STUK-B-YTO 233 / JULY 2004

REGULATORY CONTROL OF NUCLEAR SAFETY IN FINLAND

Annual report 2003

Kirsti Tossavainen (ed.)

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ISBN 951-712-884-3 (nid.)
ISBN 951-712-885-1 (pdf)
ISSN 0781-2884

Dark Oy, Vantaa/Finland 2004

TOSSAVAINEN Kirsti (ed.). Regulatory control of nuclear safety in Finland 2003. STUK-B-YTO 233. Helsinki 2004. 50 pp. + Appendices 60 pp.

Avainsanat: nuclear energy, nuclear facility, nuclear waste, regulatory control, safety performance indicators

Abstract

This report covers regulatory control of nuclear safety in 2003. Its submission to the Ministry of Trade and Industry by the Radiation and Nuclear Safety Authority (STUK) is stipulated in section 121 of the Nuclear Energy Decree. Nuclear safety regulation focused on the design and operation of Finnish nuclear facilities as well as on nuclear waste management and nuclear materials.

No events occurred at the nuclear power plants that would have endangered the safe use of nuclear energy. At the Olkiluoto nuclear power plant, the number of plant conditions in non-compliance with the Technical Specifications was higher than usual. These had noteworthy common features, such as shortcomings in adherence to regulations, administration of periodic inspections, monitoring of plant states and identification of the requirements of the Technical Specifications. The licensee has launched the necessary development measures.

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

The nuclear safety indicators describing the effectiveness of STUK's activities did not indicate changes that would have warranted STUK's immediate reaction, with the exception of the above indicators pertaining to anomalies at Olkiluoto plant.

No events endangering safety occurred at the FiR 1 research reactor either. In addition, the radiation doses of those working at the research reactor and radioactive releases into the environment were clearly below set limits.

The regulation of nuclear waste management focused on spent fuel storage and preparation of final disposal as well as the treatment, storage and final disposal of reactor waste. No events occurred in nuclear waste management that would have endangered safety. In the field of nuclear material safeguards, the use of nuclear materials in accordance with current regulations and the completeness and correctness of nuclear material accounting were verified.

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

The total costs of nuclear safety regulation in 2003 were 8.7 M€. The total costs of operations subject to a charge were 7.2 M€, the full amount of which was charged to the licensees and licence-applicants.

Contents

1 Preface

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

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

Nuclear safety regulation mostly focused on the Loviisa 1 and 2 nuclear power plant units owned by Fortum Power and Heat Oy and the Olkiluoto 1 ja 2 units owned by Teollisuuden Voima Oy as well as their nuclear waste management and nuclear materials. Fortum Power and Heat Oy and Teollisuuden Voima Oy are later in the text also referred to as licensee or utility. The planning and later implementation of the final disposal of nuclear fuel, which is part of nuclear waste management, 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. In addition, matters relating to the new reactor in planning were dealt with.

Loviisa 1 began generating electricity to the national grid in 1977 and Loviisa 2 in 1981. Their operating permits were renewed in 1998 and will expire at the end of 2007. The highest allowable reactor nominal thermal power for each unit, according to a permit granted by the Government, is 1500 MW. The permits cover also facilities for waste management. 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. The operating permits of the Olkiluoto plant units were renewed in 1998. They will expire at the end of 2018 and cover also spent fuel intermediate storage as well as low and intermediate level reactor waste storage. According to the permits, 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. The permit conditions require that the licensee makes, by the end of 2008, an extensive intermediate safety assessment for the Olkiluoto nuclear power plant. Requirements for the contents of the assessment are set by STUK.

This report's section on nuclear reactor regulation describes assessment of Loviisa and Olkiluoto's safety as well as plant modifications control and of operation of licensee organisations. The efficiency and effectiveness of nuclear safety regulation is analysed using STUK's Safety Performance Indicator System. This report contains a description of the operation of Finnish nuclear power plants, the most important operational events and safety improvements at the plants. Radiation safety at the plants is analysed by looking at occupational and collective doses at the facilities as well as at the outcome of monitoring for radiation in releases and the environment.

The chapter on nuclear waste management deals with nuclear fuel intermediate storage and preparation for final disposal as well as treatment of reactor waste.

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

In addition, 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 as well.

2 Regulatory guides

Pekka Salminen

Revision and updating of YVL guides continued. The guides are detailed safety regulations for nuclear facilities, issued by STUK on the basis of the Nuclear Energy Act (990/1987) and the Government Resolution (395/1991) on the general safety regulations for nuclear power plants. The guides describe STUK's regulatory procedures as well. STUK decides, case by case, how new guides apply to facilities already in operation. Such decisions, made in 2003, are discusssed in sub-sections 3.1.1 and 3.2.1.

A total of about 45 guides were being prepared or reviewed in YVL guide working groups, with 12 guides completed by the end of the year. The number of YVL guides published in 1999–2003 is given in Fig. 1. Four guides were translated into English and two into Swedish. They were issued in print and on the Internet; the Swedish language versions were only available on the Internet, however. Principles that apply to the long-term revision of the YVL guides were incorporated in the STUK strategy and in a separate regulatory guide action plan.

The project to construct a new nuclear power plant has made it necessary to speed up the preparation of some YVL guides having a bearing on nuclear power plant design. In so far as the guides were not completed on schedule, the license applicant was regularly sent reports on their status. In addition, the license applicant was informed about any new requirements planned in the guides under revision.

During 2003, an amendment was prepared in the Nuclear Energy Act to establish a special fund arrangement for research in the field of nuclear safety. It took effect on 1 January 2004. It serves to ensure a high level in domestic research and the preservation of expertise. No amendments were prepared to the general nuclear safety regulations issued as Government Resolutions.

Nuclear safety recommendations are also given by international organisations, such as the EU, the IAEA, the OECD/NEA and various countries' national authorities. They did not give any cause to update the Finnish nuclear legislation. STUK prepared to the IAEA statements on three draft safety guides.

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

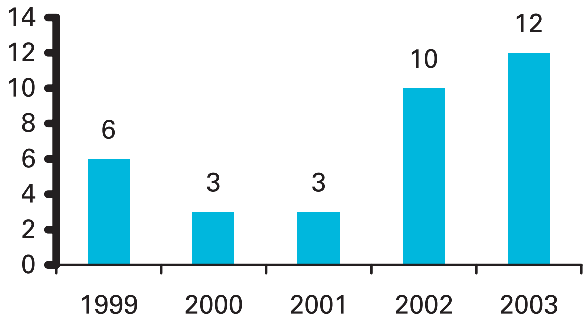


Figure 1. Number of yearly published YVL guides.

3 Nuclear facilities regulation

Kirsi Alm-Lytz, Timo Eurasto, Tarja K. Ikäheimonen, Marja-Leena Järvinen, Tapani Koljander, Seppo Klemola, Jouko Mononen, Ilkka Niemelä, Matti Ojanen, Suvi Ristonmaa, Pekka Salminen, Seija Suksi, Heimo Takala, Petteri Tiippana, Kirsti Tossavainen, Keijo Valtonen, Reino Virolainen, Tapani Virolainen, Kaisa Åstrand

3.1 Loviisa nuclear power plant

3.1.1 Overall safety assessment

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 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 5.5, Instrumentation systems and components of nuclear facilities, 13 September 2002
- Guide YVL 6.7, Quality management of nuclear fuel, 17 March 2003.

For implementation of Guide YVL 5.5, Fortum Power and Heat Oy carried out an extensive assessment by comparing Loviisa plant's I&C systems and administrative procedures with the requirements of the new guide. Established shortcomings and the procedures to eliminate them were presented in an action programme which was confirmed by STUK. Should any differences be observed in the systems' implementation, most of them will be fixed in connection with the I&C system upgrading of the Loviisa plant in the near future.

STUK noted in its decision to implement Guide YVL 6.7 that the nuclear fuel quality management and assurance procedures used by Loviisa plant cover well the requirements of the revised guide. In so far as they remain unfulfilled, Fortum Power and Heat Oy presented an action plan with schedules, which STUK confirmed.

Annual safety assessment

The annual safety assessment for Loviisa nuclear power plant looks at observations made in regulatory work pertaining to plant modifications, availability and organisational operation. The various areas contained in the assessment are discussed in more detail in this report's chapters dealing with nuclear regulation and in its appendices.

Two significant plant improvements were completed at both Loviisa nuclear power plant units in 2003: upgrading of the severe accident management system and the plant's radiation measurement system. The utility made an important decision pertaining to management of the plant's ageing, ie to entirely upgrade the plant's I&C systems in 2006–2014. Conceptual design planning for the upgrading was launched by the utility in 2000.

STUK detected no significant safety-related shortcomings in 2003 during its work to ascertain the availability of Loviisa nuclear power plant. The number of plant conditions in non-compliance with the Technical Specifications was low and only one operational event required a special report. The annual maintenance outages of Loviisa nuclear power plant were refuelling outages and no significant safety-related observations were made during them. Of inspections conducted during the outage, worth mentioning are: an inspection of the area containing the temperature sensors of the protection pipes of control rod drives and also replacement of some shroud tubes due to cracking.

No individual occupational dose at the plant exceeded the individual dose limit. The collective occupational radiation dose was low internationally. Radioactive releases were low, too, and the radiation dose calculated on their basis for the most exposed individual in the vicinity of Loviisa nuclear power plant was clearly below the limit given in a Government Resolution.

The Loviisa nuclear power plant strategy defines 50 years as the plant's service life. In connection with the renewal of the plant's organisation, ageing management is considered the organisation's essential working process, which is described in procedures completed in 2003. No significant safety defects surfaced in inspections pertaining to the ageing of mechanical components, electrical and I&C systems and structures. The safety indicators for Loviisa plant's maintenance showed a deteriorating trend in 2003.

The qualification of methods for the periodic inspection of the most important mechanical components by non-destructive testing is important in assuring the reliability of data on ageing management. The qualification of ultrasonic and eddy current testing has not been developed as quickly as STUK required, based on European recommendations. To repair the situation, new domestic arrangements have been agreed upon with both utilities for the carrying out of the qualification processes.

The renewal of Loviisa power plant's organisation plus the associated renewal of the plant's quality management system emphasise safety and the management of plant service life to assure plant safety and reliability. Assurance of personnel competence in connection with change of generation is related to this matter. Loviisa power plant has drawn up a plan to assure preservation of knowledge concerning the plant and its safety with the operating organisation.

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

STUK did not start any new investigation into the plant's operation in 2003.

Annual assessment of deterministic safety analyses

The licensees update the nuclear power plants' deterministic safety analyses in connection with the renewal of operating permits. 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 commissions the conducting, where necessary, of its own reference analyses. In 2003, no deterministic safety analyses on the Loviisa plant were submitted to STUK for review.

Annual assessment of probabilistic safety analyses

STUK reviewed Loviisa plant's updated annual maintenance outage risk analysis. It contains analyses of onsite initiating events, heavy lifts and flooding during outages. As measures reducing risks during outages, modifications decided upon for other reasons, e.g. the construction of a primary circuit shutdown cooling system, procedural modifications as well as changes in inspections and testing had been identified.

The risk of cold shutdowns, $6.5 \cdot 10^{-5}$/year, constitutes over 90% of the risk estimated so far for brief annual maintenances, or those of normal duration. Total outage risk, hot shutdowns included, is $7.1 \cdot 10^{-5}$/year. The risk assessed for cold shutdowns mainly divides between the four initiating event groups below:

- Drops of heavy load lifts in the reactor hall (21%)
- Dilution of primary coolant boron concentration (19%)
- Flooding (19%)
- Loss of service water system (18%)

Modifications were implemented at the Loviisa plant in 2003 to reduce risk during outages. A temporary dam is always constructed on the sea water outlet channel during outages, which prevents flooding in the lower compartments of the building during their inspection. An inspection was added to the work permit routines during outages to assure a sufficiently high dam. The new inspection procedure was first used in the 2003 annual maintenance.

A sampling system piping modification was made at both plant units to facilitate continuous primary circuit water sample analysis even during cold shutdowns and refuelling outages. The modification improves control of situations involving unplanned dilution of the primary coolant boron concentration and thus reduces the risk from this.

To further decrease risk during outages, emergency bonnets were made for the valves of the recirculation lines of the emergency core cooling system and they are to be kept easily available. The bonnets are installed without delay on the flange of a valve opened for maintenance if maintenance work is interrupted or a water or steam leak occurs through it. The modification reduces the risk of a leak through the valve during maintenance.

In addition to the modifications implemented, an analysis of the remaining service life of the reactor hall crane is under way. The objective is to reduce the risk from heavy lifts, which accounts for about 21% of outage risk.

Safety performance indicators

The requirements set for the safety performance indicators for nuclear power plants were fulfilled at Loviisa power plant as regards occupational doses, radioactive releases and population exposure. Releases into the sea were reduced to the current level in 1992 when caesium separation equipment were commissioned at the plant.

No events occurred at the Loviisa plant units that would have endangered plant safety. The objective set for the risk-importance of the inoperability of components with a bearing on accident risk, max 5 %, was exceeded at both Loviisa nuclear power plant units. This was due to back-up diesel generator latent defects and auxiliary feed water system maintenance work. No special action by STUK was required.

The number of events reported in accordance with Guide YVL 1.5 was decreasing compared with the previous year.

The indicators showed a deteriorating trend for maintenance at the Loviisa power plant in 2003. The failures of components subject to the Technical Specifications were apparent in multiple technical fields and no special problem area could be pointed out. It will be apparent in the future, whether an actual change has taken place in the previously decreasing trend.

The structural integrity of multiple barriers containing radioactive releases is good. There have been no fuel leaks at the Loviisa plant units for years now. The combined leakage rate of containment penetrations and airlocks increased but the limit was not exceeded. The leaktightness of the rubber bellows of the penetrations had been problematic and the Loviisa power plant had proposed their conversion to metal structures.

The effectiveness of STUK's operations is evaluated by means of indicators describing plant safety. The outcome for 2003 is given in Appendix 1. It also gives some background for the indicators and the procedures for acquiring them.

3.1.2 Oversight of plant modifications

Oversight of plant modifications 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. Modifications to improve the safety of the plant units are described in Appendix 2. During the 2003 annual maintenance outage, system modifications were completed at the plant that were part of a project in provision against severe accidents. A project to replace radiation measurements was also completed. 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 in which the licensees' representatives accounted for modifications planned, those due for implementation in the next annual maintenance, or later, and also the status of ongoing modifications. In many of these meetings, the planned I&C systems upgrading was discussed. Modifications were also regularly dealt with at STUK internal oversight meetings and topical meetings.

In consequence of modifications already implemented at the plant, several documents changed that describe the plants' operation and structure - such as the Technical Specifications, the Final Safety Analysis Report and the operating and maintenance instructions. STUK supervised the document revisions and generally followed the updating of plant documentation after the modifications. A computer-based plant modifications register was used to follow the status of safety-significant modifications. In 2003, seven new modifications at the Loviisa plant unit were entered into the register. On the register, several uncompleted modifications, registered previously, were also followed. In addition, the register was utilised in monitoring the implementation of document revisions pertaining to modifications. This resulted in the observation that document revisions relating to modifications made in 2002, which were followed on the register, were completed at the Loviisa plant in 96% by the annual maintenance of 2003 (Appendix 1, indicator A.I.6).

3.1.3 Oversight of plant operability

Compliance with the Technical Specifications

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

One situation occurred at the Loviisa plant units during which a plant unit did not comply with the Technical Specifications (Appendix 1, indicator A.I.2). This was in connection with the renewal of radiation measurements. The event is looked into in more detail in Appendix 3. The licensee has planned actions to prevent recurrence.

The Technical Specifications were also deviated from by applying in advance for STUK's approval of non-compliances. In 2003, the licensee applied for approval of 21 deviations from the Technical Specifications. (Appendix 1, indicator A.I.2). After having analysed the deviations' safety significance, STUK approved all the applications. Ten exemptions pertained to deviations from the Technical Specifications caused by plant modifications. Two approvals were granted for a deviation pertaining to a specific testing or fault detection. The other six related to non-compliances during repairs and maintenance.

Operational events

The Loviisa plant units operated reliably in 2003. The load factor of Loviisa 1 was 92.4 % and that of Loviisa 2 was 87.9%. Fig. 2 gives the plant units' load factors for 1994–2003. The duration of the annual maintenance outage at Loviisa 1 was 23.5 days and 16.5 days at Loviisa 2. There were no other production breaks at the plant units. In May Loviisa 2 operated for about 20 days at about 50% power to repair a leak in the hydrogen cooling system of the plant unit's other generator and to find out the cause of an elevated turbine supporting bearing temperature. Loviisa 2 operated at about 50% even after the annual maintenance outage for replacement of the generator stator of the plant unit's other generator. The power reduction lasted for about 41 days. In July–August power at both plant units had to be reduced due to exceptionally high sea water temperature.

Figure 3 gives the daily average gross powers of the plant units in 2003. Production losses in nominal output caused by component failures were 0.1% at Loviisa 1 and 2.6% at Loviisa 2. Production losses from component failures in a longer time period are depicted by indicators in Appendix 1 (indicator A.I.1g).

At the Loviisa plant units, one event warranted a special report and five operational transients

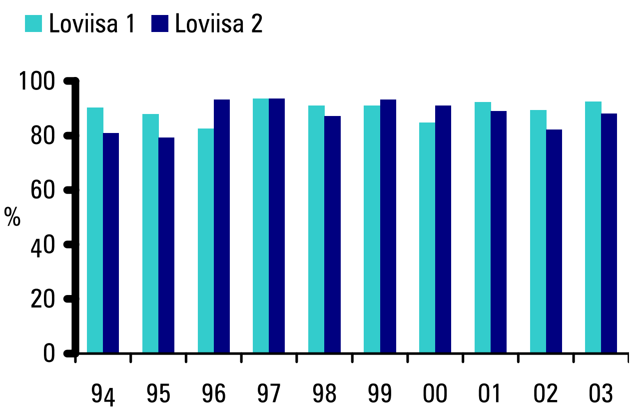


Figure 2. Load factors of the Loviisa plant units.

were reported to STUK. No reactor scrams occurred at the plant units (Appendix 1, indicator A.II.1). In addition to event reports, the Loviisa power plant submitted to STUK daily reports, quarterly reports, annual reports, outage reports, annual environmental safety reports, monthly individual dose reports, annual operational feed back reports and nuclear safeguards reports.

The special report submitted by the Loviisa plant concerned an event during which three ventilation stack monitors were simultaneously inoperational for about 20 hours during the renewal of radiation measurements at Loviisa 2. The event was classified INES Level 0. The event is explained in more detail in Appendix 3. Figure 4 gives the number of INES Level 1 events in 1994–2003. During this time period, no events exceeding INES Level 1 occurred at the Loviisa plant.

Annual maintenance outages

The annual maintenance outages of the Loviisa plant units were refuelling outages, which means that, in addition to refuelling, only necessary maintenance, repairs, testing and minor modifications were carried out. The Loviisa 1 annual maintenance outage was on 2 to 25 August, 2003. It lasted 23.5 days, whereas its planned duration was 16.5 days. The extension was due, among others, to the commissioning of new reactor pit washing equipment and the repair of a regulator valve in the primary coolant pump sealing water system during startup. The Loviisa 2 annual maintenance outage was on 23 August to 9 September 2003. It lasted 16.5 days. During it a replacement of the stator of the other generator was started, which was continued after the annual maintenance.

The licensee inspected areas of the control rod drive mechanism protection pipes around their temperature measurement devices, since cracking had been detected in the protection pipes previously (Annual Report 2002, STUK-B-YTO 224). At Loviisa 1, defects in three protection pipes were found and the pipes were replaced. Seven defective protection pipes were found at Loviisa 2. The temperature measurement device insulation shield boxes, which gather humidity thus causing stress corrosion, have now been removed from about half of all the protection pipes. The rest of the shield boxes are due for removal and the protection pipes are due for inspection in the 2004

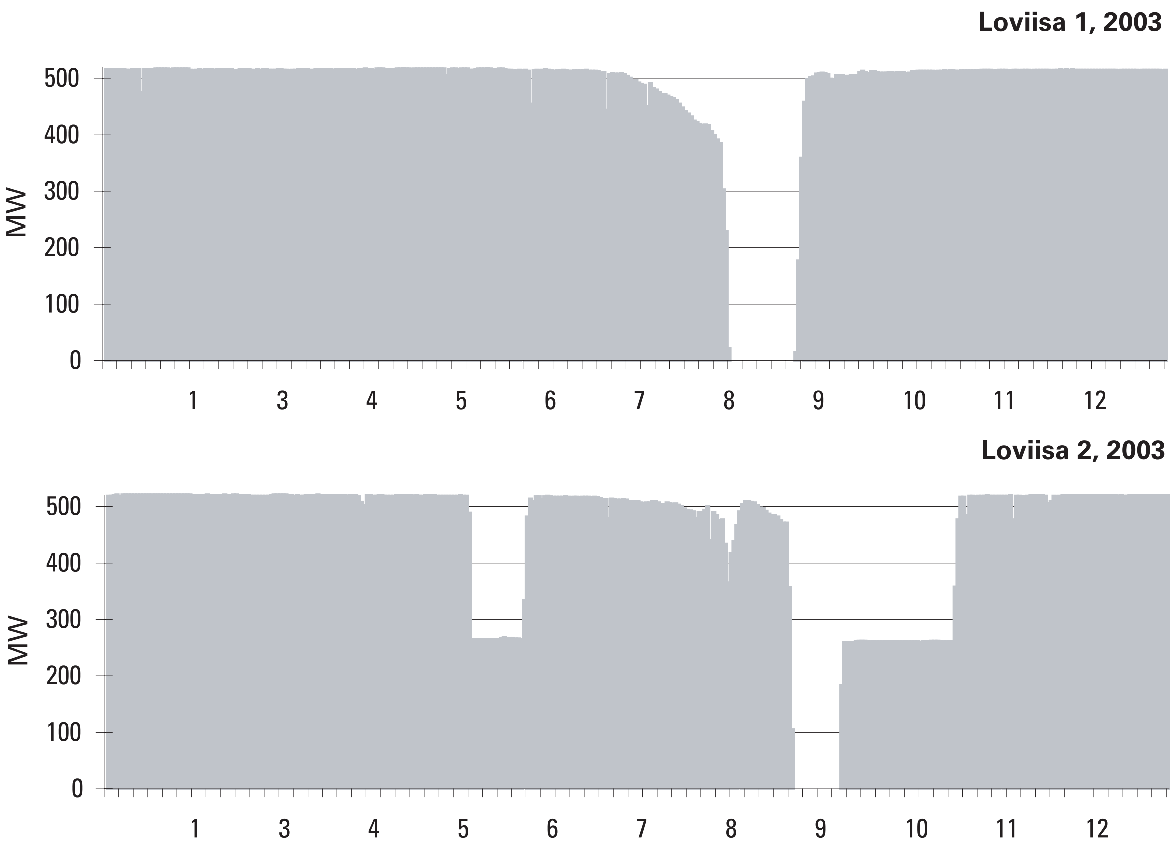


Figure 3. Daily average gross power of the Loviisa plant units in 2003.

outages. Removal of insulation lowers the measured temperature value by a few degrees, which will be taken into account in assessment of the measurement results. The protection pipes are visually inspected every two weeks during operation. Even very small leaks are detectable by the boric acid crystallised on the pipe surfaces. Potential minor leaks would not endanger plant safety but it would have to be placed into cold shutdown for repairs.

Safety improvements made during the annual maintenance outage are described in Appendix 2.

The collective radiation dose incurred in outage work was 0.56 manSv at Loviisa 1 and 0.29 manSv at Loviisa 2. The highest individual dose during Loviisa 1 annual maintenance was 7.7 mSv and that for Loviisa 2 was 4.4 mSv. Figure 5 presents the collective radiation dose incurred in annual maintenance outage work in 1999–2003. Radiation safety at the Loviisa plant units as a whole is described separately in this chapter.

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

During the annual maintenance outages, STUK carried out inspections required in the Pressure Equipment Act. In addition, the periodic inspections of pressure vessels and other pressure-bearing components were controlled by reviewing programmes pertaining to them and witnessing inspections onsite.

STUK controlled also the bringing of the plant units into a shutdown state and their subsequent startup. STUK approved on 25 July 2003 the starting of a Loviisa 1 refuelling outage and on 22 August 2003 the starting of a Loviisa 2 outage. The permission to start up Loviisa 1 was granted on 18 August 2003. STUK's inspectors ascertained the plant unit's start-up readiness onsite on 24 August 2003. Loviisa 1 was connected to the national grid on 25 August 2003. The permission for Loviisa 2's start-up was given by STUK on 7 September 2003 and the plant unit's start-up readiness was established onsite on 8 September 2003. Loviisa 2 was connected to the national grid on 9 September 2003.

The regulatory oversight of Loviisa facility's annual maintenance outages onsite took 128 working days. One resident inspector was regularly working on the site as well.

Ageing

The strategic objective for Loviisa power plant's service life management currently is 50 years' operating life. Service life management is one of the main tasks of the power plant engineering divi-

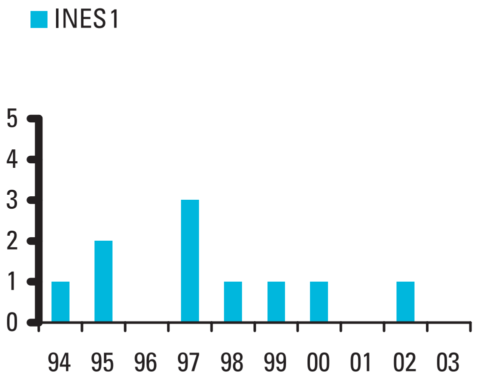


Figure 4. Loviisa plant's INES classified events (INES Level > 0).

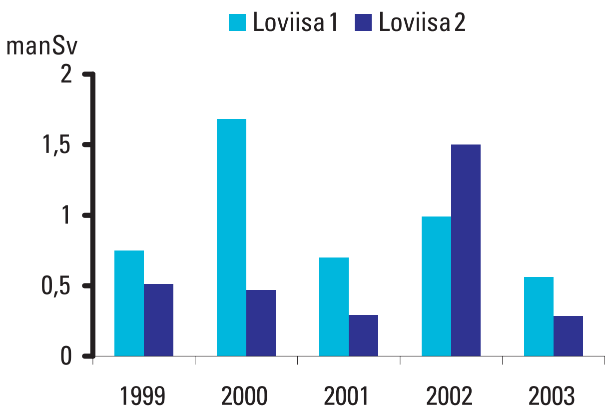


Figure 5. Collective occupational doses incurred in annual maintenance outage work at the Loviisa plant units

sion set up at the Loviisa plant in the utility reorganisation of 2002. The procedure for service life management was revised in early 2003. It divides the plant's systems, components and structures into four classes, based on their service life management. Those in the highest class are decisive for plant service life. In connection with the upgrading of the plant's information management systems, the service life management information system to be upgraded has been defined, which is due for commissioning during 2004.

Significant measures in 2003 affecting the service life of the Loviisa plant were the signing of conceptual design agreements on the upgrading of the plant's I&C systems. They are due for upgrading in 2006–2014.

STUK's oversight of plant service life management comprised the following actions: review of follow-up reports on the ageing of mechanical components and electrical and I&C systems; and of the procedures for service life management; plus the making of periodic inspections of mechanical components, electrical and I&C systems and structures.

Inspection methods are to be qualified to improve the reliability of the in-service inspection of the most important mechanical components by non-destructive methods. Qualification according to the national model applied so far has proved inefficient and time-consuming. In 2003, based on STUK's requests, a review of qualification procedures was started and also discussion about a possible renewal of the qualification organisation.

Radiation safety

Occupational radiation exposure

The radiation doses of all those who worked at Loviisa nuclear power plant in 2003 were below the 50 mSv annual limit. The distribution of individual doses in 2003 is given in Table I. The highest individual dose at Loviisa nuclear power plant was 12.7 mSv. It accumulated during work at Loviisa and Olkiluoto nuclear power plants. The highest individual dose incurred at Loviisa nuclear power plant alone was 11.6 mSv. Individual radiation doses did not exceed the dose limit of 100 mSv defined for any period of five years. The highest individual dose to a Finnish nuclear power plant worker in the 5-year period 1999–2003, 71.6 mSv, was received at Loviisa nuclear power plant.

Table I. Occupational radiation dose distribution at Loviisa and Olkiluoto plant units in 2003.

Dose range (mSv)	Number of persons by dose range		
	Loviisa	Olkiluoto	total*
< 0.5	220	450	620
0.5–1	115	267	335
1–2	118	224	328
2–3	50	80	130
3–4	37	26	68
4–5	24	14	47
5–6	13	9	29
6–7	11	3	19
7–8	8	2	14
8–9	2	–	9
9–10	2	–	6
10–11	2	–	5
11–12	1	–	1
12–13	–	–	1
13–14	–	–	2
14–15	–	–	2
15–16	–	–	–
16–17	–	–	4
17–18	–	–	2
18–19	–	–	1
19–20	–	–	–
20–21	–	–	–
21–25	–	–	–
> 25	–	–	–

* The data in these columns also include Finnish workers who have received doses 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

The collective occupational radiation dose at both Loviisa plant units in 2003 was 0.94 manSv. The collective occupational dose was 0.61 manSv at Loviisa 1 and 0.33 manSv at Loviisa 2. STUK guidelines state that 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. The value was not exceeded at either plant unit. The collective occupational radiation doses over the past years are given in Appendix 1 (indicator A.I.4).

Radioactive releases

Radioactive releases from Loviisa nuclear power plant were well below authorised limits in 2003. Releases of radioactive noble gases were ca 7 TBq, ie about 0.03% of authorised limit. The releases of radioactive noble gases were dominated by argon-41, ie the activation product of argon-40, originating in the air space between the reactor pressure vessel and the biological shield. The releases of radioactive iodine isotopes were about 4 MBq, ie approx 0.002% of authorised limit. Aerosol releases were approx 80 MBq, tritium releases approx 0.2 TBq and carbon-14 releases approx 0.3 TBq.

The tritium content of liquid effluents, 15 TBq, is about 10% of the release limit. The total activity of other nuclides released into the sea was about 0.3 GBq, ie about 0.03 % of the release limit.

The release limits are to maintain individual annual radiation exposure in the surrounding population of plants clearly below the threshold value (100 microSv) determined by the Government Resolution (395/1991). The calculated radiation dose of the most exposed individual in the vicinity of the plant was about 0.05 microSv, ie less than 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 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, 293 samples were analysed in accordance with a monitoring programme. Radioactive substances originating in Loviisa nuclear power plant were measured in two samples of deposition, one sample of bottom fauna, nine samples of aquatic plants, seven samples of sinking matter and seven samples of sea water.

Cobalt-60, the dominating radioactive substance originating in power plants, was measured in all of the aforementioned kinds of sample. The total number of observations was 19. The next most dominant were the radioactive isotope of silver (silver-110m, 7 observations) and tritium (7 observations). Also cobalt-58, the activation product of nickel (2 observations), was detected in some samples as well as manganese-54, originating in iron, (2 observations) and antimonium (Sb-124, 1 observation).

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

Radioactive strontium and caesium isotopes (strontium-90, caesium-134 ja -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 (ia 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.

Dosimeters for external radiation measurement have been placed in about ten locations and 15 continuous-operation radiation dose rate measuring stations at a distance of two and 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 network.

3.1.4 Oversight of organisational operation

Safety management

A periodic inspection pertaining to safety management was conducted at the Loviisa plant in 2003. It yielded positive results as regards organisational development, quality management, development of personnel and self-assessment. Explicit goals had been set up in all these fields at the plant; development needs had been identified and are being acted upon. The plant's management follows the status of the activities.

Information accumulated during document review and other inspection activity at the Loviisa plant was examined in 2003 with a view to the management of plant safety. No significant problems were observed in plant safety management.

Quality management system

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. In addition, Fortum Power and Heat Oy has updated the guidelines describing the quality management system for the nuclear energy section of the Fortum Group.

The licensee has compared the quality management system of the Loviisa plant with, among others, the ISO Standard and the safety requirements and guidelines of the IAEA over the past three years. Based on this, the system has been further developed by, among others, management reviews and self-assessment.

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 periodic inspection. The quality management system of the licensee and Loviisa power plant was found acceptable. The procedures in use at the Loviisa plant were also found to be in compliance with the plant's own quality management system. Remarks were given during the inspections, mostly on further development of the system and definition of detail.

Personnel qualifications and training

An organisational rearrangement took place at the Loviisa plant in 2002. It was in preparation of, among others, change of generation, and done by offering a chance to knowledge transfer from senior to junior personnel in expert tasks and by assigning junior personnel to line organisation management tasks. Several persons, who had worked for a relatively short time for the Loviisa plant, participated in Finland in a 6-week basic professional training course on nuclear safety.

Within the framework of the periodic inspection programme, STUK oversaw the appropriateness and adequacy of Loviisa nuclear power plant's organisation and its personnel training. In a separate inspection on training, the plant procedures to assure personnel competence were reviewed and their sufficiency identified. This was in preparation of a discussion on human resources development in connection with safety management inspection.

Upon application by Fortum Power and Heat Oy, STUK authorised two persons to function as deputies to the responsible manager at Loviisa nuclear power plant, as referred to in section 79 of the Nuclear Energy Act (990/87) and sections 122–127 of the Nuclear Energy Decree (161/88).

In addition, upon application by the licensee, STUK authorised persons in the licensee's employ to work as shift managers or operators at the power plant. Twelve persons employed at the Loviisa plant were authorised. Both authorisations and reauthorisations took place.

Operational experience feedback

Licensee operational experience feedback consisted of the handling of events at own and other plants. Even events at plants abroad were dealt with in special operational feedback working groups. The objective of operational experience feedback is to prevent recurrence of events that endanger plant safety.

STUK's oversight of operational feedback activities was by periodic inspection and review of operational reports and the annual operational feedback report submitted by the licensee. The Loviisa plant has systematic and regulated procedures for event investigation, assessment and implementing of corrective action. In a periodic inspection, requirements were put forth for the further development of operations.

Furthermore, STUK evaluated the appropriateness of experiences learned from events abroad for consideration at Finnish plants. Event information was obtained through the Incident Reporting System (IRS) of the IAEA and the OECD. In 2003 twenty event reports were reviewed, eight of which lead to detailed inspection after preliminary assessment. No event in 2003 warranted immediate action from the licensees. At the Loviisa plant, two events led to consideration of lessons learnt in the course of normal STUK inspection activity.

Periodic inspection programme

In 2003 STUK carried out 21 periodic inspections at the Loviisa plant. Safety management, the main processes of operation and also procedures as well as the technical acceptability of systems were looked into. Compliance of safety assessment, operation, maintenance and protection activities (ia radiation protection, fire protection and physical protection) with the requirements of nuclear safety regulations was verified by the inspections. The annual inspection programme was brought to the attention of the licensee at the beginning of 2003 and inspection dates were agreed upon with licensee representatives. Inspections contained in the periodic inspection programme are listed in Appendix 4.

Information was acquired through oral reports requested from representatives of the power plants, personnel interviews, document reviews, walk rounds, observing of working as well as various measurements, ia to establish accuracy of measuring equipment. None of the observations made had an immediate bearing on the safety of the plant units. Actions were initiated onsite to repair the defects observed.

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

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

In addition, upon application by Fortum Power and Heat Oy, testers employed by four separate testing organisations were authorised to carry out in-service inspection of mechanical components and structures at the Loviisa plant units. Previous decisions pertaining to manufacturers and testing organisations are valid, as mentioned in the decisions.

Inspection Organisation Loviisa YVL, authorised in 2002, continued in operation.

The manufacturers as well as testing and inspection organisations authorised by STUK were subject to oversight by STUK.

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 prepared for damage from a nuclear accident as prescribed by law by taking out an insurance policy for this purpose mainly in the Finnish Nuclear Insurance Pool.

In case of an accident, the funds available for compensation come from three sources: the licensee, the country of location of the facility and the international liability community. In 2003, a total of about 425 000 000 € was available for compensation from all these sources.

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

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

3.2 Olkiluoto nuclear power plant

3.2.1 Overall safety assessment

Implementation of regulations

STUK has introduced a procedure to apply new or revised YVL guides to operating nuclear facilities. A new YVL guide does not, as such, change STUK's decisions made before its publication. Only after STUK has heard those concerned, it decides how a new or revised YVL guide applies to operating nuclear facilities, or those under construction and to licensee operations. New guides apply as such to new nuclear facilities.

When STUK decides how new safety requirements in YVL guides apply to operating nuclear facilities, or those under construction, it takes into account a principle stated in section 27 of the Government Resolution (395/1991); namely, that to further improve safety, measures are to be implemented that are justifiable considering operational experience, safety research and the development of science and technology.

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

- Guide YVL 5.5, Instrumentation systems and components of nuclear facilities, 13 September 2002
- Guide YVL 6.7, Quality management of nuclear fuel, 17 March 2003.

Teollisuuden Voima Oy gave its assessment of how the requirements of the new Guide YVL 5.5 have been implemented at Olkiluoto plant. STUK considered the assessment insufficient and requested a more detailed assessment of the fulfilment of the new requirements. Consideration of the requirements of the new guide were required particularly as regards the planned control room renewal of the Olkiluoto units. Assessment pertaining to implementation continued towards the end of 2003, based on a report submitted by Teollisuuden Voima Oy.

It was established that the requirements of the revised Guide YVL 6.7 were fulfilled, except for the licensee's required auditing of the fuel manufacturer. STUK did not approve of the compensatory procedure presented by Teollisuuden Voima Oy but in its decision requested adherence to the procedure given in the revised guide.

Annual safety assessment

The annual safety assessment for Olkiluoto nuclear power plant looks at observations made during the regulation of plant modifications, plant operability and organisational operation in 2003. The areas of assessment are dealt with in more detail in this report's chapters dealing with nuclear regulation, and in its appendices.

Minor modifications were made at Olkiluoto power plant in 2003 to improve, among others, the user interface of the plant's process computer in the control room.

The number of plant situations in non-compliance with the Technical Specifications at Olkiluoto nuclear power plant was higher than usual. There were significant common factors underlining them, ie shortcomings in adherence to instructions, in management of periodic inspections, in monitoring of plant state and in identification of the requirements of the Technical Specifications. The licensee has undertaken the necessary development measures.

The annual maintenance outages of Olkiluoto power plant were refuelling outages by nature and no significant safety-related observations were made during them. Inspections conducted by the licensee during the annual maintenance of Olkiluoto 2 revealed fault indications in one of four feed water assemblies. This lead to additional inspections of feed water assemblies in the 2003 annual maintenance outage of Olkiluoto 1. Two fuel assemblies were removed in the Olkiluoto 1 annual maintenance outage: one was leaking and on the other corrosion products had accumulated.

No individual occupational radiation dose exceeded the limit set for nuclear power plant workers. The collective occupational radiation dose was low by international comparison. Radioactive releases were low, too, and the radiation dose calculated on their basis to the most exposed individual in the vicinity of Olkiluoto nuclear power plant was clearly below a limit set by Government Resolution.

At Olkiluoto nuclear power plant, long-term follow-up on the plant's ageing has been reorganised during 2003. Reporting on the maintenance function has been developed so as to enhance the options for ageing follow-up. In 2003, a turbine plant upgrading project was started that is considered important for the service life management of the Olkiluoto facility. Significant safety defects have been detected in inspections relating to the ageing management of mechanical components and of electrical and I&C systems and structures. Maintenance indicators for the Olkiluoto plant showed an improved maintenance function that was indicated ia by shorter failure repair times. No common cause failures occurred that would have prevented the plant's operation.

Qualification of the periodic inspections of the most important mechanical components by non-destructive methods is important in ascertaining the reliability of data on ageing management. Qualification of ultrasonic and eddy current inspections has not been developed as promptly as required by STUK, based on European recommendations. To repair the situation, new national arrangements for enforcement of qualification have been agreed upon with both utilities.

At Olkiluoto power plant, the number of operational events and events warranting a special report has increased from the year 2000, and has remained high. The high number of events indicates a weakened safety and quality culture in plant operation. The high number of events could also arise from the fact that safety culture was highlighted onsite in 2003. Some of the events relate to the observation of previous errors. In a STUK periodic inspection pertaining to plant operation, development needs were observed relating to improvement of the effectiveness of operational feedback activities and to allocation of sufficient resources for the tasks in question. The licensee has taken the necessary immediate corrective action and started the necessary improvements.

In 2003, new personnel were recruited to Olkiluoto nuclear power plant who will contribute to both the design, construction and commissioning of the new plant unit and the planning of modifications to operating power plants. This assures the effective transfer of knowhow acquired in the course of the planning of the new plant unit to the modernisation projects of operating plant units, provided that sufficient resources are reserved for both tasks.

No new investigations into plant operation were started by STUK in 2003.

Annual assessment of deterministic safety analyses

The licensees update deterministic safety analyses for nuclear power plants in connection with the renewal of the plants' operating permits. The analyses are also updated in connection with plant modifications or operational events, where necessary. STUK reviews licensee analyses and conducts, or commissions, own reference analyses, where necessary. No deterministic safety analyses were submitted to STUK for review in 2003.

Annual assessment of probabilistic safety analyses

A review of Level 2 Probabilistic Safety Analysis (PSA) for the Olkiluoto plant was completed. Level 2 analysis assesses the amounts of radioactive substances released into the environment in the early phases of a severe accident and also the probabilities of the releases. From the viewpoint of results interpretation, the most important observation made during the review was that Teollisuuden Voima Oy has defined as caesium-137 equivalents the radioactive release resulting from a severe accident, whereas the Government Resolution (395/1991) on the general requirements for nuclear power plant safety define the release threshold only as an inventory of the caesium-137. The calculation method used by Teollisuuden Voima Oy is stricter than that defined in the Government Resolution. Therefore, the frequency ($6.4 \cdot 10^{-6}$ / year) of a major release (100 TBq) in the early phase of an accident, as calculated by Teollisuuden Voima Oy, is somewhat higher that that ($4 \cdot 10^{-6}$ /year) calculated in accordance with the definition contained in the Government Resolution.

Safety performance indicators

The requirements set for the safety performance indicators for nuclear power plants were fulfilled at Olkiluoto power plant as regards occupational radiation doses, radioactive releases and population exposure. Releases into the sea reduced to the present level in 1998 when new equipment for process water purification and treatment were introduced.

No events occurred at the Olkiluoto plant units that would have endangered safety. One reactor scram occurred at Olkiluoto 1 that was classified an initiating event. All safety systems functioned according to design during it. The objective, max 5%, set for the risk -importance of the inoperability of components affecting accident risk was exceeded at Olkiluoto 2. This was due to the repair of ceilings of the pump sumps of the shutdown reactor service water systems at both plant units under an exemption granted by STUK. In addition, one stand-up diesel generator latent defect occurred Olkiluoto 2, which was somewhat risk-significant. It did not require any specific measures from STUK. At the same time, indicators on the quality of maintenance showed higher efficiency and better quality.

The increasing trend at Olkiluoto power plant in the number of operational events and events warranting a special report, plant conditions in non-compliance with the Technical Specifications included, for three years in succession indicates a weakened safety and quality culture in plant operation. This was also evident from the four INES Level 1 events that occurred at the plant within a short period of time towards the end of 2003. The effectiveness of STUK's regulatory activities is also assessed by adherence to the Technical Specifications. Based on the events, STUK has started discussions with the management of Teollisuuden Voima Oy, underlining the need for a common effort in the overall development of safety culture in nuclear power plant operation.

The structural integrity of multiple barriers to contain radioactive releases has been good. The number of fuel leaks at Olkiluoto plant has been small. In the operating cycle 2002–2003, unidentified leaks from the primary circuit increased, being at Olkiluoto 2 as much as 9.4% from the limit of the Technical Specifications, compared with the previous operating cycle. This was attributed to leaking check valves in the relief system of the main steam system during the entire operating cycle. The licensee is devising a new sealing solution for the valves.

The outcome of the indicators on plant safety, used in assessment of the effectiveness of STUK's operations, in 2003 are given in Appendix 1. In addition, some background is given to the indicators and the procedures used in their acquisition.

3.2.2 Oversight of plant modifications

Oversight of modifications made at the Olkiluoto plant comprised definition of their regulatory scope, handling of documents pertaining to them and control of their implementation and commissioning. Safety modifications are described in Appendix 2. STUK oversaw the implementation of component and structural modifications by inspections onsite and at the component manufacturers' premises as well as by licensee documents. Pertaining to the modifications oversight were meetings between STUK and the licensee as well as meetings internal to STUK, as described in subsection 3.1.2.

The status of safety-significant modifications was followed on a computer-based plant modifications register held at STUK. In 2003 the number of new modifications at the Olkiluoto plant units, entered in the register, was nine. Several unfinished modifications, registered earlier, were monitored on the register as well. It was also utilised specifically in monitoring the implementation of modifications-related document revisions. As a result of the follow-up, it was noticed that 86% of the document revisions made after plant modifications at the Olkiluoto plant in 2002 had been completed by the next annual maintenance.

3.2.3 Oversight of plant operability

Compliance with the Technical Specifications

Adherence to the Technical Specifications at Olkiluoto power plant was controlled by witnessing operations onsite. Specific areas of control included the testing and repair of components subject to the Technical Specifications. When the annual maintenance outages had ended, the plant unit's state in compliance with the Technical Specifications was ascertained prior to start-up. The licensee is responsible for reporting to STUK without delay all situations deviating from the requirements of the Technical Specifications.

At the Olkiluoto plant units, eight situations occurred, mentioned in the "Operational events", during which the plant unit was in non-compliance with the Technical Specifications. Two deviations were detected in the course of STUK's regulatory inspections.

The number of plant conditions in non-compliance with the Technical Specifications at the Olkiluoto plant has increased (Appendix 1, indicator A.I.2). "Operational events" presents their causes and "Safety management" in subsection 3.2.4 looks into them from the viewpoint of organisational operation.

The Technical Specifications were deviated from also by applying in advance for STUK's approval of a deviation. In 2003 the licensee applied for approval of seven situations in non-compliance with the Technical Specifications (Appendix 1, indicator A.I.2). After an analysis of their safety significance, STUK approved them all. Four of the exemptions were deviations from the Technical Specifications due to modifications, repairs or maintenance. One exemption was granted for a deviation due to a specific test.

Operational events

Both Olkiluoto plant units operated reliably. The load factor of Olkiluoto 1 was 97.0% and that of Olkiluoto 2 was 95.5%. Figure 6 gives the load factors of the plant units in 1994–2003. The annual maintenance outage of Olkiluoto 1 was nine days and that of Olkiluoto 2 was 14 days. The progress of the outages and the measures taken during them are described later in this chapter.

A reactor scram occurred at Olkiluoto 1 from low reactor water level during post-outage start-up. Since the reactor control rods were inside the reactor at the time, no actual scram occurred but only scram-related safety systems actuated. The event is explained in more detail in Appendix 3. In addition to the annual maintenance outage, a brief break in production occurred at Olkiluoto 1 to repair a leaking sealing in the inspection opening of a moisture separator and at Olkiluoto 2 to balance the turbine and to repair a leaking valve in the feed water system. In July–August, power of both plant units had to be reduced due to exceptionally high sea water temperatures.

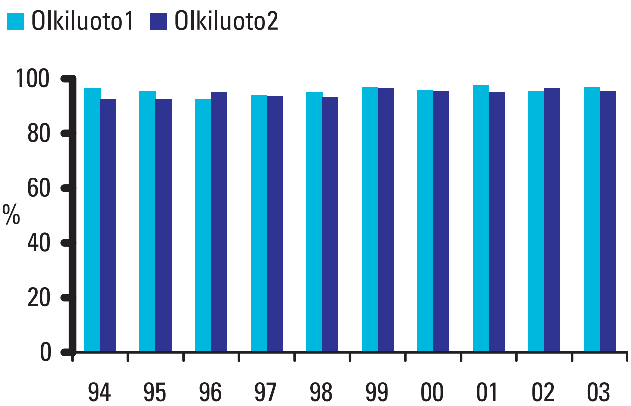


Figure 6. Load factors of the Olkiluoto plant units.

Figure 7 gives the daily average gross powers of the plant units in 2003. Production losses from component failures were 0.2% at Olkiluoto 1 and 0.4% at Olkiluoto 2. The indicators given in Appendix 1 look at production losses from component failures for a longer period (indicator A.1.1.g).

Eight events warranting a special report, one reactor scram and eight operational transients reported to STUK occurred at the Olkiluoto plant units (Appendix 1, indicator A.II.1). 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.

Events at the Olkiluoto plant, on which a special report was drawn up, and their INES classification, are as follows:

- Deterioration of the containment isolation function due to the failure to operate of a steam line isolation valve at Olkiluoto 1. INES Level 1.
- Inoperability of emergency coolant pumps at Olkiluoto 2 during annual maintenance. INES Level 1.
- A strainer clogged up at Olkiluoto 1 during annual maintenance. INES Level 0.
- The rate-of-change limit for reactor water temperature given in the Technical Specifications was exceeded at Olkiluoto 1. INES Level 1.
- Inoperability of a fire damper in the staircase of the Olkiluoto 2 reactor building. INES Level 1.
- Inoperability of a fire pump at Olkiluoto nuclear power plant. INES Level 1.
- The floor drainage level measurement function at the Olkiluoto spent fuel storage was not inspected. INES Level 1.
- High vibration levels on emergency coolant pumps at Olkiluoto 1. INES Level 1.

Event descriptions can be found in Appendix 3.

None of the events endangered plant safety. However, common factors underlying them, ia shortcomings in adherence to instructions, in administration of periodic inspections, monitoring of plant states and identification of the requirements of the Technical Specifications. Event initiation has also been affected by the insufficiency in operational feedback activities to identify event causes and thus prevent recurrence. Underlying causes include also factors relating to safety culture and procedures. The licensee set up a working group to look into the development measures necessary because of the events. Several of them have already been implemented to prevent recurrence.

Figure 8 gives the number of INES Level 1 events in 1994–2003. No events above that occurred.

Annual maintenance outages

The refuelling and maintenance outage of Olkiluoto 2 was on 11 to 26 May, 2003 and that of Olkiluoto 1 on 27 May to 6 July, 2003. Olkiluoto 1 discontinued electricity generation for about nine days and Olkiluoto 2 for about 14 days.

At Olkiluoto 1, a fuel leak detected on 27 February 2003 was localised during the annual maintenance outage to one leaking fuel bundle. In addition, one fuel bundle with an exceptional amount of corrosion products was detected. The bundles were removed from the reactor. Fuel cladding integrity over the past years is examined in Appendix 1 (indicator A.III.1).

In a periodic inspection during annual maintenance, an indication along the pipe centre line was detected at Olkiluoto 2 in one of four reactor pressure vessel feedwater assemblies. This is explained in more detail in Appendix 3. An internal inspection of feedwater assemblies was conducted at Olkiluoto 1, too, because of the event, even if it was not due according to the 2003 inspection programme. No reportable indications were detected at Olkiluoto 1, however.

Safety improvements made in the annual maintenance outage are explained in Appendix 2.

The collective occupational dose during the outage was 0.20 manSv at Olkiluoto 1 and 0.71 manSv at Olkiluoto 2. The highest individual radiation dose at Olkiluoto 1 during the outage was 2.5 mSv and 7.9 mSv at Olkiluoto 2. Figure 9 presents the collective radiation doses incurred in annual maintenance in 1999–2003. Radiation safety at the Olkiluoto plant overall is separately described in this chapter.

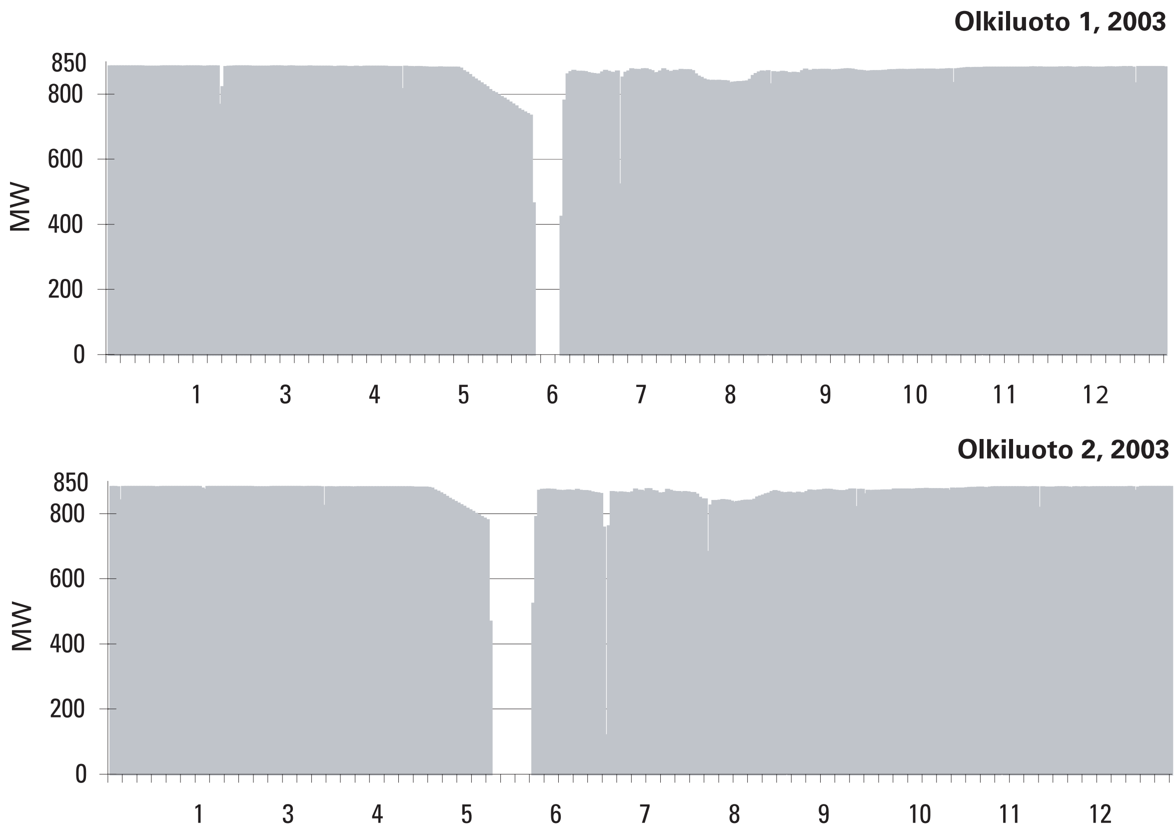


Figure 7. Daily average gross power of the Olkiluoto plant units.

Regulatory oversight by STUK focused ia on the administrative arrangements of outage work, the activities of the operating and maintenance personnel, refuelling as well as inspections and tests by the licensee and sub-contractors. Attention was also paid to the implementation of radiation protection, control room operations and housekeeping. Prior to the start of a new fuel cycle, safety analyses made for both plant units were checked. In addition, it was checked that the fuel assemblies were loaded into the reactor according to plan. The nuclear material inventory was inspected prior to the closing of the reactor pressure vessel head.

During the annual maintenance outages, STUK carried out inspections required in the Pressure Equipment Act. In addition, periodic inspections of pressure vessels and other pressure-bearing components were controlled by reviewing programmes pertaining to it and witnessing inspections onsite.

In addition, STUK controlled the plant unit's placement in a shutdown state and its subsequent startup. On 8 August 2003 STUK approved the starting of refuelling -related measures. A corresponding approval was granted to Olkiluoto 1 on 22 May 2003. The permission to start up Olkiluoto 2 was granted on 23 May 2003. STUK's inspectors ascertained the plant unit's start-up readiness onsite on 25 May 2003. Olkiluoto 2 was connected to the national grid on 26 May 2003. The permission for Olkiluoto 1's start-up was given on 3 June 2003 and the plant unit's start-up readiness was ascertained onsite on 3–4 June 2003 by STUK's inspectors. A minor water leak from the cable penetrations of a primary circulation pump was detected in start-up inspections and the plant unit was brought back to cold shutdown for repairs. During the plant's cooling down a reactor scram occurred from erroneous operational action (see Appendix 3 for a separate description). The leaking penetrations were fixed after which start-up continued. Olkiluoto 1 was connected to the national grid on 6 June 2003.

One hundred and thirteen working days were spent onsite on the regulatory oversight of the annual maintenance outages of the Olkiluoto plant units. In addition, two resident inspectors were working on the plant site.

Ageing

In the organisation of Olkiluoto power plant, responsibility for the long-term monitoring of components, structural and systems ageing in the 2003 organisation has been with the technical department. The maintenance unit of the department of operation monitors and reports ageing phenomena observed during maintenance activities. Reporting on maintenance activities and the related database were reorganised at Olkiluoto in 2003 to facilitate monitoring of component ageing.

A project significant for the service life of the Olkiluoto plant units was started in 2003, namely turbine plant upgrading, which includes replacement of the steam driers inside the reactor pressure vessel.

STUK has reviewed follow-up reports on the ageing of mechanical components as well as of electrical and I&C systems and carried out periodic inspections pertaining to the monitoring of ageing in which also the monitoring of structural ageing was assessed.

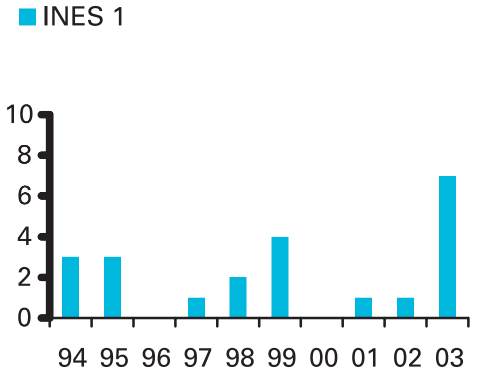


Figure 8. INES classified events at Olkiluoto plant (INES Level > 0).

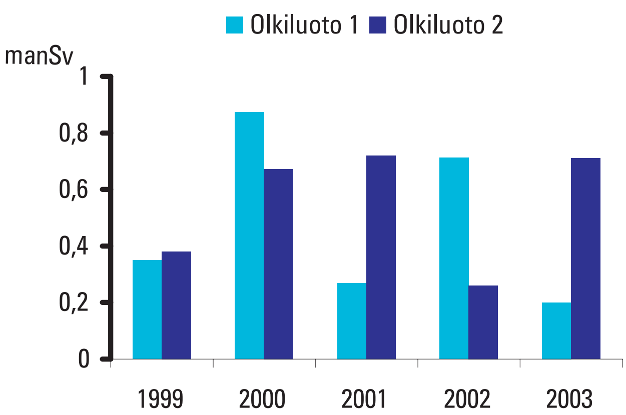


Figure 9. Collective occupational doses during annual maintenance at Olkiluoto nuclear power plant.

Inspection methods are to be qualified to improve the reliability of the in-service inspection of the most important mechanical components by non-destructive methods. Qualification according to the national model applied so far has proved inefficient and time-consuming. In 2003, based on STUK's requests, a review of qualification procedures was started and also discussion about a possible renewal of the qualification organisation.

Radiation safety

Occupational radiation doses

The radiation doses of those who worked at Olkiluoto nuclear power plant in 2003 were below the 50 mSv annual limit. The distribution of individual doses in 2003 is given in Table I. The highest individual dose at Olkiluoto nuclear power plant was 7.9 mSv. Individual radiation doses in 1999–2003 were below the 100 mSv dose limit determined for any period of five years.

In 2003 the collective occupational dose was 0.27 manSv at Olkiluoto 1 and 0.76 manSv at Olkiluoto 2; the total for both plant units being 1.03 manSv. STUK guidelines state that the threshold for one plant unit's collective dose averaged over two successive years is 2.10 manSv. This value was not exceeded in either plant unit. The collective occupational radiation doses incurred over the past years are given in Appendix 1 (indicator A.I.4).

Radioactive releases

Radioactive releases into the environment from Olkiluoto nuclear power plant were well below authorised limits in 2003. The releases of noble gases into the atmosphere were about 0.1 TBq, ie approx 0.0008% of authorised limit. Iodine releases into the atmosphere were approx 17 MBq, ie approx 0.02% of authorised limit. Aerosol releases into the atmosphere were approx 33 MBq, tritium releases into the atmosphere approx 0.3 TBq and carbon-14 releases into the atmosphere approx 0.7 TBq.

The tritium content of liquid effluents released into the sea, ie 1 TBq, is approx 6% of the annual release limit. The total activity of other nuclides released into the sea was 0.6 GBq, ie approx 0.2% of the plant-site specific release limit.

The calculated radiation doses of the most exposed individual in the environment of the Olkiluoto plant was approx 0.04 mikroSv, ie less than 0.1 % of the limit prescribed by a Government Resolution (100 mikroSv). 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 those on- and off-site radiation measurements and determination of radioactive substances that are carried out to establish population radiation exposure and radioactive substances in the environment.

In the environment of Olkiluoto nuclear power plant, 288 samples were analysed. Radioactive substances originating in Olkiluoto nuclear power plant were measured in one sample of lichen, two samples of fish, two samples of bottom fauna, in 17 samples of aquatic plants and in 15 samples of sinking matter. The dominating power plant-based radioactive substance, cobalt-60, was measured in all of the aforementioned samples. The total number of observations was 37. Apart from cobalt, silver-110m was measured in one sample of sinking matter and manganese-54 and antimonium-124 in one sample of aquatic plants each. In addition to cobalt-60, one sample of aquatic plants contained also cobalt-58, the activation product of nickel, and manganese-54, the activation product of iron.

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

Dosimeters for external radiation measurement have been placed in about 11 locations and 10 continuous-operation radiation dose rate measuring stations 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 network. The monitoring of external radiation is complemented by dose rate and spectrometric measurements. Two spectrometric measurements were made in the environment of the Olkiluoto plant.

3.2.4 Oversight of organisational operation

Safety management

Information on Olkiluoto nuclear power plant, which had accumulated in the course of document reviews and other inspection activity, was looked at during 2003 with a view to plant safety management.

A relatively large number of deviations from the procedures were observed during the annual maintenance outage, which were due to either human error or organisational factors, or due to which trouble shooting and repairs were problematic. The number of operational events was higher than usual also after annual maintenance. A meeting was therefore arranged on 25 September 2003 in which the licensee presented their own view on the event causes and the necessary measures. STUK did not consider the licensee's explanation sufficient and the matter will be dealt with again in 2004.

In the autumn of 2003, several measures to improve organisational operation were started at the Olkiluoto plant. The licensee set up ia a separate working group to develop its operations, employed more personnel for operational feedback tasks and commissioned analyses and training to external consultants. In addition, the licensee will carry out a safety culture self-assessment based on IAEA guidelines.

Quality management system

The licensee has systematically maintained and developed the quality management system of the Olkiluoto plant in accordance with their own plans. A new quality management system, based on the ISO-9001 Standard, was commissioned in 2001.

The licensee regularly assessed the functionality of their quality management system by means of an internal audit programme and a separate individual inspection procedure.

STUK oversaw quality management by document reviews and periodic inspection. In the inspections it was established that the licensee's quality management programme is acceptable. STUK has established that the operation of Teollisuuden Voima Oy complies with the plant's own quality management system. Remarks were given during the inspections, mostly on further development of the system and definition of detail.

Personnell qualifications and training

Within the framework of the periodic inspection programme, in two periodic inspections, STUK oversaw the appropriateness and adequacy of Olkiluoto power plant's organisation and its personnel training. Both inspections focused on the plant's operating unit. The objective is to ascertain, by regular inspection, that sufficient personnel is kept at the operating Olkiluoto plant units in both direct operations and their support operations during the design, construction and commissioning of the new nuclear power plant unit.

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

Upon licensee application, several of their employees were authorised to act as shift managers or operators at the nuclear power plant. A total of 28 authorisations were granted for the Olkiluoto plant, which mostly pertained to a new 3-year period.

Operational experience feedback

Licensee operational experience feedback consisted of the handling of events at own and other plants. Even events at plants abroad were discussed in a special operational feedback working group. The objective of operational experience feedback is to prevent recurrence of events that endanger plant safety.

The Olkiluoto plant units reported 16 operational events to STUK in 2003. Several internal reports on minor anomalies or operational events were drawn up at the plant as well.

STUK's oversight of operational feedback activities was by periodic inspection and review of operational reports and the annual operational feedback report submitted by the licensee. The Olkiluoto plant has systematic and regulated procedures for event investigation, assessment and conducting of corrective action. In a periodic inspection, requirements were put forth for the further development of operations.

Furthermore, STUK evaluated the appropriateness of experiences learned from events abroad for consideration at Finnish plants. Event information was obtained through the Incident Reporting System (IRS) of the IAEA and the OECD. In 2003 twenty event reports were reviewed, eight of which lead to detailed inspection after preliminary assessment. No event in 2003 warranted immediate action from the licensee. At the Olkiluoto plant, three events lead to consideration of lessons learnt in the course of normal STUK inspection activity.

Periodic inspection programme

In 2003 STUK carried out 17 periodic inspections at Olkiluoto plant. Inspections contained in the periodic inspection programme are listed in Appendix 4. Safety management, the main processes of operation and also procedures as well as the technical acceptability of systems were looked into. Compliance of safety assessment, operation, maintenance and protection activities (ia radiation protection, fire protection and physical protection) with the requirements of nuclear safety regulations was verified by the inspections. The annual inspection programme was brought to the attention of the licensee at the beginning of 2003 and inspection dates were agreed upon with licensee representatives.

Information was acquired through oral reports requested from representatives of the power plants, personnel interviews, document reviews, walk rounds, witnessing of working as well as various measurements, ia to establish accuracy of measuring equipment. None of the observations made had an immediate bearing on the safety of the plant units. Actions were initiated onsite to repair the defects observed.

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

Upon application by Teollisuuden Voima Oy, and in accordance with the Nuclear Energy Act, STUK authorised three manufacturers of nuclear pressure equipment. In accordance with the Act, STUK also authorised one testing organisation to carry out non-destructive testing of mechanical components and structures at the Olkiluoto plant units. Testers employed by six different testing organisations were authorised to carry out in-service inspection of mechanical components and structures at the Olkiluoto plant units. Previous decisions pertaining to manufacturers and testing organisations are valid, as mentioned in the decisions.

The inspection organisation of Teollisuuden Voima Oy, authorised in 2002, continued in operation. By a decision made upon application by Teollisuuden Voima Oy, the scope of activities of the inspection organisation was extended to cover periodic inspection and tests that are part of preventive maintenance.

The manufacturers as well as testing and inspection organisations authorised by STUK were subject to oversight by the Authority.

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. Teollisuuden Voima Oy has prepared for damage from a nuclear accident as prescribed by law by taking out an insurance policy for this purpose mainly in the Finnish Nuclear Insurance Pool.

In case of an accident, the funds available for compensation come from three sources: the licensee, the country of location of the facility and the international liability community. In 2003, a total of about 425 M€ was available for compensation from all these sources.

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

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

3.3 New nuclear power plant project

Oversight planning

Preparation for the oversight activities of the new nuclear power plant continued. Parliament had in 2002 left in force the Decision-in-principle on the construction of a new nuclear power plant as proposed by the Government. Teollisuuden Voima Oy thereafter launched a bidding competition for the construction of the new plant. In December 2003 Teollisuuden Voima Oy announced that the winning bid came from Framatome ANP who offered a 1600 MWe pressurised water reactor (EPR).

Because of the extent of the execution of regulatory oversight pertaining to the new plant, an oversight project comprising 11 sub-projects had been set up in STUK in 2002. Project and sub-project managers were designated and the project group line-up was established in the spring of 2003.

The project plan, which describes responsibilities and procedures as well as essential tasks for implementation of regulatory oversight, was drawn up. In addition, a process description of the licensing process was made. The most essential tasks in preparing for oversight were the establishment of project and sub-project specific oversight plans and discussions with the licensee to facilitate a smooth licensing process. Revision of YVL guides was of essential importance as well. YVL guides revision is dealt with in Chapter 2. In the plans for sub-projects, specifically tasks most important in the handling of the construction permit application have been identified and prioritised and also resources required for the review and oversight have been identified. The plans address identification of sub-project interfaces to ascertain the full scope of oversight. In addition, sub-projects mapped what external support was needed.

In addition to oversight plans, plans were drawn up to monitor the licence applicant's quality management during the project and principles were set up for an inspection programme during the plant's construction and its implementation. An important task for the project group was to develop requirements management for the systematic control of safety requirements for the entire project. In addition to the development work, the task contained the incorporation into the requirements management system of YVL guides having the most bearing on the plant's safety design,. The system is for monitoring of the fulfilment of requirements during the plant's design, construction and commissioning. Commercial tools for requirements management were assessed and an own application was developed.

Co-operation with domestic and foreign liaison groups

There was co-operation with domestic liaison groups within the framework of the oversight project. Licensing-related discussions were had with the Ministry of Trade and Industry. STUK informed the Ministry on the status and results of work being done in preparation for the oversight work. A plan to develop analysis capabilities were drawn up and executed together with VTT State Technical Research Centre of Finland. The objective was to gain readiness to analyse, during the review of the construction permit application, the different plant alternatives brought forth during the bidding competition. Potential research needs and expert opinions in other fields of technology to support STUK's regulatory work were also discussed. STUK presented YVL guides and their requirements to sub-contractors potentially participating in the project. There were over 200 participants in two training events.

Experiences were exchanged with the authorities of different countries (ia the USA, the Czech Republic, France, Belgium) on the licensing of nuclear power plants and its possible outcome, requirements pertaining to the various plant alternatives and plant construction experiences. In addition, options for future co-operation were mapped. Apart from regulatory co-operation, potential foreign consultants for areas in which there is no domestic expertise, or where a potential external third party is required, were charted. STUK underwent preliminary discussions with ia US, German, French and British consultants and technical support organisations. Topics included ia automation, accident analysis and the control room.

Liaison with the license applicant

The detailed contents requirements of the licence documents and their supply schedules as well as the time STUK needs to review them were discussed with the license applicant. STUK and the license applicant arranged a quality seminar in which the license applicant presented the principles applied to quality management and STUK those applied to regulatory oversight.

Essential topics of discussion were the interpretation of safety requirements for the plant alternatives. STUK met vendors upon the license applicant's request. In the meetings the vendors introduced plant designs and the modifications made to meet Finnish safety requirements. STUK gave its opinion of designs unacceptable from the Finnish safety requirements point of view.

Upon the license applicant's request STUK participated also in the handling of reactor pressure vessel material manufacturing. STUK gave the license applicant a statement on the starting of the material's manufacturing and took part in the assessment of the manufacturers' quality management systems. In addition, external statements were requested on the quality management systems.

3.4 FiR 1 research reactor

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

STUK's periodic inspection in 2003 focused on ia the reactor's quality management, operation, radiation protection, radioactive releases and safeguards. On the proposal of the VTT Processes, four reactor foremen and one operator were authorised. No significant problems were observed in the reactor's operation in 2003. Occupational radiation doses and radioactive releases into the environment in 2003 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 Spent nuclear fuel

4.1.1 Interim storage

STUK's regulatory control of spent nuclear fuel storage included regular inspections and review of plans and other documents. No safety-endangering events occurred in the operation of the storage facilities. The volume of spent nuclear fuel onsite the Olkiluoto plant in the end of 2003 was 5786 assemblies (1019 tU, tonnes of original uranium) with an increase of 256 assemblies (45 tU) in 2003. Corresponding accumulation in the Loviisa plant was 2755 assemblies (330 tU) including 210 assemblies (25 tU) placed in storage in 2003.

STUK made an assessment of the condition of spent nuclear fuel assemblies during storage as well as of the appropriateness of the condition of fuel intermediate storage. The conclusion was that the integrity of spent nuclear fuel bundles is not expected to be essentially compromised during the planned approx. 40 years of interim storage. Some fuel assemblies with a fuel channel have become somewhat bent or warped, which makes their manoeuvring in the storage positions less easy. The monitoring programmes are mostly appropriate and only minor adjustments in them are required.

4.1.2 Preparation for final disposal

Posiva Oy, a company owned by Teollisuuden Voima Oy and Fortum Power and Heat Oy, carries out R&D and technical design aiming at implementation of spent fuel disposal at a later date. Upon the company's application, the Government made a Decision-in-principle on the construction of a final disposal facility in Olkiluoto. The goal of the R&D and design programme is to ascertain the suitability of the repository site, to design the necessary facilities and to acquire the research data necessary for assuring the safety of final disposal.

Teollisuuden Voima Oy and Fortum Power and Heat Oy applied for an amendment in the Ministry of Trade and Industry's policy decision on the schedule of activities leading to the disposal of spent fuel in so far as it applies to the presentation of construction permit -related reports and plans to the regulatory authority. STUK in its statement was in favour of postponing the planned target date from 2010 to 2012, which was also set as the new objective in the Ministry's decision of 23 October 2003.

Repository site investigations and underground research facilities

Posiva Oy continued to carry out geological research programmes in Olkiluoto. The aim was to complement the baseline data of the site and, specifically, to investigate in detail the area of the underground research facility to be constructed on the site. Facility construction is due to start in mid-2004. It may later become part of the repository proper, which has to be considered in the application of regulatory oversight on its implementation. STUK gave Posiva and the Ministry of Trade and Industry its assessment of Posiva's report on the facility's location and its access route designs and gave to the Eurajoki board of construction a statement on Posiva's application for a municipal construction permit for the facility.

Posiva published reports describing the baseline of conditions on the site of the research facility, the plan for its technical implementation and the related research and monitoring programmes as well as the disturbances in the bedrock caused by the construction project. STUK reviewed the reports, supported by external teams of experts on bedrock structures, geohydrology, geochemistry and rock movements. The review was given to Posiva and the Ministry of Trade and Industry in February 2004.

Posiva commissioned a microseismic measuring station on the island of Olkiluoto to observe tectonic earthquakes within approx. one square kilometre and, in the future, even seismicity arising from the excavation of the underground research facility. The measurement data yields additional information on bedrock structure and stability.

Encapsulation and disposal technology

Posiva continued technical R&D on spent fuel encapsulation and disposal. Two siting options for the encapsulation facility exist: either the repository site or in connection with the Olkiluoto interim storage for spent fuel. STUK gave Posiva and the Ministry of Trade and Industry its assessment of the two alternative disposal facilities. Posiva completed an Olkiluoto-specific encapsulation and final disposal facility plan that also examines facility operation and provision for accidents.

In co-operation with the Swedish nuclear waste company SKB, Posiva continues to develop waste canister manufacturing techniques. Posiva is responsible for the development of the pierce-and-draw method for fabricating the copper shell in which progress was made in manufacturing tests in Germany. Promising results have also been reported in manufacturing tests based on the extrusion-and-forging method that SKB is responsible for.

In addition, development and manufacturing tests of the cast-iron inner part of the waste canister continued. In a manufacturing test at Rautpohja, commissioned by Posiva, the desired metallurgical composition of the casting was not reached. SKB was more successful in its corresponding manufacturing tests.

Posiva is responsible for the development of electron beam welding of the lid of the copper canister. Welding tests in Germany failed due to problems with equipment and Posiva therefore cooperates with Patria Aviation to modernise the electron beam welding equipment in Linnavuori for future testing there.

Posiva also participates in the development of friction stir welding of copper ia at SKB's Oskarshamn laboratory where full-scale equipment were installed in 2003. The Posiva–Outokumpu venture on narrow gap arc welding supported by National Technology Agency of Finland (TEKES) has been completed with the conclusion that the method cannot be applied to closing a 50 mm -thick copper canister.

4.2 Reactor waste

The utilities in 2003 followed earlier practices in carrying out their intermediate and low-level waste maintenance activities. A solidification facility is Loviisa power plant's most important nuclear waste project, the Preliminary Safety Analysis Report of which STUK approved in 2001. A modification plan for the plant was submitted to STUK for approval but the facility's construction was postponed until early 2004, in which case it could be commissioned in 2007 at the latest.

STUK inspected the handling, storage and disposal of reactor waste at both plant sites. Specific attention was paid to the storage of highly activated spent core internals on both nuclear power plant sites as well as the sufficiency and appropriateness of the handling and storage facilities for intermediate and low-level waste at Loviisa power plant.

No safety-related problems occurred in the treatment, storage and disposal of reactor waste. Currently approx. 44% of the waste from the Loviisa plant and approx. 91% of that from the Olkiluoto plant has been disposed of. The volume of reactor waste onsite the Loviisa plant at the end of 2003 was 2685 m^3 with an additional 183 m^3 in 2003. Corresponding waste accumulation at the Olkiluoto plant was 4335 m^3 with an added 123 m^3 in 2003.

4.3 Other regulatory activities

STUK gave the Ministry of Trade and Industry a statement, as referred to in section 78 of the Nuclear Waste Energy Decree, about the licensees' nuclear waste management measures and plans. The statement assesses how, in preparing for nuclear waste management, the licensees have proceeded in relation to goals set out by the Government. STUK also gave statements, as referred to in section 90 of the Nuclear Energy Decree, about making financial provision for the costs of nuclear waste management, which assess the technical plans based on which the financial provision is made.

5 Regulatory control of nuclear materials

Marko Hämäläinen, Arto Isolankila, Elina Martikka, Jaakko Tikkinen

5.1 Nuclear material safeguards

5.1.1 Safeguards at Finnish nuclear facilities

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

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

A total of 13 inspections were made at Loviisa power plant in 2003 and 20 inspections at Olkiluoto power plant. Euratom ja the IAEA participated in 25 of them.

In addition to domestic nuclear power plants, minor amounts of nuclear materials are used at other facilities. The most significant of these is FiR 1, the research reactor operated by the VTT, where one inspection was conducted in 2003. The Laboratory of Radiochemistry of the University of Helsinki, OMG Kokkola Chemicals and STUK also have small amounts of nuclear materials in their possession. They were all inspected. STUK, the IAEA and Euratom participated in the inspections. STUK made one inspection at OMG Kokkola Chemicals without the IAEA and Euratom. The amounts of nuclear materials are given in Table II. Licences and approvals in accordance with the Nuclear Energy Act are given in Appendix 5.

Nuclear material safeguards employ several methods to verify that data on nuclear materials reported by the operator, such as burn-out and cooling time, are correct and complete. Other nuclear-safety related data, from operational safety to final disposal, can also be verified by measurements. In 2003 STUK verified by non-destructive methods 76 and 349 spent fuel assemblies at Olkiluoto and Loviisa power plant respectively. In

Table II. Amounts of nuclear material in Finland on 31 December 2003.

Location	Natural uranium (kg)	Enriched uranium (kg)	Depleted uranium (kg)	Plutonium (kg)	Torium (kg)
Loviisa plant	–	405 597	–	3 224	–
Olkiluoto 1	–	224 771	–	1 089	–
Olkiluoto 2	–	207 057	–	936	–
Olkiluoto / Spent-fuel storage (KPA)	–	755 326	–	6 150	–
VTT: FiR 1 research reactor	1511	60	< 1	–	–
OMG Kokkola Chemicals	712.6	–	–	–	–
Others (non-nuclear)	84	1.7	471	0,005	4

addition, the IAEA, Euratom and STUK measured 30 dummy elements removed from the reactors of the Loviisa plant, which contained no nuclear material.

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

In 2003 STUK authorised nine Euratom and 23 IAEA inspectors to make inspections in Finland.

5.1.2 Strengthening of the IAEA safeguards

Measures to strengthen the IAEA safeguards began after the disclosure of the Iraqi nuclear weapons programme. By way of administration, safeguards strengthening is based on the Model Protocol Additional (INFCIRC/540). Finland signed the Protocol together with other EU countries in September 1998. The Protocol comes into force after all EU member states and the Commission have ratified it. Finland ratified it in the summer of 2000. In December 2003 Italy and Ireland, the last countries in the EU to ratify, announced its ratification, making possible its coming into force in 2004.

In 2003 STUK mapped the information available from Loviisa, VTT and STUK for inclusion in site declarations, as required in the Model Protocol Additional (article 2a (iii)). A declaration of the Olkiluoto site will be available in early 2004. In Olkiluoto's case, it is to be considered how the construction of the new plant unit and the excavation of the research tunnel to be connected to the planned final disposal facility affect definition of the site. In addition, STUK charted R&D activities in the nuclear field (article 2a (i)) and also new undertakings subject to oversight after the coming into effect of the Protocol.

Together with the IAEA and Euratom, STUK arranged a meeting in which the final report of a VTT field trial was approved. A field trial of safeguards implementation in accordance with the Protocol was carried out at VTT in 2000–2002, with participation from the IAEA, Euratom, VTT and STUK. Based on the experiences gained from this, STUK has been able to essentially affect safeguards implementation in accordance with the Protocol within the entire EU.

A STUK expert participated in an IAEA meeting in London in which a revision of IAEA guidelines on the implementation of safeguards in accordance with the Protocol was prepared. STUK's experts also took part in a Euratom Safeguards meeting in Luxembourg where the launching of safeguards in accordance with the Protocol within the EU was discussed. Notifications to the IAEA in accordance with the Protocol and a Euratom proposal for the harmonisation of the flow of information were addressed. STUK's opinion is that the proposal would not support the implementation of effective IAEA safeguards, quite the contrary. STUK submitted its written comments on the proposal to the Commission.

The Commission provided the member states with a revised version of Euratom Regulation 3227/76 for comments in 2002. The Regulation's revision is important now ia due to safeguards in accordance with the Protocol, the EU's enlargement and the reporting format in use today. A working group of the Council's Atomic Questions Group, AQG, has discussed the Regulation's revision. It met 13 times in 2003. STUK was active in its meetings.

5.1.3 Safeguards of nuclear fuel final disposal

The final disposal of nuclear fuel in an underground repository presents new challenges to safeguards implementation since, after encapsulation, nuclear material verification will be impossible in practice. In so far as safeguards on final disposal are concerned, STUK had started work on creating national requirements for an encapsulation and final disposal facility. The objective is to establish safeguards criteria covering both national and international regulatory needs.

Under the auspices of an IAEA support programme funded by the Ministry for Foreign Affairs, STUK arranged an international meeting on safeguards of final disposal (SAGOR). Its objective was to chart safeguards methods for long-term final disposal and to devise procedures particularly for the Olkiluoto final disposal concept. STUK's experts came forth with a preliminary plan for the control of final disposal by the Finnish regulatory system and for co-operation with the IAEA.

STUK sent the IAEA a letter about the start of construction of an underground research facility, because that facility is envisaged to become a part of a spent fuel repository in 2004. At the same time STUK requested a statement from the IAEA on the Agency's safeguards requirements. STUK also looked into the applicability of new safeguards methods, such as satellite imagery, seismic measurement and remote sensing methods, for control applied during the construction of the final disposal facility. In early 2004, the finishing touches will be applied to a plan on safeguards control during the construction of the underground research tunnel.

5.2 Supervision and control of radioactive materials transport

About 20 000 radioactive packages are transported in Finland every year. STUK is not aware of any transport accidents involving radioactive materials, or of any other safety hazards in 2003. The transport of nuclear materials require a licence from STUK. Nuclear liability insurance and sufficient physical protection, among others, are conditions for the licence. STUK approved four transport plans, three of which for the import of fresh fuel and one for the export of irradiated fuel rods for analysis. Six types of packaging were approved for use in Finland. Three of these approvals had been applied for potential transits that did not take place, however. The most significant forms of nuclear material transport in 2003 were the import of fresh fuel to the Finnish nuclear power plants from Germany, Sweden, Spain and Russia as well as the export of three irradiated nuclear fuel rods to Sweden for analysis. Of the consignments of nuclear material transported in 2003, one batch of nuclear fuel was picked up for detailed inspection. No remarks were made in the inspection. In addition, one consignment was approved for transport subject to special arrangements.

The import of radioactive and nuclear materials is subject to a licence. No related smuggling attempts were detected at the Finnish border in 2003.

No illicit consignments containing radioactive material were turned back at the border in 2001–2003. 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, consignments of scrap metal to Finland have decreased.

Safeguards as well as supervision and control of nuclear material transport are looked into in detail in the report *Nuclear Safeguards in Finland 2003* (STUK-B-YTO 231).

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. Adherence to the Treaty is monitored by means of an international observation network, which will comprise 321 monitoring stations.

The National Data Centre (NDC) in conjunction with STUK, which is based on the CTBT, contributed to the work of the preparatory commission for the Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) in establishing a cost-effective organisation functional also from the Finnish point of view. The NDC's own automatic routine monitoring was in operation for the whole year. It is facilitated by an alarm system transmitting data on unusual observations to the NDC personnel. The NDC observed on abnormal activity in 2003.

A database was developed for data yielded by the Centre's analysis programme.

In 2002 STUK signed an agreement with the makers of the analysis programme about its handing over to the national data centres of other countries for use in CTBT work. In 2003 the programme was forwarded to the national data centres of Estonia and Lithuania. In addition, the national data centres of Rumania, Iceland and Algeria requested for the programme.

6 Safety research

Esko Eloranta, Harri Heimbürger

STUK-financed safety research focuses on two areas: development of safety assessment methods and expertise as well research in direct support of regulatory decisions. The former benefits first of all from the national nuclear power plant safety and waste research programmes SAFIR and KYT. Excluded from these programmes is research commissioned by STUK pertaining to its own decisions, which must be independent of similar research by licensees or licence-applicant. In addition to these two main areas, STUK commissions independent research to develop regulatory control.

STUK's experts controlled and monitored the SAFIR and KYT programmes and contributed to the support and managing group work of the SAFIR programme. The framework of SAFIR is based on the multiple safety challenges to nuclear power plants indentified for the current decade due to the ageing of operating facilities and the new nuclear power plant.

The general research topics of the SAFIR programme, which started in 2003, were fuel and reactor core; primary circuit; containment and process safety functions; automation; control room and information technology; organisations and safety management; and risk-informed safety management. The programme was arranged into 18 research projects whose results are available at *http://www.vtt.fi/pro/tutkimus/safir/*, where also information about the SAFIR programme can be found. In the field of reactor safety, STUK contributed to several projects within the OECD/NEA and also worked with the US NRC. Of STUK-commissioned research projects outside the SAFIR programme, the most significant pertained to the development of analysis facilities needed in the regulatory oversight of the new nuclear power plant and the plant's safety analyses.

The focus of the KYT programme in 2003 was similar to that of the earlier JYT2001 programme ie earth sciences, technical barriers, migration of radioactive substances, safety analyses and technical solutions. Information on the programme can be found at *www.vtt.fi/pro/tutkimus/kyt/*.

Appendix 6 lists STUK-financed safety research completed in 2003. It was commissioned to external organisations, which too, are listed in this Appendix. The cost of nuclear safety research in 1999–2003 is given in Fig 10. Growth is due to research project orders pertaining to the new nuclear power plant.

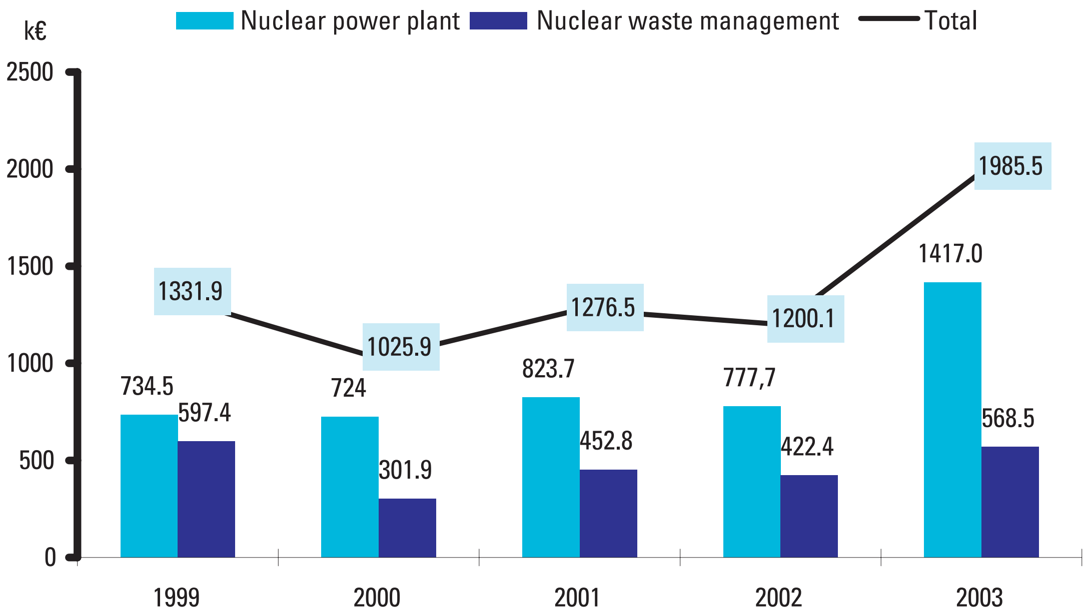


Figure 10. The cost of nuclear safety research.

7 Nuclear facilities regulation and its development

Kaisa Koskinen, Pekka Salminen, Arja Tanninen, Reino Virolainen, Kaisa Åstrand

7.1 Processes and structures

Document handling

A total of 1520 documents were submitted to STUK for review in 2003. The number of documents submitted in 2003 and earlier, whose review was completed in 2003, was 1619. The figure includes licences granted by STUK in accordance with the Nuclear Energy Act, which are listed in Appendix 5. Average document review time was 51 days. The number of documents and their average review times in 1999–2003 are given in Fig 11. Figs 12 and 13 give the distribution of the review times of documents on the Loviisa and Olkiluoto plant units.

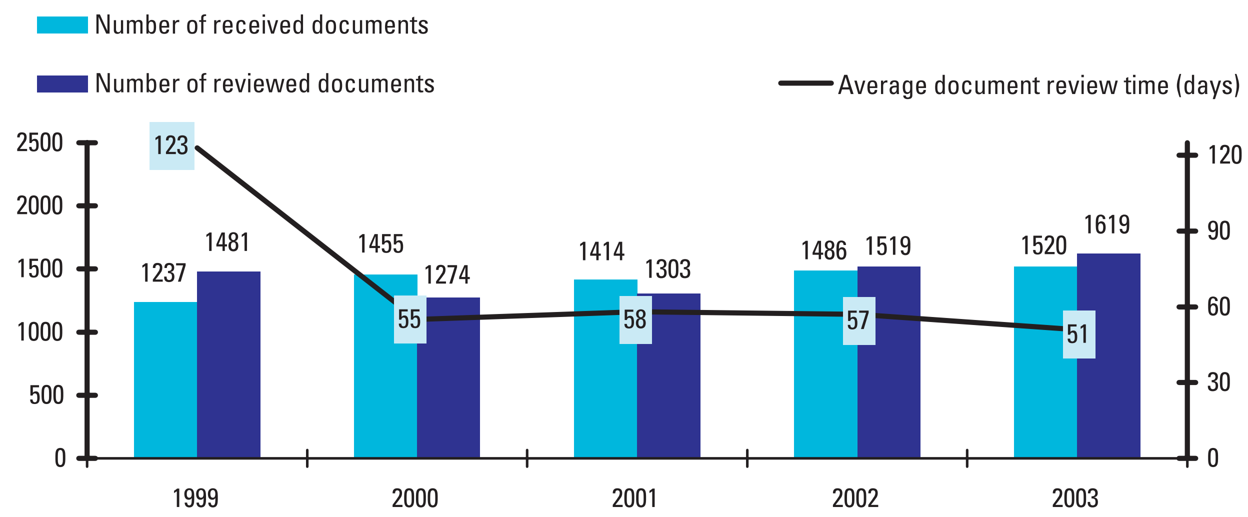


Figure 11. Number of documents received and reviewed as well as average document review time.

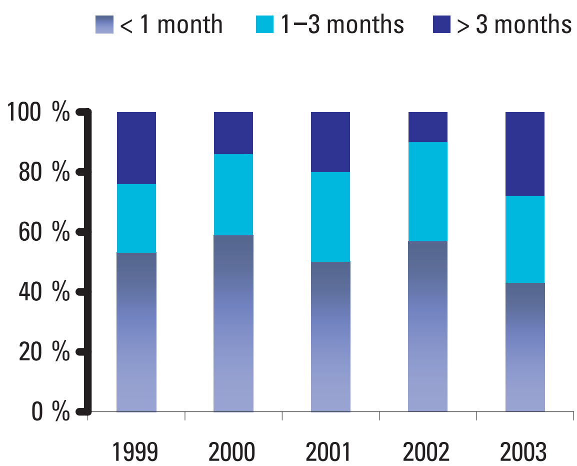


Figure 12. Distribution of time spent on preparing decisions about the Loviisa plant units.

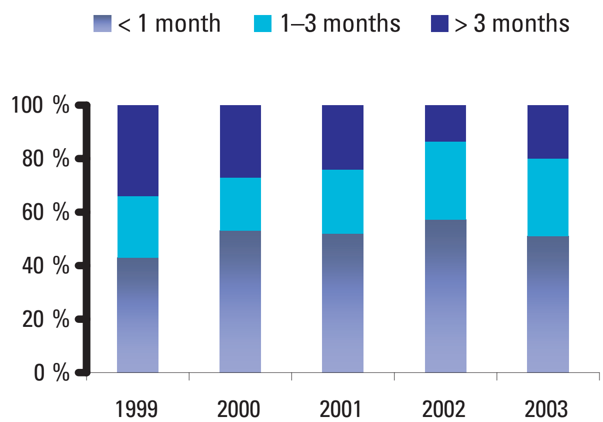


Figure 13. Distribution of time spent on preparing decisions about the Olkiluoto plant units.

STUK's own operation

The renewal of STUK's strategy was completed. The new strategy for 2003–2006 considers the following factors in the field of nuclear safety regulation as affecting ia regulatory control: ageing of operating nuclear power plants, construction of the new nuclear power plant and de-regulation of the electricity market as well as spent fuel final disposal and the coming into force of the IAEA Additional Protocol. An important task in 2003 was the development of working processes and competence. Processes essential for nuclear safety regulation were determined: overall safety assessment, plant projects and modifications control, plant operability control and organisational operation control. They divided into 7–9 sub-processes. The non-proliferation process includes safeguards, control of radioactive materials transport and control based on the CTBT. The nuclear waste process includes control of nuclear waste management operations as well as of R&D and planning activities in the area of nuclear waste management. Process and sub-process owners were designated and the drawing up of process descriptions were started. Sub-sections 3.1 and 3.2 of this report are structured along these processes.

An IRRT (International Regulatory Review Team) of the IAEA visited STUK from 31 August to 9 September 2003. Comprised of six experts, its task was to find out if STUK's operations have been improved in accordance with recommendations given in an assessment of its regulatory operations in 2000. The Review Team established that the majority of recommendations it had given in 2000 had lead to improved operations. The Team gave STUK two more recommendations and 18 proposals to consider whether certain matters could be taken care of better, using the alternative method proposed. The recommendations given dealt with the strengthening of the legal basis for the regulation of spent fuel final disposal planning and research as well as of radioactive materials transport.

The Team identified 14 procedures worth pointing out to other authorities. These pertained to the planning of own operations and the development of nuclear power plant and nuclear waste regulation. Based on the recommendations and proposals, STUK assessed the necessary further actions.

Ideas for development of own operations were obtained also from international operational experiences. An extensive fuel failure during maintenance operations at Paks nuclear power plant, Hungary, showed that requirements for the licencee's indivisible responsibility for safety and their ability to supervise their sub-contractors is to be emphasised in regulations. The licensees in Finland have been outsourcing their operations while their own operations have focused on key know-how. Supervision of sub-contractors by the licensees has become topical in Finnish safety regulation.

Document management

A STUK long-term document management project moved to the realisation phase. In 2003, several types of document management software offered by various suppliers were compared and visits made to suppliers and also to companies where such software had been commissioned. Choice was made after a call for bids and a detailed comparison of products with the help of a consultant. The software main components included a portal, a document management application, a team work application and an archiving application.

In 2003, identification and assessment of all STUK departmental processes and the associated flow of documents, presupposed by the new software, were also launched. It was specifically identified what types of document pertain to each work process, the meta data presupposed by them as well as the information resources to be transferred to the new system. Definition of the portal's functionality and content has also been started. The new system is due for commissioning in 2004.

Safety culture

STUK has target-orientedly aimed at strengthening Finnish safety culture in the whole of the nuclear field. In support of this, co-operation in related questions has been organised between Finnish safety authorities.

A seminar was held at STUK in June dealing with the bases for and procedures of the regulatory oversight of safety management and culture. The participants, of which there were 50, were from STUK, the Safety Technology Authority (TUKES), the Finnish Rail Administration, the

Finnish Maritime Administration and the occupational safety unit of the Ministry for Social Affairs and Health. The starting point for the seminar was awareness of the fact that there are latent risk factors in technical systems, in the operation and management of the objects of regulation, legislation, regulatory activities and the global economy, which contribute to, and when worst comes to worst, lead to accidents. A well operating and managed organisation with a strong safety culture is capable of identifying risks and operating safely. The role and tasks of authorities in safety regulation are undergoing change and it looks necessary to focus oversight specifically to assuring organisational operating capability.

The common challenge Finnish safety authorities are now facing is how to evolve from technical inspectors to overseers and promoters of the safety operations of organisations. The seminar dealt with abstract and practical questions pertaining to safety management and safety culture. Presentations and general discussion looked for a common opinion on how insufficient safety in technology and human activity come about and how they can be prevented by safety management. The seminar was a good means of sharing knowledge and experiences on the regulatory procedures used in the oversight of technical systems and organisational procedures.

STUK's representatives have contributed to international opinion exchange on safety culture in the nuclear field. The role of authorities in particular in the strengthening of safety culture was discussed at an IAEA meeting in September. An authority is to foster positive development in the safety culture of other organisations by setting a good example in its own field and being consistent in regulatory work.

STUK has aimed to add transparency and practicality to the concept of safety culture and the associated concept of safety management. Safety management and, more widely, management research has served as a source of concrete information as to what affects safety behaviour and organisations' safety results and what management teams in safety critical fields are to consider. A master's thesis on this topic is under way at STUK. The data thus obtained has been utilised in the revision of YVL guides as well.

Risk-informed regulatory control

Risk-informed quality management

A piece of research was completed in 2003 in how to use risk analysis to support the establishment of a quality management system and classification (Graded QA). Both utilities participated by submitting the material on what was chosen as an example and the VTT State Technical Research Centre of Finland conducted the related research. Both utilities have already classified certain organisational functions such that eg a function's safety significance and related operational experiences and requirements for operability have been considered in defining a task's requirement level. However, classification has been case by case and probabilistic safety analysis has not been utilised in the assessment of a task's safety significance. The research done showed that the utilisation of risk analysis in the classification of organisational functions makes possible the focusing of a utility's resources to where the risk from the plant's operation can be most effectively reduced.

Risk-informed development of the Technical Specifications

In 2003, a Technical Specifications development project was completed. It yielded a calculation method for identifying transients during which a change in the plant operating state may entail a bigger risk than component repair during power operation. However, prior to its commissioning, reliable reference analyses are yet to be conducted requiring a major contribution from experts in the field.

Development of the FinPSA computer program

The risk assessment program FinPSA proceeded to its test operation phase. Almost all features pertaining to management of the Level 1 PSA model have been completed. The most important numerical calculation routines (minimal cuts, their importance measures and those of basic events) have been established. The Olkiluoto plant's risk model was transferred to an entirely new program.

PSA information system

STUK has developed a Probabilistic Safety Analysis Information System (PSAIS) as a tool for risk-informed regulatory control of nuclear safety. The system provides detailed data on the results of risk analyses, methods, conclusions made, their application and utilisation in nuclear safety regulation. PSAIS is an information system from whose hypertext environment the information needed can be extracted in several ways. The system will be made available in STUK's intranet.

The first phase of PSAIS was completed in 2003 and it contains the below thematic entities on Olkiluoto nuclear power plant:

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

A plan was devised for transferring this information to STUK's intranet. System programming and preparation of its intranet pages is under way.

7.2 Renewal and working ability

A competence analysis, which was started in 2002, was completed and, on the basis of its results, competence development programmes were drawn up. The survey gathered information on competence relating to special skills and to general working skills; it defined the target situation and the current state of affairs; and their most essential gaps. On the basis of the results, training and development programmes to enhance know-how will commence.

Facilities and competence relating specifically to the new nuclear power plant in planning were developed. With this in mind STUK participated in the preparation and execution of a basic professional training course on nuclear safety with other organisations in the field. The 6-week course commenced in September 2003 and continued in 2004. Over 50 junior experts in the nuclear field from various organisations participated, eleven of which were from STUK.

A survey on well-being at the workplace was carried out at STUK. Actions to enhance it were agreed upon based on the results of the survey. Some actions could be realised right away and the implementation of some will continue in 2004.

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 rulemaking and support functions (administration, development projects in support of regulatory activities, training, maintenance and development of expertise, reporting as well as participation in nuclear safety research) were carried forward into the costs of both types of basic operation and of contracted services in relation to the number of working hours spent on each function.

In 2003, the costs of the regulatory control of nuclear safety subject to a charge were 7.2 M€. The total costs of nuclear safety regulation were 8.7 M€. Thus the share of activities subject to a charge was 83%.

The 2003 income from nuclear safety regulation was 7.2 M€. Of this, 2.3 M€ and 3.9 M€ came from the inspection and review of Loviisa and Olkiluoto nuclear power plants, respectively. In addition to the operating plant units, the income for Olkiluoto's part includes regulatory control of the new reactor in planning. The regulation of Posiva Oy's operations yielded 1.0 M€. The income from other objects of regulation (ia regulation of the FiR 1 research reactor, regulation of small-scale users of nuclear materials) was 0.01 M€. Figure 14 gives the annual income and costs of nuclear safety regulation in 1999–2003.

The time spent on the inspection and review of Loviisa nuclear power plant was 10.3 man-years, ie 12.2% of the total working time of the regulatory personnel. For Olkiluoto nuclear power plant it was 10.0 man-years, which accounts for 11.8% of total working time. In addition to the oversight of the operation of domestic nuclear power plants, the figure includes nuclear material control. The time spent on nuclear waste management inspection and review was 2.5 man-years. Preparation of the regulatory oversight of the new nuclear power

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

Duty area	1999	2000	2001	2002	2003
Basic operations subject to a charge	25.3	26.4	26.3	27.6	29.2
Basic operations not subject to a charge	5.5	7.5	7.4	6.9	6.4
Contracted services	7.0	5.4	4.4	3.8	4.9
Rule-making and support functions	24.6	25.5	28.5	27.1	28.2
Holidays and absences	14.8	15.0	16	16.2	15.9
Total	77.2	79.8	82.6	81.6	84.6

plant took 5.0 man-years and that of the FiR 1 research reactor 0.1 man-years.

Distribution of yearly working time of the nuclear regulatory personnel according to duty areas is given in Table III. Figure 15 presents the distribution of working time spent on main functions in 1999–2003.

The number of inspection days onsite and at the component manufacturers' premises totalled 1321. Not only inspections pertaining to the safety of nuclear power plants but also nuclear waste management and safeguards inspections are included. In addition, two resident inspectors worked at Olkiluoto nuclear power plant and one at the Loviisa plant. The number of inspection days in 1999–2003 is given in Figure 16.

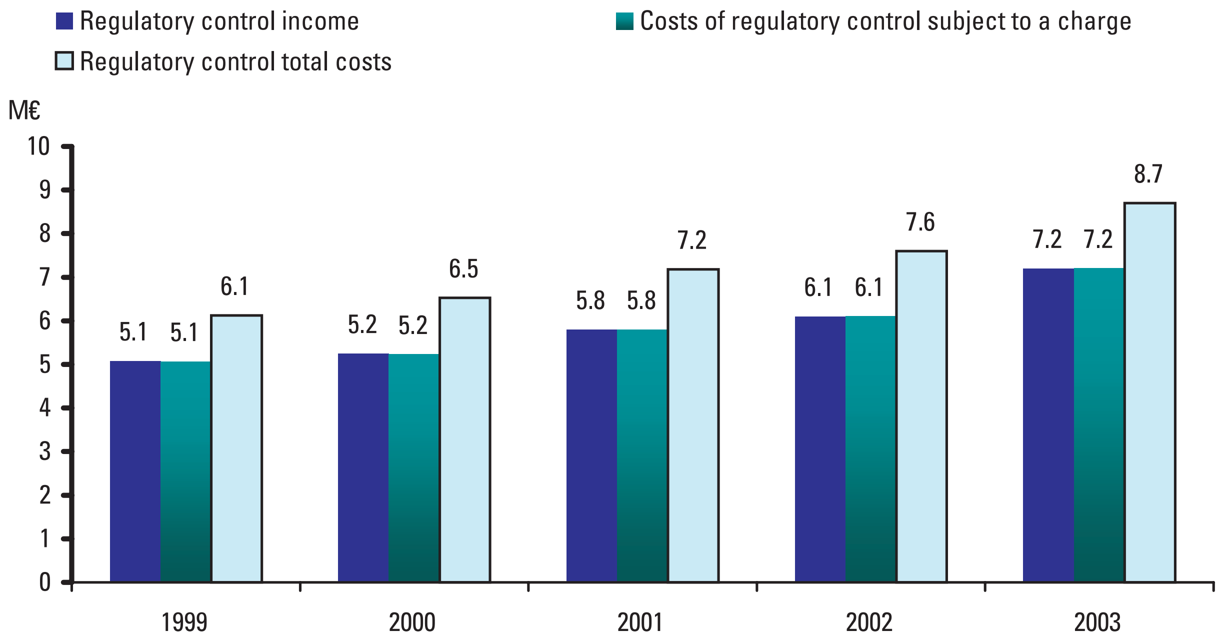


Figure 14. Income and costs of nuclear safety regulation.

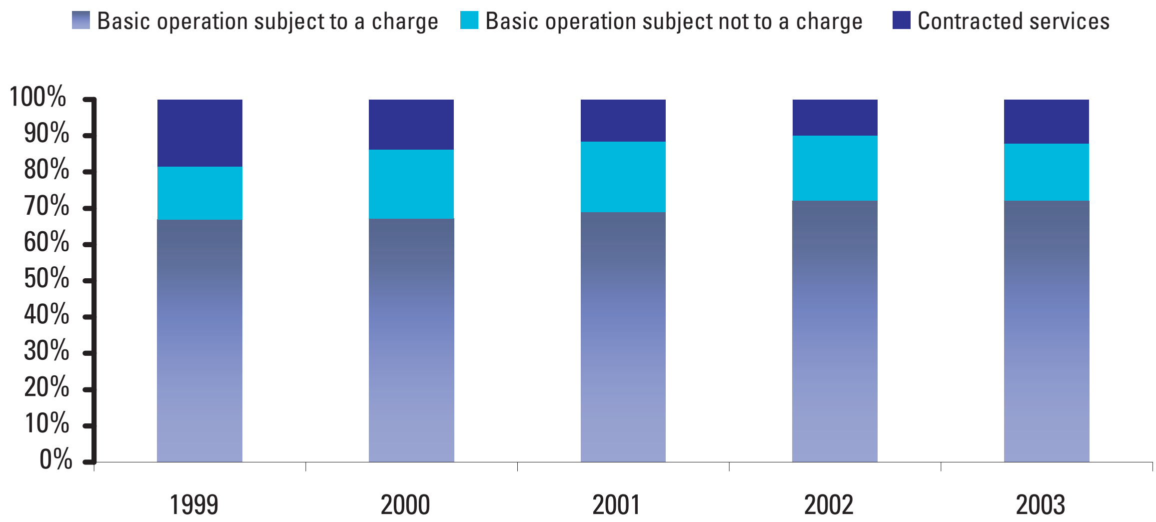


Figure 15. Working time spent on main functions.

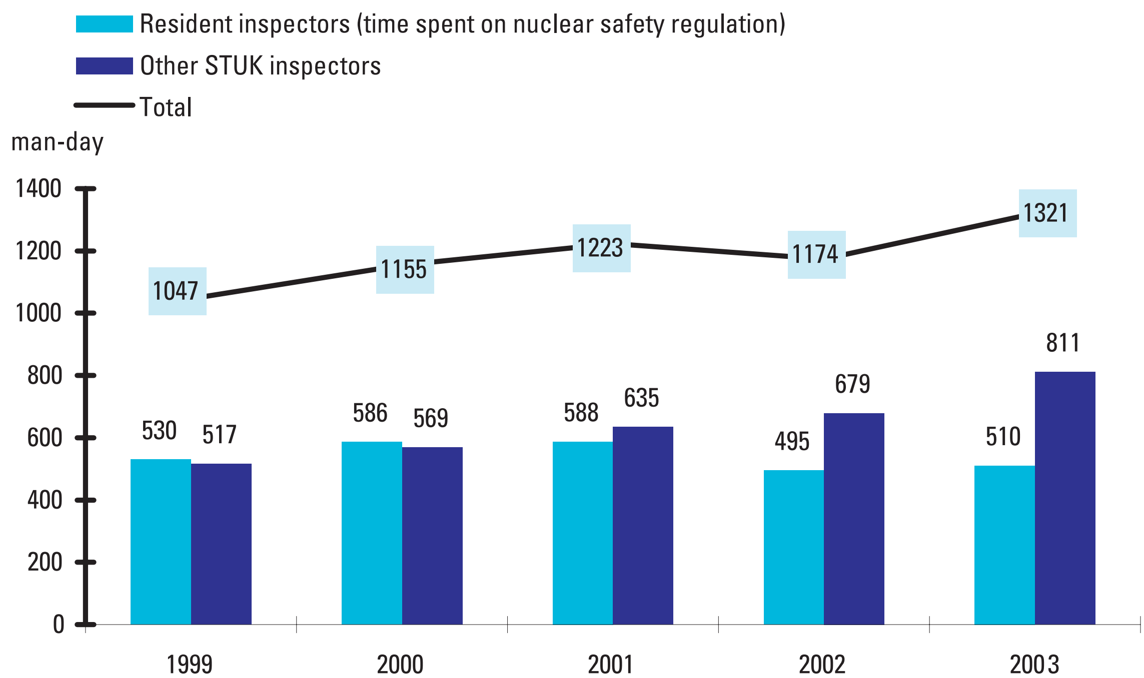


Figure 16. Number of inspection days onsite and at component manufacturers premises.

8 Emergency preparedness

Tuulikki Sillanpää

STUK arranged several training events and exercises to test and develop its own emergency response. In addition, STUK controls preparedness of the operating organisations of nuclear power plants to act in unusual situations. No such situations occurred in 2003.

Emergency response at nuclear power plants is under continuous development during plant operation and regularly tested in emergency exercises as part of emergency preparedness training. STUK has approved the emergency plans of Loviisa and Olkiluoto plants and yearly reviews the implementation of the emergency preparedness regime, including training and emergency exercises.

Two domestic emergency exercises were arranged in 2003 which STUK participated in. On 25 November 2003, over 30 domestic authorities and co-operators, media and Nordic nuclear and radiation safety authorities participated in an extensive emergency exercise of Loviisa nuclear power plant. STUK went in full-scale, with approx. 120 participants. The exercise tested inter-authority co-operation, the forming of an overall picture of the accident situation and the dissemination of information for the public and media. Tested were also the emergency plan, operation and management of the Rescue Region of Itä-Uusimaa to be established. Nordic radiation and nuclear safety authorities assessed the need for mild protective measures in the Nordic countries in the emergency event in question, based on the overall picture of the accident situation communicated by STUK. Protective measures could include ia travelling restrictions to Finland, measures imposed on trade and transportation as well as communicating information to visitors from own country to Finland.

The Olkiluoto annual emergency exercise was carried out on 19 November 2003 as a classroom exercise, with all parties taking part. The preceding training session went through the changes in operation brought about by the new emergency response centre system and the rescue region.

Fire drills were organised at Loviisa nuclear power plant on 21 May 2003 and 12 November 2003. A fire drill was organised at the Olkiluoto plant on 10 November 2003.

STUK also participated in nuclear power plant emergency exercises of international scale, which in 2003 contained no actual analysis of plant situations. A series of four EU-funded emergency exercises, held on 27 May 2003, tested the support systems to decision-making that are employed during a nuclear power plant accident to assess an accident's harmful effects in the plant's environment and the benefits of protective measures.

9 Communications

Risto Isaksson

In 2003 STUK issued 14 press releases on nuclear safety regulation. The press release of 26th November on the unusually high number of INES Level 1 events at Olkiluoto nuclear power plant got the most attention. Another press release reporting events at domestic plants was about a leak in the hydrogen system of a Loviisa 2 generator; the plant unit's other turbine was stopped to repair the leak. Two press releases routinely reported the plants' annual maintenance outages.

STUK's international co-operation and events abroad were reported in the form of press releases. Topics included eg CTBT and assessment of nuclear waste programmes internationally. The fuel failure at Paks nuclear power plant, Hungary, was dealt with in one bulletin and in a complementing memorandum at STUK's web site. Information about the opening for public access of the Nuclear Events Web-based System (NEWS) was disseminated as well.

Together with its partners in co-operation, STUK in September started a basic professional training course on nuclear safety. The need for this arises from not only change of generation in the field but also from the challenges set by the new nuclear power plant. This was reported in a press release and in the STUK magazine Alara. The composition of the new Advisory Committee on Nuclear Safety was the topic on one September press release.

All the bulletins on STUK's safety regulatory effort in 2003 exceeded the news threshold but caused no big headlines. The power plants disseminated information about their annual maintenances at the same time, so it cannot be said that STUK made them headlines.

In addition to press releases, the operation of and events at the domestic nuclear power plants were dealt with in quarterly reports on nuclear safety, which were sent to the media and interest groups. The reports were also available at STUK's web site.

Issue 4/2003 of the STUK periodical Alara focuses on issues of nuclear safety. It contained largish articles on how STUK is preparing for the safety assessment of the new nuclear power plant, on the accident at Paks, Probabilistic Safety Analysis as well as spent nuclear fuel safeguards and the Model Protocol Additional. Other 2003 issues of Alara carry shorter articles on current topics.

In early 2003, a popular review of nuclear power plant safety was published.

10 International co-operation

Ilari Aro, Juhani Hyvärinen, Elina Martikka, Matti Ojanen, Hannu Ollikkala, Esko Ruokola, Pekka Salminen, Kirsti Tossavainen, Olli Vilkamo

Co-operation with the IAEA

The IAEA continued revision of its nuclear safety guidelines (formerly Nuclear Safety Series NUSS). The revision is almost done and is expected to be completed in the coming years. STUK prepared for the IAEA several 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-representatives were active in the WASSC (waste safety) and RASSC (radiation safety) committees.

The first review meeting on the Joint Convention on the safety of spent nuclear fuel management and on the safety of radioactive waste management was held in Vienna in November 2003. The Convention requires the submission, every three years, of a report on how its obligations have been met. STUK was responsible for the drawing up of Finland's country report and a delegation headed by STUK participated in the review meeting into which 33 countries participated. Finland's written and oral reports were received rather favourably: several good practices were referred to and the recommended safety improvements were the ones already mentioned in the country report.

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

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

A report was forwarded to the IRS system about cracking in the shroud tubes of control rod drives connecting to the Loviisa 2 primary circuit, detected towards the end of 2001 and in 2002. No events reportable to the INES and IRSRR systems occurred. Yearly information on the operation of the Finnish nuclear power plants was forwarded to the PRIS system.

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

Funded from the IAEA's safeguards support programme, a STUK-representative worked as a co-ordinator to East and Middle European assistance programmes. The programme is financed by the Ministry for Foreign Affairs and executed by STUK. Its objectives include development of the IAEA's safeguards procedures, training of inspectors and provision of expert assistance. Expert assistance will not continue in this form in 2004.

In IAEA expert capacity, a STUK representative participated in the IRRT assessment of the Bulgarian and Slovakian nuclear and safety authorities as well as the investigation of the extensive fuel failure at Paks nuclear power plant in Hungary.

Co-operation with the OECD/NEA

International co-operation in nuclear safety research was mostly channelled through the OECD/NEA. The organisation also facilitated an exchange of opinions about current nuclear safety questions. STUK was represented in all of the organisation'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 also in the work of the below CNRA and CSNI Working Groups

- Working Group on Inspection Practices (WGIP)
- Task Group on Regulatory Effectiveness Indicators (CNRA/TGRE) and Task Group on Safety Performance Indicators (Joint CNRA/CNSI/TG-SPI)
- Working Group on Public Communication of Nuclear Regulatory Organisatios (WGPC)

The CSNI Working Groups' fields of activity were as follows

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

A STUK-representative was chairman of the CRPPH Expert Group on Effluent Release Options (EGRO). The final report on this work was published in 2003.

Co-operation with the EU

The Atomic Questions Group (AQG) of the Council of the European Union in the autumn of 2003 sent out an expert group to Bulgaria to gain insight into safety improvements made at Kozloduy nuclear power plant and the reorganisation of the country's nuclear sector in accordance with the requirements of EU membership. A STUK representative contributed to the preparation, execution and results assessment of this mission. The Group's final report will be completed in the spring of 2004.

STUK participated in the work of three working groups of the NRWG. One of the groups looked into the suitability of Risk Informed In-Service Inspection (RI-ISI) for the drawing up of a piping inspection programme for nuclear power plants. Represented in the working group are also authorities from France, Spain, Belgium, Sweden, Germany, England and Switzerland. The working group has been in close contact with the utilities' ENIQ working group, corresponding working groups of the OECD and the IAEA as well as the organisations that developed the methods (Westing house and EPRI) and utilities. It has drawn up a draft report describing the contents of various RI-ISI methods, European and American applications, differences/similarities between traditional methods and RI-ISI methods. In addition, the report assesses the pros and cons of the RI-ISI procedures from a regulatory point of view.

Another NRWG working group, to whose work STUK participated, dealt with the qualification of non-destructive examination. The group's task was to exchange experiences in the implementation and development of qualification in European countries and to follow and assess inspection qualification with an eye to regulatory work. Based on a survey it conducted, the working group prepared a report describing the status of qualification in nuclear EU countries and applicant countries.

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

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

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

Via the activities of the Regulatory Assistance Management Group (RAMG) of the EU, STUK participated in Phare and Tacis co-operation in support of East European regulatory organisations and their support organisation. There were two meetings of the group in 2003. It assessed the appropriateness of projects prepared by the EU to support regulatory work. STUK contributed to the then-ongoing Phare and Tacis projects. STUK participated in the work of the CONCERT working group consisting of the heads of nuclear safety authorities of the EU member states and applicant countries. The group assembled twice to discuss EU-related questions touching on regulatory work.

NKS co-operation

The new research programme of NKS, Nordic co-operation in nuclear safety, commenced in 2002. It is headed by two responsible programme managers. For the first part of 2003, STUK's representative was responsible for the programme's sub-area of reactor safety, after which responsibility was handed over to a representative of Fortum Nuclear Services Oy. STUK participated in the work of the sub-area of emergency preparedness and environmental safety. In addition, STUK has a representative in the NKS management team.

Projects on reactor safety relate well to Finland's national research programme and needs. Several experts from STUK work with the emergency preparedness and environmental safety programme that includes focus areas important to Finland.

The new programme's content in its entirety serves well co-operation between the Nordic authorities, which is a permanent objective of NKS co-operation.

Bilateral co-operation

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

A representative of STUK was chairman of a nuclear safety committee that supports the Belgian nuclear safety authority and participated as a permanent member in the work of a corresponding Lithuanian advisory committee.

STUK's co-operation with the USNRC focused on information exchange in nuclear safety matters of interest to both parties. A STUK representative worked at the USNRC as a visiting expert for one year. STUK continued, in co-operation with USNRC and VTT, development of the FRAPTRAN/GENFLO code for fuel transients. Additionally, and in co-operation with Fortum Service, Argonne National Laboratory (ANL) was provided with Zr1%Nb cladding material for the USNRC's LOCA tests. Discussions on the licensing of new nuclear power plants and experiences in their construction were had with US authorities.

Discussions were had with the French authority (DGSNR) and the Czech Republic's auhtority (SUJB) on the licensing of new nuclear power plants and experiences on their construction.

An expert on I&C technology from the Swiss authority (HSK) worked at STUK for six weeks. The visit's topic was regulatory control and supervision of extensive I&C modifications at nuclear power plants, in which the Swiss have gained experience in the past few years.

Co-operation between STUK and the Russian nuclear safety authority Gosatomnadzor (GAN) in nuclear material and waste control continued, based on a co-operation arrangement signed in 1998. For the part of nuclear waste, the development of regulatory guidelines was of particular interest.

Safeguards co-operation between STUK and the Australian Safeguards and Non-proliferation Office (ASNO) continued. STUK provided ASNO with information about nuclear materials imported to and kept in Finland as agreed.

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 had been set up to develop a method for drawing up uniform nuclear safety requirements. In accordance with the recommendations of the working group's final report, an extensive nuclear safety requirements development project was commenced in early 2003. It serves to establish nuclear safety requirements for 19 safety issues plus their status in the 17 participating countries. STUK in 2003 actively contributed to the project ia by drawing up draft requirements for licensee training and qualilfications approval as well as probabilistic safety analysis related areas.

The VVER Regulators Forum in 2002 set up a working group of authorities to compare the risk analyses (PSA) conducted for VVER facilities and to analyse their causes. The working group met twice in 2003; one of the meetings was held in STUK. The working group consists of national nuclear safety authorities from Armenia, Bulgaria, Ukraina, Russia, Slovakia, the Czech Republic, Hungary and Finland. In 2003 each participating country drew up a summary report of the PSA for their own country's VVER plants and, based on their PSA, analysed in more detail one initiating event leading to an accident plus a subsequent accident chain.

STUK participated in the work of the Network of Regulators of Small Nuclear Programs (NERS). NERS met once in 2003.

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 16 August 2000 and its term of office ended on 15 August 2003. A new Committee was appointed on 10 September 2003.

In early 2003 the Committee's Chairman was Professor Pentti Lautala (Tampere University of Technology) and its Vice-Chairman was Head of Research Rauno Rintamaa (VTT Technical Research Centre of Finland). In 2003 the members were Senior Researcher Riitta Kyrki-Rajamäki (VTT), Director Ulla Koivusaari (Pirkanmaa Regional Environment Centre), Director Olli Pahkala (Ministry of the Environment), Professor Rainer Salomaa (Helsinki University of Technology), Branch Manager Paavo Vuorela (the Geological Survey of Finland). Professor Jukka Laaksonen, Director General of STUK, was a permanent expert to the Committee. Invited experts were Doctor of Technology Antti Vuorinen and Director Christer Viktorsson (the Swedish Nuclear Power Inspectorate).

Mr Olli Pahkala and Mr Rainer Salomaa left the Committee during the year. In their place, the Government assigned Director Timo Okkonen (TUKES) and Senior Researcher Ilona Lindholm (VTT). Mr Pentti Lautala continues as Chairman and Mr Rauno Rintamaa as Vice-Chairman. Mr Antti Vuorinen and Mr Christer Viktorsson continue as invited experts.

The Committee convened eight times in 2003.

The Committee has three divisions for preparatory work: a Reactor Safety Division, a Nuclear Waste Division as well as an Emergency Preparedness and Nuclear Material Division. In addition to the Committee members proper, distinguished experts from various fields have been invited to the Divisions. A total of twelve Division meetings were held in 2003.

APPENDIX 1 STUK's safety performance indicators for nuclear power plants in 2003

Seija Suksi

Summary of the results of STUK's safety performance indicators

Background for indicators

Overall assessment of nuclear power plant safety by inspection and safety reviews is complemented by the STUK indicator system. The indicators of the system can be used to illustrate that certain safety factors under scrutiny have remained at a desired level and to gain insight into their possible changes and trends in the long run. Declining trends indicate a possible need to enhance performance and organisational operation of the plants and STUK's regulatory effort. The aim is to recognise, as early on as possible, trends in the safety-significant functions of a nuclear power plant or STUK. Even the effectiveness of actions commenced based on indicator results can be monitored by means of these indicators.

The indicator system divides into two principal groups: external indicators for the safety of nuclear facilities and internal indicators for the regulatory effort. External indicators divide into three principal subgroups: safety and quality culture; operational events; and structural integrity. These principal subgroups have a total of 14 indicator areas having 46 specific indicators.

The development of STUK's safety indicator system began in 1995. A couple of years from this, some safety and performance indicators were incorporated in the target plan of the Department of Nuclear Reactor Regulation YTO (NRR). These indicators have been systematically calculated, interpreted and reported, resulting in some measures (event investigation 1/00). Other indicators have not been calculated and used so systematically. They have resulted in individual clarifications. The information thus gathered has mostly been utilised as background for inspections.

The development of indicators, anchored to the STUK strategy, began in 2001 and they were included in the new STUK strategy, revised in early 2003. Of the effectiveness indicators for STUK's activities, the below apply to the NRR: occupational doses, radioactive releases from nuclear facilities and the resultant population exposure in the vicinity of the plants, safety-endangering events at nuclear facilities, condition of components relevant to the accident risk of nuclear facilities, updating of YVL guides, customer satisfaction and number of complaints. The last three indicators describe the NRR's own activities and are incorporated in the indicator area for regulatory activities. Indicators for plant safety, incorporated in the STUK strategy, have quantitative limits contained in legislation, YVL guides or the NRR's own objectives. Currently, all plant safety indicators are contained in the effectiveness sector of the NRR strategy.

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

An intermediate assessment of the STUK indicator system was conducted in 2003. The assessment's objective was to improve the definition and reliability of specific indicators and find ways of enhancing the system utilisation and implementing the indicator process as a part of oversight of nuclear safety. As a result, the definitions of some indicators were made more specific. A decision was made to introduce new event risk-significance indicators. It was decided to implement changes to the rest of the indicators as of the start of 2004. Indicator maintenance and reporting was changed such that they are updated quarterly and the yearly indicator report is attached to the Annual report on regulatory control of nuclear safety in Finland submitted to the Ministry of Trade and Industry.

Indicator results for 2003

Safety and quality culture

STUK's safety performance indicators for nuclear power plants in 2003 showed a deteriorating trend in the maintenance function of the Loviisa power plant in 2003. The number of failures and preventive maintenanace operations of components subject to the Technical Specifications at the plant was on the increase, as was the average time spent on work to be completed during three days. The failures distributed to multiple technical fields and no specific problem area could be pointed out. The future will show whether an actual change has taken place in the previously declining trend. In addition to the aforementioned indicators, the Olkiluoto plant followed quality of maintenance on the basis of maintenance errors and their types. These indicators, specific to the Olkiluoto plant, indicated an enhanced maintenance function and improved quality. The number of failures of components subject to the Technical Specifications at the Olkiluoto plant grew a little.

Safety systems unavailability was followed by means of international indices provided by the licensees. Monitored at the Loviisa power plant were the high pressure emergency make-up water system, the auxiliary feedwater system and the back-up diesel generators; Olkiluoto monitored the containment spray system, the auxiliary feedwater system and back-up diesel generators. The diesel generator unavailability index of the Loviisa power plant showed a deteriorating trend for the third year in succession. At the Olkiluoto plant, the unavailability index of the auxiliary feedwater system was on the increase.

At the Olkiluoto plant, a deteriorating trend for the third successive year was evident in 2003 in the safety indicator system area "Safety and quality culture", which shows the degree of adherence to the Technical Specifications (Tech Specs). Two out of a total of eight Olkiluoto deviations from the Tech Specs were detected by STUK. At the Loviisa plant, only one plant condition occurred in 2003 that did not conform to the Tech Specs. The Tech Specs non-conformances at Olkiluoto, as well as other plant events there, were mostly due to human error. Adherence/non-adherence to the Tech Specs shows the ability of the plant operating organisation to follow rules and its safety attitude. The effectiveness of STUK's regulatory effort is assessed also based on how the Tech Specs are adhered to.

In 2003 the Loviisa plant found it necessary to deviate, in a planned manner, from the Tech Specs during maintenance and modifications almost twice as often as in 2002. STUK granted the Loviisa plant some twenty exemptions from the Technical Specifications for this purpose. The number of events was affected by a project to replace the fixed radiation protection monitoring system, which could not be done without deviations in any plant operating state. The number of exemptions granted to the Olkiluoto facility was on a slight increase but remained on a par with previous years. The exemptions granted did not warrant re-evaluation of the Tech Specs.

The licensees' ability to keep plant documentation current pertaining to plant modifications improved in 2003, particularly at the Loviisa plant. The modest improvement in the safety performance indicator of the Olkiluoto plant was partly affected by a new data procurement method. During the calculation of the safety performance indicator of the Olkiluoto plant, shortcomings were observed in the use of document follow-up forms as regards safety classification documents and diagrams. If only based on the plant's own follow-up method, the indicator would have yielded a very weak value. For Loviisa's part, identification of document updates pertaining to electrical and I&C systems was problematic due to the fact that document revision needs are presented in separate installation plans not submitted to STUK. For the part of the Loviisa plant, the question surfaced of updating the Final Safety Analysis Report during extended modification projects when modifications at both plant units are time-phased.

The plant units' safety performance indicator for investments on improvements and modifications only indicates relative fluctuation in investments. Sums given in euros are the utilities' business secret not to be published here. The 2003 amount of investments was close to the average for both facilities. This safety performance indicator was included in the STUK indicator system in 2000 to indicate the potential effect of deregulated electrical markets on investment.

STUK works to affect, both directly and indirectly, the radiation doses of nuclear power plant workers and the calculated doses of surrounding populations arising from releases. This involves low radioactive releases into the environment. The safety performance indicators for radiation exposure in 2003 showed, for both plant sites, a decrease in radiation dose for workers and the surrounding population from releases. According to the safety performance indicators, releases into the sea from the Olkiluoto plant decreased further. Releases into the atmosphere from both nuclear facilities were in the magnitude of the previous year. Argon-41 was the dominant noble gas at the Loviisa plant; it does not originate from fuel or corrosion but is the activation product of argon in the atmosphere between the reactor pressure vessel and the biological shield. A fuel leakage at Olkiluoto 1 had a bearing on the modest growth of the safety performance indicators for the plant's noble gas and iodine releases. The safety performance indicators for radiation exposure indicate the success in 2003 of organisational units responsible for the ALARA programmes, which strive to restrict radiation exposure onsite and releases into the environment, and radiation protection.

Operational events

The safety performance indicators of Olkiluoto nuclear power plant indicated a deteriorating trend in operation. The number of events at Olkiluoto, of which special reports have been written, deviations from the Technical Specifications included, has almost doubled in two years' time compared with the long-time average. They were caused by non-compliance with regulations, non-recording of failures and an incorrect use of computer programs. The number of reports on operational disturbances at Olkiluoto plant grew compared with last year. All of Olkiluoto's operational disturbances occurred at Olkiluoto 2 and originated in electrotechnical malfunctions of the main circulation pumps. One reactor scram occurred at Olkiluoto 1 in 2003. No reactor scrams occurred at the Loviisa plant. The number of other events, reported in accordance with STUK Guide YVL 1.5, at Loviisa nuclear power plant was on the decrease compared with 2002. Human-error induced events at the Loviisa plant were decreasing, whereas, at Olkiluoto, they were on the increase for the third successive year, owing to the growth in the total number of events. No actual fires occurred at either plant.

The effect of the unavailability of safety systems, or their sub-systems, caused by component failures, preventive maintenance and deviations from the Tech Specs approved by STUK, on annual accident risk in 2003 exceeded its target value, ie 5%, for both Loviisa plant units and Olkiluoto 2. This was partly due to planned one-time maintenance jobs executed under exemption permits, and partly to latent component failures. At both Loviisa plant units, it was caused by back-up diesel generator latent failures and unavailability of the diesel generators, which also increased the "Unavailability of safety systems" indicator. At Olkiluoto 2 this was due to the repair, under an exemption order from the Tech Specs granted by STUK, of the ceilings of the shutdown reactor service water system suction channels and a diesel generator latent defect.

New safety performance indicators were introduced in 2003 to represent the risk-importance of events. Events were grouped to three categories according to their risk significance (Conditional Core Damage Probability – CCDP); namely, the most risk significant events (CCDP ≥ 1E–7), other significant events (1E–8 ≤ CCDP < 1E–7) and other events (CCDP < 1E–8). In addition, the events were divided into three groups: 1) unavailabilities due to component failures, 2) planned unavailabilities, and 3) initiating events. The safety performance indicator is the number of events in each risk class. The most significant event at the Olkiluoto plant in 2003 was a reactor scram at Olkiluoto 1, regardless of the fact that all safety systems operated as planned during it. In 2003, six other events of the same risk category occurred at the Olkiluoto plant and 13 at the Loviisa plant. These figures show an increase in events for both plant sites. The number of events assigned in the middle category, both at the Olkiluoto and Loviisa plants, was on a par with the previous year, ie approx. 20 events. The Olkiluoto events were mostly planned unavailabilities, including those caused by work executed under exemption from the Tech Specs and preventive maintenance. The Loviisa events were mostly caused by component failures.

Structural integrity

In the safety performance indicator area, the leaktightness of multiple barriers (fuel, primary circuit, containment) is monitored. The objective is that leaktightness complies with the requirements; deteriorating trends are not allowed, as assessed according to STUK's safety performance indicators. Based on the 2003 indicators, the set limits on barriers preventing the spread of radioactive releases were not exceeded. Fuel integrity has been good, particularly at the Loviisa plant, where not a single fuel leak has occurred in recent years. Primary circuit integrity is monitored by international chemistry performance indices used by the utilities. At the Olkiluoto plant, leakages from the primary circuit are monitored by operating cycle as well. The chemistry indices indicated that operational chemistry control had been successful at Olkiluoto plant. Compared with the previous operating cycle, unidentified leakages in the primary circuit at Olkiluoto plant increased in the operating cycle 2002–2003, being 9.4% of the limit set in the Tech Specs. This was due to leaks from check valves of the relief system of the main steam lines, which took place for the whole operating period. The utility is planning on a new seal structure for the valves.

Containment integrity has been good both in Olkiluoto and Loviisa. The overall as-found leakage of containment outer isolation valves was below set limits at the Loviisa plant units and at Olkiluoto 1. The overall leakage of Olkiluoto 2 isolation valves was twice that of the previous year. Over half of it was caused by a leaking isolation valve in the reactor pressure vessel spray system. Overall leakage through containment penetrations grew at Loviisa but the set limit was not exceeded. The leaktightness of the rubber bellows of the penetrations had been problematic and the Loviisa power plant has initiated their replacement with metal bellows.

Conclusions made from the results of the 2003 indicators

The data gathered from 2003 for nuclear plant safety indicators did not indicate such changes in individual indicators, indicator areas or the three main areas as would have warranted an immediate reaction from STUK, with the exception of indicators pertaining to unusual plant conditions at the Olkiluoto facility. The requirements set for the effectiveness indicators of STUK's activities were fulfilled as regards occupational dose, radioactive releases and population exposure. Releases into the sea from the Loviisa and Olkiluoto facilities reduced to the present level with the introduction into use of equipment to minimise these releases. No safety-endangering events occurred at the nuclear facilities.

The indicators for the maintenance function of the Loviisa plant showed a deteriorating trend for 2003. The future will show whether an actual change has occurred in the previously declining trend. An increasing fault trend would indicate a degrading plant condition and problems in component service life management.

The Olkiluoto performance indicators show an improved maintenance function and quality.

A growing trend, for the third year in succession, in the number of Olkiluoto plant's operational events and events warranting a special report, including plant conditions in non-compliance with the Tech Specs, indicated a degraded safety and quality culture in plant operation. This was evident also in the four INES Level 1 events that occurred within a short period of time towards the end of the year. The effectiveness of STUK's regulatory work is assessed also by means of adherence to the Tech Specs. STUK has started discussions with the management of Teollisuuden Voima Oy underlining the need for overall development of safety culture in the plant's operation. Teollisuuden Voima Oy has commenced the necessary development measures.

The number of situations in non-compliance with the Tech Specs at the Loviisa plant has remained low. The number of other reportable events has been on the decrease, too, for several years in succession.

The structural integrity of multiple barriers containing the release of radioactive substances has remained good.

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 2003 data, their interpretation and assessment of change.

The NRR has assigned persons responsible for the acquisition of indicator data as well as for their calculation and analysis. In 2003, 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.

The data on primary circuit leakages for Olkiluoto nuclear power plant was provided by resident inspectors. The inspectors of TUR gathered and assessed indicators describing the quality of the maintenance function at the Olkiluoto plant. TUR maintained an operational events follow-up table and the head of office was responsible for indicators based on operational events and reports. The office of risk assessment (RIS) assessed the risk-significance of events. Inspectors in the office of power plant technology (VLT) were responsible for indicators describing the functioning of the fire alarm system as well as the integrity of fuel and the primary circuit. The office of reactor and safety systems (REA) gathered and calculated indicators describing containment leaktightness. The office of radiation protection (SÄT) gathered dose and release data and the corresponding indicators. The office of plant projects (HAN) was responsible for the documentation updating and investments indicators. The nuclear power plant safety indicator system is maintained in the unit of management support (YJT) and coordinated by the event investigation manager.

During the updating of the previous year's indicators, in early 2003, the appropriateness of individual indicators and the functionality of data collection were evaluated. Towards the end of 2003, meetings were arranged for further indicator definition and improvement of system functionality. As a result, a decision was made to change specific indicators, as of the beginning of 2004, such that they would serve, as well as possible, NRR's regulatory work and its sub-processes.

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 indicators, the number of failures of components defined in the Tech Specs during power operation is followed.

Source of data
The failure data base (Loviisa NPP) or daily reports submitted by the utility (Olkiluoto NPP).

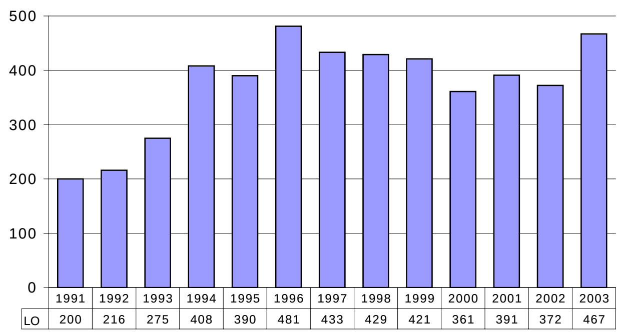
Purpose
The indicator gives the failure frequency trend of Tech Spec components at steady state operation.

Responsible unit/person(s)
Safety Management (TUR), resident inspectors
Pauli Kopiloff (Loviisa plant)
Jarmo Konsi (Olkiluoto plant)

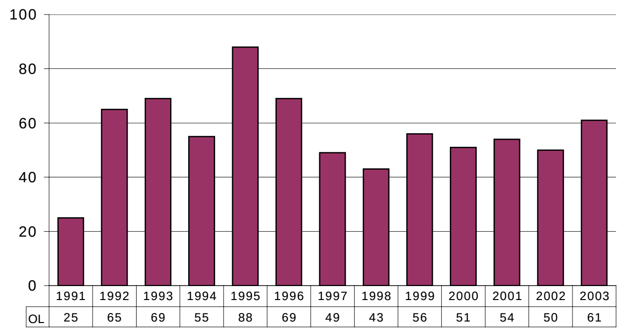
Interpretation of indicator
The number of repairs of Tech Spec components at the Loviisa plant increased in 2003 by approx. 26% from the previous year. Before this, the yearly number of fault repairs had been on a slight decrease for several years. The failures distributed to multiple technical fields and no specific problem area can be pointed out. The increase in the number of faults is not significant as such; the future will show whether an actual change has taken place in the previously downward trend. The continued growth in the number of faults would seem to indicate a deteriorating plant condition and problems with component service life management.

The number of failures of Tech Spec components in Olkiluoto in 2003 increased compared with 2002. In 2003 problems relating to vibrations on the pumps of the reactor core spray system were observed. Investigations of the pump units' mounting bases revealed that the pumps were not firmly attached to the base because of the cavities in the concrete beneath the fastening plate due to which the pumps had to be isolated for the filling out of the cavities (indicators A.I.1f and A.1.3). The number of failures has been 50–60/year over the past five years.

Number of failures causing unavailability of components specidied in Tech Spec, Loviisa NPP



Number of failures causing unavailability of components specified in Tech Spec, Olkiluoto NPP



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

Definition
The ratio of preventive maintenance work orders to failure repair work orders at steady state operation and during annual maintenance.

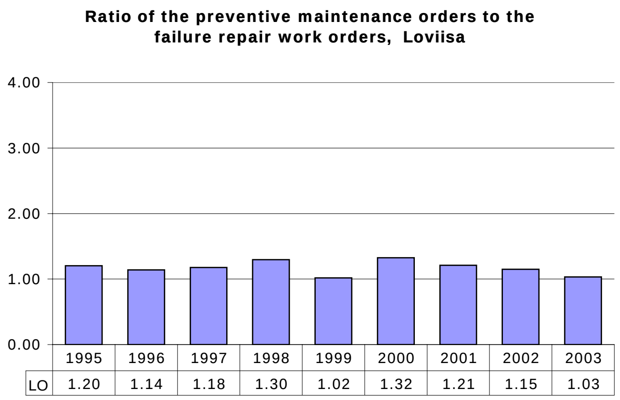
Source of data
The data is available from the work order data bases of NPPs. The utility supplies the data to the person responsible.

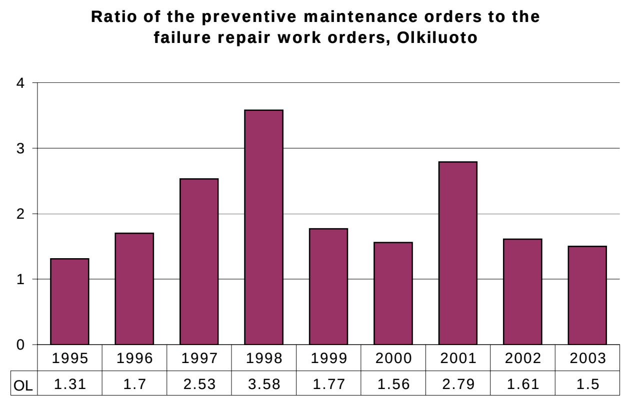
Purpose
Indicator describes the volumes of failure repairs and preventive maintenance and illustrates the conditions of the plant and its maintenance strategy.

Responsible unit/persons
Safety Management (TUR), resident inspectors
Pauli Kopiloff (Loviisa plant)
Jarmo Konsi (Olkiluoto plant)

Interpretation of indicator
The preventive maintenance volume of Tech Spec components has been stable at the Loviisa plant compared with the volume of fault repairs. The fluctuating numerical value does not indicate a clear indicator trend. The yearly-changing numerical values have been due to a natural fluctuation in the volume of preventive maintenance and failures, due to ia annual maintenance length. Since the number of faults at the Loviisa plant in 2003 was 26% higher than in 2002, the volume of preventive maintenance at the plant has been at least twice as much.

At the Olkiluoto plant, the volume of preventive maintenance of Tech Spec components in relation to the number of fault repairs further decreased a little compared with 2002. The volumes of preventive maintenance and fault repairs as a whole were on a par with those of 2002. The volume of preventive mechanical maintenance work at Olkiluoto 1 decreased and that at Olkiluoto 2 increased compared with the previous year. The duration of the plant units' annual maintenance outages in 2002 and 2003 were the same. Preventive maintenance works during plant operation are defined in the Tech Specs and their number thus stays a constant during the year. Fault repairs and preventive maintenance determined by outage duration affect the indicator.





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

Definition

Indicator shows how quickly failed Tech Spec components are repaired in relation to the repair time allowed in the Tech Specs. At the Olkiluoto plant, the monitored repair times vary and the indicator is an average of the percentage values of repair times (repair time in relation to that allowed in the Tech Specs). For the Loviisa plant, only components whose allowed repair time is three days are included.

Source of data

An annual report supplied to STUK by the utility. For the Loviisa plant, data extracted from the plant's failure database.

Purpose

To describe the plant's maintenance policy and its ability and aspiration to correct failed Tech Spec components without delay.

Responsible units/persons

Safety Management (TUR), resident inspectors
Pauli Kopiloff (Loviisan plant)
Jarmo Konsi (Olkiluoto plant)

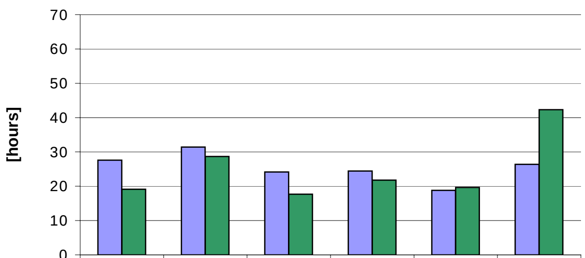
Interpretation of indicator

Average failure duration of Tech Spec components, who's allowable repair time is three days (72 hrs), at the Loviisa plant has been 24 hrs on average, as was the case at Loviisa 1 in 2003.

Average fault repair time at Loviisa 2 increased to 42.3 hrs. The increase was affected by the fact that the volume of repair work to be completed in three days according to the Tech Specs was low in all, which emphasises an individual fault and essentially affects the indicator. The emergency make-up water pump 21TJ11D01 was repaired based on an exemption to the Tech Specs granted by STUK. It took 213 hrs and this alone increased the value of the repair activities indicator by 10.7 hrs. Even without it, the average fault repair time at Loviisa 2 would have been higher than in 2002.

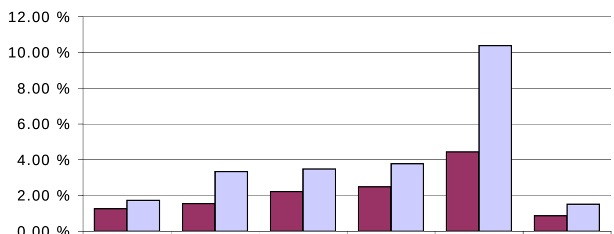
In comparison to 2002, there was a clear decrease in the repair times of Tech Spec components at both Olkiluoto plant units. The highest percentage share (26.4% of allowable limit) arose from when a fire damper of the Olkiluoto 2 reactor building ventilation system failed to open in a periodical test and when the failure was not connected to a Tech Spec component there and then. As a result was a repair time considerably longer than is allowed for a component requiring immediate repair.

Average of real repair times of components with allowed repair time of 3 days, Loviisa



	1998	1999	2000	2001	2002	2003
LO1	27.6	31.43	24.15	24.45	18.8	26.4
LO2	19.15	28.69	17.68	21.77	19.65	42.31

Average ratio of real repair times of components in relation to a repair time allowed in the Tech Spec, Olkiluoto



	1998	1999	2000	2001	2002	2003
OL 1	1.26 %	1.55 %	2.22 %	2.49 %	4.44 %	0.87 %
OL 2	1.73 %	3.34 %	3.48 %	3.78 %	10.38 %	1.51 %

A.I.1d Maintenance errors

Definition
As the indicator, the number of maintenance errors is followed. It contains also maintenance-error induced common cause failures and individual maintenance errors. Common cause failures arising during operation are included.

Source of data
Data for the indicators is extracted from the failure databases of utilities. For the time being, the Olkiluoto plant's common cause failures and individual failures have been followed as indicators. No such procedure exists for the Loviisa plant so far.

Purpose
To follow the quality of maintenance.

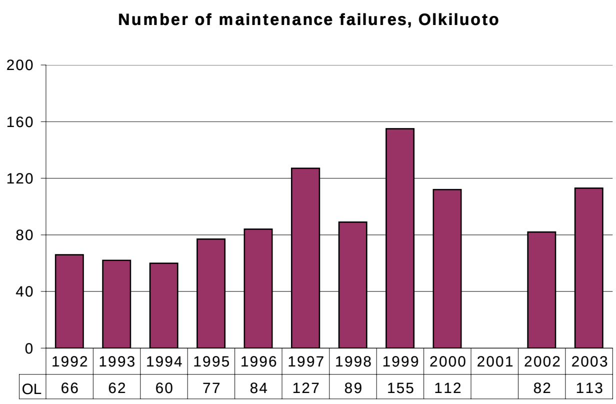
Responsible unit/persons
Safety management (TUR)
Jukka Kupila

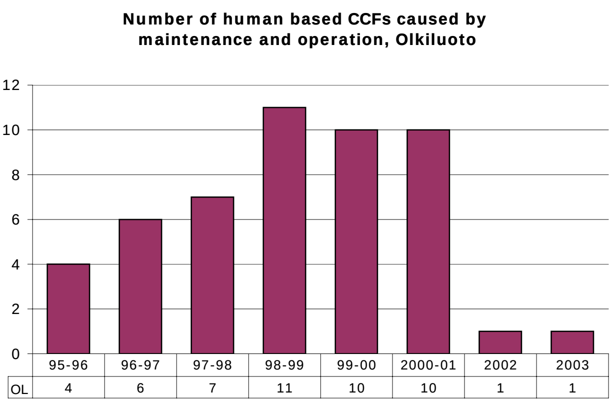
Interpretation of indicator
Compared with the previous years, the number of maintenance failures did not essentially change in 2003. The figure for 2001 is lacking because calendar-yearly monitoring replaced operating-cycle specific monitoring; no data was available for the remainder of 2001.

The decreasing number of human-error based common cause failures, since early 2002, is partly due to a changed line of assessment. The only Olkiluoto plant common cause failure in 2003 (safety isolation of emergency coolant pumps during annual maintenance) was attributed to human error. In 2002 only one maintenance failure was rated as a human based common cause failure (exceeding of the cloud point limits of the day tank for stand-up diesel generator fuel oil).

Ten human-based common cause failures were observed during the fuel cycle of 2000–2001, of which mentioned here is a programming error of the optical smoke detectors of the fire alarm system, which resulted in several failure alarms. In the operating cycle 1998-1999, the number of human-based common cause failures increased to 11 and in 1999-2000 their number was 10. They were of minor importance since not one of them was assessed to have any bearing on the plant's operation.

One of the tasks of the investigation team (1/00), set up in early 2000, was to find out how the utility assesses human-based common cause failures and how common cause failures have been taken into account in plant-specific Probabilistic Safety Analysis (PSA) models. This investigation is described in the annual report on the regulatory control of nuclear safety in Finland 2000 (STUK-B-YTO 208). The investigation is also reported in the IAEA/NEA Incident Reporting System (IRS report number 7494).





A.I.1e Common cause failures (CCF) preventing operation

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

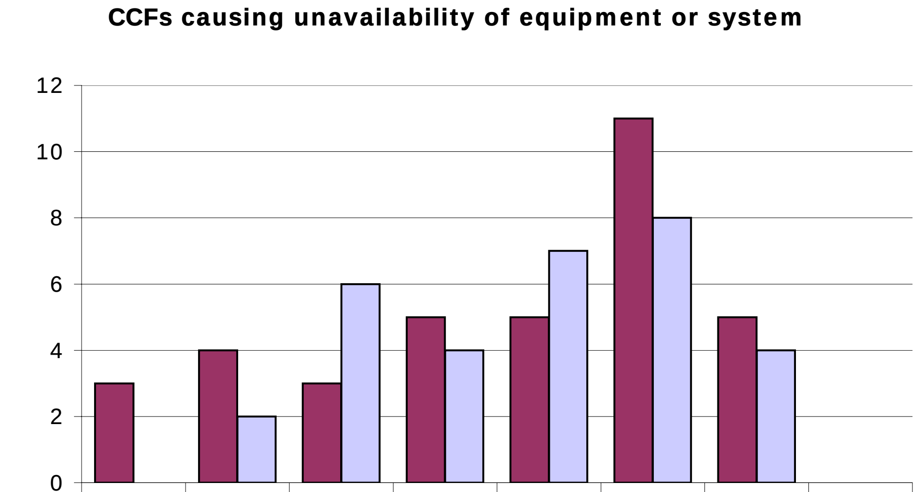
Source of data
Data for the indicators is collected from the failure databases of the utilities. For the time being, the Olkiluoto indicator has been followed. The licensee has submitted the data in Excel files from which CCFs have been analysed. A corresponding procedure for the Loviisa plant will be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

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

Responsible unit/persons
Safety Management (TUR)
Jukka Kupila

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

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



	95-96	96-97	97-98	98-99	99-00	2000-01	2002	2003
OL 1	3	4	3	5	5	11	5	0
OL 2	0	2	6	4	7	8	4	0

A.I.1f Potential common cause failures

Definition

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

Source of data

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

Purpose

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

Responsible units/persons

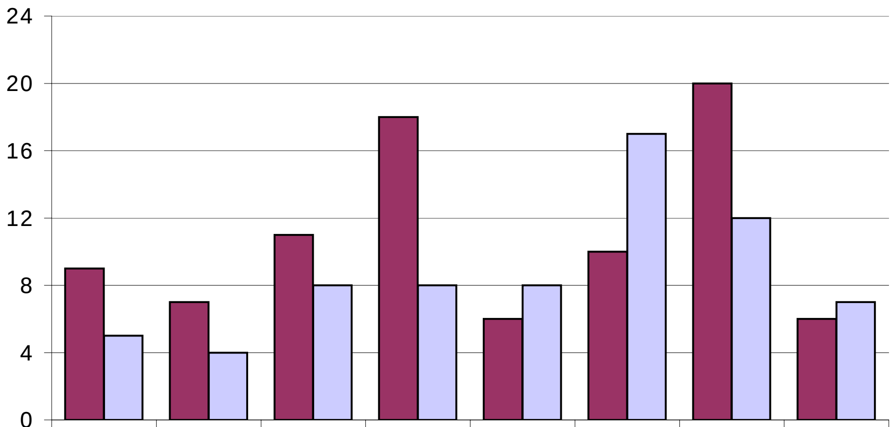
Safety management (TUR)
Jukka Kupila

Interpretation of indicator

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

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

Number of potential CCFs of technical origin



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

A.I.1g Capability 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.

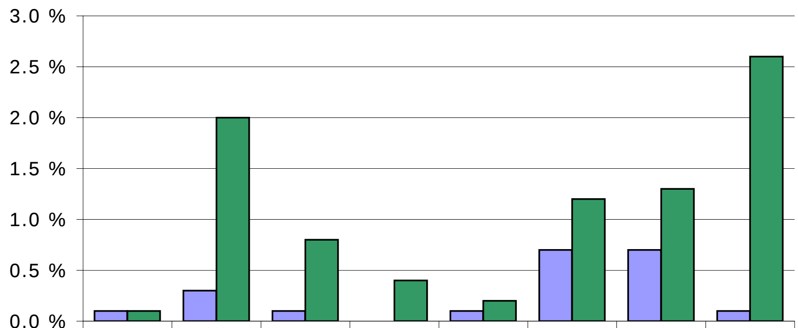
Purpose
Importance of failures from the point of view of production.

Responsible unit/person
Power Plant Technology (VLT)
Kirsti Tossavainen

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

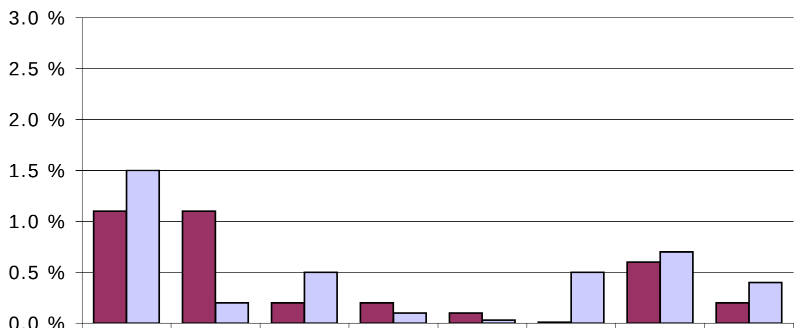
The Loviisa 2 indicator value for 1997, which is an anomaly, was caused by an approx. 7-day long shutdown to repair the primary circuit and the 2003 anomaly was caused by work to replace the stator of a plant unit generator, which took 41 days, causing a 2.6% capability loss, ie twice that of 2002. Capability losses from failures at other units in 2003 were small (less than 0.5% of rated power).

Loss of power production by failures in ratio to the rated power, Loviisa



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

Loss of power production by failures in ratio to the rated power, Olkiluoto



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

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

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

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

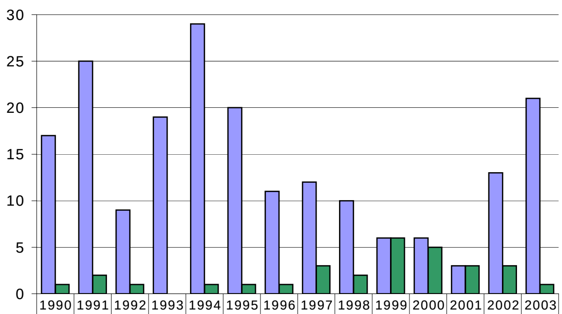
Purpose
To follow the utilities activities in accordance with the Tech Specs: compliance with the Tech Specs and identified situations during which it is necessary to deviate from them; of which conclusions can be made as regards the appropriateness of the Tech Specs.

Responsible unit/person
Safety Management (TUR)
Timo Eurasto

Interpretation of indicator
Eight plant situations in non-compliance with the Tech Specs occurred at the Olkiluoto plant in 2003, two of which were detected by STUK. The number of non-compliances with the Tech Specs was on the increase at the Olkiluoto plant for the third consecutive year. Only one plant situation in non-compliance with the Tech Specs occurred at the Loviisa plant in 2003. It was in connection with the renewal of the radiation release measurements of the ventilation stack and radiation measurement monitors of Loviisa 2. The number of Loviisa plant's situations in non-compliance with the Tech Specs has been on the decrease for several years. The non-compliances are mostly caused by human error.

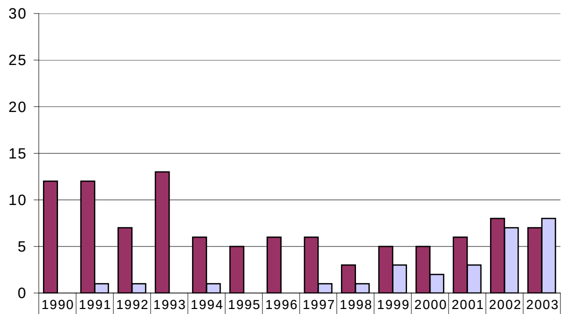
The number of exemptions from the Tech Specs has grown from the 21 cases in 2002 to 28 in 2003. The number of exemptions granted to Loviisa nuclear power plant almost doubled from 2002, being of the same magnitude as in 1994. This was mostly caused by the replacement of fixed radiation measurement system (the MONU project), which could not be carried out in any operational state without deviating from the Tech Specs. In addition, the Loviisa plant had to apply for an extension to several applications, which increased the number of applications. The number of exemptions granted to Olkiluoto nuclear power plant has remained at the level of the previous years. Four of the total of seven in 2003 dealt with the need to deviate from the Tech Specs to carry out modifications, repairs and maintenance.

Number of deviations from the Tech Spec., Loviisa



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

Number of deviations from the Tech Spec., Olkiluoto



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

A.I.3 Unavailability of safety systems

Definition
As indicators, the plant-unit specific unavailability indices of safety systems are followed. The systems followed at Olkiluoto nuclear power plant are: the containment spray system (322), the auxiliary feed water system (327) and 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 trains. It does not indicate the simultaneous unavailability of several trains. Sub-system unavailability hours include the time required for planned maintenance of components and unavailability from failures. The latter includes, in addition to the time spent on repairs, estimated unavailability time prior to failure detection. If a failure is assessed to have occurred in a previous successful testing, and is assessed to have escaped detection, the time between periodical tests is added to unavailability time. If a failure has occurred between tests such that its date of occurrence is unknown, a half of the time period between tests is added to unavailability time. Whenever the failure's occurrence can be identified to an operational, maintenance, testing or other event, the time between the event and fault detection is added to 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 ie annual operating hours.

Source of data
Data for the indicators are supplied by the utilities. Licensee representatives submit the necessary data to the relevant person in charge in STUK.

Purpose of indicators
To indicate unavailability of safety systems. By means of the indicator, the condition and status of safety systems and the development of trends are monitored.

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

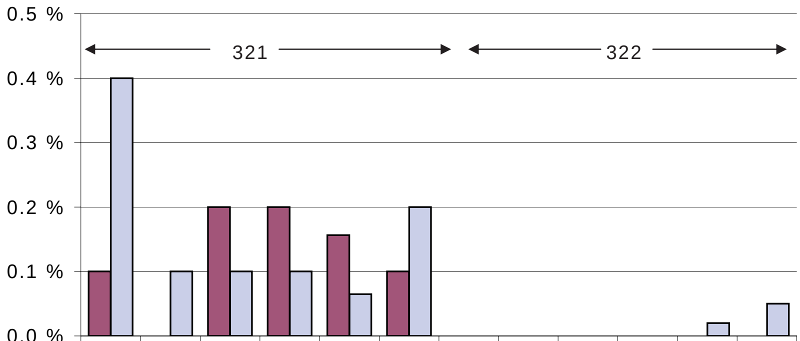
Interpretation of indicator
The unavailabilities of safety systems in the indicator system have been acceptably low. In the present situation it is not possible to point out, based on the indicators, a clear and significant trend in the development of unavailabilities since even changes taking place in a year, which appear significant, are partly caused by the method of calculation.

The unavailability of the containment spray system (322) of Olkiluoto 2 increased from 2002 due to vibration problems on the system's pumps. The pumps' concrete bases had to filled out because the original concrete castings proved insufficient. (see the indices A.I.1a and 1f).

The unavailability of the Olkiluoto auxiliary feed water system (327) at both plant units was higher than in 2002 and the trend at Olkiluoto 1 has been on the increase over the past two years. This is due to the increasing number, at both plant units, of failures of the hydraulic accumulators and valves of the system's piping.

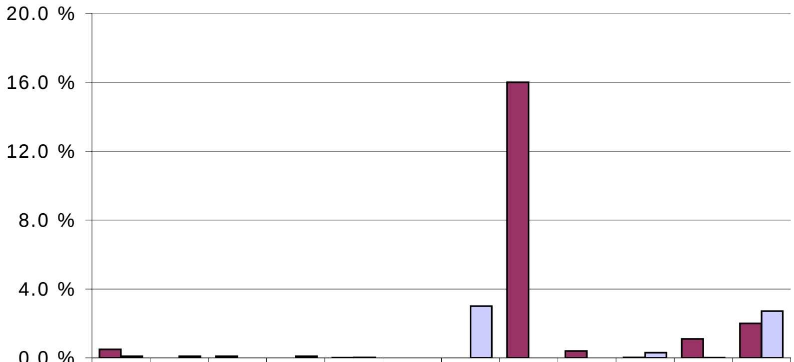
The trend indicating the unavailability of the back-up diesels of the Loviisa plant for the third year in succession is mostly due to the calculational effects of unavailability due to variations in the preventive maintenance programme and periods of latency of failures. The number of failures affecting the availability of the diesels has been six to eight a year over the past four years and the sum of their yearly repair times has been from 70 to 200 hrs.

Shut-down cooling system / containment spray system (321 / 322), Olkiluoto



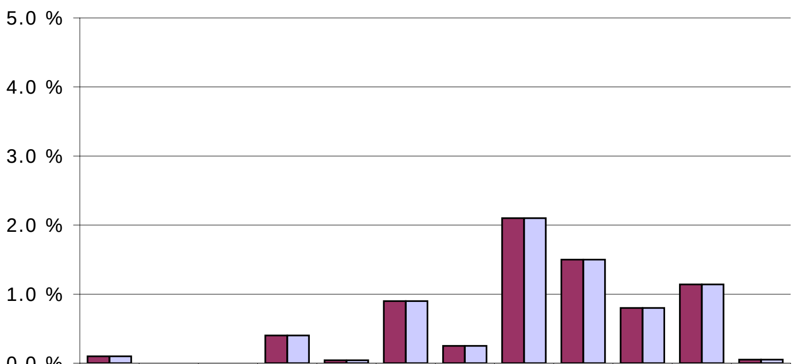
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL 1	0.10	0.00	0.20	0.20	0.16	0.10	0.00	0.00	0.00	0.00	0.00	0.00
OL 2	0.40	0.10	0.10	0.10	0.06	0.20	0.00	0.00	0.00	0.00	0.02	0.05

Auxiliary feed water system (327), Olkiluoto



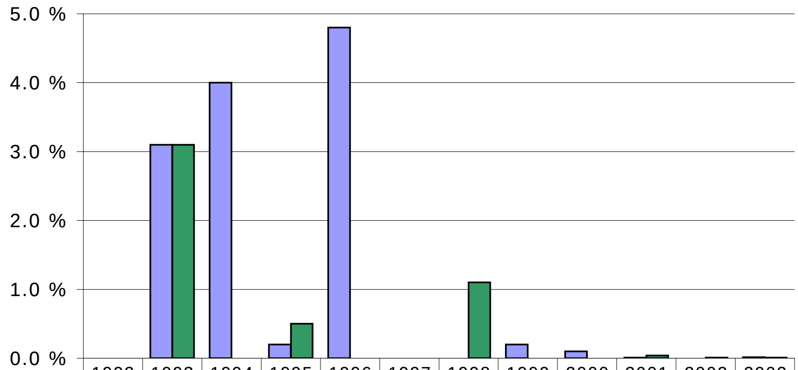
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL 1	0.50	0.00	0.10	0.00	0.01	0.00	0.00	16.00	0.40	0.03	1.10	2.00
OL 2	0.10	0.10	0.00	0.10	0.02	0.00	3.00	0.00	0.00	0.30	0.01	2.71

Diesel generators (651...656), Olkiluoto



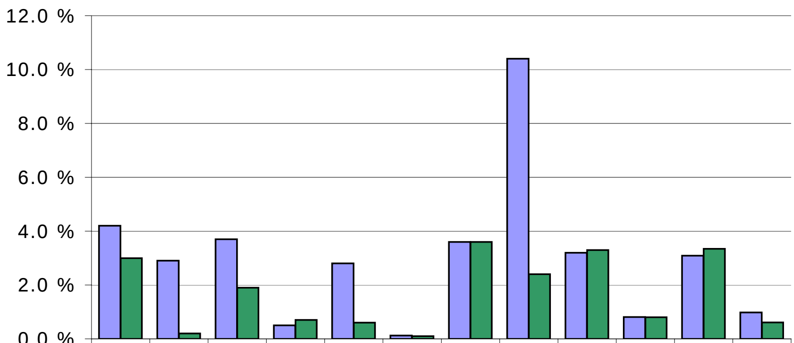
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL 1	0.10	0.00	0.00	0.40	0.04	0.90	0.25	2.10	1.50	0.80	1.14	0.05
OL 2	0.10	0.00	0.00	0.40	0.04	0.90	0.25	2.10	1.50	0.80	1.14	0.05

High pressure safety injection system (TJ), Loviisa



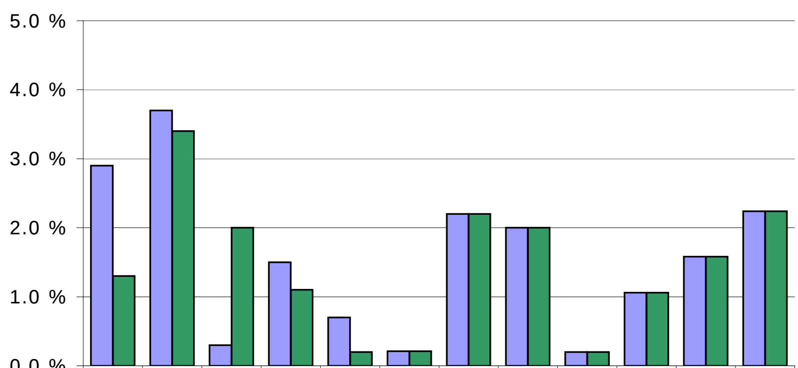
	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO 1	0.00	3.10	4.00	0.20	4.80	0.00	0.00	0.20	0.10	0.01	0.00	0.01
LO 2	0.00	3.10	0.00	0.50	0.00	0.00	1.10	0.00	0.00	0.04	0.01	0.01

Auxiliary feed water systems (RL92/93, RL94/97), Loviisa



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

Diesel generators (EY), Loviisa



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

A.I.4 Occupational radiation doses

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

Source of data
The data on collective radiation exposure comes from annual reports of the utilities. The data on ten highest radiation doses are submitted by the licensee to the person responsible for the indicator.

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

Responsible unit/person
Radiation protection (SÄT)
Suvi Ristonmaa

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

Occupational doses at nuclear power plants are below individual dose limits. The Radiation Decree (1512/1991) stipulates that the effective dose to 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.

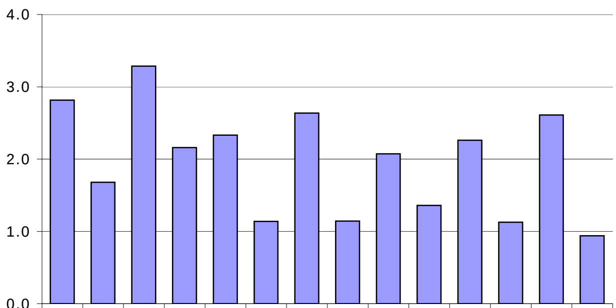
If, at one plant unit, the collective occupational radiation dose average over two successive years exceeds 2.5 manSv per one GW of net electrical power, the utility is to report to STUK the causes of this and any measures possibly required to improve radiation safety (Guide YVL 7.9).

The reporting limit was exceeded for a few times at Loviisa nuclear power plant. The reason was the higher-than-usual collective radiation doses at Loviisa 1 in 2000, 1996 and 1992 as well as those at Loviisa 2 in 1994. The annual maintenance outages of those years were of long duration and the work done contributed to radiation exposure. In the Loviisa 1 annual maintenance outage 2000, work relating to ia preparation for severe accidents (the SAM project) was carried out as well as the replacement of the feedwater collectors of two steam generators. During the 1996 annual maintenance outage, the Loviisa 1 reactor pressure vessel was annealed and extensive modernisation, maintenance and inspection work was carried out. During the 1992 annual maintenance outage, Loviisa 1 main shutdown valves were inspected and repaired and the piping of a steam generator relief system was replaced.

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

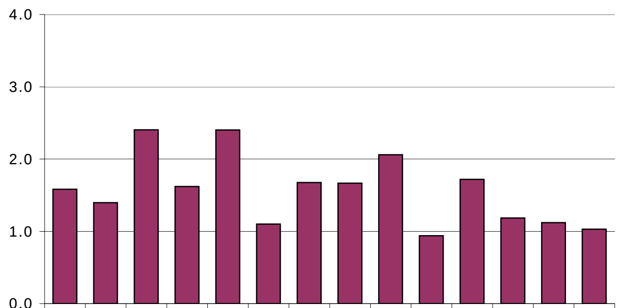
The occupational radiation exposure at the Olkiluoto plant has remained below set limits for the entire indicator analysis period.

Collective dose (manSv), Loviisa



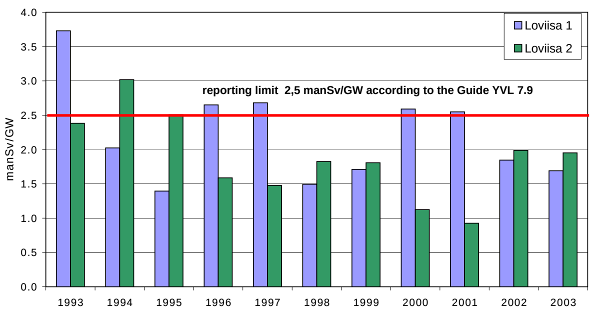
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO	2.815	1.680	3.286	2.159	2.332	1.139	2.637	1.142	2.072	1.360	2.260	1.127	2.610	0.940

Collective dose (manSv), Olkiluoto

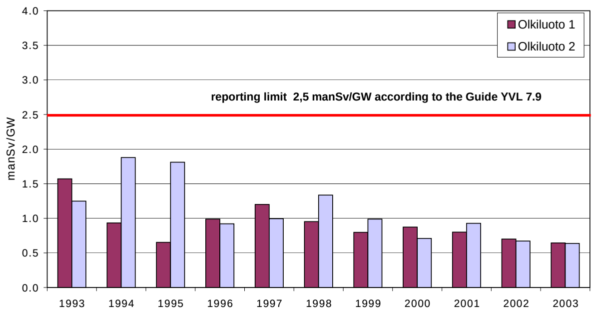


	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL	1.583	1.397	2.404	1.621	2.403	1.100	1.676	1.666	2.059	0.940	1.720	1.184	1.120	1.030

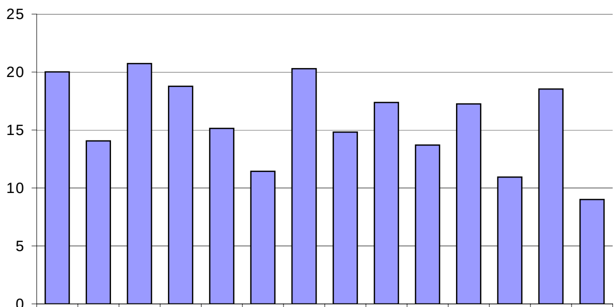
Loviisa 1 and 2
Collective dose per 1 GW of net electrical capacity
averaged over two succesive years



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

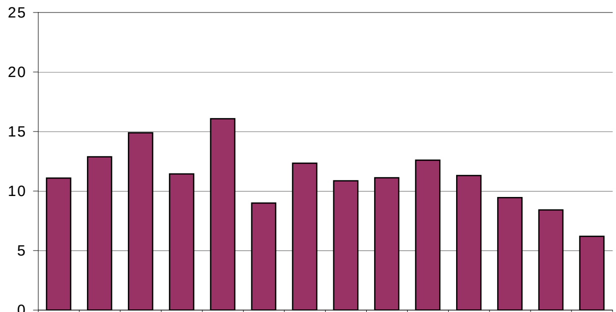


Average of the ten highest doses (mSv), Loviisa NPP



	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO	20.01	14.06	20.73	18.77	15.15	11.44	20.29	14.82	17.38	13.70	17.25	10.94	18.54	9.01

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



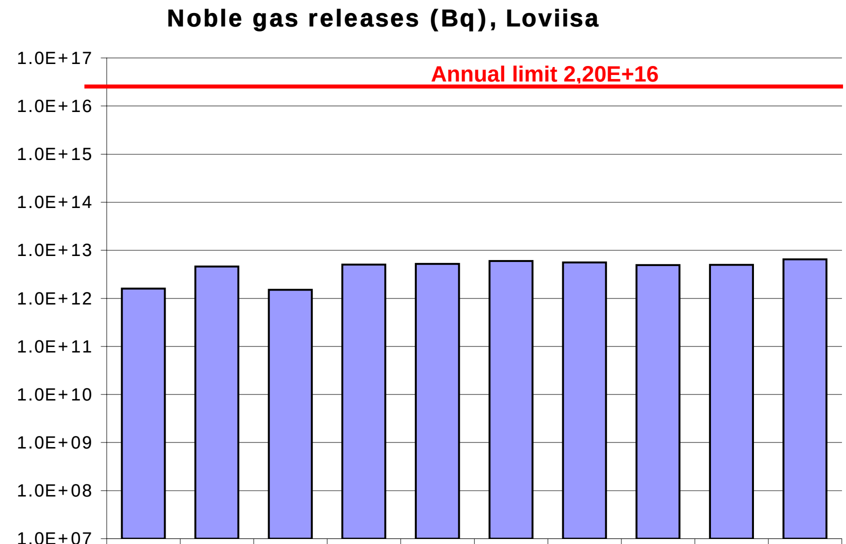
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL	11.09	12.87	14.90	11.44	16.08	9.00	12.34	10.86	11.12	12.60	11.30	9.45	8.41	6.20

A.I.5 Radioactive releases

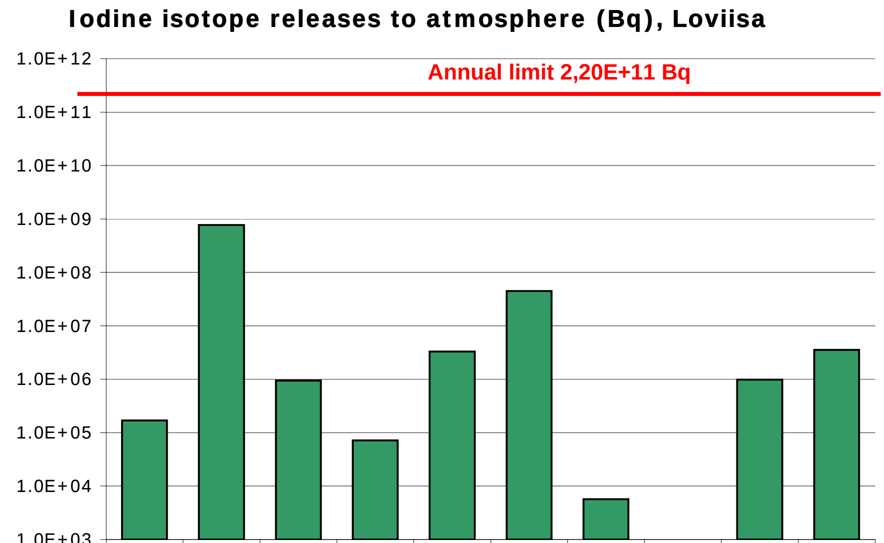
Definition
As indicators, radioactive releases into the sea and the atmosphere (TBq) from the plant are followed and the calculated dose due to releases to the most exposed individual in the vicinity of the plant.

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.



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO Noble gases 87-Kr-ekv.	1.6E+12	4.6E+12	1.5E+12	5.0E+12	5.2E+12	6.0E+12	5.6E+12	4.9E+12	5.0E+12	6.49E+12



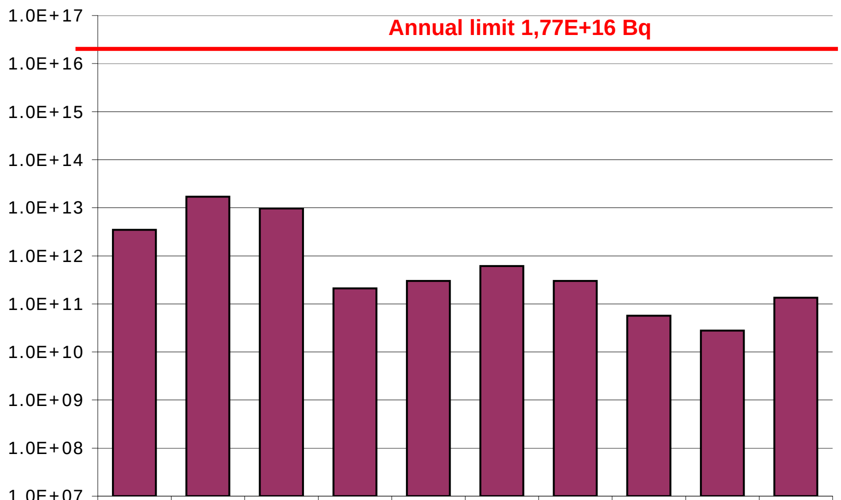
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO Iodines 131-I-ekv.	1.7E+05	7.7E+08	9.4E+05	7.2E+04	3.3E+06	4.5E+07	5.7E+03	0.0E+00	9.9E+05	3.53E+06

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 Loviisa and Olkiluoto nuclear power plants were small. They are well below set limits.

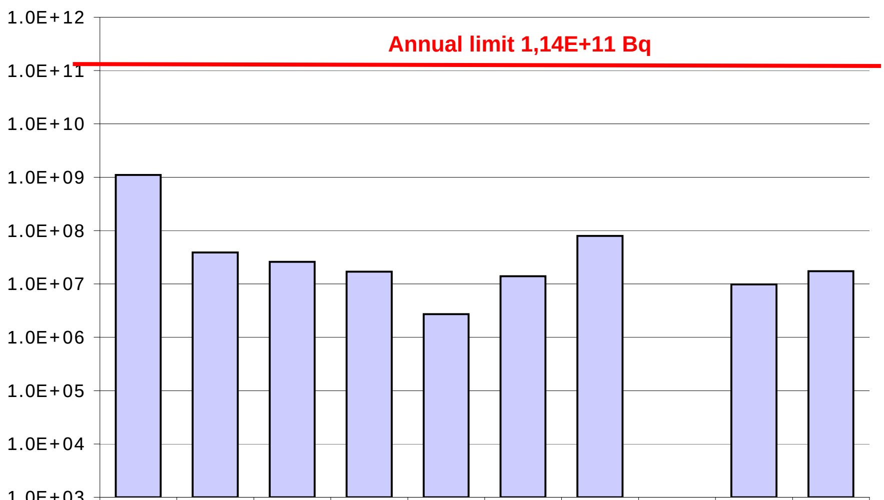
Gaseous fission products, noble gases and iodine isotopes originate in leaking fuel rods; in the

Noble gas releases (Bq), Olkiluoto



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL Noble gases 87-Kr-ekv.	3.5E+12	1.7E+13	9.7E+12	2.1E+11	3.0E+11	6.1E+11	3.0E+11	5.7E+10	2.80E+10	1.35E+11

Iodine isotope releases to atmosphere (Bq), Olkiluoto



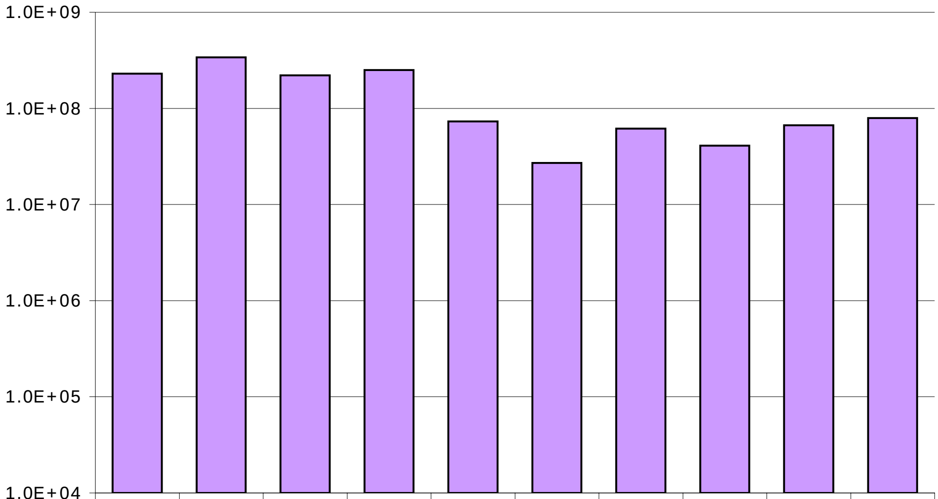
	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL Iodines 131-I-ekv.	1.1E+09	3.9E+07	2.6E+07	1.7E+07	2.7E+06	1.4E+07	7.9E+07	0.0E+00	9.8E+06	1.74E+07

minute amounts of uranium left on the outer surfaces on fuel cladding during fuel fabrication; and in reactor surface contamination from earlier fuel leaks. The number of fuel leaks at the Loviisa and Olkiluoto plant units and the amounts of fission products released into the primary circuit during them has been low. The figures show the interdependence between iodine releases and fuel leaks (indicators A.III.1).

Noble gas releases from both nuclear power plants in 2003 were of the same magnitude as in the preceding years. The noble gas releases from the Loviisa plant were dominated by argon-41, an activation product of argon-40, found in the air-space between the reactor pressure vessel and the biological shield.

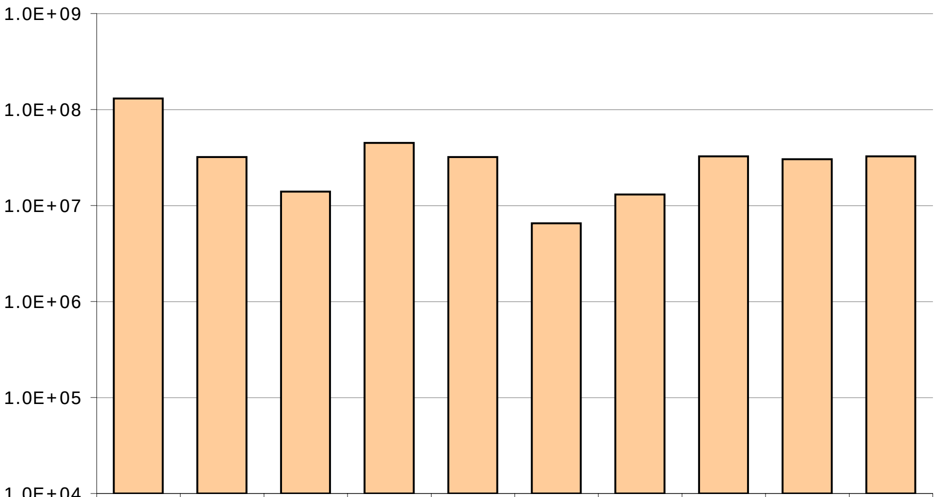
Aerosols released from both plants were of the same magnitude as in the preceding years. Aerosol nuclides (ia activated corrosion products) are released ia during maintenance work.

Aerosol releases to atmosphere (Bq), Loviisa



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO aerosols	2.3E+08	3.4E+08	2.2E+08	2.5E+08	7.3E+07	2.7E+07	6.2E+07	4.1E+07	6.7E+07	7.95E+07

Aerosol releases to atmosphere (Bq), Olkiluoto

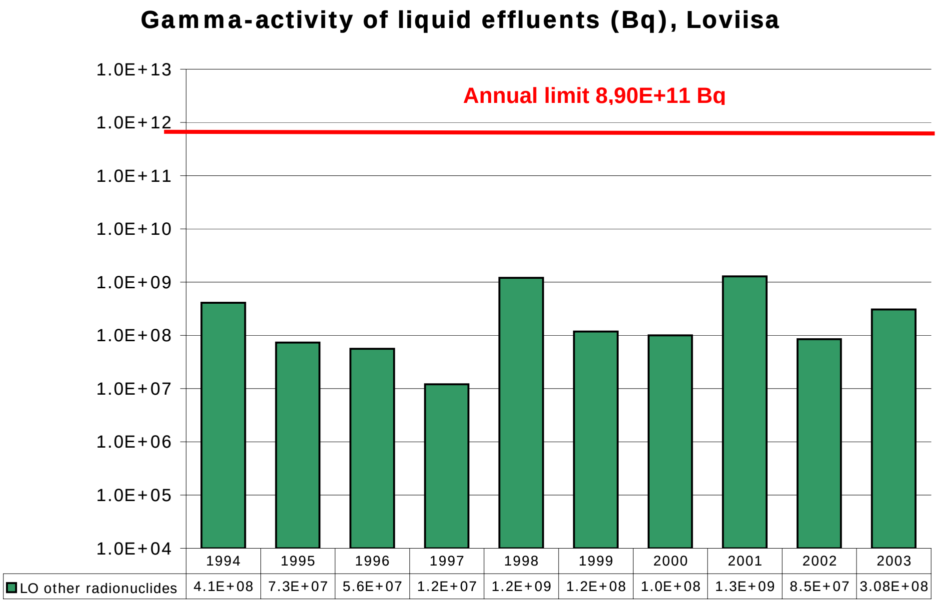


	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL aerosols	1.3E+08	3.2E+07	1.4E+07	4.5E+07	3.2E+07	6.5E+06	1.3E+07	3.3E+07	3.0E+07	3.25E+07

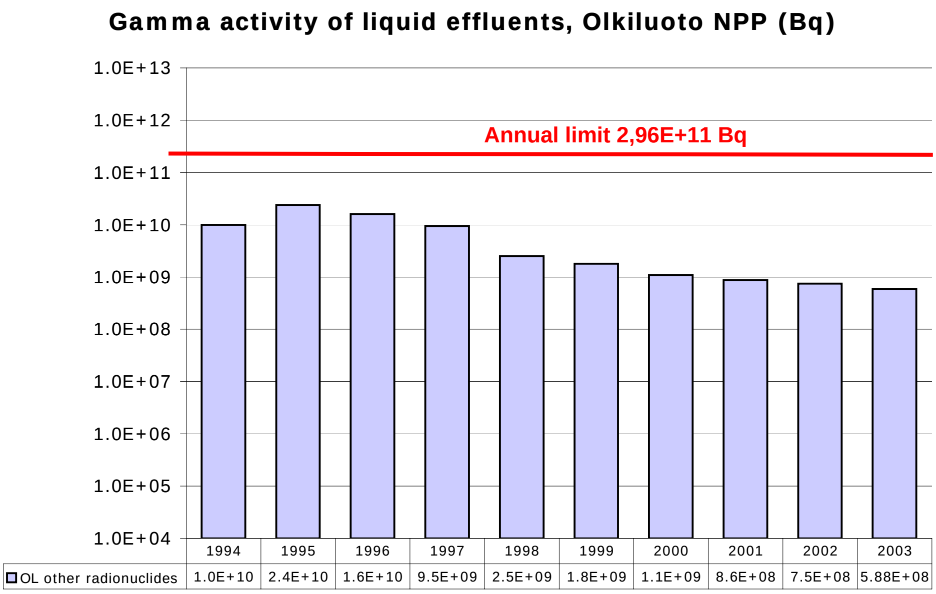
Interpretation of indicator (releases into the sea)

Releases into the sea from Loviisa power plant reduced to their present level after the commissioning of a caesium separation device in 1992. In 1998 and 2001 the plant released clarified evaporation residues from storage tanks into the sea (so called controlled liquid discharges) in a controlled manner. This shows in the trend figure as a release value a magnitude higher than usual.

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



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO other radionuclides	4.1E+08	7.3E+07	5.6E+07	1.2E+07	1.2E+09	1.2E+08	1.0E+08	1.3E+09	8.5E+07	3.08E+08

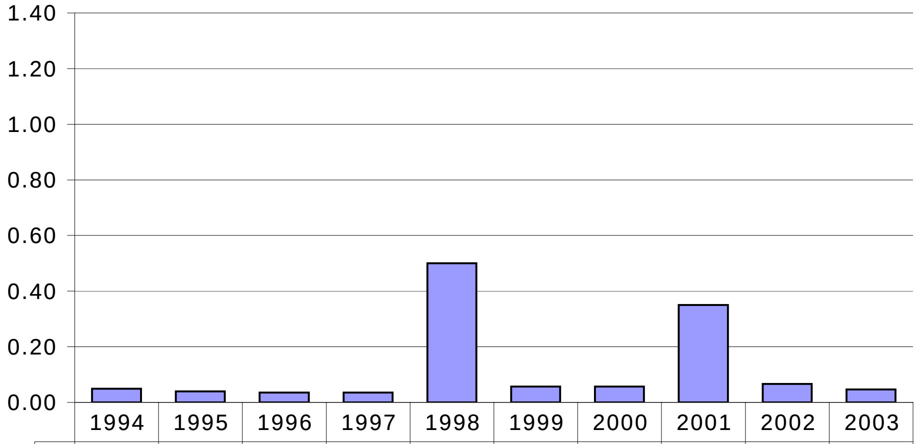


	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL other radionuclides	1.0E+10	2.4E+10	1.6E+10	9.5E+09	2.5E+09	1.8E+09	1.1E+09	8.6E+08	7.5E+08	5.88E+08

Interpretation of indicator (calculated dose due to radioactive releases)

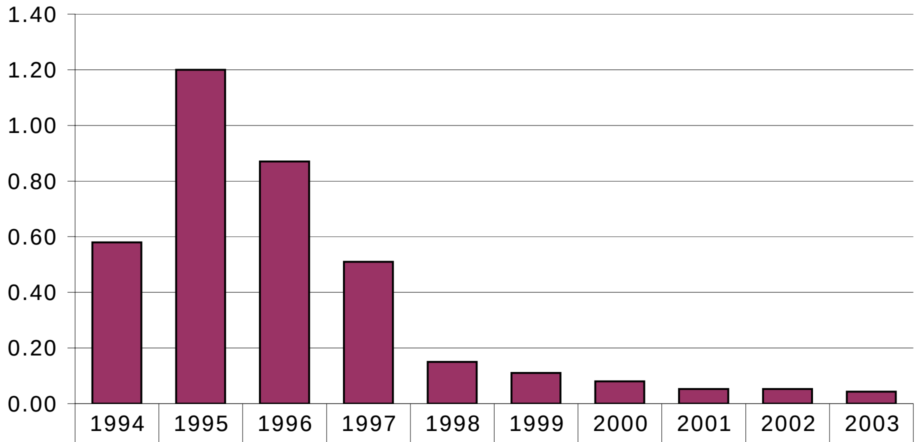
The calculated radiation doses to the most exposed individual in the vicinity of the nuclear power plants were of the same magnitude as in the previous years. The doses for both plant units are less than 0.05% (objective less than 1% of limit) of the 100 microSv limit established in the Government Resolution (395/1991).

The calculated dose of the most exposed individual in the environment of the Loviisa NPP (µSv)



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO	0.05	0.04	0.04	0.04	0.50	0.06	0.06	0.35	0.066	0.047

The calculated dose of the most exposed individual in the environment of the Olkiluoto NPP (µSv)



	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL	0.58	1.20	0.87	0.51	0.15	0.11	0.08	0.053	0.053	0.043

A.I.6 Keeping plant documentation current

Definition
This indicator area follows the need to update documents and their realisation by the next annual maintenance. The documents to be updated include: the Technical Specifications, the Final Safety Analysis Report (FSAR), safety classification documents and diagrams, PSA documentation, operation and maintenance procedures, emergency and disturbance instructions and process flowcharts. Followed is the ratio of the number of implemented document revisions to the number of identified document revisions.

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

Purpose of indicators
To follow plant quality management and ability to maintain plant documentation.

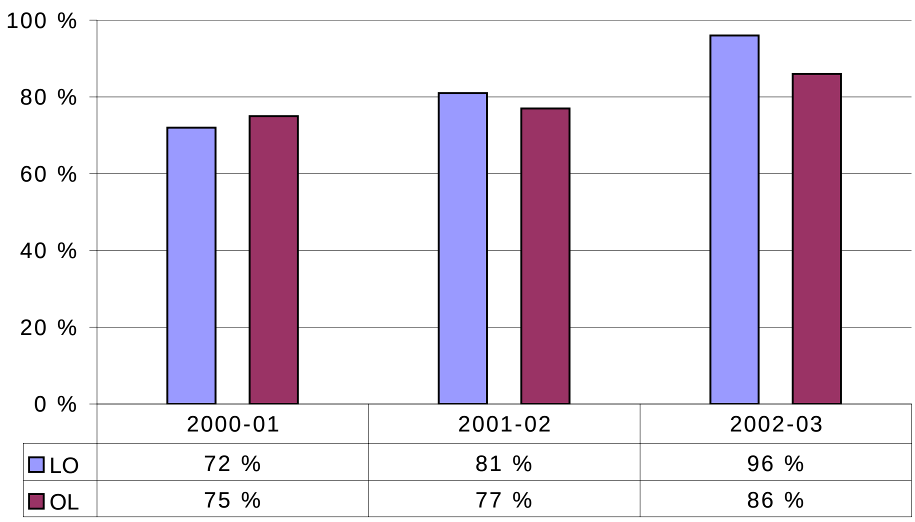
Responsible unit/person
Plant projects (HAN)
Tapani Virolainen

Interpretation of indicator
Identification of document amendments and revisions pertaining to modifications at the Loviisa plant has mostly been by preinspection documents and training notices. As a new practice for the Olkiluoto plant, its indicator is based on the follow-up forms (AV forms) pertaining to modification documentation onto which the document revision needs identified are marked. The AV forms' somewhat lacking information has been made more specific by the Olkiluoto plant modifications planning unit, since a review based only on the AV forms would have yielded a significantly weak result for Olkiluoto. As regards safety classification documents and diagrams, the estimate is still based on an assessment by the person in charge of the indicator of the need to revise the above documents in connection with modifications. Teollisuuden Voima Oy should also consider the inclusion of these documents as an entry on the AV form, since identification of the need to amend and revice documents is the licensee's duty.

Of document revisions needed after plant modifications (entered into register) in 2002, 96% and 86% were realised at Loviisa and Olkiluoto plant units, respectively, by the annual maintenance of 2003.

Corresponding figures for 2001 were 81% at Loviisa and 77% at Olkiluoto. The improved figure for the Loviisa plant is mostly due to an updating of the Final Safety Analysis Report. They were made only after the completion of extensive modification projects (SAM, TH pumps, VLOCA modifications).

Documentation



A.I.7 Investments on facilities

Definition
Utilities' annual investments on plant modernisation and renovations in current value of money improved by the building cost index.

Source of data
The licensee submits the necessary data direct to the person responsible for the index.

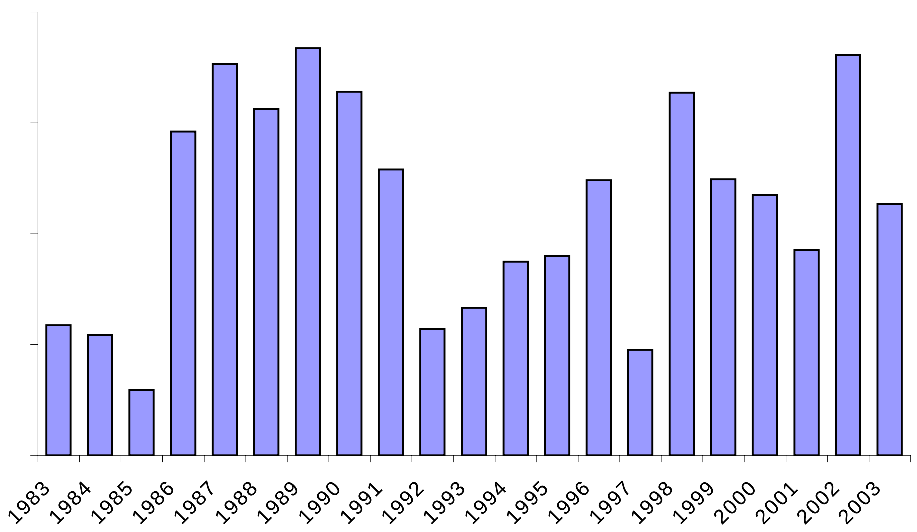
Purpose of indicator
To follow the amount of investments on plant maintenance and their fluctuations.

Responsible unit/person
Plant projects (HAN)
Tapani Virolainen

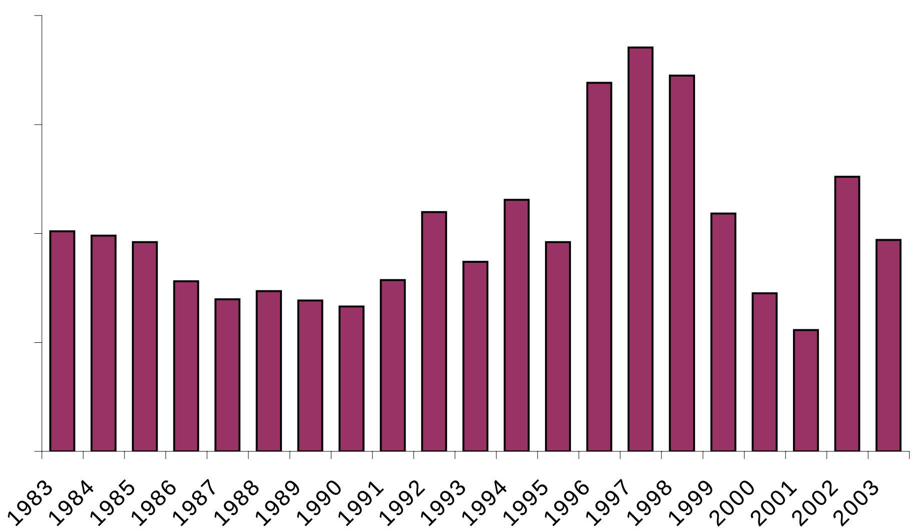
Interpretation of indicator
The indicator shows only the relative fluctuation of investments. Sums in Euro are business information of the companies involved, not to be published here.

The fluctuation in the indicator shows clearly the investments made in 1997–2000 in the plants' power upgrades and modernisation projects. The number of investments in 2003 is close to the average at both plant sites.

Maintenance investments and renovations, Loviisa



Maintenance investments and renovations, Olkiluoto



A.II Operational events

A.II.1 Number of events

Definition

As indicators, the number of events reported in accordance with Guide YVL 1.5 is followed, ie events warranting a special report, scrams and operational transients.

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

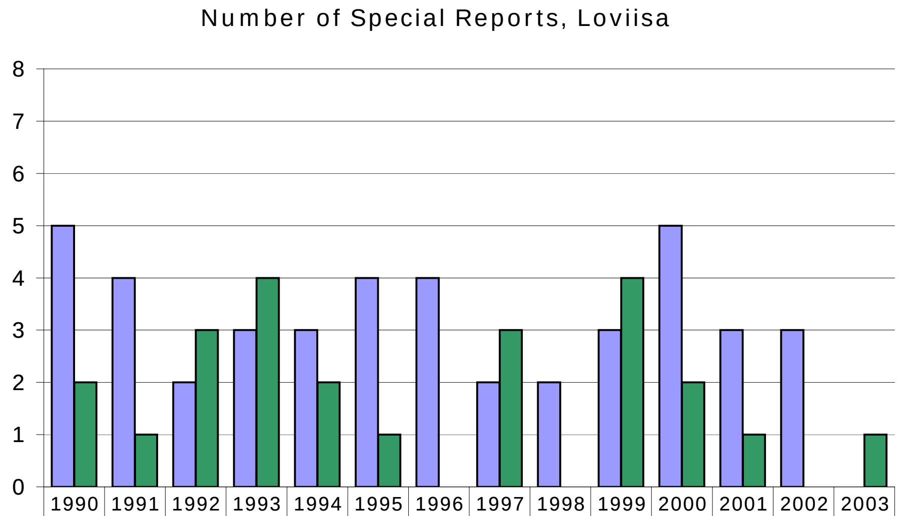
To follow the number of events important to safety.

Responsible unit/person

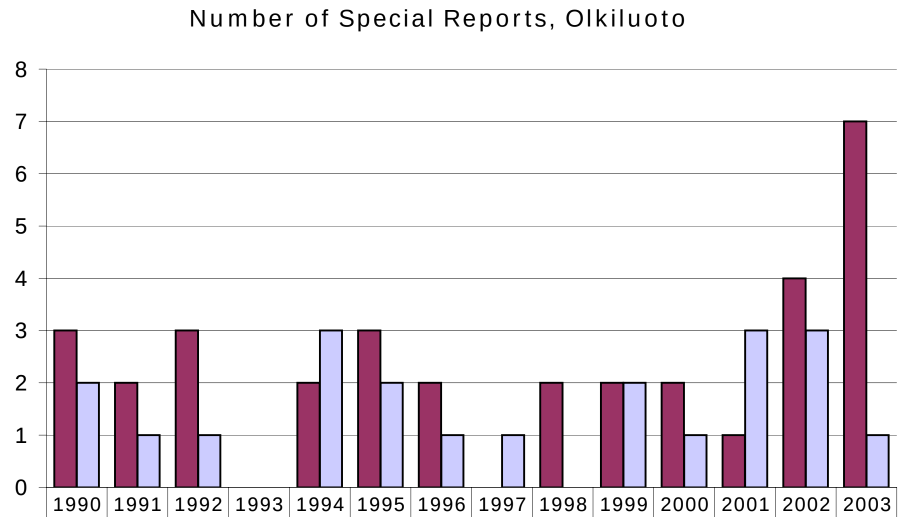
Safety Management (TUR)
Timo Eurasto

Interpretation of indicator

In 2003, the number of events at the Finnish plants, warranting a special report, was nine. Their number at the Olkiluoto plant has almost doubled in the past two years, compared with the long-term average. They have arisen from causes



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



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

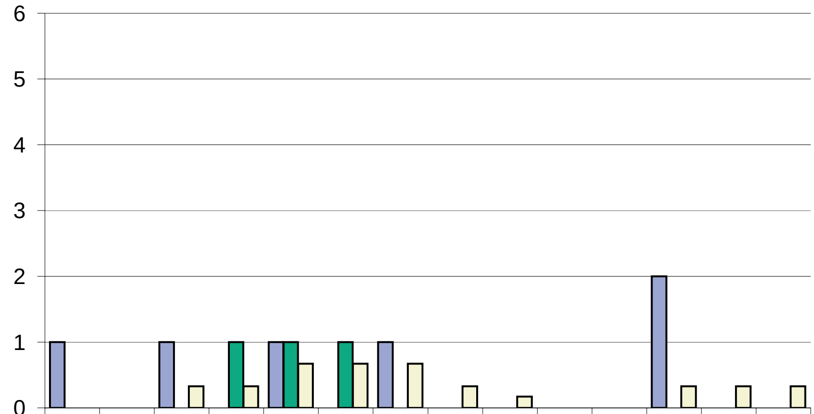
of the same kind ia non-compliance with instructions, non-registering of failures and incorrect use of computer programs. One event warranting a special report occurred at the Loviisa plant.

In 2003, eight and five operational transient reports were submitted from Olkiluoto and Loviisa power plants, respectively. The operational transients of the Olkiluoto plant occurred at Olkiluoto 2, and seven out of the eight transients were attributed to electrotechnical failures of the main circulation pumps.

Olkiluoto 1 submitted one scram report. It occurred on 4 June 2003 when a decision had been made, during post-annual-maintenance start-up, to bring the plant into a cold shutdown state to repair a leaking cable penetration of a main circulation pump motor.

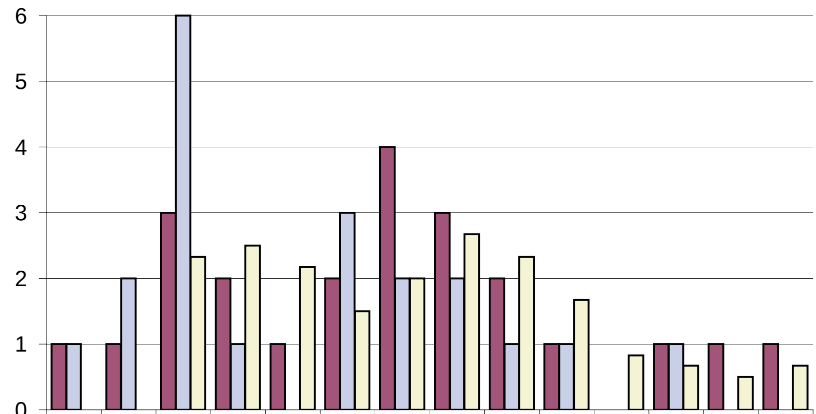
No reactor scrams occurred at Loviisa power plant in 2003.

Number of reactor scrams, Loviisa



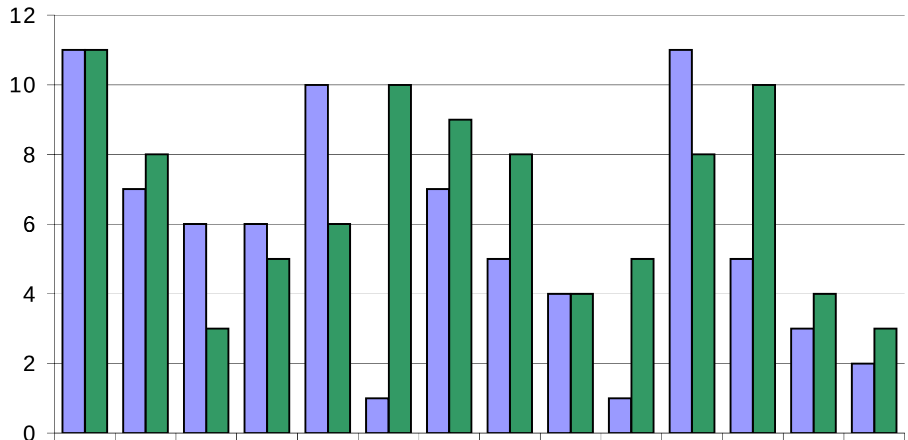
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO 1	1	0	1	0	1	0	1	0	0	0	0	2	0	0
LO 2	0	0	0	1	1	1	0	0	0	0	0	0	0	0
3 year average			0.33	0.33	0.67	0.67	0.67	0.33	0.17	0	0	0.33	0.33	0.33

Number of reactor scrams, Olkiluoto



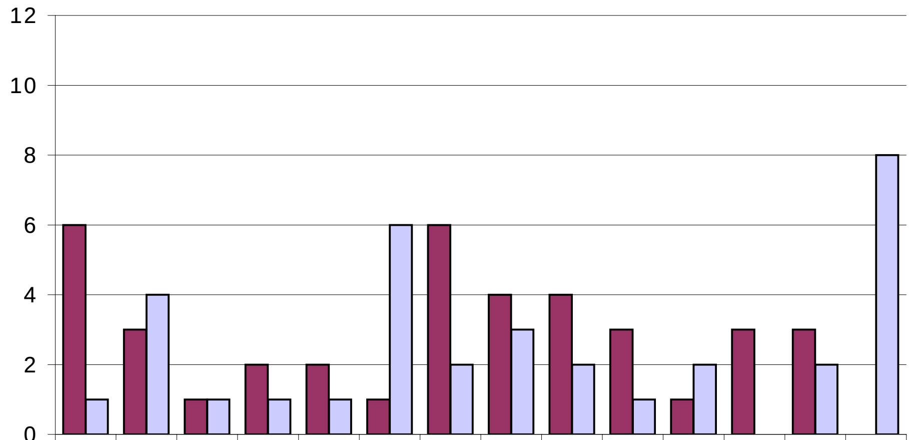
	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL 1	1	1	3	2	1	2	4	3	2	1	0	1	1	1
OL 2	1	2	6	1	0	3	2	2	1	1	0	1	0	0
3 year average			2.33	2.5	2.17	1.5	2	2.67	2.33	1.67	0.83	0.67	0.5	0.67

Number of operational disturbance reports, Loviisa



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

Number of operational disturbance reports, Olkiluoto



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

A.II.2 Risk-significance of events

Two types of indicator describe event importance. The first one pertains to the risk-significance of component unavailabilities and the second to their combined total risk.

Definition

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

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

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

Source of data

The data for calculation of indicators is collected from utility reports and exemption applications.

Purpose of indicator

To follow the risk-importance 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 of deteriorating organisational and safety culture.

Responsible unit/person

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

Interpretation of indicator

Loviisa

The most significant events at both Loviisa plant units related to latent failures of stand-up diesel generators and maintenance operations of the back-up emergency feed water system (RL94/97).

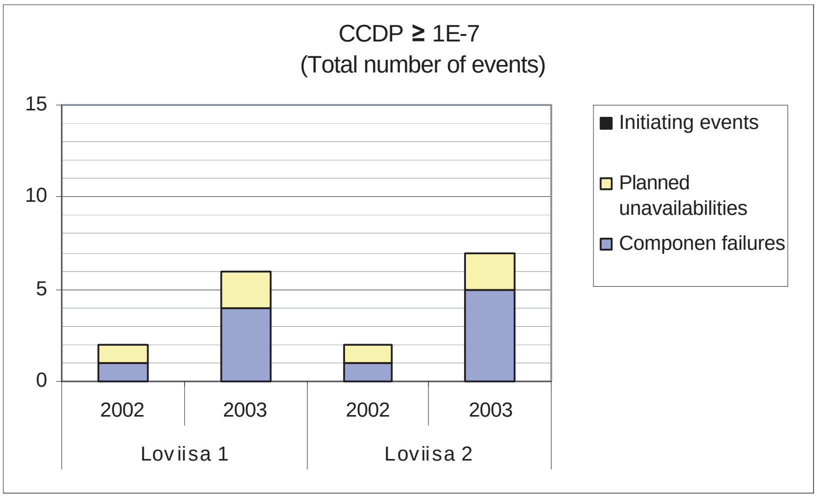
The events analysed are considered part of nuclear power plant normal operation and no further measures were required from STUK.

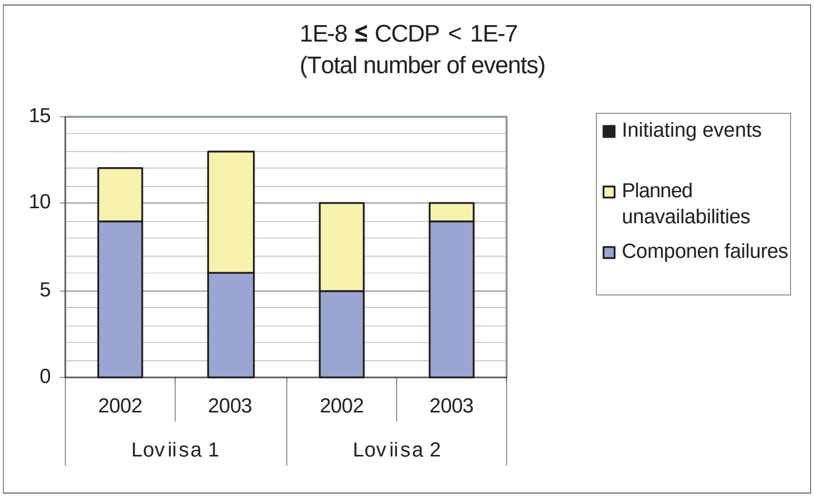
Olkiluoto

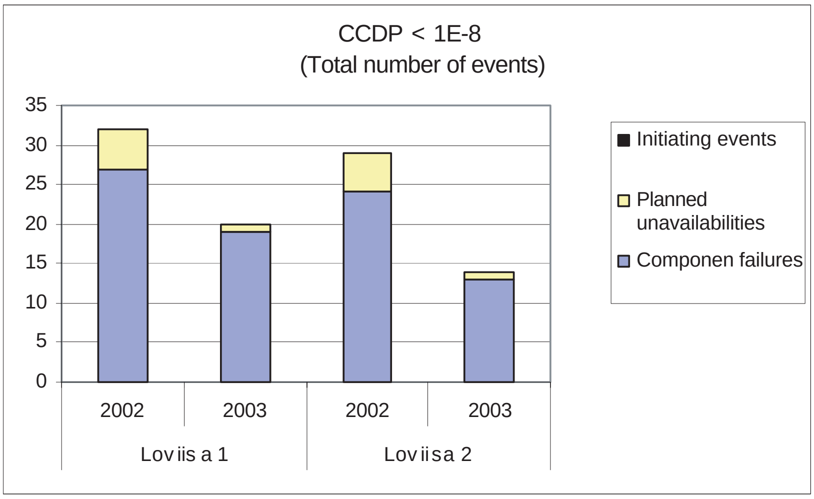
One reactor scram occurred at Olkiluoto 1 in both 2002 and 2003. All safety systems functioned according to design, the causes of the scrams have been determined and action has been taken to reduce the probability of their recurrence.

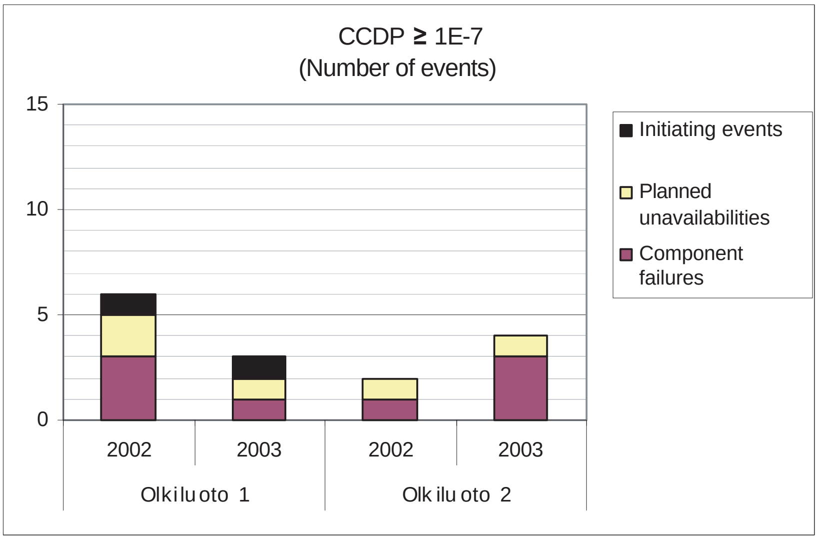
Other significant events at both plant units related to the repairs of the ceilings of the suction channels of the shutdown service water systems (712) under an exemption order from STUK. One stand-up diesel generator latent failure occurred at Olkiluoto 2, which had some risk-significance.

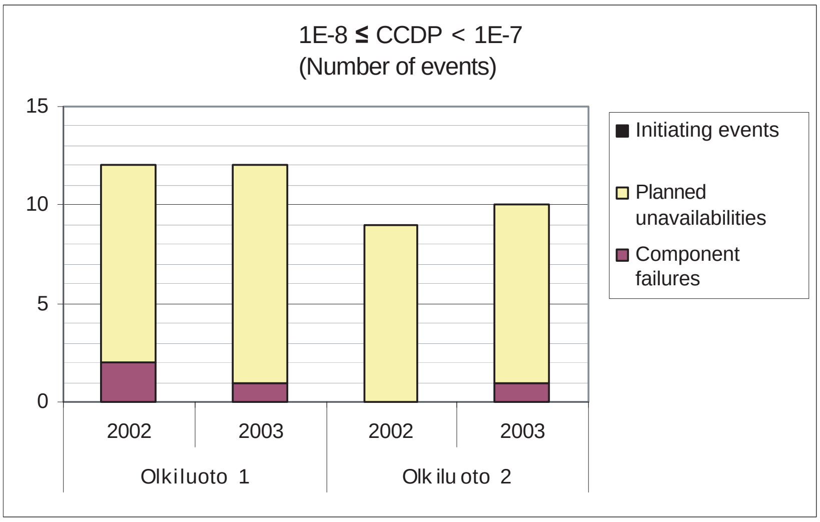
The events analysed are considered part of nuclear power plant normal operation and no further measures were required from STUK.

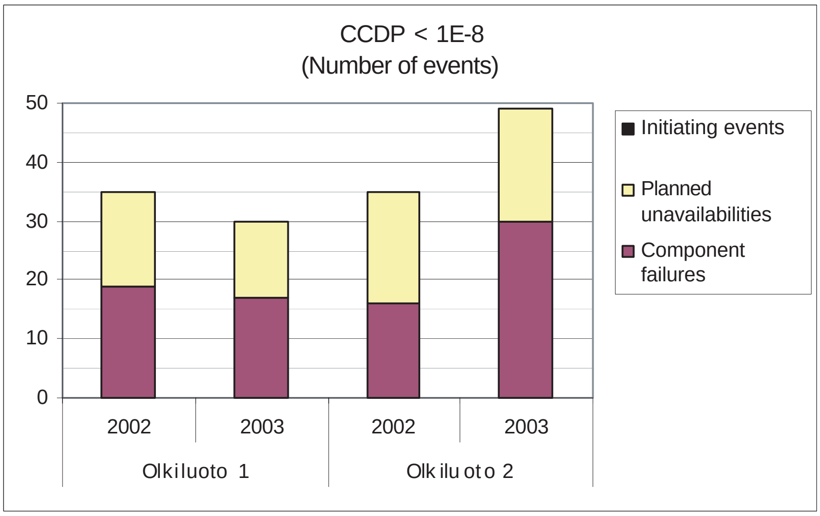

CCDP ≥ 1E-7
(Total number of events)
15
10
5
0
2002
2003
2002
2003
Loviisa 1
Loviisa 2
Initiating events
Planned unavailabilities
Componen failures


1E-8 ≤ CCDP < 1E-7
(Total number of events)
15
10
5
0
2002
2003
2002
2003
Loviisa 1
Loviisa 2
Initiating events
Planned unavailabilities
Componen failures


CCDP < 1E-8
(Total number of events)
35
30
25
20
15
10
5
0
2002
2003
2002
2003
Loviisa 1
Loviisa 2
Initiating events
Planned unavailabilities
Componen failures


CCDP ≥ 1E-7
(Number of events)
15
10
5
0
2002
2003
2002
2003
Olkiluoto 1
Olkiluoto 2
Initiating events
Planned unavailabilities
Component failures


1E-8 ≤ CCDP < 1E-7
(Number of events)
15
10
5
0
2002
2003
2002
2003
Olkiluoto 1
Olkiluoto 2
Initiating events
Planned unavailabilities
Component failures


CCDP < 1E-8
(Number of events)
50
40
30
20
10
0
2002
2003
2002
2003
Olkiluoto 1
Olkiluoto 2
Initiating events
Planned unavailabilities
Component failures

Risk-significance indicators included into STUK's permanent objectives

The STUK indicators were coupled together with the new strategy of 2003. Incorporated in the indicators for the effectiveness of STUK's activities is ia the below objective that considers the condition of components having a bearing on the accident risk of nuclear facilities: *"The risk-significance of nuclear power plant component failures, preventive maintenance and non-compliance with the Tech Specs is less than 5% of basic-level severe accident annual risk.*

Definition

As indicators, the PSA-computed risk-significance of operational events caused by unavailabilities of safety systems is followed. The areas under scrutiny include exemptions to the Tech Specs, Tech Spec component failures, preventive maintenance of Tech Spec components and other planned isolations. Each indicator is the combined total risk contribution of unavailability to annual core melt risk in the follow-up areas.

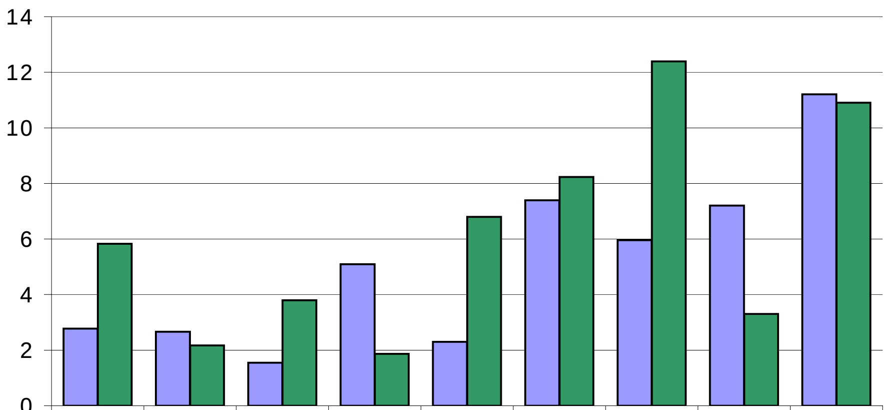
Source of data

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

Purpose of indicator

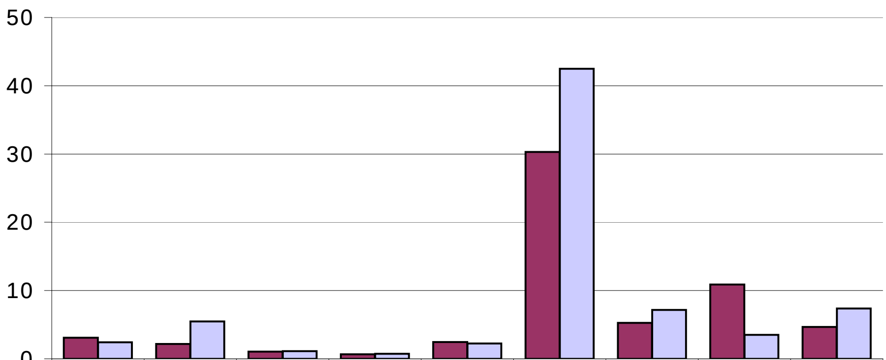
The indicators follow the risk-significance of Tech Spec component unavailabilities and monitor the

Risk contribution of the safety system unavailability at Loviisa
(percentage of the average annual core damage risk)



	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO1	2.78	2.66	1.54	5.09	2.30	7.39	5.96	7.20	11.21
LO2	5.83	2.17	3.80	1.87	6.80	8.23	12.39	3.3	10.90

Risk contribution of the safety system unavailability at Olkiluoto
(percentage of the average annual core damage risk)



	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL1	3.09	2.17	1.05	0.65	2.47	30.30	5.28	10.90	4.68
OL2	2.44	5.46	1.14	0.72	2.26	42.50	7.17	3.5	7.39

duration of planned isolations and preventive maintenances.

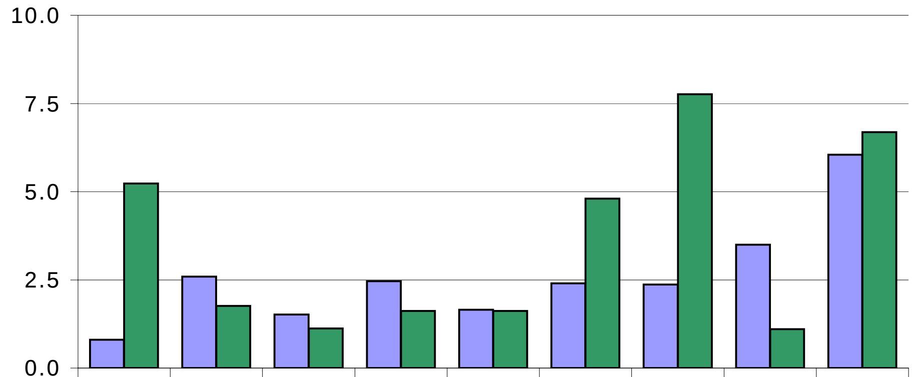
Responsible unit/person
Risk analysis (RIS), Ari Julin (PSA analyses)
Safety Management (TUR) (failure data)

Interpretation of indicators

The effect of unavailabilities caused by component failures, preventive maintenance and deviations from operation and maintenance procedures on annual accident risk exceeded its 5% target value at both Loviisa plant units and at Olkiluoto 2 in 2003. This was partly due to planned, one-time maintenance jobs carried out under an exemption order, partly to latent component failures.

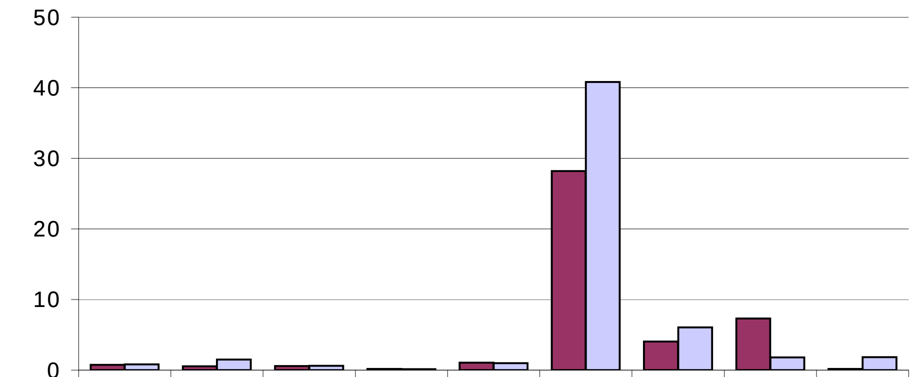
The effect of component unavailability on accident risk was approx. 11.2% and approx. 10.9% at Loviisa 1 and Loviisa 2, respectively, in 2003. The increase in the indicator is due to the random nature of the events and requires no action from STUK. The exceeding of target values at both Loviisa plant units was caused by diesel generator latent failures and maintenance work done on the auxiliary feed water system (RL94/97).

Risk contribution by unavailability of TechSpec equipment failures, Loviisa



	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO1	0.80	2.59	1.52	2.46	1.65	2.40	2.37	3.50	6.05
LO2	5.23	1.76	1.12	1.62	1.62	4.80	7.76	1.1	6.69

Risk contribution by unavailability of TechSpec equipment failures, Olkiluoto



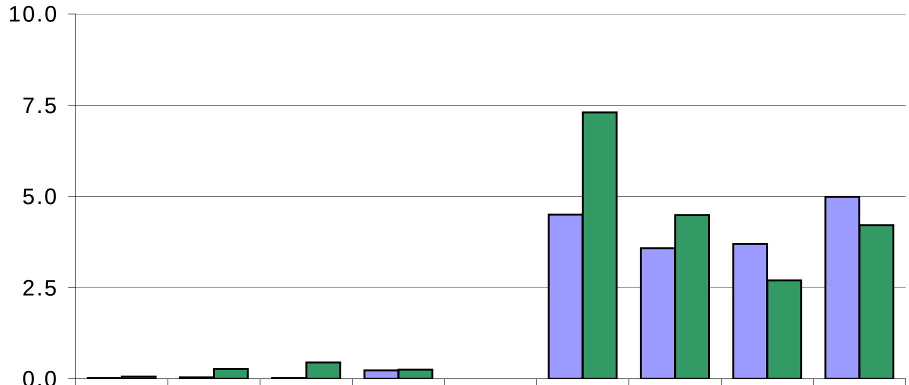
	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL1	0.74	0.54	0.57	0.16	1.07	28.20	4.05	7.30	0.18
OL2	0.81	1.49	0.62	0.15	0.97	40.80	6.06	1.8	1.83

STUK will be using an updated Loviisa PSA model in the future, which covers a much larger number of analysed events. In that case, the risk-significance of the unavailabilities of the auxiliary feed water system (RL94/97) for example will be considerably smaller from what it is now, since the analysis considers ia the use of a TK/RY coupling.

The annual total risk from component unavailabilities (failures, preventive maintenance and exemption orders) was approx. 4.7% at Olkiluoto 1 and approx. 7.4% at Olkiluoto 2 in 2003. The most significant event at Olkiluoto in 2003 was a reactor scram at Olkiluoto 1. The target value was exceeded at both plant units due to the repair of the ceilings of the suction channels of the shutdown service water system (712) carried out under an exemption order granted by STUK. In addition, one back-up diesel generator latent failure occurred at the Olkiluoto 2 plant unit, which was some risk-significant.

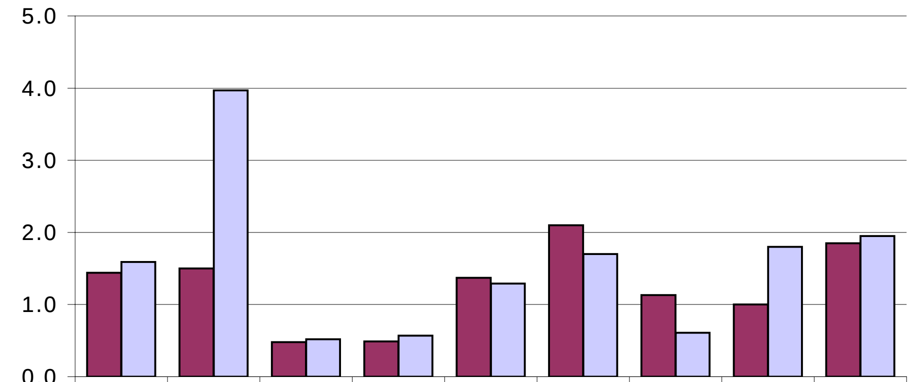
The events analysed are considered part of nuclear power plant normal operation and no further measures were required from STUK.

Risk contribution caused by unavailability of TS equipment preventive maintenance, Loviisa



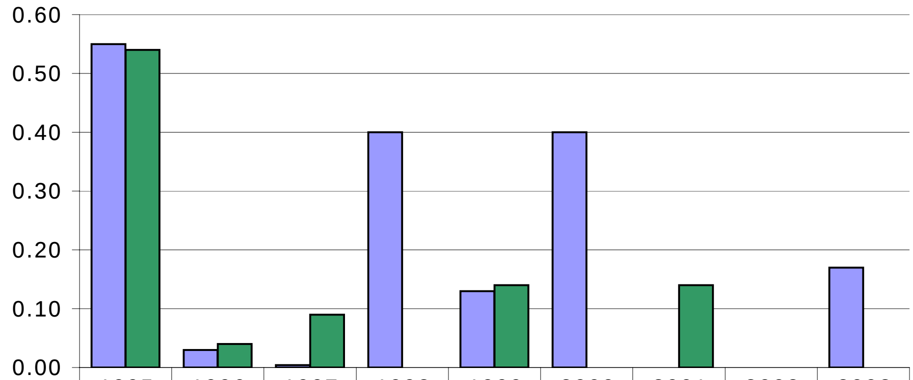
	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO1	0.02	0.04	0.02	0.23	0.00	4.50	3.58	3.70	4.99
LO2	0.06	0.27	0.45	0.25	0.00	7.30	4.49	2.7	4.21

Risk contribution caused by unavailability of TS equipment preventive maintenance, Olkiluoto



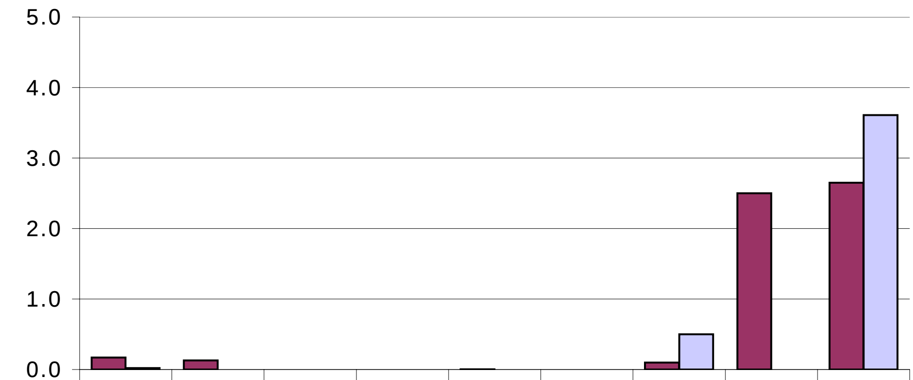
	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL1	1.44	1.50	0.48	0.49	1.37	2.10	1.13	1.00	1.85
OL2	1.59	3.97	0.52	0.57	1.29	1.70	0.61	1.8	1.95

Risk contribution (%) of TS equipment unavailability caused by exemptions from TS, Loviisa



	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO1	0.55	0.03	0.00	0.40	0.13	0.40	0.00	0.00	0.17
LO2	0.54	0.04	0.09	0.00	0.14	0.00	0.14	0	0.00

Risk contribution (%) of TS equipment unavailability caused by exemptions from TS, Olkiluoto



	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL1	0.17	0.13	0.00	0.00	0.003	0.00	0.10	2.50	2.65
OL2	0.02	0.00	0.00	0.00	0.00	0.00	0.50	0	3.61

A.II.3 Direct causes of events

Definition
As 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 to an event follow-up table maintained by TUR.

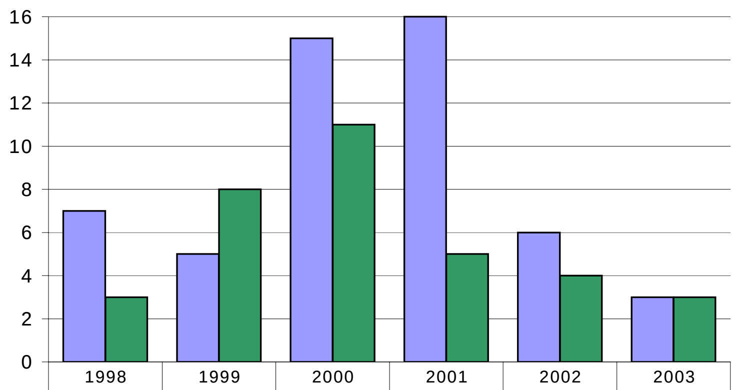
Purpose of indicators
To follow the division of the causes of reported events into technical and non-technical. "Non-technical causes" denote failures caused by erroneous operational and maintenance actions. The indicator may be descriptive of an organisation's operation.

Responsible unit/person
Safety Management (TUR)
Timo Eurasto

Interpretation of indicator
A total of six events were reported from Loviisa power plant in 2003, three of which were classified technical and three as caused by human error. Olkiluoto power plant submitted 17 event reports. Nine events were caused by a technical fault and the main reason for/significant contributor to eight of them was human error (two events were assigned as having been caused by technical failure, too).

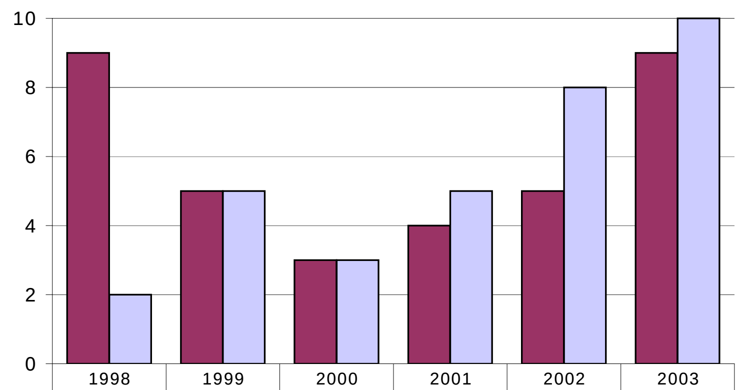
The events at the Olkiluoto plant, whose causes are human-error based or organisational, have, for a third year in succession, shown an increasing trend.

Direct causes of events, Loviisa



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

Direct causes of events, Olkiluoto



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

A.II.4 Number of fire alarms

Definition
As indicators, the number of fire alarms and actual fires is followed.

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

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

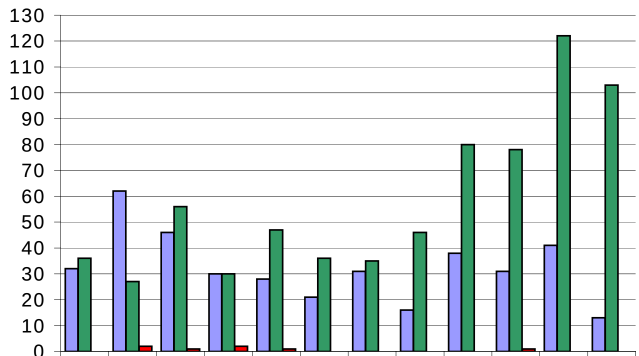
Responsible unit/person
Power Plant Technology (VLT)
Heikki Saarikoski

Interpretation of indicator
No actual fires occurred onsite at either plant.

The correct actuations of the fire alarm system of the Loviisa plant were mostly caused by unknown reasons (47 alarms) or incorrect procedures (43 alarms). The number of alarms actuated by smoke or humidity, arising from reasons other than incorrect procedures, was 13 at the Loviisa plant. The number of alarms triggered by component failures was also 13.

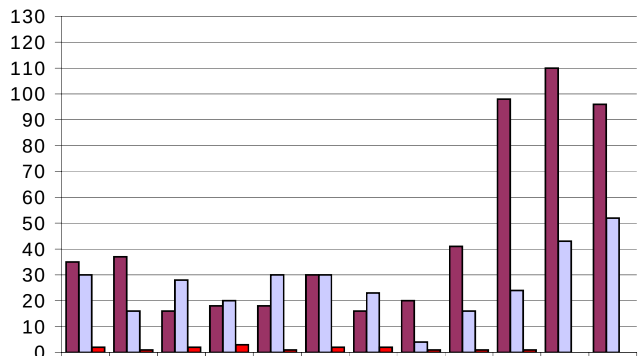
In early 2002, the automatic fire detectors of both Olkiluoto plants were replaced and commissioned in their entirety. The dominating fire alarms at Olkiluoto in 2003 were still those triggered by component failures (96 alarms). The number of alarms triggered by smoke, steam, humidity or heat totalled 52.

Number of fire alarms, Loviisa



	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
automated failures	32	62	46	30	28	21	31	16	38	31	41	13
actual automated alarms	36	27	56	30	47	36	35	46	80	78	122	103
actual fires	0	2	1	2	1	0	0	0	0	1	0	0

Number of fire alarms, Olkiluoto



	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
automated failures	35	37	16	18	18	30	16	20	41	98	110	96
actual automated alarms	30	16	28	20	30	30	23	4	16	24	43	52
actual fires	2	1	2	3	1	2	2	1	1	1	0	0

A.III Structural integrity

A.III.1 Fuel integrity

Definiton

As indicators, the maximum activity concentration of the plant unit's primary coolant on even, steady-state operation as I-131 equivalents (kBq/m³) (Olkiluoto; I-131 only) is followed as well as the number of leaking fuel assemblies removed from the reactor in each annual maintenance outage.

Source of data

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

Purpose of indicator

The indicators depict fuel integrity and the fuel leakage volume during the operating cycle.

Responsible unit/person

Power Plant Technology (VLT)
Kirsti Tossavainen

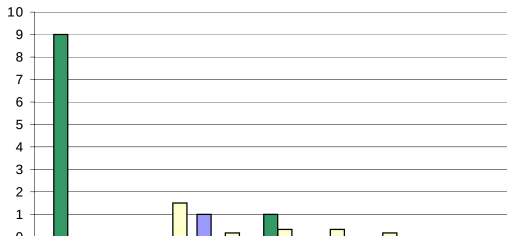
Interpretation of indicator (number of leaking fuel assemblies)

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

Fuel leakages have occurred almost every year at the Olkiluoto plant units. They have been small and the leaking assemblies have been removed in annual maintenance outages following leak detection. The combined 3-year average for the plant units shows a decreasing trend, however.

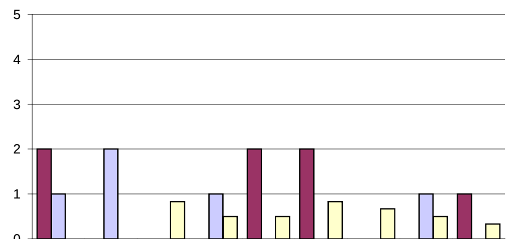
No leaking assemblies were detected at the Loviisa and Olkiluoto plant units in the 2002–2003 operating cycle or late 2003. A fuel leak was detected at Olkiluoto 1 on 27 February 2003. The leaking assembly and the assembly symmetrically positioned to it were removed from the reactor in an annual maintenance outage. Leak detection during the annual maintenance outage discovered an above-normal amount of crud in one assembly; this assembly and the one symmetrically positioned to it were removed from the reactor.

Number of fuel bundles detected annually leaking, Loviisa



	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO 1	0	0	0	1	0	0	0	0	0
LO 2	9	0	0	0	1	0	0	0	0
3 yearly average			1.5	0.17	0.33	0.33	0.17	0	0

Number of fuel bundles detected annually leaking, Olkiluoto



	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL 1	2	0	0	0	2	2	0	0	1
OL 2	1	2	0	1	0	0	0	1	0
3 yearly average			0.83	0.5	0.5	0.83	0.67	0.5	0.33

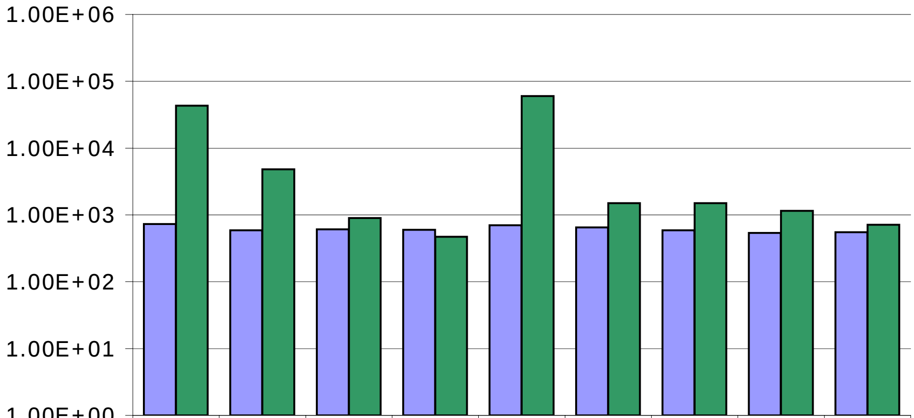
Interpretation of indicator (primary coolant activity concentration)

The I-131 activity concentration of Loviisa 1 primary coolant has remained unchanged. A 1998 fuel leakage occurred about a week before the annual maintenance outage during which the leaking assembly was removed from the reactor. The leak was so small that it did not have any actual significance for the primary coolant I-131 activity concentration. The effect of Loviisa 2 fuel leakages is clearly seen in the activity concentration of the primary coolant. Even during fuel leakages, activity concentrations have been well below the limit set in the Tech Specs (1,0E+8 kBq/m³). Since 1999, no fuel leakages have occurred at the Loviisa plant units.

The effect of fuel leakages is obvious in the changing activity concentrations of the primary coolant of the Olkiluoto plant units. Leaking assemblies were removed from the reactor in annual maintenance outages following leak detection. The activity increase caused by a leaking assembly shows in the respective diagram for both the year of detection and the year of the assembly's removal from the reactor. The I-131 activity concentration limit set in the Tech Specs (2,2E+6 kBq/m³) was not compromised during any of the events.

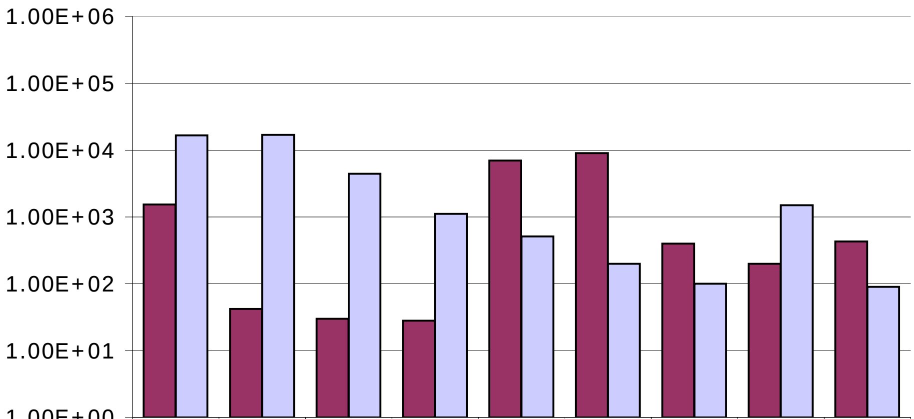
The fuel leak detected on 27 February 2003 is shown in the 2003 indicator for Olkiluoto 1. The leaking assembly was removed from the reactor in an annual maintenance outage. After the 2002 fuel leakage, the Olkiluoto 2 indicator has decreased to pre-leakage level.

Fuel integrity, I-131 activity concentration (kBq/m³) in the primary coolant of Loviisa units



	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO 1	7.30E+02	5.90E+02	6.10E+02	6.00E+02	7.00E+02	6.50E+02	5.90E+02	5.39E+02	5.50E+02
LO 2	4.30E+04	4.80E+03	9.00E+02	4.70E+02	6.00E+04	1.50E+03	1.50E+03	1.15E+03	7.10E+02

Fuel integrity, I-131 activity concentration (kBq/m³) in the primary coolant of Olkiluoto units



	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL 1	1.54E+03	4.20E+01	3.00E+01	2.80E+01	7.00E+03	9.00E+03	4.00E+02	2.00E+02	4.30E+02
OL 2	1.66E+04	1.70E+04	4.42E+03	1.11E+03	5.12E+02	2.00E+02	1.00E+02	1.50E+03	9.00E+01

A.III.2 Primary circuit integrity

Definition

The indicators are international chemistry performance indices used by the utilities, depicting the effectiveness of water chemistry control in the secondary circuits of PWRs and in the reactor circuits of BWRs. Also the amounts of identified and unidentified leakages during the operating cycle are followed as primary circuit integrity indicators. The calculating method of the chemistry index, revised in 1999, has resulted in the index being ill suited to describing a Loviisa-plant-type VVER facility. The commissioning of a new indicator is under way at the Loviisa plant.

TVO used the below indices to follow primary circuit leakages:

- 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 condensating in the air coolers of the containment cooling system 725/ Tech Specs limit).

Source of data

The licensees submit indicators describing the water chemistry control to the respective responsible person at STUK. The licensee submits the leakage amounts of Olkiluoto to the respective responsible person at STUK. Data gathering for the indicator for Loviisa power plant is yet to be established.

Purpose of indicators

To monitor and control primary circuit integrity.

Responsible unit/person

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

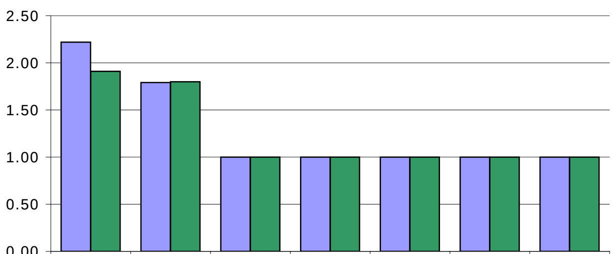
Chemistry index

Interpretation of indicator

The value of the chemistry index for the Loviisa plant has been the best possible, ie one, over the past years, when using an index calculation method specific to VVER plants. The Loviisa plant has developed their own chemistry indicators and retrospective indicator calculations are under way.

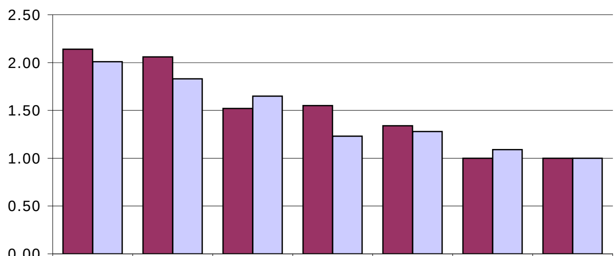
The Olkiluoto plant units' chemistry index has reached its international target value (= 1). Sulphate originating in the condensate clean-up filters has increased the index in the past. Its volume has been reduced ia by the use of sulphate-free ion-exchange resin in the filters. During the Olkiluoto 2 annual maintenance outage of 2003, the condensate system was modified such that the temperature of water entering the condensate clean-up system ion-exchange filters was reduced. This was to eliminate the disintegration of cation mass in the filters, which increases the sulphate concentration of reactor water. Olkiluoto 1, where this modification has not been implemented, uses sulphate-free ion-exchange resin in part of their filters.

Integrity of the primary circuit; chemistry index, Loviisa



	1997	1998	1999	2000	2001	2002	2003
LO 1	2.22	1.79	1.00	1.00	1.00	1.00	1.00
LO 2	1.91	1.80	1.00	1.00	1.00	1.00	1.00

Integrity of the primary circuit; chemistry index, Olkiluoto



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

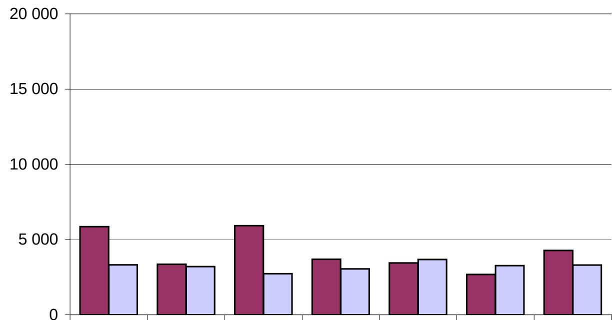
Primary circuit leakages, Olkiluoto

Interpretation of indicator

Immediately after the 2002 outages, a leak was detected at both plant units in a check valve of the blow-down pipe of the relief system (314) of the reactor building main steam lines (311). The leakages continued until the 2003 outages during which the check valves (vacuum breakers), which prevent a vacuum in the blow-down pipelines (314), were serviced. The Olkiluoto 1 leakage was considerably larger than that at Olkiluoto 2. The valve type in question (8 pcs in total/plant unit) has leaked even before this. Teollisuuden Voima Oy is planning a new type of sealing to the valves.

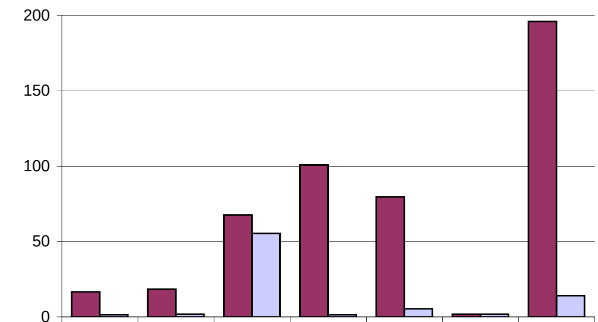
Definition of the above indicators for the Loviisa plant is under way.

Identified leakages of primary circuit (m^3), Olkiluoto



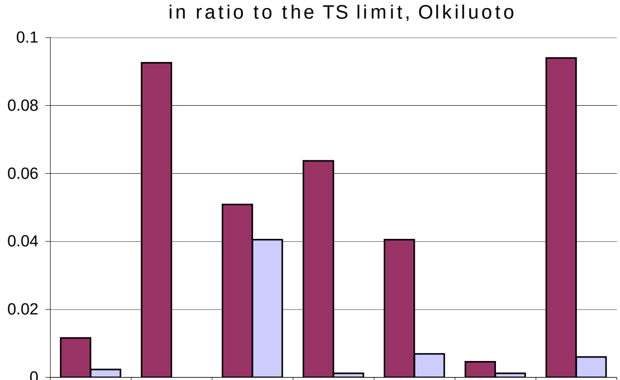
	96-97	97-98	98-99	99-00	00-01	2001-02	2002-03
OL 1 Identified leakages (352T1)	5 859	3 355	5 924	3 694	3 443	2 678	4 281
OL 2 Identified leakages (352T1)	3 316	3 209	2 731	3 047	3 677	3 262	3 307

Unidentified leakages of primary circuit (m^3), Olkiluoto



	96-97	97-98	98-99	99-00	00-01	2001-02	2002-03
OL 1 Unidentified leakages(345T33)	16.6	18.4	67.7	100.8	79.6	1.8	196.0
OL 2 Unidntified leakages (345T33)	1.4	1.8	55.4	1.4	5.4	1.8	14.0

The maximum unidentified leakage in ratio to the TS limit, Olkiluoto



	96-97	97-98	98-99	99-00	00-01	2001-02	2002-03
OL1 leakage/TS limit	1.16 %	9.26 %	5.09 %	6.37 %	4.05 %	0.46 %	9.40 %
OL2 leakage/TS limit	0.23 %	0.00 %	4.05 %	0.12 %	0.69 %	0.12 %	0.60 %

A.III.3 Containment integrity

Definition

As indicators, the below parameters 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 (ie 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. Combined leakage rate at Olkiluoto includes leakages of personnel airlocks, the maintenance dome and the containment dome. In Loviisa, combined leakage rate is comprised of the leakage test results of 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 as well as the sealings of blind-flanged penetrations of ice-filling pipes are included.

Source of data

Data is extracted from the utilities' leaktightness test reports submitted by the licensee to STUK for information within three months from the completion of an 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 (ie after completion of repairs and re-testing).

Purpose of indicators

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

Responsible unit/person

Reactor and Safety Systems (REA),
Päivi Salo

Interpretation of indicator

The overall as-found leakage of Loviisa 1 outer isolation valves has grown but is still below set limit. A leaking fire fighting water system valve accounts for approx. 50% of the leakage rate. The overall as-found leakage of Loviisa 2 outer isolation valves has decreased, being below set limit.

The percentage of isolation valves, which passed the leaktightness test at first attempt, has remained high.

The overall as-found leakage of containment penetrations, which at Loviisa includes leaktightness tests of the bellows sealings of the personnel airlock, the emergency personnel airlock, the material airlock, the reactor pit, inward relief valves, cable penetrations, the containment maintenance ventilation systems (TL23), the main steam line (RA) and the feed water system (RL), has clearly grown but set limit remains unexceeded.

At Loviisa 1, approx. 77% of the overall as-found leakage comes from a leaking main steam piping bellows sealing. At Loviisa 2, approx. 86% comes from a leaking penetration bellows sealing of the maintenance ventilation systems.

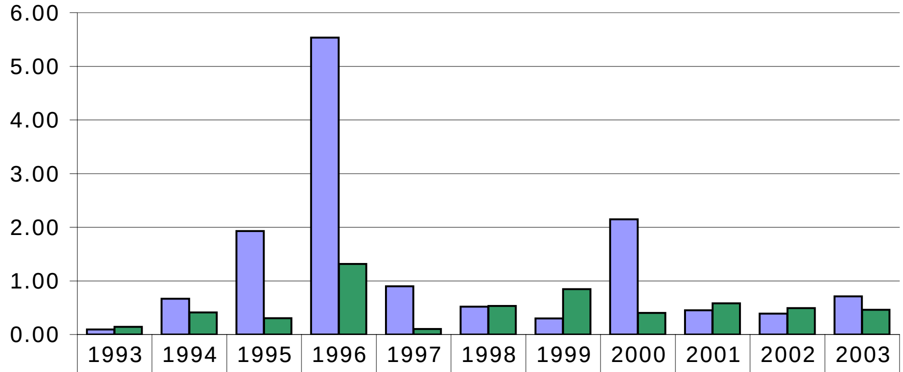
The integrity of the Loviisa containment building has been good. The leaktightness of the rubber bellows of penetrations has been problematic over the past years. The idea of replacing them with metal structures has been introduced at the plant.

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. At Olkiluoto 2, approx. 55% of the overall as-found leakage rate of outer isolation valves is caused by one leaking reactor pressure vessel spray system valve, which is almost equal to the overall as-found leakage rate allowed for outer isolation valves (= overall as-found leakage would have met the criteria without the aforementioned leakage).

The proportion of isolation valves passing the integrity tests at first attempt has remained stable.

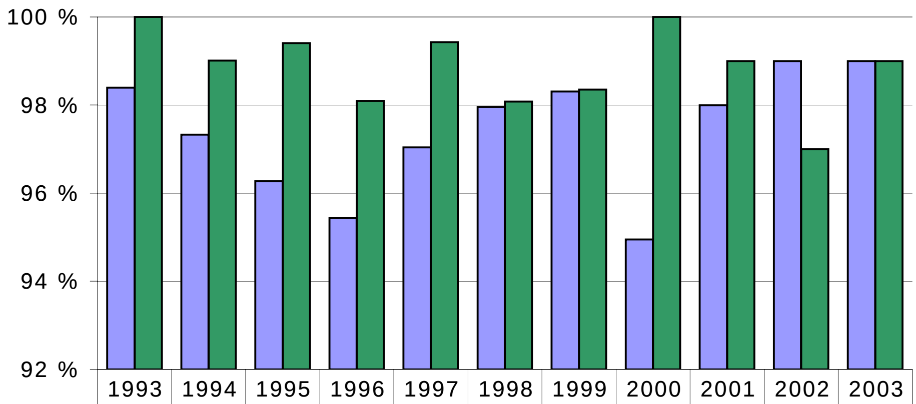
The overall as-found leakage rate of containment penetrations, which at the Olkiluoto plant includes leakages of the upper and lower personnel airlock, the maintenance dome and the containment dome, has been small.

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



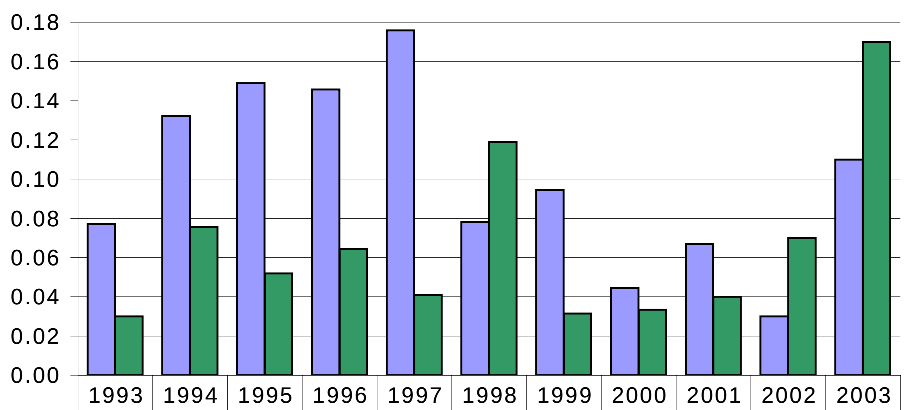
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO 1	0.09	0.67	1.93	5.54	0.90	0.52	0.30	2.15	0.45	0.39	0.71
LO 2	0.14	0.41	0.31	1.31	0.10	0.53	0.85	0.40	0.58	0.49	0.46

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



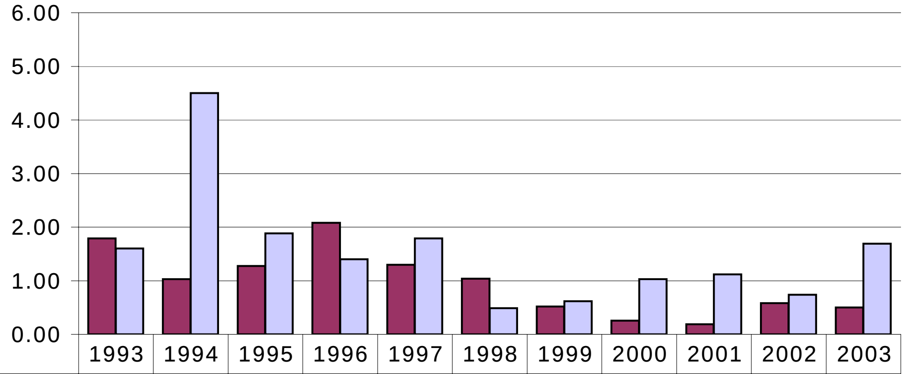
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO 1	98 %	97 %	96 %	95 %	97 %	98 %	98 %	95 %	98 %	99 %	99 %
LO 2	100	99 %	99 %	98 %	99 %	98 %	98 %	100	99 %	97 %	99 %

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



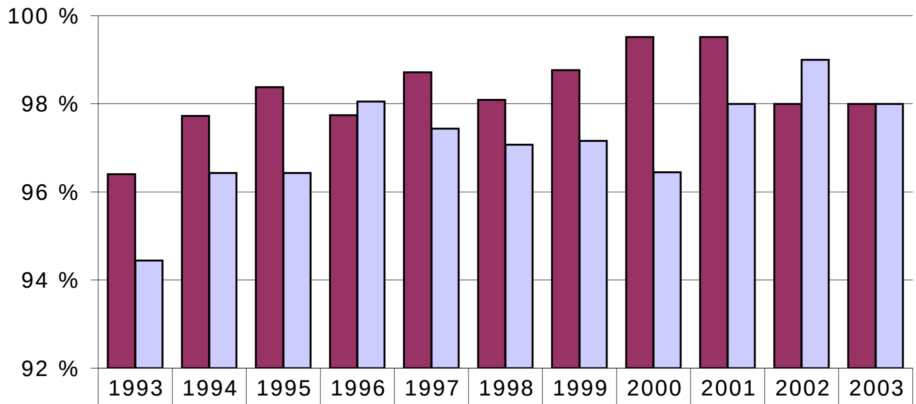
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
LO 1	0.08	0.13	0.15	0.15	0.18	0.08	0.09	0.04	0.07	0.03	0.11
LO 2	0.03	0.08	0.05	0.06	0.04	0.12	0.03	0.03	0.04	0.07	0.17

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



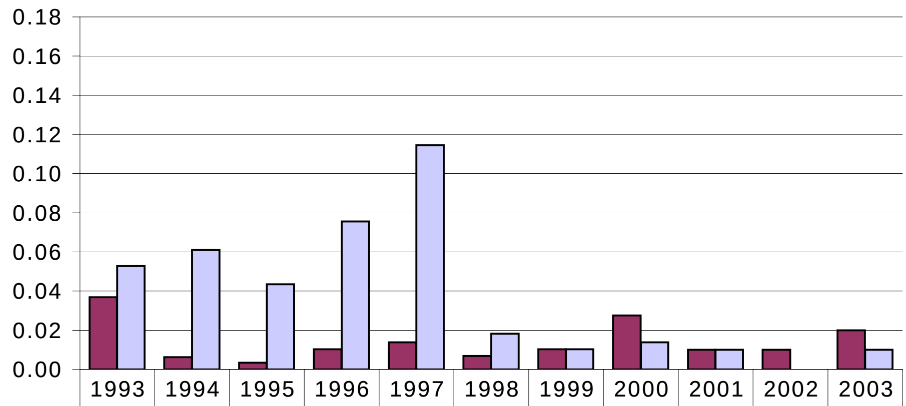
	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
OL 1	1.79	1.03	1.28	2.08	1.30	1.04	0.52	0.25	0.19	0.58	0.50
OL 2	1.60	4.50	1.88	1.40	1.79	0.49	0.62	1.03	1.12	0.74	1.69

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



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

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



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

APPENDIX 2 Safety improvements

Rauno Lehto, Veli Riihiluoma, Päivi Salo, Heimo Takala, Keijo Valtonen

Loviisa nuclear power plant

Provision for severe accidents
Measures to mitigate the consequences of severe accidents were carried out at both Loviisa plant units during the annual maintenance outages of 2003. The modifications related to hydrogen management and management of containment leaktightness. In addition, measurement installations not completed in the 2002 annual maintenance were completed.

In severe accidents, hydrogen is released inside the containment. Catalytic recombiners were installed inside the containment to burn hydrogen without quick explosive fires. Installation of the recombiners in the containment upper compartment was continued during operation. The entire installation work was completed by the end of the year.

The steam generator room has glow plugs for situations involving especially quick hydrogen releases. The plugs were qualified for severe accident conditions and their placing was changed when more recombiners were installed. In the annual maintenances, 40 glow plugs were installed at both plant units.

The sealing material on the doors of the reactor pit was replaced with material that better withstands severe accident conditions. Additional sealing could not be implemented according to plan. The deviation has STUK's approval until the 2004 annual maintenance.

In addition to those implemented previously, the option of manual tripping was provided for one more containment isolation signal necessary for the maintenance of containment leaktightness. These manually tripped special functions assure containment leaktightness against system leaks.

Replacement of radiation measurements
Replacement of fixed radiation monitors was continued at Loviisa plant. During the Loviisa 2 annual maintenance outage, 61 monitors were replaced. In addition, the radiation monitors of the ventilation stack were replaced at Loviisa 2 towards the end of the year. Corresponding modifications had been made at Loviisa 1 in 2002, excluding the ventilation stack monitors, which were replaced in 2003.

The fixed measurement system of Loviisa nuclear power plant comprises a total of 140 independently operating monitoring devices that follow dose rates in the plant's rooms, the radioactivity in processes and the amount of releases. Part of the system is capable of functioning even in severe accidents.

New radiation monitoring technologies yield data more versatile and accurate than before on the radiation levels of measured objects. In addition, measurement data from the new radiation monitors is more efficiently available for use by the plant personnel. Besides the control room and the monitors' local displays, the data can be directly utilised in the work locations of those responsible to control radioactivity and those working in the I&C unit. Some of the new devices can be easily moved if needed, facilitating an improved focusing of radiation measurements.

Supports of low pressure emergency cooling system pumps were modified
High vibration values had been observed in the low pressure emergency cooling system pumps of both Loviisa plant units. To reduce them, the supports of the pumps were modified in the annual maintenance outages. Deviating vibration values had been detected in one Loviisa 1 and three Loviisa 2

pumps. Each plant unit has four low pressure emergency cooling system pumps.

The deviating vibration values were due to the natural frequency of the entity comprising the pump unit and its supports being ca 100 Hz, which is identical to the frequency of the initiator from the pump unit's electric motor. Vibration levels can be reduced by changing the natural frequency of the structure and that of the initiator such that they are not the same. A structure's natural frequency can be increased by making it stiffer and decreased by reducing its stiffness. There have been earlier attempts to reduce vibrations by making the foundation stiffer, but its natural frequency did not improve sufficiently. The foundation's stiffness was reduced by opening the supports of the upper plate at the corners i.e. the perpendicular walls of the foundation were sawn open around the corners. After this, the natural frequencies of the pump units were measured and found to have decreased by ca. 10–15%. Test runs showed a marked reduction in the pump units' vibration levels.

Olkiluoto nuclear power plant

Feedwater distributors were replaced at Olkiluoto 2

Old feedwater distributors were replaced in the Olkiluoto 1 annual maintenance outage. The new distributors are capable of handling post power upgrade feedwater flow and their design takes into account heat stresses exerted on ascending pipes of the emergency cooling system located inside the reactor pressure vessel. The pipes are located directly under the feedwater distributors. Heat stress is imminent when cold feedwater mixes with warmer water returning from the steam separators. The new distributors are meant to mix these flows as well as possible and to thus reduce heat stresses exerted on the ascending pipes.

The process interface of process computers was modernised

In the 2003 annual maintenance outage of Olkiluoto 2, the oldest process computers plus their process interface equipment were upgraded and provided with user interfaces. The process interface gathers and transmits measurement and condition data to the process computer system and the process automation system user interface. For analogue data gathering, the upgraded equipment constitute a new "Data gathering and temperature monitoring system". The power supplies and data buses of its processors have been doubled for enhanced availability. In addition, the new system carries out temperature measurement-related actuations, monitors signal limits, carries out alarm functions and further delivery of signals to the control and alarm panels of the control room, conducts operating time calculations for electric motors, and gathers and calculates trends.

The upgraded alarm computer constitutes a system of its own. It collects binary event data on processes and transmits them to the process computer through the new "Data gathering and temperature monitoring system".

The Olkiluoto 2 system connects to two new servers of the process computer system. These servers, equipped with next generation software, were commissioned for operation abreast with the process computer system proper. Their two workstations were placed next to the user interfaces of the process computer on the control room main operation board, which was also upgraded.

Similar modifications were implemented at Olkiluoto 1 in the 2002 annual maintenance outage but the control room was not equipped with a new process computer user interface. The system's upgrading was continued in the annual maintenance by arranging the connections between its process I & C stations.

The safety significance of the process computer system and its data gathering system mainly pertains to the provision of information and they do not contribute to the actuation of safety functions.

APPENDIX 3 Significant opertation events

Jarmo Konsi, Jukka Kupila, Rauno Lehto, Hannu Ollikkala, Pentti Rannila, Rainer Rantala, Veli Riihiluoma

Loviisa nuclear power plant

A delay in the repair of a high pressure safety injection system pump at Loviisa 2

In connection with the periodic testing of a reactor high pressure safety injection system pump at Loviisa 2 on 3 March 2003, excess water was detected in the water reservoir. It was attributed to a leaking shaft gasket on the pump's coupling side. The pump was replaced with a reserve pump whose functioning was problematic, too. The utility had to apply for two exemptions from the Technical Specifications from STUK to accomplish the repairs and make the pump operational during plant unit operation.

After leak detection, the gasket was tightened without delay, with the pump running. The leak was not reduced, however, and the gasket was retightened, which resulted in smoke coming out of the gasket housing. The gasket was loosened but fuming and heating did not stop. The pump was stopped for inspection on 4 March 2003. Its shaft was found stuck and large cuts were found on the coupling side of the gasket housing. In addition, the shaft's protective sleeve was almost broken and had stuck to the shaft. A decision was made to dismantle the entire pump for repairs.

The pump in question is part of the reactor high pressure safety injection system and it pumps boron water into the primary circuit in the early stages of an accident. The system has two redundancies, two parallel pumps in each. During normal operation the pumps are only operated for ca. two hours for testing. The Technical Specifications allow for a period of three days of subsystem unavailability for repairs during plant unit operation.

This 3-day repair period would not have been sufficient to find out the cause of the pump failure and to repair it, so the utility applied for a 7-day extension, which was granted by STUK.

It was evident from the parts of the dismantled pump that the sleeve of its labyrinth shaft sealing had stuck to the shaft and had to be machined off. After its removal, the shaft was tested by liquid penetrant and long circumferential cracks were detected. A week would not have been enough to repair the original pump and so it was replaced with a corresponding spare pump. The operation of the new pump was found problematic, too. It was repaired and STUK decided on a 10-h trial run more extensive than a regular periodic functional test. The trial run was completed on 14 March 2003.

Although the pump seemed to be in good order during the trial run, the vibration spectrum of the coupling-side bearing of its electric motor indicated an imminent bearing failure. The utility applied for a 3-day extension to the deviation from the Technical Specifications, which was granted by STUK. The new permit was valid until 17 March 2003. The bearing in question was replaced but the vibration spectrum was still found ambiguous. The motor was replaced with a spare motor.

In addition to the motor failure, also the pump was found defective, i.e. it jammed when manually run. The bearing and housing of the spare pump were partially dismantled but the cause of the jamming remained unclear and it was decided to entirely dismantle, inspect and repair the pump. The repaired pump unit was tested on 17 March 2003 with acceptable results.

The utility has purchased spare parts for the pumps and initiated analyses to purchase new pumps.

Inoperability of ventilation stack release measurements at Loviisa 2

During the weekly changing of sampling filters of the sampling lines of the ventilation stack of Loviisa 2 on 16 October 2003, the filter of one sampling line was found to be in an incorrect position. The other line was out of service due to measuring device replacements. The situation was put right without delay by replacing the incorrectly positioned filter with a new one. The observation was reported to the relevant foreman by email. The event's safety significance was only recognised in December at what time it was re-evaluated and also reported to STUK.

Ventilation outflow from the controlled area of both plant units at the Loviisa facility is channelled to the ventilation stack. The radioactivity of outgoing air is monitored at each plant unit by continuous-operation measurements and once-a-week laboratory analyses. The release measurement systems comprise two independent lines in which the sampling filters and continuous-operation radiation monitors are located. The Technical Specifications require that two out of three monitors be operational. Due to the incorrect position of the sampling filter, a representative sample flow from Loviisa 2 was not obtained for the two sampling line monitors in operation and the release measurement function thus was not operational as required in the Technical Specifications. The plant unit's radiation measurement system was being upgraded at the same time and thus also the third monitor of the release measurement system was out of service. In addition to this, a representative weekly sample for laboratory analysis did not accumulate in the filter.

According to detailed utility analyses, the release measurements had been simultaneously inoperable for ca. 20 hours. Based on the plant unit's operating statistics, it has been shown that the unit operated normally during the time period in question and no exceptional releases occurred. A separate stand-by radiation monitor for accident situations was in operation the whole time.

A definite reason for the incorrect filter position has not been found. The old release measurement system has been completely removed already, making reconstruction of the event causes impossible. After equipment upgrading, recurrence of the event is impossible. Owing to the event, the Loviisa utility has paid attention in training to the procedure of reporting exceptional observations.

The event was classified INES Level 0.

Olkiluoto nuclear power plant

Deterioration of the containment isolation function due to the failure to operate of a steam line isolation valve at Olkiluoto 1

Periodic tests of the main steam line isolation valves were carried out at Olkiluoto 1 on 8 February 2003 during which the outer isolation valve of one main steam line failed to operate. These main steam lines penetrating the containment are equipped with isolation valves both within and outside the containment. The quick closure of the valves, if a steam pipe breaks, is an important safety function because it prevents level swelling of the reactor due to a pressure decrease caused by a pipe rupture and the subsequent rising of water to the steam lines and the possible damaging of steam piping. Periodic tests are conducted every two months and they measure i.a. valve closure times, which may not exceed 1.6 s. The valve in question totally failed to close in the test.

The valve's stem sealing was loosened after the test and lubrication was applied on the stem until the valve's closure time was acceptable. A total of six close-signals were sent to the valve. It did not close on the first two signals and after the next four signals it was made to close by lubricating the stem and loosening the stem sealing. The valve was considered operational based on the first below-the-approval-limit closure time and no additional tests were performed to ascertain approval. The valve closed in 1.41 secs in the approved test, i.e. closure time was very close to required value. Normal isolation valve closure time is below one second in tests.

The valve that failed to close was previously tested on 22 December 2002, with an acceptable closure time. Its stem sealing had been tightened on 27 December 2002 because it was leaking. The valve had not been tested, and it may have been inoperable, since then. The containment isolation function was thus less effective for ca. six weeks. During this time the containment isolation function for the steam line in question relied on the containment inner isolation valve.

The valve's internal parts were replaced in the 2003 annual maintenance. Nothing out of the ordinary was detected on examining the removed internal parts and after inspection the valve's failure to close was attributed to a stem sealing that was probably too tight. In addition, the valves' maintenance instructions and the procedure for assessing the acceptability of the results of periodic tests have been made more specific.

The event was classified INES Level 1.

Inoperability of emergency coolant pumps at Olkiluoto 2 during annual maintenance

During the annual maintenance outage of Olkiluoto 2, the emergency cooling pumps were not in automatic start-up readiness for ca. 14 hours, in non-compliance with the Technical Specifications.

This occurred during the maintenance of control rod actuators during which, according to the Technical Specifications, at least one auxiliary feed water system pump and at least two reactor core spray system pumps must be operational. Maintenance operations started on 12 May 2003 at about 21 hrs. All four parallel pumps in each subsystem were separated about 30 mins earlier. The error went unnoticed during the night and morning shift changes. STUK's inspectors noticed the situation during inspection in the morning of 13 May. All the four redundant pumps were immediately restored to service.

During the maintenance of a control rod actuator, a leak could occur in the bottom of the reactor pressure vessel, which would, within 60 mins, cause a 14 cm decrease in the reactor pool water level. In the situation prevalent at the time, the systems supplying emergency water would not have actuated automatically. As there is an abundance of water above the reactor core, there would have been a long period of time available for leak detection and restoration of the availability of the pumps before the situation would have become critical to safety. Any leaks would have been easily detected both from the signals received in the main control room and when working in the space beneath the reactor pressure vessel.

The event was preceded by a situation in which the pumps are to be separated in accordance with the plant unit procedures. The plant unit had been shut down for annual maintenance, the reactor water level had been raised up to the reactor pressure vessel flange and the bolts of the reactor pressure vessel head were being unfastened. The pumps are separated from switchplants to prevent their automatic starting and manual starting from the control room. This prevents their inadvertent starting when work is done on the reactor pressure vessel flange. Should the pumps inadvertently start, reactor cooling water would end up on those detaching the reactor pressure vessel head.

The pumps were separated in the morning of 12 of May. The raising of the level of the reactor pool, which connects to the reactor pressure vessel, was started on the same day, entailing, according to the plant procedures, restoration to operability of three reactor core spray system pumps and of one auxiliary feed water system pump. Once the reactor pool level had reached overflow channel level the pumps were separated again, which was against the plant procedures. The shift manager concluded that the systems are not needed since the reactor pool is full of water. In case the pumps started accidentally, the reactor water level would start to rise and could possibly rise high enough for the water to enter the reactor hall floor. One such near miss -situation had occured once in the operating history of the Olkiluoto plant units. A reactor core spray system pump started and raised the water level close to floor level.

The event was attributed to a deviation from the procedures: the pumps were separated when the reactor pool was full of water. The deviation's acceptability and appropriateness was not looked into either and it was not reported to the next shift during shift change. The plant's other monitoring methods failed to indicate the event as well.

The utility will review its procedures and the Technical Specifications to prevent recurrence. The event has been addressed in training given to the operating personnel.

The event was classified INES Level 1.

Flow indication in a welded joint of a feed water nozzle of the Olkiluoto 2 reactor pressure vessel

An indication, 12 mm in length and 9 mm in depth, along the pipe center line was detected in one of four feed water nozzles of the Olkiluoto 2 reactor presssure vessel in a periodic inspection during annual maintenance. The flaw is located in a welded joint between the reactor pressure vessel nozzle and its safe-end. The feed water pipe is welded to one end of the safe-end. New NDT techniques were used in the inspection that was carried out on the pipe inner surface. The examination, by both ultrasound and eddy current methods, was conducted by an independent company specialising in inspection with NDT testing methods commissioned by the utility.

Corresponding Inconel 182 weld metal cracks have been observed quite often also at foreign nuclear power plants. The likely cracking mechanism is Interdendritic Stress Corrosion Cracking (IDSCC). Needle-like dendrites are formed when molten metal reaches solid state in cooling. Crack formation may be connected with a partial hot crack that occurred during welding. A weld joint's stress level is high due to residual stresses formed during manufacturing. Owing to operating experience from foreign plants, reactor presssure vessel nozzle joints containing the filler material in question are inspected every 3–5 years, whereas normal weld joint inspection interval in the international standard applied here is 10 years.

Wall thickness in the area in question is 34 mm, i.e. over two times design norm minimum thickness. Even if the crack penetrated the wall, it would not lead to total pipe rupture but would be revealed while still a very small leak, i.a. the Leak Before Break (LBB) principle would apply. The crack growth rate has been assessed as low based on measurements made on test specimens and on practical experience. There are less residual stresses deeper into the joint and thus the crack growth driving force is smaller. Crack longitudinal growth is restricted by crack collision with material that better withstands stress corrosion cracking. On reviewing the measurement data on an ultrasonic examination from the external surface of the nozzle area in the year 2000, using an improved interpretive programme, a weak indication of almost equal size was detected. This shows that the flaw has not noticeably grown in three years.

The utility commissioned inspection of corresponding welds in the feed water nozzles of the Olkiluoto 1 reactor pressure vessel in the annual maintenance outage, athough they were not included in the 2003 inspection scope. No flaw indications were detected.

The flaw is due for repair in the 2005 refuelling outage, using a filler material that better withstands stress corrosion cracking. In spite of this, the indication will be inspected even in 2004 and will be repaired then in case of substantial crack growth. In addition, the sufficiency of the frequency of reactor pressure vessel nozzle inspection and the apprpopprateness of examination methods will be re-evaluated. The utility will also investigate the options of preventively repairing Inconel 182 weld joints by cladding using improved filler material.

A strainer clogged up at Olkiluoto 1 during annual maintenance

At Olkiluoto 1 on 1 June, 2003 a reduced flow was detected in one sub-system pump of the shutdown reactor sea water system. The pump's suction inlet was checked and found clean. A strainer in the same line was checked as well. A wealth of mussels and other impurities was found. In addition, a flow control flap essential for strainer flushing was in a wrong position. The strainer thus did not function properly. The flaps of three other subsystems and corresponding flaps at Olkiluoto 2 were checked without delay and found operational.

The strainer may have become clogged when sea water channels were commissioned during annual maintenance. Impurities may have dislodged then, some ending up in the strainer in question.

All four lines of the shutdown reactor sea water systems of both plant units were equipped with strainers in 1992. They prevent the heat exchangers that cool back-up diesel generators from getting clogged up by mussels and other impurities, which may dislodge from the sea water channels. The diesel generators feed power to components important to safety in a loss-of-grid situation. The actuator of the flap of the strainer in question was replaced in 2002.

The event's causes were multiple. Clogging was attributed to the actuator of the flow-controlling flap having been installed 90 degrees incorrectly. The incorrect actuator position was not disclosed in a post-maintenance functional test, which is conducted to assure component functionality and to disclose any mistakes and defects. The clogging of the strainer was not revealed in a pressure difference measurement either.

The position of the control flap's actuator was corrected. Three other strainers in Olkiluoto 1 and all four Olkiluoto 2 strainers were inspected and their correct installation ascertained. The utility will also review working instructions such that verification and recording markings for ascertaining strainer flap position will be recorded. General instructions will be drawn up for the maintenance of actuator-equipped flap valves. The utility will check the pump's flow graphs to assure its post-maintenance operability.

Corresponding events relating to the installation of valve actuators have occurred at the Olkiluoto plant. After the events, the procedures were reviewed and training was given to mechanics.

Three out of the system's four sub-systems were fully operational and thus the plant unit was in a design-basis state; its safety would not have been endangered in an accident. The event was classified INES Level 0.

The rate-of-change limit for reactor water temperature given in the Technical Specifications was exceeded at Olkiluoto 1

On 4 July 2003 during the start-up of Olkiluoto 1 from the 2003 annual maintenance outage, a reactor scram from low reactor water level occurred during reactor cool-down to cold shutdown to repair a water leak in the cable penetration of one main circulation pump. The rate of reactor temperature decrease momentarily exceeded the rate-of-change limit in the Technical Specifications.

The reactor was cooled by using a control valve of the pressure reduction system. The valve opened fully during cooling, after which the reactor pressure and level quickly decreased. The reactor water temperature decreased ca. 30 °C in ten minutes, whereas the Technical Specifications allow for a reduction of 15 °C in ten minutes. The reactor feed water pump in operation was on manual drive and was not capable of compensating for the coolant flowing from the reactor through the control valve; the reactor level thus dropped low enough to actuate a scram. All four pumps of the auxiliary feed water system started and restored normal reactor water level.

Since the reactor control rods were inside the reactor at the time of the event, no actual scram occurred but only scram safety systems started. They operated according to design. The maximum limit on the reduction in reactor water temperature protects the reactor pressure vessel from premature fatigue. Component fatigue analyses have postulated a couple of temperature changes quicker than this during the plant service life. The temperature change-of-rate limit was exceeded only briefly and primary circuit integrity was not endangered.

The event was caused by an error that was made in operating the control valve of the pressure reduction system. The operator had not updated the pressure set value for valve control prior to adjusting the reactor pressure. It was 5 bar, which is used for outages, and the valve opened too much. In addition, shortcomings were found in the operating instructions for the control valve, and the operator failed to adequately follow reactor pressure and level behaviour during cooling.

To prevent recurrence, the utility has reviewed the operating instructions for the pressure control system and given the operators plant stimulator training on the matter.

The event was classified INES Level 1.

Inoperability of a fire damper in the staircase of the Olkiluoto 2 reactor building

It was found out at Olkiluoto 2 on 25 August 2003 that a fire damper of the reactor building air-conditioning system was not operational in the way required in the Technical Specifications.

On Thursday 21 August 2003, a test in accordance with a preventive maintenance programme had been started at the plant unit to measure pressure differences in the staircases of the reactor building. In the test a blower with an intake direct from outside blows an overpressure into the stairway. The required overpressure was not reached in the first test. The matter was looked into and it looked like that the fire damper in front of the blower did not open. However, a failure notification was drawn up for the blower for which there are not requirements is the Technical Specifications. Instead, the Technical Specifications require the fire damper to be operational or fixed closed. It was now closed but not fixed closed although it was obviously inoperational.

The blower overpressurises the stairway in the event of a fire, using fresh air taken directly from the outside and facilitating exit in case the stairway is filled with combustion gases. The fire damper must open in case of fire. In an accident involving a release of radioactive substances within the reactor building, an underpressure must be established to prevent radioactive releases into the environment. The fire damper must then be in the closed position and leaktight to prevent outdoor air from entering the reactor building through it, which would prevent underpressurisation. In such a situation the off gas system handles reactor building air conditioning and filtering.

The failure notification was entered in the plant unit work order system and it was not noticed that the Technical Specifications set requirements for the failed damper. The situation prevailed over the weekend. On Monday the failure of the test was attributed to the coil of the motor of the fire damper's actuator, which was replaced. That the fire damper's failure was connected to the requirements of the Technical Specifications was disclosed when STUK's resident inspector paid attention to the matter.

During the time of inoperability of the fire damper, spent nuclear fuel was transferred from the plant unit to the spent fuel storage, using a transport container specifically designed for this purpose. The Technical Specifications require that all fuel handling onsite must be stopped if components important to the operation of the off-gas system are inoperational.

An analysis of the event disclosed that the preventive maintenance task in question, which relates to the measurement of pressure differences in the stairway room, had been inactive in the data systems of both Olkiluoto plant units for about a year. From this followed that the 2002 maintenance had not been carried out. The data base had been modified after which activation had not been carried out. The functioning of the blower and the fire damper had been checked on 23 July 2003 and they were found to function normally.

In 2003 the utility had planned and implemented several measures to prevent corresponding occurrences. The improvements focused, among others, on reviewing the plant data system and on making more effective the monitoring of inactivated preventive maintenance tasks. In addition, all tests and inspections defined in the Technical Specifications will be reviewed to ascertain that they are active tasks in the pre-maintenance and periodic testing system.

The event was classified INES Level 1.

Inoperability of a fire pump at Olkiluoto nuclear power plant

One fire pump at Olkiluoto nuclear power plant was inoperational for 42 days due to a maintenance error. A valve on the pump's pressure side was left closed after preventive maintenance. This was not noticed in functional tests and inspections of fire water valve positions. Two other fire water system pumps were available and the extinguisher system would have operated, if necessary.

The event occurred during the pump's preventive maintenance during plant operation on 20 to 29 August 2003. The pump and its motor had been isolated for safety for the duration of maintenance operations. The maintenance staff found the separation insufficient, however, and closed two valves outside the safety isolation instructions. The valve closures were not addressed and recorded in accordance with relevant utility instructions. When safety isolations were restored after the work, one valve was left unopened. It would have prevented pumping of water by the pump to the fire extinguisher system piping. After the maintenance operations, the pump was subjected to a functional test, which did not reveal the incorrect valve position.

A fire water system visual inspection is conducted weekly in which the status of the valves should have been checked and the error detected. However, it was only detected on fifth check up on 1 October 2003, after which the correct position was restored without delay.

In connection with the event, shortcomings were detected also in how the periodic inspection follow-up system was used. Tests had been acknowledged as done, even if that was not the case.

To prevent recurrence, the utility will make instructions more detailed and review how procedures, data systems and the Technical Specifications correlate with one another. In addition, the personnel will be given training on procedures and requirements pertaining to safety engineering components.

There was no imminent danger for plant safety from the event. The fire extinguisher system has three pumps one of which is capable of providing sufficient extinguishing water for the facility. One pump is electrically operated and two are diesel operated. The event compromised the reliability of the fire extinguisher system, however, and indicated significant shortcomings in the organisation's operation. It was classified INES Level 1.

The floor drainage level measurement function at the Olkiluoto spent fuel storage was not inspected

For several years, four floor drainage level transmitters in the spent fuel storage of the Olkiluoto facility had not been inspected. They are in rooms not easily accessed that are assumed to have a high radiation level. The Technical Specifications require that they are functionally tested once a year. Several rooms have been fitted with them to assure detection of any water leaks from the fuel pool cooling system. No problems relating to their testing have been brought to the attention of the organisation. The inspections were reported as having been completed, however.

Three uninspected level transmitters are in rooms accessed through a concrete hatch lifted open by crane. Due to their high radiation level, the rooms are subject to restrictions as regards time spent working there. The fourth level transmitter is in a room not easily accessed either. In addition, the yearly measurements of the rooms' radiation level had not been done. These facts have, for their part, contributed to the assumption, prevalent among inspectors, that the rooms are not to be accessed. Inspection of the transmitters has been acknowledged as done in the data system, along with inspections of other corresponding level transmitters. This is why the situation was only detected in October 2003 when the problems were openly reported to the line organisation.

To prevent recurrence, Teollisuuden Voima Oy will ascertain that procedures, data systems and the Technical Specifications correspond to one another. In addition, new instructions on the inspection of level transmitters in the spent fuel storage will be drawn up. Procedures for making room radiation measurements will be reviewed and the personnel will be given additional training on work methods as well as on requirements pertaining to components covered in the Technical Specifications.

The event had no immediate impact on the safety of spent fuel storage. However, it indicated shortcomings in the organisation's operation and in adherence to guidelines. It was classified INES Level 1.

High vibration levels on emergency coolant pumps at Olkiluoto 1

Periodic condition monitoring measurements in the autumn of 2003 revealed high vibration levels on the reactor core spray system pump units at Olkiluoto 1. These were compared with corresponding Olkiluoto 2 values, which were found to be lower.

Operating together with other systems, the reactor core spray system protects the reactor core against overheating during emergency cooling. The system's pumps provide the spray water needed. The core spray system is a stand-by safety system for long-time core cooling. One of the system's four pump units has been evaluated as having been fully available for long-term pumping. Three pump units could have failed in long-term pumping. In the early stages of an accident, two pumps have to be available, and for long-term cooling, one pump suffices. The plant unit's safety would not have been in immediate danger in an accident, even if the cooling function was significantly reduced.

Elevated vibration levels had been measured on the pump units of the Olkiluoto 1 reactor core spray system for several years already. The motor of one pump unit was replaced in 2002 but it soon reached the elevated, prior–to–replacement vibration level. It was only after the 2003 vibration measurements that Teollisuuden Voima Oy started to look into the causes of the elevated vibration levels. The matter was looked into by subjecting one pump to extensive testing and vibration measurements in early October 2003. During the tests, even the structure of the pump unit's mounting base was investigated and the steel plate under the motor was found not to be firmly attached to the concrete. In addition, unfilled cavities were found beneath the plate. The motor base's behaviour was thus flexible. A flexible base can be ascertained to cause vibration levels higher than a stiff base. A component on a flexible base is allowed higher vibration levels than one mounted on a completely stiff base.

The defective bases of pump units at Olkiluoto 1 were repaired in early November 2003 by filling out cavities beneath the steel plates with concrete. In verifying measurements, essentially lower vibration levels have been found. The utility has also taken measures to inspect fastenings and concrete castings of the bases of other systems and pump units at Olkiluoto 2.

The event was classified INES Level 1.

APPENDIX 4 Periodic inspection programme

Kaisa Åstrand

Basic programme		Inspections in 2003 Loviisa NPP	Olkiluoto NPP
A	**Safety management**	X	
B	**Main functions**		
B1	Assessment and improvement of safety	X	X
B2	Operation	X	X
B3	Plant maintenance and ageing management		
C	**Inspections by functional unit and field of competence**		
C1	Plant safety functions	X	X
C2	Electrical and I&C systems	X	
C3	Mechanical engineering	X	X
C4	Structures and buildings	X	X
C5	PSA and safety management	X	X
C6	Document and information management	X	
C7	Chemistry	X	X
C8	Nuclear waste	X	X
C9	Radiation protection	X	X
C10	Fire protection	X	X
C11	Emergency preparedness	X	X
C12	Physical protection	X	X
C13	Training / Human resources and training	X	X
C14	Quality assurance		X
C15	System line-up procedures	X	X

APPENDIX 5 Licences and approvals in accordance with the Nuclear Energy Act

Marko Hämäläinen

C214/241, 7 Febr. 2003, Teollisuuden Voima Oy
Licence to export irradiated fuel samples (two from a water channel and three from the corner of a fuel assembly spacer grid, with a combined activity of 380 GBq) from Olkiluoto nuclear power plant Unit 1 to Sweden for hot cell analysis.
Valid until 30 April 2003.

C214/244, 20 March 2003, Teollisuuden Voima Oy
Import of control rods (6 pcs) from Sweden. Valid until 31 December 2003.

C214/245, 15 April 2003, Teollisuuden Voima Oy
Import of control rods (8 pcs) from Sweden. Valid until 31 December 2003.

C214/246, 21 May 2003, Teollisuuden Voima Oy
Licence to import from Japan “Licenced Software” – FINELOAD-3, including potential later updates. Valid until 31 December 2018.

A214/40, 23 May 2003,
Fortum Power and Heat Oy (Generation)
Licence to export to Studsvik, Sweden, three irradiated nuclear fuel rods (max. 40 g of plutonium and 3000 g of enriched uranium, max. 30 g of ^{235}U) for fuel tests.

Y214/72, 12 December 2003,
Geological Survey of Finland (GTK)
Retain, use, handle and store nuclear material for analysis at the GTK (a total of max. 1.5 g of enriched uranium, in which the share of ^{235}U is 0.8 g max.).

C214/250, 22 Dec. 2003, Teollisuuden Voima Oy
Import of fresh nuclear fuel from Sweden. A total of max. 17 000 kg of enriched uranium. Provided with the Euratom control stamp “P”. Valid until 31 December 2004.

C214/251, 22.12.2003, Teollisuuden Voima Oy
Import of fresh nuclear fuel from the Federal Republic of Germany. Max. 8 700 kg of enriched uranium. The obligations of an exchange of notes pertaining to the peaceful uses of nuclear materials between the authorities of Finland and the People’s Republic of China apply to the uranium in 18 assemblies. Provided with the Euratom control stamp “N”. Valid until 31 December 2004.

C214/252, 22.12.2003, Teollisuuden Voima Oy
Import of fresh nuclear fuel from the Federal Republic of Germany. Max. 11 500 kg of enriched uranium. Obligations of the Finnish–Russian co-operation agreement on the peaceful uses of nuclear energy apply to the uranium used in the manufacture of above fuel (55 assemblies). Valid until 31 December 2004.

C214/253, 22 Dec. 2003, Teollisuuden Voima Oy
Licence to retain, store and use for training and demonstration, specimen (a total of four specimen manufactured of depleted uranium, with max. 10.3 kg of uranium) of depleted uranium. Valid until 31 December 2013.

C214/254, 22 Dec. 2003, Teollisuuden Voima Oy
Import of fresh nuclear fuel from Spain. A total of max. 1 500 kg of enriched uranium. Provided with the Euratom control stamp “P” or “N”. Valid until 31 December 2004.

APPENDIX 6 STUK's safety research projects completed in 2003

Esko Eloranta, Harri Heimbürger

Nuclear power plants

Research projects included in FINNUS

FINNUS/AGE; Fuel cladding corrosion mechanism and its modelling, a continuation project; VTT Manufacturing Technology

FINNUS/AGE; Environmentally assisted cracking of NPP materials, a continuation project; VTT Manufacturing Technology

FINNUS/AGE; Modelling of the behaviour of oxide films with regard to their role in activity build-up and different corrosion phenomena in NPPs, a continuation project;
VTT Manufacturing Technology

FINNUS/FISRE; Fire safety research, 2001; VTT Building Technology

FINNUS/FISRE; Fire safety research, 2002; VTT Building Technology

FINNUS/FISRE; Effect of smoke and heat on electronics, modelling of fire scenarios for PSA, active fire protection equipment;
VTT Building Technology

FINNUS/FISRE; Active fire protection equipment; VTT Building Technology

FINNUS/INSMO; Usage of modelling in ultrasonic testing; VTT Manufacturing Technology

FINNUS/INSMO; Risk-informed periodic inspections; VTT Manufacturing Technology

FINNUS/METRI; Risk informed leakage frequency assessment; VTT Manufacturing Technology

FINNUS/METRI; Development of human error assessment method for low power and plant shutdown risk analysis; VTT Industrial Systems

FINNUS/PASSI; Ageing related failure modes of modern I&C equipment; VTT Automation

FINNUS/PASSI; Reliability assessment and FMEA of programmable automation, a continuation project; VTT Automation

FINNUS/READY; The application of new reactor physics models in criticality safety calculations, a continuation project; VTT Processes

FINNUS/READY; FRAPTRAN-code:
Development of FRAPTRAN-GENFLO code, 2002; VTT Processes

FINNUS/READY; FRAPTRAN-code; delivery and validation of FRAPTRAN-GENFLO-code; VTT Processes

FINNUS/READY; FRAPTRAN-code: Application of statistical calculation methods in the FRAPCON 3 and FRAPTRAN-codes; VTT Processes

FINNUS/READY; Application of CDFPLIM-method in dynamic codes; VTT Processes

FINNUS/STIN; Research related to structural integrity of nuclear power plants, 2001;
VTT Industrial Systems

FINNUS/STIN; Modelling of loading to structures and equipment, 2002; VTT Industrial Systems

FINNUS/STIN; Development of integrity analysis for structures and equipment;
VTT Industrial Systems

FINNUS/STIN; Validation of computational methods, 2002; VTT Industrial Systems

FINNUS/STIN; Development of applicable methods for defining fracture mechanism characteristics of radiated steels; VTT Industrial Systems

Research projects included in SAFIR

SAFIR/CULMA; Organizational culture in Finnish NPP maintenance; Development of an assessment method, 2003; VTT Industrial Systems

SAFIR/IDEC; Interaction approach to the development of control rooms; Preliminary development of control room evaluation framework, 2003;
VTT Industrial Systems

Research activities pertaining to regulatory decision-making

Development of NDT qualification; Provision of QA documents; Serco Assurance Inc.

Numerical evaluation of effects to reactor core caused by steam explosions in the reactor pressure vessel lower plenum; VTT Energy

Fire analysis of Loviisa NPP turbine hall, a continuation project; VTT Energy

Studies in concrete technology for the construction, inspection and repairing of NPP structures, a continuation project, 2002; VTT Building Technology

Ruthenium research; the behaviour of ruthenium in severe reactor accidents, 2002; VTT Processes

FINFLO-code; Development of the code for the analysis of two-phase flow; Finflo Inc.

Nuclear waste management

Research activities pertaining to regulatory decision-making

IMGS (Investigations and Modelling of Geological Structures) support group; Dr. John W. Cosgrove, Imperial College

IMGS (Investigations and Modelling of Geological Structures) support group; Sven A. Tirén, Geosigma Ab

IMGS (Investigations and Modelling of Geological Structures) support group; Prof. Jaakko Siivola

IMGS (Investigations and Modelling of Geological Structures) support group; Paavo Vuorela, Geological Survey of Finland

The national expert group for the safeguards of final disposal (LOSKA); the use of geophysical methods in the monitoring of final disposal; University of Helsinki, Institute of Seismology.

The national expert group for the safeguards of final disposal (LOSKA); the use of environmental surveillance and the monitoring of spent fuel capsules; VTT Processes

The national expert group for the safeguards of final disposal (LOSKA); the use of satellite surveillance and aerial photography in the safeguards monitoring of final disposal; VTT Information Technology

Review of the reports by Posiva Oy and the evaluation of the progress of Posiva's R&D concerning geohydrological issues; Prof. Auli Niemi, Uppsala University

Review of Posiva's development work, 2002; Enterpris Ltd

Review of Posiva's baseline studies at Olkiluoto; Prof. David Read, Enterpris Ltd

Modeling flow and transport in heterogeneous fractured media; Dr. Tsang, Lawrence Berkeley National Laboratory

Independent verification of radioactive waste packages; VTT Processes

Research pertaining to the development of regulatory control

The geochemical indicators of the last ice age in the bedrock. University of Helsinki, Laboratory of Radiochemistry.

Evaluation of sensors to monitor the effect of bentonite on the corrosion rate of copper in Olkiluoto-type saline groundwater; Helsinki University of Technology, Department of Materials Science and Rock Engineering.

The geochemical behaviour of filled fracture; Helsinki University of Technology, Department of Materials Science and Rock Engineering.

IAEA coordinated research project (CRP). Natural geochemical concentrations and fluxes on the Baltic shields in Finland as indicators of nuclear waste repository safety; year 2002; Geological Survey of Finland

DECOVALEX III; the reporting of rock mechanical simulations for BMT2 in the year 2003. Helsinki University of Technology, Department of Materials Science and Rock Engineering.

DECOVALEX III; The coupled thermo-hydro-mechanical modelling of bentonite in the year 2003; Helsinki University of Technology, Institute of Mathematics.

DECOVALEX III; BMT2 simulations and final repoting 2003; Uppsala University.

The interaction between radionuclides and the corrosion products of copper in saline and reducing environment (KOSU); Helsinki University of Technology, Department of Materials Science and Rock Engineering.

The release of the results of the Palmottu project. Geological Survey of Finland.

IAEA coordinated research project (CRP). Natural geochemical concentrations and fluxes on the Baltic shields in Finland as indicators of nuclear waste repository safety; year 2003; Geological Survey of Finland