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REGULATORY CONTROL OF NUCLEAR SAFETY IN FINLAND

Annual report 2005

Erja Kainulainen (ed.)

STUK
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Radiation and Nuclear Safety Authority

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Abstract

This report covers regulatory control of nuclear safety in 2005. 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, construction and operation of Finnish nuclear facilities as well as on nuclear waste management and nuclear materials.

No events endangering the safety of the use of nuclear power occurred at the Olkiluoto and Loviisa 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 was above normal due to the modernisation work done at the Olkiluoto 2 turbine plant and exceeded the average dose measured at BWRs in the OECD countries. At Loviisa 1, the collective dose threshold per one gigawatt of net electrical power, calculated according to STUK's guidelines, was exceeded due to the extended 2004 outage. 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.

STUK's safety performance indicators for nuclear power plants, which describe the effectiveness of STUK's activities, did not indicate changes requiring 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 the assessment of safety, oversight focused on the design of the plant unit's systems, the manufacturing of its main components and construction 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.

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 were €10.6 million. The total costs of operations subject to a charge were €9.3 million, 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 oversight 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 focused on the Loviisa 1 and 2 nuclear power plant units owned by Fortum Power and Heat Oy and the Olkiluoto 1 ja 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 under construction, was also subject to control. Fortum Power and Heat Oy and Teollisuuden Voima Oy are later in the text also referred to as licensee, licence applicant or utility. 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 ja 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 the licence 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 plant units 1 and 2 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 each Olkiluoto plant unit is 2500 MW. A corresponding nominal gross electrical power is 870 MW and net electrical power 840 MW for Olkiluoto 1. Corresponding values for Olkiluoto 2 are 890 MW and 860 MW. The licence conditions require that the licensee makes, by the end of 2008, an extensive periodic safety review for the Olkiluoto nuclear power plant. The requirements for the contents of the assessment are set by STUK.

Upon the application of Teollisuuden Voima Oy, the Government on 17 February 2005 granted a construction licence for Olkiluoto 3 in accordance with the Nuclear Energy Act. The new plant unit is a light-water PWR with a reactor thermal power of 4300 MW and a net electrical power of approx. 1600 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; oversight 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.

The report discusses the assessment of safety analyses for Olkiluoto 3, which is under construction, the oversight of the plant project and of the operation of organisations participating in the construction project.

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 safeguards for the final disposal of spent fuel as well as activities in accordance with the IAEA's Additional Protocol. Regulation of radioactive materials transport 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

The 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 and obligate facilities already in operation. Such decisions made in 2005 are discussed in subsections 3.1.1, 3.2.1 and 3.3.2.

A total of about 23 guides were prepared or reviewed in YVL guide working groups, with four guides completed by the end of the year. The number of Finnish language YVL guides published in 2001–2005 is given in Fig. 1. The number of guides published in English was 13 and those in Swedish two. The guides were available in print and on STUK's web site (*www.stuk.fi/julkaisut_maaraykset/viranomaisohjeet/en_GB/yvl/*) and on the Finlex portal (*www.finlex.fi*). Swedish language translations were published only as online-versions.

A preparatory working group started work on a project to revise the structure of the YVL guide collection. Representatives of the Finnish utilities were invited to participate. The working group gave STUK it's expert opinion on i.a. the structure of the new guidelines system and the internal structure of individual guides. The project will span over several years.

No amendments to the general regulations on nuclear safety, issued in the form of Government Resolutions, were prepared. The revision of the resolutions was started however. The first internal draft on the Government Resolution (395/1991) was completed. By virtue of Finland's new Constitution, it will become necessary to consider next on what regulatory level various requirements will be presented.

The Atomic Questions Group of the Commission discussed the draft directive on the supervision and control of shipments of radioactive waste and spent nuclear fuel, which is intended to replace Directive 92/3. STUK participated actively in the handling of the matter in Finland.

In a working group of the Western European Nuclear Regulators' Association (WENRA) STUK's experts participated in the drawing up of reference levels for European safety requirements. WENRA's work aims at the harmonisation of safety requirements in the EU countries. The experience gained in WENRA work was utilised in the then-ongoing work on YVL guides.

Nuclear safety recommendations are given by international organisations, such as 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 and delivered to the IAEA statements on 13 draft safety guides.

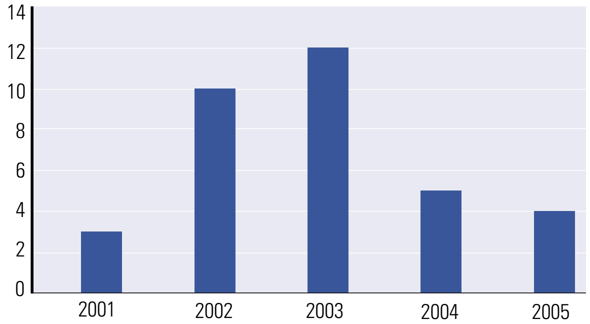

Figure 1. Number of yearly published YVL guides.

3 Nuclear facilities regulation

Kirsi Alm-Lytz, Timo Eurasto, Juhani Hinttala, Juhani Hyvärinen, Tarja K. Ikäheimonen, Ari Julin, Marja-Leena Järvinen, Seppo Klemola, Tapani Koljander, Jukka Kupila, Nina Lahtinen, Jouko Mononen, Matti Ojanen, Rainer Rantala, Suvi Ristonmaa, Vesa Ruuska, 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 the 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 the development of science and technology.

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

- Guide YVL 5.6, Ventilation systems and components of nuclear facilities, 25 November 2004
- Guide YVL 6.4, Transport packages and packagings for radioactive material, 4 April 2005
- Guide YVL 6.5, Transport of nuclear material and nuclear waste, 4 April 2005.
- Guide YVL 5.2, Electrical power systems and components at nuclear facilities, 6 April 2005

STUK had no remarks to make on the licensee's assessment of the fulfilment of the requirements of Guides YVL 6.4 and YVL 6.5 at their nuclear facility and in their operation.

Prior to the implementation of Guide YVL 5.6, Fortum Power and Heat Oy gave an assessment of the fulfilment of the guide's requirements. STUK found it insufficient and called for a clarification of the actions planned to fulfil the requirements set for the detection of concentrations of radioactive and toxic substances. The licensee has presented STUK with a more specified plan for action.

In its decision enforcing Guide YVL 5.2, STUK made remarks and presented further requirements pertaining to the overcurrent protection of the 110 kV back-up plant transformer, the offsite alternating current supply to the plant, the feasibility assessment of cabling and the updating of plant procedures to comply with the revised guide.

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.

The emergency operating procedures of Loviisa nuclear power plant were revised in the HOKE project, launched in 2000. The project encompassed the drawing up of diagnosis procedures for transients and emergencies arising from primary and secondary leaks as well as procedures for operators and safety engineer, as well as action sheets for onsite measures. The project's aim has been to develop extensive and uniform emergency operating procedures, to provide support for the forthcoming I&C and control room upgrading as well as to pass on information to a new generation. The revised procedures consist of guidelines and instructions presented as flow charts. The guidelines define strategy and give grounds for operator actions during emergencies and transients. STUK reviewed the analyses justifying the procedures, which were supplied by the utility, and authorised their taking into use.

The emergency operating procedure for a steam generator heat exchanger tube break was revised as regards pressuriser injection and the operation of pressure relief valves to manage the situation. STUK reviewed the analyses justifying the modification. Other deterministic safety analyses of the Loviisa plant were not submitted to STUK for review.

Probabilistic safety analyses

STUK continued to work with questions relating to the weather risk analysis for Loviisa plant's shutdown states. A general review of the analysis data was made in 2004. 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 constituted a large part of the core damage probability for the Loviisa plant. The most risk-important environmental phenomena include simultaneous high air and sea water temperatures, large oil spills or chemicals releases (at least hundreds of tons of oil in seawater), which could be transported to the sea water channel and prevent the plant's sea water intake.

For a more exact risk assessment, the utility carried out further analyses and follow-up measurements. They show that the risk arising from simultaneously high air and sea water temperatures is considerably smaller than previously assessed, which makes oil and chemical spills into the sea the single most important risk factor relating to weather and environmental phenomena.

The risk from oil spills at the sea for Loviisa power plant while on power operation has been assessed at $4 \cdot 10^{-9}$/year and at $8.5 \cdot 10^{-6}$/year during an outage, which accounts for approx. 10 per cent of the total core damage frequency for the Loviisa plant units (power operation and outages together account for approx. 10^{-4}/year).

Oil spills could endanger plant safety since oil possibly ending up in the plant sea water intake could clog up service water systems (band screens or heat exchangers). The risk from oil spills is at its highest during annual maintenance outages when the primary circuit is open and the back-up emergency feed water system, which does not require sea water, and the steam blow-down function to the atmosphere are unavailable for decay heat removal via the secondary circuit.

The operational procedures of Loviisa power plant prevent the entrance of oil in the service water systems i.a. by oil booms and stopping of the main service water pumps in case of an oil hazard. The Finnish Maritime Administration notifies the main control room of Loviisa 1 of any oil hazards.

The utility is developing its own solutions to reduce the risk of oil and chemical spills. After the completion of the ongoing plant modifications, the sea water required by the cooling systems can be drawn from the sea water discharge channel in case of an oil hazard. Most of the modifications have been implemented at Loviisa 1 and will be implemented at Loviisa 2 in 2006.

The utility has commissioned more exact analyses of oil spill frequencies and the spreading of oil. According to preliminary data, the spreading of oil simultaneously to the intake and discharge sides of the sea water channel is highly unlikely. Therefore, the risk assessed will probably be reduced.

The Loviisa power plant has plans to modify the coarse bar screen (for filtering of marine growth as well as flotsam and jetsam) in connection of which hatches are planned to isolate the sea water inlet channel. The hatches would also prevent the access of oil into the inlet channel in case of an oil hazard when cooling water intake is taking place from the discharge side.

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. 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 oversight project was set up at STUK to co-ordinate document review and other regulatory activities, such as onsite inspection, pertaining to the I&C upgrading. STUK has reviewed among other things plans for operational modifications due for implementation during the I&C upgrading and plans relating to compliance with the diversity principle. STUK has reviewed the detailed plans for the buildings to be constructed for the new plant I&C systems. The utility continued construction of the buildings based on the approved plans. The construction of Loviisa 1 advanced well and that of Loviisa 2 was started. STUK monitors work progress.

Plant life management includes the replacement of devices in operation with new technology. In 2004 and 2005 the utility replaced the personnel monitors of the Loviisa plant units, which measure all workers exiting the controlled area for possible contamination. STUK approved the conceptual design plan for the renewal of the monitors in June 2004, supervised their commissioning onsite and reviewed their test-run documentation and results.

A solidification facility for liquid radioactive waste is under construction and the final repository for low and intermediate level waste is being extended at the Loviisa plant site. The construction of the solidification facility began in 2004 and it is due for commissioning towards the end of 2006. The overview project set up in STUK in 2004 continued. STUK reviewed i.a. the pre-inspection documents of the systems in the solidification facility and documents on the construction of the final disposal facility for solidified waste. The commissioning inspection of section 2 of the low level maintenance waste disposal facility of the final repository was in May.

During the annual maintenance outage, the testing of the back-up systems of the decay heat removal system of the Loviisa plant units was completed. This modification was described in the 2004 Annual Report (STUK-B-YTO 241).

In consequence of the plant modifications, several documents describing plant operation and layout, such as the Technical Specifications, the Final Safety Analysis Report and the operating and maintenance procedures, changed. STUK supervised the revision of these documents and followed the updating of the plant documentation after the modifications. The results are given in Appendix 1 (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 reviewing regular and topical reports on plant operation and 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 verified before startup. The licensee is obliged to immediately report to STUK all plant situations in non-compliance with the Technical Specifications.

No events occurred at the Loviisa plant due to which the plant units would have been in non-compliance with the Technical Specifications (Appendix 1, indicator A.I.2).

The Technical Specifications were deviated from by applying in advance for STUK's approval of a non-compliance. The licensee applied for approval of seven deviations from the Technical Specifications (Appendix 1, indicator A.I.2). After an analysis of the deviations' safety significance, STUK approved the applications. Four exemptions pertained to deviations from the Technical Specifications due to plant modifications or modernisation.

Operation and operational events

The Loviisa plant units operated reliably. The load factor of Loviisa 1 was 95.4 % and that of Loviisa 2 was 95.7 %. Fig. 2 gives the plant units' load factors for 1996–2005. The durations of the annual maintenance outages were 17 days at Loviisa 1 and 15 days at Loviisa 2. In addition, brief reductions in output capacity occurred at both plant units due to technical failures. The most significant of these was the the tripping of one Loviisa 1 turbine on 16 to 17 April from a generator stator earth fault.

Production losses in nominal output caused by component malfunctions were 0.27 % at Loviisa 1 and 0.15% at Loviisa 2. Production losses from component malfunctions in a longer time period are depicted by the indicators in Appendix 1 (indicator A.I.1g). Figure 3 gives the daily average gross powers of the plant units.

At the Loviisa plant units, one event warranted a special report and eight operational transients were reported to STUK. (Appendix 1, indicator A.II.1). The event subject to a special report was an increase in sea water level in January. The event's INES classification was Level 0.

The event is explained in more detail in Appendix 3. Figure 4 gives the number of INES Level 1 events in 1996–2005. No events exceeding INES Level 1 occurred at the Loviisa plant during this time period.

A small primary circuit leak in the steam generator was detected at Loviisa 2 in the autumn of 2004. The locating of the leak was among the most significant tasks during this annual maintenance outage. The leak was very small and had no bearing on plant operation.

In addition to event reports, the Loviisa power 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 outages of both plant units were refueling outages.

Loviisa 1 was shut down for annual maintenance on 30 July. The annual maintenance took 17 days and ended on 16 August, approx. 21 hours behind from planned schedule. The outage was extended mostly due to the washing of the reactor pit, which took longer than planned, carried out towards the end of the outage.

Loviisa 2 was shut down on 20 August for annual maintenance, which ended on 5 September, approx. 20 hours later than planned. The extension

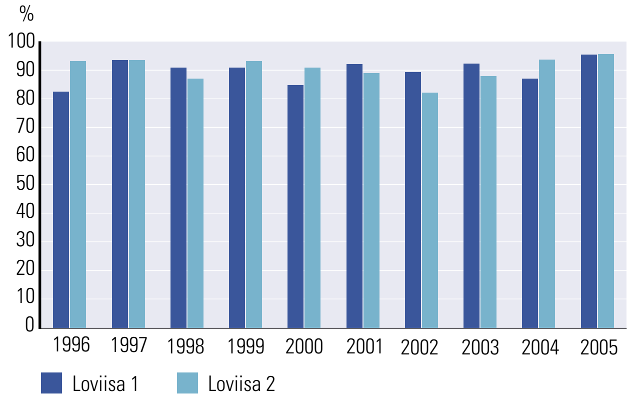

Figure 2. Load factors of the Loviisa plant units.

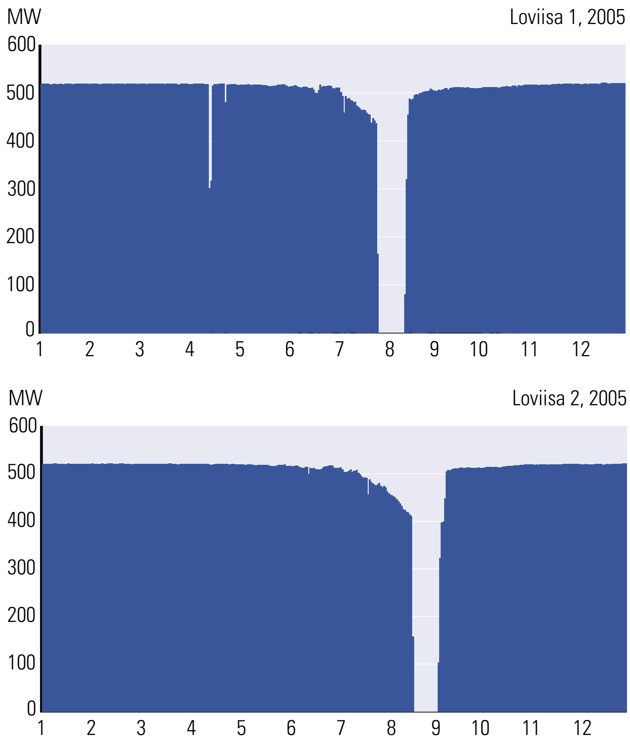

Figure 3. Daily average gross power of the Loviisa plant units in 2005.

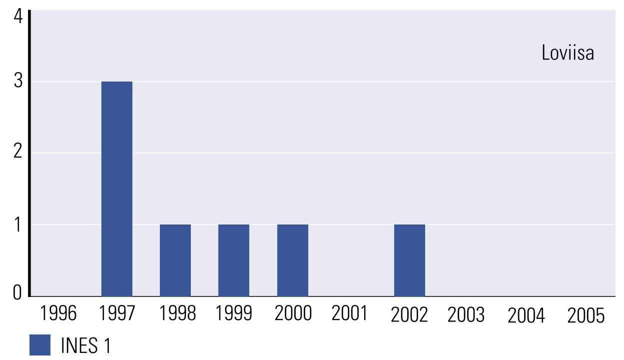

Figure 4. Loviisa plant's INES classified events (INES Level 1 and higher).

of the Loviisa 2 annual maintenance was due to the grinding, welding and machining of a crack in the inner sealing groove of the flange of the reactor pressure vessel upper edge.

The locating of a leaking steam generator pipe, which was detected in the Loviisa 2 annual maintenance, was attempted but, due to the leak's small size, this failed. The utility continued follow-up of the leak during the new operating cycle. It has no bearing on the radiation safety of the plant and the environment. The leak and its locating is described in more detail in Appendix 3.

The collective radiation dose incurred in outage work was 0.403 manSv at Loviisa 1 and 0.300 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, refueling 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 for the 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.

STUK paid attention to housekeeping in general and to control room operations during outages. The plant premises were mostly in good order with cleanliness and order improved from that observed in the 2004 annual maintenances. Work loads during the annual maintenances were significantly less intense than in 2004, which essentially affects the upkeep of cleanliness and order.

The actions to make working in the plant's main control room hassle-free went ahead reasonably well. As in previous years, the handling of work orders had been moved mostly to a room beside the main control room. During its inspections, STUK regularly observed working in the control room during plant rounds and found it to be matter-of-fact and undisturbed.

STUK found several shortcomings in the use of the personnel's personal protective equipment. Those responsible for radiation protection and industrial safety at the Loviisa plant were informed and the matter was brought up i.a. at the meetings of work supervisors and the personnel.

The regulatory oversight of the Loviisa facility's annual maintenance outages took 98 working days. A resident inspector worked regularly at the site. In addition, a total of 117 days outside normal working hours was spent in inspection work to oversee annual maintenances.

Repairs and maintenance

Both Loviisa plant units underwent brief refueling outages involving no extensive maintenance and repair work.

The most important Loviisa 1 work were the maintenance and inspection of the pressuriser main relief valves and their pilot valves, the annual testing of the steam generator relief valves, the maintenance and inspection of two primary coolant pumps and the maintenance of control rod drive mechanisms. In addition, three heat exchanger tubes of one steam generator were plugged using new plugging equipment.

Similar maintenance and inspections were carried out at Loviisa 2 with the exception of steam generator tube plugging. A crack in the sealing groove of the reactor pressure vessel was repaired by surface welding. In addition, the tightness of two protective sleeves of the reactor pressure vessel control rod drive mechanisms were checked since water had been found in them in the previous outage. The situation was found not to have changed between inspections. The utility prepares for repairs in the 2006 outage. Leak detection on the heat exchanger tubes of one steam generator was carried out but unsuccessfully.

Periodic inspection of the reactor pressure vessel and piping in accordance with Guide YVL 3.8, which is the responsibility of the licensee, was carried out at both plant units.

STUK's overview included approval of inspection programmes prior to the start of inspections as well as inspection supervision and review of the results at the plant. The final results reports will be submitted to STUK for approval after the annual maintenance. STUK reviewed onsite the results of condition monitoring inspections of secondary piping made by the licensee.

There were no periodic inspections of pressure equipment in STUK's inspection area at either plant unit. STUK supervised at both plant units inspections of Safety Class 3 and 4 as well as Class EYT (non-nuclear) pressure equipment made by inspection organisations.

STUK carried out 163 construction inspections, inspections of repairs and modifications at the plant as well as commissioning inspections. Ten electrical and I&C system related inspections were made.

Ageing management

Technical analyses relating to the extension of the lifetime of both plant units were started at Loviisa power plant. Current operating licences will expire in 2007 and the utility plans to apply for an extension of 20 years and 23 years for Loviisa 1 and Loviisa 2 respectively. The 30-year technical lifetime of the plant units, the planned basis for commercial agreements, will then be exceeded by 20 years.

Technical analyses relating to the renewal of the operating licences are divided into seven subprojects for whose implementation a project organisation was set up. A report will be drawn up on the principles and implementation of lifetime management as well as on the state of systems, structures and components and on the justification for lifetime extension. Specifically analysed will be the justification for the design for adequate strength as regards lifetime extension and the justification for the lifetime extension of components restricting lifetime as well as of electrical and I&C components. A pressure equipment periodic inspection summary programme shall be drawn up.

The analyses for the design for adequate strength update component fatigue analyses by considering the corrosion effect of the operating environment on the components in the way required in Guide YVL 3.5 "Ensuring the strength of pressure equipment at nuclear power plants".

A strength analysis register will be set up to improve the data management of the strength analyses and the design bases of the most important components. The ageing of components restricting plant lifetime will be analysed, their most significant parts included, considering those ageing phenomena that could become a hinderance to attaining a 50 years lifetime. Plans are to revise the in-service inspection programme to make it a risk-informed programme covering the entire plant.

STUK evaluated the lifetime management programme during the annual inspections made at the Loviisa plant and also by reviewing annual reports on component ageing. An important object in the ageing of I&C systems and components are protection system relays, which have to be regularly replaced or repaired and for which replacement parts are hard to obtain. The availability of replacement parts for old computer-based I&C systems has proved problematic as well. Subsection 3.1.3 describes the project to upgrade the I&C systems of the Loviisa plant units and STUK's regulatory work. Owing to high containment temperatures, special attention is paid to the ageing follow-up of the cabling of electrical systems. The utility said in its report on the condition monitoring of cabling in late 2005 that the ageing phenomena will remain under control in case condition monitoring and the necessary replacements of the cables remain at the present level.

As regards mechanical components, the inspection objects were pressure and temperature transients, piping vibrations and erosion corrosion. Attention was paid to the correlation of stress factors occurring each year with observations made of the various ageing phenomena. Local stress points were identified in the primary circuit where measurement-based intensified monitoring is necessary. STUK called for the development of a systematic monitoring programme for secondary circuit vibrations whose level has increased after the power upratings made in connection with operating licence renewal in 1998.

In-service inspection with non-destructive testing methods plays a significant role in the lifetime management of primary circuit pressure equipment, piping in particular. These inspection methods have to be qualified in accordance with Guide YVL 3.8. The organisation responsible for their qualification, which had signed an agreement with the utilities, continued implementation of the qualifications. STUK oversaw planning and implementation on the basis of the documents submitted by the licensee and approved the qualification organisation's assessment reports submitted by the licensee.

STUK reviewed documents on ageing-related modifications and participated in the supervision of research relating to the ageing of power plants.

Radiation safety

Occupational radiation doses

The radiation doses of all those who worked at Loviisa nuclear power plant were below the 50 mSv annual limit. The distribution of individual doses is given in Table I. The highest individual dose to a Finnish nuclear power plant worker was 13.5 mSv. It accumulated at Loviisa nuclear power plant during annual maintenances. 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 2001–2005, 69.2 mSv, was received at Loviisa, Olkiluoto and Swedish nuclear power plants.

The collective occupational radiation dose was 0.47 manSv at Loviisa 1 and 0.34 manSv at Loviisa 2, i.e. totalling in 0.81 manSv for both plant units. The collective occupational dose is mostly incurred in outage work. The collective occupational dose that accumulated in annual maintenance outage work is 0.40 manSv and 0.30 manSv for Loviisa 1 and 2 respectively. 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 (1.24 manSv). The licensee has reported to STUK the causes for this and the measures necessary to improve radiation safety. The collective occupational dose (1.93 manSv) that accumulated in the extended 2004 annual maintenance outage of Loviisa 1 contributed to it. Collective occupational radiation doses over the past years are given in Appendix 1 (indicator A.I.4).

Table I. Occupational radiation dose distribution at Loviisa and Olkiluoto plant units in 2005.

Dose range (msv)	Number of persons by dose		
	Loviisa	Olkiluoto	total*
< 0,1	635	1162	1662
0.1–0.5	171	592	656
0.5–1	106	266	340
1–2	80	294	336
2–3	43	171	206
3–4	30	86	130
4–5	22	66	95
5–6	23	41	64
6–7	8	17	29
7–8	–	11	21
8–9	2	8	12
9–10	2	4	8
10–11	–	1	2
11–12	4	4	8
12–13	–	–	6
13–14	1	–	2
14–15	–	–	3
15–16	–	–	1
16–17	–	–	–
17–18	–	–	1
18–19	–	–	1
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

Radioactive releases

Radioactive releases from Loviisa nuclear power plant were well below authorised limits. Releases of radioactive noble gases were approx. 6.6 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-40, originating in the air space between the reactor pressure vessel and the main biological shield. The releases of radioactive iodine isotopes were about 0.06MBq, which is less than a millionth 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. 14 TBq, i.e. approx. 9% of the release limit. The total activity of other nuclides released into the sea was approx. 0.9 GBq, i.e. about 0.1% of the release limit. The release limits are intended to maintain the annual individual radiation exposure of the population surrounding the 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 approx. 0.06 microSv, i.e. 0.1 % 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's 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, 310 samples were analysed in accordance with the monitoring programme. Radioactive substances originating in the Loviisa plant were measured in nine samples of sinking matter, eight samples of aquatic plants, five samples of deposition, three samples of sea water and one sample of bottom fauna.

Cobalt-60, the dominating radioactive substance originating in power plants, was measured in 21 samples. Silver-110m (17 observations), cobalt-58 (5 observations), antimonium-124 (5 observations), tritium (3 observations) and manganese-54 (2 observations) were measured as well. 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, there are dosimeters for external radiation measurement in about ten locations around the nuclear power plants.

3.1.5 Organisational operation

Safety management

Information accumulated during document review and other inspection activity at the Loviisa plant was examined with a view to plant safety.

The current operating licence of Loviisa power plant expires on 31 December 2007 and Fortum Power and Heat Oy intends to submit an application for its extension to the Ministry of Trade and Industry in late 2006. The utility has set up the KLUPA project to prepare for the application. In addition to licence extension, the project's aim is to deepen Loviisa power plant and Fortum Nuclear Service's expertise and strategic partnership and to transfer plant related information and skills from old to new generation. Essential project sectors are lifetime management, plant safety, deterministic and probabilistic safety analyses, plant operation as well as matters relating to the environment, nuclear waste and nuclear fuel. As part of the subproject on plant operation, descriptions of the plant's operating organisation and safety culture will be drawn up.

STUK has set up its own project to monitor the renewal of Loviisa's operating licence. Before the application proper will be submitted, STUK and the utility have been discussing the project's implementation plans at regular project level meetings and technical-field specific meetings.

Deficient personnel resources in some areas of activity have been identified as the most important improvement area in safety management at the Loviisa plant. This has been due to retirement, change of duties or workplace. The Loviisa plant has recognised the problem and taken action to remedy the situation i.a. by recruiting new personnel. STUK follows the situation during periodic inspection. Other than this, the organisation's resources and competences are adequate to safely operate the plant units.

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 in accordance with agreed practices. Fortum Power and Heat Oy updated the guidelines describing the quality management system for the nuclear energy sector of Fortum corporation.

The licensee has earlier 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 improve the management system and the organisation's operation. 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, which dealt with quality assurance resources, internal inspection, vendor evaluation and approval as well as actions to improve the management system and quality management.

STUK established that the licensee and Loviisa power plant's quality management was acceptable. However, the need was identified in the organisation's operation to improve the procedures for evaluation and approval of the sub-contractors used by the Loviisa plant.

Personnel qualifications and training

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 the chance to transfer knowledge 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.

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. No significant changes took place in the plant's operating organisation or procedures. Personnel changed more than normally owing to change of generation, duties and workplace.

Upon application by the licensee, STUK authorised persons in the licensee's employ to work as shift managers, operators or operator trainees at the power plant. Authorisations were granted to 32 persons employed by the Loviisa plant, seven of which are operator trainees.

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 the operational experience feedback, minor improvements were carried out at the plant units relating to methods of action and guidelines for the most part but including 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. Deficient personnel resources have been the most significant problem in operational feedback assessment at the plant and has presented itself in the form of delayed reporting and lesser report quality. Attention has been paid to the problem and the increase in resources planned at the Loviisa plant is expected to improve the situation in early 2006.

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). The increase in sea water level in January at the Loviisa plant was reported to the IRS system.

Event investigation

STUK started no event investigations. 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.

Pressure equipment manufacturers as well as inspection and testing organisations

Upon application by Fortum Power and Heat Oy's Loviisa power plant1, and in accordance with the Nuclear Energy Act, STUK authorised two manufacturers of nuclear pressure equipment. STUK extended the manufacturer approval of Loviisa power plant by approving a new manufacturing method.

Upon application by Fortum Power and Heat Oy and in accordance with the Nuclear Energy Act, STUK authorised testing personnel from three different testing organisations to carry out non-destructive testing of mechanical components and structures of 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. By its decision STUK expanded the scope of the inspection organisation's inspection area.

STUK oversaw the inspection of Safety Class 3 and 4 as well as Class EYT mechanical components by the utility's own inspection organisation by reviewing the inspection protocols during the commissioning inspections. Safety Classification is based on STUK's Guide YVL 2.1 according to which components are divided into the Safety Classes 1, 2, 3 and 4 as well Class EYT (non-nuclear). Components of the highest safety importance belong to Safety Class 1.

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.

STUK oversaw the operation of the "Inspection Organisation Loviisa YVL, Electrical engineering and I&C Technology" it has approved as well as the electrotechnical commissioning inspections made by its inspectors. Its operation was established as being in accordance with Guide YVL 5.2.

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. About €425 milloin was available for compensation from all these sources. An increase in the sum is expected in the near future as 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 near future compared with the current situation. Finland has decided to enact unlimited licensee liability by law. The law amendment has not taken effect as yet but is pending the entry into force of the aforementioned international agreements.

The ascertaining of the contents and conditions of a licensee's insurance policy in Finland belongs 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 the transport of nuclear materials. STUK has ascertained that all nuclear material transport has had 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 calculational reporting threshold per one gigawatt of net electrical power in relation to the collective dose, as established in Guide YVL 7.9, was exceeded at Loviisa 1, and was affected by the dose incurred during the extended 2004 annual maintenance outage.

Judged by the safety indicators, the operation of the Loviisa plant showed no significant deficiencies. Operational events were mostly caused by technical malfunctions. Judged by the malfunctions of components subject to the Technical Specifications and the indicators for maintenance, the maintenance function at the plant was reliable and indicated no signs of weakening in quality. The total annual maintenance volume of components subject to the Technical Specifications at the Loviisa plant, including fault repairs and preventive maintenance, was on the increase owing to the slightly growing trend in fault repairs. The number of preventive maintenance jobs was lower than in 2004, and the preventive maintenance/fault repairs ratio at Loviisa 2 was remarkably low. The volume of the plant's preventive maintenance work is affected by preventive maintenance work dictated by the length of annual maintenance outages. The preventive maintenance volume has decreased in the long run as planned. The assessment and development of preventive maintenance programmes will continue in the future. Changes will take place i.a. due to the condition monitoring measurement methods taken into use. The average repair time of components subject to the Technical Specifications at the Loviisa plant was on the decrease for a second year in succession, which could indicate an improvement in the maintenance function. However, long-term conclusions can only be made after the dominant failure types are known.

The number of operational events at Loviisa power plants was about the same as in the previous years. Nine events occurred of which an operational report was written. Operational transients were typically caused by malfunctioning primary coolant pumps. A special report was written on one event pertaining to an emergency standby from high sea water level.

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. No significant safety-endangering events occurred at the Loviisa plant. The most significant event was the moving of an air condenser of the air cooling system of the control building instrumentation room and main control room required during the construction of the I&C buildings from beside the turbine hall wall to its roof. Other events related to latent failures in the auxiliary service water system (Loviisa 1) and the auxiliary feed water system (Loviisa 2). The events in 2005, 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 2004, are normal statistical fluctuation.

Judged by the safety indicators, the limits set for barriers containing radioactive releases were not exceeded. The number of fuel leaks at the Loviisa plant units has been nil for several years.

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

3.1.7 Overall safety assessment

The annual safety assessment for Loviisa nuclear power plant looks at the enforcement of YVL guides at the plant as well as observations on plant safety analyses, modifications, availability and organisational operation made during regulatory work. The assessment is discussed in more detail in sub-sections 3.1.1–3.1.6 and in the appendices of this report. STUK did not detect any significant nuclear safety related shortcomings.

It was established during the implementation of new YVL guides on nuclear facility air conditioning systems and equipment, radioactive materials transport packages, nuclear materials and waste transport as well as nuclear facility electrical systems and components that introduction of the new technical safety requirements and procedures can be done as planned. The utility was required to complement its plans for the detection of concentrations of radioactive and toxic substances, to improve the plant's power supply and intensify the updating of its electrical engineering procedures.

Loviisa nuclear power plant completed the project, which started in 2000, to revise the plant's emergency operating procedures and to establish extensive, uniform procedures with relevant background data. The introduction of new event and symptom based procedures in 2006 provides for the arrival of new digital control room technology.

According to Loviisa nuclear power plant's updated shutdown risk analysis, weather and other environmental phenomena account for a major part of the plant's estimated core damage probability. According to more detailed analysis, oil and chemicals spills are the most important risk relating to weather and environmental phenomena. The risk from oil spills at sea for Loviisa power plant has been assessed at $4 \cdot 10^{-9}$/year during power operation and $8.5 \cdot 10^{-6}$/year during annual maintenance, i.e. approx. 10 per cent of the total core damage frequency of the Loviisa plant units (power operation and outage account for approx. 10^{-4}/year). Loviisa power plant has initiated measures to further reduce the risk.

Loviisa power plant has implemented modifications by introducing new systems or by substituting new technology for that removed from service. The trial run of the new decay heat removal system shared by the plant units was completed. New personnel monitors to detect possible contamination of workers exiting the controlled area have been taken into service at both plant units. A significant project, which is due to the ageing of technology, is the upgrading of I&C systems at Loviisa whose conceptual design planning moved ahead. The project started with the construction of a new I&C building due for 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 at Loviisa 1 progressed well and the construction of the Loviisa 2 I&C building began.

No significant safety-related shortcomings were detected during plant operability oversight. No significant disturbances occurred during the operation of the plant units, which complied with the Technical Specifications, with the exception of seven deviations authorised by STUK. One operational event – high sea water level in January – warranted a special report. The Loviisa 1 and 2 annual maintenance outages were short refueling outages with no extensive maintenance, repair or inspection work. The plugging of steam generator heat exchanger tubes continued at Loviisa 1 and 2. No significant observations were made during inspection.

The doses of all nuclear power plant workers were below the individual dose limit. The collective occupational dose was low by international comparison. However, the threshold for one plant unit's collective dose per one gigawatt of net electrical power, calculated in accordance with STUK guidelines, was slightly exceeded at Loviisa 1 owing to safety modifications made in the steam generator room in 2004. 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 current operating licences expire in 2007 and the utility plans to apply for an extension of 20 and 23 years for Loviisa 1 and 2 respectively. The 30-year technical lifetime of the plant units, the planned basis for commercial agreements, will then be exceeded by 20 years. The utility has set up a licence renewal project. Apart from licence renewal, the aim is to deepen Loviisa power plant and Fortum Nuclear Service's expertise and strategic partnership and transfer plant related information and skills from old to new generation. As part of a subproject relating to plant operation, descriptions of the plant's operating organisation and safety culture will be drawn up.

The section of the licence renewal project dealing with ageing management specifically analyses the justification for the design for adequate strength as regards lifetime extension and that for the lifetime extension of electrical and I&C components and systems as well as of components restricting lifetime. The ageing-related inspections of mechanical equipment, electrical and I&C systems and structures revealed no significant safety deficiencies. Secondary circuit oscillations have increased in consequence of past power upratings and have to be systematically monitored. The impact of the ageing of safety significant cabling can be managed by the condition monitoring programme currently in use and by a timely replacement of cables. The structural integrity of multiple barriers containing plant releases has been good.

The plant's operating organisation or procedures did not significantly change. A temporary deficiency in resources has been caused by retirement, change of duties or workplace. The Loviisa plant has recognised the problem and taken action to remedy the situation i.a. by recruiting new personnel.

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.

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. 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

- Guide YVL 5.6, Air conditioning systems and components of nuclear facilities, 25 November 2004
- Guide YVL 6.4, Transport packages and packagings for radioactive materials, 4 April 2005
- Guide YVL 6.5, Transport of nuclear material and waste, 4 April 2005.
- Guide YVL 5.2, Electrical power systems and components at nuclear facilities, 6 April 2005

STUK had no remarks to make on the utility's description of the fulfilment of the requirements of Guides YVL 6.4 and YVL 6.5 at their nuclear facility and in their operation.

Prior to the decision to implement Guide YVL 5.6, Teollisuuden Voima Oy gave an assessment of the fulfilment of the guide's requirements. STUK considered it insufficient and called for an additional description by 30 June 2006 of the actions planned to fulfil the requirements set for the detection of concentrations of radioactive and toxic substances.

In its decision implementing Guide YVL 5.2 STUK brought forth the additional requirement of a quality plan to be drawn up by the utility with an eye to its own and contracted design and implementation.

3.2.2 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. No deterministic safety analyses on the Olkiluoto plant were submitted to STUK for review.

Probabilistic safety analyses

STUK reviewed the weather risk analysis update for the Olkiluoto plant and provided Teollisuuden Voima Oy with its remarks and requests for analysis. The utility submitted the required analyses to STUK in October. In co-operation with the Swedish BWR plants, Teollisuuden Voima Oy analysed the effects of the loss of reactor building heating during a heavy cold on i.a. the impulse lines of the instrumentation area. Analyses show that the instrumentation area cools to 0°C in about two hours with an external temperature of –20°C, with the reactor building heating lost and the air conditioning remaining in operation. This could result in the freezing of the reactor level measurement impulse lines and further in the loss of the control of safety systems. According to the utility's updated heating and air conditioning procedures, excessive cooling is prevented by closing down reactor building normal air conditioning and starting up low capacity emergency air conditioning. In spite of the updating of the procedure, this phenomenon has considerable risk significance. The core damage risk assessment of $1.7 \cdot 10^{-5}$/year increases to $3.4 \cdot 10^{-5}$/year. The utility is investigating the possibility of automatically shutting down the air conditioning to reduce the risk. STUK set a time limit for the submission of a plan of action.

An update of the weather risk analysis had considered the remarks made in the review report of the previous version; other than that, only minor updates were made. No remarks were made about the update of the weather risk analysis proper, with the exception of the aforementioned risk of cooling of the reactor level measurement function, for which corrective action is under way. STUK analyses the assessed occurrence frequencies of extreme weather phenomena etc external phenomena during the risk analysis of Olkiluoto 3 external events. Should any new information of fundamental importance emerge then, STUK will present possible remarks on the Olkiluoto 1 and 2 risk analyses as well.

3.2.3 Oversight of plant modifications

The Olkiluoto plant is undergoing turbine plant upgrading, including the replacement of steam driers in the reactor pressure vessel. These modifications were implemented at Olkiluoto 2. The safety improvements completed at the plant units 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 meetings.

Plant lifetime management includes the replacement of the devices and equipment in use with new technology. The radiation monitoring systems of the Olkiluoto plant units are due for upgrading in 2007 and 2008. At the end of the year, the utility submitted the modification's conceptual design plan to STUK for approval.

In consequence of the modifications 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 procedures. 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 in particular were subject to oversight. 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.

Four events occurred at the Olkiluoto plant during which the plant unit was in non-conformity with the Technical Specifications (Appendix 1, indicator A.I.2). They were as follows

- Maximum lifting height for reactor pressure vessel head was exceeded at Olkiluoto 1 and 2
- A power failure occurred at Olkiluoto 2 during the annual maintenance outage
- Alarm testing of the carbon-dioxide fire suppression system for diesel generator rooms was not done at Olkiluoto 1 and 2
- Back-up diesel generator air intake opening was closed at Olkiluoto 2.

The events are described in more detail in Appendix 3, which also explains the actions planned and carried out by the licensee to prevent recurrence.

The Technical Specifications were deviated from by applying in advance for STUK's approval of non-compliances. 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. Four exemptions pertained to deviations made from the Technical Specifications owing to plant modifications or modernisation and two were in preparation for the construction of the new plant.

Operation and operational events

Both Olkiluoto plant units operated reliably. The load factor of Olkiluoto 1 was 98.3% and that of Olkiluoto 2 was 94.0%. Figure 5 gives the load factors of the plant units in 1996–2005. The annual maintenance outage of Olkiluoto 1 was seven days and that of Olkiluoto 2 was 22 days. The progress of the outages and the activities carried out are separately described in this chapter.

In addition to the annual maintenance outages no breaks in power generation or significant power losses occurred at Olkiluoto 1 and 2.

Losses in nominal output from component malfunctions were 0.02% and 0.05% at Olkiluoto 1 and 2 respectively. Appendix 1 looks at production losses from component malfunctions for a longer period (indicator A.1.1.g). Figure 6 gives the daily average gross powers of the plant units.

Six events warranting a special report and six operational events reported to STUK occurred at the Olkiluoto plant units (Appendix 1, indicator A.II.1).

A special report was written of the below events at the Olkiluoto plant:

- A setting error in electrical power supply circuit breakers shared by the Olkiluoto plant units (INES Level 1)
- Maximum lifting height for reactor pressure vessel head was exceeded at Olkiluoto 1 and 2 (INES Level 0)
- A power failure occurred at Olkiluoto 2 during the annual maintenance outage (INES Level 1)

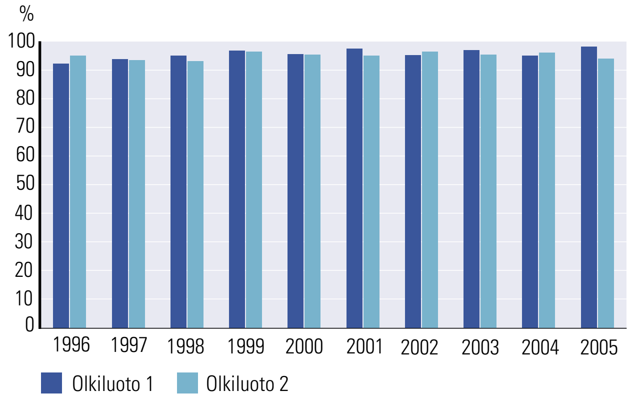

Figure 5. Load factors of the Olkiluoto plant units.

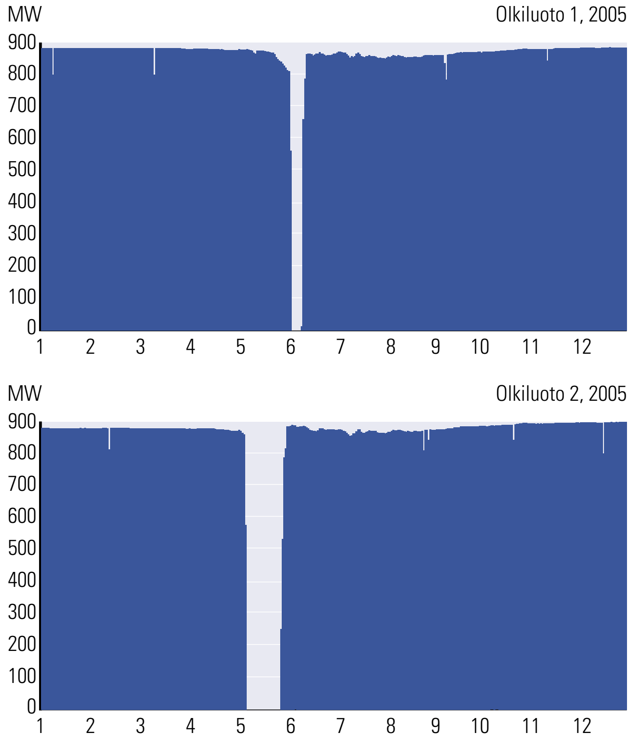

Figure 6. Daily average gross power of the Olkiluoto plant units in 2005.

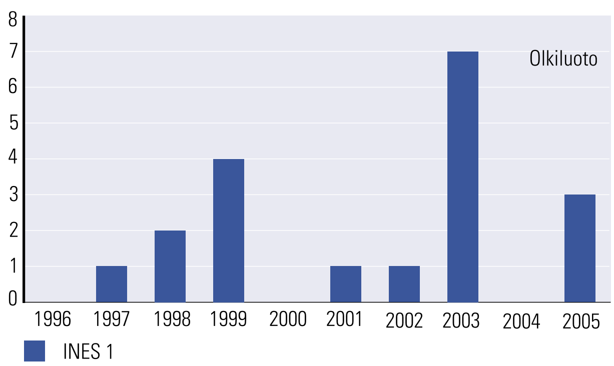

Figure 7. INES classified events at Olkiluoto plant (INES Level 1 and higher).

- Alarm testing of the carbon-dioxide fire suppression system for diesel generator rooms was not done at Olkiluoto 1 and 2 (INES Level 1)
- Fuel cladding leaks at Olkiluoto 2 (INES Level 0)
- Back-up diesel generator air intake opening was closed at Olkiluoto 2 (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 1996–2005. No events exceeding INES Level 1 occurred.

Annual maintenance outages

The Olkiluoto 1 refueling outage was on 5 to 12 June and the Olkiluoto 2 maintenance outage on 8 to 30 May. Olkiluoto 1 stopped electricity generation for about 7 and Olkiluoto 2 for about 21 days. The Olkiluoto 1 outage went almost according to plan, that of Olkiluoto 2 was about two days longer than planned.

The Olkiluoto 2 annual maintenance was an extended maintenance outage during which, in addition to the refueling outage programme, extensive maintenance work, modifications and modernisation were carried out. The most significant of them were modernisation of the turbine plant, replacement of the switchgear of the 6.6 kV switchplant, replacement of the reactor steam dryer, renovation of the containment intermediate level sealing and replacement of the supports of the main steam pipes.

After the synchronisation of Olkiluoto 2, trial runs following the turbine plant modernisation work began, which included system and plant specific testing. The most important test from the nuclear safety point of view was a load reduction test completing the trial runs. After it, a long-term test was started to ensure the plant unit's operation after the modifications. Preliminary measurements showed the power of Olkiluoto 2 having increased by approx. 18 MW after the turbine plant modernisation.

In addition to reactor refueling, 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 are described in Appendix 2.

During the annual maintenance two events warranting a special report occurred and a fuel assembly, which had been found leaking during the operating cycle, was found to have become so badly damaged that a special report was made of it. Another event warranting a special report related to switchgear modernisation work and the related deficiencies in work planning. The utility discontinued the work for some time to ensure its safe and correct carrying out.

A third special report is about an event during which, in connection with modifications, a setting error was found in the relay protection of a supply circuit breaker of a system having to do with the power supply between the plant units. In inspections the same error was found in all corresponding supply circuit breakers i.e. it was a common cause failure. It could have weakened power supply from one plant unit to the other in the event of an accident.

Teollisuuden Voima Oy applied STUK for two exemptions from the requirements of the Technical Specifications for work arrangements during the annual maintenance. The utility let STUK know prior to the start of the modernisation of the Olkiluoto 2 switchgear that some of the necessary work had not been included in the plans. The exemption granted made it possible for the utility to continue work according to the main schedule. The other deviation pertained to the lifting of the Olkiluoto 1 reactor vessel head more than allowed in the Technical Specifications. The utility had established between annual maintenances that the Technical Specifications have been violated for years by exceeding the highest allowable lifting height for the reactor head. This was because a steam separator removed from service was stored in the fuel pool and the reactor head had to be lifted over it. This had no bearing on safety. The significance of the event was in that the utility failed to recognise a requirement of the Technical Specifications, which had not been properly included in the procedures and brought to the knowledge of the personnel. Corresponding information management problems have occurred at Olkiluoto power plant before this. A special report was written of the event. The need to exceed the allowable lifting height will be no more in 2006 when the old steam dryer will be removed from the pool. The exemptions granted did not endanger plant safety.

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, refueling as well as inspections and tests by the licensee and contractors. Of specific interest were the trial runs of the Olkiluoto 2 turbine plant and switchgear after their modernisation, the most important of the trial runs being the generator load reduction test. It was performed in accordance with a STUK-approved test programme. The plant went to internal power supply mode in a controlled way and was resynchronised with the national grid. Based on the approved results of the tests, STUK gave Teollisuuden Voima Oy the permit to start long-term testing.

Attention was paid to the implementation of radiation protection, control room operations and housekeeping. Prior to the start of the new operating cycle, safety analyses for the new fuel charge were reviewed. In addition, the loading of fuel assemblies into the reactor according to plan was ascertained. The nuclear material inventory was inspected prior to the closing of the reactor pressure vessel head. STUK controlled the placement of the plant units into shutdown state and their post-outage start-up.

The collective radiation dose incurred in outage work was 0.360 manSv and 1.74 manSv at Olkiluoto 1 and 2 respectively. Occupational radiation doses are discussed in more detail later in the report under "Radiation safety" and in Appendix 1 (indicator A.I.4).

The regulatory oversight of Olkiluoto facility's annual maintenance outages onsite took 138 working days. Two resident inspectors were regularly working at the site. In addition, a total of 126 inspection days outside normal working hours were spent in outage oversight work.

Repairs and maintenance

Olkiluoto 1 underwent a brief refueling outage with no significant work done on mechanical components. The inspection of the feedwater distributors installed in 2004 and the servicing and inspection of inner main steam valves and two primary coolant pumps were the most important pieces of work done.

Steam reheaters and a high pressure turbine were renewed in the extended Olkiluoto 2 annual maintenance. A steam drier in the reactor pressure vessel was replaced. The feed water distributors removed from service in 2004 due to cracking were reinstalled after the repair of supporting plates of their lugs. The modifications made in the annual maintenance outage are described in Appendix 2. Main steam valves and primary coolant pumps were serviced and inspected and control rod mechanisms serviced.

In-service inspection of the reactor pressure vessel and piping, which is the duty of the licensee, was carried out at both plant units in accordance with Guide YVL 3.8. STUK's control included the approval of inspection programmes prior to the start of inspection as well as inspection oversight and results review onsite. Final results reports are submitted to STUK for approval after annual maintenance. STUK reviewed onsite the results of the condition monitoring inspections of secondary piping made by the licensee.

STUK made 19 periodic inspections of Safety Class 1 and 2 pressure equipment at Olkiluoto 2 and 214 construction inspections and inspections of repairs and modifications that hade been made at the plant. At Olkiluoto 2, the commissioning inspections of 12 new pressure equipment were carried out to definitively approve each item of equipment for service. An item of pressure equipment's commissioning inspection verifies the acceptability of its structure, installation and placement and includes the functional testing of its safety-significant accessories. Four inspections of electrical and I&C systems were made as well.

Ageing management

Ageing management at the Olkiluoto plant is taken care of by a lifetime management team set up in early 1990s. The team has preliminarily identified plant sections which could restrict plant lifetime or which require, due to various ageing phenomena, replacement of large parts of a whole, a complete overhaul, or specific condition monitoring. Based on this, the utility has planned the necessary actions for about ten years ahead. After the transfer to the system of equipment responsibility and maintenance planning specific to component location, the plant's operating and maintenance organisations, too, significantly contribute to ageing management.

STUK assessed the ageing management programme for the plant units by its periodic inspection programme. The assessment was based on international guidelines on ageing management (the IAEA, WENRA, the IEC). Special emphasis was placed on the monitoring of the ageing of electrical and I&C systems.

In its assessment STUK wrote that the utility's ageing management consists of separate routines of action and that the related distribution of responsibilities between functional units as well as the means of identifying and managing ageing phenomena have not been described as a programme entity in the plant documents. The most concrete objective in the utility's ageing management has been the planning of the plants' modernisation programmes, which has gone ahead well.

STUK assesses the lifetime management programme of the Olkiluoto plant by reviewing yearly reports on component ageing. The reports describe essential ageing phenomena from the preceding year and the actions taken thereupon. STUK oversees the ageing of mechanical components, pressure equipment in particular, by several inspection procedures based on legislation and regulations. An example of an inspection procedure is in-service inspection in accordance with Guide YVL 3.8.

In addition to plant ageing management inspection, which is part of the periodic inspection programme, STUK oversaw the ageing management of electrical and I&C systems and components by reviewing the utility's report on ageing follow-up and the documents pertaining to modifications. Components replacements carried out earlier were continued in the annual maintenances in particular due to the ageing of a specific relay comb material and the occurrence of whisker growth in the zinc coated parts of relays. Teollisuuden Voima Oy has participated in the national WHISKE research of the national SAFIR research programme, which has yielded significant new data on the occurrence and nature of whisker growth.

An important modernisation project at Olkiluoto 2 included the high pressure turbine and steam reheater systems as well as the turbine plant process automation with its control console in the plant unit's control room. In addition, the plant unit's 6.6 kV switchgears were renewed. The modifications made in the annual maintenance are described in Appendix 2. Similar measures are due for implementation at Olkiluoto 1 in 2006.

A precondition for the granting of an operating licence for the Olkiluoto plants is that the licensee makes an periodic safety review by the end of 2008. Ageing management is an essential theme in it. STUK will review more extensively the ageing management programme and the status of observations made during the approval procedure of the periodic safety review.

Radiation safety

Occupational radiation safety

The radiation doses of all those who worked at Olkiluoto nuclear power plant in 2005 were below the 50 mSv annual limit. The distribution of individual doses is given in Table I. The highest occupational dose to an individual at Olkiluoto nuclear power plant was 11.9 mSv. In 2001–2005 individual radiation doses did not exceed the dose limit of 100 mSv defined for any period of five years.

The collective occupational dose was 0.46 manSv at Olkiluoto 1 and 1.83 manSv at Olkiluoto 2, the total for both plant units being 2.29 manSv. The collective occupational dose from outage work at Olkiluoto 1 was 0.36 manSv and at Olkiluoto 2 it was 1.74 manSv. Olkiluoto 2 underwent an exceptionally extensive annual maintenance outage as regards the number of personnel involved and the amount of work done. STUK guidelines state that the threshold for one Olkiluoto 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 at the Olkiluoto plant was above normal, exceeding the average dose for BWRs in the OECD countries. 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. The releases of noble gases into the atmosphere were approx. 0.2 TBq, i.e. approx. a hundred thousandth part of the set limit. Iodine releases into the atmosphere were approx. 69 MBq, i.e. approx. 0.06% of the set limit. Aerosol, tritium and carbon-14 releases into the atmosphere were approx. 38 MBq, approx. 0.3 TBq and approx. 0.7 TBq respectively.

The tritium content of liquid effluents released into the sea was 2 TBq, i.e. approx. 11% of the annual release limit. The total activity of other radionuclides released into the sea was 0.7 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 0.06 microSv, i.e. less than 0.1% of the limit prescribed by Government Resolution (100 microSv). 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, 298 samples were analysed in accordance with the monitoring programme. Radioactive substances originating in Olkiluoto nuclear power plant were measured in 12 samples of aquatic plants, 11 samples of sinking matter, two sample of air, two samples of bottom fauna, and two samples of sea water. The dominating power-plant based radioactive substance, cobalt-60, was measured in 27 samples. Apart from cobalt, manganese-54 (4 observations), tritium (2 observations) and cobalt-58 (1 observation) and were measured. The caesium-137 concentration of one sample of milk was above normal, which was probably due to fallout from the Chernobyl accident.

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.

3.2.5 Oversight of organisational operation

Safety management

The information accumulated during document review and other inspection activity at the Olkiluoto plant was examined with a view to plant safety management.

In the autumn of 2003 the Olkiluoto plant initiated several measures to improve the operation of its organisation. 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 conducted a self-assessment of safety culture within its organisation based on IAEA guidelines. As a result, development programmes were started at the plant in the autumn with themes such as "zero tolerance" and "a learning organisation". The self-assessment and its results were presented at STUK in the autumn.

Matters and deficiencies emerged similar to those encountered in 2003 before the starting of the development programme. In the background of the events common factors could be seen that the utility has been unable to resolve. STUK and Teollisuuden Voima Oy have agreed upon a meeting in early 2006 to discuss the utility's procedures in making observations as well as its resources and ability to resolve problems.

No significant changes have taken place in the plant's operating organisation or procedures. The construction of the new plant unit has considerably increased the number of Teollisuuden Voima Oy's personnel and their rotation of duties. Teollisuuden Voima Oy's organisation has adequate resources and competence to safely operate the plant units.

Quality management system

Teollisuuden Voima Oy has systematically maintained and improved the quality management system of the Olkiluoto plant according to own plans. The licensee has regularly evaluated 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 about further improvement of the system and definition of detail. In the quality assurance inspections a remark was made about the vendor evaluation procedure of Teollisuuden Voima Oy, urging the utility to consider the requirements for vendor quality management systems in the relevant IAEA standard.

Personnel qualifications, training and resources

Personnel recruitment by Teollisuuden Voima Oy continued, mostly for 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 5-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 training guidelines and resources as well as the use of outside training resources plus the training of shift workers, simulator training on control room modifications and the development of expertise in I&C technology 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 32 Olkiluoto personnel were authorised, most of them for a new 3-year period.

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 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 based on operational experience feedback were minor improvements to mostly methods of action and guidelines but also 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 non-conformance with the Technical Specifications in 2003. Factors common to the events included insufficient compliance with guidelines and deficiencies in the administration of periodic testing, follow-up of plant states and recognition of the requirements of the Technical Specifications. The events were thoroughly 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. Observations relating to the effectiveness of operational experience feedback are discussed above in connection with safety management.

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 IAEA and the OECD's Incident Reporting System (IRS).

Event investigation

STUK started no event investigations. 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.

Pressure equipment manufacturers, and inspection and testing organisations

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

In accordance with the Nuclear Energy Act, STUK 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 five separate testing organisations were authorised to carry out the 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.

The inspection unit of the Olkiluoto plant, "Teollisuuden Voima Oy inspection organisation", authorised in 2002, continued in operation.

STUK authorised two other inspection organisations to carry out duties relating to the assessment and approval of the compliance with requirements of the design and manufacturing of Safety Class 3 and 4 mechanical components and structures for Olkiluoto 1 and 2.

STUK oversaw at both plant units the inspections of Safety Class 3 and 4 as well as Class EYT (non-nuclear) pressure equipment carried out by the inspection organisations. STUK controlled also the inspection of mechanical components in Safety Classes 3 and 4 and Class EYT (non-nuclear) by the utility's own inspection unit. Safety Classification is based on STUK's Guide YVL 2.1, according to which components are assigned to the Safety Classes 1, 2, 3 and 4 as well as Class EYT (non-nuclear). Items with the highest safety significance belong to Safety Class 1.

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.

STUK oversaw the operation of Teollisuuden Voima Oy's inspection unit "Teollisuuden Voima Oy, Inspection, electrical and I&C inspection", authorised by STUK, and the electrotechnical commissioning inspections made by its inspectors. These were found to be in compliance with Guide YVL 5.2.

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 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 the case of an accident, the funds available for compensation come from three sources: the licensee, the facility's country of location and the international liability community. About €425 million 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. Finland has decided to enact unlimited licensee liability by law. The law amendment has not taken effect yet but is pending the coming into force of the aforementioned international agreements.

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

Judged by the safety indicators, operational experience feedback at the Olkiluoto plant is deficient. STUK has paid attention to its efficiency and non-conformances have been discussed at a STUK/utility meeting. Based on the safety indicators on the failure and maintenance of components subject to the Technical Specifications, the maintenance function at the Olkiluoto plant was reliable and showed no signs of weakening in quality. It was more proactive in nature than in 2004. The indicators on safety system unavailability indicated weakening however: the inoperability of the containment spray system increased significantly at one unit and the unavailability index of the auxiliary feedwater system increased slightly at both plant units. For the time being, the factors contributing to the growth in the unavailability of safety systems are not known to STUK. Latent failures affecting safety system unavailability dominated in events classified in the risk-importance medium category. This could indicate possible deficiencies in the maintenance strategy or in the evaluation of the safety significance of failures. Fuel integrity problems occur every year at the Olkiluoto plants; however, measured by the indicators, radiation protection has attained its set objectives and releases have been small.

The deficiencies in the operation of the Olkiluoto plant are evident in the root causes of events warranting a special report, six of which occurred at the plant. An operational transient report was written on six events. The immediate causes of the 12 events that occurred at the plant have emphasis on errors made in own operation. Only one event was attributed to a technical failure.

The indicator system looks also 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. No event at the plant significantly endangered safety. The most significant events at both plant units related to the repair of the pump sumps of the service water system under an exemption granted by STUK. Other events had to do with latent failures in the containment spray system, the auxiliary feedwater system and the back-up diesel generator system. The events analysed for 2005 are part of a nuclear power plant's normal operation and required no further action by STUK.

The effect on annual accident risk of the periods of unavailability at both Olkiluoto plant units, which arise from significant events such as component failures, preventive maintenance and deviations from the Technical Specifications, exceeded the STUK-established 5% target value. This was due, in part, to planned one-off repairs performed under exemption granted by STUK as well as to latent component failures in safety systems and the back-up diesel generator system. No specific action by STUK was required.

The structural integrity of multiple barriers containing radioactive releases has been mostly good. Small fuel leaks have occurred at the Olkiluoto plant units annually. An Olkiluoto 2 fuel leak, which started in late August 2004, lasted until the 2005 annual maintenance outage. Inspections attributed the cause of the leak to a thin metal strip. Another fuel leak was detected at Olkiluoto 2 towards the end of July. After the finding of the above foreign material and the detection of the new fuel leak, STUK called for the utility to evaluate its guidelines on the cleanliness of installation and procedures for work done on an open reactor and the primary circuit.

The results of STUK indicators depicting 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 the observations made in the regulatory oversight of plant safety analyses, modifications, availability and organisational operation. These are discussed in more detail in subsections 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 YVL guides on nuclear power plant air conditioning systems and components, radioactive materials transport packages, transport of nuclear material and waste as well as nuclear facility electrical systems and components, it was established that the new technical safety requirements and procedures can be introduced by taking the actions planned. The utility was required to complement its plans for the detection of concentrations of radioactive and toxic substances and to improve procedures ensuring the quality of design of electrical systems and components.

Severe accident probability at the Olkiluoto plant is approx. 1.7 10^{-5}. It increased some from 2004 in consequence of the taking into consideration of a previously unidentified risk factor. Had this been included in the 2004 risk assessment, accident risk would have remained unchanged or been smaller. A weather risk from a very cold period has been identified at the plant, which affects the reliability of the reactor level measurement. A plan to eliminate the risk is due for implementation in the 2007 annual maintenance outage.

Significant from the viewpoint of the lifetime of Olkiluoto nuclear power plant is the turbine plant upgrading project that was continued and includes the replacement of steam driers inside the reactor pressure vessels. The modifications were implemented in the Olkiluoto 2 maintenance outage and will be implemented at the Olkiluoto 1 annual maintenance outage of 2006. After the turbine automation modification the plant underwent a load reduction test important to nuclear safety in which it operated as planned. Turbine automation is implemented using processor-based technology. The turbine plant modification has enabled operational experiences with user interfaces that employ new computer-based technology in the control room. Other important modifications implemented at Olkiluoto 2 were the replacements of the 6.6 kV switchgear, the renovation of the intermediate level sealing of the containment and the replacement of the supports of the main steam pipes.

No significant disturbances occurred during the operation of the plant units, which was in compliance with the Technical Specifications, with the exception of 13 deviations. Six events, three of which were INES Level 1, warranted a special report.

The Olkiluoto 1 annual maintenance outage was a brief refueling outage and that of Olkiluoto 2 an extended maintenance outage. During maintenance and repairs carried out during the annual maintenances, no significant safety-related observations surfaced.

Radiation doses to all nuclear power plant workers were below the individual dose limit. The total occupational dose incurred at the Olkiluoto plant was above normal, exceeding the average for BWRs in OECD countries, due to the modernisation of the Olkiluoto 2 turbine plant. Radioactive releases were small and the dose calculated on their basis to the most exposed individual in the vicinity of Olkiluoto nuclear power plant was clearly 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. In inspections relating to the ageing management of mechancial components, electrical and I&C systems and structures it was required that the ageing management procedures be further improved. Whisker growth in the zinc coatings of relays of the reactor protection system, due to which more relays were replaced, has been of significance in the ageing of I&C systems. The structural integrity of multiple barriers containing radioactive releases has been good, although there have been problems in fuel integrity almost every year.

The plant's operating organisation or procedures did not significantly change. Development programmes with themes such as "zero tolerance" and "a learning organisation", initiated at the plant in the autumn as a result of a self-assessment, will have an effect in the years to come. Matters or deficiencies emerged similar to those prevalent in 2003 prior to the start of the organisational development programme. Common factors can be seen in the background of the events that the utility has been unable to eliminate. Special attention is still required to remedy the matter.

The construction of the plant unit has considerably increased the number of Teollisuuden Voima Oy's personnel and the rotation of their duties. The utility's organisation has adequate resources and competence 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.

3.3 Olkiluoto 3

The Olkiluoto 3 nuclear power plant unit is based on the Franco-German pressurised water reactor concept EPR (European Pressurised Water Reactor). The reactor, with a thermal power of 4300 MW and a plant unit net electrical output of approx. 1600 MW, is based on the German Konvoi and the French N4 concepts, with net electrical outputs of the order of 1300 - 1450 MW. Compared with the aforementioned plants, the safety of the Olkiluoto 3 EPR is improved by the application of the principle of defence-in-depth even more systematically than before. Significant safety modifications include, i.a. the making of provision for a severe accident and a large aircraft impact specifically in containment design. A careful application of the redundancy, separation and diversity principles in safety systems design and implementation ensure the accomplishment, with a good certainty, of the most important safety functions. Emergency coolant recirculation has been simplified and the strainers are dimensioned to handle heaviest estimated loading. They are equipped with a flushing function to ensure their operation in the long term. Safety analyses show that, instead of the upper limit for the burn-up of the most burned up fuel assembly, 50 MWd/kgU, given in the Probabilistic Safety Analysis Report (PSAR), the upper limit of 45 MWd/kgU is to be used, unless experimentally proven that the target value meets all safety requirements.

3.3.1 Construction licence

STUK forwarded its statement on the construction licence application for Olkiluoto 3 and the related safety assessment to the Ministry of Trade and Industry on 21 January. According to the safety assessment, it is possible to construct the new nuclear power plant such that its operation will not cause a radiation hazard to the personnel or the population or harm the environment or property.

STUK required in its statement that, since the design of the plant unit's details continues during its construction, STUK's continued inspection and control must be ensured, with sufficient time reserved for it. STUK made a remark on the plant's waste management function, saying that plans more detailed than the present ones are needed and that Teollisuuden Voima Oy must be able to ensure adequate expertise. STUK noted that, in the long run, the use of nuclear energy is in the overall interest of society only in case Finns pledge to keep up safety-relevant societal structures.

Before issuing the statement, STUK requested the opinion of the Advisory Committee for Nuclear Safety for inclusion in the safety assessment. STUK requested the Ministry for the Interior for statements on the new plant's preliminary physical protection and emergency response plan.

3.3.2 Implementation of regulations

STUK has introduced a procedure for the 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 the 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.

No implementation decisions as regards Olkiluoto 3 were made.

3.3.3 Assessment of safety analyses

Deterministic safety analyses

During the construction licence phase STUK reviewed the Olkiluoto 3 safety analyses provided with the Preliminary Safety Analysis Report to assess the fulfilment of safety requirements in design. The safety analyses include transient and accident analyses and severe accidents.

During the review process it was ascertained that the safety analyses have included all essential initiating events and that these have been correctly classified; that the calculation models contain sufficient physical models which have been adequately validated; and that the correct initial values have been used in the calculations. As part of the review, STUK commissioned reference analyses to the VTT and the German ISaR (Institute for Safety and Reliability GmbH) for independent assessment of the most important transients and accidents. Based on the analyses delivered by the utility, the initiating events most significantly affecting the plant design were chosen as the reference analyses: primary circuit leaks of varying sizes, a primary-to-secondary leak in consequence of a steam generator failure, a steam tube rupture, certain disturbances relating to a diluted primary circuit boron concentration, the tripping of reactor coolant pumps and erroneous control rod operation.

As regards severe accidents, the functionality of the severe accident management strategy was evaluated. It was ascertained by the review that the functionality of systems and structures related to strategy has been adequately verified experimentally in severe accident conditions. In relation to the matter, STUK ordered tests related to coolability of core debris from Lappeenranta Technical University.

In the construction licence phase, the plant's design is incomplete in several respects and analyses are partly based on preliminary plant data, which will become more specific when design progresses.

In summary, the analyses and experimental results delivered by the utility during the construction phase and those commissioned by STUK provided adequate confidence of the Olkiluoto 3 nuclear power plant unit meeting the requirements of the Government Resolution (395/191) and of the YVL guides.

Probabilistic safety analysis

STUK reviewed the Probabilistic Safety Analysis (PSA) for the Olkiluoto 3 design phase, which was submitted in connection with the construction licence application, and the related parts of construction licence documentation. Owing to the inaccuracies found in the PSA model, STUK made its own calculations during the PSA review to ascertain that the plant can be designed and constructed to meet the design objectives. The design basis core damage frequency (CDF) target value for the new nuclear power plant is 10^{-5}/year and the target value for severe accident releases is 5·10-7/year. The design phase PSA must demonstrate that the plant meets the probabilistic design objectives. Since the plant's design is still incomplete in several respects, the PSA is complemented during construction when the plant's detailed design is finalised.

According to the Olkiluoto 3 design phase PSA, the CDF estimate is approx. $1.8 \cdot 10^{-6}$ /year (power operation and shutdown states).The most important intiating event groups contributing to the CDF are operational transients (45%), of which loss of feedwater and component cooling system disturbances are dominating, and the loss-of-coolant accidents (24%). Other initiating events contribute to the CDF as follows: loss of off-site power 5%, fires 2%, flooding 2%, external events 16% and initiating events during shutdown states 6%. The vendor's preliminary assesssment of the frequency of exceeding the severe accident release limit is $1 \cdot 10^{-7}$/year. STUK has reviewed the assessment and considers it acceptable.

In summary STUK established that the Olkiluoto 3 construction phase plans have been adequately analysed, by PSA to demonstrate the fulfilment of the safety requirements prescribed in section 6 of the Government Resolution (395/1991) and Guide YVL 2.8.

3.3.4 Oversight of plant project

Conceptual design planning

The acceptability of the plant's conceptual design planning was assessed during the review of the construction licence application. It is included in the plant's Preliminary Safety Analysis Report (PSAR), which was approved by STUK with some remarks. Prior to the approval, several correctives and additions were to be made to the PSAR as well as some revisions to increase the reliability of the operation of safety systems. Added redundancy was required specifically in systems relating to severe accident management.

Radiation safety

STUK assessed the plant's radiation-safety principles during the review of the construction licence application. Included in the PSAR were, among others, a description of the plant site, an estimate of the plant's radiation sources, the design of radiation shields, an estimate of the occupational radiation dose, design bases for the plant's radiation measurement systems as well as environmental analyses for the radiological consequences of normal operation and accidents. The design bases of systems and components as well as their location, radiation shields and accessibility are reviewed in more detail during the review of systems pre-inspection documents.

Ageing management

The plant's design bases and principles are presented in the PSAR and in more detail in the systems pre-inspections documents and the Final Safety Analysis Report (FSAR). The basis for the ageing management of main components is that leading edge technology is used for their materials and in their manufacturing. Attention has been paid to the matter during the review of the construction plans and the supervision of the manufacturing of main components.

The basic inspections of the in-service inspection programme relating to the commissioning of mechanical components at Olkiluoto 3 are to be conducted using methods qualified in accordance with Guide YVL 3.8. The vendor and Teollisuuden Voima Oy are negotiating an agreement to implement the qualifications.

The PSAR dealt little with the ageing of electrical and I&C components since the types of component to be used and thus their characteristics are unknown. Only a few components preinspection documents have been submitted as yet. In future, ageing management will be assessed during component-level review as design becomes more detailed. During the review of the PSAR, STUK required that a preliminary ageing management programme be set up for the electrical and I&C systems and components during the construction of the new plant unit.

Systems planning

STUK began to review the details of process systems design early in the year. Its approval is a prerequisite for the design and approval of the systems' process equipment. The design review will continue in 2006. STUK has reviewed the plans for the most essential power supply systems and the related concept plans, i.a. as regards lightning protection systems and cabling. A review of the I&C systems design has been started as regards the details of design of the most essential systems.

STUK required modification to the original design to improve the reliability of systems important to safety by the application of the diversity and redundancy principles as well as by improved systems separation. Analyses of the effects of a large primary circuit pipe break on core and reactivity control were required. STUK required that the primary circuit depressurisation valves needed in the management of severe accidents be provided with redundancy. STUK required improvements in the structure of the core damage spreading area, in hydrogen management within the containment during accidents and in the management of steam generator tube breaks. In the review special attention was paid to the ensuring of emergency coolant recirculation; verification tests were also required.

Component and structural design

Main emphasis in the review of detailed component design was on the construction plans of the main components. STUK has reviewed the construction and manufacturing plans of the reactor pressure vessel, the steam generators, the pressuriser, the primary coolant pumps, primary circulation piping and the control rod drives prior to the start of manufacturing. The construction and manufacturing plans of the internals of the main components were reviewed as well.

As regards the design of concrete and steel structures, STUK has reviewed the Safety Class 2 pre-inspection documents of the containment and safeguard buildings as well as their strength analyses. STUK has reviewed the detailed plans for the base plate beneath the containment and the safeguard buildings prior to the starting of concrete casting. The review of steel structures focused on the construction and manufacturing plans of the steel liner of the inner containment.

Manufacturing and construction
STUK supervised the manufacturing of the forgings of the reactor pressure vessel and the steam generators at the factory of Japan Steel Works (JSW) and conducted structural inspection of the completed forgings, authorising their shipment to the factory of Chalon in France and the factory of Mitsubishi Heavy Industries (MHI) in Japan. The last forgings were manufactured at and shipped from the JSW factory in spring. The manufacturing of steam generators continued in Chalon. MHI began manufacturing of the reactor pressure vessel in January after having received authorisation from STUK. STUK's inspectors have overseen the manufacturing of the reactor pressure vessel as well as the steam generators and their internals by regular inspections at the places of manufacture. STUK has overseen the manufacture of other main components (pressuriser, reactor coolant pumps, primary coolant piping and control rod drives) at their places of manufacture. The number of Olkiluoto 3 inspections was 278.

STUK has overseen the plant's construction by undetaking regular inspections at the plant site. STUK has ensured readiness for all of the concrete castings essential for safety and authorised the starting of concreting. Four inspections were made prior to the starting of concreting. As regards steel structures, STUK has specifically overseen the manufacturing of the steel liner.

Qualification and verification of applicability
Teollisuuden Voima Oy presented the general procedures and conditions for the qualification of systems, structures and components in the PSAR, the related topical reports and systems pre-inspection documents. The utility presented system-specific plans for the qualification of the I&C systems, which STUK approved with remarks. The acceptability and suitability of mechanical components and certain electrical devices to their intended use has been dealt with in the construction plans.

Teollisuuden Voima Oy will further specify its procedures specifically as regards the qualification of electrical and I&C components to environmental conditions. A more extensive evaluation of their suitability will start in 2006 in connection with qualification plans and the assessment of their results as well as the review of suitability assessments.

Modifications and repairs
Teollisuuden Voima Oy has submitted to STUK for approval detailed Olkiluoto 3 plans during construction. With the plant's design having become more detailed the utility has presented some design modifications, which STUK has reviewed. STUK has approved the modifications after having first assessed their safety significance. The most significant design modification was a change in the air conditioning of the containment intermediate space. STUK approved it after having received from TVO sufficient justification of and data on its cause as well as its effects on the plant overall safety.

3.3.5 Oversight of the operation of organisations participating in plant construction

Safety management
Early in the year STUK started a construction inspection programme with the objective of specifically inspecting and assessing the operation of Teollisuuden Voima Oy in ascertaining the high-quality implementation of the new nuclear power plant. The programme includes inspection of the project's main activities such as management, quality and project management as well as handling of safety-related matters and of other functions such as quality assurance, training and radiation safety plus technical-field specific inspections. STUK draws up a bi-annual plan of the inspections.

STUK reviewed the vendor's design activity in the autumn to find out about their requirements management, handling of design modifications, management of interfaces between multiple technical fields as well as room layout and radiation safety planning and the utilisation of PSA in support of detailed design. Improvement areas were identified due to which Teollisuuden Voima Oy has started corrective actions together with the vendor.

To ascertain adequate vendor competence for the plant project, STUK has participated as an observer in 28 of Teollisuuden Voima Oy's vendor audits. Improvement needs have been identified in the operation of many vendors for the correction of which i.a. special Olkiluoto 3 specific quality plans have been required.

Management and quality management system

The management system of Teollisuuden Voima Oy presents procedures and responsibilities for project management and implementation. The quality management system, which is based on processes, is integrated with the operating management system of the operating Olkiluoto plant units. The project's quality assurance covers the evaluation and control of the project itself, its subcontractors, the consortium and vendors.

Teollisuuden Voima Oy has maintained and improved the project's management and quality management system based on i.a. internal audits and the results of STUK's inspections. The remarks included in STUK's inspection results have required, among others, that the project's internal auditing is to be further improved and that defects detected in operation are to be put right by the deadline given. STUK has called for the project to ascertain that the quality systems of subcontractors who manufacture components important to safety meet the quality management requirements of the respective IAEA standard. In the inspection of the management system, it has been required that the utility improves i.a. the handling of safety matters and the procedures to control construction as well as initiates actions to improve the project organisation.

The personnel resources of the project's quality assurance unit have been increased as planned. In 2006 the project will recruit quality control experts in the fields of i.a. electrical engineering and I&C technology.

Inspection and testing organisations as well as vendors of nucler pressure equipment

Upon application by Teollisuuden Voima Oy, and in accordance with the Nuclear Energy Act, STUK authorised 39 manufacturers of nuclear pressure equipment for Olkiluoto 3.

In accordance with the Nuclear Energy Act, STUK authorised 27 testing organisations to conduct destructive and nondestructive testing of mechanical components and structures at Olkiluoto 3. Upon application by Teollisuuden Voima Oy, STUK approved three inspection organisations to carry out tasks relating to the assessment and approval of the compliance with requirements of the design and manufacturing of Safety Class 3 and 4 mechanical components and structures.

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.

3.3.6 Overall safety assessment

The overall safety assessment of the new plant project looks at observations made based on data and experiences gained from the review of detailed plans, oversight of manufacturing and construction, the results of the construction inspection programme, oversight of the vendor and their subcontractors, and the communication between STUK, Teollisuuden Voima Oy and the vendor. Based on oversight, prerequisites exist for the high quality implementation of the project to construct the new nuclear power plant.

Based on the review of detailed plans, the plant design is established to have continuously become more specific but the vendor and utility have left much to be desired in the drawing up of adequately detailed design documents. During the work done on review, the various project participants have learned to better understand the requirements presented by each others' operations. No essential defects in design-related operation have surfaced that would render unacceptable the plant's detailed design.

Based on STUK's oversight of manufacturing and construction, both the vendor and Teollisuuden Voima Oy have sufficiently well attended to their supervisory obligations. The supervision of the manufacturing of the main components in particular revealed non-conformances and defects, which the vendor and utility have began to put right. These observations show there is a need for comprehensive manufacturing supervision. No significant defects were revealed during construction supervision.

The results of manufacturer and vendor audits have shown that many have failed to take into account the quality requirements of the nuclear field in their operation. Where necessary, manufacturers have been required to submit Olkiluoto 3 specific quality plans to complement their quality system such that it encompasses the specific requirements of the nuclear field as regards the components to be manufactured.

As a result of the construction inspection programme, STUK has gained an understanding of how Teollisuuden Voima Oy manages the project, of the resources, of the handling of safety matters and of quality management as well as of the functions supporting these main functions. Judged by the results of the inspection programme, the utility's operations are advanced as regards the management and construction planning and management. Teollisuuden Voima Oy has presented an action plan as regards the improvement areas identified in its operation.

Evaluation of the vendor's operations is based on intercommunication with them at meetings, review of the documents they have drawn up, review of their quality management system and plans, review of the project manuals, and audits of the vendor's operation. Based on all the above, it has been established that the vendor has adequate expertise to accomplish the plant project. However, the need exists to improve design process, specifically to ascertain the fulfilment of safety requirements.

3.4 FiR 1 research reactor

In addition to the electricity-generating nuclear power plants, STUK regulates 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 production of radioactive tracers, activation analysis, student training and for BNCT (Boron Neutron Capture Therapy) treatment of brain tumors and BNCT reseach.

STUK's oversight focused on i.a. the reactor's operation, radiation protection, nuclear waste and safeguards. Upon application by VTT Processes STUK in December approved four reactor operators and one foreman. No significant problems were observed in the reactor's operation. Occupational radiation doses and radioactive releases into the environment were clearly below set limits.

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

In accordance with the policy lined out in the Ministry of Trade and Industry letter of 3 November 2002, Posiva Oy, Teollisuuden Voima Oy and Fortum Power and Heat Oy in 2004 published the report TKS-2003, 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. The report on nuclear waste management, put out by the utilities in 2005, was largely based on the above TKS-2003 report. STUK reviewed the utilities' nuclear waste management related documents and drew up a statement on them in accordance with section 78 of the Nuclear Energy Decree.

STUK reviewed updated documents on the financial provision made for the costs of nuclear waste management referred to in section 90 of the Nuclear Energy Decree and gave statements on them to the Ministry of Trade and Industry. In its statements STUK addressed the technical plans on which financial provision is based.

4.2 Spent nuclear fuel

4.2.1 Intermediate storage

STUK's regulatory control of spent nuclear fuel storage included regular inspections and review of plans for 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 at the end of 2005 was 6284 assemblies (1106 tU, tonnes of original uranium), with an increase of 234 assemblies (41 tU) in 2005. Corresponding accumulation at the Loviisa plant was 3157 assemblies (376 tU) with an increase of 210 assemblies (25 tU). A decision has been made to increase the storage capacity of the Loviisa plant by the introduction of fuel racks that can take more fuel assemblies. Detailed planning relating to this is under way. STUK will review and oversee the relevant documents and actions.

4.2.2 Final disposal

Posiva Oy's operations most important from the nuclear safety regulatory point of view were as follows:

The planning of Posiva's encapsulation and final disposal facilities has progressed based on long-term planning and the next main objective is the publication of preliminary design phase plans towards the end of 2006. A new report on the design bases of the waste canister was published, according to which the design of the Posiva canister is alike to that of the Swedish SKB.

Posiva, in co-operation with SKB, continues to develop the manufacturing, closing and inspection techniques of the iron-copper canister. Posiva is responsible for the pierce and draw method in particular whereas SKB develops the forging and extrusion method. Both develop the manufacturing method for the waste canister's iron insert. Posiva continued copper canister manufacturing tests in Germany. No cast-iron insert manufacturing tests took place but the testing programme is due to resume in 2006. Although progress was made in the manufacturing technology, method development is required to attain the desired material characteristics in the canister components.

Of the canister closing methods, the development of the electron beam welding method is Posiva's responsibility. In co-operation with Patria Aviation, Posiva started copper capsule head welding tests using the electron beam welding equipment in Linnavuori factory in Central Finland. Progress has been made in welding technology such that preliminary welding specifications are intended to be drawn up during 2006.

The most significant design and development projects in final disposal relate to the horizontal disposal of waster canisters (the so called KBS-3H concept). Posiva has signed a development programme on this concept with SKB, which extends until 2007. The preparatory work for full-scale demonstration tests has been launched at the hard rock laboratory at Äspö Sweden.

Posiva continued research programmes in Olkiluoto to confirm the suitability of the repository site, the construction of the underground research facility ONKALO included. Excavation has not proceeded according to schedule, which has postponed some planned investigations. Posiva cancelled its 4-year contract agreement with Kalliorakennus Oy, signed in 2004, on ONKALO's first phase construction. Posiva acts now as construction developer and oversees the construction works and their quality. Posiva has set up a project for the construction of ONKALO.

Posiva will carry out production-outcome investigations in connection with the construction of ONKALO's access tunnel. The first annual reports on ONKALO's monitoring programme are nearing completion. The construction of ONKALO has not essentially affected rock mechanics or geochemical monitoring results and even its geohydrological effects have been relatively insignificant.

Posiva has developed its management system by incorporating in it quality and environmental management procedures for the ONKALO project. They concentrate on the safety critical activities of the construction of ONKALO, i.a. surface-drilled boreholes, groundwater inflow management, use of rock-injection materials and limiting the excavation damaged zones. A special process of co-ordinated engineering, design and construction activities (the CEIC process) has been created for the management of modifications.

Five new deep holes were drilled in the investigation area to verify the location of rock structures and to characterise the western section of the ONKALO region. A new rock lineament analysis for the Olkiluoto region was completed and the corresponding sea area analysis was revised in accordance with new sounding data. Posiva developed the Olkiluoto region rock model into a geological model, which comprises rock deformation and fracturing models as well as lithological and rock transformation models.

The Olkiluoto Site Description 2004 was published in early 2005. STUK will present an assessment of it in 2006. At the same time, an assessment of the final report on the third phase of Posiva's Host Rock Classification will be given.

STUK oversaw the confirming repository site investigations at Olkiluoto according to an oversight plan. The number of inspections to the construction site was 26, with nine follow-up meetings with Posiva. The list of open issues pertaining to the Olkiluoto repository site investigations was updated twice with the assistance of an international team of experts.

Posiva's safety research is mostly based on long-term bi- or multilateral collaboration projects. Most of the bilateral research projects are contained in the Posiva/SKB (Sweden) collaboration, which was enhanced particulary in the betonite and copper corrosion research.

The most significant multilateral projects are the integrated projects NF-PRO (Near Field Processes) ja ESRED (Engineering Studies and Demonstrations of Repository Design) within the EU's sixth framework programme, both launched in early 2004. Additionally, in early 2005 the integrated project FUNMIG (Fundamental Processes of Radionuclide Migration) was launched in which Posiva and Finnish research institutes participate.

Posiva's safety justification case is contained in the report 'Plan for Safety Case' published in 2005. The forthcoming safety case will consist of a portfolio comprising ten main reports that will be updated where necessary. The first versions of five of them have been published. Posiva organised the compilation of the safety case via the SAFCA project set up in 2005. The company has main responsibility for the safety analysis of the feasibility of the KBS-3H final disposal concept, due for publication in 2007, which assumes Olkiluoto as the repository site. One of the SAFCA project objectives is to manage the necessary know-how in the area.

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. No safety-related problems occurred in the treatment, storage and 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 the year was 2840 m^3. Volume increase from 2004 is 163 m^3. Corresponding waste accumulation at the Olkiluoto plant was 5425 m^3 and the increase was 765 m^3. Scrapped steam reheaters are the most significant addition to the increase in waste volume. Approx. 47% of the waste from the Loviisa plant and approx. 82% of that at the Olkiluoto plant has been disposed of. At the Loviisa plant, cleared from control was mostly maintenance waste, which was taken to the Kymenlaakson Jäte Oy landfill. Cleared from control at the Olkiluoto plant were maintenance waste taken for burial at the local landfill, waste oil taken to Ekokem Oy and recyclable scrap metal taken to Eurajoen Romu Oy.

The low and intermediate level waste subject to long-term storage at Olkiluoto mostly includes components removed from inside the reactor pressure vessels and they are stored in the fuel pools. The cutting up and disposal of steam separators continued. At the Olkiluoto plant site, some large components with a relatively low radiation level are also stored for whose treatment a decontamination chamber and a crusher have been purchased. Introduced into service was a new storage building – a component storage – for steam reheaters removed from service in 2005 and 2006.

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 the end of 2006. A second rock tunnel for the disposal of maintenance waste was commissioned and the construction of a concrete vault where solidified waste will be emplaced was started. After the final disposal of solidified waste has been launched, the Loviisa plant site still has to accommodate for the long-term storage of highly active components removed from inside the reactor pressure vessels and for approx. 200 m^3 of other waste.

The Loviisa plant has plans to develop low and intermediate level waste management by taking into use facilities for centralised treatment, activity measurement and temporary storage of waste. A relevant plan is nearing completion and project realisation will start in 2006. Gate monitoring equipment for vehicle activity and dose rate measurement were introduced.

5 Nuclear non-proliferation

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5.1 Safeguards of nuclear materials

5.1.1 Safeguards at Finnish nuclear facilities

STUK's safeguards activities aim to ensure regulatory control of the use of nuclear energy necessary to prevent nuclear proliferation. In addition, STUK's task is to attend to the control pertaining to international agreements in the field of nuclear energy signed by Finland. 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-weapon member states of the EU, the European Atomic Energy Community (Euratom) and the IAEA. EU safeguards are based on the Euratom Treaty and Commission Regulation EURATOM 302/2005, which replaced Commission Regulation 3227/6 of 20 March 2005.

Insofar as nuclear power plants are concerned, STUK's safeguards activities are mostly focused on fuel import, transport, storage, internal transfers and refueling. The utilities submit to STUK activity programmes, advance notifications and reports relevant to their nuclear materials management.

Seven inspections were carried out at Loviisa power plant and 17 inspections at Olkiluoto plant, totalling in 24 inspections at the Finnish plants. Euratom and the IAEA participated in 21 of them. STUK made three inspections at the construction site of the Olkiluoto final repository with the IAEA participating as an observer in one of them.

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 VTT, where one inspection was made. It was carried out by STUK, the IAEA and Euratom. In addition to VTT's FiR 1 research reactor, STUK, the Laboratory of Radiochemistry at the University of Helsinki, OMG Kokkola Chemicals, the University of Jyväskylä, the Geological Survey of Finland and some other small nuclear materials holders have small amounts of nuclear materials in their possession. The amounts of nuclear materials at Finnish facilities are given in Table II and licences and approvals in accordance with the Nuclear Energy Act in Appendix 4.

An important objective of nuclear material safeguards is to verify that the data on nuclear materials reported by the operators, such as burn-up and cooling time, are correct and complete. STUK verified by non-destructive methods 13 and 389 spent fuel assemblies at Olkiluoto and Loviisa power plants respectively. For the Olkiluoto measurements, the gamma burn-up verification (GBUV) method was used, which is precise enough to reveal a missing rod, although not all levels of partial defect. The use of GBUV is time-consuming as it requires the fuel assemblies to be transferred to the stationary measurement device. The Loviisa measurements were carried out with a spent fuel attribute tester (SFAT). The measurement device is attached to the fuel transfer machine, which facilitates relatively rapid scanning of the fuel assemblies from the top. SFAT is not suitable for strongly profiled assemblies or for fuel extension. Video surveillance by the IAEA had spotted a transfer of a partly filled transfer cask from the Loviisa 1 reactor hall to the spent fuel storage in 2004. Since the transfer took place during annual maintenance, and the reactor was not yet closed and sealed, it brought about an anomaly within the IAEA safeguards. The problem was solved by non-destructive methods in August, when the IAEA, Euratom and STUK measured four fuel assemblies loaded

Table II. Amounts of nuclear material in Finland 31 December 2005.

Location	Natural uranium (kg)	Enriched uranium (kg)	Depleted uranium (kg)	Plutonium (kg)	Torium (kg)
Loviisan plant	–	460 990	–	3 744	–
Olkiluoto 1	–	188 799	–	775	–
Olkiluoto 2	–	193 224	–	877	–
Olkiluoto / Spent fuel storage (KPA)	–	878 827	–	7 256	–
VTT/FiR 1 research reactor	1 511	60	< 1	–	–
OMG Kokkola Chemicals	2 419	–	–	–	–
STUK	44.7	1.4	592.4	0.003	2.5
University of Helsinki, laboratory of radiochemistry	40.4	0.3	20	0.003	2.5
Other facilities	~0	~0	817	~0	–

to and five removed from the Loviisa 1 reactor.

STUK approved Fortum's manual for the accounting and control of international transfers. STUK also approved three persons to safeguards duties for the Olkiluoto power plant. Two of them, for whom approval was granted in 1989, participated in new examinations due to changes that had taken place in the safeguards of nuclear materials. In addition, a new person appointed by TVO to safeguards duties was interviewed and approved. STUK further approved the responsible manager and his deputy for the Geological Survey of Finland (GTK).

Nineteen Euratom and 18 IAEA inspectors were approved to carry out inspections in Finland. Based on a hearing, which pertains to the inspector approval procedure, of those in possession of construction and operation licences for nuclear activities, STUK did not approve one inspector proposed by the IAEA and therefore, in accordance with the Nuclear Energy Decree, handed over the matter to the Ministry of Trade and Industry to decide.

In conclusion, each material balance area operated in compliance with STUK-approved manuals and in a way that facilitates STUK to fulfil the obligations of international agreements in the nuclear field signed by Finland.

5.1.2 Activities in accordance with the Additional Protocol (INFCIRC/540)

STUK prepared the declarations required by the Additional Protocol, the most important of which were the descriptions of the sites and of R&D pertaining to the nuclear fuel cycle. STUK delivered within the given time limits directly to the IAEA the updates to the declarations that are Finland's responsibility. The Commission provided the updates of the declarations under its responsibility and of those it is jointly responsible for with Finland to the IAEA in May and for information to STUK in June. In addition, Finland delivered quarterly information about exportations in accordance with the Protocol. STUK delivered to the IAEA and the Commission a total of 18 declarations and the Commission to the IAEA four declarations pertaining to Finland. In September STUK replied to questions raised about the declaration by the IAEA. The IAEA conducted a Complementary Access at the Olkiluoto site in accordance with the Additional Protocol at two hours' notice following a periodic inspection on 13 September and another one at 24 hours' notice at STUK. The Commission participated in both Complementary Accesses.

5.1.3 Safeguards for final disposal

The final disposal of nuclear fuel in an underground repository presents new challenges to safeguards implementation since, after encapsulation, the direct verification of nuclear material will be impossible. The IAEA has proposed that safeguards for the final repository be implemented during construction already, notwithstanding the Commission Regulation (EURATOM) 302/2005, which merely states that the European Commission will oblige licensees to submit reports on nuclear material, and on the facilities handling them, not later than 200 days prior to the transfer of the nuclear materials to new premises. Based on the Nuclear Non-Proliferation Treaty, the government is under obligation to facilitate effective IAEA safeguards in Finland. Based on negotiations between STUK and the Ministry of Trade and Industry on 29 September 2004, it was considered appropriate to oblige Posiva Oy, who are responsible for final disposal and its implementation, to take care, in the manner of a nuclear facility, of the implementation of nuclear safeguards during the construction of the underground research facility (ONKALO) of the final repository. This decision aims to assure the IAEA of Finland's capability to implement sufficient safeguards and to plan national control and inspection procedures. On 24 May an IAEA representative participated in a meeting of a group of consultants discussing the long-term safety of nuclear waste management for final disposal and visited the underground premises under construction. STUK and Posiva's representatives visited the IAEA on 16 September to present national safeguards arrangements for the final repository based on the Safeguards Agreement (INFCIRC/193) in accordance with the Nuclear Non-Proliferation Treaty and to discuss the implementation of related co-operation with the IAEA.

As regards the final disposal facility, STUK approved the Code of conduct for nuclear non-proliferation in ONKALO, prepared by Posiva, which is equivalent to a nuclear material accounting and control manual and focuses on the verification of construction documents and environmental monitoring prior to the handling and transfer of nuclear materials to the underground facilities. STUK approved a person to attend to nuclear materials safeguards for the final repository.

On 8 July STUK provided the IAEA with a summary of the inspections made during the first year of ONKALO's construction.

5.2 Control of radioactive materials transport

About 20 000 radioactive packages are transported in Finland every year. There were no accidents or safety hazards involving the transport of radioactive materials in 2005. 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. The most significant cases of nuclear material transport were the imports of fresh nuclear fuel to the Finnish nuclear power plants from Sweden, Spain and Russia.

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

No illicit trafficking of radioactive materials was detected at the border in 2001–2005. 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 the number of consignments of scrap metal to Finland has decreased.

Safeguards as well as the supervision and control of nuclear material transport are described in more detail in the report *Nuclear Safeguards in Finland 2005* (STUK-B-YTO 245).

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 commission, which assembles in Vienna, is preparing for the Treaty's coming into force. All signatory states are represented in it. The Provisional Technical Secretariat operates in Vienna as well.

The National Data Centre (NDC), which is based on the CTBT and operates in conjunction with STUK, contributed to the work of the Preparatory commission for the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) in establishing a cost-effective 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 results yielded by stations detecting radioactive particles in the atmosphere. Routine monitoring is facilitated by an alarm system transmitting data on unusual observations to the NDC personnel. No abnormal activity levels were observed by the NDC.

The results of the analyses are fed to the LINSSI 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.

The Treaty's entire monitoring system was tested. The NDC participated in the test by providing the results of automatic analysis and some results of interactive analyses. The secretariat fed the results yielded by the national data centres participating in the test to the LINSSI database, which was distributed to all the participants. Based on preliminary test results, the analysis system of the NDC is operating well.

STUK in 2002 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. The programme was delivered to the national data centre of Tunisia.

6 Safety research

Esko Eloranta, Harri Heimbürger, Kaisa-Leena Hutri

In accordance with the Nuclear Energy Act, 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 research projects which, as an entity, support the purpose for which the funds are collected. Each year VYR distributes the funds to various research projects as proposed by the Minsitry of Trade and Industry. STUK submitted to the Ministry of Trade and Industry statements, as referred to in the Nuclear Energy Act, on the annual plans for the national research programme on nuclear power plant safety (SAFIR) and on nuclear waste management (KYT).

Projects under SAFIR received €2.6 million and those under KYT approx. €1.1 million. SAFIR is not financed by VYR only, its total financing being approx. €5 million. Even financiers other than VYR may bring along in the programme their projects that are in line with the programme's content and objectives.

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 project. The general research themes of the SAFIR research programme were fuel and the reactor core, the reactor circuit, 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 24 research projects. STUK's experts participated in the reference and steering group activities of the SAFIR programmes. Information about the SAFIR programme is available at *http://virtual.vtt.fi/safir*.

The KYT 2002–2005 research programme consisted of nuclear waste management strategic analyses and research into the long-term safety of the final disposal of nuclear waste. The emphasis in the KYT programme is in the implementation of projects that strengthen the basis on which national competence in the field of nuclear waste rests. No financing is granted for research directly relating to projects carried out by those with a nuclear waste management obligation, or anyone representing them, and research directly required by nuclear waste management regulation. The research programme period ended in 2005, with 12 research projects in the programme. The projects focused on earth sciences, technical barriers to release, migration of radioactive substances, safety analyses and technical solutions. The KYT 2002–2005 research programme was managed by a steering group whose chairmanship was with STUK.

According to a Ministry of Trade and Industry decision, the next KYT programme will cover five years. STUK participated in the drawing up of the KYT2010 framework programme prepared by the steering group. The annual budget of the programme will remain at approx. €1 million. In accordance with the earlier KYT programmes, the framework programme focused on strategic analyses of nuclear waste management, with nuclear non-proliferation as a new topic. The research programme will be extended to cover even sociological research. STUK's representatives hold chairmanship in the KYT2010 steering group and in the project's reference group. Information about the KYT programme is available at *http://virtual.vtt.fi/kyt.*

7 Nuclear facilities regulation and development of regulation

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

7.1 Processes and structures

STUK ascertains by inspection and other oversight that the prerequisites for operation, and the operation, of the licensee and their subcontractors as well as the systems, structures and components of nuclear facilities meet set safety requirements. STUK's oversight is composed of document reviews and various types of inspections onsite or at the suppliers' premises. The YVL guides presuppose document review as well as inspections onsite or at the suppliers' premises. In addition, STUK carries out its own inspection programmes during construction and operation, and resident inspectors work at the plant site. The inspection procedures are described in the quality manual for nuclear safety regulation. Document review, the various types of inspection and the related indicators are described in more detail below. The results of the review and inspections are dealt with in Chapters 3–5 of this report.

Document review

A total of 2541 documents were submitted to STUK for review, 924 of which were about the plant under construction. The number of completed document reviews was 2211, including documents submitted in 2005, those submitted earlier and licences granted by STUK in accordance with the Nuclear Energy Act, which are listed in Appendix 4. Average document review time was 51 days. The number of documents and their average review times in 2001–2005 are given in Fig 8. Figs 9, 10 and 11 give the distribution of the review times of documents on each plant unit.

Inspections onsite and at suppliers' premises

Safety management, main processes and procedures of operation as well as the technical acceptability of systems were looked into in inspections of the periodic inspection programme. 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 early in the year and the inspection dates were agreed upon with the licensee's representatives. The inspections contained in the periodic inspection programme are given in Appendix 5.

The construction inspection programme of Olkiluoto 3 aims to verify that the functions required by the construction of the plant ensure high quality implementation in accordance with approved plans and in compliance with regulations, and

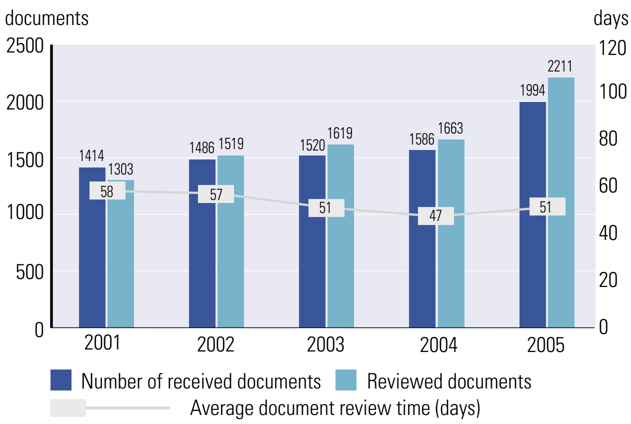


Figure 8. Number of documents received and reviewed as well as average document review time.

without endangering the plants already in operation on the site. The inspection programme assesses and supervises the licensee's activities to implement the plant project, the procedures pertaining to the plant's construction in the various technical fields involved, licensee expertise and their use of it, the handling of safety matters, and quality management and control. STUK draws up a bi-annual plan for the Olkiluoto 3 inspections. The inspections of the periodic inspection programme during construction are given in Appendix 6.

Information was acquired through reports requested from the utility's representatives, personnel interviews, document reviews, walk rounds and observation of working. None of the observations thus made had significant bearing on the safety of the plant units.

Nineteen inspections of the periodic inspection programme were planned for the Loviisa and Olkiluoto plants. During the year, the inspection programme was updated such that 16 inspections were made at each plant.

STUK conducted 12 inspections in accordance with the periodic inspection programme implemented during the construction of Olkiluoto 3.

A total of 683 inspections (other than inspections of the periodic or construction inspection programmes, which are looked into later in this document) onsite or at the suppliers' premises were made as well as nuclear material safeguards inspections. 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 a commissioning inspection. Of the inspections, 278 pertained to oversight of the plant under construction and 405 to that of the operating plants. Relevant documents are reviewed prior to onsite inspection.

The total number of inspection days onsite and at the component manufacturers' premises during office hours was 1781. Not only inspections pertaining to the safety of nuclear power plants but also nuclear waste management and safeguards inspections are included. In addition, 253 inspection days outside office hours were spent at the operating nuclear power plants, mostly during annual maintenance outages. The number of days spent on inspection has been increased by inspections relating to the licensing of the new nuclear power plant. Two resident inspectors worked at Olkiluoto nuclear power plant and one at the Loviisa plant. The number of inspection days during office hours in 2001–2005 is given in Fig 12.

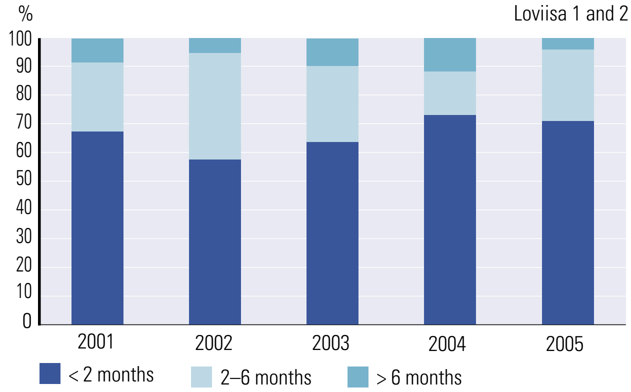


Figure 9. Distribution of time spent on preparing decisions on the Loviisa plant units.

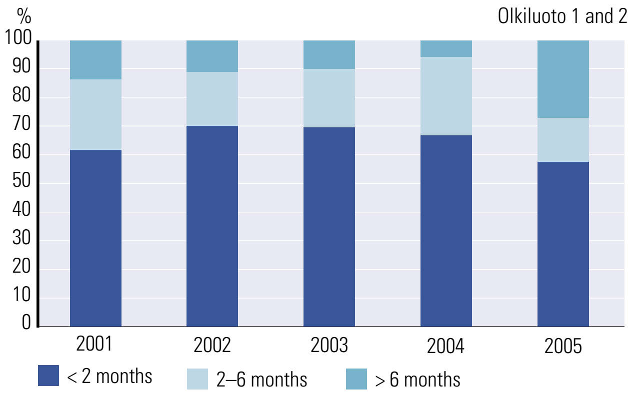


Figure 10. Distribution of time spent on preparing decisions on the Olkiluoto plant units 1 and 2.

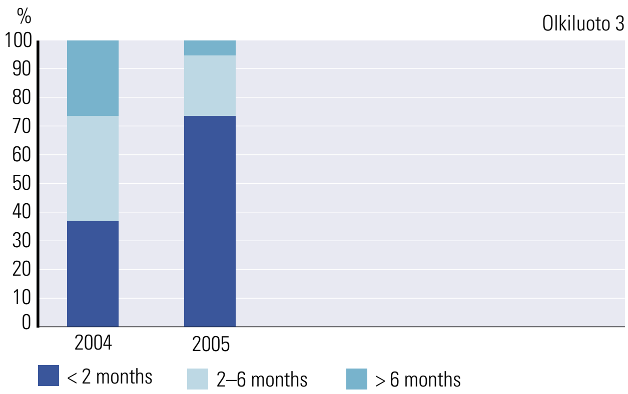


Figure 11. Distribution of time spent on preparing decisions on the Olkiluoto plant unit 3.

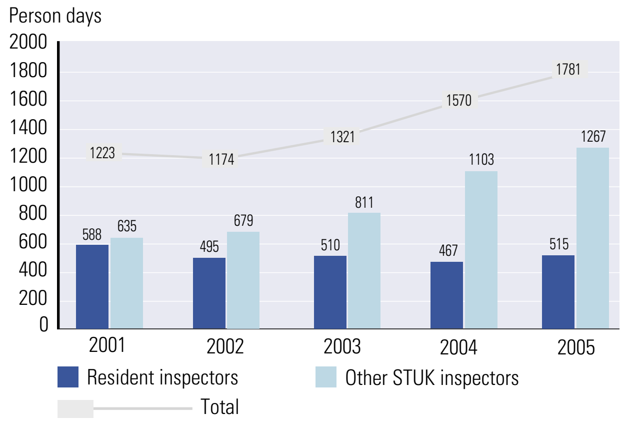


Figure 12. Number of inspection days onsite and at component manufacturers' premises.

STUK's own operation

The development of STUK's own operation focused on processes. The process chart was complemented as regards nuclear reactor regulation and the updating of the quality manual was continued, which work will be given the finishing touches in early 2006. The development objectives in nuclear non-proliferation were regulatory control in accordance with the IAEA's Additional Protocol, and nuclear material safeguards during the construction of the final repository for spent fuel. New entries of both were prepared for the quality manual and their final approval will take place in 2006. The most significant object of development in nuclear waste management was the oversight of Olkiluoto's underground research facility ONKALO. A related plan was updated in May.

Self-assessment focused on client/interest group relationships. No significant shortcomings surfaced but, based on client feedback, some procedures were made more specific.

Development of document management

A long-term document management project is under way at STUK. In 2003 the supplier and the application software were chosen. The main components are a portal, knowledge management, document management, collaboration module and records management. In 2004 work continued by a closer analysis of 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.

The document administration application was introduced to limited use. All personnel were trained in its use. At the same time, the definition of a closely related archiving and registering administration application was initiated. Separate development projects were set up to define and implement the portal and the data retrieval services. Current assessment is that all the aforementioned sub-applications will be commissioned by the end of 2007.

As development projects relating to document administration, the quality and quantity of the printing services available to STUK's inspectors were improved as well as the data security of printers and laptops available for general use.

7.2 Renewal of competence and human resources

Development of competence in nuclear reactor regulation was continued based on earlier plans. Own training focused on increasing knowledge of the features of facility design of the operating plants and the new plant. Newly recruited personnel were given basic professional training in nuclear safety in Finland, which was organised by STUK in co-operation with other parties active in the nuclear field.

Recruitments continued to ensure adequate know-how and personnel resources. Five new experts were recruited for the Department of Nuclear Reactor Regulation. They were in the fields of concrete and rock construction, programmable technology, mechanical equipment and their manufacturing and inspection techniques, PSA as well as management and evaluation of organisational operation. The Office of Nuclear Material Regulation underwent reshuffling of duties and, consequently, two new experts were recruited. Their tasks related to statutory regulatory oversight (the IAEA's strengthened nuclear material safeguards, international transport) and anti-terrorism activities. In this connection, some of the Department of Nuclear Waste and Material Regulation's duties relating to the implementation of the CTBT could be reduced. Nuclear waste management expertise was increased by the recruitment of a safety analysis expert.

A well-being survey was conducted among the STUK personnel in the spring. For the Department of Nuclear Reactor Regulation, an improvement in the results was seen in almost all sectors. The results for the Department of Nuclear Waste and Materials Regulation showed some deterioration but were still at the average STUK level. The results of the survey were extensively discussed with the personnel.

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 nuclear safety regulation, 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.

The costs of the regulatory control of nuclear safety subject to a charge were €9.3 million. The total costs of nuclear safety regulation were €10.6 million. Thus the share of activities subject to a charge was 88%.

The income from nuclear safety regulation was €9.3 million. Of this, €1.7 million and €7 million came from the inspection and review of Loviisa and Olkiluoto nuclear power plants, respectively. In addition to the operating plant units, the income from the Olkiluoto plant includes regulatory control of the new plant unit. The regulation of Posiva Oy's operations yielded €0.7 million. Figure 13 gives the annual income and costs of nuclear safety regulation in 2001–2005.

The time spent on the inspection and review of Loviisa nuclear power plant was 9.2 person-years, i.e. 9.1% of the total working time of the regulatory personnel. For Olkiluoto nuclear power plant's operating units it was 10.6 person-years, which accounts for 10.4% of total working time. In addition to the oversight of the operation of nuclear power plants, the figure includes nuclear material cont-

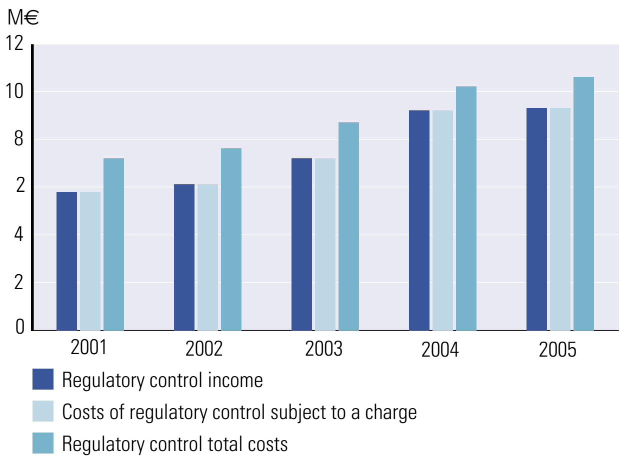


Figure 13. Income and costs of nuclear safety regulation.

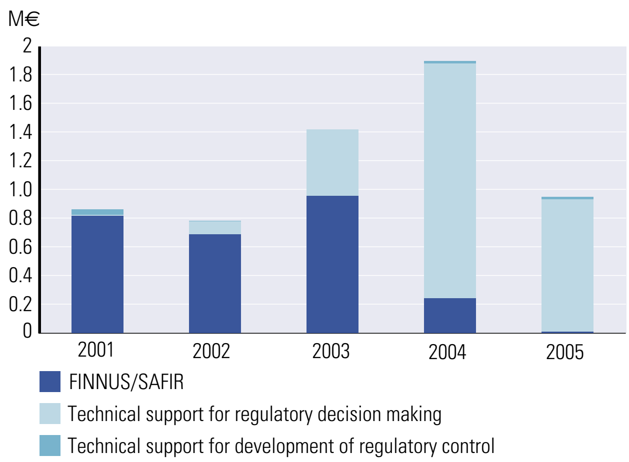


Figure 14. The cost of research and commissioned work pertaining to the safety of nuclear power plants.

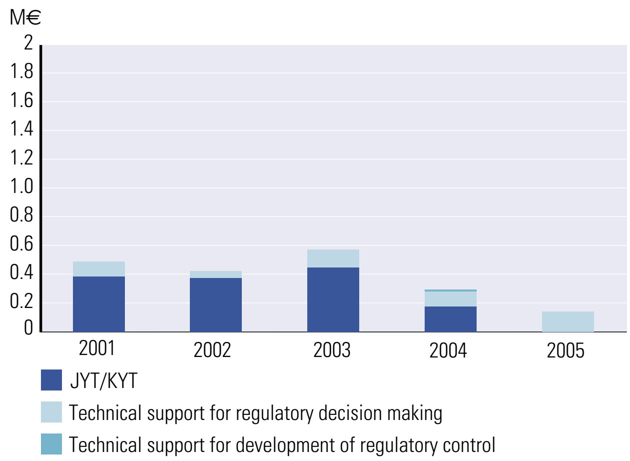


Figure 15. The cost of research and commissioned work pertaining to nuclear waste management and nuclear non-proliferation.

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

Duty area	2001	2002	2003	2004	2005
Basic operations subject to a charge	26.3	27.6	29.2	44.7	47.1
Basic operations not subject to a charge	7.4	6.9	6.4	5.1	7.2
Contracted services	4.4	3.8	4.9	5.1	3.3
Rule-making and support functions	28.5	27.1	28.2	22.7	27.5
Holidays and absences	16	16.2	15.9	16.9	16.9
Total	82.6	81.6	84.6	94.5	101.9

rol. The time spent on the inspection and review of Olkiluoto 3 was 23.8 person-years, i.e. 23.3% of total working time. The time spent on nuclear waste management inspection and review was 3.7 person-years and that spent on the FiR 1 research reactor 0.07 person-years. The working time spent on small-scaler users of nuclear material was 0.08 person-years.

Where necessary, STUK contracts technical support organisations to perform independent safety analyses and assessments for regulatory decision-making. Figures 14 and 15 give the costs of nuclear safety research in 2001–2005. In addition to technical support projects, the pre-2005 figures show the costs of national nuclear safety research. The costs for 2005 mostly relate to reference analyses and independent assessments made for the plant unit under construction. Appendix 7 lists completed STUK-financed technical support projects.

The distribution of the yearly working time of the nuclear regulatory personnel according to duty areas is given in Table III. Figure 16 presents the distribution of working time spent on main functions in 2001–2005.

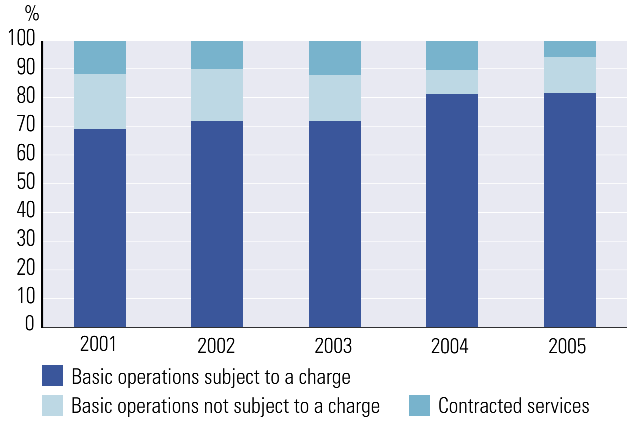


Figure 16. Working time spent on main functions.

8 Emergency preparedness

Tuulikki Sillanpää

STUK organised 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 take action in abnormal situations. No situations occurred that would have endangered the safety of the population or the environment and would have required the taking of protective action.

A significant increase in the sea water level in the Gulf of Finland on 9 January brought about an emergency standby at Loviisa nuclear power plant. The plant sent STUK the relevant notices and started up the operation of its own emergency organisation. STUK's own emergency organisation was partly summoned at STUK's emergency centre to follow the situation and communicate with Loviisa nuclear power plant as well as key authorities and partners of co-operation. STUK issued press releases to domestic authorities and the media. The sea water level increase was not observed to have caused leaks into the plant's rooms or other corresponding phenomena that would endanger the plant's safety; both plant units were in normal operation. The event was classified as INES Level 0. For a more detailed technical description, see Appendix 3.

The emergency response systems of nuclear power plants have been under continuous development 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.

Two domestic emergency exercises were organised. The participants to an Olkiluoto nuclear power plant rescue operations exercise, "OLKI 05", on 8 November, were some 20 domestic authorities or partners in co-operation, media representatives and Nordic nuclear and radiation safety authorities. The date and time of the exercise were not given in advance. Initiation of activities, inter-authority co-operation, assessment of accident situation and dissemination of information to the public and the media were tested. The emergency plans, operation and management arrangements of the Satakunta rescue services area were tested as well. STUK's emergency operations were fully activated in the exercise. Over 90 people from STUK participated.

The annual Loviisa power plant emergency exercise was on 23 November with the plant's emergency organisation and part of the STUK emergency organisation participating. Tested were, among others, accident status analysis and maintenance as well co-operation between the power plant and STUK.

Fire drills are arranged annually at both power plants with fire brigades from the plants and the rescue services of the surrounding municipalities participating. Loviisa power plant's fire drill was on 25 May and that of Olkiluoto power plant on 21 and 28 November.

STUK participated in international nuclear power plant emergency exercises. Some 60 countries participated in the IAEA's ConvEx 3 exercise on 11 to 12 May. The accident country simulated was

Rumania. STUK received messages during the exercise, followed the accident status and actively relayed information about the accident's progress and the migration of radioactive substances to the European Commission in accordance with the Commission's RESPEC agreement on emergency preparedness activities.

The emergency exercise of the Russian Kola nuclear power plant was on 6 to 8 September. Part of STUK's emergency organisation participated in it. STUK's representatives followed the exercise as observers at Kola nuclear power plant and in Moscow.

The INEX 3 series of exercises organised by the nuclear energy organisation of the OECD countries focus on recovery actions in a fallout situation. In Finland the first exercise was organised in two phases, on 13 January and 8 February. Part of STUK's emergency organisation participated together with 25 domestic partners in co-operation.

9 Communications

Risto Isaksson

STUK issued four press releases on nuclear safety regulation. On 9 January two press releases came out on the emergency standby situation, and its ending, at Loviisa nuclear power plant, which was caused by an exceptionally hight water level on the Gulf of Finland. A press release of 14 January was about STUK's statement and safety assessment to the Ministry of Trade and Industry on the construction licence of the new nuclear power plant. On 15 May a press release was issued on a power failure that occurred at Olkiluoto 1 the previous day.

According to a press release on nuclear material safeguards on 4 February, no radioactive consignments were stopped at the Finnish border in 2004.

The press releases were sent to the media and partners in co-operation and were made available to read at STUK's web page. The news section of the STUK web pages told about the annual maintenances of Olkiluoto and Loviisa nuclear power plants.

The press releases did not make big news but STUK and its personnel were visible in the media a couple of times in matters relating to nuclear safety. Towards the end of January the media took notice of STUK's statement and safety assessment on the new nuclear power plant project. The new Olkiluoto nuclear power plant was in the headlines on 17 and 18 February after the government granted it a construction licence. These pieces of news made reference to STUK's expertise and the statement given.

During the summer and autumn the media followed the progress and delay of the construction of Olkiluoto 3. Reference was made to STUK as the regulatory authority and STUK's experts were interviewed. Some of these pieces of news elaborated on the effect regulation has on the plant's construction schedule. The writing style was neutral as regards STUK and the importance of the Authority's work and expertise was emphasised.

STUK's expert opinion about an event that made the headlines in Sweden was requested in June. Waste packages in the Forsmark radioactive waste storage had got wet and elevated radiactivity levels had been measured in the seepage waters. Journalists contacted STUK for information in December after Greenpeace had made it known in public that illegal Russian nuclear waste shipments were being transported on the Gulf of Finland. In the same month the media told about an accident in a low-level radioactive waste treatment facility in the vicinity of the Russian Sosnovyi Bor nuclear power plant.

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

STUK held journalists a course on the fundamentals of radiation and nuclear safety. The participants visited Olkiluoto and Sosnovyi Bor nuclear power plants. In connection with the Sosnovyi Bor plant visit the course participants paid a visit to the Sillamäki radioactive waste dump in Estonia. Nineteen journalists participated in the course.

10 International co-operation

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

10.1 International conventions

International Convention on Nuclear Safety

The International Convention on Nuclear Safety obliges the ratifying States to submit every three years a national report on compliance with the obligations of the Convention. The reports are assessed at a joint meeting of the Contracting Parties. The Parties assembled for a third time for a "peer review" meeting. Of the Convention's 55 Parties, 50 participated in the third meeting to review compliance with the Convention. India participated as a newly ratifying State.

The meeting paid special attention to important current topics, including the challenges posed to safety regulation by the de-regulation of the energy market, and also information management and change of generation in the nuclear energy field, ageing management for nuclear power plants, the impact of national energy strategies on developments in the nuclear field, nuclear terrorism and regulation of research reactors. The meeting focused on the roles of safety infrastructure and the regulatory authority. Other topics were financial and human resources, a safety-first attitude, human factors, safety analyses, emergency preparedness, radiation protection and the design, construction and operation of nuclear power plants.

Finland's report (STUK-B-YTO 234) was well received and, judged by it and its review, no shortcomings were detected that would have required specific additional reporting by Finland for the next meeting, which will assemble in 2008. Finland is expected to report there on i.a. the modifications made at Olkiluoto and Loviisa nuclear power plants, the re-licensing of the Loviisa plant and the construction of the new plant unit. In addition, some developing sectors of interest included the maintenance and development of nuclear-safety related know-how, ageing management for nuclear facilities, strengthening of safety culture, a qualification system for non-destructive testing methods and the development of risk-informed regulation.

The improvement of Convention-related procedures was widely discussed. Procedures were agreed upon that aim to improve the efficiency of the review meetings.

Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management

The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management requires the sumbission, every three years, of a report addressing the measures taken to implement the obligations of the Convention. STUK drew up Finland's second national report, which was submitted to the IAEA, acting as the Convention's secretariat, in October as agreed (STUK-B-YTO 243). The first corresponding report was made in 2003. The second report will be reviewed at an international review meeting of the Contracting Parties in Vienna in spring 2006.

10.2 Co-operation in international organisations and bilateral co-operation

Co-operation with the IAEA

The IAEA continued revision of its nuclear safety guidelines (formerly Nuclear Safety Series NUSS). 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), TRANSSC (transport safety) and RASSC (radiation safety) committees.

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 Trafficing 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.

The IAEA safeguards support programme, launched in 1988, continued. 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 was the organising in Finland of two training courses relating to the implementation of the Additional Protocol.

In IAEA expert capacity, a STUK representative participated in the development of the nuclear power plant safety performance indicator system intended for use by nuclear safety authorities.

A STUK representative participated in IAEA expert capacity in a team whose task was to create a system for the Incident and Emergency Center (IEC) to process incident information submitted via multiple channels (NEWS, ENAC, ITDB, the media).

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

- Working Group on Inspection Practices (WGIP)
- Task Group on Regulatory Effectiveness Indicators (/TGRE) and Task Group on Safety Performance Indicators (Joint CNRA/CNSI/TGSPI)
- Working Group on Public Communication of Regulatory Organisations
- Working Group on Operating Experience (WGOE)

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).

Co-operation with the EU

Upon the request of the Ministry of Trade and Industry, STUK participated in the work of the Working Party on Nuclear Safety (WPNS). Its task is to formulate a comment to the Working Party on Atomic Questions and, further, to the Council of the European Union. This is a follow-up task, which the Council called for when aborting the handling of the nuclear safety package proposed by the European Commission. The work will continue until the end of 2006.

STUK contributed to regulatory co-operation within the EU through the Nuclear Regulators Working Group (NRWG) and Concertation on European Regulatory Tasks (CONCERT). The European Commission abolished both working groups in 2005. It has plans to establish new working groups in 2006. STUK took part in the operation of an NRWG working group on safety-critical software, which continues its work within the framework of WENRA. The group gathers 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 European Commission. It's main tasks pertain to radiation protection regulations.

An expert from STUK participated in the work of the Commission's permanent working group on the transport on radioactive materials.

The renewal of the European Commission's Safeguards began five years ago. A team of external experts gave a recommendation for its reorganisation. The objective was to renew the safeguards activities such that the effects on the Euratom safeguards of the EU's enlargement and of the developments that have taken place in the nuclear field, considering technological developments, are taken into account. A secondary objective was to make it compatible with the Commission's nuclear material safeguards to better serve the IAEA's strengthened safeguards. In 2005 the Commission presented the Member States with new safeguards models. An important task during Great Britain's EU chairmanship was to enhance the implementation of the Euratom Safeguards New Approach. The matter was discussed in the Atomic Questions Group (AQG) of the Council of the European Union and at a meeting of experts in London, which was summoned by Great Britain. An expert from STUK participated in the aforementioned meetings. In December the AQG prepared the document "New Framework for Euratom Safeguards", based on which reorganisation of the Commission's nuclear material safeguards continues at AQG expert meetings.

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

STUK participated in EU-financed Phare and Tacis co-operation in support of East European regulatory organisations and their support organisations. The co-operation covered participation in the activities of the Regulatory Assistance Management Group (RAMG) and in several individual projects the beneficiaries of which were Bulgaria, Latvia, Lithuania, Rumania, Hungary, Ukraine and Russia. The European Commission was the beneficiary in a couple of projects.

NKS co-operation

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

The project entity on reactor safety contains projects relating to Finland's publicly financed SAFIR research programme. The emergency preparedness and environmental safety programme includes focus areas important to Finland such as development of information 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 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, waste management and nuclear material safeguards were discussed. Information exchange with the Swedish Radiation Safety Authority (SSI) continued as regards individual occupational radiation doses to Finns who had worked at nuclear power plants in Sweden and to Swedes who had worked at Finnish plants.

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. A representative of STUK worked six months as a visiting expert at the USNRC. STUK participated in meetings on LOCA tests organised by the USNRC at the Argonne National Laboratory (ANL).

STUK's representative was a member of the Groupe Permanent des Reacteurs (GPR), a permanent adviser to the French nuclear safety authority Autorité de Sûreté Nucléaire (ASN). Of the considerable number of GPR meetings, STUK's representative participated in those dealing with EPR plant design. The information exchange is bidirectional: Finland utilises French analyses to the approppriate extent and, at the same time, information about Finnish analyses and actions thereupon are imparted to France.

STUK co-operated with French authorities in the regulation of the design and construction of the new plant project. At meetings, information was exchanged about design solutions, construction status, construction oversight, environmental qualification of componenets and aircraft impact analyses.

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. A specific item of co-operation was the development of regulatory guides for oversight of radioactive substances and sources. Representatives of Finland's Ministry of Transport and Communications participated in discussions on the implementation of regulations on the transport of nuclear and radioactive materials. The guidelines on the quality control of the manufacturing of MOX nuclear fuel were the topic of a seminar in 2005. The assembling of a spent nuclear fuel measurement device, which was designed during the project of co-operation, began at STUK. The Russian authority and representatives of Rosenergoatom familiarised themselves with the progress of the project during a visit to STUK.

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 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 of 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 formulated 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 and its work meetings to put the finishing touches to these European reference requirements and to review member state self-assessments evaluating coverage of national regulations against the reference level and the implementation of the requirements in practice. The final report on the work done on nuclear safety requirements was completed in November. STUK participated in WENRA's decommissioning and nuclear waste working group, which put out draft safety requirements for the decommissioning of nuclear facilities and the storage of nuclear waste.

The working group on risk asessment set up by the VVER Regulators Forum in 2002 held its last project meeting in Bratislava. The working group consists of national nuclear safety regulators from countries operating VVER facilities. It compared the results of PSAs for VVER facilities, the modelling and results of the loss of offsite grid and a small LOCA, and analysed the causes of the differences found. It drew up a report on the risk-informed regulation and management of VVER facilities. The participants drew up a summary report on PSA-based modifications made to VVER facilities. It prepared a final report and the results were presented at a VVER Regulators Forum meeting in Finland. The Forum further gave it the task to continue the making of comparisons for other initital events and of looking into the causes of the differences found between analyses. The new project lasts for three years. In 2004, a VVER working group was set up to look into the utilisation of lessons learned from nuclear power plant operational experience feedback. An I&C working group began work with the objective of drawing up, over the next three years, a report on experiences gained from I&C modernisation implemented by programmable technology.

STUK participated in the work of the Network of Regulators of Small Nuclear Programs (NERS). It is a channel via which information about the ways of action and experiences of colleagues working on similar-sized nuclear energy programmes can be exchanged. Nuclear safety authorities from eight European countries, Argentina, South Africa and Pakistan participate in the co-operation. The licensing of new nuclear power plants, the utilisation of operational experiences and safety analyses as well as quality management and safety culture were addressed among others.

As regards physical protection in the nuclear field, STUK has participated in the work of the European Nuclear Security Regulators Association (ENSRA) and that of the Nordic Fysiskt skydd i Nordisk kärnteknisk verksamhet (NORDFYS).

STUK contributed to the work of the Nordic working group on transport (NORTRAM).

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). The members were Professor Riitta Kyrki-Rajamäki (Lappeenranta Technical University), Director Ulla Koivusaari (Pirkanmaa Regional Environment Centre), Development Director Timo Okkonen (INSPECTA OY), Senior Researcher Ilona Lindholm (VTT) and Branch Manager 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). Director Christer Viktorsson left the Committee for the IAEA.

The Committee convened nine times. It prepared statements to STUK on i.a. the construction licence application for the new nuclear power plant unit and on two YVL guides under revision. The preparation of statements on seven other draft YVL guides was started. The Committee gave a statement on a draft prepared by STUK for a national report about the implementation of the obligations of the Joint Convention on the Safety of Spent Fuel Management and the Safety of Radioactive Waste Management.

The Committee followed regularly the progress of the construction of the Olkiluoto 3 plant unit and operating events at the operating nuclear facilities and participated, together with the Advisory Committee on Nuclear Energy, in the organising of the annual nuclear energy seminar. It convened once at the Olkiluoto nuclear power plant, specifically acquainting itself with the new plant unit under construction.

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. Four Division meetings were held.

APPENDIX 1 STUK's safety performance indicators for NPPs in 2005

Seija Suksi

Summary of the results of STUK's safety performance indicators

Background and purpose

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 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 any corrective 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), as well as the target values contained in the objectives of the department of Nuclear Reactor Regulation (NRR), will be applied where available.

STUK's indicator system is divided into two principal groups: external indicators for the safety of nuclear facilities and internal indicators for the regulatory effort. External nuclear plant safety 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 at the NRR site on STUK's intranet.

The STUK indicators were included in the revised strategy of early 2003. Of the indicators describing the effectiveness of STUK's activities, the following 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 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 NRR's own objectives.

All of the nuclear plant safety indicators are considered to describe and measure the effectiveness of NRR's activities. Their values are updated quarterly and any deviations and their causes are either immediately tracked down by the responsible persons or considered more widely at departmental or oversight meetings. 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.

Indicator results for 2005

Safety and quality culture

The indicators in this area illustrate the condition of the plant and the success of the operations of the various organisational units (maintenance, operation, radiation protection, etc.) participating in plant operation. Compliance with the Tech Specs is monitored, as well as identified needs for deviating from the Tech Specs. The area also includes an indicator for monitoring the updating of principal documents after plant modifications, as well as an indicator for monitoring the relative fluctuations of investments used for plant maintenance and renovation.

Maintenance activities were evaluated by plant unit concerning the yearly volume of maintenance works, the volume of preventive maintenance and failure repairs of Tech Spec components, and on the basis of the volume of repair works during power operation, the average time spent on failure repairs and the production losses caused by failures. The unavailability of systems required for accomplishing the critical safety functions is also monitored.

In Loviisa the total volume of the yearly maintenance works of Tech Spec components, including both failure repairs and preventive maintenance, has been increasing in the last few years. In 2005 the volume of failure repairs was at the level achieved a few years previously and is still increasing slightly. The volume of preventive maintenance was below the previous year's volume, which was significantly high. In 2005 the ratio of preventive maintenance to failure repairs at Loviisa 2 remained well below one (0.79). The volume of preventive maintenance at the plant is affected by preventive maintenance works determined by the length of the annual maintenance outage. The volume of preventive maintenance has decreased in the long-term as planned. Evaluation and development of preventive maintenance will also continue in the future. There will be changes due to, for example, adopted condition monitoring measurement methods.

The volume of failure repairs during power operation at Loviisa plant has increased slightly in the last few years. The marked increase in the number of failures since 2002 cannot be attributed to a single straightforward reason. One factor may be the revised work recording procedure. However, the number of failures has shown similar variation in the long term. The number of failures causing an operation restriction while isolating the component for repair work showed an increase in 2005.

The average repair time of Tech Spec components has varied over the years from one day (24 hours) to over two days (over 48 hours) at the Loviisa plant units. The average repair time at Loviisa decreased for the second successive year to just over 32 hours in 2005, which may indicate an enhanced maintenance function. Since there is no data available on which failure types were dominant, it is not easy to draw any conclusions.

The total yearly volume of maintenance works of Tech Spec components at the Olkiluoto plant has been increasing for the past two years, which is partly caused by the increase in preventive maintenance works. The distribution of preventive maintenance between plant units is determined by the length of the annual maintenance outages. The volume of preventive maintenance at Olkiluoto 2 was considerable in 2005, since turbine plant modifications were carried out at the plant during the long annual maintenance outage. The volume of failure repairs decreased slightly from the previous year.

The volume of failures during power operation causing an operation restriction at the Olkiluoto plant has been on the increase for the past few years. In 2005 their number decreased markedly compared with the two previous years. The decrease may be partially attributed to the long maintenance outage at Olkiluoto 2 and the repairs and preventive maintenance carried out during the outage. The number of failures causing an immediate operation restriction at Olkiluoto 2 exceeded the number of failures causing an operation restriction when isolating the component for repair work.

Over the years the average repair time of failures of Tech Spec components has varied from four to twelve hours at the Olkiluoto plant units. The average repair time at the Olkiluoto plant showed an increase for the second successive year, standing at some 8 hours in 2005. An assessment of the situation would require detailed information on the type of failures for any conclusions to be drawn concerning the efficiency of the maintenance function. The average repair time is still short, however, and thus no action is necessary.

Production losses due to failures at the Loviisa and Olkiluoto plants remained relatively small in 2005. At Loviisa 1 production losses were slightly higher than in 2003 or 2004, although still low. Losses were caused by failures in single independent equipment and systems that were not exceptional. The heaviest production loss of just under 1% occurred at Loviisa 1, as one of the generators tripped out of service due to an earth fault signal in the stator. At Olkiluoto, production losses due to failures at both plant units have decreased considerably compared with recent years to only some hundredths of a per cent in 2005. This is a successful result, considering that the annual maintenance of Olkiluoto 2 included considerable modifications which may cause new failures in the initial stages of operation.

The unavailability of safety systems was followed by means of international indices provided by the licensees. The high pressure safety injection system, the auxiliary feed water system and the back-up diesel generators were monitored at the Loviisa power plant; Olkiluoto monitored the containment spray system, the auxiliary feed water system and the back-up diesel generators. At the Loviisa plant units the safety system unavailability values decreased or remained low for all systems monitored. The latent failures in the auxiliary feed water system nevertheless emerged as events assigned in the middle category of risk-significance.

Containment spray system unavailability at the Olkiluoto plant decreased from the previous year's level at Olkiluoto 2, but increased by one order of magnitude at Olkiluoto 1. The unavailability index for the auxiliary feed water system rose from the extremely low figures in 2004 to a normal low level at both plant units in Olkiluoto. Back-up diesel unavailability fell by almost 50% compared with 2004. In 2005 diesel availability corresponded to the long-term average. Factors contributing to the increase in safety system unavailability at the Olkiluoto plant units in 2005 are not yet known. Latent failures contributing to safety system unavailability were dominant in events assigned in the middle category of risk-significance.

There were four plant conditions in non-compliance with the Technical Specifications in 2005, all of which occurred at the Olkiluoto plant. Thus the number of non-compliances with the Tech Specs at the plant is on the increase; on the other hand, two of the non-compliances were long-term events, which were only now detected due to conscious action. Two non-compliances with the Tech Specs occurred during annual maintenance. At Olkiluoto 1 it was noted that since the 1998 maintenance outage, it had been necessary to lift the reactor pressure vessel head above the maximum lifting height allowed in the Tech Specs. A non-compliance with the Tech Specs also occurred in connection with the modification work (REMES work) during the annual maintenance outage of Olkiluoto 2 as there was a power failure in the diesel-backed busbar and the back-up diesel failed to start due to simultaneous testing. The longer-term situation concerned the failure to carry out the weekly schedules tests of the diesel room carbon dioxide fire suppression system, also since 1998. The fourth non-compliance with the Tech Specs occurred at both plant units when the intake air opening above the entrance to the diesel generator room was blocked in connection with the replacement of the entrance doors.

The Olkiluoto power plant found it necessary to deviate in a planned manner from the Tech Specs nine times. The number of the deviations is the same as the previous year. Four of the exemptions concerned deviations caused by plant modifications or renovations and two installations related to the construction of the new plant. The most risk-significant events at both plant units at Olkiluoto concerned the repair of the suction channels of the service water system carried out under exemption to the Tech Specs.

At the Loviisa plant there were no events in 2005 causing the plant units to be in non-compliance with the Tech Specs. The need for the Loviisa power plant to deviate from the Tech Specs in a controlled manner showed a further decline compared with 2004. The seven exemptions granted to the Loviisa plant were, for the most part, concerned with the need to deviate from the Tech Specs caused by modifications and renovations. At

Loviisa, the most risk-significant event concerned the transfer of the air condenser, which was part of the air cooling system covering the I&C building test facilities and main control room at Loviisa 1; the transfer was carried out under an exemption granted by STUK. 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 2005 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 Olkiluoto 2 had been relatively successfully updated with regard to all documents that had to be updated by the start-up. Deficiencies were observed concerning updating of diagrams. There was no significant modification work at Olkiluoto 1 in 2005. At the Loviisa plant there were no significant modifications requiring monitoring.

The plant units' safety performance indicator for investments in improvements and modifications indicates relative fluctuations in investments. The amounts given in Euro are the utilities' confidential information, and 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 electricity 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 2005 indicate the decreasing trend at the Loviisa plant and the increasing trend at the Olkiluoto plant. The main investments at the Loviisa plant during the past couple of years have included provisions for severe reactor accidents and the modernisation of the turbine. The most significant current plant modification project at Loviisa concerns the upgrading of the plant units' I&C systems. One of the main investments made at the Olkiluoto plant in the past few years was the turbine plant upgading project, which also included replacement 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 which remain clearly below the set limits. The indicators followed in the area of radiation protection are collective radiation exposure of employees the average of the ten highest yearly radiation exposures and compliance with the YVL Guide's calculatory threshold. Other indicators followed include radioactive releases into the sea and the atmosphere from the plant, and the calculated dose due to releases to the most exposed individual in the vicinity of the plant.

Releases into the air and water at the Loviisa and Olkiluoto plants remained low in 2005, as did the calculated radiation dose for the most exposed individuals in the population surrounding the plants. Releases of iodine and aerosols into the atmosphere indicated a small increase at the Olkiluoto plant. Releases into the sea at Loviisa fell somewhat compared with the previous year since the plant released low-activity evaporation residues into the sea as controlled liquid discharges. Releases into the sea from the Olkiluoto plant have reduced since the plant commissioned new process water purification and treatment equipment.

The individual occupational doses were below the limits set for nuclear power plant workers at the Olkiluoto and Loviisa plants. The collective radiation dose at the Olkiluoto plant was higher than in the previous years due to the long repair and maintenance outage at Olkiluoto 2. At Loviisa the collective radiation dose from the plant was lower than in the previous year. However, the collective dose remained above the calculatory reporting threshold confined to net electric power specified in the Guide YVL 7.9, which was further affected by the dose accumulated during the long annual maintenance outage of Loviisa 1 in 2004.

Operational events

The indicators of this area monitor the volume and risk-significance of operational events reported in accordance with Guide YVL 1.5. Reports are classified according to the nature of events or significance for nuclear safety, as well as immediate reasons. The risk indicators in the area monitor the risk-significance of component unavailability and to gain insight into the operation of the plant and the success of the operational experience feedback. A review of the area indicators jointly with the previous area's indicators, such as non-compliances with the Tech Specs, safety system unavailability, failures of Tech Spec components and production losses from failures, provides more information on the significance of related planned and unplanned component unavailabilities.

The numbers of operational events at the Loviisa and Olkiluoto power plants in 2005 were at the average level of the past few years. Nine events occurred at the Loviisa power plant for which the plant submitted an operational event report. Operational transients were typically due to disturbances in the operation of the reactor coolant pumps. One event warranting a special report occurred at the Loviisa plant, which was related to the emergency standby due to high seawater levels. Deficiencies in the operation of the Olkiluoto plant appear as the main causes for events warranting a special report. There were six events warranting a special report at Olkiluoto. The plant also submitted six operational transient reports. The immediate causes of the 12 events at Olkiluoto focus on errors in plant operation. Only one event was caused by technical failure.

The effect of the unavailability of safety systems, or their subsystems, caused by component failures, preventive maintenance and exemptions from Tec Specs on annual accident risk exceeded the 5% target value set by STUK at both Olkiluoto plant units. This was partly due to planned, one-off maintenance operations executed under an exemption granted by STUK, and partly to latent component failures in the safety systems and back-up diesel generator system. No special action by STUK was required.

New safety performance indicators were introduced in 2003 to represent the risk-importance of 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 2005 are considered part of normal nuclear power plant operation and no further measures were required from STUK.

The numbers of risk-significant events showed a decrease from the previous year at both Loviisa and Olkiluoto. The most significant events at both plants were related to modifications or renovations carried out under exemption from the Tech Specs. The most significant event at Loviisa was the transfer of the air condenser, which was part of the air cooling system covering the control room building test facilities and the main control room, from its place near the turbine hall wall to the roof of the turbine hall. The transfer was necessitated by the construction of the I&C buildings. Other events at Loviisa were related to latent failures in the secondary service water system at Loviisa 1 and the auxiliary feed water system at Loviisa 2. Four events of the highest risk category occurred at the Loviisa power plant; at Loviisa 1, the events were planned component unavailabilities and at Loviisa 2 unavailabilities due to failures.

At Olkiluoto the most significant events for both units were related to the repairs to the suction channels of the service water system under an exemption order from STUK. Other events at the Olkiluoto plant were related to latent failures in the containment spray system, auxiliary feed water system and back-up diesel generators. There were six events of the highest risk category at Olkiluoto, four of which were caused by failures and two were planned unavailabilities.

The number of events falling into the middle category of risk-significance was higher than the previous year at Loviisa: thirteen events which were unavailabilities due to component failure. At Olkiluoto the number was at the level of the previous year: twenty-three events. The Olkiluoto events were mostly due to planned unavailabilities, including component isolations executed under exemption from the Tech Specs and preventive maintenance. The events were relatively evenly divided between the plant units.

The number of analysed events falling into the least risk-significant category increased in 2004 as there was a shift in the reporting towards a policy in accordance with Guide YVL 1.5 (the unavailabilities of all Tech Spec components are presented in monthly or quarterly reports). The number of events falling into this category decreased from the previous year at both Loviisa plant units; in 2005, there were a total of 166 events. The number of events falling into this category is on the increase at Olkiluoto; in 2005 there were 189 events in total. At Loviisa the events were mostly caused by failures, and at Olkiluoto either planned unavailabilities or caused by failures. The kind of events analysed now were partly eliminated from the analysis before 2004.

No fires occurred at either plant in 2005. The automatic fire detectors were replaced at Loviisa in 2000 and at Olkiluoto in 2001. The numbers of alarms increased at both units thereafter because of more sensitive equipment and equipment failures. The marked reduction in the number of 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. After the modification the number of alarms caused by component failure decreased significantly at both plants: There were no alarms caused by component failure at Olkiluoto in 2005, and only six alarms at Loviisa. The number of actual detector alarms also decreased at Loviisa in 2005 to only 18 alarms. At the Olkiluoto plant the number of actual detector alarms has been steadily increasing for several years. In 2005 the number was 74, which is twice as high as the level prior to the system upgrade. Alarms triggered by dust, smoke or humidity dominated the automatic fire detector alarms at both plants in 2005. A significant number of alarms triggered by sprinkler leakage occurred at Olkiluoto, which in part explains the growing trend of true detector alarms compared with the previous year.

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 not allowed, as assessed according to STUK's safety performance indicators.

Based on the 2005 indicators, the limits set 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 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. The Olkiluoto 2 reactor contained leaking fuel throughout 2005. The leaking fuel bundle, which was discovered in late August 2004, was removed from the reactor during the 2005 annual maintenance outage. Inspection revealed a thin sliver of metal in the bundle, which had caused the original fuel damage. Four months later secondary damage was detected in the lower half of the leaking fuel rod. Towards the end of the operating cycle the damage expanded into a transverse fracture of the rod. A new fuel leak was detected in late July 2005 following the annual maintenance. Following the discovery of the foreign object and fuel leak, STUK required that the utility assess the clean installation instructions and procedures related to an open reactor and primary circuit.

Primary and secondary circuit integrity is monitored by international chemistry indices used by the utilities or by indices developed 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 and Olkiluoto plant units in 2005. 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 at the Loviisa and Olkiluoto plant units, or the iron content of the feed water of the Loviisa secondary circuit or Olkiluoto primary circuit during the monitoring period.

The chemistry index value of Olkiluoto 2 in the third and fourth quarters, which is higher than the target value, is due to a sulphate concentration higher than the target value. Since the power increase, both Olkiluoto plant units have had the problem of a sulphate content exceeding 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, except for brief minor exceedances. The index values being higher than the target value in the third quarter of 2004 is suspected to be due to a change in the quality of the ion-exchange resin. Exceedances of the sulphate concentration target value in 2005 were due to the running times of many condensate cleaning filters being long. Following the replacement of the ion-exchange resin of the filters, sulphate concentrations fell below the target value and the duration of the deviation did not exceed the limit of four days allowed in Teollisuuden Voima Oy's instructions.

At the Olkiluoto plant, leakages from the primary circuit are monitored by operating cycle as well. During the operating cycle 2004-2005, the volume of identified leaks in the primary circuit was low at both Olkiluoto plant units. The volume of unidentified leaks was minimal at Olkiluoto 1 but considerably higher than before at Olkiluoto 2, which was mainly due to a loose flange joint in one vacuum breaker in the blow-out system (314).

Containment integrity has remained good at 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 outer isolation valves at both Loviisa and Olkiluoto decreased from the previous year.

In leakage testing, the largest single leak at the Olkiluoto plant units was through the inner main steam valve.

In both cases the leak was caused by a broken internal check valve.

The percentage of isolation valves that passed the leaktightness test at first attempt has remained high, and both Loviisa and Olkiluoto show an improvement 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 airlock, the reactor pit, inward relief valves, cable penetrations, live steam system and feed water system has decreased at Loviisa 2 and is now small at both plant units. 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 2005 indicators

The data gathered from 2005 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.

The requirements set for indicators of the effectiveness of STUK's activities were fulfilled as regards individual occupational dose, radioactive releases and population exposure. The collective radiation dose for Loviisa 1 continued to exceed the calculatory reporting threshold confined to net electric power specified in Guide YVL 7.9 due to the collective dose accumulated during the long repair and maintenance outage in 2004.

The releases of radioactive substances at the nuclear power plants were clearly below the set limits. Releases into the atmosphere and into the sea were small at both Loviisa and Olkiluoto. Releases of iodine and aerosols at Olkiluoto showed a very slight increase due to fuel leaks and the long repair and maintenance outage at Olkiluoto 2. Releases into the sea at Loviisa fell somewhat from the previous year's levels, since the plant had released low-activity evaporation residues into the sea as controlled liquid discharges in late 2004. Releases into the sea from the Olkiluoto plant have remained small since 2000, as the plant commissioned new process water purification and treatment equipment. The calculatory radiation dose for the most exposed individual in the vicinity of Loviisa and Olkiluoto was of the same magnitude as in the previous years and considerably below the limit set in the Government Resolution.

The plants were mainly used according to the Technical Specifications. Four situations in non-compliance with the Tech Specs occurred at the Olkiluoto plant; thus, the improved trend of the previous year was not permanent. Two of the non-compliances were long-term events which were only detected at this time due to conscious action. All of the deviations were related to the design of modifications or repairs and two to testing. No accidents occurred at the Loviisa plant that would have caused non-compliance with the Tech Specs.

The Olkiluoto plant found it necessary to deviate in a controlled manner from the Tech Specs nine times. This number is the same as the year before. Four exemptions were concerned with plant modifications or renovations and two with installations related to the construction of the new plant unit. The need for the Loviisa power plant to deviate from the Tech Specs in a controlled manner showed a further decline compared with 2004. The seven exemptions granted were for the most part concerned with the need to deviate from the Tech Specs caused by modifications and renovations. The exemptions granted did not warrant re-evaluation of the Tech Specs.

The most risk-significant events were, at both plants, related modifications or renovations carried out under exemption from the Tech Specs. Other significant events concerned latent failures in the secondary service water system (Loviisa 1) and auxiliary feed water system (Loviisa 2) and, at Olkiluoto, with latent failures in the containment spray system, auxiliary feed water system and back-up diesel generator system. The events analysed for 2005 are considered part of normal nuclear power plant operation and no further measures were required from STUK.

The effect of unavailabilities caused by significant events on annual accident risk exceeded its 5% target value at both plant units at Olkiluoto in 2005. No special action by STUK was required.

No events endangering nuclear safety occurred at the nuclear facilities. An alert situation lasting over six years occurred at Loviisa in early January due to high seawater levels, of which the plant submitted a special report. The numbers of operational events at the Loviisa and Olkiluoto power plants in 2005 were at the average level of the past few years. The Olkiluoto power plant submitted twelve event reports in 2004, while the Loviisa plant submitted ten, including events warranting a special report. Technical failures were the determining causes of events at Loviisa in 2004. Deficiencies in the operation of the Olkiluoto plant appear as immediate causes of the events, focusing on errors in plant operation. Only one event was caused by technical failure. Due to the nature of the events warranting a special report, a total of six of which occurred at Olkiluoto in 2005, STUK has focused attention on the efficiency of operational experience feedback at the plant and the matter has been discussed by the utility and STUK.

Maintenance activities were reliable in 2005 at both Loviisa and Olkiluoto, and there were no signs indicating a decline in the quality of maintenance. Maintenance at Olkiluoto was more proactive than the year before. The total yearly volume of maintenance work of Tech Spec components at the Loviisa plant, including both failure repairs and preventive maintenance, increased further, due to a gradually increasing trend in the volume of failure repairs. The volume of preventive maintenance works was smaller than the year before. At Loviisa 2 the ratio of preventive maintenance to failure repairs was remarkably low. The volume of preventive maintenance is affected by preventive maintenance works determined on the basis of annual maintenance outages; no changes are indicated in these operations on the basis of component failure. The volume of preventive maintenance has decreased in the long-term, as planned. Evaluation and development of preventive maintenance will also continue in the future. There will be changes due to adopted condition monitoring measurement methods. The volume of failure repairs during power operation at Loviisa 2 has increased slightly in the last few years. The marked increase in the number of failures since 2002 cannot be attributed to one straightforward reason. One factor may be the revised work recording procedure. However, the number of failures has shown similar variation in the long term. In 2005 the number of failures causing an operation restriction only when isolating the component for repair work showed an increase. Production losses due to failures remained small. They were caused by failures of single independent equipment and systems. The average repair times of Tech Spec components at Loviisa showed a decrease for the second consecutive year, which may indicate an enhanced maintenance function. Since there is no data available on the failure types, it is not easy to draw any conclusions.

The total yearly volume of maintenance work of Tech Spec components at the Olkiluoto plant showed an increase, which is partly caused by the increase in preventive maintenance operations. The distribution of preventive maintenance between plant units is determined by the length of the annual maintenance outages. The volume of preventive maintenance at Olkiluoto 2 was considerable in 2005, since turbine plant modifications were carried out at the plant during the long annual maintenance outage. The volume of failure repairs decreased slightly from the previous year. The volume of failures causing an operation restriction during power operation showed a significant decrease compared with the past two years. The decrease may be partially attributed to the long maintenance outage at Olkiluoto 2 and the repairs and preventive maintenance carried out during the outage. The number of failures causing an immediate operation restriction at Olkiluoto 2 exceeded the number of failures causing an operation restriction only when isolating the component for repair work. Production losses due to failures were only some hundredths of a per cent. The average repair time of failures in Tech Spec components at Olkiluoto showed an increase for the second consecutive year. An assessment of the situation would require detailed information on the type of failures for any conclusions to be drawn concerning the efficiency of the maintenance function.

The unavailability of safety systems was followed by means of international indices provided by the licensees. The high pressure safety injection system, the auxiliary feed water system and the back-up diesel generators were monitored at the Loviisa power plant; Olkiluoto monitored the containment spray system, the auxiliary feed water system and the back-up diesel generators. At the Loviisa plant units the safety system unavailability values decreased or remained low for all systems monitored. At the Olkiluoto plant, unavailability of the containment spray system increased at Olkiluoto 1 and the unavailability index of the auxiliary feed water system showed a small increase at both plant units. Factors contributing to the increase in safety system unavailabilities at the Olkiluoto plant units in 2005 are not yet known. However, latent failures contributing to safety system unavailabilities were dominant in events assigned to the middle category of risk-significance.

The structural integrity of multiple barriers containing the release of radioactive substances has mostly remained good. Fuel leaks have been rare at the Loviisa plant units in the past few years, and no leaks occurred in 2005. Fuel leaks have occurred every year at the Olkiluoto plant units; a fuel leak at Olkiluoto 2 which began in late August 2004 continued until the annual maintenance outage 2005. Inspections revealed a thin sliver of metal as the cause of the leak. Another fuel leak at Olkiluoto 2 was detected at the end of August 2005. Following the discovery of the foreign object and fuel leak, STUK required that the utility assess the clean installation instructions and procedures related to an open reactor and primary circuit.

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 level of corrosion products in the circuits. No significant changes occurred in the indicator values in 2005. The chemistry indices indicated that process chemistry control had been successful at the Loviisa and Olkiluoto plant units in 2005. However, in the third and fourth quarter the sulphate concentration of reactor water at Olkiluoto 2 exceeded the target values, which is also indicated in the chemistry index. The higher sulphate concentrations were due to the condensate cleaning filters' running times being long.

Containment integrity has remained good at both Olkiluoto and Loviisa. The overall as-found leakage of outer isolation valves at both plants decreased from the previous year. In leakage testing, the largest single leak at the Olkiluoto plant units was through the inner main steam valve. In both cases the leak was caused by a broken internal check valve. The percentage of isolation valves that passed the leaktightness test at the first attempt has remained high, and both Loviisa and Olkiluoto show an increase from the previous year. The overall as-found leakage of containment penetrations decreased at Loviisa 2, thus being small for both plant units at Loviisa. Due to problems in the leaktightness of the rubber bellows of penetrations, they have been replaced with metal structures. The overall as-found leakage of containment penetrations has remained small at the Olkiluoto plant units.

The investments of 2005 indicate an increasing trend at Olkiluoto, which is affected by modernisation projects for the units currently in operation and preparation for a new plant project. Investments at Loviisa were somewhat smaller than the year before. The main investments at the Loviisa plant last year included the upgrading of the plant units' I&C systems. As concerns updating of document revisions necessary after plant modifications (entered into the register) in 2005, the situation was good for the Olkiluoto units at the time of plant start-up. There were no modifications that required monitoring at Olkiluoto 1 and the Loviisa power plant.

Judging by the indicators, there are deficiencies in the operational experience feedback at Olkiluoto, owing to which STUK has focused attention on the efficiency of the operational experience feedback at the plant and discussed deviations with the utility. The events were due to more general operational deficiencies, which nevertheless did not cause any problems regarding reactor operation. Judging by the indicators describing failures in Tech Spec components and maintenance, the maintenance function at Olkiluoto was reliable and no signs were found indicating a decline in the quality of maintenance. Maintenance at the plant was also more proactive than the year before. Indicators describing the unavailability of the safety systems nevertheless showed a deterioration: unavailability of the containment spray system increased at one of the plant units and the unavailability index of the auxiliary feed water system showed a small increase at both plant units at Olkiluoto. Factors contributing to the increase in safety system unavailabilities at the Olkiluoto plant units in 2005 are not yet known to STUK. Latent failures contributing to safety system unavailabilities were dominant in events assigned to the middle category of risk-significance. They may indicate deficiencies in the maintenance strategy or in the assessment of the risk-significance of the failures. While problems with fuel integrity occur annually at the Olkiluoto plant, radiation protection, as measured by indicators, has nevertheless achieved the set objectives and emissions have remained small.

Judging by the indicators, no serious deficiencies were observed in the operation of the Loviisa plant. Operational events were mainly caused by technical failures. Judging by the indicators describing failures in Tech Spec components and maintenance, the maintenance function at Loviisa was reliable and no signs were found indicating a decline in the quality of maintenance. The total yearly volume of maintenance work on Tech Spec components at the Loviisa plant, including both failure repairs and preventive maintenance, increased further, due to a gradually increasing trend in the volume of failure repairs. The volume of preventive maintenance was smaller than the previous year, and the ratio of preventive maintenance to failure repair was significantly low. The volume of preventive maintenance at a plant is affected by preventive maintenance operations determined on the basis of the duration of the annual maintenance outage. The volume of preventive maintenance has decreased in the long-term as planned. Evaluation and development of preventive maintenance will continue also in the future. The average repair times of Tech Spec components at Loviisa showed a decrease for the second consecutive year, which may indicate an enhanced maintenance function. However, it is not possible to draw any long-term conclusions before the types of dominant failures are known.

At Loviisa 1, the collective dose remained above the calculatory reporting threshold confined to net electric power specified in Guide YVL 7.9, which was further affected by the dose accumulated during the unit's long annual maintenance outage 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 2005 data, their interpretation and assessment of change.

The NRR has assigned persons and units responsible for the acquisition of indicator data as well as for their calculation and analysis. In 2005, 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 the indicator concerning production losses due to failures. The data on primary circuit leakages for the Olkiluoto nuclear power plant was provided by the resident inspector. The TUR inspectors 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 from 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 investment indicators. The nuclear power plant safety indicator system was maintained in the management support unit (YJT) and co-ordinated by the event investigation manager.

There were some personnel changes at TUR concerning those responsible for indicators. Definitions of the safety indicator system or individual indicators were not revised from the previous year. In 2005, indicators describing the overall risk-significance of operational events were re-incorporated in the indicator area which describes the risk-significance of operational events. These indicators were not reported in connection with the 2004 results.

The indicators system, including graphics in both Finnish and in English, is maintained in an Excel file. The system administrator enters the data provided by those responsible for the indicators and updates the indicator figures every 3 months. Excel is not the most suitable tool for managing, analysing and presenting the indicators. Excel files are also vulnerable to user mistakes and system failures. Furthermore, they have not allowed simultaneous access to several users (entering information, updating graphs, reporting). There was a need for tools that would allow speedier data input and graph updating, the use of standardized graphs and generating presentations and reports.

In the latter half of 2005, STUK ordered the INDI (INdicator DIsplay) application for indicator management, analysis and reporting. The agreement also covers the transfer of the existing data for the indicators in NRR's current system into the INDI database. The program will be introduced in connection with the updating of the first-quarter indicators in 2006. Those responsible for the indicators and system administration attended INDI user training at STUK in November 2005.

The purpose of the program is to simplify and verify the maintenance of indicator data at the NRR and speed up the quarterly updating and reporting of nuclear plant safety indicators. Indicators developed for the needs of other units in the future can also be entered in the program.

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.

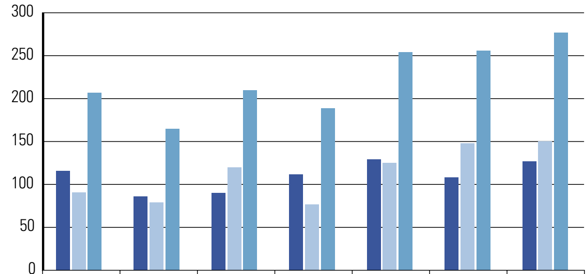
Source of data
The data is obtained from the work order systems and operational documents of the power plants.

Purpose of indicator
The indicator is used to assess 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)

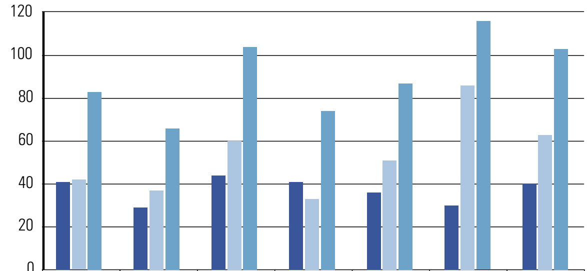
Interpretation of indicator
The number of failures causing an operation restriction at the Loviisa plant has increased slightly during the past three years. On the whole the total number has remained at the same level as in previous years, however. A significant change in the number of failures is not identifiable.

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



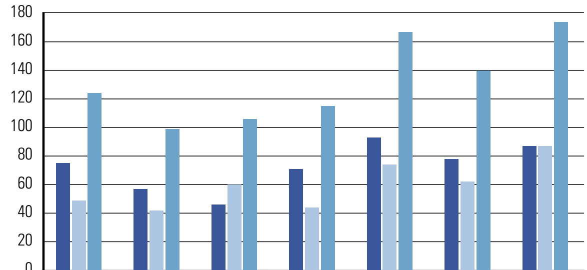
	1999	2000	2001	2002	2003	2004	2005
LO1	116	86	90	112	129	108	127
LO2	91	79	120	77	125	148	150
LO1,2	207	165	210	189	254	256	277

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



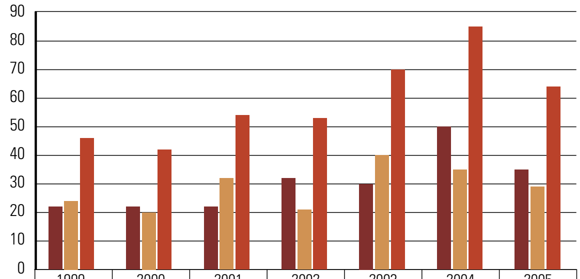
	1999	2000	2001	2002	2003	2004	2005
LO1	41	29	44	41	36	30	40
LO2	42	37	60	33	51	86	63
LO1,2	83	66	104	74	87	116	103

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



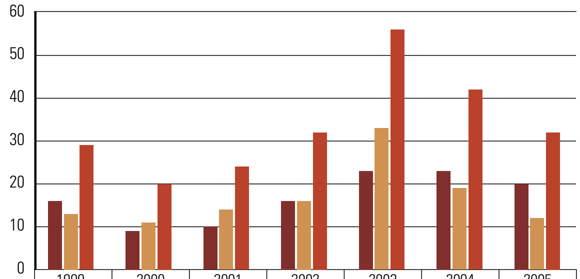
	1999	2000	2001	2002	2003	2004	2005
LO1	75	57	46	71	93	78	87
LO2	49	42	60	44	74	62	87
LO1,2	124	99	106	115	167	140	174

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



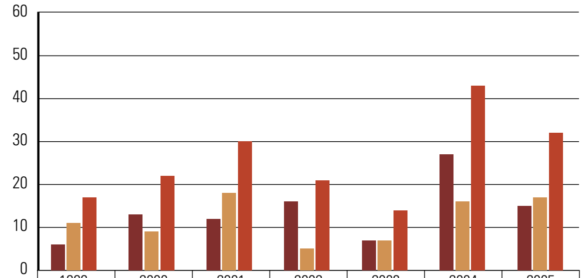
	1999	2000	2001	2002	2003	2004	2005
OL1	22	22	22	32	30	50	35
OL2	24	20	32	21	40	35	29
OL1,2	46	42	54	53	70	85	64

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



	1999	2000	2001	2002	2003	2004	2005
OL1	16	9	10	16	23	23	20
OL2	13	11	14	16	33	19	12
OL1,2	29	20	24	32	56	42	32

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



	1999	2000	2001	2002	2003	2004	2005
OL1	6	13	12	16	7	27	15
OL2	11	9	18	5	7	16	17
OL1,2	17	22	30	21	14	43	32

The marked increase in the number of failures since 2002 cannot be attributed to one straightforward reason. One factor may be the revised work recording procedure. However, the number of failures has shown similar variation in the long term. While the number of failures causing an immediate operation restriction is somewhat lower than in 2004, it is essentially at the same level. The number of failures that cause an operation restriction from the start of repair work remains within normal variation.

The numbers of failures of Tech Spec components during power operation that caused an immediate operation restriction and the failures that caused a restriction while isolating the component at Olkiluoto were the same (32) in 2005. The number of failures decreased slightly from 2004, and thus the increasing trend of the previous years levelled off.

The number of failures causing an immediate operation restriction at Olkiluoto 1 was 15 and at Olkiluoto 2, 17. At Olkiluoto 2, the greatest number of failures occurred in the control valve (314V21): there were 4 failures altogether, caused by a single reason.

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 works 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

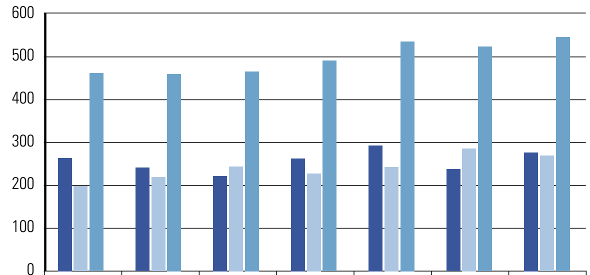
Safety Management (TUR),
resident inspectors
Pauli Kopiloff (Loviisa nuclear power plant)
Jarmo Konsi (Olkiluoto nuclear power plant)

Interpretation of indicator

The number of failures causing an operation restriction at the Loviisa plant has increased slightly during the past three years. On the whole the total number has remained at the same level as in previous years, however. A significant change in the number of failures is not identifiable.

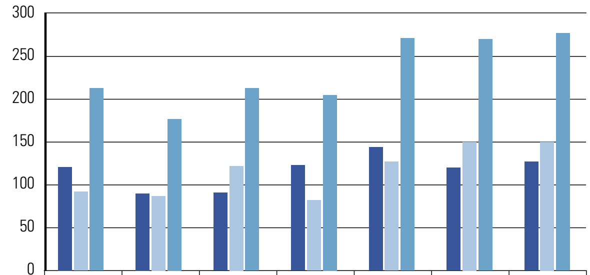
The marked increase in the number of failures since 2002 cannot be attributed to one straightfor-

Volume of annual maintenance works of Tech Spec components, Loviisa NPP



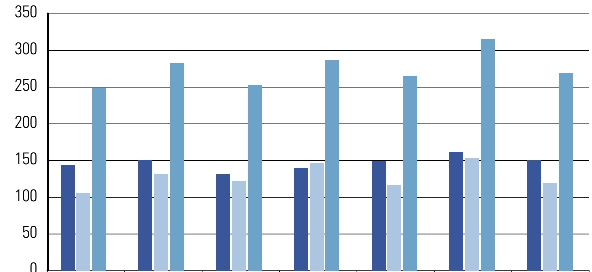
	1999	2000	2001	2002	2003	2004	2005
LO1	264	241	222	263	293	238	277
LO2	198	219	244	228	243	286	269
LO1,2	462	460	466	491	536	524	546

Number of annual failure repair works of Tech Spec components, Loviisa NPP



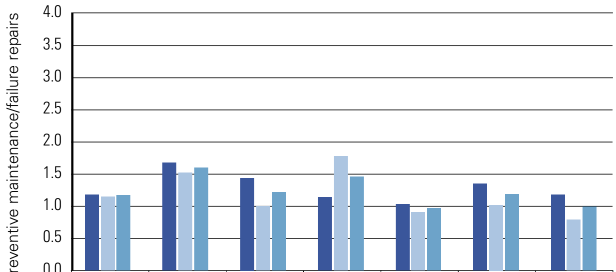
	1999	2000	2001	2002	2003	2004	2005
LO1	121	90	91	123	144	120	127
LO2	92	87	122	82	127	150	150
LO1,2	213	177	213	205	271	270	277

Number of annual preventive maintenance works of Tech Spec components, Loviisa NPP



	1999	2000	2001	2002	2003	2004	2005
LO1	143	151	131	140	149	162	150
LO2	106	132	122	146	116	153	119
LO1,2	249	283	253	286	265	315	269

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



	1999	2000	2001	2002	2003	2004	2005
LO1	1.18	1.68	1.44	1.14	1.03	1.35	1.18
LO2	1.15	1.52	1.00	1.78	0.91	1.02	0.79
LO1.2	1.17	1.60	1.22	1.46	0.97	1.19	0.99

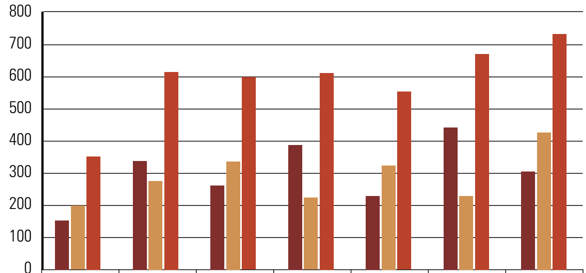
ward reason. One factor may be the revised work recording procedure. However, the number of failures has shown similar variation in the long term. See A.I.1a.

The number of preventive maintenance works during plant operation at the Loviisa plant has stabilised at just over 250 per year. The unit-specific changes are also very small annually. The variation is probably attributable to differences in annual maintenance outages.

The ratio of preventive maintenance works to failures, which has varied between approximately 1 and 1.5, also clearly indicates that the situation has stabilised.

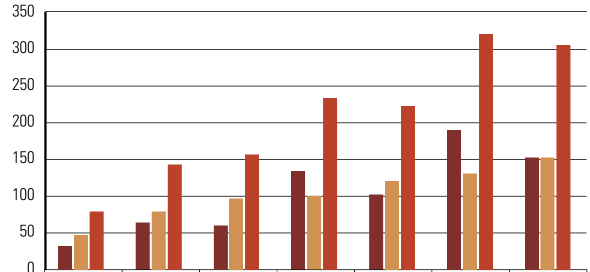
The preventive maintenance volume of Tech Spec components showed an increase from 2004 at the Olkiluoto plant compared with the volume of failure repairs. At Olkiluoto 1 the ratio of the number of preventive maintenance works to the number of failure repairs was 1.0 in 2005, whereas at Olkiluoto 2 the ratio was well above 1.5. The number of preventive maintenance works at Olkiluoto 2 in 2005 was considerable (274), because of a long outage due to TIMO modifications (21 days). As for Olkiluoto 1, there was a brief (7 days) annual maintenance outage, which showed in the decrease in the number of preventive maintenance works compared with the previous year. A corresponding TIMO outage is scheduled for Olkiluoto 1 for 2006.

Volume of annual maintenance works of Tech Spec components, Olkiluoto NPP



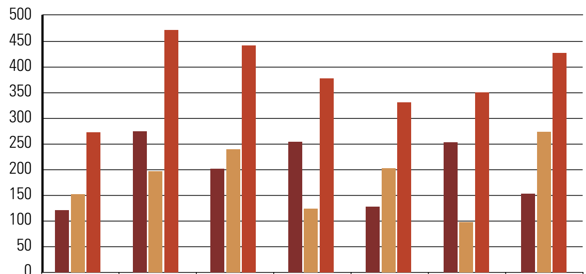
	1999	2000	2001	2002	2003	2004	2005
OL1	153	339	262	388	230	443	306
OL2	199	276	337	224	324	229	427
OL1,2	352	615	599	612	554	672	733

Number of annual failure repair works of Tech Spec components, Olkiluoto NPP



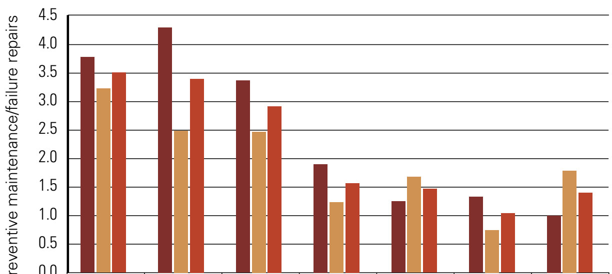
	1999	2000	2001	2002	2003	2004	2005
OL1	32	64	60	134	102	190	153
OL2	47	79	97	100	121	131	153
OL1,2	79	143	157	234	223	321	306

Number of annual preventive maintenance works of Tech Spec components, Olkiluoto NPP



	1999	2000	2001	2002	2003	2004	2005
OL1	121	275	202	254	128	253	153
OL2	152	197	240	124	203	98	274
OL1,2	273	472	442	378	331	351	427

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



	1999	2000	2001	2002	2003	2004	2005
OL1	3.78	4.30	3.37	1.90	1.25	1.33	1.00
OL2	3.23	2.49	2.47	1.24	1.68	0.75	1.79
OL1,2	3.51	3.40	2.92	1.57	1.47	1.04	1.40

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)

In certain cases individual instances of long-term operation restriction work may distort the image of average repair times. The following two examples occurred in 2005:

The following repairs were carried out in the first quarter (I/05): maintenance of water pressure control valve VF24S037, work order no. 381961A, repair time 499.7 h; and, during the same isolation, maintenance of valve VF24S040, work order no. 381961B, repair time 499.7 h. If these repair times are excluded on the basis that the repairs are not significant (allowed repair time 21 days), the average repair time of the remaining works is 20.2 h (928/46).

Work related to hydrogen measurements carried out during the second quarter (II/05): investigation and inspection of the failure in measurement XW38A01, work order no. 383387A, repair time 437.1 h and inspection of measurement XW38A02, work order no. 387707A, repair time 482.4 h. Work was also carried out on the seawater pump of the containment external spray water system: inspection of pump and piping VU02D01, work order no. 388808A, repair time 359.2 h. If these repair times are excluded on the basis that the repairs are not significant (allowed repair time 21 days), the average repair time of the remaining works is 21.1 h (737/35).

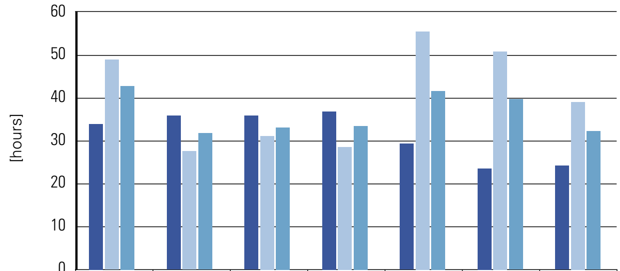
Interpretation of indicator

In 2005 the average repair time at the Loviisa plant decreased somewhat from 2004. Over the years the average repair time has settled at between 30 and 43 hours, and a more detailed analysis of the repair times in 2005 is not necessary.

The average repair time is currently some 32 hours per failure, compared with some 40 hours in 2004. The change in level (see A.I.1.a and b) after 2002 is also reflected in repair times.

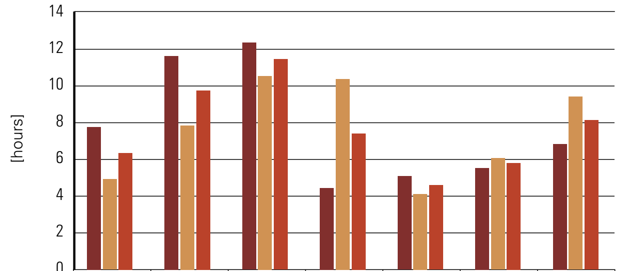
From 1999 to 2005 the average repair times for Tech Spec components at the Olkiluoto plant units have varied between four and twelve hours; the past three years have shown a rising trend. In 2005 the average repair times exceeded the level for 2004.

Average of real repair times of Tech Spec component failures, Loviisa NPP



	1999	2000	2001	2002	2003	2004	2005
LO1	34.00	35.90	35.90	36.90	29.40	23.60	24.26
LO2	49.00	27.60	31.20	28.60	55.60	50.90	39.13
LO1,2	42.85	31.85	33.18	33.51	41.67	39.74	32.31

Average of real repair times of Tech Spec component failures, Olkiluoto NPP



	1999	2000	2001	2002	2003	2004	2005
OL1	7.77	11.64	12.35	4.44	5.08	5.54	6.84
OL2	4.92	7.85	10.55	10.38	4.12	6.07	9.42
OL1,2	6.35	9.75	11.45	7.41	4.60	5.81	8.13

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 works causing an operation restriction.

Purpose of indicator
To follow the quality of maintenance.

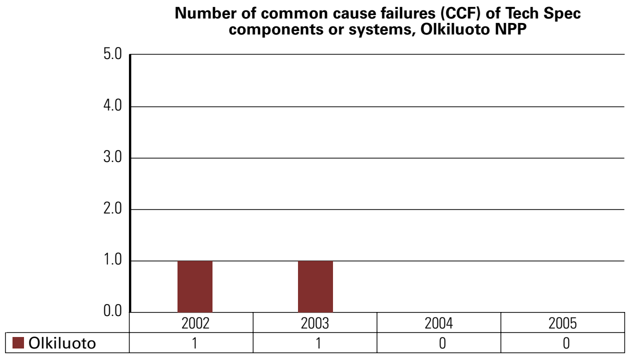
Responsible unit/person
Safety Management (TUR)
Jukka Kupila

Interpretation of indicator
At the Loviisa plant no realised common cause failures were detected in systems defined in Tech Spec in 2005.

At the Olkiluoto plant no realised common cause failures were detected in systems defined in Tech Spec in 2005.

In connection with calculating the indicator, two back-up diesel generators were discovered to be inoperable simultaneously at the Olkiluoto power plant. This, however, was not a common cause failure: one of the back-up diesels was isolated for periodic maintenance. 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 11 January 2005 between 5:11 and 18:50.

In the previous year, two back-up diesels were also discovered to be simultaneously inoperable. One of the back-up 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 and A.I.1f Potential common cause failures

These indicators are currently under development. The latest results are for 2003 and thus not included in this report.

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)
Tomi Koskiniemi

Interpretation of indicator

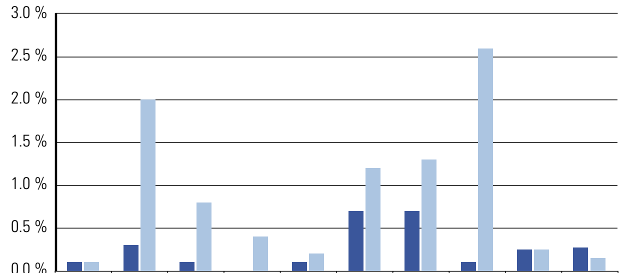
Production losses due to failures at the Loviisa and Olkiluoto plant units have been small. The Loviisa 2 indicator value for 1997, which is an anomaly, was caused by an approx. 7-day-long shutdown to repair a leakage of the primary circuit, and the 2003 anomaly was caused by work to replace the stator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

In 2005 production losses per quarter have shown random variation at both the Loviisa and Olkiluoto plants. The relatively heavier production loss of just under 1% occurred at Loviisa 1, as one of the generators tripped out of service due to an earth fault signal in the stator. Generally the failures have occurred in separate, independent components and systems.

A comparison of production losses due to failures in 2005 with previous years reveals that, at the Loviisa plant, production losses at Loviisa 1 have increased minimally compared with 2003 and 2004 and remain low. At Loviisa 2, losses have decreased clearly to the levels of 1996 and 2000, achieving the values for Loviisa 1.

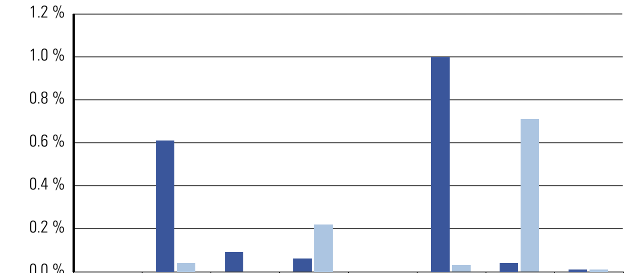
At Olkiluoto, production losses due to failures have decreased considerably from previous years for both plants. The figures correspond to the peak values in 2000. This may be regarded as a successful achievement, especially as the annual maintenance of Olkiluoto 2 in 2005 included extensive modifications.

Loss of power production due to failures, Loviisa NPP



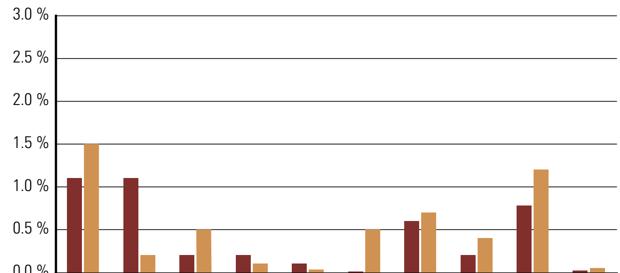
	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
LO1	0.10	0.30	0.10	0.00	0.10	0.70	0.70	0.10	0.25	0.27
LO2	0.10	2.00	0.80	0.40	0.20	1.20	1.30	2.60	0.25	0.15

Loss of power production due to failures in 2004–2005, Loviisa NPP



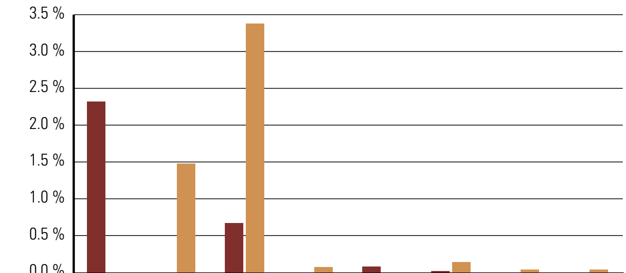
	I/04	II/04	III/04	IV/04	I/05	II/05	III/05	IV/05
LO1	0.00	0.61	0.09	0.06	0.00	1.00	0.04	0.01
LO2	0.00	0.04	0.00	0.22	0.00	0.03	0.71	0.01

Loss of power production due to failures, Olkiluoto NPP



	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
OL1	1.10	1.10	0.20	0.20	0.10	0.01	0.60	0.20	0.78	0.02
OL2	1.50	0.20	0.50	0.10	0.03	0.50	0.70	0.40	1.20	0.05

Loss of power production due to failures in 2004–2005, Olkiluoto NPP



	I/04	II/04	III/04	IV/04	I/05	II/05	III/05	IV/05
OL1	2.32	0.00	0.67	0.00	0.08	0.02	0.00	0.00
OL2	0.00	1.48	3.38	0.07	0.00	0.14	0.04	0.04

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 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)
Tomi Koskiniemi

Interpretation of indicator

The non-compliances with the Tech Specs, a total of 4 in 2005, all occurred at the Olkiluoto plant. Two of the non-compliances are long-time events which were only now discovered due to conscious action.

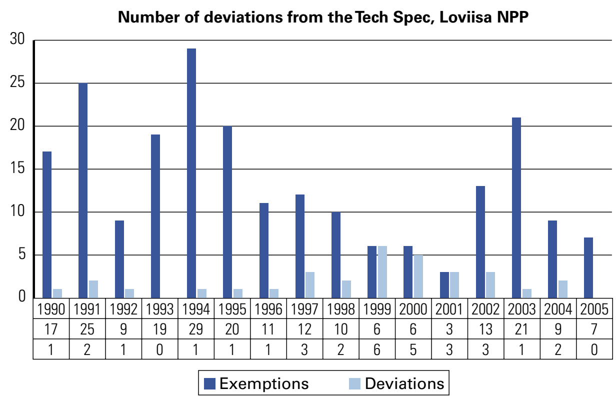
The non-compliances with the Tech Specs in the second quarter concerned the following events which occurred during annual maintenance: exceeding allowed lifting height of the reactor pressure vessel head at Olkiluoto 1, which occurred in the period 1998–2004, and a power failure in the diesel-backed busbar caused by the Olkiluoto 2 switch and the simultaneous failure of the D-sub diesel to start in 2005.

The non-compliances with the Tech Specs identified in the third quarter were due to the air intake opening of one diesel becoming blocked when the entrance door to the diesel building was replaced, as well as the failure to perform periodic weekly testing of the carbon dioxide fire suppression system alarm in the diesel facilities in the period 1998–2005.

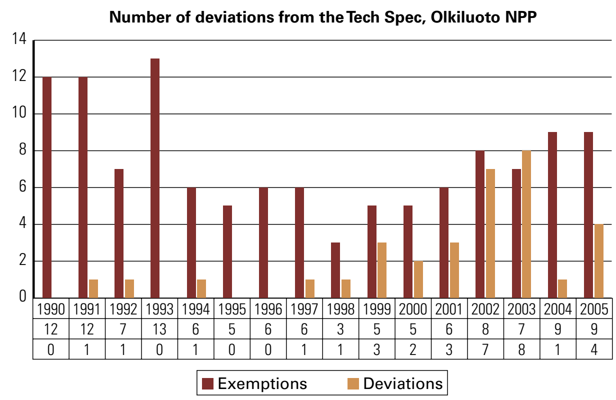
No non-compliances with the Tech Specs occurred at the Loviisa plant in 2005.

The number of granted exemptions from the Tech Specs (a total of 16) remained at the previous year's level at both plants: Olkiluoto has shown an upward trend (9 exemptions), which is largely due to plant modernisation and installations related to the construction of Olkiluoto 3. As the construction of OL3 progresses, it can be expected that at least a similar number of exemptions will be required also in the future.

At Loviisa the number of exemptions has shown a clearly descending trend in the past years, reaching a reasonably good level in 2004 (9 exemptions), as well as in 2005 (7 exemptions). In general, more exemptions are required in Loviisa than in Olkiluoto, as the plant systems have been largely designed as two redundant (cf. four redundancy of Olkiluoto), for which reason repairs or modifications during operation almost always require an exemption.



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Exemptions	17	25	9	19	29	20	11	12	10	6	6	3	13	21	9	7
Deviations	1	2	1	0	1	1	1	3	2	6	5	3	3	1	2	0



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Exemptions	12	12	7	13	6	5	6	6	3	5	5	6	8	7	9	9
Deviations	0	1	1	0	1	0	0	1	1	3	2	3	7	8	1	4

A.I.3 Unavailability of safety systems

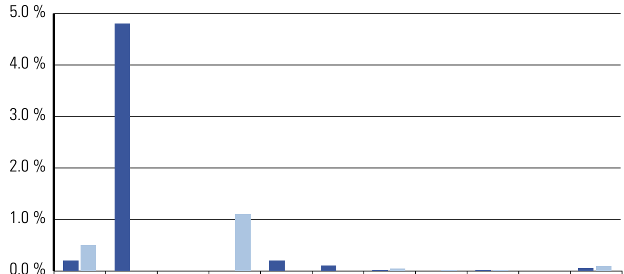
Definition

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 back-up 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 back-up 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 subsystems 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 periodic 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.

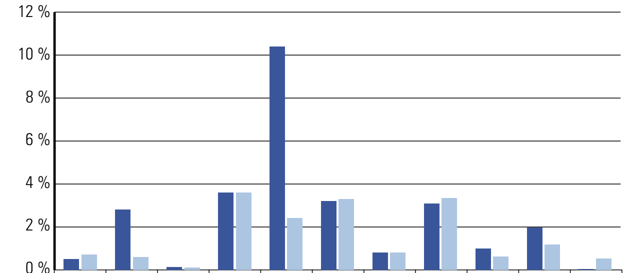
Annual plant criticality hours are the availability requirement for the 322, 327, TJ and RL systems, and the requirement for diesels is continuous – i.e. annual operating hours.

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



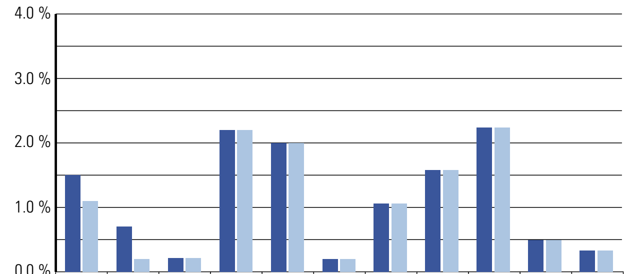
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
LO1	0.20	4.80	0.00	0.00	0.20	0.10	0.01	0.00	0.01	0.00	0.05
LO2	0.50	0.00	0.00	1.10	0.00	0.00	0.04	0.01	0.01	0.00	0.09

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



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
LO1	0.50	2.80	0.12	3.60	10.40	3.20	0.81	3.09	0.98	1.96	0.03
LO2	0.70	0.60	0.10	3.60	2.40	3.30	0.80	3.34	0.61	1.17	0.53

Unavailability of emergency diesel generators (EY), Loviisa NPP



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
LO1	1.50	0.70	0.21	2.20	2.00	0.20	1.06	1.58	2.24	0.49	0.33
LO2	1.10	0.20	0.21	2.20	2.00	0.20	1.06	1.58	2.24	0.49	0.33

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)

Interpretation of indicator

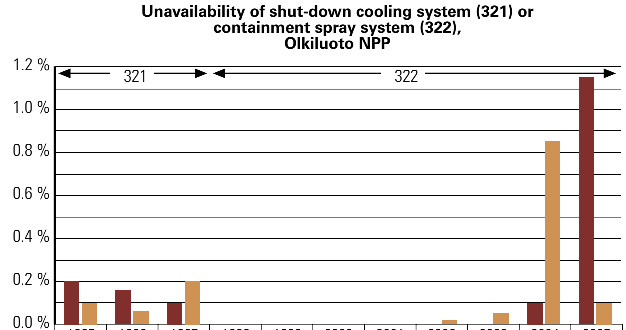
The unavailability of the safety systems chosen for the indicator system has been acceptably low.

At the Loviisa plant units, the unavailability of safety systems has decreased or remained very low for all monitored systems (TJ, RL92-97, EY) in the past few years. The increase in the unavailability of diesel systems in the period 2001–2003 was largely due to spray system diesel EY05 having been erroneously included in the indicator.

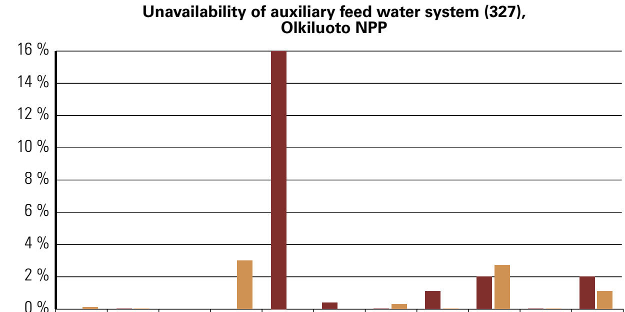
At the Olkiluoto plant the total unavailability of the containment spray system has increased slightly; on the other hand, the distribution of unavailabilities between plant units has been contrary to the distribution in the previous year.

The unavailability of the auxiliary feed water system at Olkiluoto plant units has increased significantly compared with the practically non-existent level of 2004. The value is on a par with 2003.

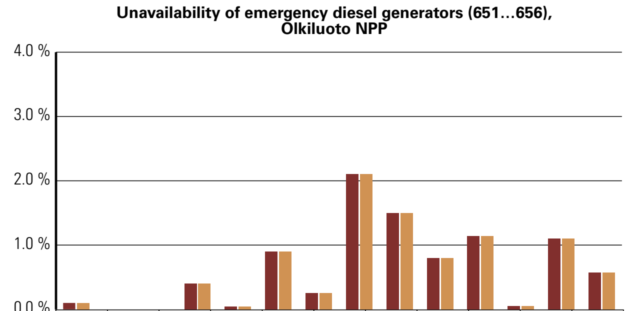
Diesel unavailability seems to have fallen by almost 50% compared with 2004. In 2005 diesel availability probably corresponds to the long-term average.



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
OL1	0.20	0.16	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.10	1.15
OL2	0.10	0.06	0.20	0.00	0.00	0.00	0.00	0.02	0.05	0.85	0.10



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
OL1	0.00	0.01	0.00	0.00	16.00	0.40	0.03	1.10	2.00	0.01	2.00
OL2	0.10	0.02	0.00	3.00	0.00	0.00	0.30	0.01	2.71	0.01	1.10



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
OL1	0.40	0.04	0.90	0.25	2.10	1.50	0.80	1.14	0.05	1.10	0.57
OL2	0.40	0.04	0.90	0.25	2.10	1.50	0.80	1.14	0.05	1.10	0.57

A.I.4 Occupational radiation doses

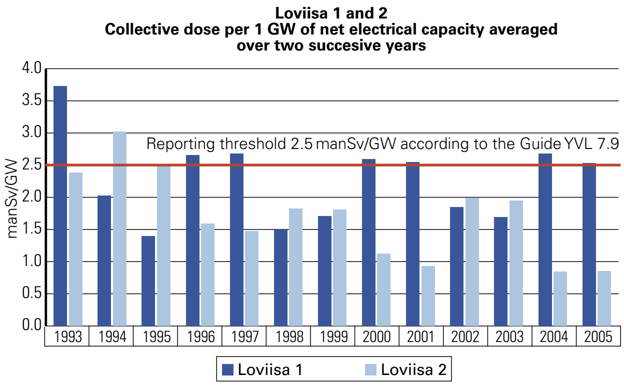
Definition
As the indicators, collective radiation exposure by plant site and plant unit is followed, as well as the average of the ten highest yearly radiation exposures.

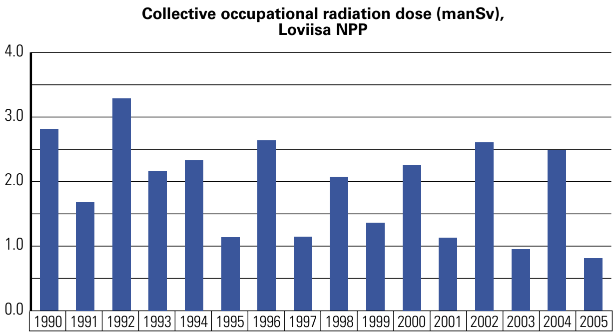
Source of data
The data on collective radiation exposure is obtained from quarterly and annual reports. The data on individual radiation doses is obtained from the national dose register.

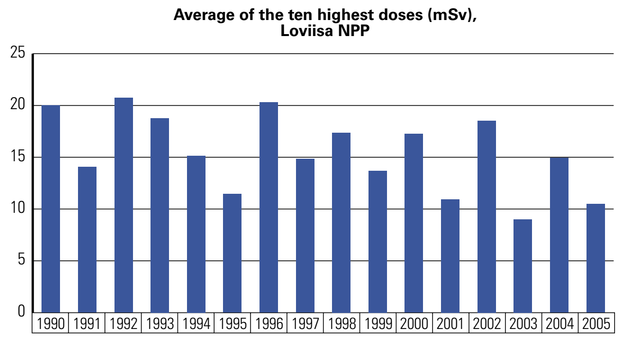
Purpose of indicator
The indicators are used to control the radiation exposure of employees. In addition, compliance with the YVL Guide's calculatory threshold for one plant unit's collective dose averaged over two successive years is followed. The threshold value, 2.5 manSv per one gigawatt of net electrical power, means a radiation dose of 1.22 manSv for one Loviisa plant unit and 2.10 manSv for one Olkiluoto plant unit.

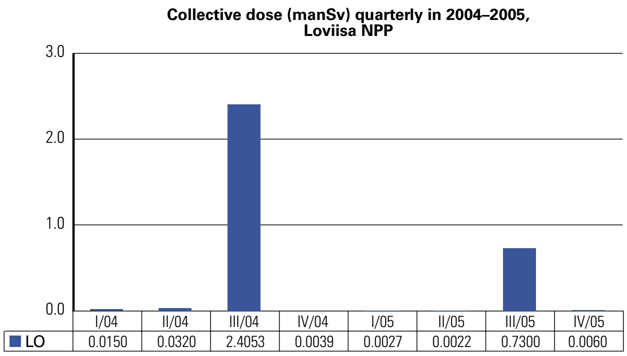
The collective radiation doses describe the success of the plant's ALARA programme. The average of the ten highest doses indicates how close to the 20 mSv dose limit the individual occupational doses at the plants are, at the same time indicating the effectiveness of the plant's radiation protection unit.

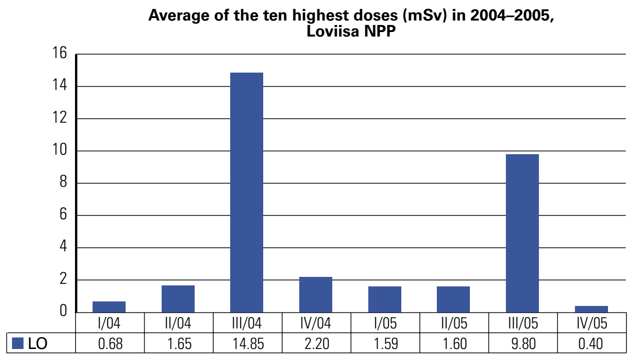
Responsible unit/person
Radiation protection (SÄT)
Suvi Ristonmaa









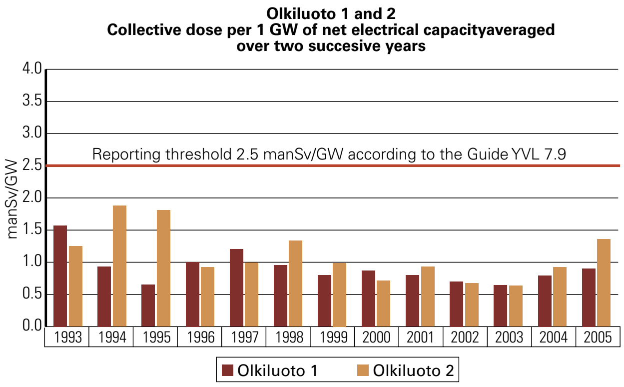


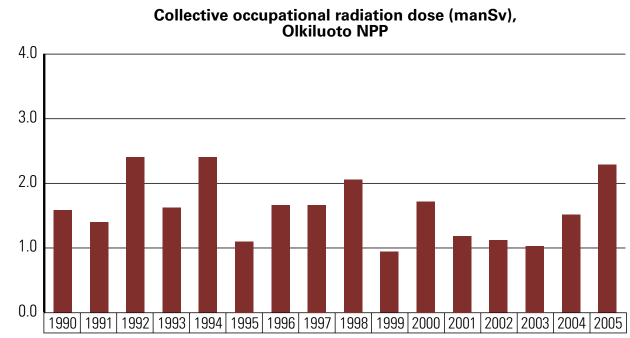
Interpretation of indicator

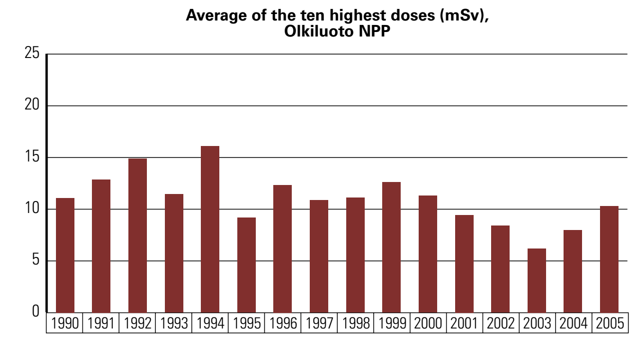
Most doses are incurred in work done during outages; thus outage duration and the amount of work having significance in radiation protection affects the yearly radiation doses. The collective occupational radiation dose at the Olkiluoto plant was higher than in previous years, particularly as a result of the annual maintenance outage of Olkiluoto 2, which was exceptionally extensive in terms of personnel resources and workload.

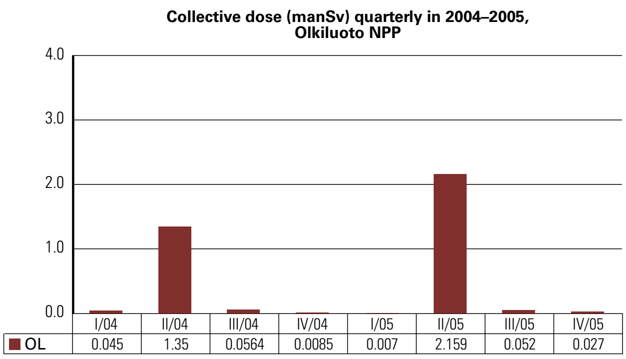
The radiation doses for the workers at nuclear power plants are below the personal dose limits. The Radiation Decree (1512/1991) stipulates that the effective dose for a worker from radiation work may not exceed the 20 mSv/year average over any period of five years or 50 mSv in any one year.

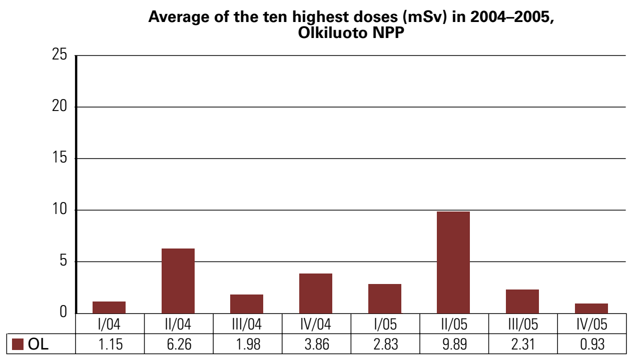
If at one plant unit the collective occupational radiation dose average over two successive years exceeds 2.5 manSv per one GW of net electrical power, the utility is to report the causes of this to STUK, and any measures possibly required to improve radiation safety (Guide YVL 7.9). The reporting threshold was exceeded at the Loviisa nuclear power plant. This was particularly due to the collective occupational radiation dose (1.93 manSv) accumulated during the long annual maintenance outage of Loviisa 1. The power plant has reported the causes of the event and the necessary action to be taken for the improvement of radiation safety to STUK.











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

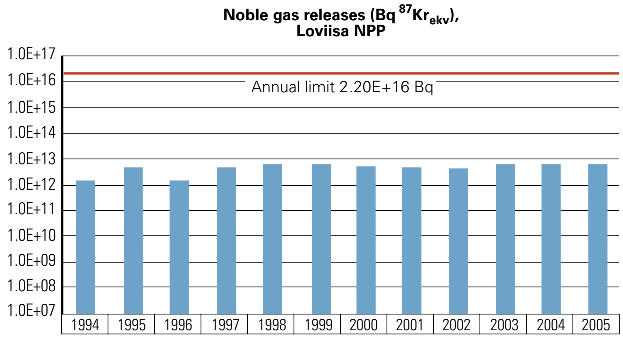
Radiation protection (SÄT), Suvi Ristonmaa (release data)
Research and Environmental Surveillance (TKO), Environment of nuclear power plants (YVL)
Seppo Klemola (dose calculation)

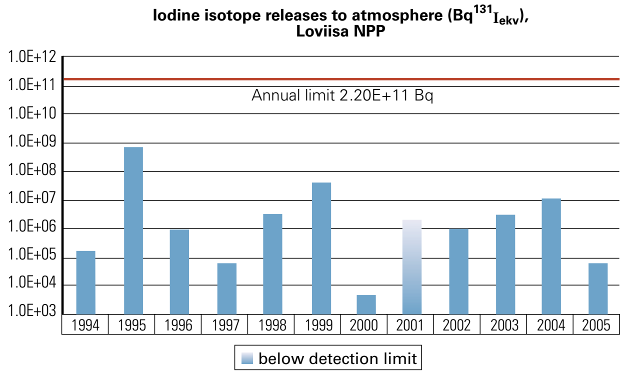
Interpretation of indicator (releases into the atmosphere)

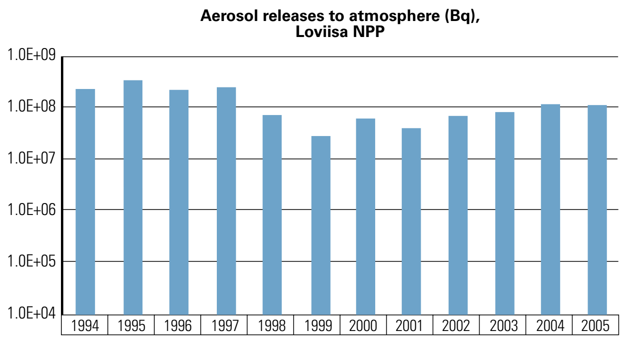
Radioactive releases into the environment from the Loviisa and Olkiluoto nuclear power plants were small. They are well below the set limits.

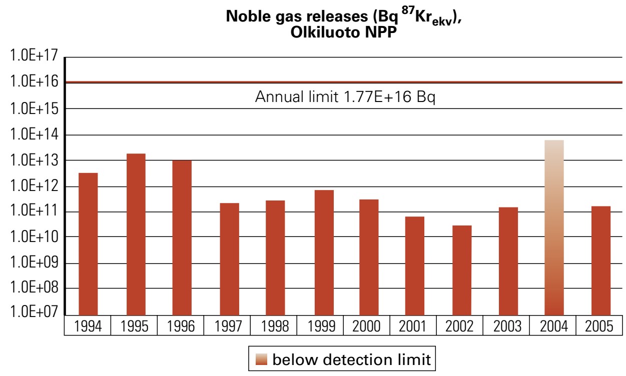
Gaseous fission products, noble gases and iodine isotopes originate in leaking fuel rods, in the minute amounts of uranium left on the outer surfaces on fuel cladding during fuel fabrication, and in reactor surface contamination from earlier fuel leaks. At both Loviisa and Olkiluoto the numbers of fuel leaks have been very small. The indicators A.III.1 describe fuel integrity. The noble gas releases from the Loviisa plant are dominated by argon-41, an activation product of argon-40, found in the airspace between the reactor pressure vessel and the biological shield. Aerosol nuclides (including activated corrosion products) are released during maintenance work.

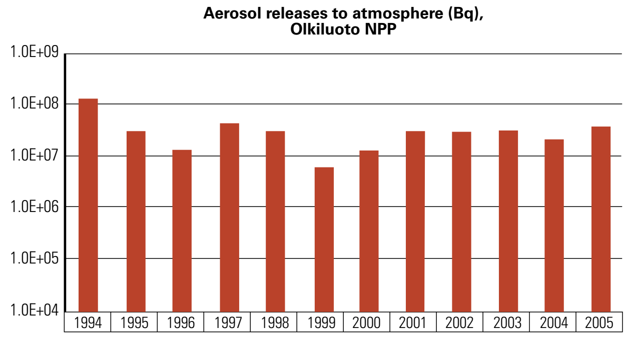
The releases of noble gas activities and aerosols released from both plants were of the same magnitude as in the preceding years. At the Loviisa plant, releases of iodine activities were smaller than in the preceding years.

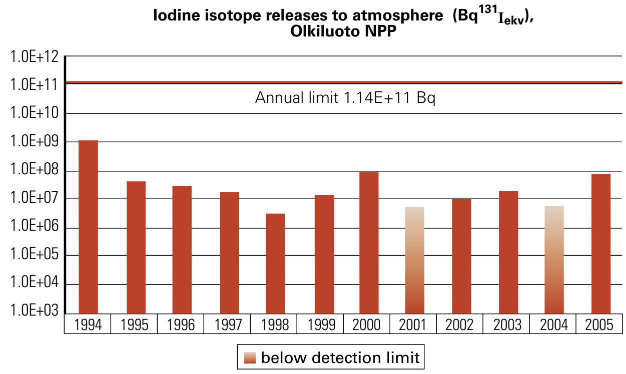






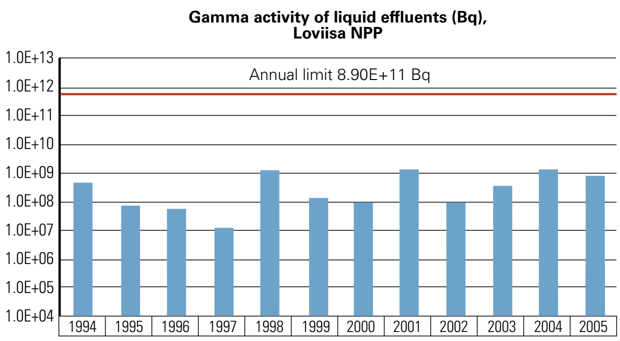




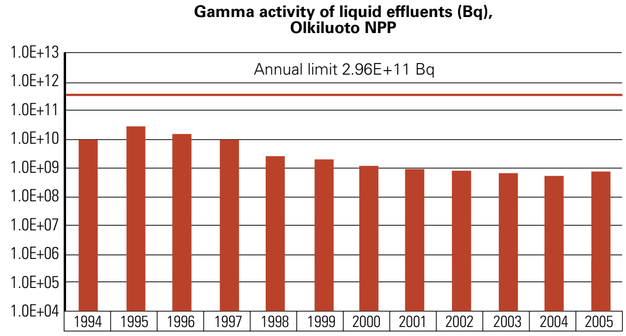


Interpretation of indicator (releases into the sea)

Releases into the sea from the Loviisa power plant were slightly smaller than in the previous year. The power plant discharged low-activity evaporation residues into the sea as planned in 2004.



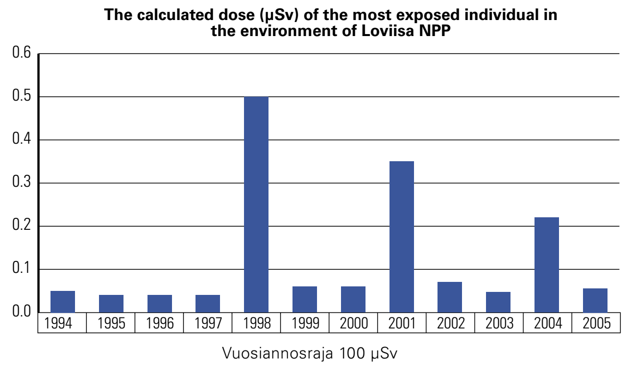
Releases into the sea from the Olkiluoto plant have reduced since the plant commissioned new process water purification and treatment equipment.

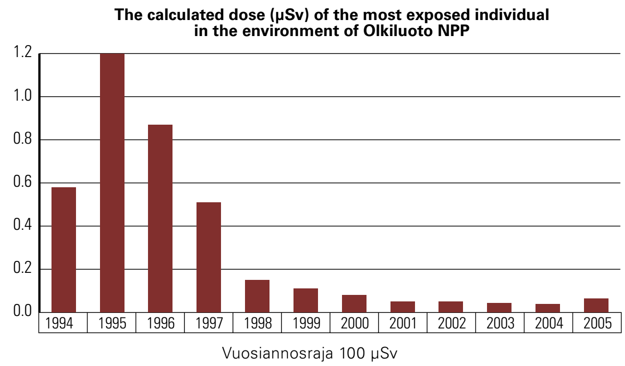


Interpretation of indicator (calculated dose due to radioactive releases)

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 year. In Loviisa the dose was smaller than in the previous year. The 2004 dose 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 0.1% of the 100 microSv limit established in the Government Resolution (395/1991).





A.I.6 Keeping plant documentation current

Definition

This indicator area follows the need to update documents due to plant modifications 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, 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 their realisation. In addition, STUK reviews the realisation of document amendments and revisions (Tech Specs, the operating manual and PI diagrams) in the main control rooms of both plants.

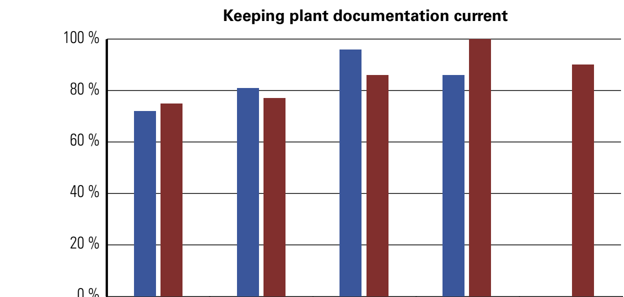
At the Loviisa plant there were no significant modifications that required monitoring using the plant modifications register.

As regards the Olkiluoto plant, the indicator is based on the identified needs for document updating related to modifications implemented during annual maintenance R205 of the Olkiluoto 2 unit and their realisation (need for updating/implemented). There were no significant modifications conducted at Olkiluoto 1 in 2005.

On the basis of a random inspection it was noted that most of the document revisions necessitated by modifications in the main control room during the annual maintenance R205 had been carried out. The ignored changes in the Tech Specs (periodic test 683-5 which can no longer be conducted due to REMES modifications) can be regarded as not safety-significant. The calculated indicator indicates that as in previous years, document updates were reasonably successful.

On the basis of the presented documents it can be noted as a new practice that document revisions required by individual modification activities have now been documented at the plant on a project-specific basis. The presented lists of revisions to instructions link an individual revision to a given modification assignment.

TVO should pay attention to the PI diagram updating routines in connection with annual maintenance. At plant start-up, there should be final, approved PI diagrams in the control room.



	2000–2001	2001–2002	2002–2003	2003–2004	2004–2005
Loviisa	72 %	81 %	96 %	86 %	–
Olkiluoto	75 %	77 %	86 %	100 %	90 %

A.I.7 Investments in facilities

Definition

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

Source of data

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

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

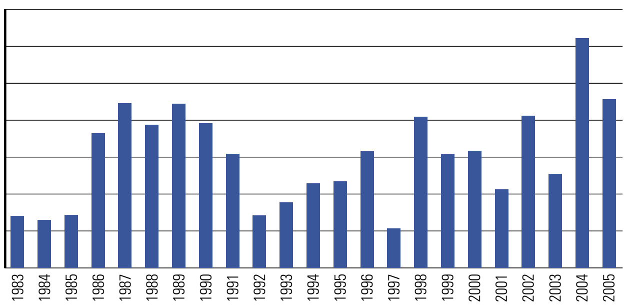
The indicator shows the relative fluctuation of investments. Sums in Euro are business information of the companies involved, not to be published here. Furthermore, the scales of the investment and modernisation figures of the Loviisa and Olkiluoto power plants are not comparable.

The fluctuation in the indicator clearly shows the investments made in 1997–2000 in the plants' power upgrades and modernisation projects. The investments of 2004–2005 are above average at both the Loviisa and the Olkiluoto plant. Since 2004, the calculation of the indicator value for Loviisa has changed; major periodic preventive maintenance and QC inspections related to annual maintenance are now regarded as investments. This change is due to the introduction of IFRS reporting.

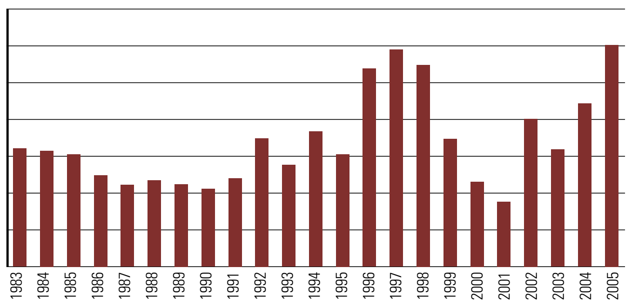
The following investments were made at the Loviisa power plant in 2005: upgrading of the maintenance and material management systems and modernisation of the laboratory building. Progress was also made in work related to the liquid waste solidification facility, a new fire station and I&C system upgrading. The plant units' safety injection pumps will be replaced within the next few years, which already incurred expenses for 2005. Other major investments included generator stator replacements, initiation of fuel rack modernisation, repair of screws in the reactor core baskets and replacement of personnel monitors.

The principal investments at the Olkiluoto power plant in 2005 concerned the turbine plant modernisation project, which also included replacement of the high pressure turbine, steam reheaters, turbine automation and switchgear equipment at Olkiluoto 2. The steam dryer of the plant unit was also replaced in the project. Construction of a gas turbine plant also began at Olkiluoto.

Maintenance investments and renovations, Loviisa NPP



Maintenance investments and renovations, Olkiluoto NPP



A.II Operational events

A.II.1 Number of events

Definition

As indicators, the numbers of events reported in accordance with Guide YVL 1.5 (events warranting a special report, reactor 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

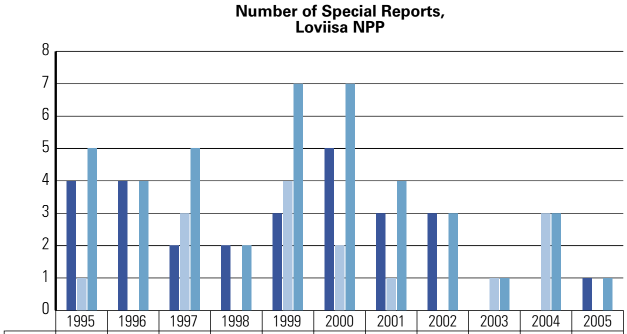
Safety Management (TUR)
Jukka Kupila

Interpretation of indicator

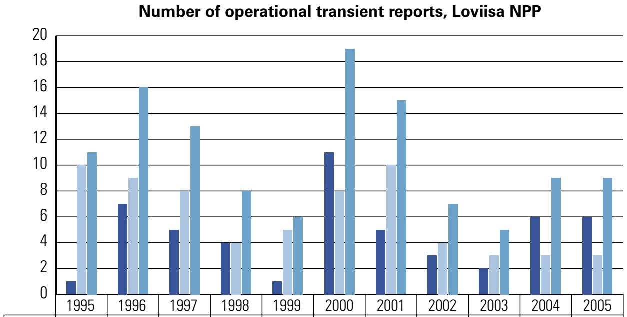
Loviisa

No reactor scrams occurred at the Loviisa plant units in 2005. There was one event warranting a special report, related to the emergency standby caused by high seawater levels. Nine events occurred at the Loviisa power plant in 2005 for which the plant submitted an operational event report to STUK.

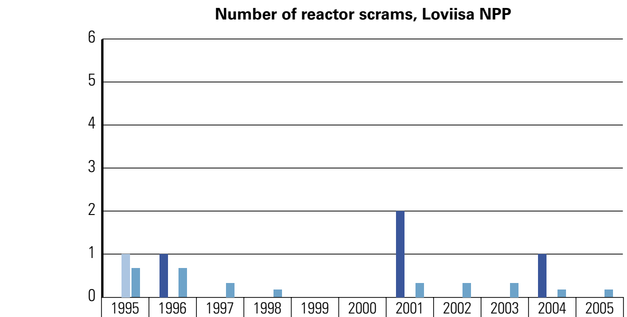
The number of special and operational event reports does not warrant special attention. Operational transients were typically due to disturbances in the operation of the reactor coolant pumps.



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
LO1	4	4	2	2	3	5	3	3	0	0	1
LO2	1	0	3	0	4	2	1	0	1	3	0
LO1,2	5	4	5	2	7	7	4	3	1	3	1



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
LO1	1	7	5	4	1	11	5	3	2	6	6
LO2	10	9	8	4	5	8	10	4	3	3	3
LO1,2	11	16	13	8	6	19	15	7	5	9	9



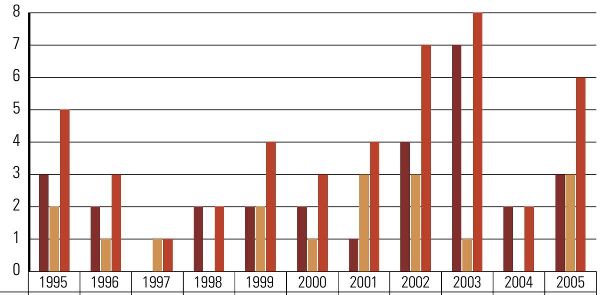
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
LO1	0	1	0	0	0	0	2	0	0	1	0
LO2	1	0	0	0	0	0	0	0	0	0	0
3-year average	0.67	0.67	0.33	0.17	0	0	0.33	0.33	0.33	0.17	0.17

Olkiluoto

No reactor scrams occurred at the Olkiluoto plant units in 2005. However, deficiencies have occurred in the general operation of the plant, which emerge as the main causes for events warranting a special report. There were six such events at Olkiluoto in 2005. While events warranting an operational event report were also mainly due to more general deficiencies in plant operation, they have not as such caused problems with reactor operation. Six events occurred at the Olkiluoto power plant in 2005 for which the plant submitted an operational event report to STUK.

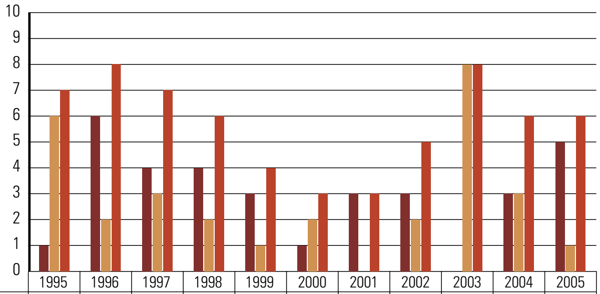
The number of special and operational event reports does not warrant special attention. Because of the type of the events warranting a special report, STUK has focused attention on the efficiency of TVO's operational experience feedback and discussed the matter with TVO.

Number of Special Reports, Olkiluoto NPP



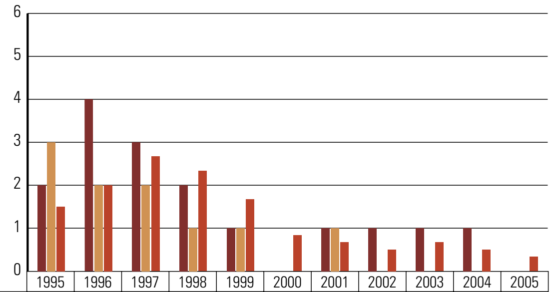
	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
OL1	3	2	0	2	2	2	1	4	7	2	3
OL2	2	1	1	0	2	1	3	3	1	0	3
OL1,2	5	3	1	2	4	3	4	7	8	2	6

Number of operational transient reports, Olkiluoto NPP



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
OL1	1	6	4	4	3	1	3	3	0	3	5
OL2	6	2	3	2	1	2	0	2	8	3	1
OL1,2	7	8	7	6	4	3	3	5	8	6	6

Number of reactor scrams, Olkiluoto NPP



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
OL1	2	4	3	2	1	0	1	1	1	1	0
OL2	3	2	2	1	1	0	1	0	0	0	0
3-year average	1.5	2	2.67	2.33	1.67	0.83	0.67	0.5	0.67	0.5	0.33

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 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 trends.

Source of data

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

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 error. In addition, an objective in event analysis is to systematically identify signs indicating deterioration of organisational and safety culture.

Responsible unit/person

Risk assessment (RIS), Ari Julin (PSA computation)

Safety Management (TUR) (failure data)

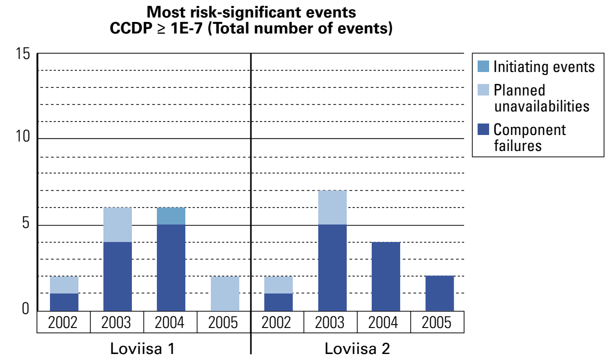
Interpretation of indicator

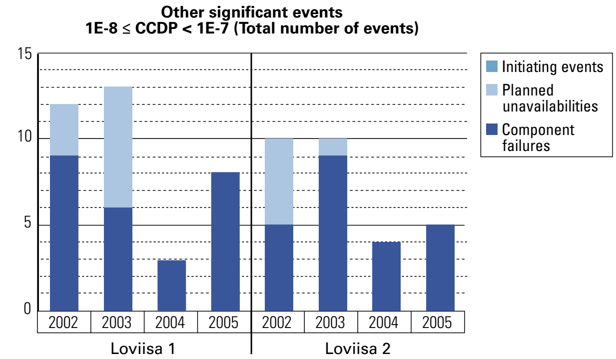
Loviisa

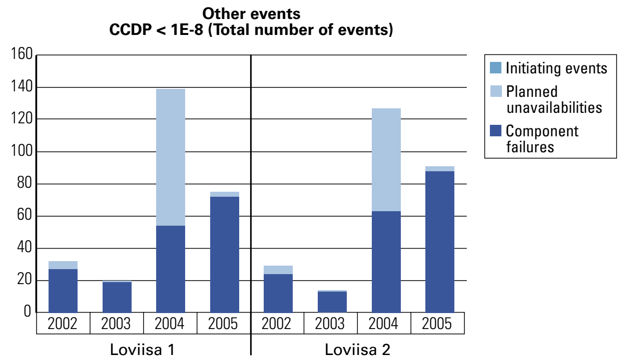
The most significant event at Loviisa 1 was the transfer of the air condenser (12UV25B004), which was part of the air cooling system covering the equipment facilities in the control room building and the main control room, from its place near the turbine hall wall to the roof of the turbine hall. The transfer was necessitated by the construction of the I&C buildings. The transfer was carried out under an exemption granted by STUK (A272/182).

Other significant failures concerned latent failures in the secondary service water system (VF; Loviisa 1) and auxiliary feed water system (RL92; Loviisa 2).

The number of analysed events falling into the least risk-significant category (CCDP<1E-8) has increased because there has been a shift in



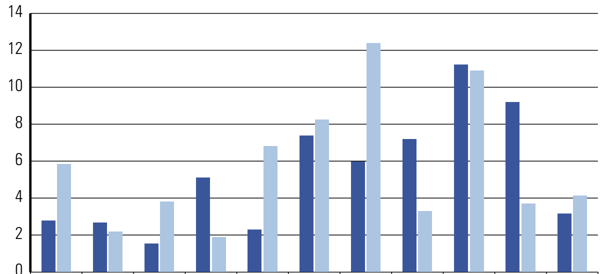




the reporting towards a policy in accordance with Guide YVL 1.5 (the unavailability of all Tech Spec components are presented in monthly or quarterly reports). This is shown in the enclosed figures. The kind of events analysed now were partly eliminated from the analysis in previous years.

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

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



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
LO1	2.78	2.66	1.54	5.09	2.30	7.39	5.96	7.20	11.21	9.20	3.15
LO2	5.83	2.17	3.80	1.87	6.80	8.23	12.39	3.30	10.90	3.70	4.14

Olkiluoto

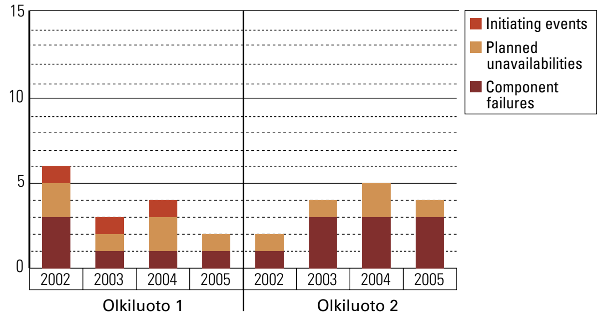
The most significant events at both plant units concerned the repairs of suction channels (712) carried out under an exemption granted by STUK (C272/140). The risk-significance of these repairs has increased from the estimate presented in the exemption application due to previously unidentified risk factors modelled in PSA.

Other significant events were related to latent failures in the containment spray system (322), auxiliary feed water system (327) and back-up diesel generator system (653).

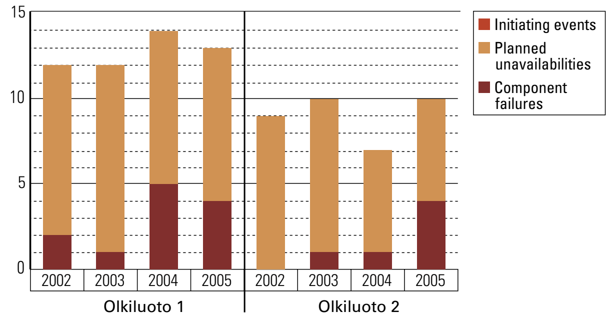
The number of analysed events falling into the least risk-significant category (CCDP<1E-8) has increased because there has been a shift in the reporting towards a policy in accordance with Guide YVL 1.5 (the unavailability of all Tech Spec components are presented in monthly or quarterly reports). This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

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

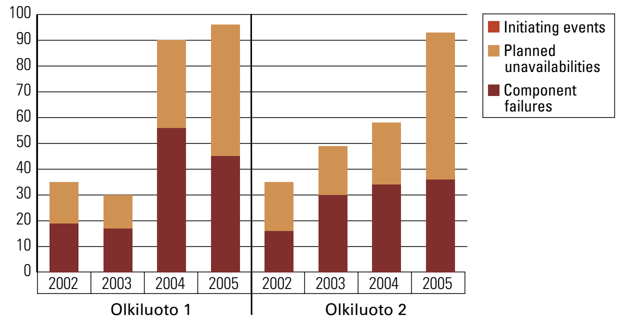
Most risk-significant events
CCDP ≥ 1E-7 (Total number of events)



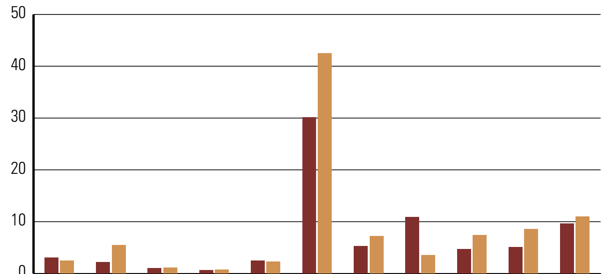
Other significant events
1E-8 ≤ CCDP < 1E-7 (Total number of events)



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



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



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
OL1	3.09	2.17	1.05	0.65	2.47	30.30	5.28	10.90	4.68	5.10	9.64
OL2	2.44	5.46	1.14	0.72	2.26	42.50	7.17	3.50	7.39	8.60	10.95

Risk-significance indicators included in STUK's permanent objectives

Incorporated in the indicators for the effectiveness of STUK's activities is the following objective that considers the condition of components having a bearing on the accident risk of nuclear facilities: "The condition of the nuclear power plant components is such that the accident risk is reduced or remains unchanged."

Definition

As indicators, the PSA-computed risk-significance of operational events is followed and each indicator is the combined total risk contribution of unavailability to the annual core damage risk . The areas under scrutiny include exemptions to the Tech Specs, Tech Spec component failures, preventive maintenance of Tech Spec components and other planned isolations. STUK has set as its internal objective that the indicator value remains below 5%.

Source of data

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

Purpose of indicator

The indicator follows the risk-significance of Tech Spec component unavailabilities and monitors the duration of planned isolations and preventive maintenances.

Responsible unit/person

Risk analysis (RIS), Ari Julin (PSA analyses)
Safety Management (TUR) (failure data)

Interpretation of indicator

The effect of unavailabilities caused by component failures, preventive maintenance and deviations from operation and maintenance procedures on annual accident risk exceeded the 5% target value set by STUK at both Olkiluoto plant units in 2005. This was partly due to planned, one-off maintenance works executed under exemption granted by STUK, and partly to latent component failures in the safety system and back-up diesel generator system. No special action by STUK was required.

Risk calculation is based on conservative assumptions and simplifications to facilitate analyses, which materially reduces the usability of the results in trend monitoring. If the risk significance on average remains at the target level from year to year, there is no need to focus special attention on the annual fluctuation.

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)
Jukka Kupila

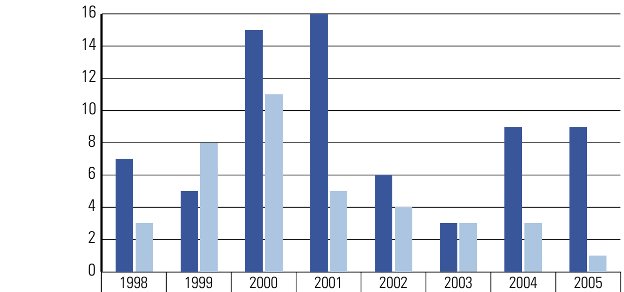
Interpretation of indicator

The immediate causes of the nine events reported by the Loviisa power plant in 2005 focus on technical failures (9). Only one event was classified to be due to human error. The Loviisa power plant included several events in its internal operational event reporting. For this reason the ratio may show some distortion.

The immediate causes of the 12 events at Olkiluoto focus on errors in plant operation (11). Only one event was caused by technical failure. This development is being monitored and related supervisory actions have been carried out concerning the events.

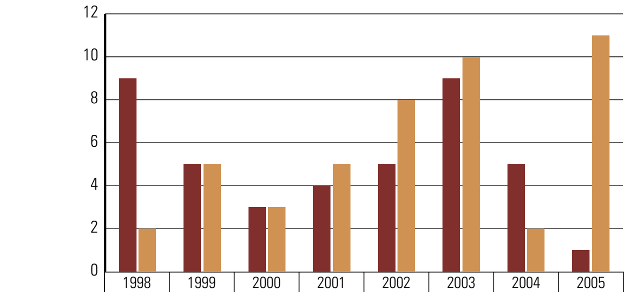
The ratio of technical failures to human errors has varied greatly during the past few years. In 2004 technical failures were the determining causes of events at both plants.

Direct causes of events, Loviisa NPP



	1998	1999	2000	2001	2002	2003	2004	2005
Technical	7	5	15	16	6	3	9	9
Human	3	8	11	5	4	3	3	1

Direct causes of events, Olkiluoto NPP



	1998	1999	2000	2001	2002	2003	2004	2005
Technical	9	5	3	4	5	9	5	1
Human	2	5	3	5	8	10	2	11

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.

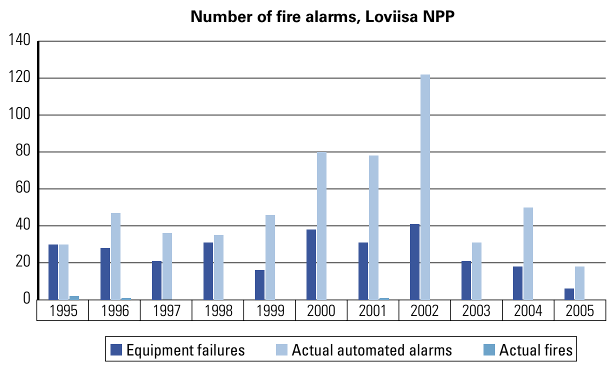
Purpose of indicator
To follow the effectiveness of fire protection at the nuclear power plants.

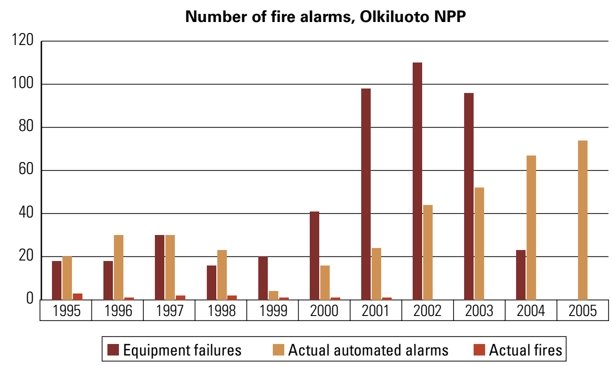
Responsible unit/person
Power Plant Technology (VLT)
Heikki Saarikoski

Interpretation of indicator
No actual fires occurred in the plant area at either operating plant, spent fuel storage or intermediate and low-level waste storage. Alarms triggered by dust, smoke or humidity dominated the automatic fire detector alarms at both plants in 2005. A significant number of alarms triggered by sprinkler leakage occurred at Olkiluoto, which in part explains the growing trend of true detector alarms compared with the previous year.

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 gives a pre-warning before the actual fire alarm. After the modification the number of alarms caused by equipment failures decreased significantly at both plants: There were no alarms caused by component failure at Olkiluoto in 2005, and only six alarms at Loviisa. The number of true detector alarms also decreased at Loviisa in 2005 to only 18 alarms. At the Olkiluoto plant the number of true detector alarms has been steadily increasing for several years. In 2005 the number was 74, which is twice as high as the level prior to the system upgrade.





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 of the primary coolant (Loviisa: as I-131 equivalent; Olkiluoto: I-131 only) and the peak value of maximum activity concentration in 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 graphical 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

The licensees submit the indicator values directly to the person responsible for the indicator at STUK. The maximum activity levels are also available in the quarterly reports submitted by the utilities.

Purpose of indicator

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

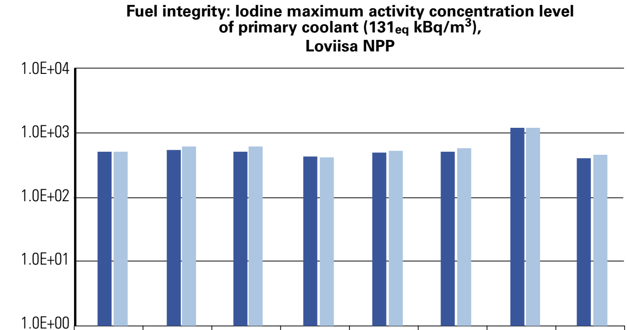
Responsible unit/person

Power Plant Technology (VLT)
Kirsti Tossavainen

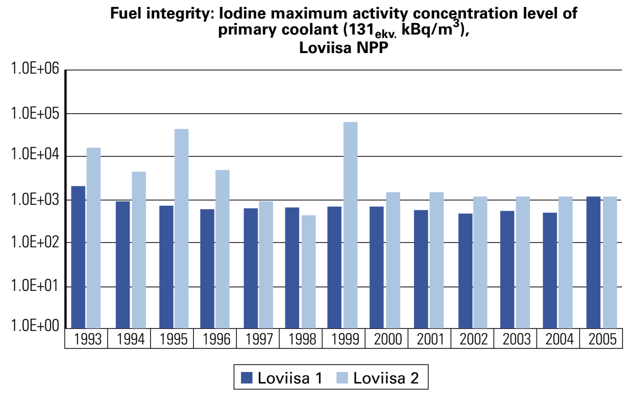
Interpretation of indicator (primary coolant activity, Loviisa)

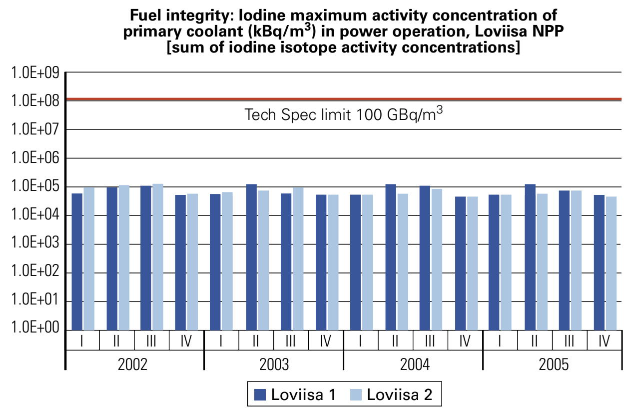
There were no fuel leaks at the Loviisa plant units in the operating cycle 2004–2005 and the activity concentration of the primary coolant remained unchanged. In addition to the activity concentration calculated as I-131 equivalents, the sum of the activity concentrations of different iodine isotopes of the primary coolant is followed at the Loviisa plant. According to the Tech Specs, the sum activity

Primary coolant maximum activity concentrations in power operation, Loviisa

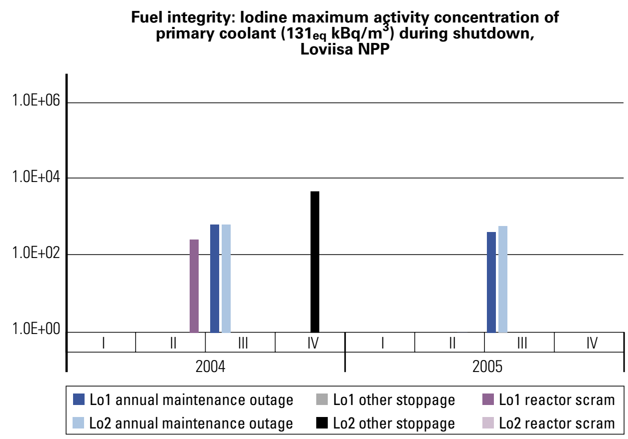


	I/04	II/04	III/04	IV/04	I/05	II/05	III/05	IV/05
Lo1	4.90E+02	5.30E+02	5.00E+02	4.00E+02	4.92E+02	5.2E+02	1.10E+03	3.80E+02
Lo2	5.00E+02	6.00E+02	6.00E+02	4.20E+02	5.17E+02	5.6E+02	1.10E+03	4.30E+02





Primary coolant maximum activity concentrations during shutdown, Loviisa



may not exceed a value of 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 since 1999.

Interpretation of indicator (primary coolant activity, Olkiluoto)

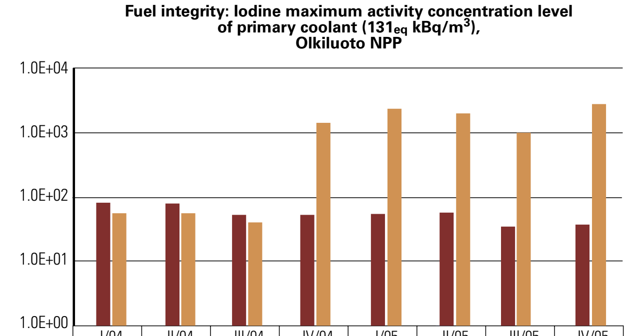
The activity concentration of Olkiluoto 1 primary coolant remained unchanged in 2005, and the activity level continued to decrease after the fuel leak which occurred in the operating cycle 2003–2004.

The Olkiluoto 2 reactor contained leaking fuel throughout 2005, as a result of which the I-131 activity concentration of the primary coolant remained above normal. The leak was discovered on 30 August 2004 and the leaking fuel bundle was removed from the reactor during the annual maintenance outage. Following the outage, a new fuel leak was discovered on 25 July 2005 (quarterly report 3/2005: Based on laboratory analyses, the leak was estimated to have begun on 23 July 2005).

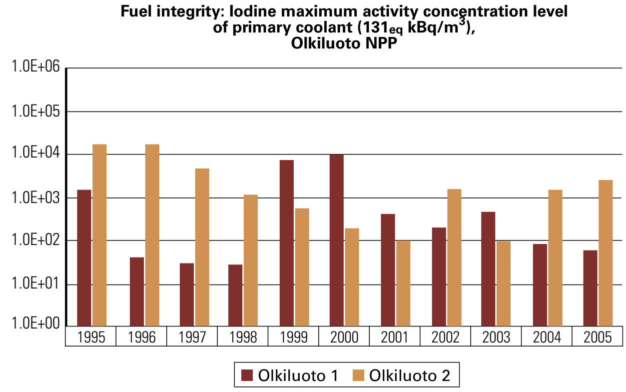
As a result of the 2004 leak, the Np-23 activity concentration of the coolant began to increase in January 2005, which indicated build-up of secondary damage in the cladding. Before the annual maintenance outage, uranium corresponding to two fuel pellets reached the coolant water through the secondary damage. The maximum value of the I-131 activity concentration of the primary coolant was 3,100 kBq/m³, which is approximately 0.14 % of the Tech Specs limit. The leaking fuel had been localised to the coverage area of control rod L70 in October 2004. The rod was part of a four-rod operating group, whose position in the reactor was 80%. The power load on the fuel cladding during operation was reduced by operating control rod L70 and its symmetry rod at 76% for the rest of the cycle. Furthermore, L70 operations were minimised by means of sequence planning and the fortnightly 2% movement tests on the control rods were suspended on March 2005. A report on the fuel leak is also included in Appendix 3 to the Annual Report.

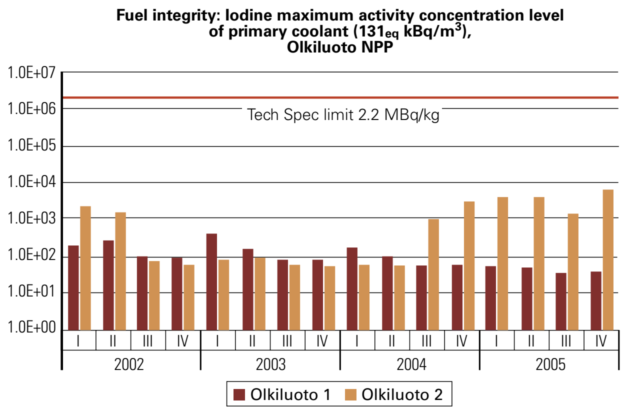
At the beginning of the operating cycle

Primary coolant maximum activity concentrations in power operation, Olkiluoto

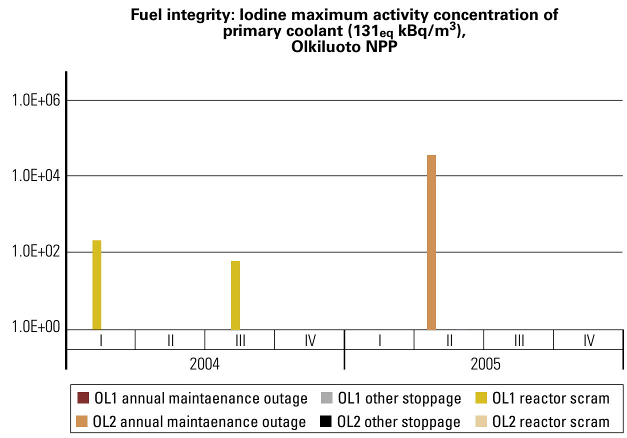


	I/04	II/04	III/04	IV/04	I/05	II/05	III/05	IV/05
OL1	8.20E+01	7.80E+01	5.40E+01	5.40E+01	5.50E+01	5.80E+01	3.60E+01	3.70E+01
OL2	5.80E+01	5.70E+01	4.20E+01	1.49E+03	2.40E+03	2.02E+03	9.50E+02	3.00E+03





Primary coolant maximum activity concentrations during shutdown, Olkiluoto



2005–2006, the activity concentration of the primary coolant was approximately 800 kBq/m³. The new fuel leak detected on 25 July 2005 did not immediately cause an increase in the activity of the primary coolant. The activity level remained almost unchanged until mid-November, when periodic tests requiring reduced power were carried out and the I-131 activity concentration rose to 6,520 kBq/m³, which was the maximum value in 2005 and approximately 0.3% of the Tech Specs limit. It is not certain whether the increase in activity was due to the power reduction. Having reached its maximum value, the activity concentration stabilised at a level of 300 kBq/m³. The fuel leak did not cause any uranium contamination in the reactor core in 2005. As a result of the 2004 fuel leak the uranium contamination of the fuel leak is 2 g of uranium.

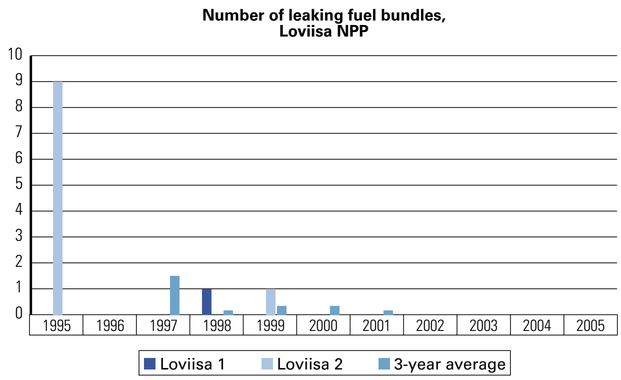
The increases in coolant activity caused by fuel leaks in 2003 at Olkiluoto 1 and in 2002 at Olkiluoto 2 are shown as notably larger I-131 activity concentrations while shutting down plant units for annual maintenance outages. In the other reactor shutdowns the coolant I-131 activity concentrations have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

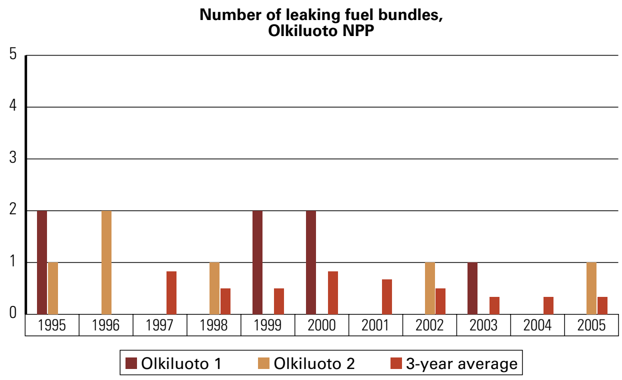
Interpretation of indicator (number of leaking fuel rod bundles)

At Olkiluoto 2, a leaking fuel bundle was removed from the reactor during the annual maintenance outage. The leak had been discovered on 30 August 2004. An inspection revealed a thin sliver of metal in the bundle, which chafed against the corner rod in the bundle and caused the original damage to the cladding. Four months later secondary damage was detected in the lower half of the leaking fuel rod. Towards the end of the operating cycle the damage expanded into a transverse fracture of the rod. The integrity of all fuel bundles used in the reactor during the operating cycle 2004–2005 was inspected during the maintenance outage. No other leaking bundles were discovered. A fuel leak was discovered at Olkiluoto 2 on 25 July 2005. The leaking bundle will be removed from the reactor in the 2005 annual maintenance outage at the latest. No leaking fuel rod bundles were discovered at Olkiluoto 1 during the operating cycle 2004–2005.

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

- 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. The indicator for Olkiluoto is the international index used by the plant. The indicator for Loviisa is a new index developed and introduced at the plant in 2004 parallel to the international index. The new index describes the water chemistry conditions in the secondary circuit at Loviisa with a higher degree of sensitivity than the corresponding international index for WER plants. This new index observes corrosive factors and the concentrations 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 concentration 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 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.

The licensee submits data on primary circuit leakages at the Olkiluoto power plant to the responsible person at STUK.

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.

Indicators for primary circuit leakages are used to monitor and control primary circuit integrity.

Responsible units/persons

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

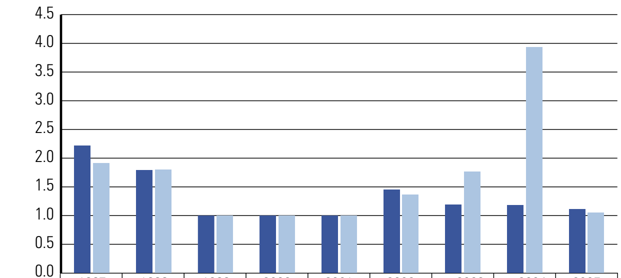
Water chemistry conditions, Loviisa

Interpretation of indicators

Chemistry index

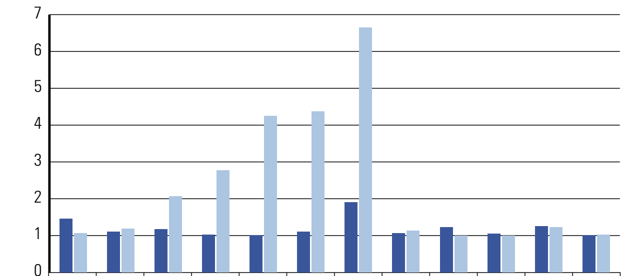
No deviating chemistry index values were reported by either plant unit at Loviisa in 2005. The high values of the index at Loviisa 2 in previous years were due to a seawater leak in the condenser of the other turbine (50), which began in 2002 and was repaired during the 2004 annual maintenance outage.

Integrity of the secondary circuit: Chemistry index, Loviisa NPP



	1997	1998	1999	2000	2001	2002	2003	2004	2005
LO1	2.22	1.79	1.00	1.00	1.00	1.45	1.19	1.18	1.11
LO2	1.91	1.80	1.00	1.00	1.00	1.36	1.76	3.93	1.05

Integrity of the secondary circuit: Chemistry index, Loviisa NPP



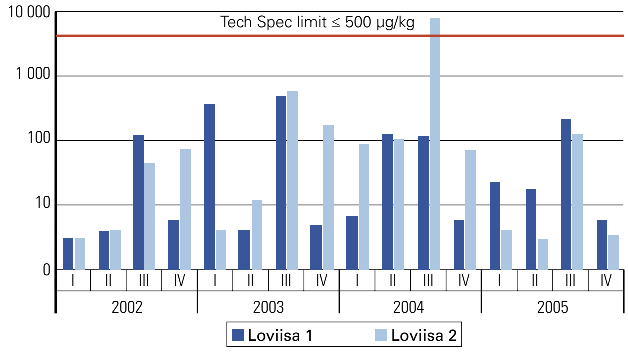
	I/3	II/3	III/3	IV/3	I/4	II/4	III/4	IV/4	I/5	II/5	III/5	IV/5
LO1	1.46	1.10	1.17	1.02	1.01	1.11	1.91	1.06	1.23	1.05	1.25	1.01
LO2	1.07	1.19	2.07	2.77	4.25	4.37	6.65	1.13	1.00	1.00	1.22	1.02

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 a value of 0.5 mg/kg. If the excess is minor (0.5–1.0 mg/kg), the plant has one week to bring the concentration into agreement 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.

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.

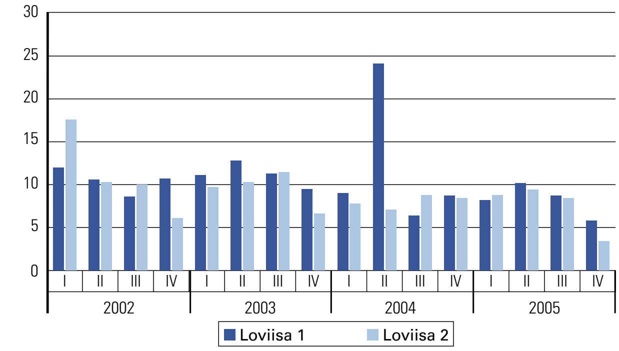
Integrity of primary circuit: Corrosive impurities; Maximum chloride concentration of a steam generator blow-down (µg/kg), Loviisa NPP



Iron content of secondary circuit feed water

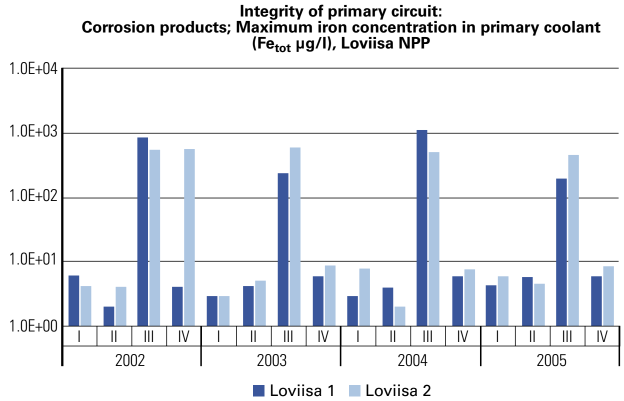
The iron content of the feed water has been followed in the STUK indicators since 2002. No significant changes have taken place in the indicator values. At Loviisa 1 the iron concentration was higher than normal in the second quarter of 2004. This was due to a reactor scram that occurred on 29 June 2004, causing impurities to be released from the surfaces of the secondary circuit. No other significant changes have taken place in the indicator values.

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



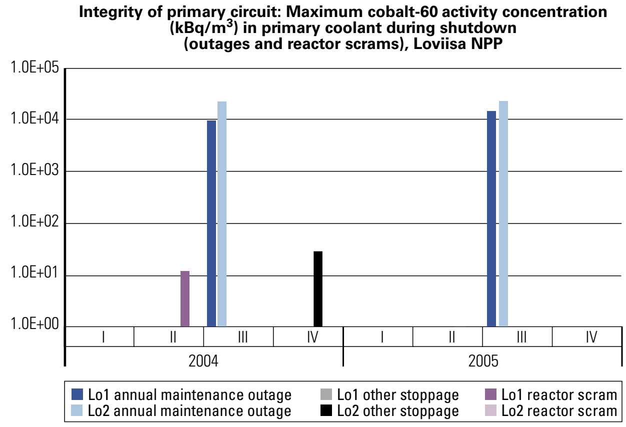
Iron in primary coolant

The maximum values of the iron concentration of the primary coolant are from situations when plant units have been brought to a shutdown. 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.



Cobalt-60 concentration in shutdown

The indicator has been followed since 2002. No fundamental changes have taken place in the Co-60 activity concentrations at either plant unit in Loviisa.

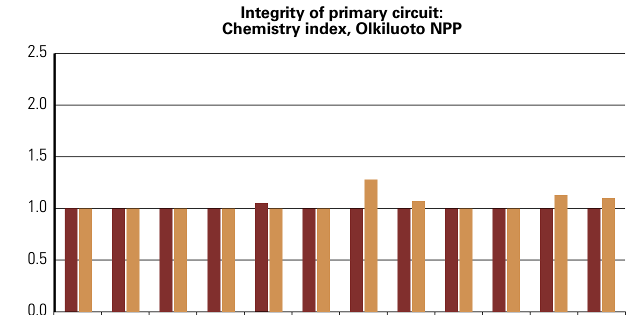


Water chemistry conditions, Olkiluoto

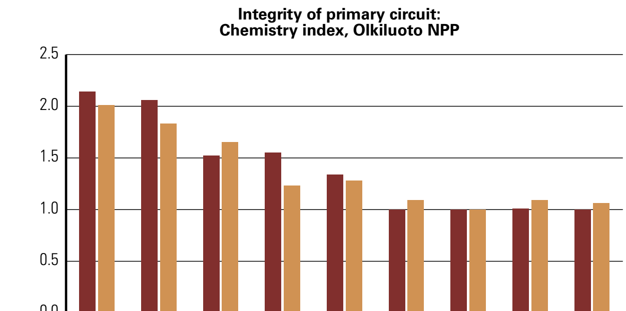
Interpretation of indicators

Chemistry index

At Olkiluoto 1, the chemistry index remained at the target value (1.00) in 2005. At Olkiluoto 2, the third and fourth quarter target values, which are slightly greater than the target value, are due to sulphate concentrations which exceed the target value.



	I/3	II/3	III/3	IV/3	I/4	II/4	III/4	IV/4	I/5	II/5	III/5	IV/5
OL1	1.00	1.00	1.00	1.00	1.05	1.00	1.00	1.00	1.00	1.00	1.00	1.00
OL2	1.00	1.00	1.00	1.00	1.00	1.00	1.28	1.07	1.00	1.00	1.13	1.10

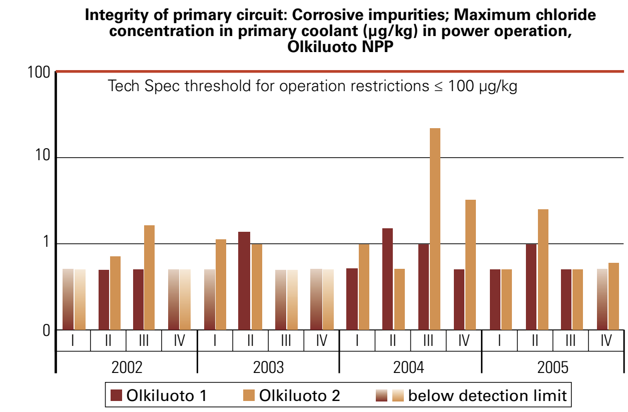


	1997	1998	1999	2000	2001	2002	2003	2004	2005
OL1	2.14	2.06	1.52	1.55	1.34	1.00	1.00	1.01	1.00
OL2	2.01	1.83	1.65	1.23	1.28	1.09	1.00	1.09	1.06

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

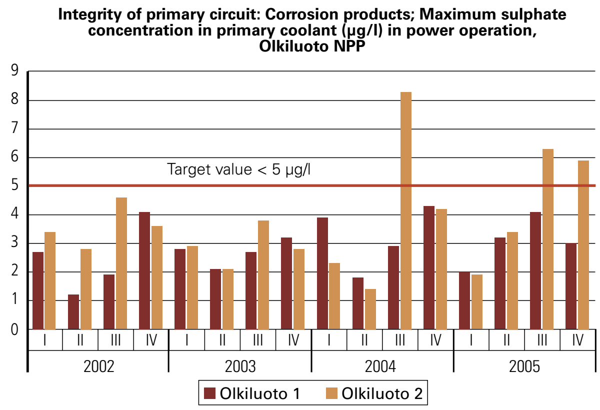
The chloride content during operation has usually been around one per cent of the limit set in the Tech Specs at both plant units. In the third quarter of 2004 there was a chloride content higher than normal at Olkiluoto 2. This was due to a leak in the turbine condenser, during which seawater got into the reactor water and the chloride content rose to 21.3 µg/l. After leak repair the chloride content returned to normal levels by the end of the year. The 2005 values which exceeded the target values were due to annual maintenance outages.



Sulphate content in reactor water

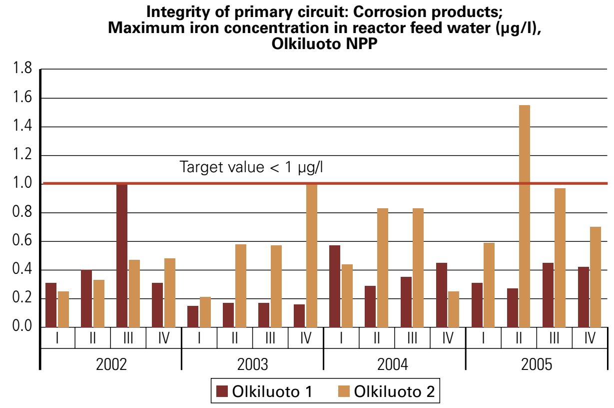
Both Olkiluoto plant units have had the problem of a sulphate concentration higher than the reactor water target value. Under certain circumstances, sulphate is a significant factor in stress corrosion. The sulphate in the reactor water originates in the sulphate released from the ion-exchange resin 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 preheater bypass at 60oC. 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 preheater. The pre-heater was relocated to after the condensate cleaning filters, whereas it was earlier located before the filters. Thanks to the modification, the temperature of the condensate entering the condensate cleaning filters decreased to an average of 50oC. 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 must not be exceeded. Since the plant modifications the sulphate concentration has remained below the target level at both plant units, excluding the exceedances occurring at Olkiluoto 2. The index values being higher than the target value in the third quarter of 2004 is suspected to be due to a change in the quality of the ion-exchange resin. In 2005 the sulphate content exceeded the set target limit in the third and fourth quarters. The events were due to the running times of many condensate cleaning filters being long. Following the replacement of the ion-exchange resin of the filters, sulphate contents fell below the target value and the duration of the deviation did not exceed the limit of four days allowed in Teollisuuden Voima Oy's instructions.



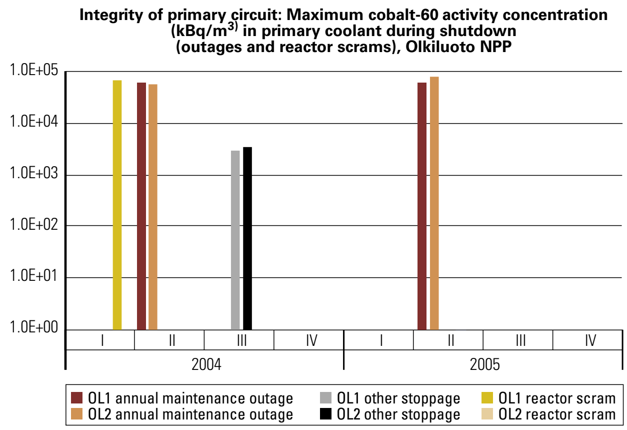
Iron concentration in feed water

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, which may not be exceeded during plant operation. This target value was exceeded during the second quarter of 2005. The exceptional value was due to the annual maintenance completed on the day before sampling. The impurity contents of the reactor water are higher during annual maintenance than during operation. The action threshold set in Teollisuuden Voima Oy's instructions for the content has been 2 µg/l. There have not been any other instances of the target value being 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 ma-



terials 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.

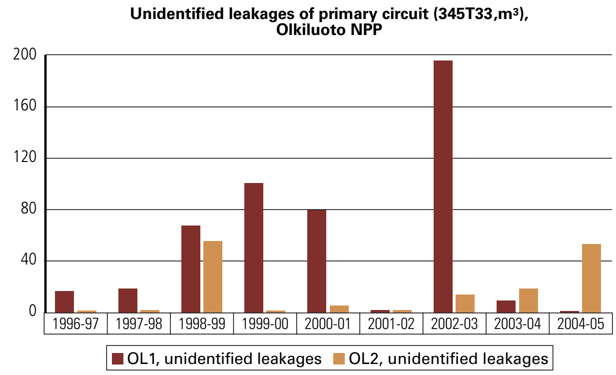
Primary circuit leakages, Olkiluoto

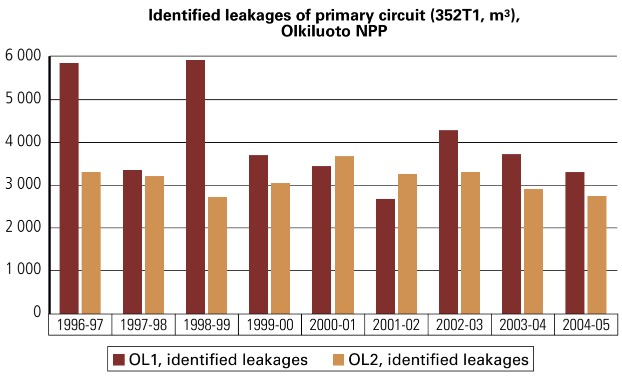
Interpretation of indicator

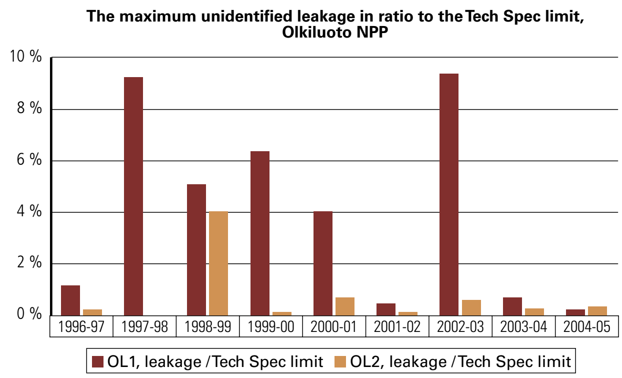
Leaks identified in the operating cycle 2004–2005 were 3,300 m³ (OL1) and 2,741 m³ (OL2). There were no fundamental changes compared with 2004.

In the operating cycle 2004–2005 the volume of unidentified leaks was very small, 1.14 m³. At Olkiluoto 2, however, the volume was much larger, 53 m³. At Olkiluoto 2, the leakage volume was mainly due to a loosened flange joint of one vacuum breaker in the system (314) as 9 bolts had stripped their threads and only three more were still in place, although also loose.

In the operating cycle 2004–2005 the ratio of the greatest containment internal leakage volume to the allowed leakage volume in the Tech Specs was low for both plant units: 0.23% at Olkiluoto 1 and 0.35% 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

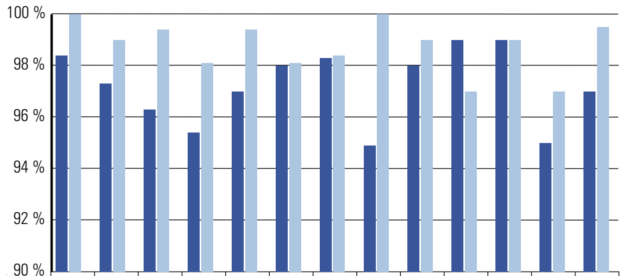
Loviisa

The overall as-found leakage of outer isolation valves at both plant units has decreased. The percentage of isolation valves that passed the leaktightness test at the first attempt has remained high.

The overall as-found leakage of containment penetrations, which, at Loviisa, includes leaktightness tests of the personnel airlock, the emergency personnel airlock, the material airlock, the reactor pit, inward relief valves, cable penetrations and the bellows seals has decreased at Loviisa 2 and is small at both plant units.

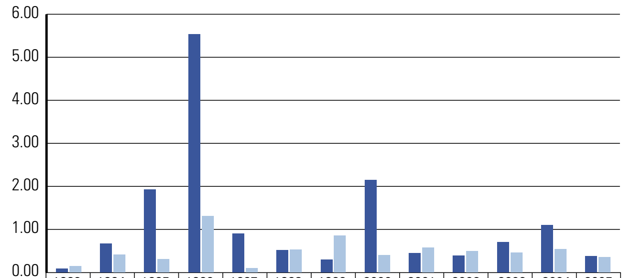
The integrity of the Loviisa containment building has remained good. Due to problems in the leaktightness of the rubber bellows of penetrations they have been replaced with metal structures.

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



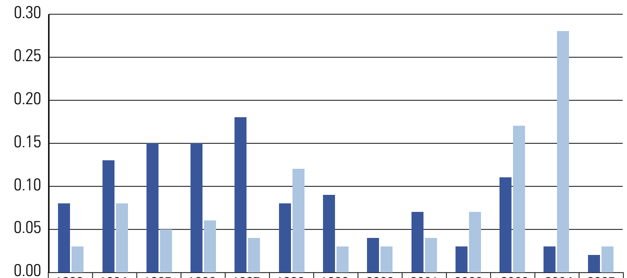
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
LO1	98	97	96	95	97	98	98	95	98	99	99	95	97
LO2	100	99	99	98	99	98	98	100	99	97	99	97	96

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	2005
LO1	0.09	0.67	1.93	5.54	0.90	0.52	0.30	2.15	0.45	0.39	0.71	1.10	0.38
LO2	0.14	0.41	0.31	1.31	0.10	0.53	0.85	0.40	0.58	0.49	0.46	0.54	0.36

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	2005
LO1	0.08	0.13	0.15	0.15	0.18	0.08	0.09	0.04	0.07	0.03	0.11	0.03	0.02
LO2	0.03	0.08	0.05	0.06	0.04	0.12	0.03	0.03	0.04	0.07	0.17	0.28	0.03

Olkiluoto

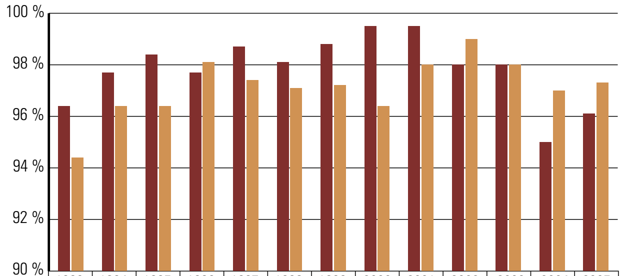
The overall as-found leakage of the Olkiluoto 1 outer isolation valves was, as in previous years, below the limit set in the Tech Specs. Approx. 30% comes from leaks in two isolation valves in the scram system (354). Approx. 8% comes from leaks in one valve in feed water system (312). In leakage testing, the largest leak was through the inner main steam valve (311V4). The reason for the leak was a broken internal check valve.

The overall as-found leakage of the Olkiluoto 2 outer isolation valves was below the limit set in the Tech Specs. 57.8% comes from leaks in two isolation valves in the scram system (354) and approx. 17% from a leak in one valve in the feed water system (321). In leakage testing, the largest single leak was through the inner main steam valve (311V2). The reason for the leak was a broken internal check valve.

The percentage of isolation valves that passed the leaktightness test at first attempt has remained stable.

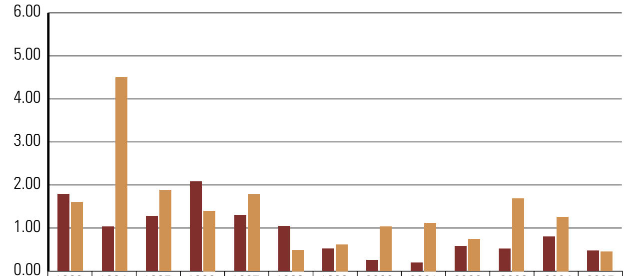
The overall as-found leakage rate of containment penetrations, in which TVO includes leakages in the upper and lower personnel airlock, the maintenance dome and the containment dome, has remained small.

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



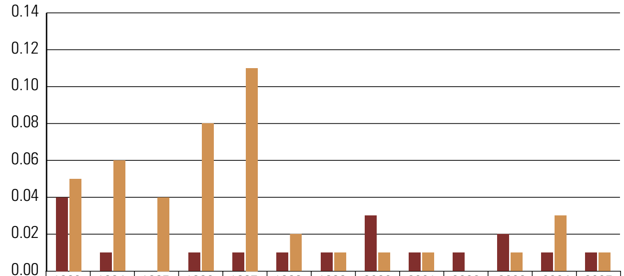
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
OL1	96	98	98	98	99	98	99	99	99	98	98	95	96
OL2	94	94	96	98	97	97	97	96	98	99	98	97	97

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	2005
OL1	1.79	1.03	1.28	2.08	1.30	1.04	0.52	0.25	0.19	0.58	0.50	0.80	0.47
OL2	1.60	4.50	1.88	1.40	1.79	0.49	0.62	1.03	1.12	0.74	1.69	1.26	0.45

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	2005
OL1	0.04	0.01	0.00	0.01	0.01	0.01	0.01	0.03	0.01	0.01	0.02	0.01	0.01
OL2	0.05	0.06	0.04	0.08	0.11	0.02	0.01	0.01	0.01	0.00	0.01	0.03	0.01

APPENDIX 2 Safety improvements in 2005

Tapani Eurasto, Soile Metso, Janne Nevalainen, Hannu Ollikkala, Rainer Rantala, Heikki Saarikoski, Päivi Salo, Heimo Takala, Tapani Virolainen

Loviisa nuclear power plant

The emergency operating procedures were revised

The emergency operating procedures of Loviisa nuclear power plant were revised in the HOKE project, launched in 2000. The project encompassed the drawing up of diagnosis procedures for transients and emergencies arising from primary and secondary leaks, procedures for operators and the safety engineer as well as action sheets for onsite measures. Some old procedures have been deleted and the rest have been revised as appropriate i.a. as regards transition between old and new procedures.

In accordance with the new procedures, nuclear power plant operators follow their own separate procedures and initiate the necessary actions in their fields of responsibility in the event of an emergency or a transient. The shift manager co-ordinates these actions and reviews the main actions and parameters using his own procedures. The safety engineer in parallel with the operators independently oversees safety functions using separate procedures to ensure that plant behaviour is as planned.

The revised procedures consist of guidelines and instructions presented as flow charts. The guidelines define strategy and give grounds for operator actions during emergencies and transients. It serves as a basis for actual control room procedures containing operator procedures. The guidelines are used for training purposes as well.

The revised control room procedures of the Loviisa plant are based on French nuclear power plant procedures. The project's French experts also participated in the validation and verification of the procedures and their background material in co-operation with the plant's own personnel. Validation ascertains authenticity of the procedures i.a. by comparison with the plant and by simulator tests. Verification authenticates i.a. correlation and functioning of the new procedures with other plant procedures. The project included training given to the control room personnel of the Loviisa plant in the use of the new procedures. Due to the revision's significance, both structurally and contents-wise, STUK required that shift supervisors and operators working in the control room have given shift-specific proof of workmanship prior to the introduction into use of the revised procedures.

STUK in December 2005 authorised the introduction into service of the revised emergency operating procedures, which is due at Loviisa power plant in early 2006.

Olkiluoto power plant

Sealing changes in the expansion joints of the containment building intermediate level and the transportation shaft at Olkiluoto 2

The sealings of the expansion joints of the containment building intermediate level and the transportation shaft were replaced in the annual maintenance outage. The intermediate level separates the upper drywell and wetwell. Systems containing high pressure water and steam are housed in the upper drywell. The wetwell is the water-filled part of the containment to which steam discharging from the reactor is channelled during accidents. The sealing, installed in the expansion joint between the reinforced-concrete intermediate level and the containment building, is required to withstand dislocations, pressure differences and heat loads during accidents. The transportation shaft between the containment upper and lower drywell is rigidly attached to the concrete casing at both ends. A construction joint is fitted to it to accommodate for thermal and other constrained motion. The different sections of the containment building are shown in Figure L2.1.

The original rubber sealings of the expansion joints have exceeded their design service life. In addition, the original design did not consider severe accident conditions, which makes the sealing of the intermediate level expansion joint and that of the transportation shaft a hazard to the pressure suppression function.

A new intermediate level expansion joint sealing was installed on top of the old operational sealing. Old transport shaft sealing was removed and a new one was installed in the existing flange. The new sealing material withstands severe accident conditions better that the old one. Post-installation leakage tests showed the trasportation shaft to be leaktight. The leaktightness of the new intermediate level sealing was satisfactory and is intended to be improved.

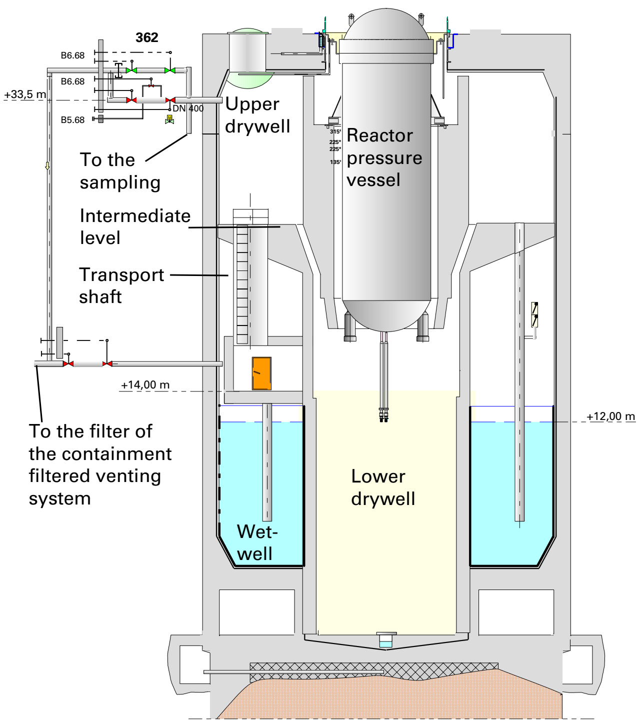


Figure L2.1. A diagrammatic plan of the Olkiluoto 1 and 2 containment buildings.

Containment sampling system modification at Olkiluoto 2

The sampling system at Olkiluoto 2 was improved to facilitate gas sampling in the containment gas space during an accident. The evaluation of radionuclide concentrations in the containment gas space must be possible by sampling, or some other method, even during severe accidents. A sample can be used to assess a release time and the necessary protective measures .

The new system samples gas from the gas space of the containment upper drywell by a sampling tube connected to the containment filtered venting system (see Figure L2.1). It determines the concentration of noble gases and iodine in the containment gas space. The volumes of aerosols released cannot be determined but they are rather effectively adsorbed onto the system's filter. Measurements enable the evaluation of the magnitude and environmental impact of a possible release through the filters of the filtered venting system during a severe accident.

The sampling system is normally in stand-by mode and requires no electrical power to function. Gas sampled from the system is analysed in the laboratory. The system complements and backs up other monitoring systems as well as the radiation monitoring system for rooms, which is coupled to the battery-backed system. The sampling system was installed in the 2005 annual maintenance but has not yet been introduced into service owing to malfunctions in the angle transmissions of its valves.

Feed water distributors were reinstalled at Olkiluoto 2

In the 2005 annual maintenance outage at Olkiluoto 2, new feedwater distributors, repaired in the winter of 2005, were reinstalled in place of the old ones. The new distributors were first installed in the 2003 outage but were replaced with the old ones in the 2004 annual maintenance outage, since cracks had been found in them (see Annual Report 2004).

The new distributors are designed to handle feed water flow after a power uprating and their design takes into account the thermal stresses to which the emergency cooling system riser pipes, located inside the reactor pressure vessel, are subjected. The riser pipes are located directly where the feed water distributors are. A thermal stress hazard arises when cold feed water mixes with the hot water returning from the steam separators. The new distributors are intended to bring the flow mixing point further away from metal surfaces and to thus restrict riser pipe thermal stress.

No cracks were detected in the new feed water distributors replaced at Olkiluoto 1 in 2004. The distributors of Olkiluoto 1 and 2 are due for inspection in future outages.

The steam dryer was replaced at Olkiluoto 2

The steam dryer was replaced in the 2005 annual maintenance outage at Olkiluoto 2. The moisture content of the reactor–to–turbine steam at Olkiluoto 1 and 2 increased after a power uprating in 1998. The moisture content was approx. 0.1% before the power uprating. After it, the annual average moisture content has been 0.27–0.33% at Olkiluoto 1 and 0.31–0.34% at Olkiluoto 2. The moisture in steam has not been ascertained to have increased erosion-corrosion in turbine systems. The steam from the reactor at Olkiluoto 1 and 2 is channelled direct to the turbine plant. Thus, along with the moisture, radioactive substances dissolved in water are transported to the turbine plant, causing elevated radiation levels there. The dose rates measured at the turbine plant have been 2–10 fold compared with those measured before the power uprating. An increase in the steam moisture content essentially increases occupational doses when working with or around systems having to do with steam. Collective occupational doses at Olkiluoto 1 and 2 have been below the limit established by STUK (see chapter 3.2.4).

Teollisuuden Voima Oy ordered new steam dryers to reduce the steam moisture content. The more effective design of their dryer panels aims at reducing steam moisture below 0.1%. The new dryer was installed at Olkiluoto 2 in the 2005 annual maintenance outage and will be installed at Olkiluoto 1 in the 2006 annual maintenance outage.

The Olkiluoto 2 steam dryer was completed and delivered in January 2005. Its packaging had broken in transit, however, letting in snow and impurities. In the receiving inspection i.a. machining chips left inside the dryer during manufacturing were found. Before moving it to the reactor hall, Teollisuuden Voima Oy submitted the dryer to thorough cleansing. At the same time investigation and corrective action was initiated to avoid similar problems with the Olkiluoto 1 dryer.

A steam moisture content of 0.009% was measured after the annual maintenance with Olkiluoto 2 operating at full power. With continued operation, the moisture values have been 0.007%.

A high pressure turbine and steam reheaters were replaced at Olkiluoto 2

A high pressure turbine and steam reheaters were replaced at the 2005 annual maintenance of Olkiluoto 2 to increase the turbine power output and reduce the moisture content of steam. The efficiency of the high pressure turbine had significantly deteriorated in consequence of modifications made over the years, one of which was the removal of two blading stages. The power uprates accomplished in 1998 had increased the loading on the reheaters. Some of their tubes have been plugged, which has restricted their service life.

The utility replaced one-stage steam reheating with two-stage steam reheating to improve turbine efficiency. With two-stage steam reheating, a new high pressure turbine extraction point was required to lead steam to the first-stage piping group of the new two-stage reheater. Live steam is directed from the reactor to the other reheater piping group. The high pressure turbine blading were improved, which increased the turbine output.

Turbine plant automation system renewal at Olkiluoto 2

In the annual maintenance outage, a new automation system was installed in the Olkiluoto 2 turbine plant control system. One reason was the need to switch from analogue to programmable technology. The other major reason was that spare parts procurement for the old system was getting difficult. In addition, the modifications made in the turbine plant process in 2005, and those planned for 2006, required some additional modifications to the automation system. The new system facilitates component maintenance. Another system renewal objective is increased reliability and reduced susceptibility to malfunctions. The new system was pre-installed at Olkiluoto 1 and 2 in the 2004 annual maintenance.

The new automation system is implemented by programmable technology. This allows an increased number of process status measurements. As regards turbine automation, it facilitates for turbine operators more versatile information management, process control at operating work stations, trend monitoring and setting of safety limits. Safety limit settings enable turbine operator reaction to even minor process changes. The control desk for the turbine side in the control room was replaced with a safety systems control desk and a turbine systems control and monitoring desk and the control room was fitted with a giant screen display. In addition, the process computer system capacity had to be upgraded in connection with the control system renewal to handle the large volume of data yielded by the turbine automation.

The turbine plant automation system renewal made it possible, for the first time at a Finnish nuclear power plant, to control some processes from the control room via the operating work station system. The processes thus controlled are of minor safety importance.

The automation interface was introduced at the Olkiluoto 1 and 2 training simulator in September 2004, which made possible the training of operating personnel in its use.

Modernisation of Olkiluoto 2's medium voltage switchgears

In the 2005 annual maintenance outage at Olkiluoto 2, the 6.6 kV medium voltage switchgears of the internal power supply system, which distributes most of the internal electrical power required by the unit, were modernised. This was done mainly because of the ageing of the original switchgears, the reduced availability of spare parts and to bring the switchgears up to modern requirements. During this REMES project, a total of over 60 medium voltage switchgear cubicles were modernised. The project included several significant modifications and replacements as regards i.a. the control, relay protection and auxiliary voltage systems, cabling and structural work.

The modernisation improved the availability, protection, control and resistance to malfunctions of the switchgears. The same modifications are due for implementation at Olkiluoto 1 in 2006.

APPENDIX 3 Significant operational events

Tapani Eurasto, Jukka Kupila, Risto Sairanen, Jorma Sandberg, Rainer Rantala, Kirsti Tossavainen

Loviisa nuclear power plant

A significant seawater level increase and a consequent emergency standby at Loviisa nuclear power plant
The seawater level at the Loviisa plant reached +1.4 m at 4.35 hrs on 9 January 2005. In accordance with the plant's emergency operating procedures, a special situation was declared onsite and monitoring was stepped up. At 7.39 hrs the water level reached +1.60 m. An emergency standby was declared at the plant in accordance with the emergency operating procedures and the plant's emergency organisation was summoned. At 11.55 hrs the water level reached its maximum value of +1.73 m. Flood monitoring was implemented. No flooding of the plant, or other phenomena endangering the plant's safety, were observed and both plant units operated as usual. The plant notified STUK of the special situation and the emergency standby whereafter STUK activated its own emergency organisation.

At 13.00 hrs the seawater level had decreased below the emergency standby limit of +1.60 m. The emergency standby was called off at 14.00 hrs and the special situation at 19.00 hrs.

The design basis seawater level for the Loviisa plant is +2.0 m. Significant flooding would only occur if +2.5 m were exceeded with simultaneous heavy sea swells. Had the seawater level exceeded +1.75 m at Loviisa 1 and +1.8 m at Loviisa 2, the units should have been placed in a shutdown state, as required by the emergency operating procedures.

Minor revisions of instructions as well as plant modifications have been carried out at the plant due to the event i.a. in order to harmonise the operation of different organisational units and to ascertain the operation of the drainage pumps of the plant's groundwater wells. The instructions, intervention limits and actions relating to a high seawater level have also been assessed. According to a utility assessment, the emergency operating procedures are not deficient. STUK will look further into the matter in 2006.

The seawater level along the entire Finnish south coast rose exceptionally high on 9 January 2005, with a relatively marked exceeding of previous maximum values by 15–30 cm. This was due to a heavy wind in the Baltic, water level oscillation across the Baltic basin caused by fluctuating airpressure and the large volume of water in the Baltic brought about by winds in the North Sea in the long term.

The safety level of the plant units was not significantly reduced by the exceptionally hight sea water level. The event was classified INES Level 0.

At the Olkiluoto power plant the seawater level increase was significantly less than in Loviisa and no measures needed to be taken.

A primary–to–secondary leak at Loviisa 2
Towards the end of 2004 it was discovered that primary circuit water enters the secondary circuit via one steam generator at Loviisa 2. The leak is very small and does not affect the radiation safety of the plant or the environment.

In the tubes of the plant unit's six steam generators circulates primary circuit water of approx. 300 degrees that vaporizes secondary circuit water into steam that is conveyed to turbines. Ejectors remove air and uncondensed gas from the turbine condenser and blow them to the atmosphere. In case of a primary–to–secondary leak, radioactive substances could escape to the atmosphere along with gas exiting the condenser and to the sea via secondary circuit drainage. During normal operation with no leaks, the secondary circuit contains no radioactive substances.

The leak was detected by laboratory measurements in October–November 2004 when a small amount of the isotope of arsenic-76, originating in primary circuit water, was found in main ejector air monitoring samples. The arsenic concentration was higher in December than before. In December the leak was confirmed by measurements according to which the tritium concentration in the Loviisa 2 secondary circuit exceeded that in Loviisa 1. The tritium, too, originates in primary circuit water. The leak point was located in a steam generator and was estimated at a few tens of millilitres per hour. The Technical Specifications allow a two-litre leak per hour before repair measures are to be taken. In case of a small leak, progress monitoring suffices.

Location of the leak point was attempted in the 2005 annual maintenance but this failed due to the leak's small size. The secondary side was pressurised to 6 bar to monitor air bubbles rising from the steam generator collector. The method has been used at other Loviisa type plants i.e. VVER-440 plants. Bubbles caused by the leak went unnoticed i.a. because gas that had become dissolved in water formed bubbles as well. The utility is looking into improvements in leak location methods.

Since 2002, there has been a primary-to-secondary leak in an other steam generator of the plant unit. It is considerably smaller than the one detected in 2004. Its locating has been unsuccessful due to its small size.

Releases from the Loviisa secondary circuit into the atmosphere are monitored by continuous activity monitors in the turbine plant steam lines and the main ejector exhaust lines and by laboratory analyses. In addition, secondary circuit activity measurements monitor water releases via the drainage system to the sea caused by secondary circuit leaks. Further, releases are evaluated, where necessary, by computational methods based on the activity concentration of primary-to-secondary leaks.

The heat transfer tubes of two steam generators at the Loviisa plant units are inspected by eddy current every two years i.e. all heat transfer tubes are inspected every six years. Almost 40 tubes have been plugged based on the inspections. The figure is small compared with other PWRs. Whenever possible, defective tubes are plugged before a through-wall flaw develops. The tubes' dimensioning allows for a relatively extensive through-wall defect before break. This concept of LBB implies that the margin to pipe rupture is adequate at the time of leak detection.

Olkiluoto nuclear power plant

Fuel cladding leaks at Olkiluoto 2

The leak detected on 30 August 2004

A leaking fuel rod was detected at Olkiluoto 2 on 30 August 2004. The first indication of a leak came from a turbine condenser exhaust gas activity measurement. The leak was confirmed by a laboratory measurement of a coolant sample taken the same day. A small pin-hole leak was concluded based on the measurements.

Fuel rods are thin metal tubes filled with uranium dioxide pellets. The fuel rod structure is shown in Fig L3.1. The gas tight cladding prevents radioactive fission products escaping from fuel to coolant. Activity concentrations in the reactor-to-turbine steam lines and condensate exhaust gas lines are monitored by continuous measurements providing the quickest indication of a fuel leak. In addition, the amounts of gaseous radioactive substances, and those dissolved in the coolant, are monitored by regular laboratory measurements.

Leak development was monitored for the entire operating cycle. The activity concentration released through the leak increased slowly first. The neptunium-239 activity concentration in the coolant began to increase in January 2005, indicating a cladding secondary leak. A secondary leak is formed when coolant enters the rod through the original leak, causing fuel cladding embrittlement from the inside. A secondary leak is usually larger than the original. Uranium from fuel pellets may enter coolant through the secondary leak. The first signs of this were obtained on 20 January 2005. Prior to the annual maintenance, a maximum of 12 g of uranium, equivalent to two fuel pellets, leached to the coolant via the secondary leak.

The leaking fuel assembly was localised on 16 October 2004. The load to the fuel cladding was reduced by limiting manoeuvring of the control rod located close to the assembly. The failed fuel assembly was removed from the reactor in the 2005 annual maintenance outage. On inspection, a thin metal strip was found in the assembly. The original failure was caused by the wear of the strip against the fuel assembly's corner rod cladding. Four months after this, a secondary cladding failure occurred at the lower end of the leaking fuel rod. It developed into a full transverse rupture towards the end of the fuel cycle

During the maintenance outage, Teollisuuden Voima Oy inspected all fuel assemblies that had been in the reactor during the 2004–2005 operating cycle for leaktightness and found no other leaking assemblies. The fuel leak did not have much bearing on the plant radiation levels and occupational doses incurred during the annual maintenance. Radioactive releases into the environment from the leak were insignificant and have no bearing on environmental radiation.

The event was classified INES Level 0.

The leak detected on 23 July 2005

Another fuel cladding leak was detected at Olkiluoto 2 on 23 July 2005. Based on continuous activity measurements of the turbine condenser exhaust gas, it was concluded to be a minor fuel leak. It has remained small and there has been no interaction between the coolant and uranium pellets. The leak is monitored i.a. by means of the reactor water iodine-131 activity concentration. By the end of 2005 the iodine-131 concentration was approx. three parts per thousand of the limit value at most, the exceeding of which restricts the operation of the reactor.

The utility follows leak progression by continuous activity measurements and laboratory measurements. The leaking assembly will be removed from the reactor not later than in the 2006 annual maintenance outage.

The event was classified INES Level 0.

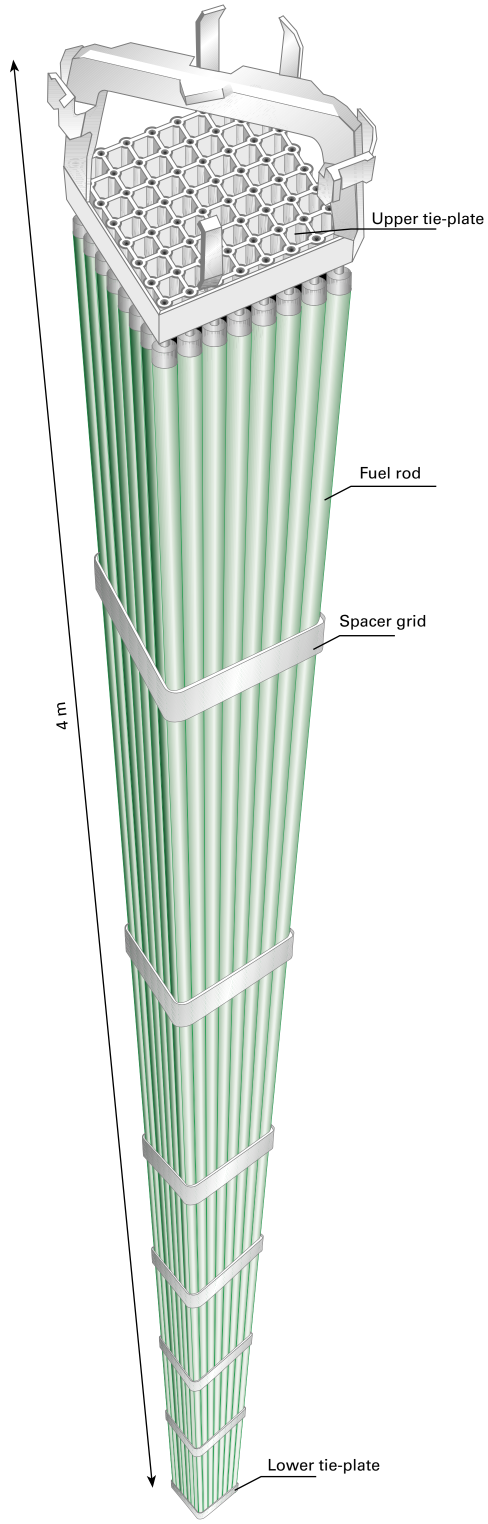


Figure L3.1. A diagrammatic drawing of an Olkiluoto 2 fuel assembly.

Maximum lifting hight for reactor pressure vessel head was exceeded at Olkiluoto 1 and 2

The reactor pressure vessel head has been lifted in non-conformance with the Technical Specifications (Tech Specs) at Olkiluoto 1 and 2. Since the annual maintenances of 1998, the normal lifting route has been unavailable due to steam separators removed from service being stored in the fuel pools. The RPV head has been lifted up to approx. 7.5 m in order to safely move it above and over the old steam separator. However, the Tech Specs defines approx. 5.7 m as the highest allowable lifting height. This ascertains reactor and fuel integrity in case the RPV head dropped on top of the open reactor during lifting.

Teollisuuden Voima Oy found out about the non-conformity during crane driver training on 29 April 2005 when the Tech Specs conditions relating to lifting were discussed. The utility thereafter applied STUK's approval for a manner of lifting that is in non-conformity with the Tech Specs. In the application, the safety significance of the increased lifting height had been assessed as regards the possible dropping of the RPV head. According to the new analyses presented in the application, the non-conformity did not jeopardise structural integrity. STUK approved it but required that earlier deviations from the Tech Specs be clarified and reported.

The event was classified INES Level 0.

The old Olkiluoto 2 steam separator was scrapped prior to the 2005 annual maintenance outage and the scrapping of the old Olkiluoto 1 steam separator was begun in September 2005; the work is estimated to be completed February 2006. This being the case, the original lifting height need not be deviated from anymore during RPV head lifts.

A setting error in electrical power supply circuit breakers shared by the Olkiluoto plant units

During the Olkiluoto 2 annual maintenance, on 9 May 2005, a setting error was detected in the relay protection of the electrical power supply circuit breakers shared by Olkiluoto 1 and 2, which could have brought about disturbances in the power supply connections between the units in case of need.

Electric cable connections have been established between the diesel-backed 660 V switchgears of Olkiluoto 1 and 2 to feed diesel-backed electrical power from one unit to the other, if necessary. If the need arises, the cable connections are used to replace one unit's failed back-up diesel generator with the other unit's operational diesel generator. The cable connections are equipped with eight identical supply circuit breakers to implement electrical power supply.

During the Olkiluoto 2 annual maintenance, medium voltage switchgear modernisations (the REMES project) were carried out requiring temporary electric systems connections to be set up. These utilised the supply circuit breakers of the electrical power supply connections between the plant units. During the taking into service of a temporary connection it was detected that two supply circuit breakers of the electrical power supply connections between the plant units opened. During problem shooting it was found out that the short-circuit protection set values of the circuit breakers in question were incorrect and lacked the 0.1 second design time delay. Later analyses established incorrect short-circuit protection in all eight circuit breakers.

The analyses give reason to suspect that this has been a latent defect since the circuit breakers in question were installed in 1989. Due to the temporary nature of the connections the event had little impact on the safety of the plant units. In case of a real need, however, the incorrect circuit breaker protection set values could have caused disturbances in the electrical power supply connections. The event was classified INES Level 1.

Due to the event, Teollisuuden Voima Oy checked the set values of all cirucit breakers and replaced incorrect values with design values. In addition, the utility has ascertained the appropriateness of the preventive maintenance and relay testing programmes for equivalent circuit breakers.

A power failure at Olkiluoto 2 during the annual maintenance outage

During the annual maintenance of Olkiluoto 2, on 11 May 2005, a power failure occurred that stopped the operation of some plant unit components ensuring nuclear safety, such as pumps ensuring decay heat removal during the outage, until the back-up diesel generators started up. The power failure brought about i.a. lighting, ventilation and lift malfunctions.

In connection with temporary coupling arrangements made during modifications carried out during the annual maintenance, one offsite 110 kV grid supply circuit breaker opened in consequence of an incorrectly planned isolation of the control cables of a supply circuit breaker. The circuit breaker's opening caused loss of voltage in two of the plant unit's four diesel-backed internal power supply sub-systems. A diesel generator backing up the operation of one sub-system started up immediately, supplying reserve electrical power as designed. Another sub-system's diesel generator failed to start automatically, however, since it had undergone simultaneous relay protection testing preventing automatic actuation and engagement. The diesel generator was started manually but the closing of its switch failed due to the incorrectly planned isolation of the switch control circuit. Teollisuuden Voima Oy analysed the event's causes and re-energised the sub-system in about half an hour after the power failure.

The event did not endanger nuclear fuel cooling or cause any other dangerous situations. Several human errors were related to it, however, which could have resulted in a significantly longer power failure. It was also an indication of shortcomings in the work planning of systems important to safety and was thus classified INES Level 1.

The power failure was due to an electrical couplings isolation error made during electrical systems modifications. Due to the event, the utility discontinued the work in question and reviewed the plans for the safety couplings of the modifications and verified the timetables. In addition, improvements were planned in the co-ordination of the testing of systems important to safety.

Back-up diesel generator air intake opening was closed at Olkiluoto 2

In connection with the replacement of outer doors at the Olkiluoto 1 and 2 plant units, an air intake opening above the outer doors of the diesel generator room was covered to shut out concrete dust from an air duct. The closing of a diesel engine's intake air opening would not have made the engine totally inoperational but it did reduce the likeliness of its successful starting.

Both Olkiluoto plant units have four back-up diesel generators that automatically start to supply the electrical power required by the plant units in a situation where a plant unit's off- and onsite power supplies have been lost. The diesel generators are housed in separate rooms. The Tech Specs require that each plant unit has available at least two operational diesel generators plus their auxiliary systems. The outer doors of the power plant's buildings and those of the back-up diesel generator rooms are due for replacement. The diesel engine combustion air intake opening and its air ducts are right above the diesel generator room doors.

At Olkiluoto 1, one diesel generator room door was replaced on 17 to 21 March 2005. During the work it was found out that the frame of the new door exceeds in height the opening for the old door. On both sides of the air intake opening, some of the concrete wall above the door had to be removed and the latticework of the opening reshaped to fit in the frame of the new door. The concrete was removed using an angle grinder. The air intake opening was covered with a plywood board for the duration of the operation to prevent dust entering it. It was allowed to be in place only when the concrete was being cut. It was to be removed on exit from the place of work or in case a diesel engine starts while the work was being done. The board was blocking the air intake opening for approx. two hours.

At Olkiluoto 2, diesel generator room doors were replaced as of 15 July and 13 September 2005 on, employing the same procedure. When replacing the latter door, attention was paid to the plywood board covering the air intake opening. It was removed and work was continued without it.

In consequence of the event, work methods were changed to make it unnecessary to cover the opening. In addition, the utility revised the work permit procedure for door replacement work.

The event was classified INES Level 0.

Alarm testing of the carbon-dioxide fire suppression system for diesel generator rooms was not done at Olkiluoto 1 and 2

The alarm testing of the carbon-dioxide fire suppression system for the diesel generator rooms has not been done once a week as required in the Tech Specs.

The system is intended for the automatic or manual suppression of a possible fire in the waste building or the back-up diesel generator rooms. The system is also intended to prevent a fire from spreading to rooms in the vicinity of an object of ignition. The system is basically comprised of a 5000 kg subcooled CO_2 tank, with separate CO_2 lines to the back-up diesel generators, the bitumen handling facilities as well as the waste storage. The system is always available. If a fire, considered beyond the capacity of a portable fire extinguisher, is detected in one of the diesel generator rooms, the ventilation system is shut down and CO_2 , actuated by a manual switch device, is discharged to the room. In other objects of ignition the system functions automatically and guided by its own detectors, or by manual trip.

Towards the end of 1998, CO_2 tank weight measurements made by an unreliable mechanical crank arm method were replaced by measurements made by electronic equipment. The tank's weight lower limit alarm became difficult to test. Control was changed: instead of periodic alarm testing every seven days, receipt of the alarm signal at the central control room is ascertained in connection with quarterly test actuations. The Tech Specs' requirement for the periodic testing frequency, or the need to revise the Tech Specs, were not recognised. However, the volume of carbon dioxide in the tank has been controlled in connection with the weekly inspection required in the Tech Specs by writing down the reading yielded by an electronic scales.

Due to the event, the utility updated the Tech Specs and reviewed document uniformity.

The event was classified INES Level 1 due to the occurrence of previous events where the need to review the Tech Specs had not been recognised (see i.a. Annual Reports 2000, 2002 and 2003).

APPENDIX 4 Licences in accordance with the Nuclear Energy Act in 2005

- C81/2, 14 Feb 2005 Teollisuuden Voima Oy
Transfer of a 9.4 m^3 batch of waste oil cleared from regulatory control from Olkiluoto nuclear power plant to Ekokem Oy for use as saw chain oil. Valid until 31 December 2005.
- A214/68, 18 Feb 2005 Fortum Power and Heat Oy
Export to Germany of documentation on the I&C system of Loviisa power plant. Valid until 30 June 2006.
- C3163/2, 22 Feb 2005 Teollisuuden Voima Oy
Permission to handle and store contaminated components in the building situated at the western side end of the MAJ storage building (components storage). Valid until 31 December 2018.
- Y214/99, 11 Apr 2005 TUMO OY
The possession, storage, handling and use of a 15 g batch of thorium nitrate does not require a licence in accordance with the Nuclear Energy Act but a notification of the activity shall be given in accordance with section 17 of the Nuclear Energy Decree.
- D81/1, 3 May 2005 Teollisuuden Voima Oy
Transfer of a 50 m^3 batch of waste oil cleared from regulatory control from Olkiluoto nuclear power plant to Ekokem Oy for use as saw chain oil. Valid until 31 December 2005.
- A214/71, 20 May 2005 and A214/72, 20 May 2005 Fortum Power and Heat Oy
Amendment to the conditions of the licences A214/50A and A214/50B to import nuclear fuel containing Russian and Kazakhstan origin uranium, 19 February 2004.
- D214/9, 22. Sep 2005, Teollisuuden Voima Oy
Import from Sweden of control rods made of zirconium alloy for use as spare parts. Two rods with a total max. of 4 kg of zirconium. Valid until 30 June 2005.
- C214/262, 31 Oct 2005, Teollisuuden Voima Oy
Import of fresh nuclear fuel from Sweden. Max. 10 100 kg of uranium with a U-235 enrichment not exceeding 5%. Provided with the Euratom obligation code “P”. Valid until 31 December 2006.
- C214/263, 9 Nov 2005, Teollisuuden Voima Oy
Import of fresh nuclear fuel from Spain. Max. 7650 kg of uranium with a U-235 enrichment not exceeding 5%. Provided with the Euratom obligation code “C”. Valid until 31 December 2006.
- C214/264, 9 Nov 2005, Teollisuuden Voima Oy
Import of fresh nuclear fuel from Spain. Max. 13 650 kg of uranium with a U-235 enrichment not exceeding 5%. Provided with the Euratom obligation code “S”. Valid until 31 December 2006.
- C821/81, 21 Dec 2005 Teollisuuden Voima Oy
Transfer of two batches of waste oil, 8.4 m^3 and 7.7 m^3, cleared from regulatory control from Olkiluoto nuclear power plant to Ekokem Oy for use as saw chain oil. Valid until 31 December 2006.

APPENDIX 5 STUK's periodic inspection programme

Basic programme	Inspections in 2005	
	Loviisa nuclear power plant	Olkiluoto nuclear power plant
A. Safety management		
B. Main functions		
B.1. Assessment and improvement of safety	x	x
B.2. Operation		x
B.3. Plant maintenance and ageing management		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	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	
C.13. Training / Human resources and training		x
C.14. Quality assurance	x	x

* An inspection is comprised of multiple subinspections

APPENDIX 6 STUK's periodic inspection programme during construction

	Inspections in 2005
Main functions	
Project quality management (two inspections in 2005)	x
Project management and resources	x
Safety issues	x
Project management and realisation, document management	x
Work processes	
Training of operational personnel	x
Quality assurance of construction	x
Utilisation of PSA	x
Radiation safety	x
Inspection procedures	x
Inspection of:	
• I&C design	x
• Main components design and inspection	x
To be inspected in connection with the periodic inspection programme	
Emergency preparedness	x
Physical protection	
Fire protection	x
Nuclear waste	

APPENDIX 7 STUK-financed technical support projects completed in 2005

Nuclear power plants

Technical support for regulatory decision-making

FIN5 – STUK's safety review during construction licence phase. Independent comparative analysis in order to analyse the reactor circuit behaviour during accident situations; VTT Processes

FIN5 – STUK's safety review during construction licence phase. Independent comparative analysis in order to analyse behaviour of the containment during accident situations; VTT Processes

FIN5 – STUK's safety review during construction licence phase. Independent comparative analysis of severe accidents; VTT Processes

OL3 – Review of the design phase PSA; VTT Industrial Systems

OL3 – Radiation doses to the surrounding population; Review of computer based systems for prediction of radiation doses in emergency situations; VTT Processes

ASTRID-calculation tool; development of the programme; VTT Energy

Evaluation of conceptual designs of I&C systems for nuclear power plants; VTT Industrial Systems

OL3 – Assessment of the fire safety; FRNC-cables; VTT Building and Transport

OL3 – Analysis of Aircraft Crashes; VTT Industrial Systems

OL3 – Review of design documents for the fuel building (UFA) and safeguards buildings (UHJ/UJK), Insinööritoimisto Pontek Oy

OL3 – Corrosion resistance of the steel liner embedded in concrete structures; VTT Building and Transport

OL3 – STUK-GRS-04: Development and review of criteria for external hazards specially aircraft impact and fire; Gesellschaft für Anlagen- und Reaktorsicherheit (GRS) mbH

OL3 – Review of design documents for the reactor building base slab; Insinööritoimisto Pontek Oy

OL3 – Water chemistry of the primary circuit; consultation; VTT Industrial Systems

OL3 – Review of design documents for the containment building; VTT Building and Transport

OL3 – Concrete structures; Review of design documents for the anchoring and steel parts embedded in concrete; VTT Building and Transport

APROS 3D -ohjelma; Diplomityö: FANP-PKL-koelaitteiston mallintaminen; VTT Prosessit

OL3 – Conceptual design of earthing, lightning protection, EMC, cabling and HEMP/HPEM systems; Expert opinions; Nemko Product Services Oy

OL3 – Thermal loads of the reactor pit structural concrete in a severe accident. VTT Processes

Loviisa power plant, Final disposal repository of solidified waste, Review of the structural design; VTT Building and Transport

OL3 – Review of the 3D-Nonlinear Finite Element Analysis; VTT Building and Transport

Consulting assignments of OL3- primary circuit strength analysis, manufacturing technology and construction plans, VTT Industrial Systems

OL3 – Requirements for coatings of nuclear power plant containment; VTT Building and Transport

OL3 – Review of design documents for the concrete structures inside reactor building steel liner; Insinööritoimisto Pontek Oy

Loviisa power plant, design of the new automation buildings; review of structural design; VTT Building and Transport

Impact of meteorological phenomena on nuclear power plant safety. Participation in a seminar on meteorological phenomena and other environmental conditions; Finnish Meteorological Institute.

Effects of a 12-hour shift system on the work of NPP operators; University of Helsinki / Department of Psychology

OL3 – Review of the specification for seismic qualification of electrical and I&C components; VTT Building and Transport

Volley test facility, facility upgrading and experiments with the new facility. Lappeenranta University of Technology

IZNA-4 literature survey, Annual report + 2 special reports, Advanced Nuclear Technology International

Nuclear waste management

Technical support for regulatory decision-making

National expert group for the safeguards of final disposal (LOSKA); Application of geophysical radar method for safeguards monitoring at Olkiluoto spent fuel disposal site; JP Fintact Oy

Regulatory control of Posiva's site confirmation investigations at Olkiluoto; Siivola 2005; private consultants

Safety of nuclear waste management; 2004; Alternative, transparent tools for uncertainty analysis in safety assessment and for decision making; Comissáo Nacional de Energia Nuclear