanisms at both plant units based on previous crack indications (Annual Reports 2002 and 2003). At Loviisa 1, defects were detected in two protection pipes in 2004 and they were replaced. At Loviisa 2, ten protection pipes were found defective. Defective protection pipes have now been replaced at both plant units. Similarly, moisture-collecting and thus stress corrosion inducing insulation shield boxes of the temperature measurement devices have been removed from all protection pipes.

In inspections of the reactor pressure vessel head at both plant units during annual maintenances, the licensee detected water between through-hole assembly and corrosion protection sleeve in two penetrations for control rod drive mechanisms in the reactor pressure vessel head. The inspections were made on the basis of operating experience feedback from other VVER plants. Visual inspection of nozzle inner surfaces by camera showed no bulging or other visible changes in the thermal protection sleeves. Before plant unit start up, the licensee sent to STUK a report on the observations made and their safety significance, with the conclusion that the event does not call for immediate corrective action. Long-term corrective action is looked into during the current operating cycle.

The heat exchanger piping of two steam generators were inspected at both plant units. Based on the results, 13 and 4 heat exchanger pipes were plugged at Loviisa 1 and 2 respectively.

During the annual maintenance outages of the Loviisa plant, STUK inspected 26 items of pressure equipment in Safety Classes 1 and 2 subject to registration in accordance with the Pressure Equipment Act. The periodic inspection of pressure equipment was controlled by reviewing programmes pertaining to it. A total of 323 structural inspections, repairs and modifications as well as commissioning inspections of mechanical components were made. One inspection comprises one or more partial inspections such as a results review; an inspection of a component or structure; a pressure or leakage test; a functional test; or an operational safety inspection. Also 22 inspections of electrical and I&C equipment were made, which comprise several partial inspections themselves.

STUK witnessed onsite inspections of Safety Class 3, 4 and Class EYT nuclear pressure equipment and other mechanical components and structures carried out by the Loviisa plant inspection unit "Inspection Organisation Loviisa YVL". The safety classification is based on the STUK Guide YVL 2.1 according to which a nuclear power plant's systems, structures and components are assigned to the Safety Classes and 1, 2, 3 and 4 as well as to Class EYT (non-nuclear). Items with the highest safty significance are Safety Class 1.

Ageing

The strategic objective for Loviisa power plant's lifetime management is 50 years' operating life. Lifetime management is one of the main tasks of the power plant engineering division set up at the Loviisa plant in the utility's re-organisation in 2002. The lifetime management procedure was revised in early 2003. The administrative procedures contained in it have been developed during 2004. It is intended to make the system's use more effective in 2005 by means of a new information management system, which is under development. Guidelines for follow-up reporting on the ageing of electrical and I&C systems and components have been drawn up in 2004.

Important factors affecting the lifetime of the Loviisa plant were the decision made at the end of 2004 to upgrade the plant's I&C systems and also the choice of the supplier. The plant's I&C systems are due for upgrading in 2006–2014.

STUK's oversight of lifetime management comprised the following actions: review of follow-up reports on the ageing of mechanical components and electrical and I&C systems and of the lifetime management procedures. Lifetime management was also overseen during inspections of STUK's periodic inspection programme and in the inspections of mechanical components, electrical and I&C systems and structures.

Inspection methods are to be qualified to improve the reliability of the in-service inspection of the most important mechanical components by non-destructive methods. An agreement on the renewal of the qualification organisation was signed by Teollisuuden Voima Oy, Fortum and Inspecta Oy. It entered into force on 1 January 2005 and is valid until 31 December 2010. According to the agreement, SFS Inspecta Certification is the organisation responsible for the activities of a qualification body in accordance with Guide YVL 3.8. During 2004, the national regulations on qualification were amended to comply with the new organisation. The implementation of first qualifications in 2004 was in accordance with the level of requirements of the new operations model.

Radiation safety

Occupational radiation doses

The radiation doses of all those who worked at Loviisa nuclear power plant in 2004 were below the 50 mSv annual limit. The distribution of individual doses in 2004 is given in Table I. The highest occupational dose to an individual at Loviisa nuclear power plant was 16.9 mSv. It accumulated during work at Loviisa and Olkiluoto nuclear power plants. The highest individual dose incurred at Loviisa nuclear power plant alone was 15.8 mSv. Individual radiation doses did not exceed the dose limit of 100 mSv defined for any period of five years. The highest individual dose to a Finnish nuclear power plant worker in the 5-year period 2000–2004, 65.0 mSv, was received at Loviisa, Olkiluoto and Swedish nuclear power plants.

The collective occupational radiation dose was 2.00 manSv and 0.49 manSv at Loviisa 1 and Loviisa 2 respectively, i.e. a total of 2.49 manSv for both plant units. The collective occupational dose is mostly incurred in outage work. According to STUK guidelines, the threshold for one plant unit's collective dose averaged over two successive years is 2.5 manSv per one gigawatt of net electrical power. This means a radiation dose of 1.22 manSv per one Loviisa plant unit. It was exceeded at Loviisa 1 by

Table I. Occupational radiation dose distribution at Loviisa and Olkiluoto plant units in 2004.

Dose range (msv)	Number of persons by dose		
	Loviisa	Olkiluoto	total*
< 0,5	166	434	557
0.5–1	79	243	296
1–2	120	240	331
2–3	79	148	213
3–4	56	68	109
4–5	36	33	77
5–6	30	15	44
6–7	24	8	36
7–8	21	2	25
8–9	17	–	25
9–10	16	–	12
10–11	15	–	15
11–12	5	–	4
12–13	13	2	17
13–14	13	–	19
14–15	21	–	25
15–16	3	–	4
16–17	–	–	2
17–18	–	–	–
18–19	–	–	–
19–20	–	–	–
20–21	–	–	–
21–25	–	–	–
> 25	–	–	–

* The data in this column include Finnish workers who have received doses also at Swedish nuclear power plants. The same person may have worked at both Finnish nuclear power plants and in Sweden.

Source: STUK's dose register

0.09 manSv and cannot be considered low by international comparison. The collective occupational dose (1.93 manSv) that accumulated in the extended 2004 annual maintenance outage of Loviisa 1 contributed to it. The licensee is obliged to report to STUK the causes for this and any measures necessary to improve radiation safety. Collective occupational radiation doses over the past years are given in Appendix 1 (indicator A.I.4).

Radioactive releases

Radioactive releases from Loviisa nuclear power plant in 2004 were well below authorised limits. Releases of radioactive noble gases were ca 7 TBq, i.e. about 0.03 % of authorised limit. The releases of radioactive noble gases were dominated by argon-41, i.e. the activation product of argon, originating in the air space between the reactor pressure vessel and the main biological shield. The releases of radioactive iodine isotopes were about 11 MBq, i.e. approx. 0.005% of authorised limit. Aerosol releases were approx. 0.1 GBq, tritium releases approx. 0.2 TBq and carbon-14 releases approx. 0.3 TBq.

The tritium content of liquid effluents was approx. 17 TBq. The total activity of other nuclides released into the sea was about 1 GBq, i.e. about 0.2% of the release limit. Loviisa nuclear power plant released low-level evaporation waste to the sea according to plan towards the end of 2004. The volume of liquid releases from the Loviisa plant was thus higher than in 2003. A previous corresponding release was in 2001.

The release limits are to maintain individual annual radiation exposure in the surrounding population of plants clearly below the threshold value (100 microSv) determined by the Government Resolution (395/1991). The calculated radiation dose of the most exposed individual in the vicinity of the plant was about 0.2 microSv, i.e. less than 0.2% of the set limit. Appendix 1 (indicator A.I.5) gives radioactive releases and calculated radiation doses to the most exposed individual in the plant vicinity over the past years.

Environmental radiation monitoring

Environmental radiation monitoring around a nuclear power plant comprises on- and off-site radiation measurements as well as determination of radioactive substances to establish public exposure and radioactive substances in the environment.

In the environment of Loviisa nuclear power plant, 329 samples were analysed in accordance with the monitoring programme. Radioactive substances originating in the Loviisa plant were measured in two samples of air, six samples of deposition, one sample of bottom fauna, ten samples of aquatic plants, eight samples of sinking matter and five samples of sea water.

Cobalt-60, the dominating radioactive substance originating in power plants, was measured in 24 samples. The next most dominant were silver-110m (16 observations), cobalt-58 (10 observations), antimonium-124 (8 observations), manganese-54 (8 observations), and tritium (5 observations). In addition, chromium-51, iron-59, zirconium-95, niobium- 95 and tellurium-123m were detected in one sample of aquatic plants.

All the detected concentrations were low and had no bearing on radiation exposure.

Radioactive strontium, caesium and plutonium isotopes (strontium-90, caesium-134 and -137, plutonium-238, -239 and -240) originating from the Chernobyl accident and the fallout from nuclear weapons tests are still measurable in environmental samples. Natural radioactive substances (i.a. beryllium-7, potassium-40 as well as uranium and thorium with their decay products) are also detected. Their concentrations usually exceed those of nuclides originating from the power plant or fallout.

External radiation is monitored by 15 automatic radiation measuring stations at a radius of two and five kilometres from the plant. The measurement data are transferred to the power plants' control rooms and to the national radiation-monitoring system. In addition, dosimeters for external radiation measurement have been placed in about ten locations around the nuclear power plants. No dose rates exceeding the natural background were measured.

3.1.5 Oversight of organisational operation

Safety management

Information accumulated during document review and other inspection activity at the Loviisa plant was examined in 2004 with a view to plant safety. No significant problems were observed in plant safety management.

Quality management

Loviisa nuclear power plant has systematically maintained and developed its quality management system according to own plans. In 2002 and 2003, the system was updated to correspond to the organisational and procedural changes implemented at the plant. It has been routinely updated since. Fortum Power and Heat Oy will in early 2005 update the guidelines describing the quality management system for the nuclear energy section of Fortum corporation.

Over the past years, the licensee has compared the quality management system of the Loviisa plant with, among others, the standard ISO 9001 and the safety requirements and guidelines of the IAEA. Based on this, the system has been further developed by, among others, management reviews and self-assessment to help identify improvement needs in the management system and operations.

The Loviisa plant regularly evaluates the functionality of its quality management system by means of an internal audit programme and a separate, independent inspection procedure.

STUK oversaw quality management by document reviews and by an inspection of its periodic inspection programme. For reasons of schedule, the inspection was postponed to January 2005. It dealt with the licensee's organisation, safety management, quality management and safety improvements. STUK found quality management by the licensee and Loviisa power plant acceptable.

Personnel qualifications, training and resources

The organisation of the Loviisa plant was rearranged in 2002. This was in preparation for, among others, change of generation and it was done by offering a chance to knowledge transfer from senior to junior personnel in expert tasks and by assigning junior personnel to managerial tasks in the line organisation. Several persons, who had worked for a relatively short time for the Loviisa plant, participated in a 5-week basic professional training course on nuclear safety in Finland in 2004.

Within the framework of the periodic inspection programme, STUK oversaw the appropriateness and adequacy of Loviisa nuclear power plant's organisation and its personnel training. In a separate inspection on training, the plant's procedures as regards training arrangements, personnel qualifications and special training pertaining to annual maintenances were assessed.

Upon application by the licensee, STUK authorised persons in the licensee's employ to work as shift managers or operators at the power plant. Authorisations were reauthorisations and were granted to 25 persons employed by the Loviisa plant.

No significant changes took place in the plant's operating organisation or procedures. Personnel changed normally owing to change of generation, duties and workplace. Deficient personnel resources have been observed at Loviisa power plant, mostly in work supervision during annual maintenances. The organisation's resources and competences are otherwise adequate to safely operate the plant units.

Operational experience feedback

In its operational experience feedback work, the licensee reviewed events at own and other plants. Events at plants abroad were dealt with in special operational feedback working groups. The objective of operational experience feedback work is to prevent recurrence of events endangering plant safety. Based on operational experience feedback, minor improvements were carried out at the plant units in 2004 relating to methods and guidelines for the most part but including also component inspections and additional analyses. Operational experience feedback information was passed on to the personnel in the form of reports and training.

STUK's oversight of operational feedback activities was by review of event reports and the annual operational feedback report submitted by the licensee. The Loviisa plant has systematic guidelines for event investigation, assessment and corrective action.

STUK evaluated the feasibility of experiences learned from events abroad for consideration at Finnish plants. Event information was received through the IAEA/OECD Incident Reporting System (IRS). Eighty event reports were reviewed in 2004, seven of which lead to detailed inspection after preliminary assessment. No event in 2004 warranted immediate action by the licensee. At the Loviisa plant, one event led to consideration of lessons learnt in connection with normal STUK inspection activity.

STUK's periodic inspection programme

In 2004 STUK carried out 13 inspections of the periodic inspection programme at the Loviisa plant one of which was postponed to early 2005 for reasons of schedule. Safety management, main processes and procedures of operation as well as the technical acceptability of systems were looked into. The compliance of plant safety assessment, operation, maintenance and protection activities with the requirements of nuclear safety regulations was verified by the inspections. The annual inspection programme was brought to the attention of the licensee and inspection dates were agreed upon in early 2004. The inspections contained in the periodic inspection programme are given in Appendix 4.

Information was acquired through oral reports requested from the licensee's experts, personnel interviews, document reviews, walk rounds, observing of working as well as various measurements, i.a. to establish the accuracy of measuring equipment. None of the observations made had an immediate bearing on the safety of the plant units. Actions were initiated at the plant to repair detected defects.

Event investigation

STUK started no event investigations in 2004. An event investigation team is appointed when the licensee's own organisation has not operated as planned in connection with an event or when the event is estimated to lead to significant modifications in the plant technical layout or procedures. A STUK investigation team is set up if the licensee has not adequately clarified the root causes of an event.

A topical inspection of the use of contractors was carried out at Loviisa power plant. The use of system, component and services suppliers at the plant was assessed as well as the procedures applied and practices in their use. The following were chosen as examples of contracted work and contractors: a routine services purchase (piping condition monitoring), spare parts and servicing of a highly demanding item of equipment (primary coolant pumps) and an engineering service purchase (Fortum Nuclear Services). In the inspections, deficiencies were found in Loviisa power plant's procedures for co-ordination and supervision of contractor work, supplier evaluation and familiarisation with the plant procedures.

Authorisation of pressure equipment manufacturers as well as inspection and testing organisations

Upon application by Fortum Power and Heat Oy, and in accordance with the Nuclear Energy Act, STUK authorised ten manufacturers of nuclear pressure equipment.

STUK also authorised, in accordance with the Nuclear Energy Act, six testing organisations to carry out manufacturing-related nondestructive testing of mechanical components and structures of the Loviisa plant units. Further, upon application by Fortum Power and Heat Oy, testing personnel employed by four testing organisations were authorised to carry out periodic inspection of mechanical components and structures at the Loviisa plant units. Previous decisions on manufacturers and testing organisations are valid, as mentioned in the decisions. Loviisa power plant's inspection unit "Inspection Organisation Loviisa YVL", authorised in 2002, continued in operation.

STUK oversaw the operation of manufacturers as well as testing and inspection organisations it had approved. Their operation was established as being in accordance with the requirements of Guides YVL 3.4 and YVL 1.3.

In accordance with Guide YVL 5.2, which took effect on 1 December 2004, and upon application by Loviisa power plant, STUK authorised "Inspection Organisation Loviisa YVL, electrical engineering and I&C technology" and persons in the employ of Loviisa power plant to carry out the commissioning inspections of safety classified electrical and I&C equipment at Loviisa nuclear power plant.

Nuclear liability

The users of nuclear energy must have acquired liability as stipulated in the Nuclear Liability Act (484/1972), or other financial guarantee, for a possible accident at a nuclear facility that would harm the environment, population and property. Fortum Power and Heat Oy has provided for damage from a nuclear accident as prescribed by law by taking out an insurance policy for this purpose mainly in the Finnish Nuclear Insurance Pool.

In case of accident, funds for compensation are available through three sources: the licensee, the facility's country of location and the international liability community. In 2004, a total of about 425 000 000 € was available for compensation from all these sources. In the coming years, an increase in the sum is expected as international negotiations about the revision of the Paris/Brussels nuclear liability agreements were completed in 2004. The funds available for compensation will more than triple in the near future compared with the current situation. In addition, the enactment of unlimited licensee liability by law is under consideration in Finland.

The ascertaining of the contents and conditions of a licensee's insurance policy belongs in Finland to the Insurance Supervisory Authority. It has approved Fortum Power and Heat Oy's liability insurance and STUK has verified the existence of the policy in accordance with section 55 of the Nuclear Energy Act (990/1987).

The Nuclear Liability Act covers also the transport of nuclear materials. STUK has ascertained that all nuclear material transport has liability insurance approved by the Insurance Supervisory Authority.

3.1.6 Nuclear safety indicators

The requirements set for the safety indicators of the effectiveness of STUK's operations were fulfilled at Loviisa power plant as regards individual occupational doses, radioactive releases and population exposure. The Loviisa 1 collective radiation dose incurred during the annual maintenance outage, an extended repair and maintenance outage, was somewhat higher than estimated. As a result, the calculational reporting threshold per one gigawatt of net electrical power, as established in Guide YVL 7.9, was exceeded. After the controlled release of stored, clarified low-level effluent to the sea in late 2004, the total activity of radioactive releases into the sea exceeded that of 2003. This is a procedure, repeated every few years, requiring advance notice to STUK.

No events at the Loviisa plant units endangered plant safety. The number of events reported in accordance with Guide YVL 1.5 was on a slight increase. No onsite fires occurred. Three events warranted a special report and nine an operational transient report. The licensee's report on the electrical accident during the Loviisa 1 annual maintenance is not contained in any of the above classes of event reports and thus is not included in the nuclear safety indicators. STUK's safety indicators do not depict the number of accidents at work.

The safety indicator system looks also at the risk-importance of operational events. Events are divided into three categories according to their risk-importance, the indicator in each category being the number of events. One reactor scram initiated by the malfunctioning of the reactor protection system occurred at Loviisa 1 during which all safety systems functioned according to design. Since no significant safety-endangering events occurred at the Loviisa plant, this scram became the most risk-significant event. Nine other events in the highest risk category occurred at the plant. The unavailability of safety systems during these events was caused by latent component failures of emergency diesel generators, the emergency feed water system and the containment spray system. Because of conservative modelling, the annual maintenances of the back-up emergency feed water system were included in the most significant events. The number of events in the most risk-significant class at the Loviisa plant decreased from 2003. The events in 2004, which were analysed, are considered part of normal operation and called for no additional measures by STUK. The differences in the number of events, as compared to 2003, are normal statistical fluctuation.

The previous year's decreasing trend for the maintenance function of the Loviisa power plant slowed down based on the 2004 indicators. The number of annual maintenance tasks decreased slightly from 2003. This was due to a reduction in the total number of failures since the number of preventive maintenance tasks at annual level has remained a constant. The number of failures requiring an immediate operational restriction during power operation has been on the increase over the past years at Loviisa 2. The failures occurred in such backup systems as do not directly affect the operation of the plant units or nuclear safety. Their repair is prioritised within available resources and according to urgency and safety significance. This is evident in approximate repair times that have been long at the Loviisa plants, particularly at Loviisa 2 in 2003 and 2004.

The structural integrity of multiple barriers containing radioactive releases has been good. No fuel leaks have occurred at the Loviisa plant units for years now. The combined leakage rate of containment penetrations and airlocks increased but the set limit was not exceeded. The leaktightness of the rubber bellows of the penetrations had been problematic and their conversion to metal structures has been initiated at Loviisa power plant. The chemistry indices showed only a low impurity and corrosion content in the primary and secondary coolants of Loviisa 1 in 2004. The high chemistry index value at Loviisa 2 in 2003–2004 was due to a service water leak from the condenser of one turbine. This was apparent due to the chloride concentration of the blow down systems of the steam generators. The leak was repaired in the 2004 annual maintenance outage, whereafter the indicator values resumed pre-leak level.

Shortcomings in the supervision of work done onsite and that commissioned to outsiders were detected at the plant. The objectives set for document updating were not fully achieved. Objectives of radiation protection planning during the Loviisa 1 annual maintenance outage were not achieved and the collective dose reporting threshold prescribed in YVL guides was exceeded. STUK's safety indicator follow-up showed some deficiencies in the authenticity of reported laboratory results. Similar problems surfaced in the clarification of mistakes observed in the calculation of indicators depicting safety systems unavailability. The increase in the average repair times of components subject to the Technical Specifications was not unambiguously clarified. The long repair times could indicate problems in ageing management or limited resources in the maintenance operations.

The results of STUK's safety performance indicators for nuclear power plants in 2004 are given in Appendix 1.

3.1.7 Overall safety assessment

The annual safety assessment for Loviisa nuclear power plant looks at the implementation of YVL guides at the plant as well as observations on plant safety analyses, modifications, availability and organisational operation made in regulatory work in 2004. The assessment is discussed in more detail in sub-sections 3.1.1–3.1.6 and in the appendices of this report. No significant nuclear safety related shortcomings were detected during regulatory oversight.

During the implementation of new YVL guides on reporting, safety analyses, commissioning of nuclear power plants, testing, nuclear fuel and radiation protection nothing was found to prevent the commissioning of the revised procedures. In the case of some guides, the realisation of licensee plans, which span several years, calls for determined and persistent work. As a deviation from the set level of requirements in nuclear power plant design, it was approved, as regards Guide YVL 2.8, that the design-basis core melt frequency established for new nuclear power plants is not achieved at Loviisa nuclear power plant. According to the licensee, the core melt frequency for the Loviisa plant units is approx. $1.5 \cdot 10^{-4}$/year, whereas the target value in accordance with Guide YVL 2.8 is 10^{-5}/year.

According to Loviisa nuclear power plant's updated shutdown risk analysis, weather and other environmental phenomena account for a major part of the core melt probability estimated for the plant. The most significant environmental phenomena from the risk point of view include simultaneous high air and sea water temperatures as well as oil spills or chemicals releases and the occurrence of algae, which could be transported to the sea water channel and prevent the plant's coolant intake. The core melt probability from weather risks (oil spills included) during an annual maintenance outage is approx. $1.3 \cdot 10^{-5}$.

Important projects relating to plant lifetime management were implemented at the Loviisa power plant in 2004. A new operating permit was granted for the Loviisa 1 reactor pressure vessel and a conceptual design plan for the I&C modifications was approved. A new back-up decay heat removal system, shared by the plant units, was completed.

The new operating permit for the Loviisa 1 reactor pressure vessel was granted until the 2012 annual maintenance outage. The thermohydraulic and fracture mechanical analyses of reactor pressure vessel loadings have been entirely modified. The most significant change, however, is the reassessment of the ductile-brittle transition temperature, using VTT State Technical Research Centre's "Master curve" method to reduce uncertainties relating to the definition of fracture toughness. It can be considered that the rate of re-embrittlement has been sufficiently conservatively determined; that a deterministic analysis shows the reactor pressure vessel maintains its integrity in all postulated loadings; and that the fracture risk, as derived by probabilistic analysis, accounts only for a minor part of the total risk of severe accidents.

The I&C modification at Loviisa plant reached implementation phase at the end of 2004. The project started with the construction of the new I&C building and is due for final completion in 2014. Implementation is planned to take place phase-by-phase such that modified sections of the I&C system can be commissioned during annual maintenances. The different phases of the modification are implemented first at Loviisa 1 and then at Loviisa 2 every two years later. The construction of the new I&C building was begun at Loviisa 1.

No significant safety-related shortcomings were detected during plant operability oversight in 2004. No significant disturbances occurred during the operation of the plant units, which was in compliance with the Technical Specifications with the exception of two events. Three operational events warranted a special report. The annual maintenance outage of Loviisa 1 was an extended 8-yearly annual maintenance and that of Loviisa 2 a refuelling outage of short duration. During the Loviisa 1 annual maintenance outage, STUK paid attention to deficient safety procedures during the renewal of decay heat removal system piping and inferior plant unit housekeeping. No remarks were made on housekeeping during the Loviisa 2 annual maintenance outage.

Because the Loviisa 1 annual maintenance outage was an extended outage, the periodic inspection programme of mechanical components was highly extensive in scope. The plant's primary and secondary circuits underwent pressure testing early in the outage. An internal inspection of the reactor pressure vessel was done by STUK-approved, qualified inspection methods. These, or any other inspections in accordance with a pre-approved programme, revealed no indications exceeding the threshold of approval. The protective sleeves of the penetration nozzles of the reactor pressure vessel head were inspected based on operational feedback data from other VVER-type plants. Water was found behind two protective sleeves at both plants. This has no immediate effect on the continued safe operation of the plants.

An electrical accident occurred during the Loviisa 1 annual maintenance outage in which one worker died and two were injured. The event's investigation, due for completion in early 2005, is headed by the Uusimaa industrial safety district, with expert assistance from the Safety Technology Authority of Finland (TUKES). The event revealed significant shortcomings in procedures relating to electrical work safety.

The doses of all nuclear power plant workers were below the individual dose limit. At Loviisa 1, the threshold for one plant unit's collective dose per one gigawatt of net electrical power, calculated according to STUK guidelines, was slightly exceeded due to work done in the steam generator compartment. The collective occupational dose cannot be considered low by international comparison. Radioactive releases were low and the dose calculated on their basis for the most exposed individual in the vicinity of Loviisa nuclear power plant was well below the limit established by Government Resolution.

The life management procedures of Loviisa nuclear power plant were further developed in 2004. No significant safety deficiencies surfaced in inspections relating to the ageing of mechanical components as well as electrical and I&C systems and structures. The negative trend shown by the indicators for the maintenance function of Loviisa nuclear power plant did not continue in 2004. The structural integrity of multiple barriers containing plant releases has been good.

Qualification of the periodic testing of the most important mechanical components by nondestructive methods was developed in 2004. Both licensees and Inspecta Oy have agreed upon national arrangements for carrying qualification into effect and for designating SFS Inspecta Certification as the organisation responsible for the operation of the qualification organisation. First qualifications were carried out in 2004 in accordance with the level of requirements of the new operations model.

The plant's operating organisation or procedures did not significantly change. The electrical accident and the accumulated collective radiation dose can be atttributed to scarce personnel resources mostly in work supervision during annual maintenances. Apart from these, the organisation has sufficient resources and qualifications to safely operate the plant units.

The periodic inspection programme of Loviisa power plant, implemented by STUK, revealed no significant safety defects.

STUK did not start any new investigations into the plant's operation in 2004.

3.2 Olkiluoto 1 and 2

3.2.1 Implementation of regulations

STUK has introduced a procedure for application of new or revised YVL guides to operating nuclear facilities. A new YVL guide does not, as such, alter any previous decisions made by STUK. After having heard those concerned, STUK makes a separate decision on how a new or revised YVL guide applies to operating nuclear facilities, or those under construction, and to licensees' operational activities. New guides apply as such to new nuclear facilities.

When considering how new safety requirements presented in YVL guides apply to operating nuclear power plants, or those under construction, STUK takes into account the principle stated in section 27 of the Government Resolution (395/1991), which prescribes that for further safety enhancement, action shall be taken which can be regarded as justified considering operating experience and the results of safety research as well as the advancement of science and technology.

Implementation decisions in accordance with the new procedure were made on the below guides

- Guide YVL 1.5, Reporting nuclear facility operation to the Radiation and Nuclear Safety Authority, 8 September 2003
- YVL 2.2, Transient and accident analyses for justification of technical solutions at nuclear power plants, 26 August 2003
- YVL 2.5 Pre-operational and start-up testing of nuclear power plants, 29 September 2003
- YVL 2.8, Probabilistic safety analyses for safety management of nuclear power plants, 28.5.2003
- YVL 3.8, Nuclear power plant pressure equipment. In-service inspection with non-destructive testing methods, 22 September 2003
- YVL 6.3, Regulatory control of nuclear fuel and control rods, 28 May 2003
- YVL 6.8, Handling and storage of nuclear fuel, 27 October 2003
- YVL 7.5, Meteorological measurements of a nuclear power plant, 28 May 2003
- YVL 7.11, Radiation monitoring systems and equipment in nuclear power plants, 13 July 2004
- YVL 7.18, Radiation safety aspects in the design of a nuclear power plant, 26 September 2003.

Prior to the making of the above decisions, Teollisuuden Voima Oy assessed how the requirements in each guide would be fulfilled. Olkiluoto 1 and 2 fulfil all the requirements of Guides YVL 1.5, YVL 6.3 and YVL 6.8 and they entered into force as such at the plant.

In its assessment of Guide YVL 2.2, Teollisuuden Voima Oy suggested that the transient and accident analyses for Olkiluoto 1 and 2 fulfil, for the most part, the requirements of the new guide. The deficiencies detected by the licensee pertain to sensitivity analyses, which have been extensively addressed in connection with probabilistic safety analyses (PSA). In addition, the assessment of severe accident test results on the coolability of a core melt is under way. So far, the results have not shown any need to update the severe accident analyses. STUK established in its decision that after the completion of a final assessment, Teollisuuden Voima Oy will have to further define the assumptions used in the anlyses, if necessary.

As regards Guide YVL 2.5, STUK was able to establish, based on a report submitted by the licensee, that the requirements of the new guide are fulfilled for the most part. STUK additionally required, however, for the licensee to consider whether a separate guide is needed on the drawing up of pre-operational testing programmes for modifications to be made at Olkiluoto 1 and 2.

In its assessment of Guide YVL 2.8, the licensee presented schedules for, among others, the development of in-service piping inspection programmes using risk-informed methods. At STUK's request, the licensee further defined its clarification on the use of risk analyses to develop the Technical Specifications, safety classification and the preventive maintenance programme during operation. By its decision, STUK confirmed the schedules proposed by the licensee to apply new requirements. As a deviation from the level of requirements, higher than previously, in nuclear power plant design, it was approved that the design-basis core melt frequency for new nuclear power plants is not achieved at Olkiluoto 1 and 2. Licensee analysis gives $1.64 \cdot 10^{-5}$/year as the core melt frequency of the plant units, whereas the target value in Guide YVL 2.8 is 10^{-5}/year.

The licensee presented a plan to fulfil the new qualification requirements of Guide YVL 3.8. STUK approved the assessment about the fulfilment of safety requirements and the plan for inspection qualification. The qualification schedule extends until the year 2008.

STUK considered insufficient the clarification on Guide YVL 7.5 and called for an improvement of the onsite weather measurement system and for more measurement stations in the plant's protective zone. The review of a more detailed plan submitted by the licensee is under way at STUK. As regards Guide YVL 7.11, STUK was able to establish, based on the licensee's clarification, that the guide's requirements are fulfilled when the forthcoming renewal of the fixed radiation measurement system is taken into consideration. The licensee's clarification on Guide YVL 7.18 was in line, for the most part, with STUK's view of the fulfilment of the requirements. However, STUK required additional clarifications on certain requirements on provision made for radiation conditions during severe accidents.

3.2.2 Assessment of safety analyses

Deterministic safety analyses

The licensees update deterministic safety analyses for nuclear power plants in connection with the renewal of operating licences. The analyses are updated also in connection with plant modifications, or whenever operational events warrant it. STUK reviews licensee analyses and conducts, or commissions the conducting, where necessary, of its own reference analyses. In 2004 the Olkiluoto plant commissioned a new type of fuel the deterministic safety analyses for which Teollisuuden Voima Oy submitted to STUK for approval. STUK reviewed the analyses and approved the use of the new fuel type at the Olkiluoto plant as of the 2004 refuelling. No other deterministic safety analyses were submitted to STUK for review.

Probabilistic safety analyses

STUK reviewed the flood risk analysis for the Olkiluoto plant. Onsite flooding accounts only for a small share of the core melt frequency although the new flood route found in a previous inspection (flooding in the sea water circuit spreads via the turbine building to the auxiliary building) accounts for a significant part of the flood risk. The modelling of the new flood route plus the lower flow rates yielded by new fault statistics contribute to the outcome. If calculated using the model employed in the previous analysis update (rev. 2) and its flow rates, the plant's core melt frequency from flooding of the sea water system would be by a factor of approx. ten higher than the analysis outcome now updated.

The frequency of the most significant flood-initiating event (a large sea water system pipe leak) has decreased only by a factor of approx. 3, i.e. relatively less than those of other flood-initiating events. This is because analyses of the spreading of sea water system flooding brought forth new risk-increasing factors. The risk from sea water system flooding thus increased compared with other flood events.

The most significant leaks from the sea water system are from the system's leaking rubber seals, which lead to the loss of shutdown cooling. The major part of the risk in sea water system leaks is from the loss of shutdown cooling.

Based on the new analysis data, flooding-induced core melt probability per year has reduced from approx. $1.5 \cdot 10^{-6}$ to approx. $1.6 \cdot 10^{-7}$. Because of the new failure data, the overall frequency/year of flood-initiating events has decreased from approx. $8 \cdot 10^{-2}$ to $5.5 \cdot 10^{-3}$. Considerable uncertainties still relate to the frequencies of the flood-initiating event, particularly as regards flanges and rubber sealings.

Teollisuuden Voima Oy has submitted to STUK a plan to reduce the risk of flooding in sea water systems. It also submitted an updated flood-risk analysis (rev. 4) to STUK for review at the end of 2004.

3.2.3 Oversight of plant modifications

The Olkiluoto plant is undergoing turbine plant upgrading, which includes the replacement of steam driers in the reactor pressure vessel. This upgrading is discussed later in this report under "Ageing". Safety improvements at the plant units, completed in 2004, are described in Appendix 2.

Plant modifications oversight consisted of the definition of regulatory scope, the handling of documents pertaining to the modifications as well as the supervision of their implementation and commissioning. STUK supervised the carrying out of component and structural modifications by inspections at the plant sites and the manufacturers' premises as well as by reviewing documents submitted by the licensees. Modifications oversight included STUK/licensee meetings and STUK internal oversight meetings.

In consequence of the modifications already implemented at the plant, several documents changed that describe the plants' operation and structure – such as the Technical Specifications, the Final Safety Analysis Report and the operating and maintenance instructions. STUK reviewed the document revisions and generally followed the updating of plant documentation after the modifications. The results of the follow-up are given in Appendix 1 (indicator A.I.6).

3.2.4 Oversight of plant operability

Compliance with the Technical Specifications

Compliance with the Technical Specifications at the Olkiluoto power plant was controlled by witnessing operations onsite. The testing and repair of components subject to the Technical Specifications were subject to oversight in particular. After the completion of the annual maintenance outages, the plant unit's compliance with the Technical Specifications was ascertained before startup. The licensee is obliged to immediately report to STUK all plant situations in non-compliance with the Technical Specifications.

One situation occurred at the Olkiluoto plant units during which a plant unit was in non-compliance with the Technical Specifications (Appendix 1, indicator A.I.2). This happened when one subcondition of the reactor protection system was briefly bypassed at both plant units. The event is looked into in more detail in Appendix 3. The licensee has planned and carried out actions to prevent recurrence.

The Technical Specifications were deviated from also by applying in advance for STUK's approval of non-compliances. In 2004, the licensee applied for approval of nine situations in non-compliance with the Technical Specifications. (Appendix 1, indicator A.I.2). After an analysis of the safety significance of the events, STUK approved the applications. Five exemptions were in preparation for the construction of the new plant. Two approvals pertained to the future operation of the plant units: one to the testing of a 12-h operator shift and the other to the renovation of pumps in the sea water systems.

Operation and operational events

Both Olkiluoto plant units operated reliably. The load factor of Olkiluoto 1 was 95.1% and that of Olkiluoto 2 was 96.1%. Figure 5 gives the load factors of the plant units in 1995–2004. The annual maintenance outage of Olkiluoto 1 was 16 days and that of Olkiluoto 2 nine days. The progress of the outages and the measures carried out are separately described in this chapter. At Olkiluoto 1, one reactor scram and one partial reactor scram occurred, both of which briefly interrupted power generation. The first scram followed the inadvertent closing of a main steam valve and the second was caused by a malfunction in the cooling system of a diesel generator. The scrams are explained in more detail in Appendix 3.

In addition to the annual maintenance outages and the reactor scrams, brief interruptions in power generation due to component malfunctions occurred at both Olkiluoto 1 and 2. The interruption at Olkiluoto 1 was due to trouble shooting pertaining to disturbance peaks in the position indicator of a relief system control valve. At Olkiluoto 2 it was due to the repair of a component malfunction in the cooling system of a diesel generator.

Losses in nominal output from component malfunctions were 0.8% at Olkiluoto 1 and 1.2% at Olkiluoto 2. Appendix 1 looks at production losses

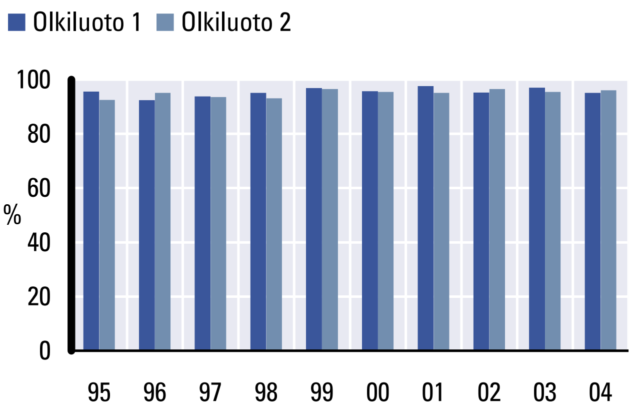

Figure 5. Load factors of the Olkiluoto plant units.

from component malfunctions for a longer period (indicator A.1.1.g). Figure 6 gives the daily average gross powers of the plant units in 2004.

Two events warranting a special report, two reactor scrams and six operational transients to be reported to STUK occurred at the Olkiluoto plant units (Appendix 1, indicator A.II.1).

The below events at the Olkiluoto plant warranted a special report:

- A fuel handling error at the Olkiluoto spent fuel storage (INES Level 0)
- A non-compliance with the Technical Specifications when protection limits were bypassed during testing (INES Level 0).

The events are described in Appendix 3.

In addition to event reports, Olkiluoto plant submitted to STUK daily reports, quarterly reports, annual reports, outage reports, annual environmental safety reports, monthly individual radiation dose reports, annual operational feedback reports and safeguards reports.

Figure 7 gives the number of INES Level 1 events in 1995–2004. No events higher than Level 1 occurred.

Annual maintenance outages

The Olkiluoto 1 maintenance outage was on 9 to 25 May 2004 and the Olkiluoto 2 refuelling outage on 25 May to 3 June 2004. Olkiluoto 1 stopped electricity generation for about 16 days and Olkiluoto 2 for about 9 days. Both outages lasted for about a day longer than planned. At both plant units, refuelling machine malfunctions were the main cause for the extensions.

In addition to reactor refuelling, the licensee carried out maintenance and inspection of components, structures and systems during the annual maintenances. The inspections are described in more detail later under "Maintenance and repairs". The safety modifications made during annual maintenance are described in Appendix 2.

One near miss situation occurred during the Olkiluoto 1 annual maintenance when three fire fighters were exposed to escaped gaseous nitrogen onsite. They were taken to hospital by ambulance but were sent home the same evening after a health inspection.

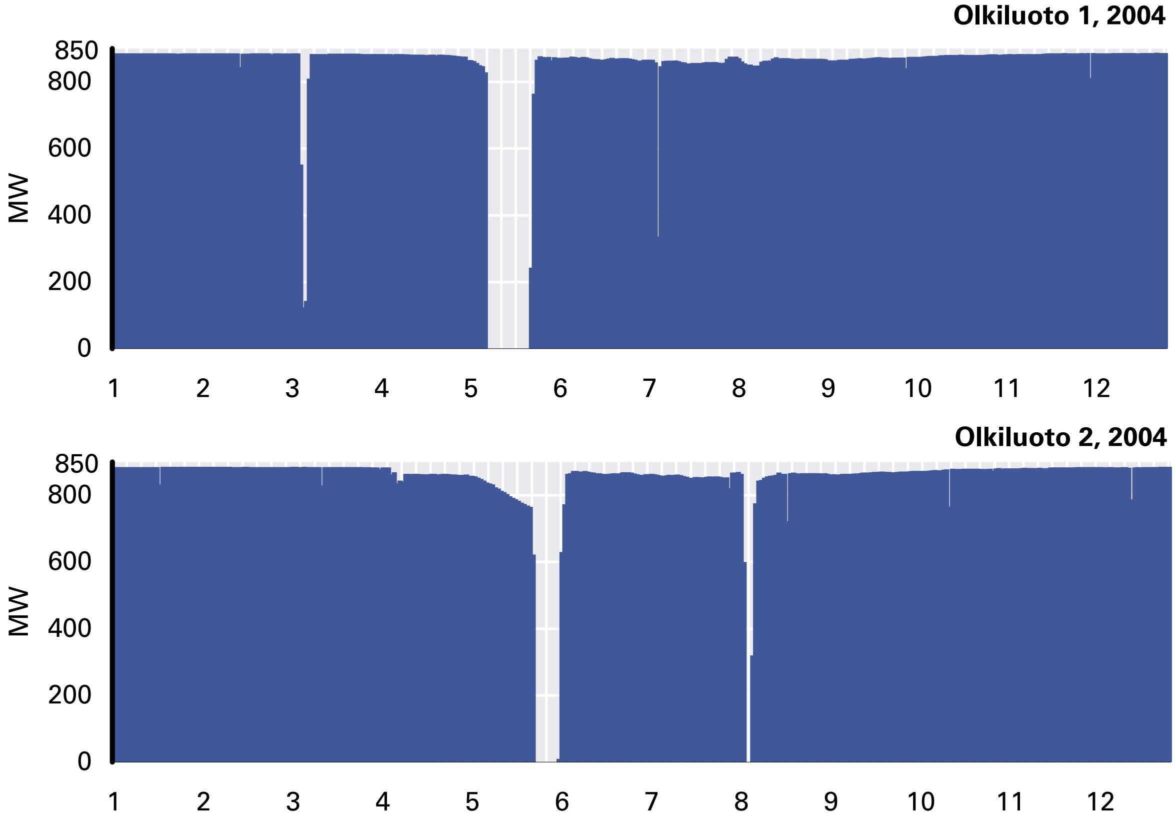

Figure 6. Daily average gross power of the Olkiluoto plant units in 2004.

The collective radiation dose incurred in outage work was 0.92 manSv at Olkiluoto 1 and 0.39 manSv at Olkiluoto 2. Occupational radiation doses are discussed in more detail later in the report under "Radiation safety" and in Appendix 1 (indicator A.I.4).

Regulatory oversight of the annual maintenance outages of Olkiluoto nuclear power plant focused, among others, on the administrative arrangements of outage work, the activities of the operating and maintenance personnel, refuelling as well as inspections and tests by the licensee and contractors. Attention was also paid to the implementation of radiation protection, control room operations and housekeeping. Prior to the start of a new fuel cycle, safety analyses for the new fuel charge were reviewed. In addition, it was inspected that fuel assemblies were loaded into the reactor according to plan. The nuclear material inventory was inspected prior to the closing of the reactor pressure vessel head. In addition, STUK controlled the placement of the plant units into shutdown state and their post-outage start-up.

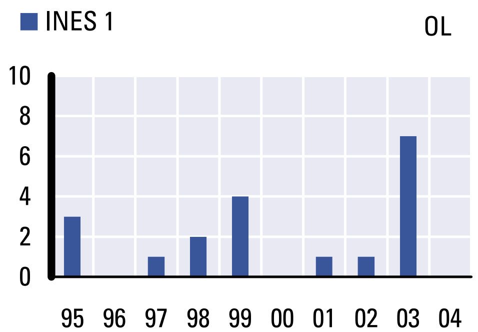

Figure 7. INES classified events at Olkiluoto plant (INES Level 1 and higher).

The regulatory oversight of Olkiluoto facility's annual maintenance outages onsite took 99 working days. Two resident inspectors were regularly working on the site as well.

Repairs and maintenance

A containment leakage test and the replacement of feedwater distributors were among the most important repairs and maintenance carried out during the Olkiluoto 1 annual maintenance outage.

A crack detected in a feedwater nozzle at Olkiluoto 2 in 2003 was checked and ascertained to have remained the same, i.e. it does not prevent the plant's operation. The most significant new observation was the cracking of the support plates of the lugs of new feedwater distributors that were installed in 2003. This matter is separately discussed in Appendix 3.

During the annual maintenance outages of the Olkiluoto plant, STUK inspected 22 Safety Class 1 and 2 items of pressure equipment subject to registration in accordance with the Pressure Equipment Act. In addition, the periodic inspection of pressure equipment was controlled by reviewing the relevant programmes. A total of 223 structural inspections of mechanical components, inspections of repairs and modifications as well as commissioning inspections were made. An inspection comprises one or several partial inspections such as review of results documentation, inspection of a component or structure, a pressure or leakage test, a functional test or an operational safety inspection. In addition, nine inspections of electrical and I&C equipment were made, which, too, comprise several partial inspections.

STUK witnessed at the plant site inspections of mechanical components and structures in Safety Classes 3, 4 and Class EYT (non-nuclear) by the utility's inspection unit "Teollisuuden Voima Oy inspection organisation". Safety classification is based on STUK guidelines, i.e. Guide YVL 2.1, which assigns a nuclear power plant's systems, structures and components to the Safety Classes 1, 2, 3 and 4 as well as Class EYT. Items with the highest safety significance belong to Safety Class 1.

Ageing

In the 2003 organisation of Olkiluoto power plant, responsibility for the long-term follow-up of the ageing of components, structures and systems has been with the engineering department. The operations department follows and reports on any ageing observed in maintenance. The engineering department was divided into two in 2004. Responsibility for the structural upkeep of production capability, considering lifetime follow-up, rests with the new department of power plant engineering.

In 2004, a project significant for the operating lifetime of Olkiluoto 1 and 2 was continued: a turbine plant upgrading project, which includes replacement of steam dryers inside the reactor pressure vessels. Olkiluoto 2 is due for modification in the 2005 annual maintenance outage. Turbine automation is replaced by computer-based technology and, for the upgraded system sections, new control interface technology will be commissioned, which was included in the training simulator in the autum of 2004.

STUK reviewed follow-up reports on the ageing of mechanical components and electrical and I&C systems and assessed structural ageing follow-up during inspections. The analysis and management of whisker growth in the zinc coated parts of realys was an important object of control.

Inspection methods are to be qualified to improve the reliability of the in-service inspection of the most important mechanical components by non-destructive methods. An agreement on the renewal of the qualification organisation was signed by Teollisuuden Voima Oy, Fortum and Inspecta Oy. It entered into force on 1 January 2005 and is valid until 31 December 2010. According to the agreement, SFS Inspecta Certification is the organisation responsible for the activities of a qualification body in accordance with Guide YVL 3.8. The national regulations on qualification were amended in 2004 to comply with the new organisation.

Radiation safety

Occupational radiation safety

The radiation doses of all those who worked at Olkiluoto nuclear power plant in 2004 were below the 50 mSv annual limit. The distribution of individual doses in 2004 is given in Table I. The highest occupational dose to an individual at Olkiluoto nuclear power plant was 12.95 mSv. In 2000–2004, individual radiation doses did not exceed the dose limit of 100 mSv defined for any period of five years.

In 2004 the collective occupational dose was 1.06 manSv at Olkiluoto 1 and 0.45 manSv at Olkiluoto 2; the total for both plant units being 1.51 manSv. STUK guidelines state that the threshold for one plant unit's collective dose averaged over two successive years is 2.10 manSv. This was not exceeded in either plant unit. The collective occupational dose was low by international comparison. The collective occupational radiation doses incurred over the past years are given in Appendix 1 (indicator A.I.4).

Radioactive releases

Radioactive releases into the environment from Olkiluoto nuclear power plant were well below authorised limits in 2004. The releases of noble gases and iodine into the atmosphere were below the detection limit. Aerosol releases into the atmosphere were approx. 21 MBq, tritium releases into the atmosphere approx. 0.3 TBq and carbon-14 releases into the atmosphere approx. 0.8 TBq. The tritium content of liquid effluents released into the sea was 2 TBq. The total activity of other radionuclides released into the sea was 0.5 GBq, i.e. approx. 0.2% of the plant-site specific release limit.

The calculated radiation dose of the most exposed individual in the environment of the Olkiluoto plant was approx 0.04 mSv, i.e. less than 0.04% of the limit prescribed by a Government Resolution (100 mSv). Appendix 1 (indicator A.I.5) presents radioactive releases and the radiation doses calculated for the most exposed individual in the plant's environment over the past years.

Environmental radiation monitoring

Radiation monitoring in the environment of a nuclear power plant encompasses on- and off-site radiation measurements and determination of radioactive substances to establish population radiation exposure and radioactive substances in the environment.

In the environment of Olkiluoto nuclear power plant, 293 samples were analysed in accordance with the monitoring programme. Radioactive substances originating in Olkiluoto nuclear power plant were measured in two samples of air, one sample of bottom fauna, 15 samples of aquatic plants and 14 samples of sinking matter. The tritium content of one sea water sample was above normal. The dominating power plant based radioactive substance, cobalt-60, was measured in all of the aforementioned samples. The total number of observations was 33. Apart from cobalt, cobalt-58 and manganese-54 were measured in one sample of aquatic plants.

All the detected concentrations were low and had no bearing on radiation exposure.

For external radiation measurement, 10 automatic radiation measuring stations have been placed at a distance of about five kilometres from the plants. The measurement data from these stations are transferred to the power plants' control rooms and to the national radiation-monitoring system. There are 11 dosimeters in the environment of the nuclear power plants. No radiation doses above background level were measured.

3.2.5 Oversight of organisational operation

Safety management

Information accumulated during document review and other inspection activity at the Olkiluoto plant was examined in 2004 with a view to the management of plant safety.

In the autumn of 2003, several measures to improve the plant's organisation were launched at the Olkiluoto plant. The licensee set up a working group to develop operations, recruited more personnel for tasks pertaining to operational experience feedback and commissioned analyses and training to external consultants, among others. The licensee also conducted a self-assessment of safety culture within its organisation based on IAEA guidelines.

Quality management system

Olkiluoto nuclear power plant has systematically maintained and developed its quality management system according to own plans. A revised, ISO 9001-based management system was launched in 2001.

The licensee regularly evaluates the functionality of its quality management system by an internal follow-up programme and a separate, independent inspection procedure.

STUK oversaw quality management and its functionality by document reviews and inspections of its periodic inspection programme. The quality management system of the licensee was found acceptable. The operation of Teollisuuden Voima Oy was found to be in compliance with the plant's own quality management system. The remarks made during the inspections were mostly on further development of the system and definition of detail.

Personnel qualifications, training and resources

Personnel recruitment by Teollisuuden Voima Oy continued, mostly for the purpose of the new nuclear power plant unit. Experienced operating personnel from the operating plant units have moved to tasks pertaining to the new plant unit and new employees have been recruited in their place. Several persons recently employed by Teollisuuden Voima Oy participated in a 6-week basic professional training course on nuclear safety in Finland.

STUK oversaw the appropriateness and adequacy of Olkiluoto power plant's organisation and its personnel training within the framework of its periodic inspection programme. The plant's procedures pertaining to personnel qualifications, training and resources as well as training relating to the personnel of Olkiluoto 3 and the construction project were evaluated in a separate training inspection.

Upon licensee application, several employees were authorised to act as shift managers or operators at the nuclear power plant. A total of 22 Olkiluoto personnel were authorised, most of them for a new 3-year period. A person was authorised for the Olkiluoto plant with responsibility for emergency preparedness and physical protection. A deputy for the responsible manager was authorised as well.

The plant's operating organisation or procedures have not significantly changed. The construction of the new plant unit has considerably increased the number of personnel at Teollisuuden Voima Oy as well as their task rotation. A significant change for the operating plants is an increase in the resources of operational experience feedback and the recruitment of an expert in behavioural science. Teollisuuden Voima Oy's organisation has sufficient resources and qualifications to safely operate the plant units.

Operational experience feedback

STUK oversaw operational feedback activities by reviewing the event reports and the annual operational experience feedback report submitted by the licensee. The Olkiluoto plant has systematic and regulated procedures for event investigation, assessment and corrective action.

The licensee's operational experience feedback consisted of the handling of events at own and other plants. Events at plants abroad were dealt with in a special operational feedback working group. The objective is to prevent recurrence of events endangering plant safety. The development measures carried out at the plant units in 2004, based on operational experience feedback, were minor improvements to mostly methods of action and guidelines as well as component inspections and additional analyses. Operational experience feedback information was distributed to the personnel in the form of reports and training.

The Olkiluoto plant continued improvements made due to the higher-than-usual number of plant conditions in 2003 in non-conformance with the Technical Specifications. Factors common to the events included insufficient compliance with guidelines, administration of periodic testing, follow-up of plant states and indentification of the requirements of the Technical Specifications. The events were throgoughly reviewed at the plant. Teollisuuden Voima Oy commissioned an analysis of the events to an external expert. The conclusions were discussed in the various organisational units of the licensee as well as in a STUK/licensee seminar. STUK follows how the licensee incorporates the lessons learned into the plant's procedures.

STUK evaluated the feasiblity of the lessons learned from events abroad for taking into account at Finnish plants. Data on the events was obtained through the Incident Reporting System (IRS) of the IAEA and OECD. In 2004, 80 event reports were reviewed, eight of which led to a detailed inspection after preliminary assessment. No event in 2004 required immediate action by the licensee. One event led to the taking into consideration of a lesson learned at the Olkiluoto plant during STUK's normal oversight activities.

STUK's periodic inspection programme

Fifteen inspections of the periodic inspection programme were conducted at the Olkiluoto plant in 2004, one of which was postponed until early 2005. The inspections contained in the periodic inspection programme are listed in Appendix 4. Safety management, main operational processes and procedures as well as the technical acceptability of systems were looked into. The inspections ensured that plant safety assessment, operation, maintenance and protection activities comply with nuclear safety regulations. The annual inspection programme was brought to the attention of the licensee at the beginning of 2004 and inspection dates were agreed upon with the licensee.

Information was acquired through oral reports requested from licensee's experts, personnel interviews, document reviews, walk rounds, witnessing of work on site as well as various measurements, i.a. to establish accuracy of measuring equipment. None of the observations had significance for plant unit safety. Relevant corrective action was initiated onsite.

Event investigation

STUK started no event investigations in 2004. A team is set up to investigate an event whenever the licensee organisation has not functioned as planned in connection with an event or when an event is assessed to lead to significant modifications in the plant technical layout or procedures. A STUK investigation team is set up also in case the licensee has not sufficiently analysed the root causes of an event.

STUK conducted a topical inspection of the use of contractors at Olkiluoto power plant. The use of system, component and services suppliers at the plant was assessed as well as the relevant procedures and practices. Demanding maintenance of special components (control rod drive actuator maintenance) and engineering service contracting (renewal of steam dryers) were chosen as examples of contracted work and service suppliers used by the power plant. The power plant's procedures to co-ordinate and control the work of suppliers, to assess the suppliers and familiarise them with the plant procedures were found deficient. Attention was paid to the preservation of the know-how of an important engineering supplier in particular as well as to the assessment and assurance of the plant's own know-how as regards outsourced maintenance tasks.

Pressure equipment manufacturers, and inspection and testing organisations

Upon application by Teollisuuden Voima Oy, and in accordance with the Nuclear Energy Act, STUK authorised two manufacturers of nuclear pressure equipment.

In accordance with the Nuclear Energy Act, STUK also authorised six testing organisations to conduct nondestructive testing relating to the manufacturing of mechanical components and structures for the Olkiluoto plant units. Testers employed by four separate testing organisations were authorised to carry out in-service inspection of mechanical components and structures of the Olkiluoto plant units. Previous decisions pertaining to manufacturers and testing organisations are valid as mentioned in the decisions.

Inspection Unit "Teollisuuden Voima Oy inspection organisation", authorised in 2002, continued in operation.

The manufacturers as well as testing and inspection organisations authorised by STUK were subject to regulatory oversight. Their operation was established to comply with the requirements of Guides YVL 3.4 and YVL 1.3.

In accordance with Guide YVL 5.2, valid as of 1 December 2004, and upon application by Teollisuuden Voima Oy, STUK authorised Teollisuuden Voima Oy's inspection unit "Teollisuuden Voima Oy, Inspection, electrical and I&C inspection" and persons in Teollisuuden Voima Oy's employment to conduct commissioning inspections of Olkiluoto nuclear power plant's safety classified electrical and I&C components.

Nuclear liability

The users of nuclear energy must have acquired liability, or other financial guarantee, as stipulated in the Nuclear Liability Act (484/1972) for a possible accident at a nuclear facility that would harm the environment, population and property. Teollisuuden Voima Oy has prepared for damage from a nuclear accident as prescribed by law by taking out an insurance policy for this purpose mainly in the Finnish Nuclear Insurance Pool.

In the 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 2004, a total of about 425 000 000 € was available for compensation from all these sources. An increase in the sum is expected in the near future since international negotiations about the revision of the Paris/Brussels agreements on nuclear liability were completed in 2004. The funds available for compensation will more than triple in the coming years compared with the current situation. In addition, the enactment of unlimited licensee liability by law is under consideration in Finland.

The revision of the contents and conditions of a licensee's insurance policy in Finland belongs to the Insurance Supervisory Authority. It has approved Teollisuuden Voima Oy's liability insurance and STUK has verified the existence of the policy in accordance with section 55 of the Nuclear Energy Act (990/1987).

The transport of nuclear materials is subject to the Nuclear Liability Act. STUK has seen to it that all nuclear material transport has had liability insurance approved by the Insurance Supervisory Authority, or in accordance with the Paris Convention, and approved by the authorities of the sending country.

3.2.6 Nuclear safety indicators

The requirements set for the indicators on the effectiveness of STUK's activities were fulfilled at Olkiluoto power plant as regards occupational radiation doses, collective radiation doses, radioactive releases and population exposure.

No safety-endangering events occurred at the Olkiluoto plant units. The number of events reported in accordance with Guide YVL 1.5 was on a marked decrease. No fires occurred on the Olkiluoto site. A special report was written on two events and an operational transient report on six events.

The indicator system looks at the risk-importance of operational events. Based on their risk-significance, events are divided into three categories, the indicator being the number of events in each category. One reactor scram occurred at Olkiluoto 1 and all safety systems operated as designed. Since no events at Olkiluoto power plant significantly compromised safety, the scram in question became the event most significant from the risk point of view in 2004. Eight other events belonging in the highest risk category occurred at the plant. They were caused by both planned unavailabilities and failures relating to latent emergency diesel generators at both plant units and, at Olkiluoto 2, to the shutdown reactor intermediate cooling system. The number of the most risk-significant events was on the increase at Olkiluoto. The events analysed for 2004 are part of nuclear power plant normal operation and required no additional action by STUK.

The annual maintenance volume of components subject to the Technical Specifications at Olkiluoto power plant has been on the decrease over the past two years, which is affected by the downward trend in the total volume of preventive maintenance work for several years now. Correspondingly, the number of failures has grown linearly. The volume of operation restriction work during power operation showed an increasing trend for the second year in succession. The number of failures of Tech Spec components causing operation restrictions was specifically high at Olkiluoto 1 in particular. The growing trend in failures would indicate a weakening plant condition. A simultaneously decreasing volume of preventive maintenance jobs could indicate problems in component lifetime management. Average failure repair times were short at the Olkiluoto plant units. Production losses from them were higher than over the past years on average. The coming years will show whether an actual change has occurred in the trend.

The structural integrity of multiple barriers containing radioactive releases has been good. Small fuel leaks have occurred at the Olkiluoto plant units almost annually. The status of the leaks has been followed during power operation and leaking fuel assemblies have been removed from service in forthcoming annual maintenance outages. The number of identified and unidentified primary circuit leaks at both plant units was small during the operating cycle 2003–2004. The indicators for primary circuit chemistry at Olkiluoto 1 showed a low impurities and corrosion product content in 2004. High chloride concentrations at Olkiluoto 2 indicated turbine condenser leaks. No unambiguous explanation was found for the sulphate concentration of Olkiluoto 2 reactor water, which exceeded threshold value in the third annual quarter. Concentrations of corrosion-inducing impurities, which briefly exceed normal level, have not been shown to negatively affect structural materials.

The indicators show improvement in the operation of the Olkiluoto plant. Set objectives were achieved in quality assurance and radiation protection. Indicators for failure of components subject to the Technical Specifications, maintenance and unavailability of safety systems indicated possible problems in the maintenance strategy or in the plant's lifetime management. This observation is supported by technical causes for events and growth in the number of the most risk-significant events and their underlying component failures. Fuel integrity has been problematic at the Olkiluoto plants almost every year.

The results of STUK indicators for 2004, which depict plant safety, are given in Appendix 1.

3.2.7 Overall safety assessment

The annual safety assessment for the operating Olkiluoto 1 and 2 units looks at the implementation of new YVL guides at the plant as well as observations made in regulatory oversight in 2004 on plant safety analyses, modifications, availability and organisational operation. These are discussed in more detail in sub-sections 3.2.1–3.2.6 and in the appendices of this report. No significant nuclear safety related shortcomings surfaced during STUK's oversight activities.

During the implementation of new YVL guides on reporting, safety analyses, commissioning, testing, nuclear fuel and radiation protection nothing prevented the commissioning of the revised procedures. In the case of some guides, the realisation of licensee plans several years of duration calls for determined and persistent work. As a deviation from the set level of requirements in nuclear power plant design, it was approved, as regards Guide YVL 2.8, that the design-basis core melt frequency established for new nuclear power plants is not achieved at Olkiluoto 1 and 2. According to a licensee analysis, the core melt frequency for the Olkiluoto plant units is approx. $1.64 \cdot 10^{-4}$/year, whereas the target value in accordance with Guide YVL 2.8 is 10^{-5}/year.

According to Olkiluoto nuclear power plant's new, updated flood risk analysis, flood-caused core melt probability is approx. $1.6 \cdot 10^{-7}$/year. The licensee has devised a plan to further decrease the flood risk.

A project significant for the lifetime of Olkiluoto nuclear power plant, i.e. turbine plant upgrading, continued in 2004, and it includes the replacement of steam driers inside the reactor pressure vessels. The modifications will be first implemented in the Olkiluoto 2 maintenance outage of 2005. Turbine automation will be realised by computer-based technology. At the same time, new operator interface technology for the upgraded sections of automation will be introduced in the control room.

No significant disturbances occurred during the operation of the plant units, which was in compliance with the Technical Specifications, with one exception. The number of events requiring reporting to STUK was small. Two events warranted a special report and six operational disturbances were reported. The construction of the new plant unit required special measures to ascertain the safety of operating plant units. These mostly had to do with supervision of blasting operations, physical protection and supply of electrical power and cooling water. The construction work also made it necessary for the operating plant units to deviate from the Technical Specifications i.a. due to electrical cable routing work.

The annual maintenance outages of the Olkiluoto plant units were short and mostly consisted of refuellings and normal maintenance and inspection. At Olkiluoto 1, also a containment leak test was made and a condensate purification process was modified. Of the observations made during the annual maintenances, the detection of a new crack in the feed water distributors warrants a mention. The administration of the annual maintenances complied with the licensee's procedures and no major deviations were made. One near-miss event occurred at the Olkiluoto 1 annual maintenance when three fire fighters were exposed to nitrogen gas that escaped inside the plant.

The radiation doses of all nuclear power plant workers were below the individual dose limit. The collective occupational dose was low internationally. Radioactive releases were low and the dose calculated on their basis for the most exposed individual in the vicinity of Olkiluoto nuclear power plant was well below the limit established by Government Resolution.

In consequence of an organisational renewal in 2004, a task important for the plant's ageing management, i.e. lifetime follow-up, rests with the new department of power plant engineering. No specific safety shortcomings surfaced in inspections of the ageing management of mechancial components, electrical and I&C systems and structures. Respective indicators show an unfavourable trend, however. Indicators depicting the malfuctioning of components subject to the Technical Specifications, the maintenance function and safety system unavailability show possible problems in the maintenance strategy or in the plant's lifetime management. An important matter under clarification is whisker growth in the zinc coatings of relays of the reactor protection system, which relates to ageing of I&C systems. The structural integrity of multiple barriers containing radioactive releases is good, although problems in fuel integrity have occurred almost every year.

Qualification of the in-service testing of the most important mechanical components by nondestructive methods was improved in 2004. Both licensees and Inspecta Oy have agreed upon national arrangements for carrying qualification into effect and for designating SFS Inspecta Certification as the organisation responsible for the operation of the qualification organisation. First qualification operations were carried out in 2004 in accordance with the level of requirements of the new operations model.

The plant's operating organisation or procedures did not significantly change in 2004. The safety indicators show an improvement in the operation of Olkiluoto power plant. The construction of the new plant unit has markedly increased the number of Teollisuuden Voima Oy's personnel and their job rotation. The many measures started in 2003 to improve the operation of the organisation were continued. A significant change for the operating plants is an increase in the resources of the operational experience feedback function and the recruitment of an expert in behavioural sciences. In addition, a self assessement of safety culture was conducted in 2004. Teollisuuden Voima Oy has sufficient resources and qualifications to safely run the plant units.

The periodic inspection programme of Olkiluoto power plant, implemented by STUK, revealed no significant safety defects.

STUK did not start any new investigations into the plant's operation in 2004.

3.3 Olkiluoto 3

Teollisuuden Voima Oy (TVO) applied to the Government for a licence, in accordance with the Nuclear Energy Act, for the construction of a nuclear power plant unit called Olkiluoto 3 in Eurajoki, Olkiluoto. The plant unit is a European pressurised water water reactor (EPR) with a 4300 MW reactor thermal power and a net electrical capacity of approx. 1600 MW. The licence application was submitted to the Ministry of Trade and Industry on 8 January 2004. On 16 January 2004, the Ministry requested statements on it from STUK, among others.

The plant unit is supplied by a consortium of Framatome ANP and Siemens AG, CFS. When preparing its statement to the Ministry, STUK assessed the plant unit's safety. The manufacturing of main components and earth-moving operations on the site were supervised. STUK evaluated the operation of the licence applicant, vendor and subcontractors by inspections and audits.

Review of documents pertaining to the construction licence application

In early 2004 Teollisuuden Voima Oy submitted to STUK documents, as referred to in section 35 of the Nuclear Energy Decree, relating to the construction licence application. The documents include a Preliminary Safety Analysis Report, a draft classification document, an analysis of quality assurance during construction, plans for physical protection and emergency preparedness, a plan for the arrangement of control necessary to prevent the proliferation of nuclear weapons and a description of arrangements to enable STUK's control. The licensee also submitted to STUK a Preliminary Probabilistic Safety Analysis and safety assessments for the plant and its systems. A part of an analysis of quality assurance during construction, STUK reviewed the project's quality management system. The licensee complemented these documents several times during 2004 due to observations made by STUK during reviews and the progress made in planning. These document reviews were the basis for an assessment of plant safety; the results can be found in a safety assessment attached to the statement.

The plant unit's safety was mostly assessed at STUK but also external experts were used to review the plans. In support of its own inspection activity, STUK commissioned i.a. independent reference analyses of the plant's behaviour during disturbances and accidents and the radiation effects of events. The work was mostly commissioned to VTT State Technical Research Centre in Finland and some of it to the German research institute ISaR. To complement own inspections, STUK commissioned an expert opinion on reactor primary circuit design and a study of aircraft impacts in design to the German research institute Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH. In addition, expert opinions were requested on i.a. I&C systems, emergency cooling systems, primary coolant water chemistry, buildings design, fire safety and provision made for weather and electromagnetic phenomena. In addition to VTT, ISaR and GRS, other domestic and foreign independet experts and enterprises were used.

To evaluate the acceptability of technical solutions, STUK commissioned analyses and tests on severe accident management and the examination of the effects of aircraft impacts. In addition, i.a. plans for emergency preparedness and fire safety were discussed with other authorities (authorities of the Eurajoki municipality, the Ministry for the Interior, among others).

STUK required modifications to the plant design to fulfill Finnish safety requirements. These focused on the improvement of the reliability of safety functions: increased redundancy of systems important to safety, more extensive utilisation of the diversity principle in the implementation of safety functions and improvement of the physical separation of systems.

STUK required TVO to make its quality management procedures more specific to fulfil the requirements of YVL guides. Physical protection and emergency preparedness arrangements need to state in more detail the consideration of the Olkiluoto 3 construction site in the Olkiluoto 1 and 2 guidelines for physical protection and emergency preparedness.

Vendor evaluation

Evaluation of vendor performance was based on a review of the quality management programme, quality plans and manuals as well as audits to verify operations. STUK participated in almost all audits of vendor performance conducted by Teollisuuden Voima Oy. The audits were conducted to establish the vendor's capability to high-quality planning and construction. The audits focused on quality management, project administration and planning in various technical fields (electrical, I&C, process, mechanics, air conditioning, structural engineering, safety and strength analyses).

STUK participated in the audits of some of the vendor's subcontractors important to safety. STUK reviewed the vendor's radiation protection plan and the compilation of the probabilistic safety analysis and its utilisation in the plant's planning. As a result, several observations were made requiring corrective action. The status of the measures was checked and ascertained acceptable prior to the issuing of the statement.

Control of the manufacturing of main components

Control of the manufacturing of primary circuit main components and review of related documents continued in 2004. STUK witnessed the manufacturing of the forged parts of the reactor pressure vessel and steam generators at the Japan Steel Works.

Upon their completion, STUK conducted a structural inspection and granted permission for consignment to the Chalon factory in France and to Mitsubishi Heavy Industries (MHI) in Japan. The welding of first steam generator components was started at the Chalon factory in September 2004. STUK authorised manufacturing in September 2004 after having reviewed 1st phase construction plans for steam generator manufacturing and technical documents. The licence was conditional since the plant design bases were under review at the time. Upon receipt of STUK's permission, MHI started the manufacturing of the reactor pressure vessel in January 2005. STUK's inspectors witnessed the manufacturing of the reactor pressure vessel and the steam generators at Chalon and MHI.

In addition to the above manufacturers, STUK audited the manufacturers of other, mostly primary-circuit related components (primary circulation pumps, pressuriser, reactor pressure vessel internals, primary circuit piping, steam generator heat transfer pipes) to ascertain that the requirements of YVL guides are fulfilled. In relation to the manufacturing of main components, STUK audited and approved testing and inspection organisations.

Inspection of TVO's operations

Inspection of TVO's operation was based on an assessment of its quality management system, the quality of its documents and the results of its safety assessments. STUK inspected also Teollisuuden Voima Oy's project operation in Olkiluoto during the autumn. The objective was to ascertain Teollisuuden Voima Oy's readiness to realise the plant project safely and in high-quality. Inspection was focused on project management and resources, handling of safety-related matters, project administration, quality management and document administration. As a result, STUK required that the procedures for safety assessment and handling of safety-related matters, such as the identification and handling of safety problems within the organisation and decision-making in particular be made more specific. STUK underlined the assurance of the safety of the operating units against the potential effects of the Olkiluoto 3 construction work.

STUK controlled preparatory work on the site by inspecting excavated rock surfaces and witnessing the construction of sea water inlet and outlet structures. STUK approved the construction plans in July 2004. The approvals were conditional because the plant design basis review was still under way. STUK witnesssed the attachment of the technical area circling the Olkiluoto 3 site to the construction site of the new plant. The area provides i.a. electricity, fire water and drainage for the construction site. STUK drew up an inspection programme for inspection of TVO's operations after the start of construction.

Approval of the inspection and testing organisations of pressure equipment manufacturers

Upon application by Teollisuuden Voima Oy, and in accordance with the Nuclear Energy Act, STUK approved two manufacturers of nuclear pressure equipment.

STUK approved, in accordance with the Nuclear Energy Act, three inspection organisations to conduct nondestructive testing relating to the manufacturing of mechanical components and structures and three testing organisations to conduct destructive testing relating to the manufacturing of Olkiluoto 3 mechanical components and structures. The scope of activities of Olkiluoto plant's inspection unit "Teollisuuden Voima Oy inspection organisation", approved in 2002 upon application by Teollisuuden Voima Oy, was extended to include assessment and approval of the design and manufacturing of mechanical components and structures for Olkiluoto 3.

STUK authorised three inspection organisations to conduct third party inspections relating to the manufacturing of components for Olkiluoto 3.

STUK oversaw the operation of the manufacturers and testing and inspection organisations it had approved. Their operation was established as being in compliance with the requirements of Guides YVL 3.4 and YVL 1.3.

Statement

Prior to the submission to the Ministry of Trade and Industry of its statement on the construction licence application, STUK approved documents as referred to in section 35 of the Nuclear Energy Decree. The statement was forwarded to the Ministry in January 2005. Attached to it were a safety assessment and a clarification of the review of documents in accordance with section 35 of the Nuclear Energy Act and a statement by the Advisory Committee on Nuclear Safety.

According to STUK's assessment, it is possible to construct a safe plant unit based on the submitted conceptual design plan. STUK brought forth observations and restrictions, however, as regards fuel burn-up, inspection of planning details, arrangement of regulatory control during construction, radioactive waste final disposal plans, development of Teollisuuden Voima Oy's expertise, and societal commitment to the safe use of nuclear energy. STUK's statement, the safety assessment and the statement by the Advisory Committee on Nuclear Safety can be accessed on the STUK web site (*www.stuk.fi*).

3.4 FiR 1 research reactor

In addition to the electricity-generating nuclear power plants, STUK regulated the FiR 1 research reactor operated by the VTT Technical Research Centre of Finland. The reactor is located in Otaniemi, Espoo, and its maximum thermal power is 250 kW. The reactor is used for fabrication of radioactive tracers, activation analysis, student training and the development of Boron Neutron Capture Therapy (BNCT).

STUK's periodic inspection in 2004 focused on i.a. the reactor's fire protection, emergency preparedness and safeguards. No significant problems were observed in the reactor's operation. Occupational radiation doses and radioactive releases into the environment were clearly below set limits.

STUK confirmed by its decision the licensee's (VTT Processes) proposal for the application of the requirements of Guide YVL 1.5 to the FiR 1 research reactor. An additional requirement was made, however, about the reporting of operational experience feedback to STUK in accordance with the guide's requirements.

3.5 Other nuclear facilities

The regulatory control of nuclear facilities relating to nuclear waste management, such as storage space, is dealt with in Chapter 4.

4 Nuclear waste management regulation

Esko Ruokola

4.1 Nuclear waste management programmes

Posiva Oy, Teollisuuden Voima Oy and Fortum Power and Heat Oy published in early 2004 a report called “Nuclear waste management of the Olkiluoto and Loviisa power plants. Programme for research, development and technical design for 2004–2006”. It is an overview of the R&D and technical design in the field of nuclear waste management by Posiva and its owners in the recent years and also a plan for future activities. It is focused on the years 2004–2006. This new practice of issuing an extensive nuclear waste management report every three years is based on a Ministry of Trade and Industry letter of 3 December 2002.

STUK extensively reviewed the report with the assistance of an external team of experts, and commented it to its writers and the Ministry of Trade and Industry. STUK’s review suggested several improvements to the programme. STUK’s annual statement to the Ministry of Trade and Industry about the licensees’ nuclear waste management actions and plans, as referred to in section 78 of the Nuclear Energy Decree, was also based on the review.

STUK gave statements, as referred to in section 90 of the Nuclear Energy Decree, about financial provision made for the costs of nuclear waste management. The statements addressed the technical plans on which financial provision is based.

4.2 Spent nuclear fuel

STUK’s regulatory control of spent nuclear fuel storage included regular inspections and reviews of plans of storage systems and practices. No safety-endangering events occurred in the operation of the storage facilities. The volume of spent fuel onsite the Olkiluoto plant in the end of 2004 was 6050 assemblies (1065 tU, tonnes of original uranium) with an increase of 262 assemblies (46 tU) in 2004. Corresponding accumulation in the Loviisa plant was 2947 assemblies (351 tU) with an increase of 192 assemblies (23 tU).

Posiva continued technical R&D on spent fuel encapsulation and final disposal. At Metso Oy’s Rautpohja factory, casting of the insert of the waste canister (mode of spheroidal graphite iron) was successful as regards dimensions, and quite successful as regards material characteristics. A full-scale pressure test performed on the insert, which had been manufactured earlier, showed that its strength complied with the requirements. At Outokumpu Oy’s Pori factory, ten castings of the billets of the copper shell were done quite successfully. In Germany, one waste canister with an integrated bottom was fabricated by the pierce and draw method. Progress was made in the manufacturing technology but the desired particle size in the canister bottom/wall junction was not reached. Joint ventures headed by the Swedish nuclear waste company SKB included copper canister manufacturing tests based on forging and extrusion.

The tests on the electron beam welding of the lid of the copper canister, commissioned by Posiva in Germany earlier, were moved to Patria Oy’s Linnavuori factory in 2004 and the test programme was launched in the autumn of 2004. Friction stir welding is an alternative method, which is being developed under SKB. In addition, SKB has principal responsibility in the development of the copper canister’s non-destructive testing methods.

The development of final disposal technology will mostly be at the Äspö rock laboratory. A test programme aiming at full-scale demonstration of the horizontal disposal of waste canisters (the so called KBS-3H concept) was launched in 2004.

Posiva continued research programmes in Olkiluoto to assure the suitability of the repository site. Diamond core drilling from the surface, drillhole logging and sampling were carried out to complement research and extend its scope. The underground research facility ONKALO is the most important project relating to the geological research programmes in Olkiluoto and its construction began in mid-2004. The research facility is subject to control at this stage already since it will most probably be part of the final disposal facility proper later. STUK in 2004 drew up a plan for control of the geological research programmes in Olkiluoto, which gives the objectives, organisation and procedures of control. Control measures in accordance with the plan were launched by STUK.

In its planning report Posiva brought forth its strategy for the long-term safety case of the final disposal of spent nuclear fuel. The reports in question will form a safety case portfolio comprised of ten major reports. Posiva have completed their first report belonging to this entity.

Safety research is mostly based on long-term bilateral or multilateral collaboration projects. Most of the bilateral research projects are contained in the Posiva/SKB (Sweden) collaboration. The most significant multilateral projects are the integrated projects NF-PRO (Near Field Processes) and ESRED (Engineering Studies and Demonstrations of Repository Design), launched in early 2004, which are contained in the EU's sixth framework programme. Included is also FUNMIG (Fundamental Processes of Radionuclide Migration), launched in early 2005, into which Posiva participates together with Finnish research institutes. Research projects contained in the EU's fifth framework programme are in the reporting stage.

4.3 Low and intermediate level waste and decommissioning

The utilities followed earlier practices in carrying out their intermediate and low-level waste maintenance activities in 2004. No safety-related problems occurred in the treatment, storage or disposal of low and intermediate level waste. STUK's inspection of the handling, storage and disposal of low and intermediate level waste at both plant sites revealed no shortcomings requiring immediate action.

The volume of low and intermediate level waste onsite the Loviisa plant at the end of 2004 was 2677 m^3, which is 60 m^3 less than in 2003 due to a reduction in the volume of liquid waste. Corresponding waste accumulation at the Olkiluoto plant was 4683 m^3 , which includes an additional 348 m^3 in 2004. Currently approx. 46% of the waste from the Loviisa plant and 88% of that of the Olkiluoto plant has been disposed of.

Low and intermediate level waste subject to long-term storage at the Olkiluoto plant mostly includes components removed from inside the reactor pressure vessels, which are stored in the fuel pools. The cutting up and final disposal of steam separators was begun in 2004. At the Olkiluoto plant, some large components with a relatively low radiation level are also stored for whose treatment a decontamination chamber and a crusher have been purchased. A new storage building is under construction at the site to accommodate turbine plant steam reheaters due for removal in 2005 and 2006. The Olkiluoto plant in 2004 cleared from control maintenance waste taken to the local landfill and recyclable metal sent to the local scrap metal collector Eurajoen Romu Oy .

The most important low and intermediate level waste projects at the Loviisa plant are the construction of a solidification facility and the extension of the final disposal facility. These projects were started in 2004 and are due for completion by early 2007. After the final disposal of solidified wastes has been launched, the Loviisa plant site still has to accommodate for the long-term storage of high activity components, which have been removed from inside the reactor pressure vessels, and of approx. 200 m^3 of other waste.

The Loviisa plant in 2004 cleared from control maintenance waste taken to the Kymenlaakson Jäte Oy landfill in Anjalankoski and recyclable scrap metal sent to the Imatra steelworks. In the scrap metal consignments, objects were detected twice which exceeded the alarm limit applied by the steelworks and were returned to the plant. To avoid corresponding problems in the future, the Loviisa plant is developing its practices for the sorting, activity measurement and storage of scrap metal cleared from control.

Both utilities put forward their updated decommissioning plans at the end of 2003. STUK in its statements to the Ministry of Trade and Industry in 2004 assessed these plans. According to the statements, the feasibility of the basic decommissioning concepts was good, with the exception of the Olkiluoto plant for which an analysis of a shorter-than-planned controlled storage time prior to the plants' decommissioning was recommended.

5 Nuclear non-proliferation

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5.1 Safeguards of nuclear materials

5.1.1 Safeguards at Finnish nuclear facilities

International safeguards are implemented by the IAEA and EU safeguards by the European Commission's Directorate-General for Transport and Energy, Directorates H and I. IAEA safeguards are based on the Nuclear Non-Proliferation Treaty and the Safeguards Agreement (INFCIRC/193) signed by the non-nuclear EU member states, European Atomic Energy Agency and the IAEA. EU safeguards are based on the Euratom Treaty and Commission Regulation 3227/76 given by virtue of the Treaty. STUK's safeguards activities aim to assure regulatory control of the use of nuclear energy necessary to prevent nuclear proliferation. In addition, STUK's tasks include control related to international agreements in the field of nuclear energy signed by Finland.

In so far as nuclear power plants are concerned, STUK's safeguards activities are mostly focused on fuel import, transport, storage, internal transfer and refuelling. The utilities submit to STUK activity programmes, advance notifications and reports.

A total of nine inspections were carried out at Loviisa power plant in 2004 and 16 inspections at Olkiluoto plant. Euratom participated in 21 and the IAEA in 22 of these inspections. The IAEA's inspectors visited the Olkiluoto repository construction site twice.

In addition to nuclear power plants, minor amounts of nuclear materials are used at other facilities. The most significant of these is FiR 1, the research reactor operated by the VTT, where one inspection was carried out in 2004 by STUK, the IAEA and Euratom. In addition, the Laboratory of Radiochemistry at the University of Helsinki, OMG Kokkola Chemicals, the University of Jyväskylä, the Geological Survey of Finland and STUK have small amounts of nuclear materials in their possession. The amounts of nuclear materials are given in Table II and licences and approvals in accordance with the Nuclear Energy Act in Appendix 5.

Nuclear material safeguards employ several methods to verify that the data on nuclear materials reported by the operator, such as burn-out and cooling time, are correct and complete. Other nuclear-safety related data, from operational safety

Table II. Amounts of nuclear material in Finland 31 December 2004.

Location	Natural uranium (kg)	Enriched uranium (kg)	Depleted uranium (kg)	Plutonium (kg)	Thorium (kg)
Loviisa plant	–	433 058	–	3 474	–
Olkiluoto 1	–	217 723	–	1 042	–
Olkiluoto 2	–	180 974	–	750	–
Olkiluoto / Spent fuel storage (KPA)	–	824 342	–	6 771	–
VTT/FiR 1 -research reactor	1 511	60	< 1	–	–
OMG Kokkola Chemicals	1 687.2	–	–	–	–
Others (non-nuclear)	83.7	1,7	612.5	0.006	4.4

to final disposal, can also be verified by measurements. In 2004 STUK verified by non-destructive methods 148 and 129 spent fuel assemblies at Olkiluoto and Loviisa power plants respectively. In addition, the IAEA, Euratom and STUK verified by non-destructive methods 13 fuel assemblies that had been in the reactor hall of Loviisa 1.

Every material balance area operated in compliance with STUK-approved manuals and in a way facilitating STUK's fulfilling of the obligations of international agreements in the nuclear field signed by Finland.

In 2004 STUK approved five Euratom and 199 IAEA inspectors to make inspections in Finland. STUK also approved the responsible manager, and his deputy, of the accelerator laboratory in the Department of Physics at the University of Jyväskylä.

5.1.2 Strengthening of IAEA safeguards

Measures to strengthen the IAEA safeguards began after the disclosure of the Iraqi nuclear weapons programme. By way of administration, safeguards strengthening is based on the Additional Protocol (INFCIR/540). Finland signed the Protocol together with other EU countries in September 1998 and ratified it in the summer of 2000. Other EU member countries completed ratification towards the end of 2003. The Protocol was ratified by the Commission in April 2004, and it entered into force on 30 April 2004 – just prior to the enlargement of the EU.

In preparation for safeguards in accordance with the Protocol, STUK in March 2004 negotiated with the IAEA a procedure for the provision of declarations, i.e. notifications as required in the Protocol, and chose for this purpose the "Protocol Reporter" -software developed by the IAEA. During the same visit STUK familiarised itself with the IAEA's system to assure the data security of confidential data contained in the declarations. In April STUK visited Luxembourg to agree with the Commission about formalities relating to the submission of declarations on the Commission.

After the Additional Protocol had entered into force, the Act amending the Nuclear Energy Act (12 May 2004) and the Decree amending the Nuclear Energy Decree (31 May 2004) entered into force in Finland. Commission Regulation No 302/2005 did not come into force during 2004 but the Commission asked in writing licensees and the representative of the site (STUK) to act as if it had already taken effect where measures relating to the Protocol are concerned. At the same time, the Regulation No 302/2005 is the Commission's judical tool for collecting data for control activities in accordance with the Protocol.

STUK prepared declarations required in the Protocol, the most important of which were descriptions of plant sites and of R&D pertaining to the nuclear fuel cycle. These were delivered to the IAEA and the Commission on 8 July 2004. Finland's declaration was the first EU declaration delivered to the IAEA of which the IAEA expressed satisfaction in writing. Finland submitted to the IAEA and Euratom 11 declarations in 2004. On 21 December 2004 the IAEA conducted a complementary audit in accordance with the Protocol to the Laboratory of Radio Chemistry at the University of Helsinki.

STUK was active in discussions to develop the Commission's new approaches. A STUK representative participated in an IAEA seminar on the strengthened safeguards in Hungary in November and in the Working Party on Atomic Questions' meetings on safeguards or related topics. A Commission information seminar in Luxembourg in December was also attended.

STUK arranged several discussion and training events in co-operation with licensees on control in accordance with the Protocol.

5.1.3 Safeguards for final disposal

The final disposal of nuclear fuel in an underground respository presents new challenges to safeguards implementation since, after encapsulation, nuclear material verification will be impossible in practice. In so far as safeguards on final disposal are concerned, STUK has started work on creating national requirements for an encapsulation and final disposal facility. The objective is to establish safeguards criteria to cover both national and international regulatory needs for the entire lifetime of the repository. The excavation of the underground research facility, which is planned to be part of the repository, was begun in the summer of 2004. Therefore, the framework for international safeguards were established.

In accordance with Comission Regulation (EURATOM 3227/76), the European Commission obliges licensees to submit reports on nuclear materials, and facilities handling them, not later than 200 days prior to the transfer of the nuclear materials to new premises. The Commission further reports to the IAEA. Based on the Nuclear Non-Proliferation Treaty, the government (i.e. STUK) is obliged to facilitate effective IAEA safeguards in Finland. Thus, based on talks between STUK and the Ministry of Trade and Industry on 29 September 2004, it was considered appropriate to oblige Posiva Oy, who is looking into final disposal, to take care in the manner of a nuclear facility of the implementation of nuclear safeguards during the construction of the underground research facility of the final repository. This obligation aims to assure the IAEA of Finland's capability to implement sufficient safeguards and plan national control and inspection procedures. The IAEA's first visit to the repository under construction was on 4 October 2004. During a visit to STUK, the experts gave a preliminary plan for the regulation of final disposal by a national system and for realisation of co-operation with the IAEA.

5.2 Control of radioactive materials transport

About 20 000 radioactive packages are transported in Finland every year. STUK is not aware of any transport accidents involving radioactive materials, or of any other safety hazards in 2004. The transport of nuclear materials requires a licence from STUK. The conditions for the licence include nuclear liability insurance and sufficient physical protection. STUK approved three transport plans for the import of fresh fuel. In addition, six types of packaging were approved for use in Finland. One of these was applied for a potential transit that did not take place, however. The most significant forms of nuclear material transport in 2004 were the import of fresh nuclear fuel to the Finnish nuclear power plants from Germany, Sweden, Spain and Russia. In addition, two consignments of radioactive material were approved for transport subject to special arrangements.

The import of radioactive and nuclear materials is subject to a licence. No smuggling attempts were detected at the Finnish border in 2004.

No illicit trafficking of radioactive materials was detected at the border in 2001–2004. The highest number, 23 consignments, was turned back in 1997. The reason was typically radioactivity measured in scrap metal. The decrease in number is partly due to the most significant consignors now measuring the radioactivity of their scrap metal. On the other hand, also consignments of scrap metal to Finland have decreased.

Safeguards as well as supervision and control of nuclear material transport are looked into in detail in the report *Nuclear Safeguards in Finland 2004* (STUK-B-YTO 238).

5.3 The Comprehensive Nuclear Test Ban Treaty (CTBT)

The Comprehensive Nuclear Test Ban Treaty (CTBT) prohibits all nuclear testing. The Treaty was opened for signing in 1996. It enters into force after ratification by 44 separately designated states. Finland ratified it in 1999. Compliance with the Treaty is monitored by an international observation network, which will comprise 321 monitoring stations. Of the stations, 80 measure radioactive particles in the atmosphere. The results are available for use by all member states.

A special preparatory committee, which assembles in Vienna, is preparing for the Treaty's coming into force. All signatory states are represented in it. In Vienna, also the Provisional Technical Secretariat is operating.

The National Data Centre (NDC) in conjunction with STUK, which is based on the CTBT, contributed to the work of the preparatory committee for the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) in establishing a cost-effective organisation that is functional from the Finnish point of view. The NDC's own automatic routine monitoring was in operation for the whole year analysing the results of stations detecting radioactive particles in the atmosphere. Routine monitoring is facilitated by an alarm system transmitting data on unusual observations to the NDC personnel. The NDC did not observe any abnormal activities in 2004.

The NDC's analyses yield a high number of data files for whose management a system was developed. For improved availability, the results are fed into a database. The database and its user interface were developed in co-operation with STUK's Laboratory of Airborne Radioactivity, the Helsinki University of Technology and the Canadian National Data Centre.

In 2002 STUK signed an agreement with the developers of the analysis programme used by the NDC about its handing over to the national data centres of other countries for use in CTBT work. In 2004 the programme was delivered to the national data centres of Romania, Iceland, Algeria, Libya, Burkina Faso, the Philippines, Brazil, Vietnam, Uganda and Indonesia.

6 Safety research

Esko Eloranta, Harri Heimbürger

In support of regulatory decision-making, STUK commissions independent safety analyses and research to research institutes and expert organisations. Independent research is commissioned, where necessary, to develop the regulatory control effort. In addition to these, STUK contributes to the oversight of the national safety research programmes SAFIR and KYT on nuclear power plants and nuclear waste management. Corresponding previous programmes were FINNUS and JYT. The basis for these public nuclear safety research programmes is to create prerequisities for the preservation of know-how to ascertain the continued safe use of nuclear power, the development of new know-how and international co-operation. The programme planning period is four years. The KYT programme started in 2002 and the SAFIR programme in 2003.

Assignments commissioned in support of regulatory decisions mostly related to the review of the construction permit application for the new nuclear power plant and are addressed in this report's section on regulatory control.

In accordance with an amendment to the Nuclear Energy Act, passed by Parliament in 2003, funds are collected from the licensees to the State nuclear waste fund (VYR), to two separate assets, kept separate from other assets of the Fund, to finance nuclear safety research and nuclear waste research. The funds available for distribution every year are used to finance research projects which, as an entity, support the cause for which the funds are collected. In 2004 projects under SAFIR recived 2.7 M€ and those under KYT 1.0 M€. The SAFIR programme is financed not only by VYR and its total financing in 2004 was approx. 5 M€ and that of the KYT programme approx. 1 M€.

STUK's experts controlled and monitored the ongoing SAFIR and KYT programmes and contributed to the support and managing group work of the programmes. STUK submitted to the Ministry of Trade and Industry statements, as referred to in the Nuclear Energy Act, on the annual plans of these programmes.

The general plan for the SAFIR research programme is based on safety challenges identified for this decade, which are many due to the ageing of operating nuclear power plants, their modernisation and the new plant under way. The general research themes of the SAFIR research programme were fuel and the reactor core, the reactor circuit and structural safety, the containment and process safety functions, I&C, the control room and information technology, organisations and safety management as well as risk-informed safety management. In the field of reactor safety, the programme entailed participation in several international projects within the framework of the OECD/NEA and the US regulatory authority the NRC. The research programme comprised a total of 18 research projects. Information on the SAFIR programme is available at *http://www.vtt.fi/pro/research/safir/*.

The focus of the KYT programme in 2004 was in geosciences, technical barriers, migration of radioactive substances, safety analyses and technical solutions. Information on the programme can be found at *www.vtt.fi/pro/research/kyt*.

Appendix 6 lists STUK-financed safety research and commissioned work completed in 2004.

Figures 8 and 9 give the costs of nuclear safety research in 2000–2004. The diagrams differentiate between work commissioned in support of regulatory decisions and that channelled via the STUK budget i.e. publicly funded safety research. Owing to an amendment to the Nuclear Enegy Act, no publicly financed nuclear safety research has rested with STUK as of the beginning of 2004. In this respect, the costs incurred come from delayed research projects commissioned earlier and postponed billing dates.

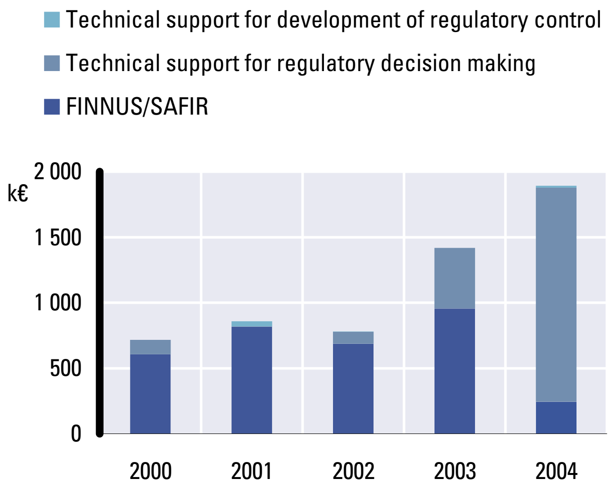


Figure 8. The cost of research and commissioned work pertaining to the safety of nuclear power plants.

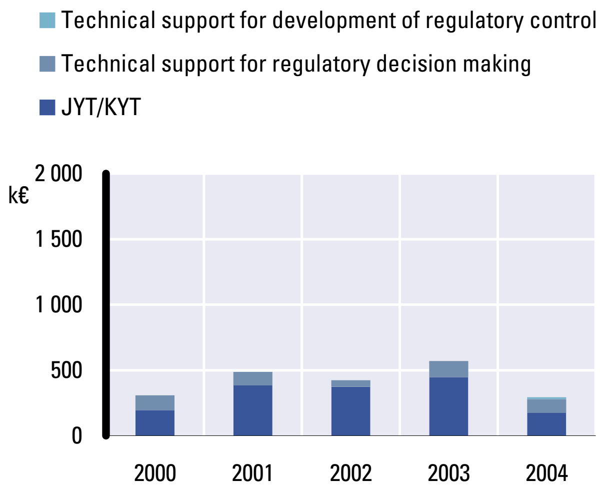


Figure 9. The cost of research and commissioned work pertaining to nuclear waste management and nuclear non-proliferation.

7 Nuclear facilities regulation and its development

Marja-Leena Järvinen, Kaisa Koskinen, Pekka Salminen, Arja Tanninen, Reino Virolainen

7.1 Processes and structures

Document handling

A total of 1568 documents were submitted to STUK for review in 2004. The number of documents submitted in 2004 and earlier, whose review was completed in 2004, was 1663. The figure includes licences granted by STUK in accordance with the Nuclear Energy Act, which are listed in Appendix 5. Average document review time was 47 days. The number of documents and their average review times in 2000–2004 are given in Fig 10. Figs 11 and 12 give the distribution of the review times of documents on the Loviisa and Olkiluoto plant units.

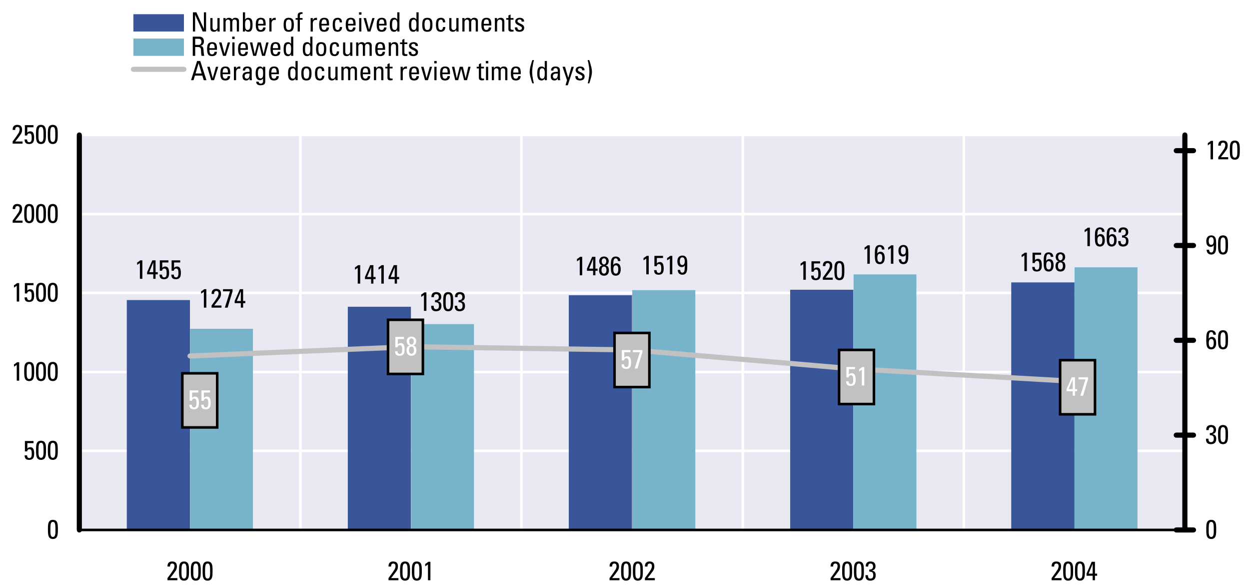


Figure 10. Number of documents received and reviewed as well as average document review time.

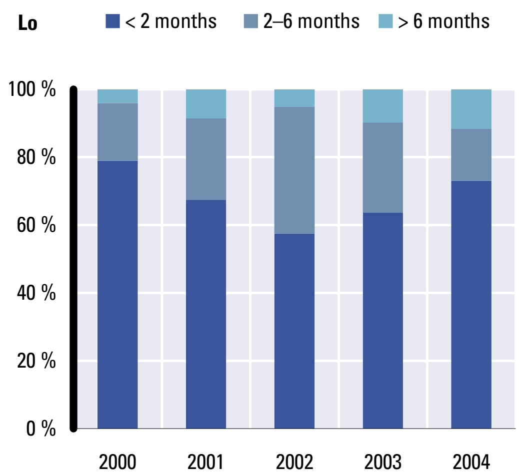


Figure 11. Distribution of time spent on preparing decisions on the Loviisa plant units.

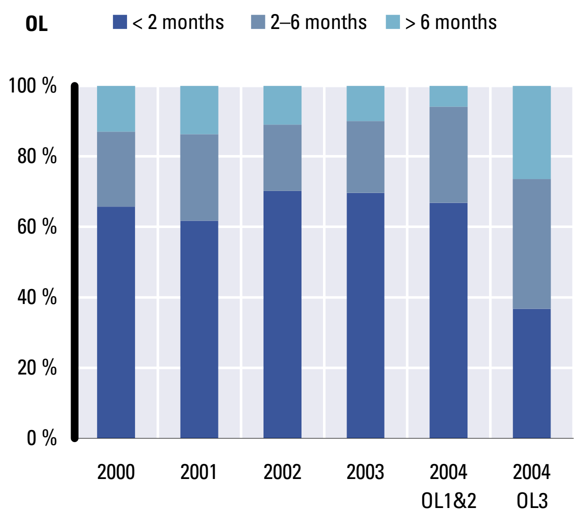


Figure 12. Distribution of time spent on preparing decisions on the Olkiluoto plant units.

STUK's own operation

The development of STUK's own operation focused on processes. During the year, the four working processes in nuclear reactor regulation (overall assessment of safety, oversight of plant projects and modifications, oversight of plant availability, oversight of organisational operation) were described and the relevant internal quality guidelines prepared. Descriptions and guidelines were completed for subprocesses as well. Two entirely new process guidelines for nuclear non-proliferation were established and three others were updated. The new guidelines were about nuclear material inspections and inspection criteria and the upkeep of the nuclear material accounting system. A new guideline on the declarations contained in the Additional Protocol is under way as well. At the same time, process indicators were developed that will be tested in 2005.

In a self-assessment conducted at the department of Nuclear Reactor Regulation, which complied with the a quality award criteria, the most important development object was the completion of ongoing projects i.e. the development of working processes and expertise. The results of the self-assessment slightly improved compared with the previous assessment. Its results were separately discussed with the personnel and, in addition to the above two projects, the development of new working processes for the department, knowledge management and internal feedback culture were discussed. A self-assessment conducted at the department of Nuclear Waste and Material Regulation brought forth a number of minor development objects, which were discussed at a departmental meeting. The majority of the jointly agreed measures were carried out in 2004.

Document management

A long-term document management project has been under way at STUK. In 2003 the supplier and the application software were chosen. The main components are portal, knowledge management, document management, collaboration module and records management. In 2004 the was work continued by analysing more closely the STUK functions needed to determine in detail the system required and the resultant functional requirements. Extensive software test plans were drawn up followed by multiple-phased testing.

Owing to the need for further definition and development, which surfaced during testing, the system's commissioning had to be postponed until 2005.

Risk-informed regulatory control

The FinPSA program

The risk assessment program FinPSA was further developed to contain the basic functions for a level 1 PSA. The Olkiluoto 1 and 2 risk model was transferred to a new program. The features and numerical calculation routines (minimal cuts, their importance measures and those of basic events) relating to the management and calculation of a Level 1 PSA code were tested. After the testing period, the FinPSA Level 1 beta version was released towards the end of 2004. The Swiss authority HSK purchased a Level 1 beta version was delivered to the buyer towards the end of 2004. Program development continues for a Level 2 risk analysis, the objective being the preparation of a commercial, integrated Level 1 and 2 PSA program.

PSA information system

STUK continued the development of the Probabilistic Safety Analysis Information System (PSAIS) as a tool for risk-informed nuclear safety regulation. The system will provide general and detailed data on the results and methods of risk analyses, the conclusions made, their application and utilisation in nuclear safety regulation. From the PSAIS information system, simplified risk-information can be extracted without the need for a profound knowledge of risk-analysis.

In the first phase of PSAIS, the below thematic entities for Olkiluoto 1 and 2 were developed:

- PSA level 1 main results
- Systems analyses
- Accident progression and plant response
- General (initiating events, success criteria in various initiating events, etc)

System programming was done in 2004 and the system's pilot version was completed.

7.2 Renewal of competence and human resources

The development of competence in nuclear reactor regulation, which began a few years ago, was continued. The central theme was improvement of competence relating to nuclear power plant system knowledge and quality management. Two training courses on system knowledge were arranged. They dealt with both the operating plant types and the one under design. Eight inspectors passed quality management training required of a lead auditor. Several junior personnel from nuclear safety regulation participated in a national nuclear training programme. Several recruitments were done to ascertain competence. New experts were employed in the fields of reactor safety, construction engineering, electrical engineering, strength analysis and pressure vessel manufacturing and, at the same time, no one in nuclear reactor regulation resigned from STUK's service.

The development of competence in nuclear waste management regulation mostly related to the modelling tools used. In early 2004, VTT trained three inspectors in the use of Porflow, a simulation software application for spent fuel final disposal, and one inspector acquainted himself with two different geological modelling softwares. Assessing Posiva's plans together with external experts offered an opportunity for hands-on experience. The most important competence deficiency in nuclear waste management is in safety analyses.

The coming into force of the Additional Protocol and the establishment of safeguards criteria for spent fuel final disposal posed new challenges in IAEA safeguards. No external training is available for either but learning is mostly by orientation together with colleagues internationally and by putting into practice matters thus learned. Liaison with international organisations and participation in international meetings has been an important mode of learning. The oversight of radioactive materials transport and, over the past years, the implementation of CTBT has rested too heavily on one individual. Therefore, training of people providing back-up for them was started.

7.3 Finances and resources

The duty area of nuclear safety regulation included basic operations subject and not subject to a charge. Basic operations subject to a charge mostly comprised of the regulatory control of nuclear facilities, with their costs charged to those subject to control. Those basic operations not subject to a charge included international and domestic co-operation as well as emergency response and communications. Basic operations not subject to a charge are publicly funded. Overheads from rule-making and support functions (administration, development projects in support of regulatory activities, training, maintenance and development of expertise, reporting and 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 2004, the costs of the regulatory control of nuclear safety subject to a charge were 9.2 M€. The total costs of nuclear safety regulation were 10.2 M€. Thus the share of activities subject to a charge was 90%.

The 2004 income from nuclear safety regulation was 9.2 M€. Of this, 1.7 M€ and 6.7 M€ came from the inspection and review of Loviisa and Olkiluoto nuclear power plants, respectively. In addition to the operating plant units, the income for Olkiluoto's part includes regulatory control of the new plant unit. The regulation of Posiva Oy's operations yielded 0.8 M€. Figure 13 gives the annual income and costs of nuclear safety regulation in 2000–2004.

The time spent on the inspection and review of Loviisa nuclear power plant was 9.7 man-years, i.e. 10.2% of the total working time of the regulatory personnel. For Olkiluoto nuclear power plant's operating units it was 8.8 man-years, which accounts for 9.3% of 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 23.2 man-years, i.e. 24.5% of total working time. The time spent on nuclear waste

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

Duty area	2000	2001	2002	2003	2004
Basic operations subject to a charge	26.4	26.3	27.6	29.2	44.7
Basic operations not subject to a charge	7.5	7.4	6.9	6.4	5.1
Contracted services	5.4	4.4	3.8	4.9	5.1
Rule-making and support functions	25.5	28.5	27.1	28.2	22.7
Holidays and absences	15.0	16	16.2	15.9	16.9
Total	79.8	82.6	81.6	84.6	94.5

management inspection and review was 3.1 man-years and that spent on the FiR 1 research reactor 0.03 man-years. The working time spent on small-scaler users of nuclear material was 0.01 man-years.

The distribution of yearly working time of the nuclear regulatory personnel according to duty areas is given in Table III. Figure 14 presents the distribution of working time spent on main functions in 2000–2004.

The number of inspection days onsite and at the component manufacturers' premises totalled 1570. Not only inspections pertaining to the safety of nuclear power plants but also nuclear waste management and safeguards inspections are included. Two resident inspectors worked at Olkiluoto nuclear power plant and one at the Loviisa plant. The number of inspection days in 2000–2004 is given in Figure 15.

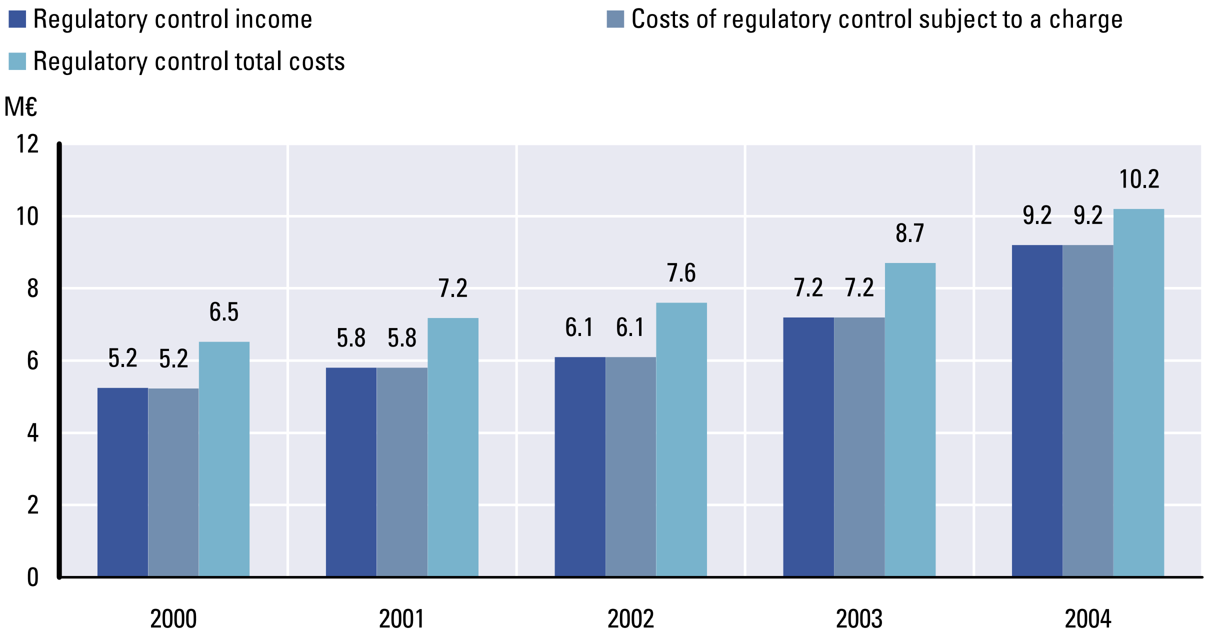


Figure 13. Income and costs of nuclear safety regulation.

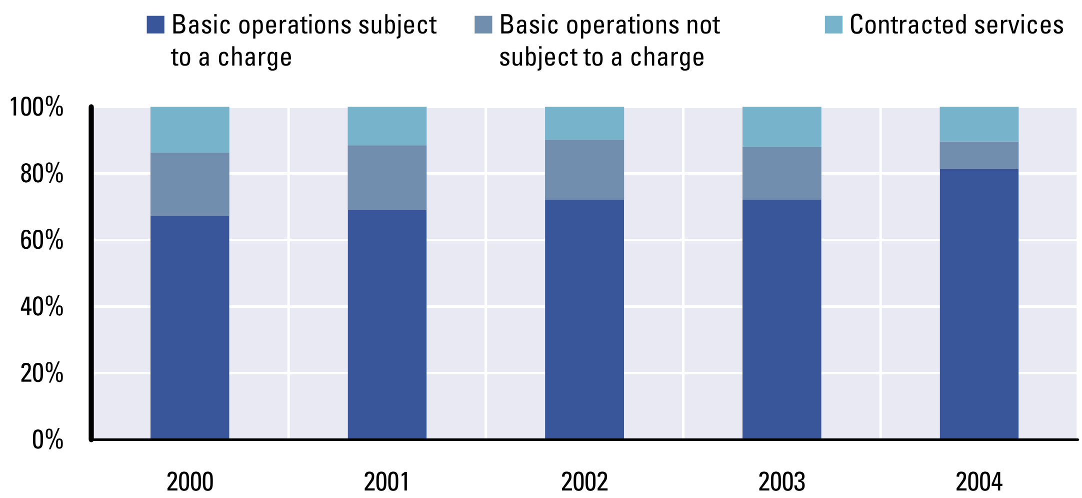


Figure 14. Working time spent on main functions.

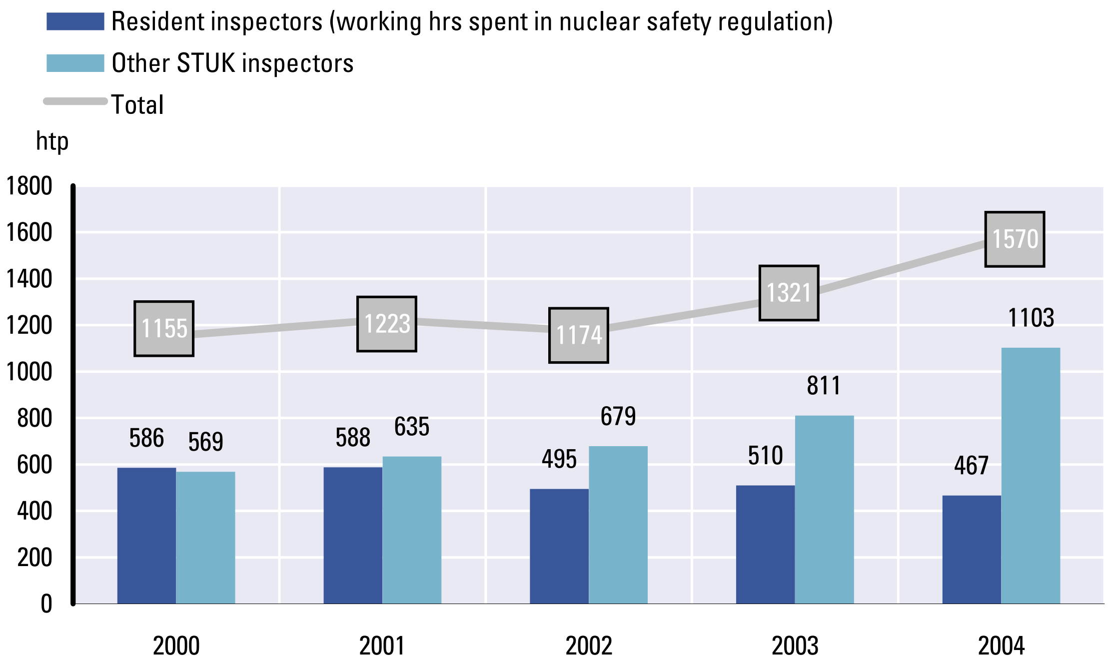


Figure 15. Number of inspection days onsite and at component manufacturers' premises.

8 Emergency preparedness

Tuulikki Sillanpää

STUK arranged several training events and exercises to test and develop its own emergency response. In addition, STUK supervises the emergency preparedness of the operating organisations of nuclear power plants to act in abnormal situations. No such situations occurred in 2004.

The emergency response systems of nuclear power plants are developed during plant operation and regularly tested in emergency exercises as part of emergency preparedness training. Other related training by the licensees encompasses practical exercises for radiation measurement teams, sampling during accidents and measurement of samples, assessment of accident situations and review and development of emergency guidelines in seminars. STUK has approved the emergency contingency plans of the Loviisa and Olkiluoto plants and yearly reviews the implementation of emergency preparedness, including training and emergency exercises.

In 2004, two domestic emergency exercises were arranged in which STUK participated. Both were combined fire drills and emergency excerices. Their aim was to test co-operation between the emergency organisation and the fire service and to develop the operation of the emergency organisation during an emergency in which a plant's technical safety is assured but the plant's personnel and the environment are not in danger.

The exercise was carried out at Loviisa power plant on 10 November 2004 such that the fire brigade operated in real time in accordance with the exercise event during a hypothetical fire onsite and the emergency organisation in its own rooms. A separate fire drill was carried out at Loviisa power plant on 12 May 2004.

The exact starting time of the emergency exercise, which was part of an exercise arranged at Olkiluoto on 22 November 2004, was not told to the participants in advance. The starting up of the operation of emergency organisations was thus tested and so was the management of status analysis outside actual office hours, when most personnel have left their work places.

STUK participated in international nuclear power plant emergency exercises in 2004. In September Sweden arranged Havsörn, a rescue services exercise at Forsmark power plant, into which STUK and the Åland Islands, a province of Finland, participated from Finland. In February and August STUK participated in the IAEA's information exchange exercises via the Agency's protected web site. The latter exercise dealt with a hypothetical nuclear power plant accident. STUK also contributed to the support given to the emergency preparedness activities of the Commission of the European Communities (RESPEC).

9 Communications

Risto Isaksson

In 2004 STUK issued eight press releases on nuclear safety regulation. Two were about events at nuclear power plants. One was about a production break due to a reactor scram at Olkiluoto 1 (7 March 2004) and the other about a repair outage at Loviisa 2 (19 October 2004). One routinely reported the annual maintenance of Loviisa nuclear power plant. In 2004 information about the annual maintenance of Olkiluoto nuclear power plant was given only on STUK's web site and on the radiation safety pages of teletext.

Two press releases were issued on nuclear material safeguards. The one put out in February reported that no radioactive consignments were caught at the Finnish border in 2003. A June press release was about an amendment to the Nuclear Energy Decree and the strengthening of nuclear nuclear material safeguards.

Press releases were issued about the nomination of a STUK head of office to membership in the French nuclear safety council, the first national course aimed at the enhacement of professional competence in nuclear safety and the publication of the book "Nuclear safety", which is one in a STUK series of books called "Radiation and nuclear safety". The 418 paged book came out in April.

The press releases were sent to the media and partners in co-operation and they were available on the STUK web site. An abstract was available on the radiation safety pages of YLE's teletext. Nuclear safety did not become big news or give cause for significant societal discussion. Even Finland's new nuclear power plant project was mostly written about on the economic pages of the press.

In addition to the press releases, the operation of and events at the Finnish nuclear power plants were explained in quarterly nuclear safety reports sent to the media and interest groups. The reports were available on the STUK web site as well.

10 International co-operation

Juhani Hyvärinen, Kaisa Koskinen, Elina Martikka, Matti Ojanen, Hannu Ollikkala, Rainer Rantala, Esko Ruokola, Pekka Salminen, Seija Suksi, Arja Tanninen, Kirsti Tossavainen, Olli Vilkamo

Co-operation with the IAEA

The IAEA continued revision of its nuclear safety guidelines (formerly Nuclear Safety Series NUSS). The revision is almost done and is expected to be completed in the coming years. STUK prepared for the IAEA statements on draft guidelines requested from Finland. It also contributed to the work of teams preparing the draft guidelines. A representative of STUK continued as chairman of the NUSSC (nuclear safety) committee. In addition, STUK's representatives were active in the WASSC (waste safety) and RASSC (radiation safety) committees.

The Nuclear Safety Convention requires the submission, every three years, of a report on the fulfilment of the Convention's obligations. STUK was responsible for the drawing up of Finland's country report submitted to the IAEA, the Convention's secretariat, in accordance with an agreed schedule in the autumn of 2004. Corresponding reports were drawn up in 1999 and 2002. This latest report will be reviewed at an international meeting of the parties to the Convention in Vienna in the spring of 2005.

STUK was Finland's liaison organisation for the below information exchange systems for nuclear facilities maintained by the IAEA:

- Incident Reporting System (IRS)
- Incident Reporting System for Research Reactors (IRSRR)
- International Nuclear Event Scale (INES)
- Power Reactor Information System (PRIS)
- Nuclear Fuel Cycle Information System (NFCIS)
- Net enabled Waste Management Database (NEWMDB)
- Directory for Radioactively Contaminated Sites (DRCS)
- Illicit Trafficking Database (ITDB)
- Events that have arisen during the Transport of Radioactive Material (EVTRAM).

The Director General of STUK was the Vice Chairman of the International Nuclear Safety Advisory Group INSAG. The Group provides information and advice in nuclear safety issues to the Director General of the IAEA and gives recommendations for safety improvements in the IAEA member countries.

STUK's Director General participated in the work of the "Expert group on multilateral approaches to the nuclear fuel cycle" summoned by the Director General of the IAEA. The group assessed the establishment of multilateral facilities for nuclear material treatment to reduce the need for national facilities. The international facilities would be aimed at limiting the risk of nuclear proliferation.

The IAEA safeguards support programme, launched in 1988, continued in 2004. It is financed by the Ministry for Foreign Affairs, STUK being responsible for co-ordination and project implementation. The objective is development of the IAEA's verification methods, training of inspectors and provision of expert assistance. The most important project in 2004 was the planning of IAEA inspector training relating to the implementation of the Additional Protocol and the arrangement of the first course in Finland.

In IAEA expert capacity, a STUK representative participated in the development of the regulatory effectiveness indicators intended for use by nuclear safety authorities. The work started in 2003 and it will continue in 2005.

Co-operation with the OECD/NEA

STUK was represented in all of the OECD's main committees dealing with radiation and nuclear safety. The main committees are as follows

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

STUK's Director General acted as chairman of the CNRA.

STUK took part in the work of the below CNRA and CSNI Working Groups. The CNRA Working Groups' fields of activity were as follows

- Working Group on Inspection Practices (WGIP)
- Task Group on Regulatory Effectiveness Indicators (TGRE) and Task Group on Safety Performance Indicators (Joint CNRA/CNSI/TGSPI)
- Task Group on Regulatory Decision Making
- Working Group on Public Communication of Nuclear Regulatory Organisations (WGPC)

The CSNI Working Groups' fields of activity were as follows

- Working Group on Operating Experience (WGOE)
- Working Group on Integrity of Components and Structures (IAGE)
- Working Group on Accident and Analysis (GAMA)
- Working Group on Risk Assessment (WGRISK)
- Special Expert Group on Human and Organisational Factors (SEGHOF)
- Special Expert Group on Fuel Safety Margins (SEGFSM).

STUK participated in the work of the RWMC's Integration Group for the Safety Case (IGSC) as well.

Co-operation with the EU

STUK participated in the work of a working group of the NRWG. The group looked into the suitability, from the regulatory point of view, of Risk Informed In-Service Inspection (RI-ISI) for the drawing up of a piping inspection programme for nuclear power plants. The working group has been in close contact with the utilities' ENIQ working group, corresponding working groups of the OECD and the IAEA as well as the organisations that developed the methods (Westinghouse and EPRI) and utilities. The working group's draft report describes the contents of various RI-ISI methods, European and American applications, differences/similarities between traditional methods and RI-ISI methods as well as the pros and cons of the RI-ISI procedures from a regulatory point of view. In 2004 the draft report was completed to a final report due for publication as an EUR report .

STUK took part in the operation of an NRWG working group on safety-critical software. The group's task is to gather views common to EU authorities on what is required of safety-critical software.

STUK contributed to the work of the advisory Expert Group A31 of the Commission of the European Union. It's main tasks pertain to radiation protection regulations.

In the field of nuclear material safeguards, STUK participated in the operation of the European Safeguards R&D Association (ESARDA). ESARDA's task is to promote and harmonise European R&D in nuclear material control. ESARDA offers a forum for an exchange of information and ideas to authorities, researchers and nuclear power plant operators.

Via the activities of the Regulatory Assistance Management Group (RAMG) of the EU, STUK participated in Phare and Tacis co-operation in support of East European regulatory organisations and their support organisations. The group evaluated the appropriateness of projects, which support regulatory oversight, prepared by the EU. STUK contributed to the then-ongoing Phare and Tacis projects. STUK participated in the work of the CONCERT working group consisting of the heads of nuclear safety authorities of the EU member states and applicant countries.

NKS co-operation

The 4-year research programme of NKS, Nordic co-operation in nuclear safety, commenced in 2002. It is headed by two programme managers. STUK's representatives participated in the programme's sub-area of reactor safety and in the work of the programme of emergency preparedness and environmental safety. In addition, STUK has a representative in the NKS steering committee.

Projects on reactor safety relate well to Finland's national research programme and needs. The emergency preparedness and environmental safety programme includes focus areas important to Finland such as development of data management and communication during emergencies.

The entire programme content serves well co-operation between the Nordic authorities, which is a permanent objective of NKS co-operation.

Bilateral co-operation

A representative from STUK was a permanent member of the Reactor Safety Committee assisting the Swedish Nuclear Power Inspectorate (SKI). A representative of SKI was an invited expert in the Advisory Committee on Nuclear Safety that functions in conjunction with STUK. Co-operation with SKI continued, with regular meetings during which current questions of nuclear safety regulation and waste management were discussed. Information exchange with the Swedish Radiation Safety Authority (SSI) continued as regards doses to Finns who had worked at nuclear power plants in Sweden and to Swedes who had worked at Finnish plants. STUK's representatives participated in an international seminar on regulatory strategies arranged by SKI.

STUK's Director General was chairman of a nuclear safety committee that supports the organisation conducting regulatory activities in Belgium and participated as a permanent member in the work of the advisory committee of the Lithuanian nuclear regulatory authority.

STUK's co-operation with the USNRC focused on information exchange in nuclear safety matters of interest to both parties. In co-operation with the USNRC and VTT, STUK continued development of the FRAPTRAN/GENFLO code for fuel transients. STUK participated in LOCA tests that the USNRC commissioned to Argonne National Laboratory (ANL). Licensing of new nuclear power plants and experiences in their construction were discussed with US authorities.

The Director General of Autorité de Sûreté Nucléaire (ASN), the French nuclear safety authority, invited a representative of STUK as a member in the Groupe Permanent des Reacteurs (GPR), a permanent advisor to the ASN. Of the rather numerous GPR meetings, a STUK representative attended those dealing with plans for an EPR facility, operational experience feedback from operating plants and selected safety improvements planned for operating plants.

Discussions were had with the French authority (DGSNR) on the licensing of new nuclear power plants and related special questions.

A representative of the Argentinian authority ARN worked in STUK for three months. The topic of the visit was oversight of the planning and construction of the new nuclear power plant and reactor pressure vessel embrittlement of which Argentina is obtaining experiences for utilisation in the future.

Co-operation between STUK and the Russian nuclear safety authority Federal Service for Ecological, Technological and Atomic Supervision (formerly Gosatomnadzor GAN) in nuclear material and waste control continued, based on a co-operation arrangement signed in 1998. The development of regulatory guidelines was of particular interest.

Safeguards co-operation between STUK and the Australian Safeguards and Non-proliferation Office (ASNO) continued. According to agreed practice, STUK provided ASNO with information on nuclear materials of Australian origin imported to and kept in Finland.

Other forms of co-operation

STUK participated in the work of the Western European Nuclear Regulators' Association (WENRA). In 2000, a working group on harmonisation was set up to develop a method for drawing up uniform nuclear safety requirements. In accordance with the recommendations of the working group's final report, an extensive nuclear safety requirements and nuclear waste management development project was commenced in early 2003. It establishes nuclear safety requirements for 17 safety areas and the status of two areas of nuclear waste management in the 15 participating countries. STUK contributed actively to the harmonisation project. In 2004 work meetings continued to put the finishing touches to these European reference requirements and to review member state self-assessments evaluating coverage of national regulations against reference level and the realisation of the requirements in practice.

VVER Regulators Forum is a body of co-operation for the nuclear safety authorities of countries operating VVER plants. The objective of a risk assessment working group, set up in 2002, is to compare the results of the Probabilistic Safety Analyses (PSA) of VVER plants and analyse the causes of possible differences. In 2004 each participating country drew up a summary report on the analysis of a small diameter pipe leak and the loss of offsite grid as dealt with in the PSAs of their own country's VVER plants. In addition, the participants prepared a report on the risk-informed oversight and safety management of VVER plants. In 2004, a VVER working group was set up to look into the utilisation of lessons learned from nuclear power plant operational experience feedback.

STUK participated in the work of the Network of Regulators of Small Nuclear Programs (NERS).

STUK arranged a Nordic nuclear material safeguards seminar in Helsinki in October. About 50 individuals participated from Sweden, Norway and Finland as well as the invited representatives of the IAEA, Hungary and Lithuania.

11 The advisory committee on nuclear safety

Pekka Salminen

In accordance with section 56 of the Nuclear Energy Act (990/1987), the preliminary preparation of matters relating to the safe use of nuclear energy is vested with the Advisory Committee on Nuclear Safety. It is appointed by the Government and functions in conjunction with STUK. Its term of office is three years. The Committee was appointed on 10 September 2003 and its term of office ends on 9 September 2006.

The Committee's Chairman was Professor Pentti Lautala (Tampere University of Technology) and its Vice-Chairman was Head of Research Rauno Rintamaa (VTT Technical Research Centre of Finland). In 2004 the members were Professor Riitta Kyrki-Rajamäki (Lappeenranta Technical University), Director Ulla Koivusaari (Pirkanmaa Regional Environment Centre), Director Timo Okkonen (TUKES), Senior Researcher Ilona Lindholm (VTT), Branch Manager Paavo Vuorela (the Geological Survey of Finland) and Research Professor Runar Blomqvist (the Geological Survey of Finland). Professor Jukka Laaksonen, Director General of STUK, was a permanent expert to the Committee. Invited experts were Dr Antti Vuorinen and Director Christer Viktorsson (the Swedish Nuclear Power Inspectorate).

Branch manager Paavo Vuorela left the Committee in 2004. In his place the Government assigned Research Professor Runar Blomqvist.

The Committee convened nine times in 2003. At its meetings it prepared statements to STUK on the continued operation of the Loviisa 1 reactor pressure vessel, the construction licence application for Olkiluoto 3, Finland's national report as required in the Nuclear Safety Convention and six YVL guides due for revision, among others. The Committee followed regularly operational events at nuclear facilities and arranged an annual nuclear energy seminar together with the Advisory Committee on Nuclear Energy.

The Committee has three divisions for preparatory work: a Reactor Safety Division, a Nuclear Waste Division as well as an Emergency Preparedness and Nuclear Material Division. In addition to the Committee members proper, distinguished experts from various fields have been invited to the Divisions. A total of 18 Division meetings were held in 2004.

APPENDIX 1 STUK's safety performance indicators for nuclear power plants in 2004

Seija Suksi

Summary of the results of STUK's safety performance indicators

Background to the indicators

The overall assessment of nuclear power plant safety by inspection and safety reviews is complemented by the STUK indicator system. The system indicators can be used to illustrate that certain safety factors under scrutiny have remained at a desired level or to gain insight into their possible changes and trends in the short and the long run. Declining trends indicate a possible need to enhance the performance and organisational operation of the plants and STUK's regulatory effort in those areas. Even the effectiveness of actions commenced based on indicator results can be monitored by means of these indicators. No specific action or threshold limits have been defined for the indicators. Rather, the aim is to recognise trends in the safety-significant functions of a nuclear power plant or STUK as early as possible. The limit values set in the legislation, in the YVL guides and in the Technical Specifications (Tech Specs) of the plants, as well as the target values contained in the objectives of the department of Nuclear Reactor Regulation (NRR), will be applied where available.

The indicator system is divided into two principal groups: external indicators for the safety of nuclear facilities and internal indicators for the regulatory effort. External indicators are divided into three principal subgroups: safety and quality culture; operational events; and structural integrity. These principal subgroups have a total of 14 indicator areas having 51 specific indicators.

Guide YTV 1.4, "Calculation, assessment and utilisation of the NRR indicators", in the NRR Quality Manual defines the responsibilities and procedures for data collection and calculating indicators for the NRR; and for assessing, reporting and utilising their values. Appendix 1 to the guide describes the NRR's external indicators (indicators for safety of nuclear facilities); their definitions and data acquisition; the person responsible for the updating of each indicator (person in charge of indicator); and the person who maintains the indicator system (administrator). Indicator definitions, graphs and results interpretation can be found on the NRR site in STUK's intranet.

The STUK indicators were included in the revised strategy of early 2003. Of the effectiveness indicators for STUK's activities, the below apply to the NRR: occupational doses, radioactive releases from nuclear facilities and the resultant population exposure in the vicinity of the plants, safety-endangering events at nuclear facilities, condition of components relevant to the accident risk of nuclear facilities, updating of YVL guides, customer satisfaction and number of complaints. The last three indicators describe the NRR's own activities and are incorporated in the indicator area for regulatory activities. Indicators for plant safety, incorporated in the STUK strategy, have quantitative limits contained in the regulations or the NRR's own objectives.

All nuclear plant safety indicators are contained in the effectiveness sector of the NRR strategy. Their values are updated quarterly and the deviations and their reasons are tracked down immediately. The development trends of indicators and indicator areas are assessed in the annual summary. The summary is utilised in conjunction with other assessments and inspection observations in the overall assessment of nuclear plant safety conducted by STUK. The annual summary of the indicators is attached to the annual report on regulatory control of nuclear safety submitted to the Ministry of Trade and Industry.

Actions decided on the basis of the indicator results for 2003

The results of STUK's safety performance indicators for nuclear power plants in 2003 have been presented in Appendix 1 to the annual report on regulatory control of nuclear safety 2003 (STUK-B-YTO 230). After the completion of the summary, the conclusions presented in the report concerning indicator results, as well as their justifications, were reviewed with the people responsible for the indicators and the management of NRR and STUK in a joint meeting early in 2004. The indicator results were presented to all of NRR in a common departmental meeting. Issues discussed at these meetings included factors affecting the results of the indicators that show a deteriorating trend, the reasons behind them and measures to discontinue the trend.

There was reason for a closer evaluation of the deteriorating trend of the maintenance function of the Loviisa power plant. It was decided to evaluate in more detail the development of the indicators depicting maintenance operations in 2004 in connection with the quarterly update. In addition, the departmental management decided on directing the focus of the periodic inspection programme towards the maintenance operations and ageing management of the Loviisa plant. Also, the Nuclear Safety Committee of the Loviisa nuclear power plant took notice of the growing trend in defects and repair time, and asked the plant for an explanation.

The deterioration of the safety and quality culture of the Olkiluoto power plant, especially in operations, was, on the grounds of the indicators, no longer considered a reason for further measures or directing resources because Teollisuuden Voima Oy (TVO) had taken the necessary development measures on the basis of the discussions triggered by the INES Level 1 events that occurred within a short period of time towards the end of the year 2003. During the planning of the periodic inspection programme, it had been decided early in the year that a B-level inspection concerning operations would be included in the periodic inspection programme of the Olkiluoto plant in 2004. In connection with the A inspection (Safety Management), likewise in the 2004 programme, there was reason to evaluate the development measures presented by TVO and their realisation. The office of NRR responsible for controlling operations (TUR) decided to intensify the monitoring and evaluation of the operations of Olkiluoto. The structure of the periodic inspection programme and the inspections in 2004 are listed in Appendix 4.

STUK evaluated the increased need to deliberately deviate from the technical specifications that became evident in 2003. The main reason for the increase in the exemptions granted by STUK at the Loviisa power plant was the replacement of fixed radiation measurement system (the MONU project). The number of exemptions granted to the Olkiluoto plant had remained at the level of the previous years. The exemptions did not warrant re-evaluation of the Tech Specs at either plant. From STUK's point of view, the increased number of applications for exemptions means an increased amount of work in handling and assessing them.

Indicator results for 2004

Safety and quality culture

According to the indicators for 2004, there was a deceleration in the previous year's deteriorating trend in the maintenance functions of the Loviisa power plant. The maintenance operations were evaluated by plant unit concerning yearly volume of maintenance work, preventive maintenance and failure repairs of Tech Spec components, and on the basis of the volume of repair work during power operation, the average time spent on failure repairs and the production losses caused by failures. In Loviisa the total volume of the yearly maintenance work of Tech Spec components, including both failure repairs and preventive maintenance, has been increasing for three consecutive years. In 2004 the volume of failure repairs decreased slightly. The volume of preventive maintenance has remained steady on the yearly level. The volume of failure repairs during power operations has increased slightly in the last few years, especially at Loviisa 2. However, significant numbers of failures have been in such back-up systems that have no direct influence on the operation of the plant units or nuclear safety. This also had an effect on the average repair time of the Tech Spec components, which was high in 2003 and 2004, especially at Loviisa 2.

The total yearly volume of maintenance work of Tech Spec components at the Olkiluoto plant has been decreasing during the past two years, which is partly caused by the total volume of preventive maintenance, which has been on the decrease for several years. The distribution of preventive maintenance between plant units has been determined by the length of the annual maintenance outages. During the corresponding monitoring period, the number of failure repairs has been increasing in a linear fashion. The number of failures during power operation also indicated an increasing trend for the second successive year. At Olkiluoto 1 there were an exceptionally large number of failures of Tech Spec components causing immediate operation restrictions in 2004. The average repair times remained low at Olkiluoto.

Production losses due to failures at the Loviisa and Olkiluoto plants remained relatively small in 2004. The minor production loss at Loviisa 1 was mainly due to power reductions caused by failures in reactor protection systems and, eventually, a scram during the second quarter. The minor production loss at Loviisa 2 in the last quarter was caused by the repair of the check valve in the feed water line of the secondary circuit. At the plant units of Olkiluoto the production losses due to failures were higher than the average of the past few years. The most significant production losses were caused by the repair of the generator water cooling system at Olkiluoto 2 – for which purpose the plant unit was brought to a hot shutdown in the third quarter – and by the deterioration of the isolation resistance of the primary coolant pump, which caused the plant to be operated with five pumps and the power to be restricted for more than a month until the annual maintenance outage. The most significant production loss at Olkiluoto 1 in the first quarter was partly due to the failures and replacement of the position indicator of the control valve of the relief system during hot shutdown and the reactor scram during the subsequent start-up, caused by the inadvertent closing of the isolation valve of the main steam line. The plant was brought to a cold shutdown in order to repair the valve.

Safety systems' unavailability was followed by means of international indices provided by the licensees. The high pressure safety injection system, the auxiliary feed water system and the emergency diesel generators were monitored at the Loviisa power plant; Olkiluoto monitored the containment spray system, the auxiliary feed water system and the emergency diesel generators. According to the indicators for 2003, the diesel generator unavailability index showed a deteriorating trend for the third year in succession. In the first half of 2004 the emergency diesel unavailability index at the Loviisa power plant indicated that the unavailability level was still increasing. STUK investigated factors having an impact on the unavailability and asked the Loviisa power plant to survey the validity of the international unavailability index. After correction of the errors detected in the calculations, the value of the indicator representing the emergency diesel unavailability for 2004 fell to the pre-2001 level.

The indicator representing the emergency diesel unavailability at the Olkiluoto plant for 2004 was considerably higher than the very small value of 2003. Some of the factors that had an impact on the increasing unavailability were the stoppages of diesels caused by various reasons. The unavailability of the containment spray system of Olkiluoto 2 also increased from 2003 due to vibration problems in the system's pumps. The unavailability index of the auxiliary feed water system dropped from the 2003 values to a normal low level at both plant units.

There were two plant conditions in non-compliance with the Technical Specifications at the Loviisa plant and only one at the Olkiluoto plant in 2004, so there was a change for the better in the deteriorating trend of Olkiluoto, which had gone on for the three previous years. There was a condition in non-compliance with the Technical Specifications at Loviisa 2 when the activity measurements of the exhaust pipelines of the turbine condenser's main ejectors were not in an operational condition because of a design error in the modification of measurements carried out the previous summer. The other condition in non-compliance with the Technical Specifications was a short-term disorder in the reactor's decay heat removal during the annual maintenance of Loviisa 2 in cold shutdown. The condition in non-compliance with the Technical Specifications at Olkiluoto involved bypassing the protection limit that monitors condensate conductivity within the reactor protection system. This was done as a safety precaution for a preventive maintenance check of the safety valve at both units of the Olkiluoto plant. Adherence/non-adherence to the Tech Specs shows the safety attitude of the plants and the ability of the plant operating organisations to follow the rules and their own guidelines. The non-compliances at Loviisa were caused by defects in supervision of the contracted work.

The need for the Loviisa power plant to deliberately deviate from the Tech Specs fell in 2004 from the relatively high level of the previous year to a level corresponding to the long-term average. The nine exemptions granted to the Loviisa plant were for the most part concerned with the need to deviate from the Tech Specs caused by modification and improvement work. At the Olkiluoto plant there were also nine exemptions granted, which is slightly more than in the year before. Five of these exemptions were concerned with the construction of the new plant unit. The exemptions granted did not warrant re-evaluation of the Tech Specs.

The indicator describing the currency of plant documentation shows the document revisions, which relate to safety-significant or extensive modifications carried out in the 2004 annual maintenances of Loviisa and Olkiluoto and which must be implemented before the plant is started up after the annual maintenance in question. After the plant modifications carried out in the annual maintenance, the plant documentation at the Olkiluoto plant had once again been updated with regard to all documents that had to be updated by the start-up. With regard to the Loviisa power plant, the result can be considered reasonable as well, although there were more deviations than previously. The numbers do not yet include any monitoring with regard to plant documents that only need to be updated by the next annual maintenance.

The plant units' safety performance indicator for investments on improvements and modifications indicates relative fluctuation in investments. Sums given in euro are the utilities' business secret not to be published here. This safety performance indicator was included in the STUK indicator system in 2000 to indicate the potential effect of deregulated electrical markets on investment. The fluctuation in the indicator clearly shows the investments made in 1997–2000 in the plants' power upgrades and modernisation projects. The investments of 2004 indicate the increasing trend at both the Loviisa and the Olkiluoto plants. The main investments at the Loviisa plant during the past couple of years have been the provisions for severe reactor accidents and the modernisation of the turbine. In the latter part of 2004 the construction of areas related to the upgrading of I&C systems, as well as the planning of the automation renewal project, began at Loviisa. One of the main investments in the Olkiluoto plant in 2004 was the turbine plant renewal project, which also includes renewal of the steam dryers.

STUK works to affect, both directly and indirectly, the radiation doses for nuclear power plant workers and the calculated radiation exposure for the surrounding population arising from releases. This involves low radioactive releases into the environment, clearly below set limits. Releases into the air and water at the Olkiluoto plant remained low in 2004, as did the calculated radiation dose for the most exposed individual in the population surrounding the Olkiluoto plant. Releases of iodine and aerosols into the atmosphere indicated a slight increase at the Loviisa plant. Releases into the sea at Loviisa were greater than in the previous year because towards the end of 2004 the plant released clarified evaporation residues from storage tanks into the sea (so-called controlled liquid discharges) in a controlled manner. This procedure, which reoccurs every few years and requires a prior notice to STUK, raised the calculated radiation dose to the most exposed individual in the vicinity of Loviisa, while the dose still remained clearly below the limit set in the Government's resolution. The individual doses for the workers were below the personal dose limits at the Olkiluoto and Loviisa plants. The collective doses for the workers were small and below the set limits at the Olkiluoto plants and Loviisa 2. During the long repair and maintenance outage the collective occupational dose for Loviisa 1 became slightly greater than estimated, e.g. in reactor and insulation work, exceeding the calculatory reporting threshold confined to net electric power specified in the Guide YVL 7.9.

Operational events

The numbers of operational events at the Loviisa and Olkiluoto power plants in 2004 were on the average level of the past few years. There was a change for the better in the deteriorating trend of operational events at the Olkiluoto power plant implied by the indicators for 2003. Two events warranting a special report occurred at the Olkiluoto plant and three at the Loviisa plant. In addition to non-compliances with Tech Specs, spent fuel handling malfunctions that occurred in the spent fuel storages at both plants warranted a special report. The factors behind the events included design errors in modifications, non-compliance with instructions, and defects in work management. In 2004 six operational transient reports were submitted from the Olkiluoto plant and nine from the Loviisa plant. The disorders did not focus on any specific system or an individual device. No fires occurred at either plant. In 2004 technical failures were the determining causes of events at both plants. The number of events is on a slight increase at the Loviisa plant. The report made by the plant on a fatal accident in electrical work during the annual maintenance of Loviisa 1 is not included in any of the aforementioned event reporting categories and therefore does not show in the indicators. Neither does STUK follow the numbers of occupational accidents with its indicators.

The indicator system also reviews the risk-significance of operational events. For this, the events are divided into three groups: 1) unavailabilities due to component failures, 2) planned unavailabilities, and 3) initiating events. The events in each group have been further divided by their risk-significance into three categories, and the indicator is the number of events falling into each category. The events analysed for 2004 are considered part of normal nuclear power plant operation and no further measures were required from STUK.

One reactor scram occurred at both plants in 2004. The scram at Loviisa 1 was due to a failure in the reactor protection system. At Olkiluoto 1 there was a reactor scram caused by the closing of the steam line valve. All safety systems functioned according to design during the scrams. Because no essentially hazardous events occurred at the plants, these scrams became the most risk-significant events. Nine other events of the highest risk category occurred at the Loviisa plant and eight at the Olkiluoto plant. The unavailability at Loviisa was caused by latent defects in the emergency diesel generators, the auxiliary feed water system and the containment spray system. In addition, the events in the most significant category include the annual maintenances of the back-up emergency feed water system because of the conservative method of modelling. At Olkiluoto the events included in the most risk-significant category were caused both by planned unavailability and by latent defects in the emergency diesel generators of both plant units, and the component intermediate cooling system of the shut down reactor of Olkiluoto 2. The numbers of the most risk-significant events showed an increase from the previous year at Olkiluoto and a decrease at Loviisa.

The number of events falling into the middle category of risk-significance was clearly below the previous year at Loviisa: seven events due to failures. At Olkiluoto the number was on the level of the previous year: approximately twenty events, two-thirds of which occurred at Olkiluoto 1. The Olkiluoto events were mostly planned unavailabilities, including those caused by work executed under exemption from the Tech Specs and preventive maintenance. The number of analysed events falling into the least risk-significant category has increased because there has been a shift in the reporting towards a policy in accordance with the Guide YVL 1.5 (the unavailabilities of all Tech Spec components are presented in monthly or quarterly reports). There were more than a hundred events of this risk category at both plant units of Loviisa, 266 altogether, and dozens at the Olkiluoto units, 148 in total. The Loviisa events were mostly planned unavailability; the Olkiluoto events were mostly caused by failures. The kind of events analysed now were partly eliminated from the analysis in previous years.

Structural integrity

In the safety performance indicator area, the leaktightness of multiple barriers (fuel, primary circuit, secondary circuit, containment) is monitored. The objective is that leaktightness complies with the requirements and deteriorating trends are neither allowed, as assessed according to STUK's safety performance indicators.

Based on the 2004 indicators, the set limits on barriers preventing the spread of radioactive releases were not exceeded. There have been no fuel leaks at the Loviisa plant units for years now. Minor fuel leakages have occurred almost every year at the Olkiluoto plant units. The development of the leakages has been monitored during power operation, and the leaking fuel bundles have been removed from use in the annual maintenance outage following the leak detection. A minor fuel leak was observed at Olkiluoto 2 in the third quarter.

Primary and secondary circuit integrity is monitored by international chemistry indices used by the utilities or by indices designed by the plants, and by the concentration levels of corrosive impurities and corrosion products. The chemistry indices indicated that process chemistry control had been successful at the Loviisa 1 and Olkiluoto 1 plant units in 2004. At Loviisa 2 the high value of the chemistry index in 2003 and 2004 was due to a seawater leak in a turbine condenser, which was also indicated by the chloride content of the steam generator's blow down. The leak was repaired in the annual maintenance outage in 2004, after which the indicator values were restored to pre-leak level. No significant changes took place in the cobalt-60 and iron contents of the primary coolant or the iron content of the feed water during the monitoring period.

The chemistry index value of Olkiluoto 2 in the third quarter, which is substantially higher than the target value, is due to a leak in the turbine condenser, which is also indicated by a higher than normal chloride content. The leak was repaired within a couple of days of its detection. Since the power uprates, both Olkiluoto plant units have had the problem of a sulphate content higher than the reactor water target value. After the system modifications which lowered the temperature of cleaning the condensate, the sulphate concentration has remained below the target level (5 µg/l) at both plant units, not including the third quarter of 2004 when the maximum content at Olkiluoto 2 was 8.3 µg/l. There is no straightforward reason for the sulphate content being higher than normal. No significant changes have taken place at either Olkiluoto plant unit in the cobalt-60 activity concentration of the primary coolant or the iron content of the feed water during the monitoring period.

At the Olkiluoto plant, leakages from the primary circuit are monitored by operating cycle as well. During the operating cycle 2003–2004, the volumes of identified and unidentified leaks in the primary circuit were low at both Olkiluoto plant units. During the previous operating cycle of 2002–2003, the volume of unidentified leaks was fairly high at Olkiluoto 1, which was due to leaks from check valves in the blow down system of the main steam lines, which took place for the whole operating period. The utility is planning on a new seal structure for the valves.

Containment integrity has been good in both Olkiluoto and Loviisa. The overall as-found leakage of the containment outer isolation valves was below the set limits. The overall as-found leakage of the Loviisa 1 outer isolation valves has grown for the second year in succession. Nearly half of the overall leakage was caused by group tests of the isolation valves in the tank lines of the emergency cooling system, where the leak measured for the group in question is recorded as the result for all valves. However, the multiple entries are not taken into account when calculating the overall leakage. A more valid picture of the containment leakage would result from reducing group tests or modifying the calculation method so that it would correspond to that of TVO. The overall leakage of isolation valves has decreased at Olkiluoto 2 and slightly increased at Olkiluoto 1 from that of the previous year. Approximately one-half of the leakage at Olkiluoto 1 is due to leaks in two isolation valves, apparently caused by impurities that began to move during a scram.

The percentage of isolation valves that passed the leaktightness test at first attempt has remained high, although there is a decrease from the previous year at both Loviisa and Olkiluoto.

The overall as-found leakage of containment penetrations, which at Loviisa includes leaktightness tests of the bellows seals of the personnel airlock, the emergency personnel airlock, the material airlock, the reactor pit, inward relief valves, cable penetrations, the containment maintenance ventilation systems, the main steam line and the feed water system, has still grown at Loviisa 2, but the set limit remains clearly unexceeded. At Loviisa 2 approx. 88% of the overall leakage comes from a leaking penetration bellows seal in the maintenance ventilation system. The leaktightness of the rubber bellows has been problematic over recent years, and they will, therefore, be transformed into a metal structure. The overall as-found leakage rate of containment penetrations, which at the Olkiluoto plant includes leakages in the upper and lower personnel airlock, the maintenance dome and the containment dome, has been small.

Conclusions drawn from the results of the 2004 indicators

The data gathered from 2004 for nuclear plant safety indicators did not indicate such changes in individual indicators, indicator areas or the three main areas as would have warranted an immediate reaction from STUK, with the exception of indicators pertaining to the unavailability of emergency diesels at the Loviisa plant, which were restored to the normal level after correction of the errors detected in the calculation of the international indices at the Loviisa plant.

The requirements set for the indicators of the effectiveness of STUK's activities were fulfilled as regards individual occupational dose, radioactive releases and population exposure. During the long repair and maintenance outage the collective radiation dose for Loviisa 1 became slightly greater than estimated, exceeding the calculatory reporting threshold confined to net electric power specified in the Guide YVL 7.9.

The releases of radioactive substances at the nuclear power plants were clearly below the set limits. Releases into the atmosphere were small at both the Loviisa and the Olkiluoto plants. Releases into the water decreased further at the Olkiluoto plant. Since the Loviisa plant made a controlled low-activity waste water discharge from storage tanks into the sea towards the end of 2004, releases into the water were slightly greater than the year before at Loviisa. As in the previous years, the dose in Loviisa and Olkiluoto for the most exposed individual in the vicinity due to releases by nuclear power plants was small and clearly below the threshold value set in the Government resolution. In the vicinity of Loviisa the dose for the most exposed individual was slightly increased by the controlled discharge of low-activity evaporation residues into the sea.

The plants were mainly used according to the Technical Specifications. Two situations in non-compliance with the Tech Specs occurred at the Loviisa plant and one at the Olkiluoto plant. The deviation concerning both Olkiluoto plant units and one of the deviations at Loviisa 2 were caused by incorrect working methods due to non-adherence to guidelines. The other deviation at Loviisa 2 was due to an error in the design of modifications. The events at the Loviisa plant also involved defects in the supervision of contracted work. There was a change for the better in the deteriorating trend in the compliance with the Technical Specifications, which had gone on for the three previous years at the Olkiluoto plant.

The need for the Loviisa power plant to deliberately deviate from the Tech Specs fell in 2004 from the relatively high number of the previous year to nine, which corresponds to the long-term average. The exemptions granted by STUK were for the most part concerned with the need to deviate from the Tech Specs caused by modifications and improvement work. At the Olkiluoto plant there were also nine exemptions granted, which is slightly more than in the year before. Five of these exemptions were concerned with the construction of the new plant unit. The exemptions granted did not warrant re-evaluation of the Tech Specs.

No events endangering nuclear safety occurred at the nuclear facilities. The numbers of operational events at the Loviisa and Olkiluoto power plants in 2004 were on the average level of the past few years. There was a change for the better in the deteriorating trend of operational events at the Olkiluoto power plant implied by the indicators for 2003. The Olkiluoto power plant submitted eight event reports in 2004, while the Loviisa plant submitted twelve. Technical failures were the determining causes of events at both plants in 2004. The number of events is on a slight increase at the Loviisa plant. The report made by the plant on the electrical accident that led to one person's death during the annual maintenance of Loviisa 1 is not included in any of the aforementioned event reporting categories and therefore does not show in the indicators. Neither does STUK follow the numbers of work accidents with its indicators. Owing to the event, STUK has launched conversations with the Safety Technology Authority (TUKES) supervising electrical safety and the other authorities that investigated the fatal accident. The Loviisa plant has also been asked for accounts of matters including compliance with occupational safety regulations and development of work order practice in the operation of a nuclear power plant. Fortum has launched development measures with regard to work procedures. The long-term improvement measures, and the measures launched by STUK, are still under evaluation.

According to the indicators for 2004, the previous deteriorating trend in the maintenance function of the Loviisa power plant came to a halt. The volume of yearly failure repairs decreased slightly from the previous year. This is due to the decrease in the overall volume of failures because the yearly volume of preventive maintenance has remained constant. The volume of failures during power operation causing an immediate operation restriction has increased in the last few years at Loviisa 2. However, the failures have been in such back-up systems that have no direct influence on the operation of the plant units or nuclear safety. The repair of the failures is prioritised in the realms of the resources available on the basis of their urgency and safety significance. This shows in the average repair times, which are high at the Loviisa plant, especially at Loviisa 2. However, the production losses caused by failures have remained small at the Loviisa plant. The most risk-significant events, such as the reactor scram at Loviisa 1, and the other significant events were caused by component failures. The numbers of events falling into these risk categories were smaller than in the previous year. The unavailability of safety systems during the events in question was caused by latent defects in the emergency diesel generators, the emergency feed water system and the containment spray system. In addition, the most significant events include the unavailability of the back-up emergency feed water system in annual maintenance because of the conservative method of modelling.

The total yearly volume of maintenance work of Tech Spec components at the Olkiluoto plant has been decreasing during the past two years, which is partly caused by the total volume of preventive maintenance, which has been on the decrease for several years. In proportion, the number of failures has been on a linear increase. The volume of operation restriction work during power operation showed an increasing trend for the second successive year. There were an exceptionally large number of failures of Tech Spec components causing immediate operation restrictions at Olkiluoto 1 in particular. An increasing fault trend would indicate a degrading plant condition. The simultaneous decreasing trend in preventive maintenance may indicate problems with component lifetime management. The average failure repair times were short at the Olkiluoto plant units. The production losses due to failures were higher than the average of the past few years. The future will show whether an actual change has occurred in the trend. The most risk-significant events, such as the reactor scram at Olkiluoto 1, and the other significant events were caused both by component failures and planned unavailability. The number of events falling into these risk categories was greater than in the previous year. The unavailability of safety systems during the events in question was caused by latent defects in the emergency diesel generators of both plant units and the shut down reactor intermediate cooling system of Olkiluoto 2. The international indices describing the unavailability of the emergency diesels at both Olkiluoto plant units and the containment spray system at Olkiluoto 2 indicated an increase in the unavailability levels.

The structural integrity of multiple barriers containing the release of radioactive substances has remained good, although a slight deterioration can be observed. Fuel leaks have been rare at the Loviisa plant units in the past few years, and there were none in 2004. Fuel leaks have occurred almost every year at the Olkiluoto plant units; a fuel leak was observed at Olkiluoto 2 at the end of August.

In addition to the international chemistry performance indices depicting water chemistry, new indicators were introduced in 2004 depicting impurities causing corrosion in the primary and secondary circuits as well as the concentration levels of corrosion products in the circuits. The chemistry indices indicated that chemistry control had been successful at the Loviisa 1 and Olkiluoto 1 plant units in 2004. The leaks in the turbine condensers of Loviisa 2 and Olkiluoto 2 showed as high chloride contents. No straightforward explanation was found for the sulphate concentration being higher than the target value for the third quarter at Olkiluoto 2. Short-term corrosive impurity contents higher than normal have not been proven to have a damaging impact on the construction materials.

Containment integrity has remained good in both Olkiluoto and Loviisa. The overall as-found leakage of the Loviisa 1 outer isolation valves indicates an increasing trend, which is mainly due to group tests and the method of calculating the overall leakage. A more valid picture of the containment leakage would result from reducing group tests or modifying the calculation method so that it would correspond to that of TVO. The percentage of isolation valves which passed the leaktightness test at first attempt has decreased at both Loviisa and Olkiluoto. Overall leakage through containment penetrations grew at Loviisa 2 but the set limit was not exceeded. The leaktightness of the rubber bellows of the penetrations had been problematic and the Loviisa power plant has initiated their replacement with metal bellows. The overall leakage of containment penetrations has remained small at the Olkiluoto plant units.

The investments at both Loviisa and Olkiluoto in 2004 indicate an increasing trend, which is influenced in Loviisa by the preparation for extensive safety improvement projects and in Olkiluoto by the preparation for a new plant unit project, in addition to modernisation projects for the units currently in operation. The updating situation of document revisions needed after plant modifications (entered into the register) in 2004 was tolerable for the Loviisa units and good for the Olkiluoto units by the start-up of the plants.

Judging by the indicators, there has been improvement in the operation of the Olkiluoto plant. Quality assurance and radiation protection reached the goals defined. The indicators depicting faults in Tech Spec components, maintenance and unavailability of safety systems indicate potential problems in the maintenance strategy or the plant's lifetime management. This observation is supported by the technical reasons for the events and the increase in the most risk-significant events, as well as the component failures behind them. There are problems every year with fuel integrity at the Olkiluoto units.

At the Loviisa power plant there were defects in monitoring the performance of the plant's internal units and in the supervision of contracted work. The set target was not fully reached in the updating of documents. The objectives of the radiation protection during the annual maintenance outage at Loviisa 1 were not achieved, and the reporting threshold for collective dose prescribed in the YVL Guide was exceeded. Certain defects were detected in connection with the indicator control of STUK with regard to the validity of laboratory results reported. Similar problems also occurred in connection with sorting out the errors detected in the calculation of indicators depicting unavailability of safety systems. No straightforward explanation was found for the increase in the average failure repair time of Tech Spec components. It remains to be determined whether the long repair times relate to ageing management or maintenance resources.

The number of operational events is slightly increasing in Loviisa and decreasing in Olkiluoto. The number of the most risk-significant events showed a decrease from the previous year at Loviisa and an increase at Olkiluoto. At Loviisa the most significant failures occurred in the emergency diesel generators, the emergency feed water system and the containment spray system. In addition, the most significant events include the annual maintenance of the back-up emergency feed water system. At Olkiluoto the most significant failures were related to diesel generators. The unavailability of the emergency diesels at both Olkiluoto plant units and the containment spray system at Olkiluoto 2 indicated an increase in 2004.

Introduction to indicators and their definition

Given next in the report are the definitions, data acquisition, calculation responsibilities and purpose of the indicators for nuclear power plant safety in the STUK indicator system; and indicator values updated on the basis of the 2004 data, their interpretation and assessment of change.

The NRR has assigned persons responsible for the acquisition of indicator data as well as for their calculation and analysis. In 2004 resident inspectors of the office of safety management (TUR) were responsible for indicators concerning failures and preventive maintenance of Tech Spec components and safety systems availability. TUR was also responsible for production losses due to failures. The data on primary circuit leakages for the Olkiluoto nuclear power plant was provided by the resident inspector. The inspectors of TUR gathered and assessed indicators describing the quality of the maintenance function at the Olkiluoto plant. TUR maintained an operational events follow-up table and was responsible for indicators based on operational events and reports. The office of risk assessment (RIS) assessed the risk-significance of the events. Inspectors in the office of power plant technology (VLT) were responsible for indicators describing the functioning of the fire alarm system as well as the integrity of fuel and the primary circuit. The office of reactor and safety systems (REA) gathered and calculated indicators describing containment leaktightness. The office of radiation protection (SÄT) gathered dose and release data and the corresponding indicators. The office of plant projects (HAN) was responsible for the follow-up of documentation updating and investments indicators. The nuclear power plant safety indicator system was maintained in the unit of management support (YJT) and co-ordinated by the event investigation manager.

As a result of the intermediate assessment of the STUK indicator system conducted in 2003, it was decided to specify the definitions of certain specific indicators to improve their reliability and to find ways of enhancing the indicator process. The definitions of certain indicators were also changed as of the beginning of 2004, such that they would support, as well as possible, NRR's regulatory work and its sub-processes.

New indicators concerning the risk-significance of events were introduced for 2003. In indicator areas describing the maintenance of safety-significant components (failures in Tech Spec components, maintenance, and repair time) and the integrity of the primary and secondary circuits, existing indicators were modified and new indicators introduced as of the beginning of 2004. The indicators in accordance with the new definitions have been calculated retrospectively over the previous few years to gain a base for comparison with the 2004 indicator values.

As of the beginning of 2004, the following indicators or their definitions were modified:

I.1a Failures of components subject to the Technical Specifications:

As the indicator, the number of failures causing unavailability of components defined in the Tech Specs during power operation is followed by plant unit. The failures are divided by plant unit into two groups: failures causing an immediate operation restriction and failures causing an operation restriction in connection with repair work.

Previously, the total number of failures of components defined in the Tech Specs during power operation was followed as the indicator for the whole plant.

I.1b Maintenance of components subject to the Technical Specifications:

As the indicator, the numbers of failure repairs and preventive maintenance work on components defined in the Tech Specs and their ratio are followed by plant unit.

Previously, only the ratio of preventive maintenance jobs to failure repair work orders was followed by plant. Because the numerical value as such indicated no definite variation or trend, and it was difficult to interpret the reasons for the variation, a change was made to follow the ratio of failure repairs to preventive maintenance jobs by plant unit as the indicator.

I.1c Repair time of components subject to the Technical Specifications:

As the indicator, the average repair time of failures causing unavailability of components defined in the Tech Specs is followed (as an average of the repair times of all failure repairs).

Previously, the average of the percentage values of repair times in relation to repair time allowed in the Tech Specs was followed at the Olkiluoto plant. For the Loviisa plant, only those components whose allowed repair time is three days were included. There was a wish to unify the definition of the indicator so that it would be the same for both plants. Even now, the values given by the indicator are not comparable because the Loviisa nuclear power plant has a multiple number of Tech Spec components compared with the Olkiluoto plant, so in Loviisa repairs need to be prioritised within the framework of repair times allowed and resources available.

I.1d Maintenance errors, 1e Common cause failures preventing operation, 1f Potential common cause failures:

The indicators were combined for 2004 into a single indicator: Realised common cause failures in components or systems reported in the sphere of an operation restriction under Tech Specs.

Previously, as regards all Olkiluoto systems, the number of maintenance errors were followed as the indicator, containing maintenance-error induced common cause failures and individual maintenance errors. Common cause failures arising during operation have also been included. The number of technical common cause failures causing the unavailability of equipment or systems and number of potential common cause failures had their own indicators.

The indicators still require re-evaluation and development. Definition of the indicator for the Loviisa plant is under way.

III.1. Fuel integrity:

As new unit-specific indicators, the below parameters are followed:

- The maximum activity concentration level of iodine on even, steady-state operation during the monitoring period. As regards the Loviisa plant, it means the sum of the iodine isotope activity concentrations as I-131 equivalents in hot standby, start-up state or power operation. With regard to the Olkiluoto plant, the indicator is the mere I-131 activity concentration in power operation. The maximum values are compared with the Tech Spec limit in a graphic presentation.
- The maximum activity concentration of I-131 during depressurisation while entering shutdown or after reactor scram

in addition to the old parameters:

- The maximum activity concentration on even, steady-state operation as I-131 equivalents (kBq/m^3) (Olkiluoto; I-131 only), and
- The number of leaking fuel rod bundles removed from the reactor in each annual maintenance outage.

III.2. Integrity of primary and secondary circuits:

In addition to the earlier international chemistry indices, the following new unit-specific indicators were introduced:

- Corrosive impurities:
  The maximum chloride concentration of the steam generator blow down (Loviisa) and the reactor water (Olkiluoto) compared with the Tech Spec limit is followed in the monitoring period. At the Olkiluoto plant the maximum sulphate concentration of reactor water is followed as well.
- Corrosion products released from the surfaces of the reactor circuit and the secondary circuit into the coolant:

For the Loviisa plant, the iron concentration of the primary coolant solid material and the secondary circuit feed water (maximum value of the monitoring period) are followed. For the Olkiluoto plant, the iron concentration of the reactor water (maximum value of the monitoring period) is followed. In addition, the maximum Co-60 activity concentration of the reactor coolant while bringing the plant to a cold shutdown is followed for both plants.

Instead of the international chemistry index, a new secondary circuit chemistry index was introduced at the Loviisa plant in 2003. The values of this index have been calculated retrospectively from 2002 onwards. This new index observes corrosive factors and contents of corrosion products in steam generator blow down and feed water. For steam generator venting, the calculation includes the chloride, sulphate and sodium concentrations.

In 2003 two types of indicators were used to follow the risk-significance of events (indicator II.2):

- Earlier the risk-significance calculated using the PSA of operational events was followed. The areas under scrutiny included exemptions to the Tech Specs, Tech Spec component failures, preventive maintenance of Tech Spec components and other planned isolations. As indicators were both the contribution of each follow-up area and the combined total risk of unavailabilities to annual core damage risk.
- As new indicators, the risk-importance of events caused by component unavailabilities began to be followed. As the risk measure, an increase in the Conditional Core Damage Probability (CCDP) associated with each event is employed. Events are divided into three groups: 1) unavailabilities due to component failures, 2) planned unavailabilities, and 3) initiating events. In addition, events are grouped into three categories according to their risk-significance (CCDP): the most risk-significant events (CCDP≥1E–7), other significant events (1E–8≤CCDP<1E–7) and other events (CCDP<1E–8). The indicator is the number of events in each category.

Unavailabilities caused by work for which STUK has granted exemption orders are in group 2. Possible non-compliances with the Tech Specs (indicator A.I.2) are in group 1, if they can be utilised for this indicator.

The previously used event risk indicators were dropped from the indicators for 2004.

Safety performance indicators

A.I Safety and quality culture

A.I.1 Failures and their repairs

A.I.1a Failures of components subject to the Technical Specifications

Definition

As the indicator, the number of failures causing unavailability of components defined in the Technical Specifications (Tech Spec components) during power operation is followed. The failures are divided by plant unit into two groups: failures causing an immediate operation restriction and failures causing an operation restriction in connection with repair work.

Source of data

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

Purpose of indicator

The indicator is used to assess the plant lifetime management and the development of the condition of components.

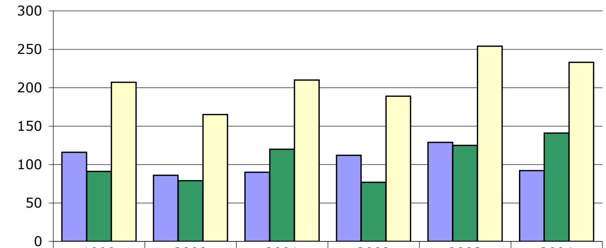
Responsible units/persons

Safety Management (TUR), resident inspectors
Pauli Kopiloff (Loviisa nuclear power plant)
Jarmo Konsi (Olkiluoto nuclear power plant)

Interpretation of indicator

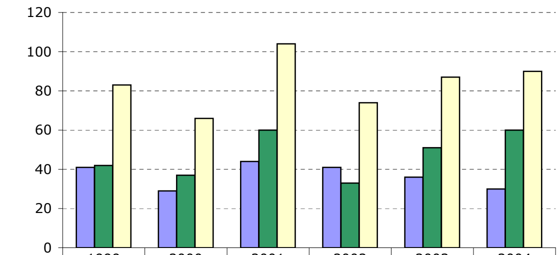
The number of repairs to Tech Spec components during power operation at the Loviisa plant decreased in 2004 from the number of the year before, which was substantial compared with those of the previous years. There were still approximately 15% more failures than previously in the 2000s. At Loviisa 2 the volume of immediate operation restriction work has been increasing in the past few years. At Loviisa 2 there was twice as many (60) failures of Tech Spec components causing immediate operation restrictions as at Loviisa 1 in 2004. At Loviisa 1 there were 64 failures in 2004 that caused an operation restriction only when isolating the component for repair work; at Loviisa 2 the figure was 80.

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



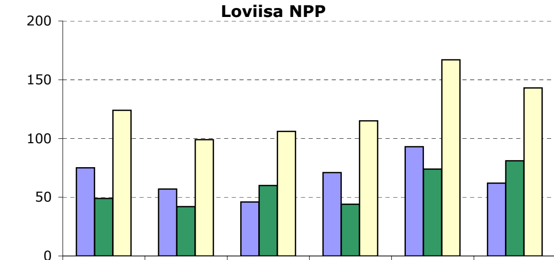
	1999	2000	2001	2002	2003	2004
LO1	116	86	90	112	129	92
LO2	91	79	120	77	125	141
LO1,2	207	165	210	189	254	233

Number of failures of Tech Spec components causing immediate operation restriction, Loviisa NPP



	1999	2000	2001	2002	2003	2004
LO1	41	29	44	41	36	30
LO2	42	37	60	33	51	60
LO1,2	83	66	104	74	87	90

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



	1999	2000	2001	2002	2003	2004
LO1	75	57	46	71	93	62
LO2	49	42	60	44	74	81
LO1,2	124	99	106	115	167	143

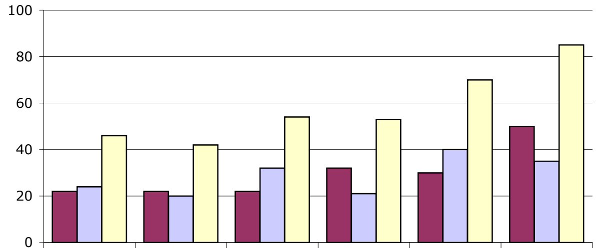
A significant type of failure at both Loviisa units for the past couple of years have been the inspections and repairs of the containment hydrogen measurement, the rotameter cleanings of the flow measurements of the steam generator blowdown lines, repairs to the radiation measurements in the ventilation of the controlled areas and the failure inspections and repairs of the diesels of the containment spray system.

The number of failures of Tech Spec components at Olkiluoto during power operation also indicated an increasing trend in 2004 for the second successive year. Previously, the number of failures had been established as 50 to 60 per year, whereas in 2004 the failures causing an immediate operation restriction added up to 85. There were an exceptionally high number of faults causing an immediate operation restriction in 2004, especially at Olkiluoto 1 (27), the overall number having previously been around twenty. The number of failures causing an operation restriction while isolating the component for repair work has been increasing at the Olkiluoto plant units. In 2004 the number was twice as high as the yearly numbers in the first years of the 2000s.

The greatest number of failures occurred in the components of the relief system 314 at Olkiluoto 1: there were 10 failures altogether, 8 of which were failures in the control valve 314V21 caused by a single reason. One type of failure at Olkiluoto 2 was the non-operation of a testing device in three internal isolation valves, detected during periodic tests. Two of the valves are located in the reactor core spray system (323) and one in the auxiliary feed water system. The same type of failure has occurred in previous years as well.

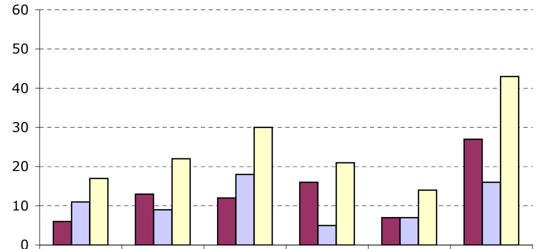
The continued growth in failures may indicate a deteriorating plant condition and problems with component lifetime management.

Number of failures of Tech Spec components causing unavailability during operation, Olkiluoto NPP



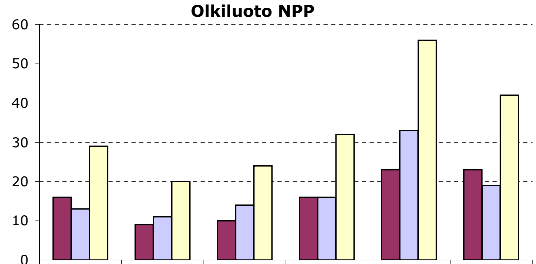
	1999	2000	2001	2002	2003	2004
OL1	22	22	22	32	30	50
OL2	24	20	32	21	40	35
OL1,2	46	42	54	53	70	85

Number of failures of Tech Spec components causing immediate operation restriction, Olkiluoto NPP



	1999	2000	2001	2002	2003	2004
OL1	6	13	12	16	7	27
OL2	11	9	18	5	7	16
OL1,2	17	22	30	21	14	43

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



	1999	2000	2001	2002	2003	2004
OL1	16	9	10	16	23	23
OL2	13	11	14	16	33	19
OL1,2	29	20	24	32	56	42

A.I.1b Maintenance of components subject to the Technical Specifications

Definition

As the indicator, the numbers of failure repairs and preventive maintenance work orders for components defined in the Tech Specs are followed by plant unit.

Source of data

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

Purpose of indicator

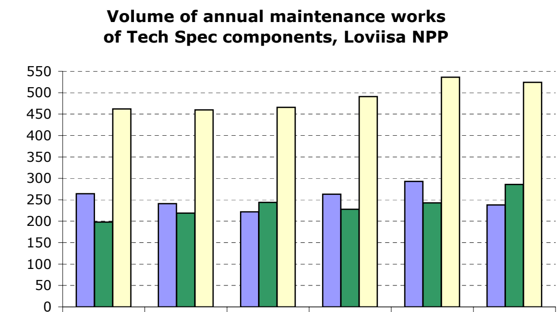
The indicator describes the volumes of failure repairs and preventive maintenance and illustrates the condition of the plant and its maintenance strategy. The indicator is used to assess the maintenance strategy executed at the plant.

Responsible units/persons

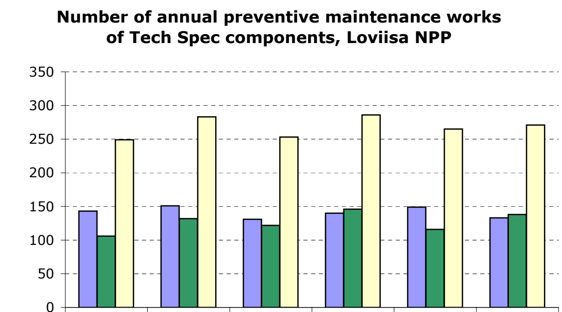
Safety Management (TUR), resident inspectors
Pauli Kopiloff (Loviisa nuclear power plant)
Jarmo Konsi (Olkiluoto nuclear power plant)

Interpretation of indicator

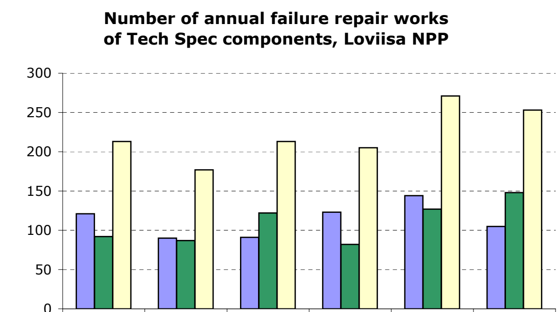
The overall volume of maintenance work on Tech Spec components has been on a slight increase at the Loviisa plant over the past three years. This is due to the fact that the yearly volume of failure repairs has increased slightly since 2000, especially at Loviisa 2. The volume of preventive maintenance has remained steady. Compared with the volume of failure repairs, the preventive maintenance volume of Tech Spec components has there-



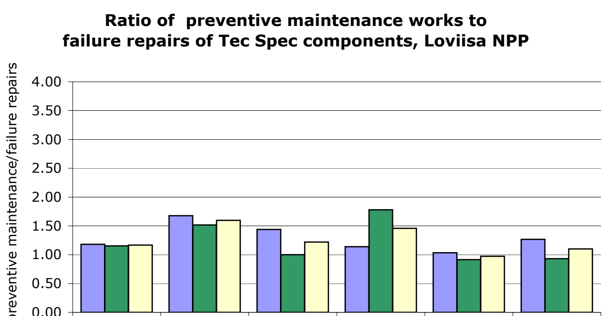
	1999	2000	2001	2002	2003	2004
LO1	264	241	222	263	293	238
LO2	198	219	244	228	243	286
LO1,2	462	460	466	491	536	524



	1999	2000	2001	2002	2003	2004
LO1	143	151	131	140	149	133
LO2	106	132	122	146	116	138
LO1,2	249	283	253	286	265	271



	1999	2000	2001	2002	2003	2004
LO1	121	90	91	123	144	105
LO2	92	87	122	82	127	148
LO1,2	213	177	213	205	271	253

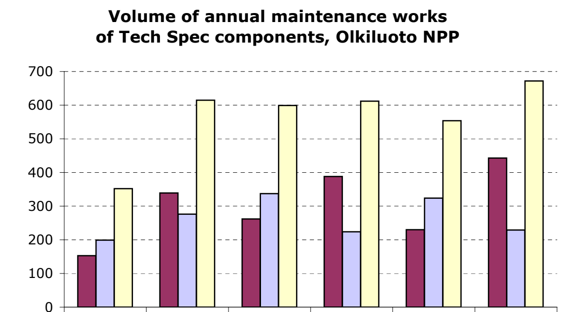


	1999	2000	2001	2002	2003	2004
LO1	1.18	1.68	1.44	1.14	1.03	1.27
LO2	1.15	1.52	1.00	1.78	0.91	0.93
LO1,2	1.17	1.60	1.22	1.46	0.97	1.10

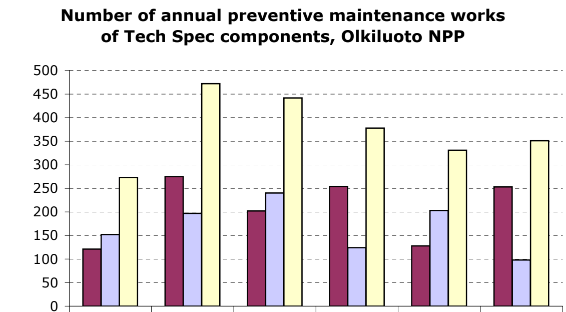
fore been on a slight decrease at the Loviisa plant. The ratio has been below one at Loviisa 2 in the past two years. In 2004 there were more failures of Tech Spec components at Loviisa 2 than Loviisa 1, while Loviisa 1 had more preventive maintenance jobs than Loviisa 2. The yearly-changing numerical values have been due to a natural fluctuation in the volume of preventive maintenance and failures, due to annual maintenance length among other things. In 2004 the annual maintenance outage lasted 47 days at Loviisa 1 and 22.5 days at Loviisa 2.

The overall number of maintenance operations on Tech Spec components in the 2000s has been around 600. In 2004 the yearly number of failure repairs at the Olkiluoto plant was 44% higher than that of the previous year; at Olkiluoto 1, the number was nearly twice as high as in 2003.

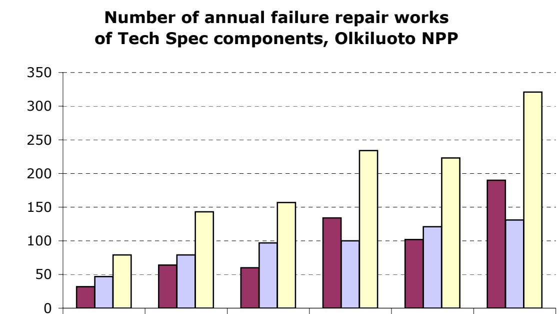
The preventive maintenance volume of Tech Spec components is on a decrease at the Olkiluoto plant compared with the volume of failure repairs. At Olkiluoto 1 the ratio of the number of preventive maintenance operations to the number of failure repairs was way above one in 2004, whereas at Olkiluoto 2 the ratio was below one. The volume of preventive maintenance decreased at Olkiluoto 2 and doubled at Olkiluoto 1 from that of the previous year. Preventive maintenance operations during plant operation are defined in the Tech Specs and their number thus stays a constant during the year. Failure repairs and preventive maintenance determined by outage duration affect the indicator. The duration of the annual maintenance outage was approximately 16 days for Olkiluoto 1 and approximately 9 days for Olkiluoto 2.



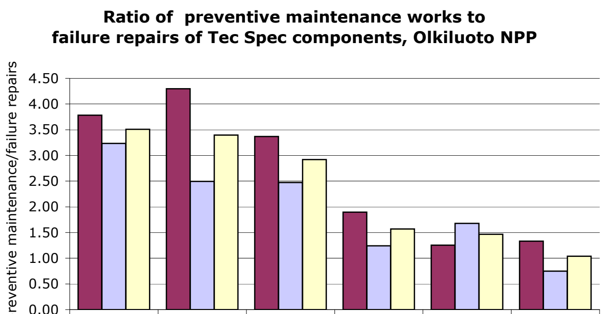
	1999	2000	2001	2002	2003	2004
OL1	153	339	262	388	230	443
OL2	199	276	337	224	324	229
OL1,2	352	615	599	612	554	672



	1999	2000	2001	2002	2003	2004
OL1	121	275	202	254	128	253
OL2	152	197	240	124	203	98
OL1,2	273	472	442	378	331	351



	1999	2000	2001	2002	2003	2004
OL1	32	64	60	134	102	190
OL2	47	79	97	100	121	131
OL1,2	79	143	157	234	223	321



	1999	2000	2001	2002	2003	2004
OL1	3.78	4.30	3.37	1.90	1.25	1.33
OL2	3.23	2.49	2.47	1.24	1.68	0.75
OL1,2	3.51	3.40	2.92	1.57	1.47	1.04

A.I.1c Repair time of components subject to the Technical Specifications

Definition

As the indicator, the average repair time of failures causing unavailability of components defined in the Tech Specs is followed. With each repair, the time recorded is the time of unavailability. It is calculated from the detection of the failure to the end of repair work, if the failure causes an immediate operation restriction. If the component is operable until the beginning of repair, only the time of the repair work is taken into account.

Source of data

The data is obtained from the work order systems and maintenance and operational documents of the power plants.

Purpose of indicator

The indicator shows how quickly failed Tech Spec components are repaired in relation to the repair time allowed in the Tech Specs.

The indicator is used to assess the maintenance strategy, resources and effectiveness of the plants.

Responsible units/persons

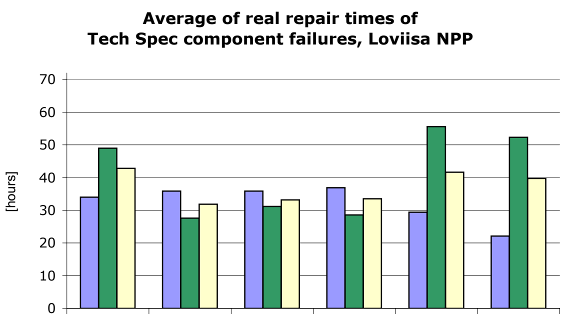
Safety Management (TUR), resident inspectors
Pauli Kopiloff (Loviisa nuclear power plant)
Jarmo Konsi (Olkiluoto nuclear power plant)

Interpretation of indicator

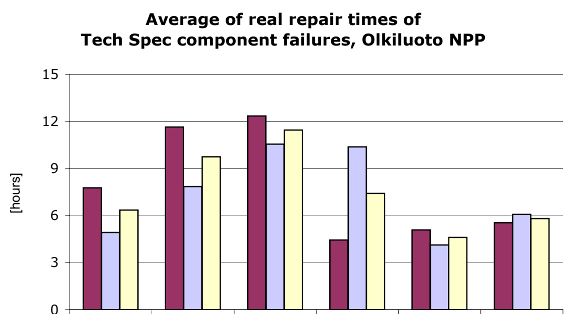
From 2000 to 2004 the average repair time of Tech Spec components at the Loviisa plant has varied between 30 and 40 hours. At Loviisa 1 there has been a clearly descending trend, the average repair time falling from 45 hours to 23 hours. At Loviisa 2 a reverse trend has taken place, the average repair time rising from 28 hours to 52 hours in that time period. Work is prioritised in the realms of repair times, taking into account the safety significance of the components and the resources available.

The 2003 peak value (55.6 hours) of the average repair time at Loviisa 2 was impacted by the failure inspections and repairs of the reactor building hydrogen control measurements (XW) and the diesels (EY05) in the containment spray system as well as the renewal of the EY05 start-up battery packs. The high value of 2004 was still impacted by the failure repairs to the reactor building hydrogen control measurements and the battery packs and rectifiers, the operation restriction of which (21 days' allowed repair time) comes into force as soon as the failure is detected.

From 1999 to 2004 the average repair times for Tech Spec components at the Olkiluoto plant units have varied between four and twelve hours. In 2004 the average repair times at both plant units were low, approximately six hours. There is a slight increase from the 2003 average repair times of only 4 to 5 hours.



	1999	2000	2001	2002	2003	2004
LO1	34.00	35.90	35.90	36.90	29.40	22.10
LO2	49.00	27.60	31.20	28.60	55.60	52.30
LO1,2	42.85	31.85	33.18	33.51	41.67	39.74



	1999	2000	2001	2002	2003	2004
OL1	7.77	11.64	12.35	4.44	5.08	5.54
OL2	4.92	7.85	10.55	10.38	4.12	6.07
OL1,2	6.35	9.75	11.45	7.41	4.60	5.81

A.I.1d Common cause failures

Definition
As the indicator, the number of common cause failures of components or systems defined in the Tech Specs is followed.

Source of data
Data for the indicators is collected from the reports by the utilities of operations causing an operation restriction.

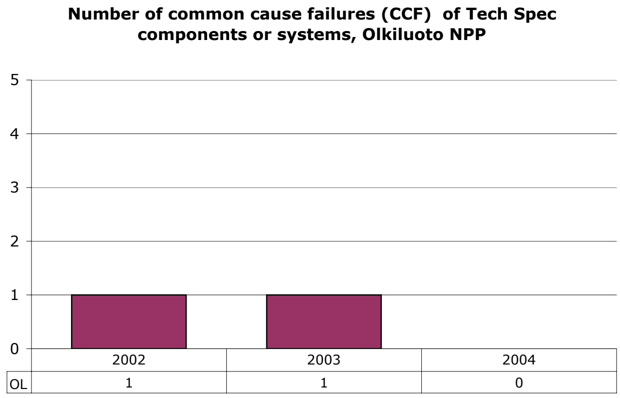
Purpose of indicator
To follow the quality of maintenance.

Responsible unit/person
Safety Management (TUR)
Jukka Kupila

Interpretation of indicator
At the Loviisa plant no realised common cause failures were detected in systems defined in Tech Spec in 2004.

At the Olkiluoto plant no realised common cause failures were detected in systems defined in Tech Spec in 2004.

In connection with calculating the indicator, two emergency diesel generators were discovered to be inoperable simultaneously at the Olkiluoto power plant. This, however, was not a common cause failure; one of the emergency diesels was isolated to repair the failure detected in the periodic test. Later, in connection with a periodic test conducted for the second redundancy, a triggering error was discovered in the diesel, which was interpreted to have been latent for half the test period. The simultaneous unavailability took place on 7 April 2004 between 7:55 and 13:15.



A.I.1e Common cause failures preventing operation

Definition

As the indicator, the number of technical common cause failures (CCFs) causing unavailability of equipment or systems is followed for all plant systems.

Source of data

Data for the indicators is collected from the failure databases of the utilities. For the time being, the Olkiluoto indicator has been followed. The licensee has submitted the data in an Excel file, from which CCFs have been analysed. A corresponding procedure for the Loviisa plant will be established after the completion of a study into CCFs.

Purpose of indicator

The indicator represents the number of CCFs of a technical origin. A CCF preventing a function refers not only to the failure of a safety system but includes all systems. Thus conclusions on the safety-significance of CCFs are not to be made based on the indicator.

Responsible units/persons

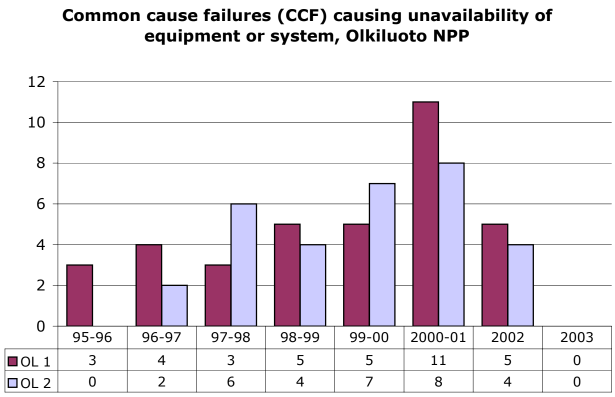
Safety Management (TUR)
Jukka Kupila

Interpretation of indicator

The indicator was not measured in 2004.

According to the analysis, no CCFs assignable to the indicator area occurred at either Olkiluoto plant unit in 2003.

In the operating cycle 2001–2002 the number of CCFs assigned to this indicator area was half of that of the previous operating cycle at both Olkiluoto plant units, the total number of failures being nine. The most significant were the accumulation of dirt on the fire detector system and the problems with the power supply, which were calculated as separate CCFs for both plant units.



A.I.1f Potential common cause failures

Definition

The indicator is the number of potential CCFs of technical origin that have no effect on the availability of the equipment or systems but do have a bearing on the reliability of their operation (ageing, wear and tear, corrosion, etc.).

Source of data

Data for the indicators is collected from the failure databases of the utilities. So far, only the indicator for the Olkiluoto plant has been available. The licensee has submitted the data in Excel files from which CCFs have been analysed. A corresponding procedure will be established for the Loviisa plant after the completion of a study into CCFs.

Purpose of indicator

The indicator is an anticipatory sign for failures that could have developed into a failure preventing the operation of equipment or systems.

Responsible units/persons

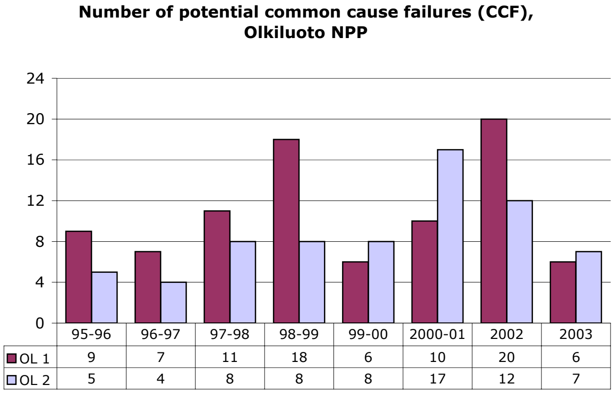
Safety Management (TUR)
Jukka Kupila

Interpretation of indicator

The indicator was not measured in 2004.

The number of potential CCFs to be assigned to the indicator decreased at both Olkiluoto plant units due to a changed line of interpretation in 2003. The most significant problem was the cavities in the concrete bases beneath safety-important pumps, which has only now surfaced (indicators A.I.1a and A.I.3).

The most significant problem in 2002 was the "bubbling" of the rubber coating of the service water channels. The sealing leakages of the main steam line isolation valves also increased the indicator. The failure events also included precipitations in heat exchangers, valve leakages and measurement failures.



	95-96	96-97	97-98	98-99	99-00	2000-01	2002	2003
OL 1	9	7	11	18	6	10	20	6
OL 2	5	4	8	8	8	17	12	7

A.I.1g Production loss due to failures

Definition
Loss of power production caused by failures in relation to rated power (gross).

Source of data
Annual and quarterly reports submitted by utilities.

Purpose of indicator
To follow the significance of failures from the point of view of production.

Responsible unit/person
Safety Management (TUR)
Timo Eurasto

Interpretation of indicator
Production losses due to failures at the Loviisa and Olkiluoto plant units have been relatively small.

The Loviisa 2 indicator value for 1997, which is an anomaly, was caused by an approx. 7-day-long shutdown to repair a leakage of the primary circuit and the 2003 anomaly was caused by work to replace the stator of a plant unit generator, which took 41 days, causing a 2.6% production loss.

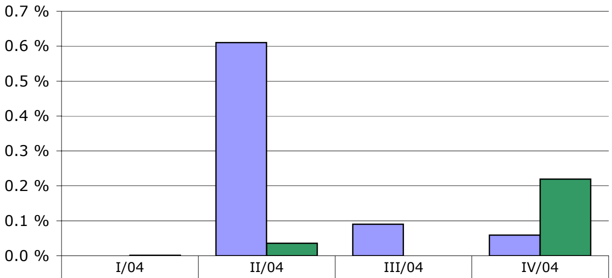
Production losses due to failures remained small at the Loviisa plant in 2004, although in the first quarter a stoppage of the primary coolant pump caused by sensor failure occurred at Loviisa 1. At Loviisa 1 there were also power reductions and a reactor scram caused by faults in the reactor protection system (SUZ). At Loviisa 2 the production losses were due to malfunctions in turbine regulators, a turbine scram and turbine stoppages required to fix the malfunctions. In addition, Loviisa 2 was brought to a start-up state on 20 October 2004 for the purpose of a temporary repair to a cover seal leakage in the check valve of the secondary circuit feed water line. The plant unit also operated at 50% power for a while in order to repair the leakage of the impulse tube in the flow measurement (RL74F01) of the feed water line.

The production losses due to failures at the plant units of Olkiluoto were higher in 2004 than the average of the past few years. The failures were not confined to specific components, systems or technical field, and the failures were in no respect exceptional.

The 0.78% production loss of Olkiluoto 1 was affected by the repair of a failure in the 314V21 valve, for which the plant was brought to a hot shutdown. In the start-up following the repair outage one of the isolation valves in the main steam line closed without reason, and in order to repair that the plant was brought to a cold shutdown. In addition, production loss was caused in the third quarter by the opening of the safety valve of the cooling system and the consequent turbine scram.

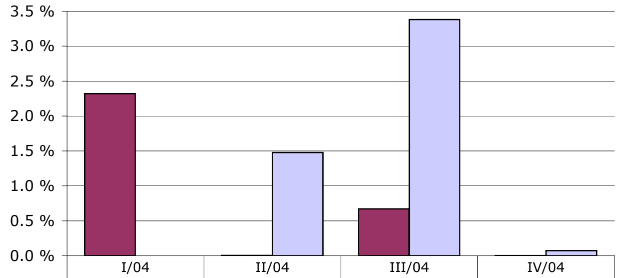
At Olkiluoto 2 the production loss due to failures in 2004 was 1.2%. The most significant reason for the production losses was the deterioration of the isolation resistance of the primary coolant pump P5, which caused the power of the plant to be restricted in the second quarter. In the third quarter the production loss at Olkiluoto 2 was caused by the repairs to the generator cooling system and the condensate seawater leak. In addition, a minor production loss was caused at Olkiluoto 2 by the locating of a fuel leak.

Loss of power production due to failures in 2004, Loviisa NPP



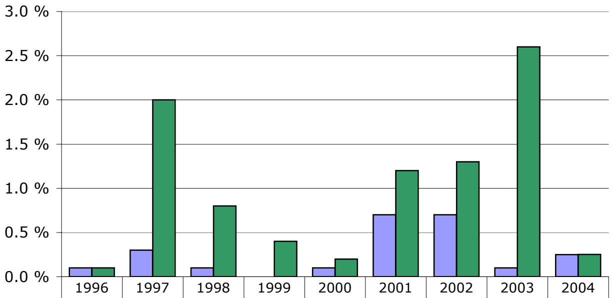
	I/04	II/04	III/04	IV/04
LO1	0.00 %	0.61 %	0.09 %	0.06 %
LO2	0.00 %	0.04 %	0.00 %	0.22 %

Loss of power production due to failures in 2004, Olkiluoto NPP



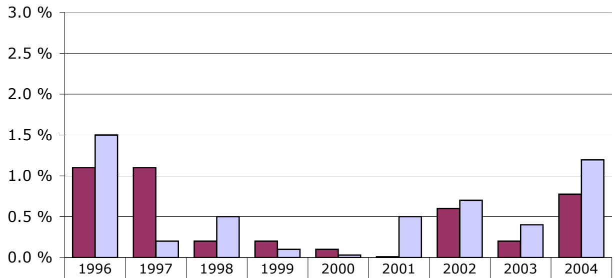
	I/04	II/04	III/04	IV/04
OL1	2.32 %	0.00 %	0.67 %	0.00 %
OL2	0.00 %	1.48 %	3.38 %	0.07 %

Loss of power production due to failures, Loviisa NPP



	1996	1997	1998	1999	2000	2001	2002	2003	2004
LO1	0.10 %	0.30 %	0.10 %	0.00 %	0.10 %	0.70 %	0.70 %	0.10 %	0.25 %
LO2	0.10 %	2.00 %	0.80 %	0.40 %	0.20 %	1.20 %	1.30 %	2.60 %	0.25 %

Loss of power production due to failures, Olkiluoto NPP



	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL1	1.10 %	1.10 %	0.20 %	0.20 %	0.10 %	0.01 %	0.60 %	0.20 %	0.78 %
OL2	1.50 %	0.20 %	0.50 %	0.10 %	0.03 %	0.50 %	0.70 %	0.40 %	1.20 %

A.I.2 Exemptions and deviations from the Technical Specifications

Definition

The number of non-compliances with the Tech Specs as well as the number of exemptions granted by STUK.

Source of data

Data for the indicators are collected from applications for exemption orders and from event reports.

Purpose of indicator

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

Responsible unit/person

Safety Management (TUR)
Timo Eurasto

Interpretation of indicator

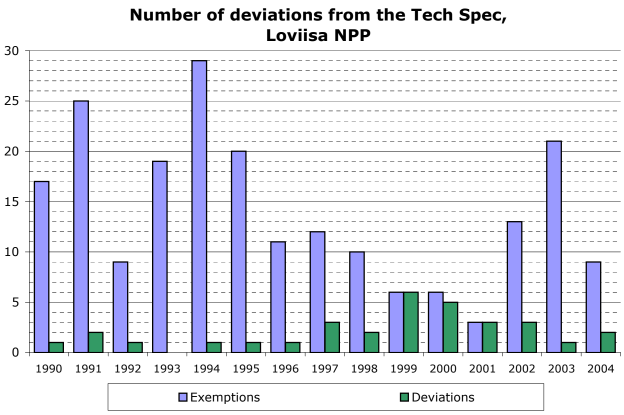
The number of non-compliances with the Tech Specs was small at both Loviisa and Olkiluoto in 2004.

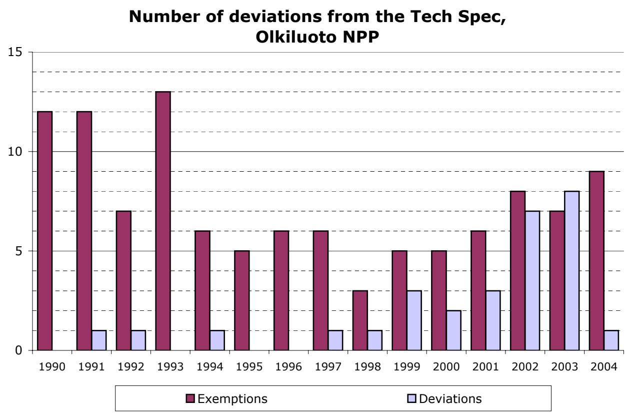
At the Loviisa plant there were two non-compliances with the Tech Specs in 2004. There was a condition in non-compliance with the Tech Specs at Loviisa 2 when the activity measurements 20SD30R001 and 20SD70R001 of the exhaust pipelines of the turbine condenser's main ejectors were not in an operational condition because of a design error. The measurements had been modified last summer in connection with the MONU project (the replacement of the fixed radiation measurement system). The other condition in non-compliance with the Technical Specifications was a short-term disorder in the reactor's decay heat removal (VF60) that happened during the annual maintenance of Loviisa 2 in cold shutdown.

Only one plant condition in non-compliance with the Tech Specs occurred at the Olkiluoto plant in 2004. It involved bypassing the protection limit that monitors condensate conductivity within the reactor protection system 516, which was done as a safety precaution for a preventive maintenance check of the safety valve at both units of the Olkiluoto plant.

The number of exemptions from the Tech Specs granted to the Loviisa power plant fell in 2004 from the previous year to nine exemptions, which corresponds to the long-term average. Of the exemptions granted to the Loviisa plant, five were concerned with the need to deviate from the Tech Specs caused by modifications and improvement work.

At the Olkiluoto plant there were also nine exemptions granted, which is slightly more than in the year before. Five exemptions were concerned with the construction of a new plant unit. This is a significant number given that the construction has not even begun. One exemption was concerned





with improvement work and one with repairs at an operational plant unit. Two exemptions were concerned with working instructions and procedures.

A.I.3 Unavailability of safety systems

Definition

As the indicators, the unavailability of safety systems is followed by plant unit. The systems followed at Olkiluoto nuclear power plant are: the containment spray system (322), the auxiliary feed water system (327) and the emergency diesel generators (651…656). Those followed at Loviisa nuclear power plant are: the high pressure safety injection system (TJ), auxiliary feed water system (RL92/93, RL94/97) and emergency diesel generator (EY).

Essentially, the ratio of a system's unavailability hours and its required availability hours are calculated as the indicator. Unavailability hours are the combined unavailability of redundant sub-systems divided by the number of subsystems. It does not indicate the simultaneous unavailability of several subsystems. Sub-system unavailability hours include the time required for planned maintenance of components and unavailability due to failures. The latter includes, in addition to the time spent on repairs, the estimated unavailability time prior to failure detection. If a failure is assessed to have occurred in a previous successful test, and is assessed to have escaped detection, the time between periodical tests is added to the unavailability time. If a failure has occurred between tests such that its date of occurrence is unknown, half of the time period between tests is added to the unavailability time. Whenever the occurrence of the failure can be identified as an operational, maintenance, testing or other event, the time between the event and the fault detection is added to the unavailability time.

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

Source of data

The data for the indicators is collected from the utilities. Licensee representatives submit the necessary data to the relevant person in charge in STUK.

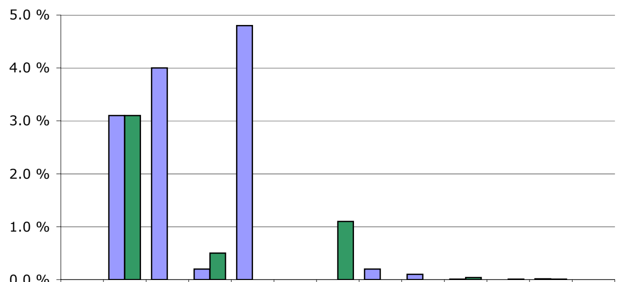
Purpose of indicator

To indicate the unavailability of safety systems; the condition and status of safety systems and their development can be monitored by means of the indicator.

Responsible units/persons

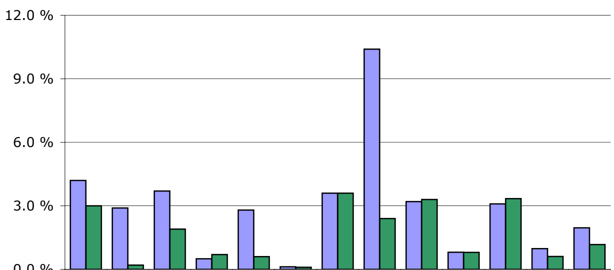
Safety Management (TUR), resident inspectors
Pauli Kopiloff (Loviisa nuclear power plant)
Jarmo Konsi (Olkiluoto nuclear power plant)

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



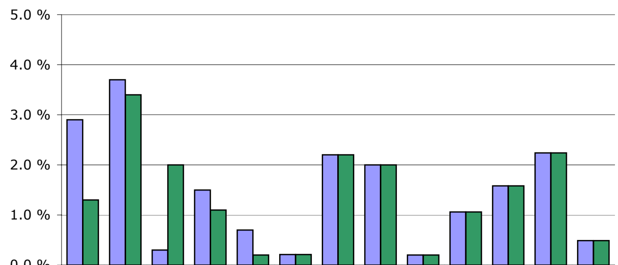
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LO 1	0.00	3.10	4.00	0.20	4.80	0.00	0.00	0.20	0.10	0.01	0.00	0.01	0.00
LO 2	0.00	3.10	0.00	0.50	0.00	0.00	1.10	0.00	0.00	0.04	0.01	0.01	0.00

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



	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LO 1	4.20	2.90	3.70	0.50	2.80	0.12	3.60	10.40	3.20	0.81	3.09	0.98	1.96
LO 2	3.00	0.20	1.90	0.70	0.60	0.10	3.60	2.40	3.30	0.80	3.34	0.61	1.17

Unavailability of emergency diesel generators (EY), Loviisa NPP



	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LO 1	2.90	3.70	0.30	1.50	0.70	0.21	2.20	2.00	0.20	1.06	1.58	2.24	0.49
LO 2	1.30	3.40	2.00	1.10	0.20	0.21	2.20	2.00	0.20	1.06	1.58	2.24	0.49

Interpretation of indicator

The unavailability of the safety systems chosen for the indicator system has been acceptably low, except for the trend indicating the unavailability of the emergency diesels of the Loviisa plant in the past three years.In the first half of 2004 the emergency diesel unavailability index at the Loviisa power plant indicated that the unavailability level was still increasing. STUK reviewed the factors affecting the unavailability of the emergency diesels and asked the plant for an account of the validity of their WANO indicator and the type of failures or defects that have caused emergency diesel unavailability.

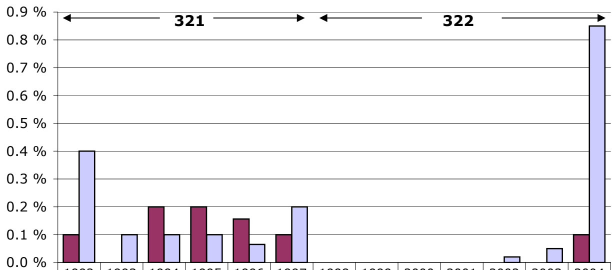
According to the Loviisa plant, most of the unavailability was caused by synchronisation problems with the diesels, caused by failures in electronic boards and impaired operation of the control servo. After the causes were pinned down, the measurement technique has been developed in order to quickly work out certain failures. The inspection of the adjustment circuit during maintenance events has also been made more effective, and the unavailability levels are, therefore, assumed to decrease. Another significant group of reasons for unavailability has been the maintenance and repairs to the start-up air system. The maintenance program has been modified so that all preventive maintenance work is done during annual maintenance instead of during operation, which was the earlier situation. In addition, unavailability has been caused by miscellaneous diesel repair and maintenance operations. Part of the repairs have been so-called latent failures. Typical examples include leaks in the lubricant system, ageing of seals, breaks in solenoid winding, and pipe fatigue fractures caused by engine vibration. STUK discovered in its own examinations that there had also been errors in the calculation of the diesel unavailability times. These errors had existed for approximately two years. There had also been errors in the evaluation of failure consequences. The errors have now been corrected and the value of the indicator representing the emergency diesel unavailability at Loviisa for 2004 fell to the pre-2001 level.

The indicator representing the emergency diesel unavailability at the Olkiluoto plant for 2004 was more than 20 times the very small value of 2003. The indicator for 2004 is identical to the indicator for 2002. In the periodic tests of emergency diesels there occurred, among other things, diesel stoppages due to failures in limit boards and power adjustment problems caused by relay failures.

The unavailability of the containment spray system (322) of Olkiluoto 2 increased further from 2003 due to vibration problems with the system's pumps. The pumps' concrete bases had to be filled out because the original concrete castings proved insufficient. (See indicator A.I.1a). The periodic tests of the system in the second quarter of 2004 also indicated a switch gear fault in the valve 322 V207 due to improper fuses at the location in question.

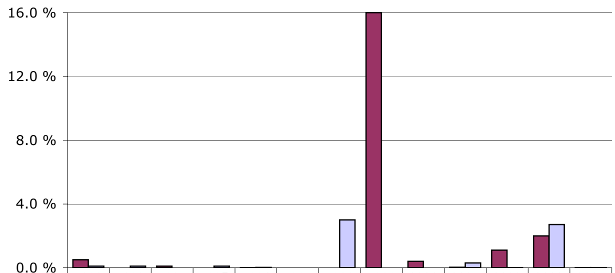
The unavailability of the auxiliary feed water system (327) of Olkiluoto dropped from the 2003 values to a normal low level at both plant units.

Unavailability of shut-down cooling system (321) or containment spray system (322), Olkiluoto NPP



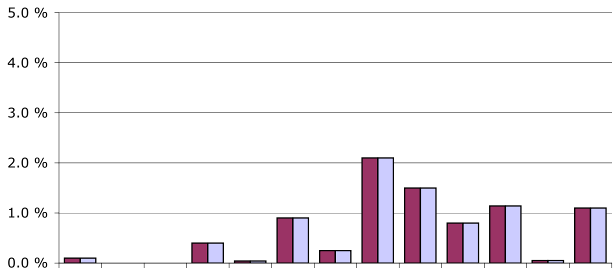
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL 1	0.10	0.00	0.20	0.20	0.16	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.10
OL 2	0.40	0.10	0.10	0.10	0.06	0.20	0.00	0.00	0.00	0.00	0.02	0.05	0.85

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



	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL 1	0.50	0.00	0.10	0.00	0.01	0.00	0.00	16.00	0.40	0.03	1.10	2.00	0.01
OL 2	0.10	0.10	0.00	0.10	0.02	0.00	3.00	0.00	0.00	0.30	0.01	2.71	0.01

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



	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL 1	0.10	0.00	0.00	0.40	0.04	0.90	0.25	2.10	1.50	0.80	1.14	0.05	1.10
OL 2	0.10	0.00	0.00	0.40	0.04	0.90	0.25	2.10	1.50	0.80	1.14	0.05	1.10

A.I.4 Occupational radiation doses

Definition

As the indicators, collective radiation exposure by plant site and plant unit is followed as well as the average of the ten highest yearly radiation exposures.

Source of data

The data on collective radiation exposure is obtained from quarterly and annual reports. The data on individual radiation doses is obtained from the national dose register.

Purpose of indicator

The indicators are used to control the radiation exposure of employees. In addition, the compliance with the YVL Guide's calculatory threshold for one plant unit's collective dose averaged over two successive years is followed. The threshold value, 2.5 manSv per one gigawatt of net electrical power, means a radiation dose of 1.22 manSv for one Loviisa plant unit and 2.10 manSv for one Olkiluoto plant unit. The collective radiation doses describe the success of the plant's ALARA programme. The average of the ten highest doses indicates how close to the 20 mSv dose limit the individual occupational doses at the plants are, at the same time indicating the effectiveness of the plant's radiation protection unit.

Responsible unit/person

Radiation protection (SÄT)
Suvi Ristonmaa

Interpretation of indicator

The indicators show no significant changes in radiation doses compared with the previous years. Most doses are incurred in work done during outages; thus outage duration and the amount of work having a bearing on radiation protection affects the yearly radiation doses.

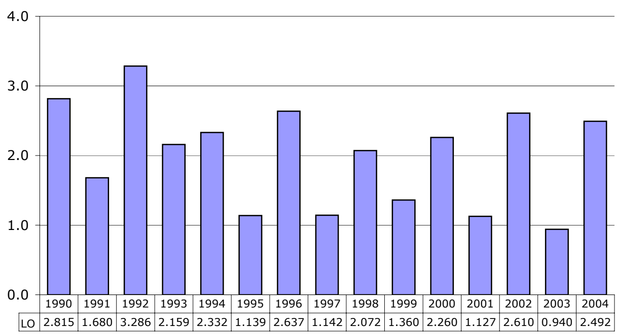
The radiation doses for the workers were below the personal dose limits at the Olkiluoto and Loviisa plants. The Radiation Decree (1512/1991) stipulates that the effective dose for a worker from radiation work may not exceed the 20 mSv/year average over any period of five years or 50 mSv in any one year.

The collective occupational radiation dose at the Loviisa plant units was 2.492 manSv and at Olkiluoto 1.512 manSv in 2004. The collective occupational doses were slightly higher than in the year before. The average of the ten highest individual doses at Loviisa was 14.93 mSv and at Olkiluoto 7.96 mSv.

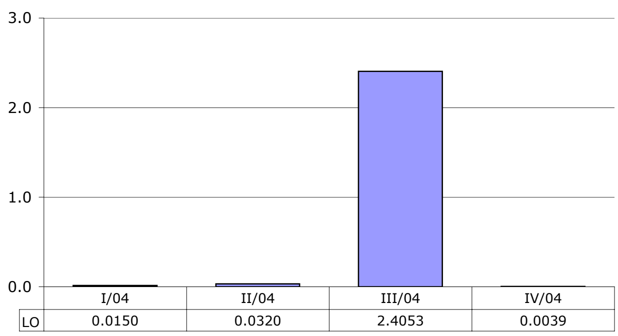
If at one plant unit the collective occupational radiation dose average over two successive years exceeds 2.5 manSv per one GW of net electrical power, the utility is to report the causes of this to STUK, and any measures possibly required to improve radiation safety (Guide YVL 7.9).

The reporting threshold of collective radiation dose was exceeded at Loviisa 1 in 2004. It has been exceeded a few times before: at Loviisa 1 in 2000, 1996 and 1992, as well as at Loviisa 2 in 1994. The reasons were the higher-than-usual collective radiation doses. The annual maintenance outages of those years were of long duration and the work done contributed to radiation exposure.

Collective occupational radiation dose (manSv), Loviisa NPP



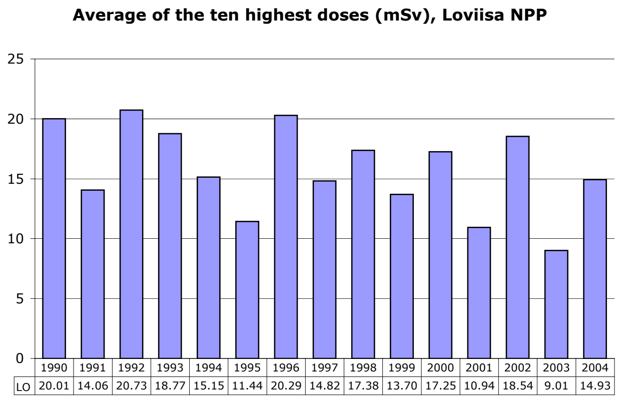
Collective dose (manSv) in 2004 Loviisa NPP

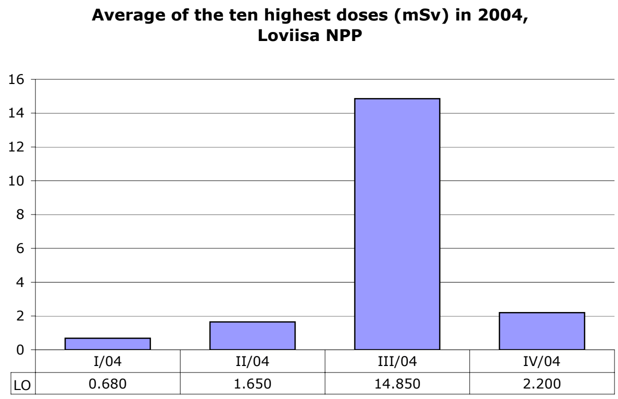


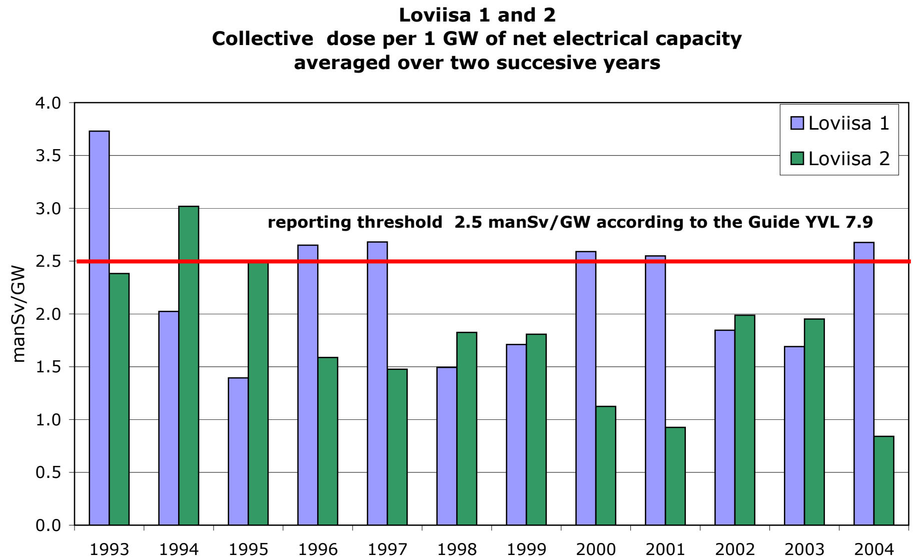
In the Loviisa 1 annual maintenance outage 2000 work relating to the preparation for severe accidents (the SAM project) was carried out as well as the replacement of the feed water collectors of two steam generators. During the 1996 annual maintenance outage the Loviisa 1 reactor pressure vessel was annealed and extensive modernisation, maintenance and inspection work was carried out. During the 1992 annual maintenance outage the Loviisa 1 main shutdown valves were inspected and repaired and the piping of a steam generator blow-down system was replaced. In the 2004 annual maintenance outage of Loviisa 1 operations such as reactor work and insulation work contributed to a higher radiation dose than estimated.

Early in the Loviisa 2 annual maintenance outage of 1994 the entire primary circuit was decontaminated because of elevated radiation levels. Work due earlier at the plant unit had been postponed to this outage and a 1.53 mSv collective dose was incurred from it. Eight manSv was assessed as the collective dose saved thanks to the decontamination. The collective radiation dose of those carrying out the decontamination was small, 15.3 manmSv.

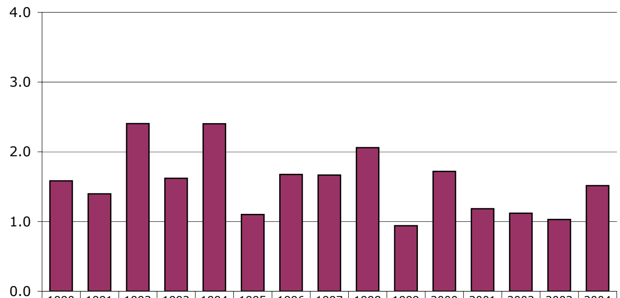
The annual maintenance of the Loviisa power plant is sequenced so that inspections and the most extensive maintenance jobs are conducted in connection with the longer annual maintenance periods that take place every four years. During the annual maintenance periods in question a larger collective occupational radiation dose is also incurred and more work done contributing to radiation exposure. Because of the four-year sequence of annual maintenance, the Loviisa power plant has begun to monitor the four-year sliding average of collective occupational radiation dose by plant unit. The power plant aims at a declining trend.





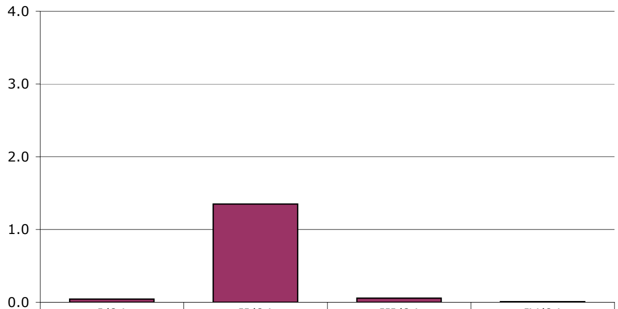


Collective occupational radiation dose (manSv), Olkiluoto NPP



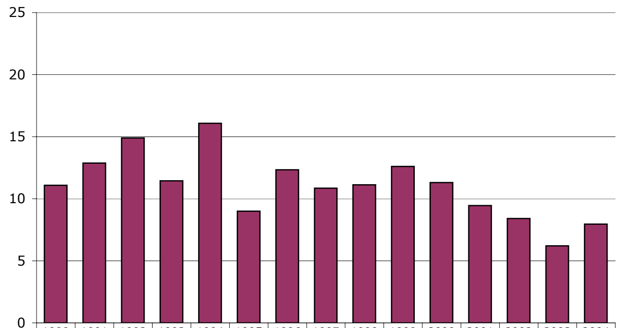
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL	1.583	1.397	2.404	1.621	2.403	1.100	1.676	1.666	2.059	0.940	1.720	1.184	1.120	1.030	1.514

Collective dose (manSv) in 2004, Olkiluoto NPP



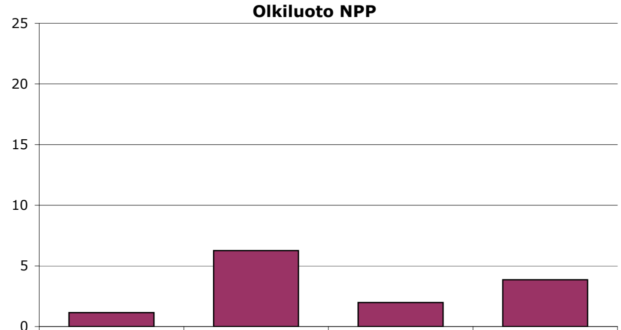
	I/04	II/04	III/04	IV/04
OL	0.0450	1.3500	0.0564	0.0085

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



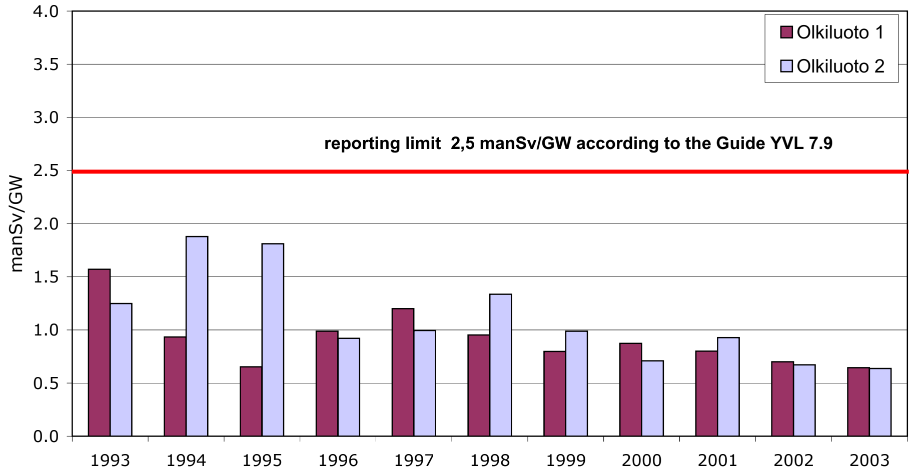
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL	11.09	12.87	14.90	11.44	16.08	9.00	12.34	10.86	11.12	12.60	11.30	9.45	8.41	6.20	7.96

Average of the ten highest doses (mSv) in 2004, Olkiluoto NPP



	I/04	II/04	III/04	IV/04
OL	1.150	6.260	1.980	3.860

Olkiluoto 1 and 2
Collective dose per 1 GW of net electrical capacity averaged over two succesive years



A.I.5 Radioactive releases

Definition

As the indicators, radioactive releases into the sea and the atmosphere (TBq) from the plant are followed as well as the calculated dose due to releases to the most exposed individual in the vicinity of the plant.

Source of data

Data for the indicators is collected from the quarterly and annual reports of the utilities. STUK's Research and Environmental Surveillance Department (TKO) calculates the dose for the most exposed person in the plant vicinity and submits it to the person in charge of this indicator.

Purpose of indicator

To monitor the amount and trend of radioactive releases and assess factors having a bearing on any changes in them.

Responsible unit/person

Radiation protection (SÄT), Suvi Ristonmaa (release data)
Research and Environmental Surveillance (TKO), Environment of nuclear power plants (YVL)
Seppo Klemola (dose calculation)

Interpretation of indicator (releases into the atmosphere)

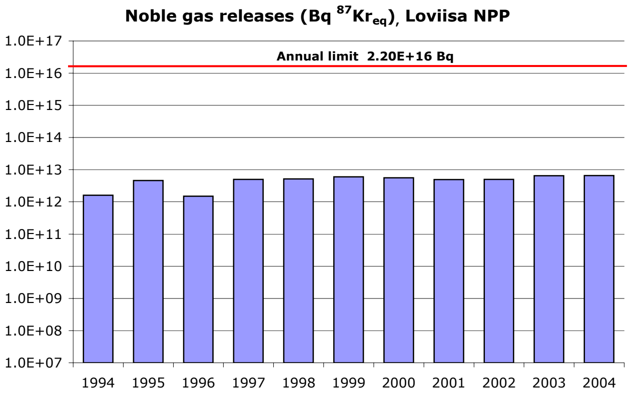
Radioactive releases into the environment from the Loviisa and Olkiluoto nuclear power plants were small in 2004. They are well below the set limits.

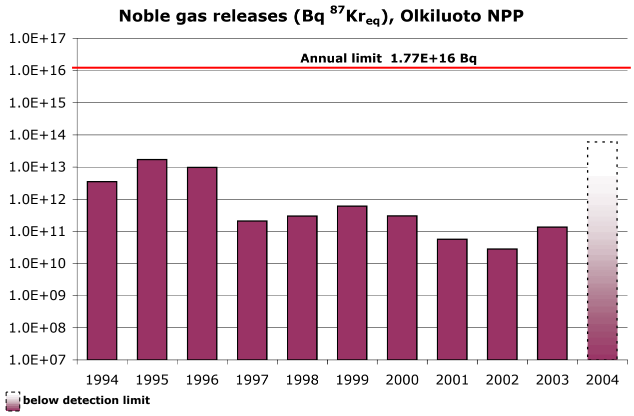
Gaseous fission products, noble gases and iodine isotopes originate in leaking fuel rods; in the minute amounts of uranium left on the outer surfaces on fuel cladding during fuel fabrication; and in reactor surface contamination from earlier fuel leaks. At both Loviisa and Olkiluoto the numbers of fuel leaks have been very small. The figures show the interdependence between iodine releases and fuel leaks (indicators A.III.1).

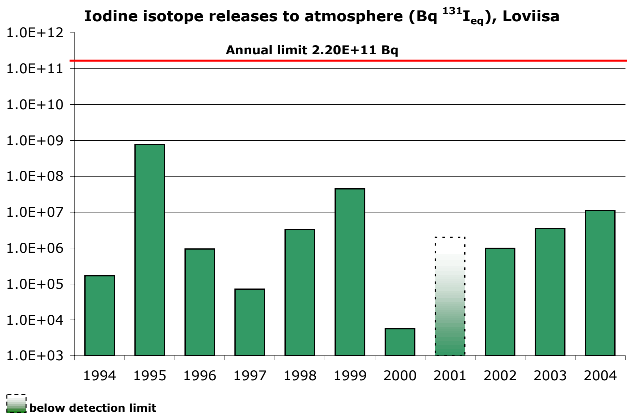
The releases of noble gas activities and iodine isotope activities into the atmosphere from the Olkiluoto plant were below the detection limits in 2004. The noble gas releases from the Loviisa plant are dominated by argon-41, an activation product of argon-40, found in the airspace between the reactor pressure vessel and the biological shield.

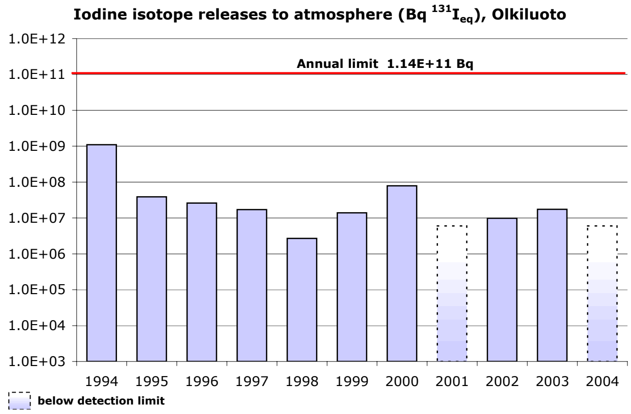
At the Loviisa plant releases of iodine activities and aerosols have been on a slight increase since 2001. Aerosols released from the Olkiluoto plant were of the same magnitude as in the preceding years. Aerosol nuclides (including activated corrosion products) are released during maintenance work.

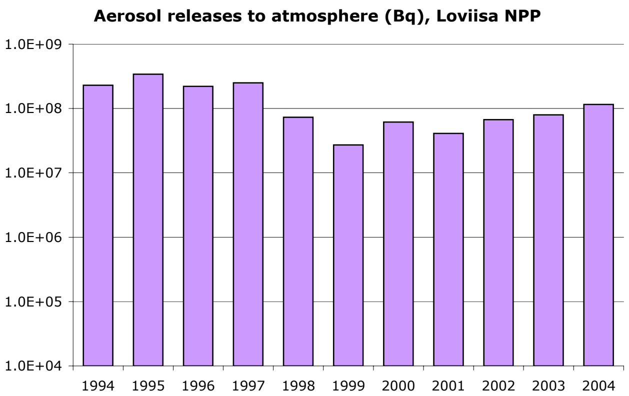
Radioactive releases into the environment from the Loviisa and Olkiluoto nuclear power plants were small. They are well below the set limits.

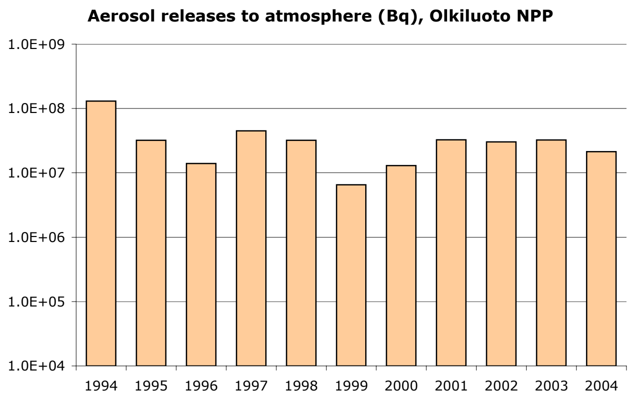

Noble gas releases (Bq 87Kreq), Loviisa NPP
Annual limit 2.20E+16 Bq
1.0E+17
1.0E+16
1.0E+15
1.0E+14
1.0E+13
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004


Noble gas releases (Bq 87Kreq), Olkiluoto NPP
Annual limit 1.77E+16 Bq
1.0E+17
1.0E+16
1.0E+15
1.0E+14
1.0E+13
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
below detection limit


Iodine isotope releases to atmosphere (Bq 131Ieq), Loviisa
Annual limit 2.20E+11 Bq
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
below detection limit


Iodine isotope releases to atmosphere (Bq 131Ieq), Olkiluoto
Annual limit 1.14E+11 Bq
1.0E+12
1.0E+11
1.0E+10
1.0E+09
1.0E+08
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1.0E+03
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004
below detection limit

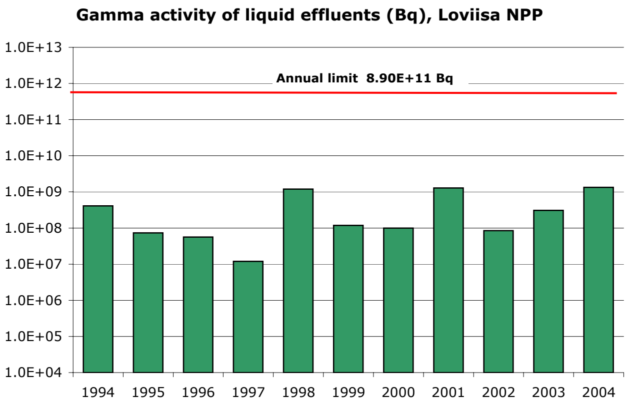

Aerosol releases to atmosphere (Bq), Loviisa NPP
1.0E+09
1.0E+08
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004

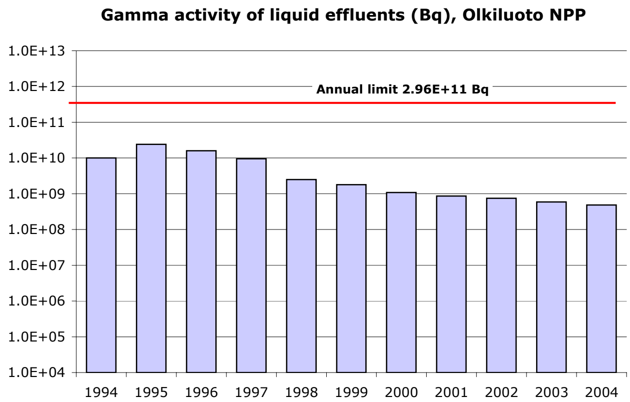

Aerosol releases to atmosphere (Bq), Olkiluoto NPP
1.0E+09
1.0E+08
1.0E+07
1.0E+06
1.0E+05
1.0E+04
1994 1995 1996 1997 1998 1999 2000 2001 2002 2003 2004

Interpretation of indicator (releases into the sea)

Releases into the sea from the Loviisa power plant reduced to their present level after the commissioning of a caesium separation device in 1992. Towards the end of 2004 the plant made a controlled discharge of clarified, low-active waste water from storage tanks into the sea. For this reason, the cumulative activity of releases into the sea was slightly larger at Loviisa than in the previous year. Similar discharges were previously made in 1998 and 2001. They appear in the trend figure as significantly larger activity values.

Releases into the sea from the Olkiluoto nuclear power plant reduced to their present level in 1998 when the plant commissioned new process water purification and treatment equipment, making possible the recirculation of discharged process water back into the processes.

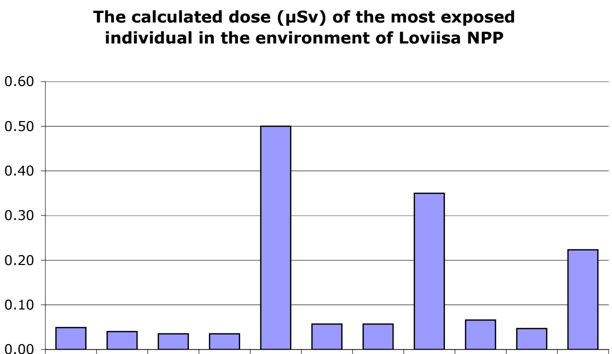




Interpretation of indicator (Calculated dose due to radioactive releases)

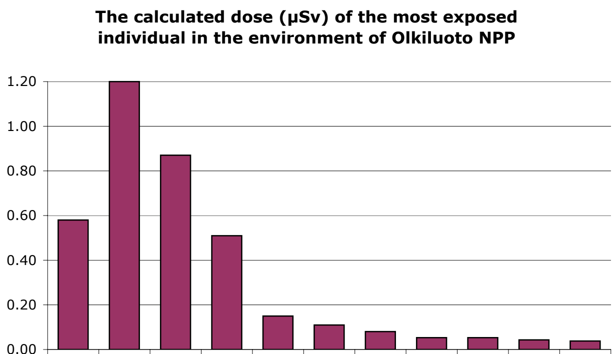
The calculated radiation dose for the most exposed individual in the vicinity of the Olkiluoto nuclear power plant was of the same magnitude as in the previous years. In the vicinity of Loviisa the dose for the most exposed individual was affected by the controlled discharge of low-activity evaporation residues into the sea.

The calculated doses of the most exposed individual in the vicinity of both plants are less than 0.3% (objective less than 1% of limit) of the 100 microSv limit established in the Government Resolution (395/1991).



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LO	0.05	0.04	0.04	0.04	0.50	0.06	0.06	0.35	0.07	0.047	0.22

Annual dose limit 100 µSv



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL	0.58	1.20	0.87	0.51	0.15	0.11	0.08	0.05	0.05	0.043	0.038

Annual dose limit 100 µSv

A.I.6 Keeping plant documentation current

Definition

This indicator area follows the need to update documents and their realisation by the start-up following the next annual maintenance. The documents to be followed-up are: the Technical Specifications, the Final Safety Analysis Report (FSAR), safety classification documents and diagrams, PSA documentation, operation and maintenance procedures, emergency and disturbance instructions, and process flow-charts. The ratio of the number of implemented document revisions to the number of identified document revisions is followed.

Source of data

The data for the indicator calculation is obtained from STUK's plant modifications register.

Purpose of indicator

To follow plant quality management and the ability to maintain plant documentation.

Responsible unit/person

Plant projects (HAN)
Tapani Virolainen

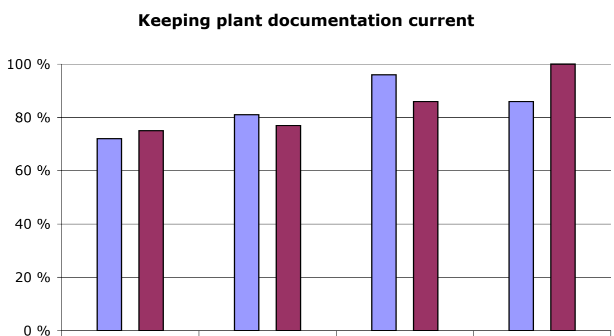
Interpretation of indicator

Identification of document amendments and revisions pertaining to modifications at the Loviisa plant is mostly by pre-inspection documents and training notices. In addition, a list of necessary changes to the operating manual maintained at the Loviisa plant is used in the identification of amendments and revisions. The indicator for the Olkiluoto plant is based on the modification project control system (PH2), which includes control forms (AV forms) describing the need to update modification documents and its realisation. In addition, STUK reviews the realisation of document amendments and revisions in the main control rooms of both plants.

The updating situation of document revisions needed after plant modifications (entered into register) in 2004 was 86% for the Loviisa units and 100% for the Olkiluoto units by the start-up after annual maintenance. The indicator does not yet include revisions to documents that need to be updated by the next annual maintenance. The corresponding figures for 2002 were 96% at Loviisa and 86% at Olkiluoto. These figures include revisions to all documents under surveillance. The improved result at Olkiluoto is mainly due to the fact that few safety-significant or extensive modification operations were conducted there in 2004. The monitoring of the realisation of document revisions needed in 2004 focused on Olkiluoto 1 because no significant (monitored) modification work was conducted at Olkiluoto 2.

Teollisuuden Voima Oy has improved the use of AV forms by including the updates of safety classification documents and diagrams. In the previous year the estimate regarding these documents and diagrams was based on an assessment by the person in charge of the indicator. In addition, the somewhat insufficient information of the AV forms had to be made more specific by the Olkiluoto plant modifications planning unit, since a review based only on the AV forms would have yielded a significantly weak result for Olkiluoto.

As regards the Loviisa power plant, the result can be considered reasonable, although more deviations were detected than in the previous years; in general, the procedures used by the Loviisa plant to update the operations manual, the Tech Specs and the PI figures has proved effective. It needs to be mentioned that at Loviisa, unlike Olkiluoto, final, approved instructions are introduced at start-up instead of hand-written versions of instructions and PI figures. The assessment has also been made against these final instructions.



	2000-01	2001-02	2002-03	2003-04
LO	72 %	81 %	96 %	86 %
OL	75 %	77 %	86 %	100 %

A.I.7 Investments in facilities

Definition

Investments on plant maintenance and modification in current value of money improved by the building cost index.

Source of data

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

Purpose of indicator

To follow the amount of investments in plant maintenance and their fluctuations.

Responsible unit/person

Plant projects (HAN)
Tapani Virolainen

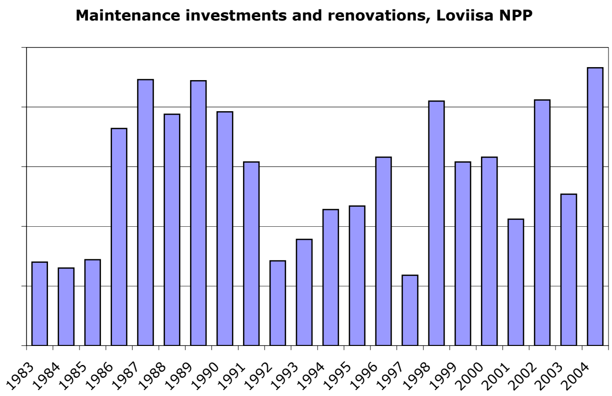
Interpretation of indicator

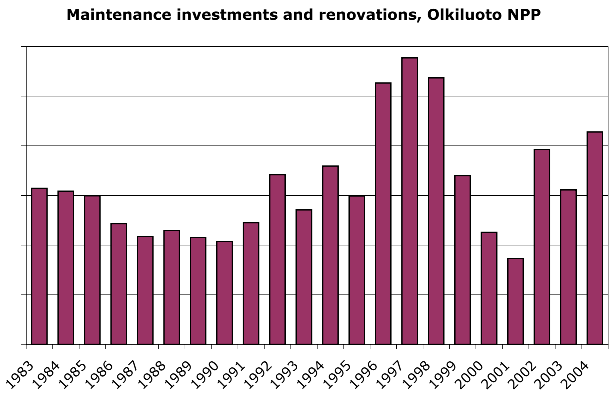
The indicator shows the relative fluctuation of investments. Sums in Euro are business information of the companies involved, not to be published here.

The fluctuation in the indicator clearly shows the investments made in 1997–2000 in the plants' power upgrades and modernisation projects. The investments of 2004 indicate an increasing trend at both the Loviisa and the Olkiluoto plant.

The main investments at the Loviisa plant during the past couple of years have been the provisions for severe reactor accidents and the modernisation of the turbine. Main investments for 2004 also included the control system for maintenance, spare parts and laboratory data (LOKE4), launching the modernisation project for automation (facilities and planning), renovation of the laboratory building, and renewing the radiation monitoring system and personal monitors (MONU and HEMU). For the time being, the investments for the solidification facility are not included in the values.

The main investments in the Olkiluoto power plant in 2004 included the renewal of the TIP neutron flux calibration system and the turbine plant renewal project (TIMO). As regards the latter, the investments for 2004 were concerned with preparation and planning, involving the renewal of high-pressure turbines, pre-heaters, the turbine automation (TARMO) and the steam dryer. The significant investments also included the extension to the central office building and the renewal of the cafeteria and the kitchen.





A.II Operational events

A.II.1 Number of events

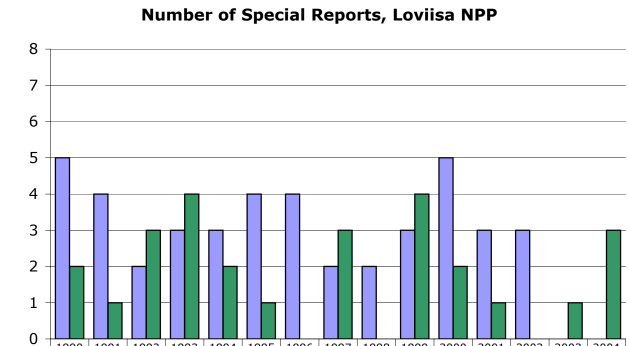
Definition
As the indicators, the numbers of events reported in accordance with Guide YVL 1.5 (events warranting a special report, scrams and operational transients) are followed.

Source of data
The data for the indicators is obtained from STUK's document administration system (YTD) and/or the events follow-up table kept by TUR.

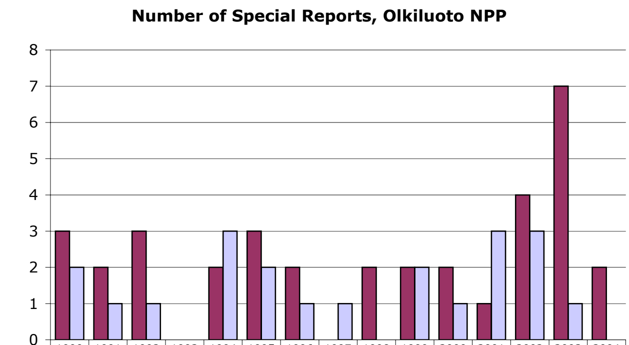
Purpose of indicator
To follow the number of events important for safety.

Responsible unit/person
Safety Management (TUR)
Timo Eurasto

Interpretation of indicator
In 2004 the number of events warranting a special report at the Finnish plants was 5. At the Olkiluoto plant there were two events warranting a special report, so the number has decreased to the level prior to the two previous years. At the Loviisa plant there were three events warranting a special report, which is the average level of the past few years. The events included the deviations from the Tech Specs mentioned in connection with indicator A.I.2. In addition, spent fuel handling malfunctions occurred in the spent fuel storages at both plants. The factors behind the events included similar reasons, such as design errors in modifications, non compliance with instructions and defects in work management.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LO 1	5	4	2	3	3	4	4	2	2	3	5	3	3	0	0
LO 2	2	1	3	4	2	1	0	3	0	4	2	1	0	1	3

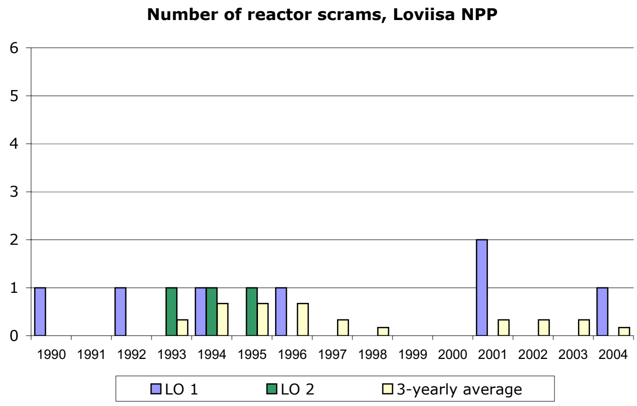


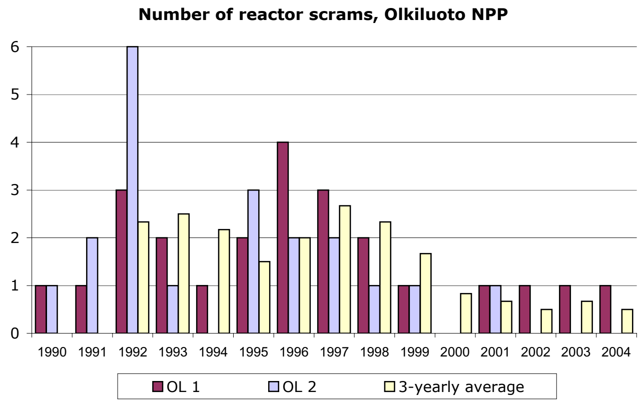
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL 1	3	2	3	0	2	3	2	0	2	2	2	1	4	7	2
OL 2	2	1	1	0	3	2	1	1	0	2	1	3	3	1	0

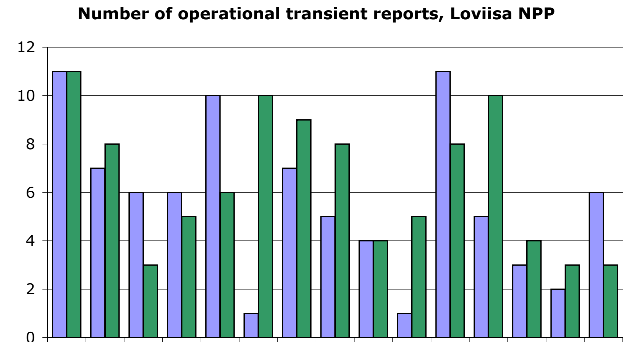
In 2004 six operational transient reports were submitted from the Olkiluoto plant and nine from the Loviisa plant. The disorders were not concentrated on any specific system or an individual device.

One reactor scram occurred at both plants. The scram at Loviisa 1 was due to a failure in the reactor protection system. At Olkiluoto 1 there was a reactor scram caused by the closing of the steam line valve. The closing was caused by a soiled valve magnet.

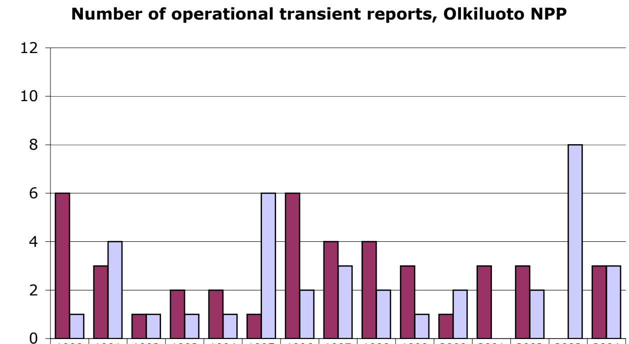
The report made by the plant on the fatal accident in electrical work during the annual maintenance of Loviisa 1 is not included in any of the aforementioned event reporting categories.







	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LO 1	11	7	6	6	10	1	7	5	4	1	11	5	3	2	6
LO 2	11	8	3	5	6	10	9	8	4	5	8	10	4	3	3



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL 1	6	3	1	2	2	1	6	4	4	3	1	3	3	0	3
OL 2	1	4	1	1	1	6	2	3	2	1	2	0	2	8	3

A.II.2 Risk-significance of events

Definition

As the indicators, the risk-significance of events caused by component unavailability is followed. As the risk measure, an increase in the Conditional Core Damage Probability (CCDP) associated with each event is employed. Events are divided into three groups: 1) unavailabilities due to component failures, 2) planned unavailabilities and 3) initiating events. In addition, events are grouped into three categories according to their risk-significance (CCDP): the most risk-significant events (CCDP≥1E–7), other significant events (1E–8≤CCDP<1E–7) and other events (CCDP<1E–8). The indicator is the number of events in each category.

Unavailabilities caused by work for which STUK has granted exemption orders are in group 2. Possible non-compliances with the Tech Specs are in group 1, if they can be utilised for this indicator. Non-compliances with the Tech Specs are dealt with under indicator A.I.2.

N.B.! Calculations for the Loviisa plant are based on an internal-initiating-event model, making them indicative only of a trend.

Source of data

Data for the calculation of the indicators are collected from utility reports and applications for exemption orders.

Purpose of indicator

To follow the risk-significance of component unavailabilities and to assess risk-significant initiating events and planned unavailabilities. Special attention is paid to recurring events, CCFs, simultaneously occurring failures and human errors. In addition, an objective in event analysis is to systematically identify signs of deteriorating organisational and safety culture.

Responsible unit/person

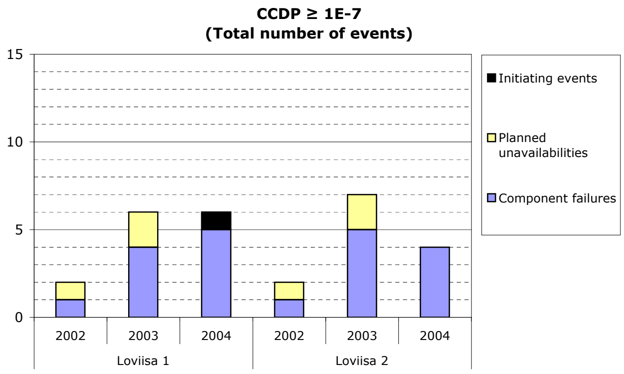
Risk assessment (RIS),
Ari Julin (PSA computation)
Safety Management (TUR) (failure data)

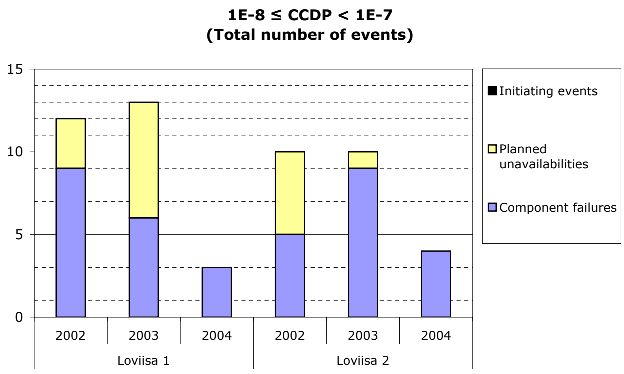
Interpretation of indicator

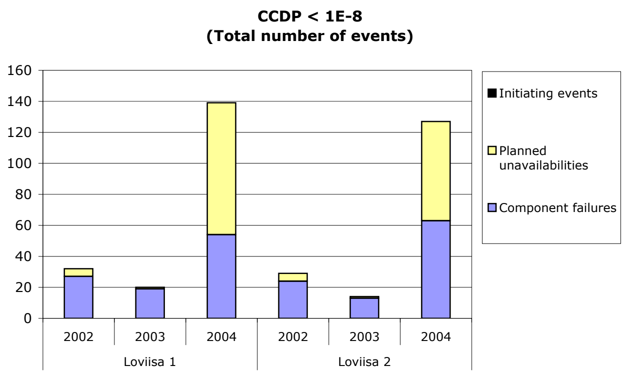
Loviisa

One reactor scram occurred at Loviisa 1 that was classified an initiating event. It was due to a failure in the reactor protection system. All safety systems functioned according to design, the causes of the scrams have been determined and action has been taken to reduce the probability of their recurrence.

The unavailabilities in the other events falling into the most risk-significant category related to latent defects in the emergency diesel generators, the auxiliary feed water system (RL92/93) and the containment spray system (TQ). In addition, the most significant events include the annual maintenance of the back-up emergency feed water system because of the conservative method of modelling (the TK-RY coupling has not been taken into account).

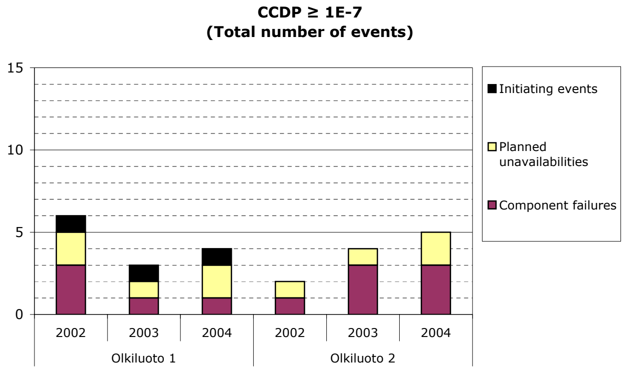






The number of analysed events falling into the least risk-significant category (CCDP < 1E–8) has increased because there has been a shift in the reporting towards a policy in accordance with the Guide YVL 1.5 (the unavailability of all Tech Spec components are presented in monthly or quarterly reports). This is shown in the enclosed figures. The kind of events analysed now were partly eliminated from the analysis in the previous years.

The analysed events are considered part of normal nuclear power plant operation and no further measures were required from STUK.



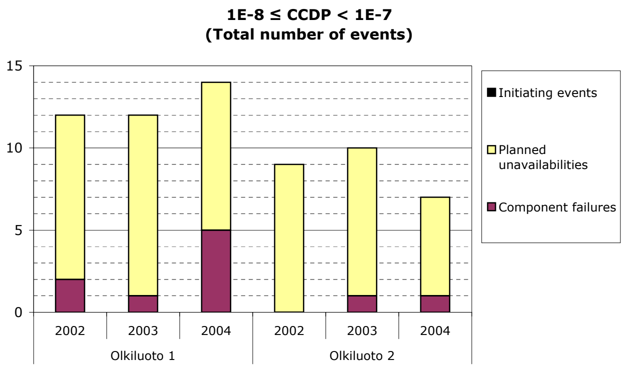
Olkiluoto

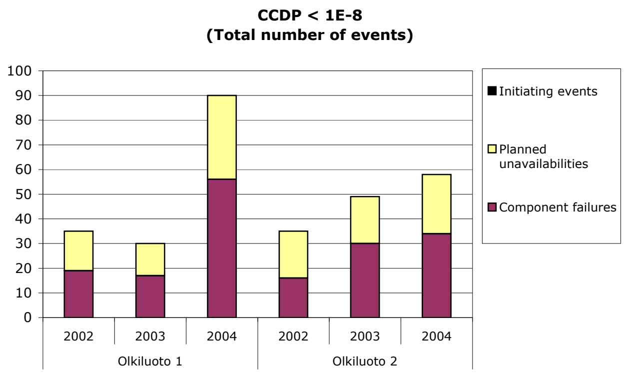
At Olkiluoto 1 a reactor scram was caused by the closing of the steam line valve. The closing was caused by a soiled valve magnet.

The unavailability of other events falling into the most risk-significant category related to latent defects in the emergency diesel generators. In addition, a latent defect in the shutdown reactor intermediate cooling system (721) at OL2 was discovered in the periodic test.

The number of analysed events falling into the least risk-significant category (CCDP < 1E–8) has increased because there has been a shift in the reporting towards a policy in accordance with the Guide YVL 1.5 (the unavailability of all Tech Spec components are presented in monthly or quarterly reports). This is shown in the enclosed figures. The kind of events analysed now were partly eliminated from the analysis in the previous years.

The analysed events are considered part of normal nuclear power plant operation and no further measures were required from STUK.





A.II.3 Direct causes of events

Definition

As the indicators, the direct causes of events reported in accordance with Guide YVL 1.5 are followed. The event causes are divided into technical failures and erroneous operational and maintenance actions (non-technical, human errors).

Source of data

Data for the indicators are collected from special reports, scram reports and operational transient reports, and are entered on an event follow-up table maintained by TUR.

Purpose of indicator

To follow the division of the causes of reported events into technical and non-technical. "Non-technical causes" denote failures caused by erroneous operational and maintenance actions. The indicator may be descriptive of an organisation's operation.

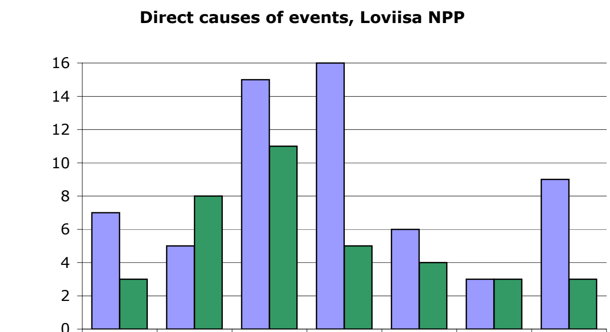
Responsible unit/person

Safety Management (TUR)
Timo Eurasto

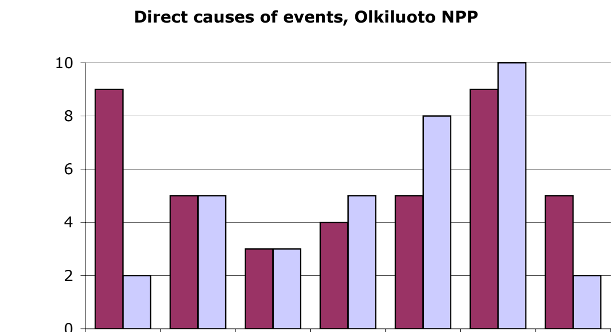
Interpretation of indicator

A total of 12 events were reported from the Loviisa power plant in 2004, 9 of which were classified technical and 3 as caused by human error. Of the 7 events at the Olkiluoto plant, five were due to a technical failure and two mainly to a human error.

The ratio of technical failures to human errors has varied greatly during the past few years. In 2004 technical failures were the determining causes of events at both plants.



	1998	1999	2000	2001	2002	2003	2004
Technical	7	5	15	16	6	3	9
Human	3	8	11	5	4	3	3



	1998	1999	2000	2001	2002	2003	2004
Technical	9	5	3	4	5	9	5
Human	2	5	3	5	8	10	2

A.II.4 Number of fire alarms

Definition
As the indicators, the numbers of fire alarms and actual fires are followed.

Source of data
The data for the indicators is collected from the utilities. The licensees submit the data needed for the indicator to the person responsible for the indicator at STUK.

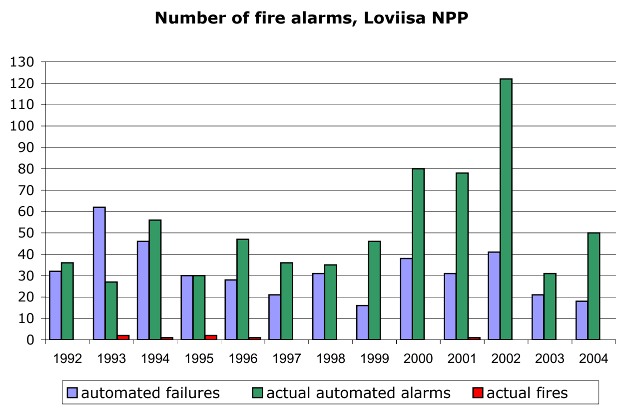
Purpose of indicator
To follow the effectiveness of fire protection at the nuclear power plants.

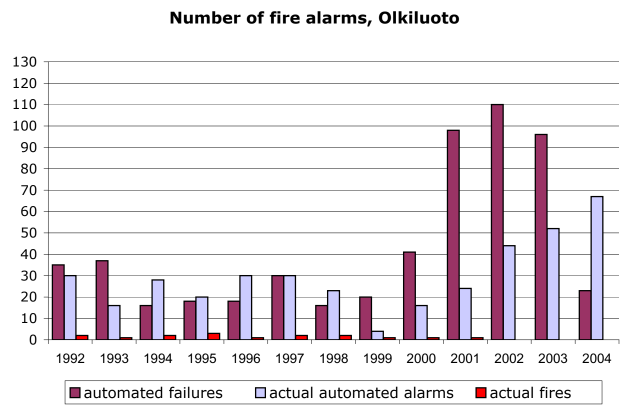
Responsible unit/person
Power Plant Technology (VLT)
Heikki Saarikoski

Interpretation of indicator
No actual fires occurred onsite at either plant. Correct actuations caused by dust or steam dominated the automatic fire detector alarms at both plants in 2004.

The automatic fire detectors were upgraded at Loviisa in 2000 and at Olkiluoto in 2001. The numbers of alarms increased at both units after that because of more sensitive equipment and equipment failures.

The distinct reduction in alarms at the Loviisa plant since 2003 and at the Olkiluoto plant since 2004 is due to pre-alarms no longer being included in the calculations; an individual detector examines the air quality and pre-warning before the actual fire alarm. After the modification the number of alarms caused by equipment failures decreased significantly at both plants. At Loviisa the number of true detector alarms decreased as well, in 2004 being on the same level (50 alarms) as before the system was upgraded. At the Olkiluoto plant the number of true detector alarms has been on a steady increase for several years. In 2004 the number was 67, which is twice as high as the level prior to the system upgrade.


Number of fire alarms, Loviisa NPP
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
automated failures
actual automated alarms
actual fires


Number of fire alarms, Olkiluoto
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
automated failures
actual automated alarms
actual fires

A.III Structural integrity

A.III.1 Fuel integrity

Definition

As the indicators, the parameters below are followed by plant unit:

- the maximum activity concentration level of the primary coolant (Loviisa: as I-131 equivalent; Olkiluoto: I-131 only) and the peak value of maximum activity concentration on even, steady-state operation (Loviisa: the sum of the iodine isotope activity concentrations in hot standby, start-up state or power operation; Olkiluoto: I-131 activity in power operation). The maximum values are compared with the Tech Spec limit in a graphic presentation;
- the maximum activity concentration of I-131 during depressurisation while entering shutdown or after reactor scram; and
- the number of leaking fuel rod bundles removed from the reactor.

Source of data

Data for the indicators is obtained from the utilities' quarterly reports (reactor operation and fuel behaviour). The licensees submit the indicator values concerning maximum activity concentrations directly to the person in charge of the indicator at STUK.

Purpose of indicator

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

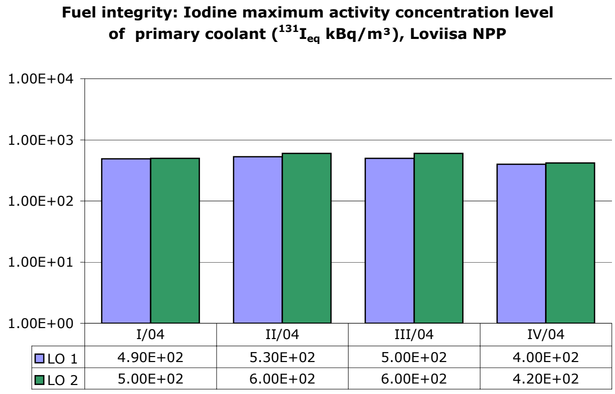
Responsible unit/person

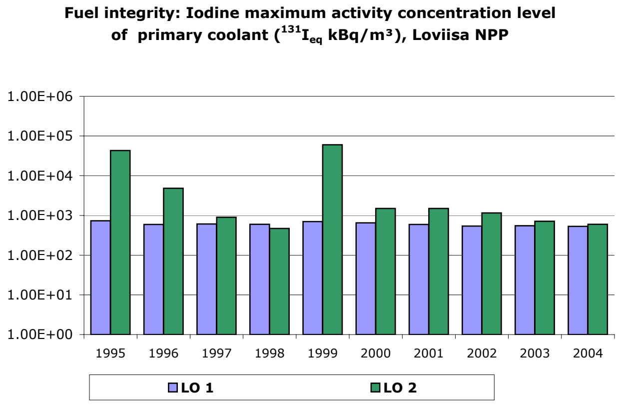
Power Plant Technology (VLT)
Kirsti Tossavainen

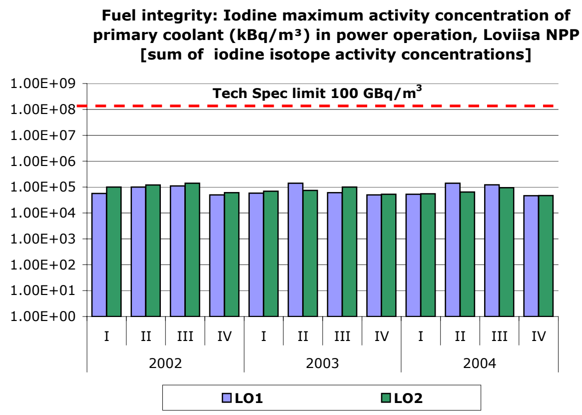
Interpretation of indicators (Primary coolant activity, Loviisa)

There were no fuel leaks at the Loviisa plant units in 2004 and the activity concentration of the primary coolant remained unchanged. In addition to the activity concentration calculated as I-131 equivalents, the sum of the activity concentrations of different iodine isotopes of the primary coolant

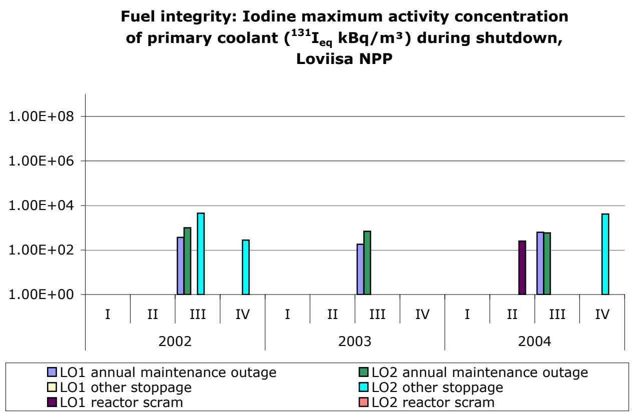
Primary coolant maximum activity concentrations in power operation, Loviisa:







Primary coolant maximum activity concentrations during shutdown, Loviisa:



is followed at the Loviisa plant. According to the Tech Specs, the sum activity may not exceed the value 1.0E+8 kBq/m³. At both plant units the sum activities have been around 0.1% of the Tech Specs limit.

The I-131 activity concentration of the primary coolant when plant units are being shut down and during reactor scrams has been followed as the STUK indicator since 2002. No significant changes have occurred in the iodine activity concentrations when plant units are being shut down at the Loviisa plant because there have been no fuel leaks at the plant units during the monitoring period.

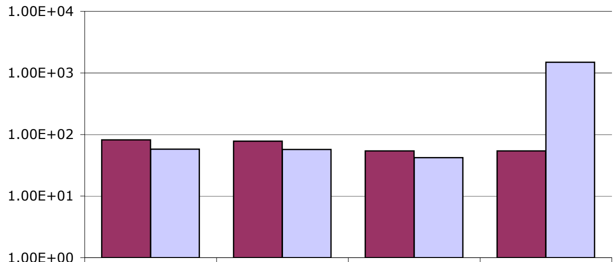
Interpretation of indicators (primary coolant activity, Olkiluoto)

The activity concentration of Olkiluoto 1 primary coolant remained unchanged in 2004. The increase in the activity level in the third quarter is due to a fuel leak observed at Olkiluoto 2 on 30 August 2004. Up to the end of 2004 the leak has remained a minor primary damage. The maximum value of the I-131 activity concentration of the primary coolant was 3.1 MBq/m³, which is 0.14% of the Tech Specs limit. The leaking fuel bundle was located in a group of four fuel rod bundles on 16 October 2004.

The increases in coolant activity caused by fuel leaks in 2003 at Olkiluoto 1 and in 2002 at Olkiluoto 2 are shown as notably larger I-131 activity concentrations while shutting down plant units for annual maintenance outages. In the other reactor shutdowns or scrams the coolant I-131 activity concentrations have not been exceptional.

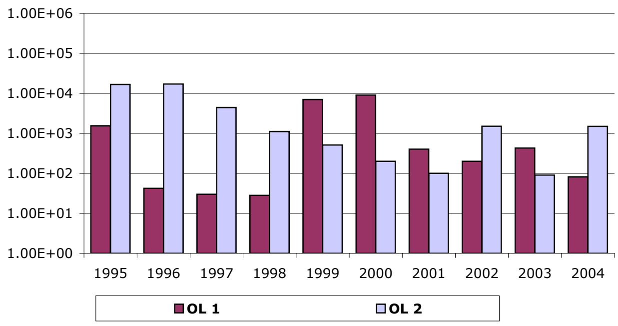
Primary coolant maximum activity concentrations in power operation, Olkiluoto:

Fuel integrity: Iodine maximum activity concentration level of primary coolant (^{131}I kBq/m³), Olkiluoto NPP

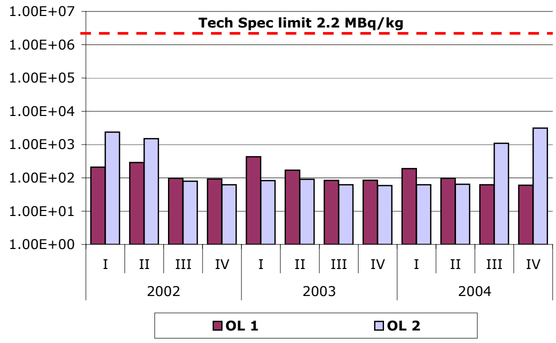


	I/04	II/04	III/04	IV/04
OL 1	8.20E+01	7.80E+01	5.40E+01	5.40E+01
OL 2	5.80E+01	5.70E+01	4.20E+01	1.49E+03

Fuel integrity: Iodine maximum activity concentration level of primary coolant (^{131}I kBq/m³), Olkiluoto NPP

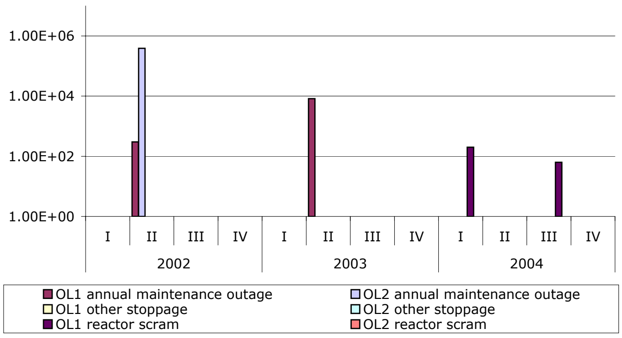


Fuel integrity: Iodine maximum activity concentration (primary coolant (^{131}I kBq/m³) in power operation, Olkilu NPP



Primary coolant maximum activity concentrations during shutdown, Olkiluoto:

Fuel integrity: Iodine maximum activity concentration of primary coolant (^{131}I kBq/m³) during shutdown, Olkiluoto NPP

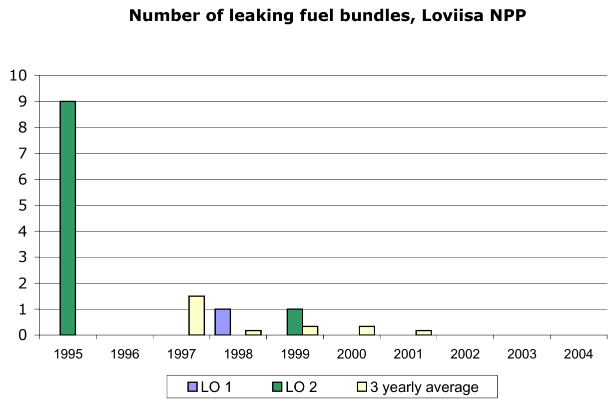


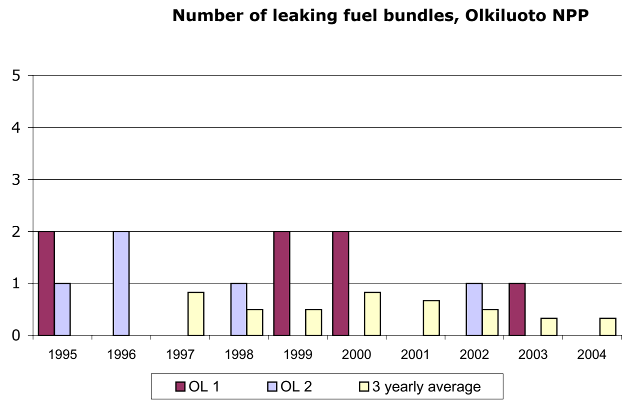
Interpretation of indicator (number of leaking fuel rod bundles)

There were no leaking fuel bundles at either the Loviisa or the Olkiluoto plant units during the operating cycle 2003–2004. A fuel leak was observed at Olkiluoto 2 on 30 August 2004. The leaking fuel bundle will be removed from the reactor in the 2005 annual maintenance outage at the latest.

Fuel leakages have been uncommon at the Loviisa plant units since 1995. The large number of fuel leakages at Loviisa 2 in 1995 was caused by corrosion products accumulating in the fuel rod bundles after decontamination of the primary circuit surfaces in the 1994 annual maintenance outage. Crud gradually attaching to the fuel rod bundles and their spacer grids reduced coolant flow and brought about vibration in the bundles. Fuel rod damage resulted from spacer grids touching the rods.

Fuel leakages have occurred almost every year at the Olkiluoto plant units. They have been small and the leaking fuel bundles have been removed in annual maintenance outages following leak detection.





A.III.2 Primary circuit integrity

Definition

The water chemistry indicators are

- international chemistry performance indices used by the utilities, depicting the effectiveness of water chemistry control in the secondary circuits of PWRs and in the reactor circuits of BWRs. A new secondary circuit chemistry index was introduced at the Loviisa plant in 2003. This new index observes corrosive impurities and contents of corrosion products in steam generator blow-down and feed water. For steam generator blow-down, the calculation includes the chloride, sulphate and sodium concentrations and acid conductivity; for feed water, it includes the iron, copper and oxygen concentrations. The chemistry index of the Olkiluoto plant is affected by the chloride and sulphate concentrations of the reactor water and the iron concentration in the feed water. The indices for both plants only cover the aforementioned values during power operation.
- the maximum chloride concentration of the steam generator blow-down (Loviisa) and the reactor water (Olkiluoto) during operation compared with the Tech Spec limit in the monitoring period. At the Olkiluoto plant the maximum sulphate content of reactor water on even, steady-state operation is followed as well.
- corrosion products released from the surfaces of the reactor circuit and the secondary circuit into the coolant. For the Loviisa plant, the iron concentration of the primary coolant solid material and the secondary circuit feed water (maximum values of the monitoring period) are followed. For the Olkiluoto plant, the iron concentration of reactor water (maximum value of the monitoring period) is followed. In addition, the maximum Co-60 activity concentration of the reactor coolant while bringing the plant to a cold shutdown or after a reactor scram is followed for both plants.

The indices below are used to follow identified and unidentified primary circuit leakages at the Olkiluoto plant units:

- total volume (m^3) of identified (from containment to collection tank 352 T1 of the controlled leakage drain system) and unidentified (total volume of leakages into the sump of the controlled floor drainage system, 345 T33) containment internal leakages during the operating cycle, and
- highest containment internal leakage volume during the year in relation to the allowed leakage volume in the Tech Specs (outflow water volume of water condensing in the air coolers of the containment cooling system 725/Tech Specs limit).

Source of data

The licensees submit indicators describing the water chemistry control to the respective responsible person at STUK. The concentration levels of corrosive substances and corrosion products are obtained from quarterly reports submitted by licensees.

Purpose of indicator

To monitor and control primary and secondary circuit integrity. The monitoring is done by indices depicting water chemistry control and by chosen corrosive impurities and corrosion products.

Responsible units/persons

Power Plant Technology (VLT),
Kirsti Tossavainen (chemistry indices)
Safety Management (TUR),
Jarmo Konsi (primary circuit leaks)

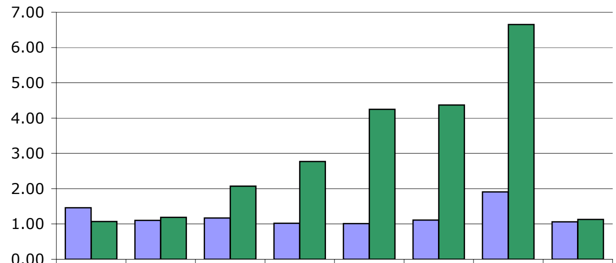
Water chemistry conditions, Loviisa

Interpretation of indicators

Chemistry index

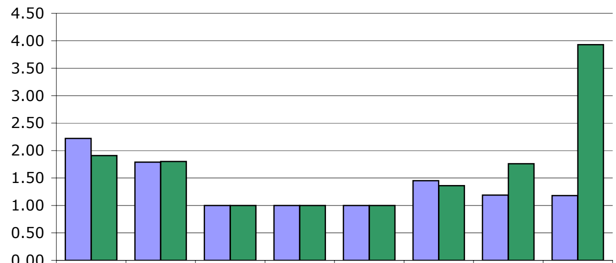
The increase in the chemistry index of Loviisa 1 in the second and third quarters compared with that of the first quarter is due to a reactor scram that occurred at the plant unit on 29 June 2004, causing the release of impurities from the surfaces of the secondary circuit. At Loviisa 2 the high value of the index is due to a seawater leak in the condenser of the other turbine (50) (see below).

Integrity of the secondary circuit: Chemistry index, Loviisa NPP



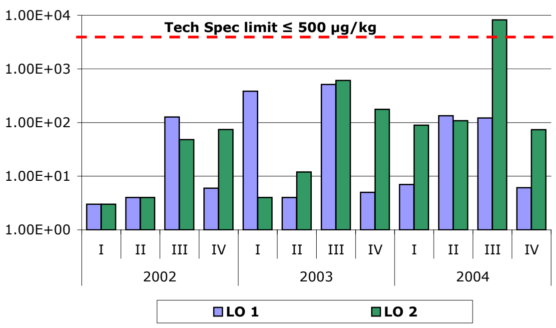
	I/03	II/03	III/03	IV/03	I/04	II/04	III/04	IV/04
LO 1	1.46	1.10	1.17	1.02	1.01	1.11	1.91	1.06
LO 2	1.07	1.19	2.07	2.77	4.25	4.37	6.65	1.13

Integrity of the secondary circuit: Chemistry index, Loviisa NPP



	1997	1998	1999	2000	2001	2002	2003	2004
LO 1	2.22	1.79	1.00	1.00	1.00	1.45	1.19	1.18
LO 2	1.91	1.80	1.00	1.00	1.00	1.36	1.76	3.93

Integrity of primary circuit: Corrosive impurities Maximum chloride concentration of a steam generator blow-down (µg/kg), Loviisa NPP



The maximum chloride contents of steam generator blow-down

As the STUK indicator, the maximum chloride concentrations of steam generator blow-down (the greatest value of the chloride concentrations of all six steam generators) have been followed since 2002. According to the Tech Specs, the chloride concentration of steam generator blow-down may not exceed the value 0.5 mg/kg. If the excess is minor (0.5–1.0 mg/kg), the plant has one week to bring the concentration to agree with the Tech Specs. If the deviation is greater (1.0–5.0 mg/kg), the plant has one day to restore the concentration. If the deviation is even greater than that, the plant unit must be shut down.

At Loviisa 1 the chloride content of steam generator blow-down has been higher than normal in the first and third quarter of 2003. The first occurrence was due to seawater momentarily getting into the main condenser and then to the other turbine's (50) steam generators during the connection of the surface measuring system. The chloride content was brought to the normal level by power venting. The second occurrence was due to the shutdown for annual maintenance.

There had been a seawater leak in the condenser of the other turbine (50) at Loviisa 2 since 2002, which had caused the chloride concentration of the steam generator blow-down to become greater than normal. The leak was repaired in the annual maintenance outage in 2004, after which the chloride concentration was also restored to pre-leak level.

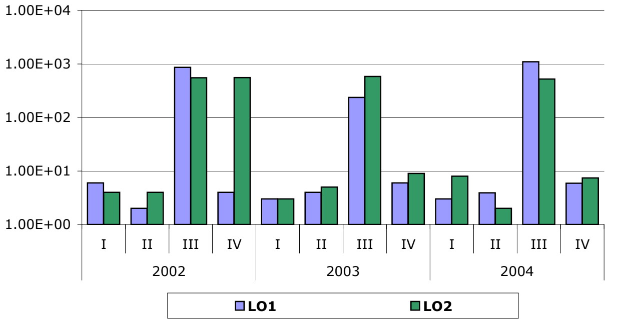
Iron content of feed water

The iron concentration of the feed water has been followed in the STUK indicators since 2002. No significant changes have taken place in the indicator values.

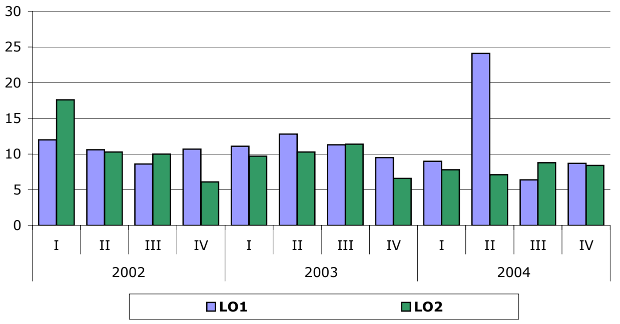
Iron in primary coolant

The maximum values of the iron concentration of the primary coolant are from situations when plant units have been brought to an annual maintenance outage. The iron content of the cooling circuit is at its peak in these situations because the changes in the process circumstances release corrosion products from the surfaces. The indicator has been followed since 2002, and, during the monitoring, there has not been any trend away from the ordinary in the maximum values of the iron concentration of the primary coolant.

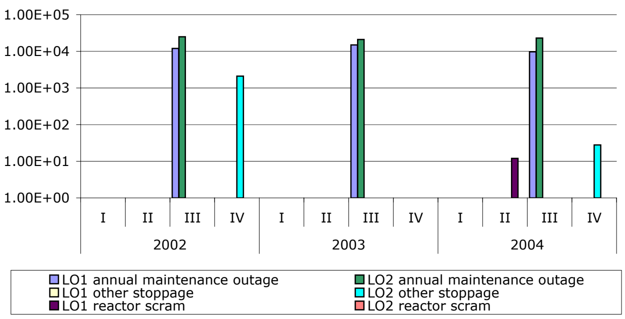
Integrity of primary circuit: Corrosion products
Maximum iron concentration in primary coolant (Fe_{tot} µg/l), Loviisa NPP



Integrity of primary circuit: Corrosion products
Maximum iron concentration in the feed water (µg/l) (RL30 / RL70), Loviisa NPP



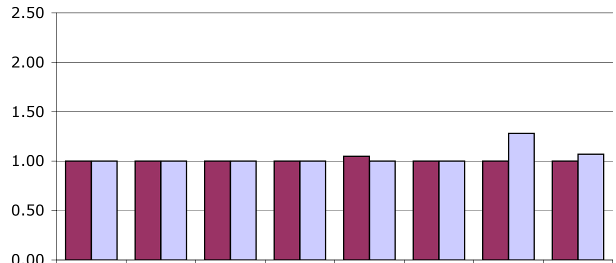
Integrity of primary circuit:
Maximum cobalt-60 activity concentration (kBq/m^3) in primary coolant during shutdown (outages and reactor scrams), Loviisa NPP



Chloride content in reactor water during operation

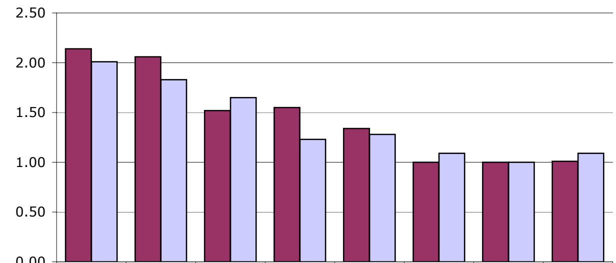
Chloride is a significant factor for stress corrosion in stainless steel. The Tech Specs limit for the chloride concentration of reactor water is 0.1 ppm (100 µg/l), which sets restrictions on the use of the plant. A chloride concentration higher than the limit is only allowed for 330 hours a year. If the requirement cannot be complied with, the plant must be brought to a cold shutdown. The plant

Integrity of primary circuit: Chemistry index, Olkiluoto NPP



	I/03	II/03	III/03	IV/03	I/04	II/04	III/04	IV/04
OL 1	1.00	1.00	1.00	1.00	1.05	1.00	1.00	1.00
OL 2	1.00	1.00	1.00	1.00	1.00	1.00	1.28	1.07

Integrity of primary circuit: Chemistry index, Olkiluoto NPP



	1997	1998	1999	2000	2001	2002	2003	2004
OL 1	2.14	2.06	1.52	1.55	1.34	1.00	1.00	1.01
OL 2	2.01	1.83	1.65	1.23	1.28	1.09	1.00	1.09

Cobalt-60 concentration in shutdown

No fundamental changes have taken place in the Co-60 activity concentrations at either plant unit in Loviisa.

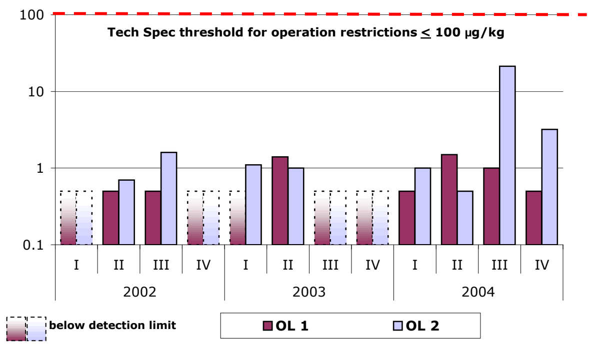
Water chemistry conditions, Olkiluoto

Interpretation of indicators:

Chemistry index

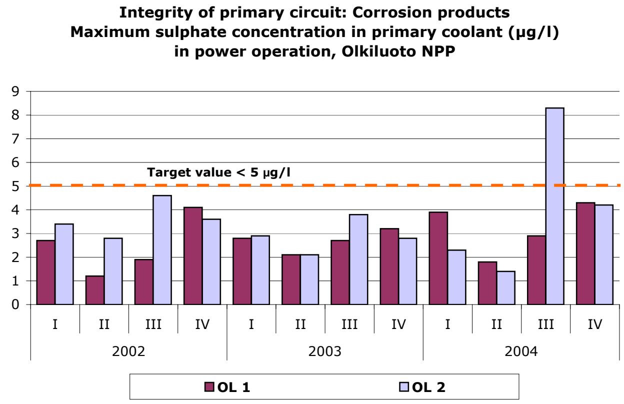
At Olkiluoto 1, the chemistry index remained close to the target value (1.00) in 2004. At Olkiluoto 2, the third quarter value, which is significantly greater than the target value, is due to a leak in the turbine condenser (see "chloride content in reactor water").

Integrity of primary circuit: Corrosive impurities
Maximum chloride concentration in primary coolant (µg/kg) in power operation, Olkiluoto NPP



must immediately be brought to a cold shutdown if the chloride content of reactor water exceeds 2 ppm (2000 µg/l).

The chloride content during operation has usually been around one per cent of the limit set in the Tech Specs at both plant units. In the third quarter of 2004 there was a chloride content higher than normal at Olkiluoto 2. This was due to a leak in the turbine condenser, during which seawater got into the reactor water and the chloride content rose to 21.3 µg/l. The leak was detected on 19 August 2004 and repaired on 21 August 2004.



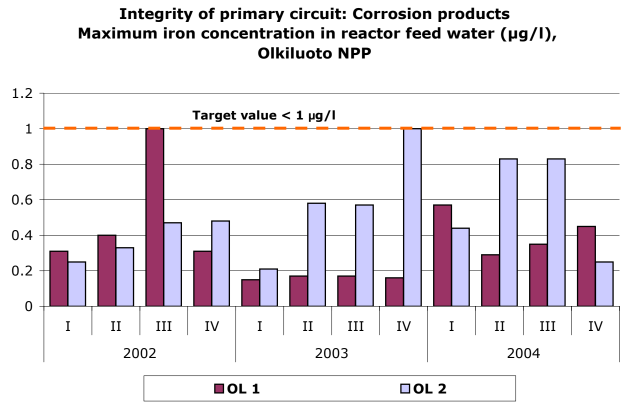
Sulphate concentration in reactor water

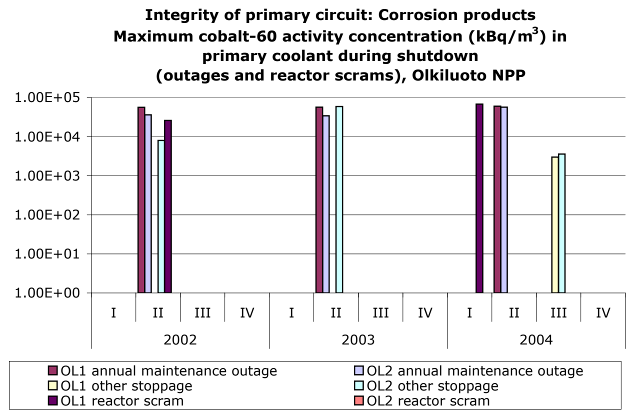
Both Olkiluoto plant units have had the problem of a sulphate concentration higher than the reactor water target value. Under certain circumstances, sulphate is a significant factor in stress corrosion. The sulphate in the reactor water originates in the sulphate released from the ion-exchange resins of the condensate cleaning filters. Temperature is one of the factors in the release of sulphate from the filter resins. The temperature of the condensate entering the filters was previously set by a partial pre-heater bypass at 60 °C. Changes have been made at the plant units to reduce the temperature of the water entering the condensate cleaning filters by changing the place of the condensate system pre-heater. The pre-heater was relocated after the condensate cleaning filters, whereas it was earlier located before the filters. Thanks to the modification, the temperature of the condensate entering cleaning filters decreased to an average of 50 °C. The modification was made at Olkiluoto 2 in 2003 and at Olkiluoto 1 in 2004.

Teollisuuden Voima Oy has set a target value of 5 µg/l for the sulphate concentration in reactor water. This target value may not be exceeded. Since the plant modifications the sulphate concentration has remained below the target level at both plant units, excluding the third quarter of 2004 when the maximum concentration at Olkiluoto 2 was 8,3 µg/l. There is no straightforward reason for the sulphate concentration being higher than normal. A possible reason may be the decomposition of the ion-exchange resins.

Iron concentration in feed water

A small amount of iron dissolves into the reactor water from the components in the reactor circuit.





Teollisuuden Voima Oy has set a target value of 1 µg/l for the iron concentration in the water supplied to the reactor. This target value may not be exceeded during plant operation. The target value has not been exceeded during the indicator monitoring by STUK, which began in 2002.

Cobalt-60 concentration in shutdown

As the STUK indicator, the Co-60 activity concentration when bringing plant units to cold shutdown has been followed since 2002. Radioactive cobalt-60 isotope is generated as an activation product of materials containing cobalt in components within the reactor circuit. Co-60 isotope is a significant source of radiation exposure at nuclear power plants. In the STUK indicator system the activity concentration of Co-60 isotope while bringing the plant to cold shutdown is used to describe the amount of corrosion products released from the surfaces of the reactor circuit, and the success of the shutdown procedures.

No fundamental changes have taken place in the Co-60 activity concentrations at either plant unit in Olkiluoto.

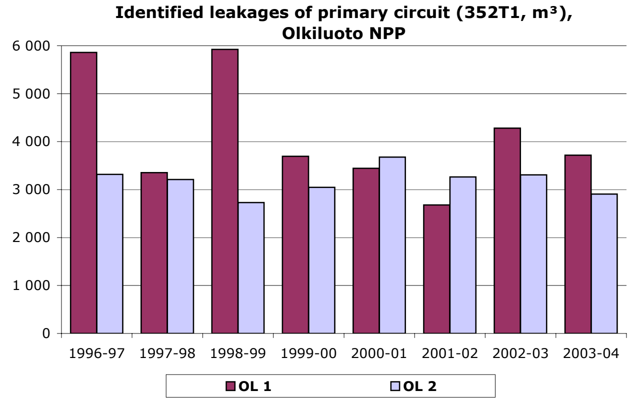
Primary circuit leakages, Olkiluoto

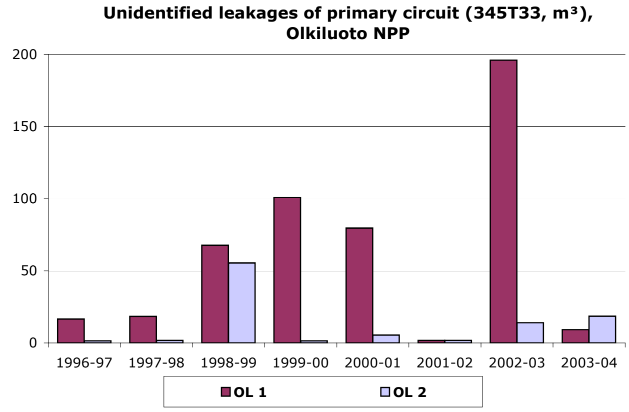
Interpretation of indicator

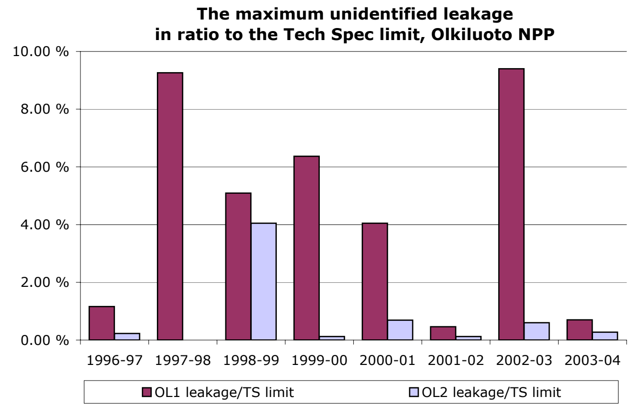
There were no fundamental changes in the identified leaks inside the containment in the operating cycle 2003–2004 compared with the previous cycle. The leaks at Olkiluoto 1 are slightly larger than those of Olkiluoto 2. Generally, the leak volumes have remained the same for several years.

During the operating cycle 2003–2004, the volumes of unidentified leaks were low at both Olkiluoto plant units. During the previous operating cycle of 2002–2003, the leak volume was fairly high at Olkiluoto 1, which was due to a leak in the underpressure valve of the relief system 314, which took place for the whole operating cycle.

In the operating cycle 2003–2004 the ratio of the greatest leakage volume inside the containment to the leakage amount allowed by the Tech Specs was restored to the level of the operating cycle 2001–2002. The high ratio of Olkiluoto 1 in the operating cycle 2002–2003 was due to the aforementioned unidentified major leak in the containment. In general, the monitoring indicates that maximum leaks have been greater at Olkiluoto 1 than at Olkiluoto 2.







A.III.3 Containment integrity

Definition

As the indicators, the parameters below are followed:

- overall as-found leakage of outer isolation valves compared with the highest allowed overall leakage of the outer isolation valves
- percentage of isolation valves tested during the year in question at each plant unit that passed the leakage test at first attempt (i.e. as-found leakage smaller than acceptance criteria of valve and no consecutive exceeding of the so-called attention criteria of a valve without repair)
- combined leakage rate of containment penetrations and airlocks in relation to their highest allowed overall leakage at each plant unit. The combined leakage rate at Olkiluoto includes leakages in personnel airlocks, the maintenance dome and the containment dome. In Loviisa the combined leakage rate is comprised of the leakage test results from personnel airlocks, the material airlock, the cable penetrations of inspection equipment, the containment maintenance ventilation systems (TL23), the main steam piping (RA) and the feed water system (RL) penetrations; the seals of blind-flanged penetrations of ice-filling pipes are also included.

Source of data

Data is extracted from the utilities' leaktightness test reports submitted by the licensee to STUK for information within three months of the completion of annual maintenance. STUK calculates the overall as-found leakages, since the reports give total leakages as they are at the end of an annual maintenance outage (i.e. after completion of repairs and re-testing).

Purpose of indicator

To follow the integrity of the containment isolation valves, penetrations and air locks.

Responsible unit/person

Reactor and Safety Systems (REA),
Päivi Salo

Interpretation of indicator

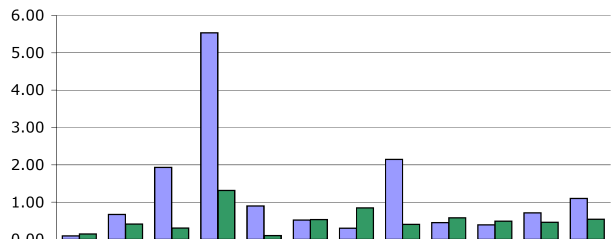
Loviisa

The overall as-found leakage of the Loviisa 1 outer isolation valves has grown but is still below the set limit; 43% of the overall leakage is from eight sump line isolation valves in the low-pressure emergency reactor cooling system (TH), tested in groups of four valves. Because the leakage volume of single valves is not known, the leakage measured for the whole group is recorded as the leakage for each valve. However, the multiple entries are not taken into account when calculating the overall leakage. A more valid picture of the containment leakage would result from reducing the group tests, or modifying the calculation method so that it would correspond to that of TVO. The overall as-found leakage of the Loviisa 2 outer isolation valves has remained below the set limit.

The percentage of isolation valves which passed the leaktightness test at first attempt has remained high, although there is a decrease from the previous year.

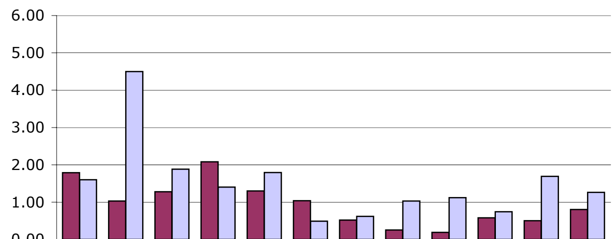
The overall as-found leakage of containment penetrations, which, at Loviisa, includes leaktightness tests of the bellows seals of the personnel airlock, the emergency personnel airlock, the material

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



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LO 1	0.09	0.67	1.93	5.54	0.90	0.52	0.30	2.15	0.45	0.39	0.71	1.10
LO 2	0.14	0.41	0.31	1.31	0.10	0.53	0.85	0.40	0.58	0.49	0.46	0.54

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



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL 1	1.79	1.03	1.28	2.08	1.30	1.04	0.52	0.25	0.19	0.58	0.50	0.80
OL 2	1.60	4.50	1.88	1.40	1.79	0.49	0.62	1.03	1.12	0.74	1.69	1.26

airlock, the reactor pit, the inward relief valves, cable penetrations, the containment maintenance ventilation systems (TL23), the main steam line (RA) and the feed water system (RL), has clearly grown, but still does not exceed the set limit. At Loviisa 1 the overall leakage of containment penetrations has decreased.

At Loviisa 1, 64% of the overall as-found leakage comes from a leaking material airlock. At Loviisa 2, approx. 88% comes from a leaking penetration bellows seal in the maintenance ventilation system (TL 23).

The integrity of the Loviisa containment building has remained good. The leaktightness of the rubber bellows of penetrations has been problematic over recent years and they will, therefore, be transformed into a metal structure.

Olkiluoto

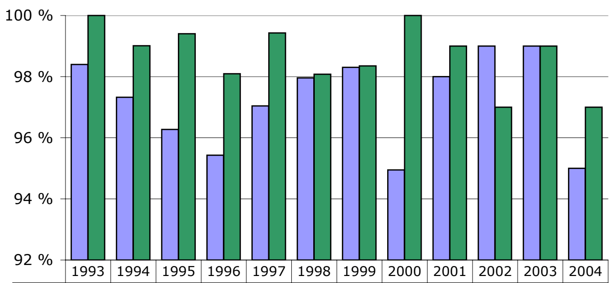
The overall as-found leakage of the Olkiluoto 1 outer isolation valves had slightly increased but was, as in previous years, below the limit set in the Tech Specs. Approx. 50% comes from leaks in two isolation valves in scram system 354. The valve leaks in the 354 system are apparently caused by impurities loosened in a scram. Approx. 8% of the leakage consists of leaks in the isolation valves in the main steam line (311), probably caused by hollows in the filter surfaces brought about by the self-closing of the valves.

Of the overall leakage of the outer isolation valves at Olkiluoto 2, approx. 46% is from a leak in one isolation valve (311V5) in the main steam line, and 25% from a leak in one valve (326V3) in the spray system of the reactor pressure vessel head.

The percentage of isolation valves that passed the leaktightness test at first attempt has slightly decreased at both Olkiluoto 1 and Olkiluoto 2.

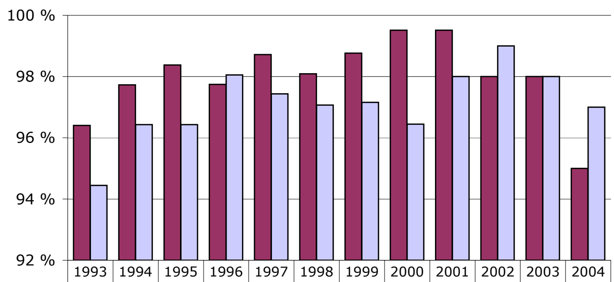
The overall as-found leakage rate of containment penetrations, which, at the Olkiluoto plant, includes leakages in the upper and lower personnel airlock, the maintenance dome and the containment dome, has remained small.

Isolation valves passing the leakage test at the first attempt, Loviisa NPP



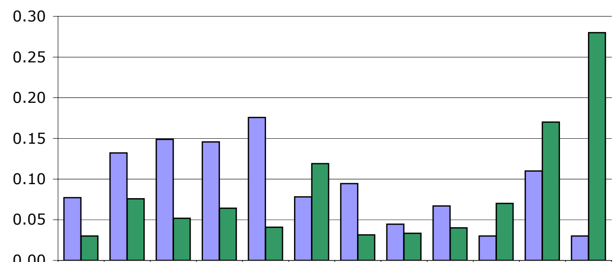
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LO 1	98 %	97 %	96 %	95 %	97 %	98 %	98 %	95 %	98 %	99 %	99 %	95 %
LO 2	100	99 %	99 %	98 %	99 %	98 %	98 %	100	99 %	97 %	99 %	97 %

Isolation valves passing the leakage test at the first attempt, Olkiluoto NPP



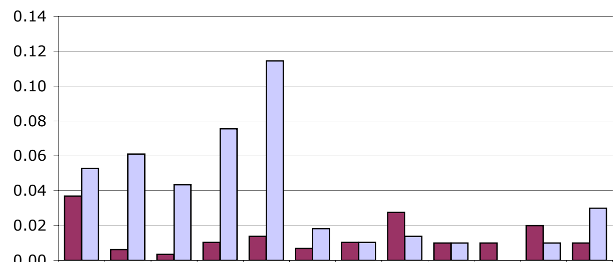
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL 1	96 %	98 %	98 %	98 %	99 %	98 %	99 %	100	100	98 %	98 %	95 %
OL 2	94 %	96 %	96 %	98 %	97 %	97 %	97 %	96 %	98 %	99 %	98 %	97 %

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



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
LO 1	0.08	0.13	0.15	0.15	0.18	0.08	0.09	0.04	0.07	0.03	0.11	0.03
LO 2	0.03	0.08	0.05	0.06	0.04	0.12	0.03	0.03	0.04	0.07	0.17	0.28

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



	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
OL 1	0.04	0.01	0.00	0.01	0.01	0.01	0.01	0.03	0.01	0.01	0.02	0.01
OL 2	0.05	0.06	0.04	0.08	0.11	0.02	0.01	0.01	0.01	0.00	0.01	0.03

APPENDIX 2 Safety improvements

Tapani Eurasto, Samuel Koivula, Hannu Ollikkala, Kirsti Tossavainen

Loviisa nuclear power plant

Construction of a back-up decay heat removal system

A new reactor decay heat removal system has been constructed at Loviisa plant. It is designed for use during the unavailability of the normal decay heat removal system. It handles decay heat removal when the reactor has cooled down enough to facilitate decay heat removal by cooling down the water recirculated on the steam generator secondary side. The pumps and heat exchangers of the system normally used for this purpose are located in the plant unit's turbine hall and could be lost in a turbine hall fire. Before the completion of the new system, it would have been impossible to bring the reactor into a cold shutdown state in such a situation; instead, it would have been necessary to release decay heat as steam into the atmosphere through the relief valves of the steam generator. In such a situation, the temperature of the primary circuit would have exceeded 100 °C.

The pumps and heat exchangers of the new system are located in a separate building external to the turbine hall. Piping and their connections to the steam lines and the feed water lines are in a section of the turbine hall that is protected against fires. Power supply for the system is ascertained such that it can be connected to the emergency diesel generators of both Loviisa 1 and Loviisa 2 as well as to a bus supplied electrical power by the nearby Ahvenkoski hydropower station. The system is shared by both Loviisa plant units and it can, where necessary, bring either one or both of the two reactors into cold shutdown. The system's heat exchangers can be cooled using the service water systems of either plant unit. The service water systems are modified, too, to improve the reliability of decay heat removal in the event of the occurrence of frazil ice, algae and flooding.

The construction of the system started in the spring of 2002 and the piping modifications were made in the winter of 2004. Test operation began in the 2004 outages and will be completed during a shutdown relating to a 2005 outage. The system was completed during the 2004 outages to such extent as to make the system available for use, if needed. The service water circuit installations are due for completion in 2006.

Olkiluoto nuclear power plant

Condensate purification system modifications

The condensate system of the Olkiluoto plant units has been modified to improve the operational conditions of the ion-exchange resins of the system's filters. The system of Olkiluoto 1 was modified during the 2004 annual maintenance outage and that of Olkiluoto 2 in 2003.

The condensate system pre-heats the condensate coming from turbine condensers and transfers it to the feed water system, which injects it to the reactor. Prior to entering the reactor, it passes through the filters of a purification system. The condensate purification systems of the Olkiluoto plant units comprise seven ion-exchange filters.

Reactor water sulphate concentrations above target value water have been a problem at both plant units. Sulphate significantly contributes to stress corrosion under certain circumstances. The sulphate concentrations have been low enough, however, not to have essentially contributed to corrosion. The sulphate in reactor water comes from sulphate released from the ion-exchange resins of the condensate purification filters. The service life of strong cationic ion-exchange resins has been restricted to decrease the sulphate concentrations. In addition, sulphate-free ion-exchange resins have been used.

Temperature is one of the factors contributing to the release of sulphate from ion-exchange resins. The temperature of condensate passing through the filters has been adjusted to 60 °C previously by partially bypassing the pre-heater. In modifications made at the plant units in 2003 and 2004, the temperature of water passing through the condensate purification filters was lowered by moving the pre-heater of the condensation system such that it is now after the filters when it was formerly before them in the process. The temperature of condensate passing through the filters was thus reduced to approx. 50 °C.

After the 2003 modifiction, Olkiluoto 2 has been able to give up restrictions on filter resin service life and the use of sulphate-free resins. Filter resins have also stayed operational for considerably longer periods with no significant increase in the sulphate concentration of the reactor water. The longer service life of the resins reduces the volume of medium-level waste at the plant.

Rectifiers replaced at Olkiluoto 1

At the 2004 annual maintenance outage of Olkiluoto plant, a modification project was started to replace ageing rectifiers with new ones carrying out corresponding functions. A total of 18 rectifiers will be replaced at both plant units. In normal operational conditions the rectifiers feed DC power to components that need it and, simultaneously, maintain batteries on float charge.

Rectifiers in the 110 V, 48 V, 24 V and ±24 V DC power systems will be replaced at both plant units. This is due to the ageing of the rectifiers currently in use, the decreasing availability of spare parts and increasing maintenance costs.

Five new rectifiers were installed and commissioned in the 2004 annual maintenance outage of Olkiluoto 1. Teollisuuden Voima Oy plans to replace the rest of the rectifiers in 2006–2007.

Modification of the turbine/reactor power monitoring system

In the 2004 annual maintenance outage of Olkiluoto 1, the plant's monitoring system for turbine/reactor power was modified by adding a function which, in the event of a turbine/reactor power disequilibrium, partially trips the reactor and limits reactor power to a level consistent with the turbine plant.

The designing of the monitoring system began in early 2002 with the objective of finding a way of preventing a reactor/turbine power disequilibrium independently of the trip signal. The importance of the modification was accentuated by a disturbance in the 400 kV network of Olkiluoto 1 on 20 April 2002. The event is described in the 2002 annual report (STUK-B-YTO 224).

The modified system detects a break in the power supplied by the 400 kV network without the help of an external signal; it is also capable of switching the plant unit over to internal power supply in case of the loss of external power supply, whether it be caused by human error or by a purely technical fault.

The monitoring system was implemented by digital technology programmed into the turbine pressure control system.

Olkiluoto 2 was similarly modified in the 2003 annual maintenance outage.

APPENDIX 3 Significant operational events

Tapani Eurasto, Timo Eurasto, Samuel Koivula, Jarmo Konsi, Pauli Kopiloff, Pekka Liuhto, Rainer Rantala, Veli Riihiluoma, Vesa Ruuska, Eero Virtanen

Loviisa nuclear power plant

Fuel handling error at the Loviisa plant spent fuel storage

Spent fuel was being moved from a transfer rack to the storage pool at the spent fuel storage of the Loviisa plant on 20 January 2004 when one fuel assembly was erroneously lowered to a wrong storage slot and on top of a fuel assembly already in the slot.

During a fuel assembly's transfer from the transfer rack to the spent fuel storage pool, its position is monitored by co-ordinates of the fuel transfer machine. During the lowering of the assembly in question to its planned slot, the driver misread the co-ordinates and placed it to an occupied slot where it remained standing on top of the assembly below. The co-driver noticed the error during the transfer of the next assembly to the pool. After a briefing at the plant it was decided to fix the situation by carefully gripping the assembly, using a tv camera for help, and moving it to its correct slot.

The event was due to inadequate transfer machine design and human error to which the work's routine character contributed. The x-co-ordinate of the transfer machine is visible only to the driver through a window on the floor of the machine's carriage. During fuel transfer, the driver is assisted by a co-driver who gives him the co-ordinates of the assembly's storage location. The co-driver cannot verify the x-co-ordinate of an assembly without disturbing the driver.

The diameter of the cylindrical inner opening of the top piece of a fuel assembly is smaller than the external diameter of its lower end piece. The assembly lowered on top of the one already in the slot thus could not be inserted but was left standing on the conical surface of the other assembly's top piece.

The assembly could have toppled down in a situation like this and, in the worst case, the claddings of the fuel rods could have sustained damage, releasing radioactive gases from the rods. Later analyses showed that the situation would not have significantly endangered the workers or the surrounding population. The event was classified INES Level 0.

After the event, the fuel transfer machine was fitted with a camera from whose display both the driver and the co-driver can verify a bundle's location.

Inoperability of activity measurements at Loviisa 2

In April 2004 an exceptionally large volume of dirt and humidity was discovered in the sampling filter of the off gas activity measurement system of the secondary circuit of Loviisa 2. Further investigation showed that the sampling flow to the activity monitor did not function as designed.

The two inadequately operating monitors are in the exhaust line of the main ejectors of the turbine condensers. The ejectors remove air and uncondensed gases from the condenser and blow them to the atmosphere. The activity measurements are continuous.

To facilitate the measuring of gaseous samples entering the activity monitors of the main ejectors, the sampling flow undergoes cooling and condensate removal prior to measurement. The sampling system includes a water seal. The system's water seal at Loviisa 2 was too low and the suction of the sampling pump had emptied it. This had made it possible that some of the sampling flow to the activity monitors of the main ejectors had come from the turbine hall through the filling opening of the empty water seal.

The Technical Specifications set availability requirements for the activity monitors of the main ejectors. If they are unavailable, corresponding live steam line activity mesurements must be operational, with their alarm limits doubled against background activity. Steam-generator specific measurements of live steam lines as well as other radiation measurements to monitor radioactivity on the turbine side were in operation during the event. They are more sensitive than the activity measurement of the main ejectors now found inoperative. In addition, weekly laboratory analyses of gases sampled from the live steam lines have been regularly carried out. It has thus been ensured that no releases have occurred during the insufficient operation of the activity measurements. The secondary circuit does not normally contain radioactivity above natural background.

The fixed radiation measurement systems of both Loviisa plant units have been modernised. The sampling systems were replaced as well: those of Loviisa 1 in 2002 and of Loviisa 2 in 2003. The systems are not identical since the supplier of the Loviisa 2 radiation measurement monitors fully implemented a sampling system planned by them whereas at Loviisa 1 the components were separately purchased. Sampling at Loviisa 1 has been faultless.

The sampling line was temporarily modified to fix the fault. The Loviisa 2 sampling line was renewed in the 2004 annual maintenance outage to make it correspond to that of Loviisa 1.

The event was classified INES Level 0.

Reactor scram at Loviisa 1 preceded by a protection system malfunction

Loviisa 1 was operating at full power on 29 June 2004 when a reactor scram occurred after the protection limit for the neutron flux of the reactor power range was exceeded in consequence of an unknown malfunction. The plant's systems operated according to design during the scram.

The scram was attributed to a latent defect whose symptoms were observed earlier; these had disappeared, however, thus making the detection of the defect impossible. It was attributed to the neutron flux protection function of protection group 1, in all of whose power range channels the protection limit had dropped from 110% to 88%. The electronics units and a card for control electronics relating to the neutron flux monitoring limits were replaced in two electronics cubicles for neutron flux measurement. This was done to prevent recurrence of the malfunction although the defect was not unambiguously determined.

The plant unit was restarted after inspection and repair. During the start-up, functional inspections of the protection system were made and neutron flux measurements were calibrated. The plant unit resumed electricity generation on 30 June 2004.

During steady-state operation, the neutron flux measuring system malfunctioned again and trouble-shooting was continued. It yielded no new information, however. Investigations during the plant unit's annual maintenace, which started on 24 July 2004, attributed the malfunctioning to a specific condenser of the reactor power protection system. After that all neutron flux measuring channels were replaced during the Loviisa 1 and 2 annual maintenances of 2004.

The plant unit's safety was not significantly reduced during the scram or the disturbances preceding it. The scram was classified INES Level 0.

An electrical accident at Loviisa 1

A fatal accident occurred at Loviisa 1 on 29 July 2004 during annual maintenance. An experienced electrician, employed by a contractor, was assigned to clean and inspect 6 kV switchgears under the supervision and control of work management. The work was to be done with the switchgears de-energised.

During the work, a bus in a switchgear short-circuited as the switchgear had been re-energised without the electrician having been told about it. In consequence of the short-circuit, an arc occurred that set his clothes on fire. He got an electric shock and was severly burned; despite intensive care treatment, he died in hospital a week later. Two other electricians in the immediate vicinity of the scene of the incident were only slightly burnt. The event did not directly affect nuclear and radiation safety at the plant. It revealed significant shortcomings in procedures relating to electrical installation work however. This was the first fatal accident at work in the operation history of the Loviisa plant.

Several safety authorities have been investigating the event and its causes. In addition, a team of experts of the licensee has exhaustively looked into the course of the event and its possible causes. In accordance with what is prescibed by law about the division of duties between authorities, lead responsibility in the investigation of accidents at work rests with the labour protection authorities; Loviisa comes under the occupational safety and health inspectorate of Uusimaa. The Finnish Safety Technology Authority (TUKES), the expert authority on electrical safety and accidents, has set up its own team of investigators to look into the event. STUK is the authority regulating nuclear and radiation safety; its task is to ascertain that this event and the procedures followed in connection with have no bearing on nuclear and radiation safety.

An official report on the event is underway.

Disturbance in decay heat removal at Loviisa 2

During the annual maintenance of Loviisa 2, on 16 September, the reactor's decay heat removal stopped momentarily in connection with the repair of a valve in the service water system.

During annual maintenance, decay heat is removed from the reactor via two steam generators and the decay heat removal system into the service water system and further to the sea. As of 12 September, the normal flow path from the service water system to the sea was being prepared for repairs and maintenance. The control room tried to open a service water system valve to re-route the water to be discharged. This failed and the valve was manually opened on the spot. A work order for checking the valve's control settings was issued, which only covered electrical and I&C work. It did not prohibit the operation of the valve since the electrical and I&C work to be performed did not require that. At the time of the work order's writing, water from the service water system did not pass through the valve under repair.

During the repairs, the fault was found to be mechanical by nature. The supervisor of electrical works on 16 September added the repair of a mechanical fault into the work order and gave it to the supervisor of mechanical works. It was further given to the contractor's supervisor for execution of the work. The situation onsite had changed and the waters from the service water system passed through the valve under repair. After the valve was fixed, the mechanics tested its operation by closing it manually. The flow in the service water system stopped and the system pressurised at approx. 8 bar. Due to the pressure increase, the operator stopped one of the two service water system pumps in operation. The mechanics opened the valve after a few minutes and normal flow resumed in the system. The stopping of the flow was indicated in the control room by alarm signals displayed on the process computer.

The short-term stopping of the flow had no bearing on plant safety. In case of a lengthier situation, a gradual warming up of the reactor coolant would have followed. The operators would have had several hours to open the closed valve or to take into use the option of routing the water from the service water system to Loviisa 1 before the reactor coolant would have reached boiling point.

The event was classified Level 0 on the INES Scale.

The event was caused by erroneous handling of the work order. According to the procedures, after additions had been made to it, it should have been taken to the control room where a prohibition to operate the valve would have been added.

Due to the event, training sessions for mechanics and supervisors will emphasise that the status of apparatuses may not be changed without the permission of the control room. In addition, routines pertaining to work orders will be discussed during training.

Olkiluoto nuclear power plant

Fuel handling error at the Olkiluoto plant spent fuel storage

A handling error occurred at the spent fuel storage on 2 February 2004 when spent fuel was moved from transfer rack to storage pool. The fuel handling machine erroneously grabbed the fuel element, which consists of the fuel assembly and its shroud tube, by the assembly alone, and not by the shroud tube. The shroud tube consequently sled down, causing the fuel element to slant when the lower end of the shroud tube hit the edge of the hauling gallery.

The gripper of the transfer machine has two alternative positions enabling gripping on the fuel assembly alone or on both the assembly and its shroud tube. In this case the gripper had only grabbed the assembly. At some stage, either during the lifting or transfer of the fuel element, the shroud tube sled off of the assembly for approx. 1 m but held its position due to the friction between it and the fuel assembly. The transfer proceeded until a bang was heard when the lower end of the fuel element hit the threshold of the gate between the pools. The entire fuel element was found slanted, its lower end resting on the edge of the threshold. The fuel assembly seemed bent but the fuel rods were undamaged. The fuel transfer machine lacks automatic stopping to provide for such events. The element was supported in its position for the night and was returned to its shroud tube the next day by carefully reversing the transfer machine.

In consequence of the event Teollisuuden Voima Oy revised the fuel handling measures plus related procedures. The transfer machine's programmable controller was modified to assure simultanous gripping of fuel assembly and shroud tube by the gripper. In addition, the transfer machine was fitted with a more powerful camera.

The event was of minor safety significance. Had the fuel assembly sustained damage, even then the radiation safety of workers or the environment would not have been endangered. The event was classified INES Level 0.

A reactor scram at Olkiluoto 1 after the inadvertent closing of an isolation valve of the main steam line

Olkiluoto 1 had resumed full power operation after the completion of a repair outage on 6 March 2004. Soon after that, a reactor scram occurred in the early hours of 7 March 2004 when a main steam line valve closed inadvertently from full power.

The chain of events leading to the scram was initiated by the inadvertent closing of a steam line isolation valve. Reactor pressure and power consequently increased and the inner isolation valves of three other steam lines closed from increased flow. The reactor tripped from high neutron power. The safety systems needed during a reactor scram operated as planned and the event did not endanger the safety of the plant or the surrounding population.

After the scram the plant unit was placed in cold shutdown to examine and repair the valve in question. The valve's internals were replaced with equivalent serviced parts. An inspection of the removed internals showed the event was due to the significantly weakened performance of the permanent magnet that normally keeps the valve open. After inspections and functional tests following the repairs, the plant unit resumed electricity generation on 8 March 2004.

At STUK's request the licensee clarified the functional criteria for permanent magnets after the event. In addition, the acceptability of the magnetising forces of the inner isolation valves of other steam lines was ascertained in the 2004 annual maintenance outage.

The event was classified INES Level 0.

Cracks detected in the feedwater distributor of the reactor circuit

In inspections performed at an annual maintenance outage of Olkiluoto 2, cracks were detected in the supporting plates of lugs at the ends of the feedwater distributor. All four distributors were cracked in the same place. The feedwater distributors are inside the reactor pressure vessel and distribute colder feedwater evenly with water recirculated inside the reactor pressure vessel. Because of the power uprating implemented in 1998, it was decided to renew the distributors to make them correspond to the flow prevalent at the new power level. At the same time, a decision was made to change the perforated section of the distributor such that cold water would not cause thermal fatigue when hitting the metallic parts close by. The feedwater distributors of Olkiluoto 2 were replaced in the 2003 annual maintenance outage.

The cracked point does not in the first place carry the load caused by pre-tensioning but there is a sharp angle in this particular spot that concentrates stresses. The cracking is preliminarily attributed to stress corrosion from cold working during manufacturing. This sensitises stainless steel to stress corrosion. Thermal fatigue may be a factor as well, caused by hot/cold water fluctuations in the area of the fixing point of the feedwater distributor.

The event is of minor safety significance. Crack growth by stress corrosion would stop at the welded seam between support plate and lug at the latest. A distributor cracked in the same way has been in operation at a nuclear power plant abroad for over ten years.

To assure safety, the distributors of Olkiluoto 2 were replaced with older distributors. Olkiluoto 1 had been provided with new distributors in its 2004 outage, which was before that of Olkiluoto 2.

The feedwater distributors of Olkiluoto 1 are due for inspection in the 2005 annual maintenance outage.

Samples have been taken from the cracked sections of the feedwater distributors removed from Olkiluoto 2 to further investigate the cause of their cracking. Thereafter, repair plans will be made.

A disturbance in the generator cooling system and a partial reactor scram at Olkiluoto 1

Olkiluoto 1 was operating at 100 % reactor power on 7 July 2004 when a relief valve in the generator water cooling system opened, causing a low level in the system's pressure containment tank. A turbine shutdown and a partial reactor scram automatically followed. The plant unit came off the national grid and its power decreased to approx. 30%. Power was further reduced to approx. 15%, and the leaking relief valve was replaced. After this, power ascension was started. The plant unit resumed electricity generation on the next day and was operating at full power on 9 July.

The relief valve opened due to a 0.5 bar increase in operating pressure caused by a system modification in a 2004 outage. That and a pressure fluctuation in the system brought about the rising of pressure close to design pressure and the opening of the relief valve.

The licensee intensifies the follow-up of process values to prevent recurrence of the event. It also negotiates with the plant's vendor to increase the margin between operating and design pressure.

The event had no bearing on safety and it was classified INES Level 0.

Non-compliance with the Tech Specs occurred when protection limits were bypassed during testing

It was found out at the Olkiluoto plant on 9 December 2004 that, during the testing of asafety valve in the feed water sampling system, one channel of the reactor protection system had been briefly bypassed at both plant units. The Tech Specs allow the bypassing of one channel for repairs but not for preventive maintenance of the kind now in question.

The bypassed channel belongs to a measurement in the sampling system to control the quality of water injected into the reactor. This control measure reveals a potential pipe failure in a turbine condenser cooled by sea water. The condensate line is fitted with four measurements. One threshold-exceeding measurement from the condensate trips a channel in the protection sequence belonging to the reactor protection system. The tripping of two channels is followed by an automatic reactor scram. When one channel is bypassed the reliability of the protection sequence is reduced. Measurement equipment must be isolated from the condensate line for valve maintenance and testing, and the sampling flow does not then enter them. When the equipment are isolated from the condensate line, the protection condition is bypassed as well.

Equipment maintenance procedures were renewed in 2002 and eight years was defined as the inspection interval for the safety valves in question. The first preventive maintenance work in accordance with the new procedure was entered into the work order system in the autumn of 2004. Safety measures are defined during the ordering of a piece of work, and it went unnoticed in this case that the Tech Specs prohibit the bypassing of a protection system channel during preventive maintenance testing. The work permits for the tests had been reviewed at work order review meetings but nobody was aware of the Tech Specs requirement on the bypassing of a control sequence channel.

The relief valve was tested at Olkiluoto 2 on 6 October 2004. The protection system's channel was bypassed for about an hour. Olkiluoto 1 began to prepare for the test on 1 December 2004 and the channel was bypassed. The shift manager noticed that the the work was in non-compliance with the Tech Specs and he did not give it a go-ahead. The subcondition was in the bypassed state for about 15 mins. The work permit was left in the control room. Testing resumed on 9 December 2004 when the shift manager on duty processed the work permit and okayed the work to begin. The work was done but the shift manager noticed afterwards that it had been in non-compliance with the Tech Specs. The channel was in the bypassed state for about four hours.

The event was caused by the preventive maintenance testing of the safety valves having been erroneously scheduled to take place during operation. This may have been due to corresponding protection systems being routinely bypassed during repairs. In addition, the requirements on preventive maintenance are scattered throughout the Tech Specs in a way making them hard to find and take in.

In the future the preventive maintenance of safety valves in the sampling system is carried out during annual maintenance. Teollisuuden Voima Oy will make more specific procedures pertaining to the processing of unfinished work. The event will be discussed in training events for operating and maintenance personnel to inform as many as possible of the lesson learned.

The event was assigned to INES Level 0.

APPENDIX 4 STUK's periodic inspection programme

Basic programme	Inspections in 2004	
	Loviisa nuclear power plant	Olkiluoto nuclear power plant
A. Safety management		x
B. Main functions		
B.1. Assessment and improvement of safety		
B.2. Operation		
B.3. Plant maintenance and ageing management	x	x
C. Inspections by functional unit and field of competence		
C.1. Plant safety functions		x
C.2. Electrical and I&C systems		x
C.3. Mechanical engineering	x	x
C.4. Structures and buildings	x	x
C.5. PSA and safety management	x	
C.6. Document and information management		
C.7. Chemistry	x	x
C.8. Nuclear waste	x	x
C.9. Radiation protection	x	x
C.10. Fire protection	x	x
C.11. Emergency preparedness	x	x
C.12. Physical protection	x	x
C.13. Training / Human resources and training	x	x
C.14. Quality assurance	x	
C.15. Operating experience		x

APPENDIX 5 Licences in accordance with the Nuclear Energy Act

C214/255, 17 February 2004,
Teollisuuden Voima Oy
Import of replacement control rods from Sweden for spare parts. Valid until 31 December 2004.

A214/50A, 19 February 2004,
Fortum Power and Heat Oy
Import of fresh nuclear fuel from Spain. A total of max. 27 000 kg of Russian origin uranium. Provided with the Euratom obligation code 'P'. Valid until 31 December 2007.

A214/50B, 19 February 2004,
Fortum Power and Heat Oy
Import of fresh nuclear fuel from Spain. A total of max. 1500 kg of Kazakstan-origin uranium. Provided with the Euratom obligation code 'P'. Valid until 31 December 2005.

A214/54, 8 April 2004, Fortum Power and Heat Oy
Licence to import three neutron flux detectors from Hungary. Valid until 30 June 2004.

Y214/82, 7 June 2004, University of Jyväskylä, Department of Physics
Licence to posses, use, handle and store nuclear materials for research purposes at the accelerator laboratory of the Department of Physics, University of Jyväskylä. A total of max. 10 g of special fissionable material. Valid until 31 December 2014.

A214/59, 9 July 2004, Fortum Power and Heat Oy
Licence to export an in-core detector to Canada. Return of defective detector to manufacturer. Valid until 31 December 2004.

C214/258, 16 August 2004, Teollisuuden Voima Oy
Import of steam dryers from the Czech Republic. Two steam dryers for the Olkiluoto nuclear power plant units OL1 and OL2. Valid until 31May 2006.

C214/259, 7 December 2004,
Teollisuuden Voima Oy
Import of fresh nuclear fuel from Spain. A total of max. 4850 kg of enriched uranium. The obligations of an exchange of notes pertaining to the peaceful uses of nuclear materials between the authorities of Finland and the People's Republic of China apply to the uranium to be imported. Provided with the Euratom obligation code 'N'. Valid until 31 December 2005.

C214/260, 7 December 2004,
Teollisuuden Voima Oy
Import of fresh nuclear fuel from Sweden. A total of max. 8900 kg of enriched uranium. The obligations of the Finnish-Russian co-operation agreement on the peaceful uses of nuclear energy apply to the uranium to be imported. Provided with the Euratom obligation code 'P'. Valid until 31 December 2005.

APPENDIX 6 STUK-financed safety research and techical support projects completed in 2004

Nuclear Power Plants

Projects in the FINNUS research program (1999–2002)

Safety assessment of programmable automation (PASSI); Development of reliability assessment methods (FINNUS/PASSI/REL+); VTT Industrial Systems

EU-Benchmark on safety evaluation of computer-based systems; (BE-SECBS); VTT Industrial Systems

Projects in the SAFIR-research program (2003–2006)

Concrete Technological Studies Related to the Construction, Inspection and Reparation of the Nuclear Power Plant Structures SAFIR/CONTECH; 2003; VTT Building and Transport

Emergency preparedness supporting studies – SAFIR/OTUS; 2003; VTT Processes

Interaction approach to development of control rooms – SAFIR/IDEC; Development of MCR-concept evaluation framework; 2003; VTT Industrial Systems

Integrity and lifetime of reactor circuits – SAFIR/INTELI; INPUT; 2003; VTT Industrial Systems

Integrity and lifetime of reactor circuits – SAFIR/INTELI; INSEL; 2003; VTT Industrial Systems

Application Possibilities of Systematic Requirements Management in the Improvement of Nuclear Safety in Finland – SAFIR/APSREM; 2003; RAMSE Consulting Oy

Enhanced methods for reactor analysis – SAFIR/EMERALD; 2003; VTT Processes

Wall response to soft impact – SAFIR/WARSI; 2003; VTT Industrial Systems

Principles and Practices of Risk-Informed Safety Management – SAFIR/PPRISMA; Maintenance strategies; classification and analysis for management of safe and competitive production, HRA-data; reliability analysis methods of programmable systems; VTT Industrial Systems

Application Possibilities of Systematic Requirements Management in the Improvement of Nuclear Safety in Finland – SAFIR/APSREM; Requirements management in the FIN5 regulatory project – basic design; RAMSE Consulting Oy

Integrity and lifetime of reactor circuits – SAFIR/INTELI; INCOM; 2003; VTT Industrial Systems

Ruthenium studies; Behaviour of ruthenium in severe accidents; 2003; VTT Processes

Potential of Fire Spread – SAFIR/POTFIS; Effects of smoke and temperature in equipments; fire spread; active and operational fire prevention; 2003; VTT Building and Transport

High-burnup upgrades in fuel behaviour modelling – SAFIR/KORU; 2003; VTT Processes

Technical support for regulatory decision-making

FIN5 – STUK's safety review during construction licence phase. Comparative analysis readiness development to analyse the reactor behaviour during disturbance situations; VTT Processes

FIN5 – STUK's safety review during construction licence phase. Comparative analysis readiness development in order to analyse the reactor circuit behaviour during accident situations; VTT Processes

FIN5 – STUK's safety review during construction licence phase. Comparative analysis readiness development in order to analyse the behaviour of the containment during accident situations; VTT Processes

FIN5 – STUK's safety review during construction licence phase. Comparative analysis readiness development in order to analyse the reactor and containment behaviour during severe accidents; VTT Processes

OL3 – Water chemistry of primary circuit; VTT Industrial Systems

OL3 – Radiation doses population in environment; Comparative calculations of doses; VTT Processes

Loviisa NPP, new I&C premises; Inspection of construction plans; VTT Building and Transport

OL3 – Structural engineering and structures; expert opinions; VTT Building and Transport

Effect of sea wind to radiation releases; Antti Jylhä-Ollila, Master's Thesis; HU / Institute of physical sciences

FIN5 – STUK's safety review during construction licence phase. Comparative thermohydraulic experiments for cooling of core melt; Lappeenranta University of Technology

OL3 – Independent comparative analyses for STUK's safety evaluation; Institute for Safety and Reliability (ISaR)

Nuclear waste management

Projects in the KYT research programme (2002–2005)

Radiation protection of the environment – code testing for non-human dose calculation; STUK, Laboratory of Ecology and Food chains

Glacial meltwaters as geochemical indicators of redox conditions at Palmottu; University of Helsinki, Laboratory of Radiochemistry

Seabed gas investigations at Olkiluoto site; Geological Survey of Finland

On-line monitoring of copper corrosion and redox conditions in compacted bentonite; VTT Industrial Systems

DECOVALEX III, Glacial effects, especially the formation of permafrost; Helsinki University of Technology, Laboratory of Structural Mechanics

Modelling of Out-Diffusion experiment applied to Palmottu granite; University of Helsinki, Laboratory of Radiochemistry

In-situ study of rocks – Characterization of pore space geometry by C-14-PMMA impregnation; University of Helsinki, Laboratory of Radiochemistry

The relationship between REE and U mobility in a glacial scenario – implications for the evolution of a radwaste repository; Helsinki University of Technology, Laboratory of Rock Engineering

IAEA coordinated research project (CRP). Natural geochemical concentrations and fluxes on the Baltic shieds in Finland as indicators of nuclear waste repository safety; Prof. D. Read 2003; Enterpris Ltd, United Kingdom

Technical support for regulatory decision-making

Baseline survey of the Olkiluoto nuclear waste repository site using earth observation; VTT Information Technology

Review of the bedrock movement studies at the Olkiluoto site; University of Helsinki, Institute of Seismology

Review of Posiva's baseline studies at Olkiluoto; prof. S.K. Frape; University of Waterloo, Canada

Support Group on Investigations and Modelling of Geological Structures (IMGS); Prof. Siivola, Espoo.

Support Group on Investigations and Modelling of Geological Structures (IMGS); Cosgrove 2003; Royal School of Mines, Imperial College, United Kingdom

Support Group on Investigations and Modelling of Geological Structures (IMGS); Tirén; Geosigma AB, Sweden

Review of Posiva's R&D programme; Research, development and technical design for 2004–2006; University of Reading, United Kingdom

Support Group on Investigations and Modelling of Geological Structures (IMGS); Mr. Jarkko Jokinen, Geological Survey of Finland

Review of Posiva's R&D programme; 2004–2006 (TKS-2003); University of Helsinki / Laboratory of Radiochemistry

Review of Posiva's program for R&D and technical design; for 2004–2006 and participation to work of STUK's external expert group; Helsinki University of Technology / Laboratory of Engineering Materials

STUK's support group for the regulatory control of Posiva's underground rock characterisation facility; and STUK's review of Posiva's programme for research, development and technical design for 2004–2006; Geosigma, Sweden

Review of Posiva's R&D programme; Research, development and technical design for 2004–2006; Quintessa Limited, United Kingdom

Review of Posiva's program for R&D and technical design; 2004–2006; Monitor Scientific LCC, USA

Review of Posiva's program for R&D and technical design; Chin-Fu Tsang 2004; Lawrence Berkeley National Laboratory, USA

STUK's support group for the regulatory control of Posiva's underground rock characterisation facility; (ONKALO) and STUK's review of Posiva's programme for research, development and technical design for 2004–2006; Prof. Ove Stephansson, Germany

Technical support for development of regulatory control

Focused modelling of bedrock fracture zones in Olkiluoto; Geological Survey of Finland

Development of rock modelling system; TerraRock, Rollcon Oy, Finland