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REGULATORY CONTROL OF NUCLEAR SAFETY IN FINLAND

Annual report 2000

Kirsti Tossavainen (ed.)

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RADIATION AND NUCLEAR SAFETY AUTHORITY

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ABSTRACT

This report concerns the regulatory control of nuclear energy in 2000. 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. STUK's regulatory work focused on the operation of Finnish nuclear facilities as well as on nuclear waste management and nuclear materials.

The Finnish nuclear power plants were operated in compliance with current regulations. No operational events occurred that would have endangered the safe use of nuclear energy. The operation of the FiR 1 research reactor was uneventful as well. The doses of all nuclear power plant workers remained below the individual dose threshold. The collective occupational dose was internationally compared low. Radioactive releases were low as well the dose calculated on their basis for the most exposed individual in the vicinity of Loviisa and Olkiluoto nuclear power plants was well below the limit established by the Council of State Decision. In addition, the occupational radiation doses arising and radioactive releases into the environment from the research reactor were well below the set limits.

The regulatory control of nuclear waste management focused on spent fuel storage as well as on final disposal plans and on the treatment, storage and final disposal of reactor waste. No events occurred in nuclear waste management that would have endangered safety.

Nuclear material safeguards verified the use of nuclear materials in accordance with current regulations and the whereabouts of every batch of nuclear material.

International co-operation continued, with financing from STUK's budget and from external sources. Externally financed co-operation focused on the improvement of safety and radiation protection at Kola and Leningrad nuclear power plants as well as on the development of nuclear material control systems in Ukraine, the Baltic Countries and Russia.

The total costs of the regulatory control of nuclear safety in 2000 were FIM 38.8 million and the income was FIM 31.2 million. The total costs of operations subject to a charge were FIM 31.1 million, the full amount of which was charged to the users of nuclear energy.

CONTENTS

1 INTRODUCTION

According to the Nuclear Energy Act (990/1987), the Radiation and Nuclear Safety Authority (STUK) is vested with the duty to regulate the safe use of nuclear energy in Finland. STUK's duties also include the control of physical protection and of emergency preparedness and the necessary control of the use of nuclear energy to prevent the proliferation of nuclear weapons.

This is a report on supervision in the field of nuclear energy that STUK provides to the Ministry of Trade and Industry once a year, as stipulated in section 121 of the Nuclear Energy Decree. In the sector of the Ministry of Trade and Industry, the general objective in the regulation of the safety of nuclear power plants was that STUK is active in a way that would prevent at Finnish nuclear facilities accidents resulting in environmental contamination. In addition, STUK was to have a role in the drawing up of domestic research programmes and to support the inclusion of Finland's objectives in international research programmes. A further objective in the regulation of the safety of nuclear power plants was that STUK is prepared for the safety regulation of a possible new nuclear power plant project.

The general objective set for STUK in the field of nuclear waste management in the sector of the Ministry of Trade and Industry was that the storage and final disposal of nuclear waste generated in Finland is safe. In addition, STUK was to define what clarifications are necessary for evaluation of the safety of a final disposal facility for spent fuel based on the requirements of the Nuclear Energy Act and the Council of State decisions in principle.

The general objective in nuclear material regulation and export control in the sector of the Ministry of Trade and Industry was for STUK to contribute to the development of nuclear material and export control as part of EU control procedures.

2 REGULATORY GUIDES

By virtue of the Nuclear Energy Act (990/1987) and the Council of State Decision (395/1991) on the general regulations for the safety of nuclear power plants, it is STUK's duty to prepare also detailed safety regulations for nuclear facilities. The YVL guides published by STUK serve this purpose. The guides present safety requirements for nuclear facilities and STUK's regulatory procedures. STUK decides, case by case, how new guides apply to and bind those facilities already in operation. In 2000 STUK issued 16 such decisions (Appendix 3). YVL guides are available on STUK's Web site (at www.stuk.fi).

The YVL guides were further revised and updated. A considerable number of them, i.e. ca. 70%, are under revision or are being assessed for their need of revision. In 2000 three guides were published and several draft guides were prepared. A decision was made to replace Guides YVL 6.11 and YVL 6.21 concerning physical protection with separate STUK decisions in the future. The number of Finnish-language guides published every year is given in Fig. 1. Most of the guides are available in English.

The need to change YVL guides due to renewed pressure equipment regulations was assessed. According to the assessment, all guides pertaining to pressure equipment are to be updated prior to 29 May 2002, the transition period expiry date of the EU's pressure equipment directive.

YVL guides and other regulations essential for nuclear safety control have been accessible, as a separate Windows application Ydintieto, through STUK's network for a few years already. The application's data content was regularly updated. Its conversion to a web-based format has been started for integration in STUK's intranet.

No significant amendments to the Nuclear Energy Act or Decree were passed in 2000. The Nuclear Energy Act was amended on account of changes made to the Model Protocol Additional of the IAEA's Safeguards Agreement. The Nuclear Energy Act, as amended, will take effect by a decree to be given separately. STUK issued a statement to the Ministry of Trade and Industry about the future amendments to the Nuclear Energy Decree.

STUK issued to the IAEA national statements on seven draft safety guides (see Appendix 4).

In the autumn of 2000, a self-assessment was launched, focused on two features of the YVL guides: how much prescriptive guidance they include and what their coverage is. In addition, an independent external study of the same subject was commissioned to the Technical Research Centre of Finland (VTT). The IAEA's higher-level regulations will be used as a reference in the self-assessment. The VTT study is focused on the mapping of the opinions and experiences of licensee representatives, to sketch a picture of how potentially harmful they consider the prescriptive nature of Finnish nuclear regulatory guides.

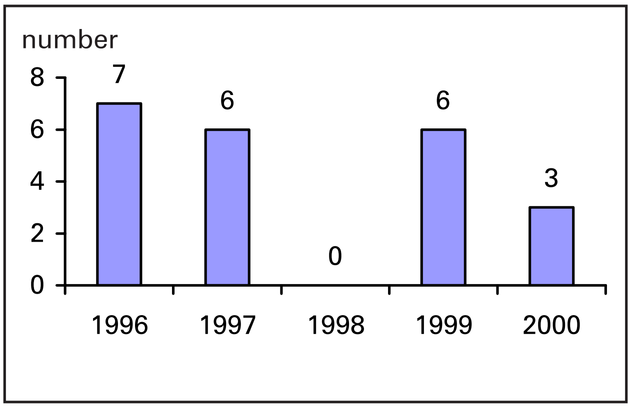

Fig 1. *Number of published YVL guides.*

3 NUCLEAR SAFETY REGULATION

3.1 Resources in nuclear safety regulation

The regulation of nuclear safety was mostly focused on the Loviisa 1 and 2 nuclear power units owned by Fortum Power and Heat Oy and the Olkiluoto 1 and 2 units owned by Teollisuuden Voima Oy as well as on their nuclear waste management and nuclear materials. 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 regulation were also the research reactor operated by the Technical Research Centre of Finland, small-scale users of nuclear materials as well as transportation of radioactive materials. This chapter gives an overall account of the control exercised by STUK, and statistics on the regulatory activities. The above activities subject to regulation are described in more detail in chapters 4, 5 and 6.

The duty area of nuclear safety regulation included those basic operations subject to a charge and those not. The basic operations subject to a charge were comprised of the regulation of nuclear facilities, with their costs charged to the licensees. Those basic operations not subject to a charge included international and domestic co-operation, public communication and emergency response. The basic operations not subject to a charge are publicly funded. The costs and income of basic operations are described in subsection 3.7. The costs of rule-making and those of support functions (administration, development of the nuclear regulatory effort, training, maintenance and development of expertise as well as reporting) were included in the costs of basic operations and of services, in relation to the number of working hours spent on each function. Rule-making is described in chapter one and some support functions in subsections 3.3 and 3.6.

Table I gives the distribution of working hours spent yearly on the various duty areas by staff whose main task is nuclear safety regulation.

The time spent on the regulatory control of the Loviisa nuclear power plant safety was 11.9 man-years, which is 14.9% of the total working time of the personnel. The time spent on Olkiluoto nuclear power plant was 12.3% man-years, i.e. 15.5% of total working time. Nuclear material safeguards are included in these figures. The time spent on nuclear waste regulation was 2.0 man-years, i.e. 2.3% of total working time. Fig 2 gives distribution of working time spent on the main functions.

Table I. *Distribution by duty area of working hours spent on nuclear safety regulation.*

	man-year				
Duty area	**1996**	**1997**	**1998**	**1999**	**2000**
Basic operations subject to a charge	26.0	29.1	24.7	25.3	26.4
Basic operations not subject to a charge	5.1	4.4	4.6	5.5	7.5
Services	6.3	8.2	6.9	7.0	5.4
Rule-making and support functions	27.5	23.8	25.1	24.6	25.5
Holidays and days of absence	13.1	14.7	13.9	14.8	15.0
Total	78.0	80.2	75.2	77.2	79.8

3.2 Operational inspections and review

Operational inspections included periodic inspections and inspections that the licensee was obliged to separately request in connection with measures carried out at the facility, or that were conducted by STUK at its discretion. In addition, STUK assessed the safety of nuclear power plants i.a. on the basis of operating experience, safety analyses as well as reports and plans submitted by the licensees, and by inspections onsite and at component manufacturers' premises.

Inspections included in the periodic inspection programme are given in Appendix 1 and topical inspections in Appendix 2. Inspections in accordance with the periodic inspection programme are, as a rule, repeated every year; the contents of individual inspections, however, may alter year by year. The yearly inspection programme is brought to the knowledge of the licensee at the beginning of every year and the inspection days are agreed upon with the licensee. The inspection programme for the year 2000 included 16 inspections at Loviisa plant and 17 at Olkiluoto plant. The management, procedures, the work of organisational units and the technical acceptability of systems were looked into during these inspections. In connection with them, also walk rounds at the plant were made to verify facts and to control, among others, overall plant cleanliness and order. Two unannounced inspections were conducted as part of the programme. These inspections were carried out at Loviisa nuclear power plant. The focus of the inspections was on the ascertaining of the operability of components during outages, on the marking off of the components as isolated from processes, and radiation protection during outages.

Primary observations of the periodic inspection programme at Loviisa and Olkiluoto facilities were connected with the real-timeness and appropriateness of plant instructions, life time management and the identification of common cause failures. At Loviisa plant the observations were also connected with radiation protection and at Olkiluoto plant with organisation and personnel training. The licensees already have, and they will, carry out actions to remedy the observed deficiencies. None of them would have essentially affected the safety of the plant units.

The annual maintenance outages were overseen by STUK. Controlled were, among others, administration of work performed during the outages, activities of the operating and maintenance personnel, refuelling, inspections and tests conducted by the licensee and subcontractors as well as radiation protection. STUK supervised also the shutdown of the plant units and their startup after the outages.

The number of inspection days onsite and at the component manufacturers' premises totalled 569. In addition to inspections at nuclear power plants, the figure also includes nuclear waste management and safeguards inspections. Addi-

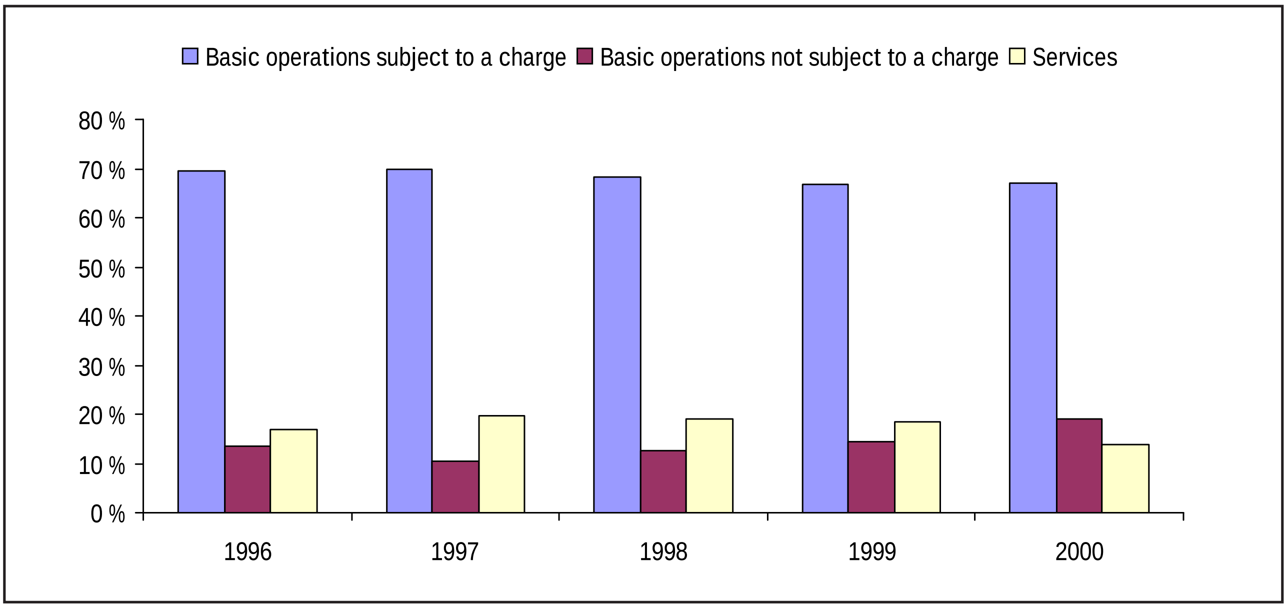

Fig 2. *Working time spent on STUK's main functions.*

tionally, two resident inspectors worked at Olkiluoto nuclear power plant and one at Loviisa plant. The number of inspection days over the past years is given in Fig 3.

The total number of documents submitted to STUK for review in 2000 was 1455. The number of documents submitted in 2000 and earlier, whose review was completed, was 1274. The figure includes the licences granted by STUK in accordance with the Nuclear Energy Act, which are listed in Appendix 3, and the decisions pertaining to nuclear power plant personnel that can be found in Appendix 4. Average document review time was 55 days. The yearly number of documents and their average review times are given in Fig 4. Figs 5 and 6 give the distribution of review

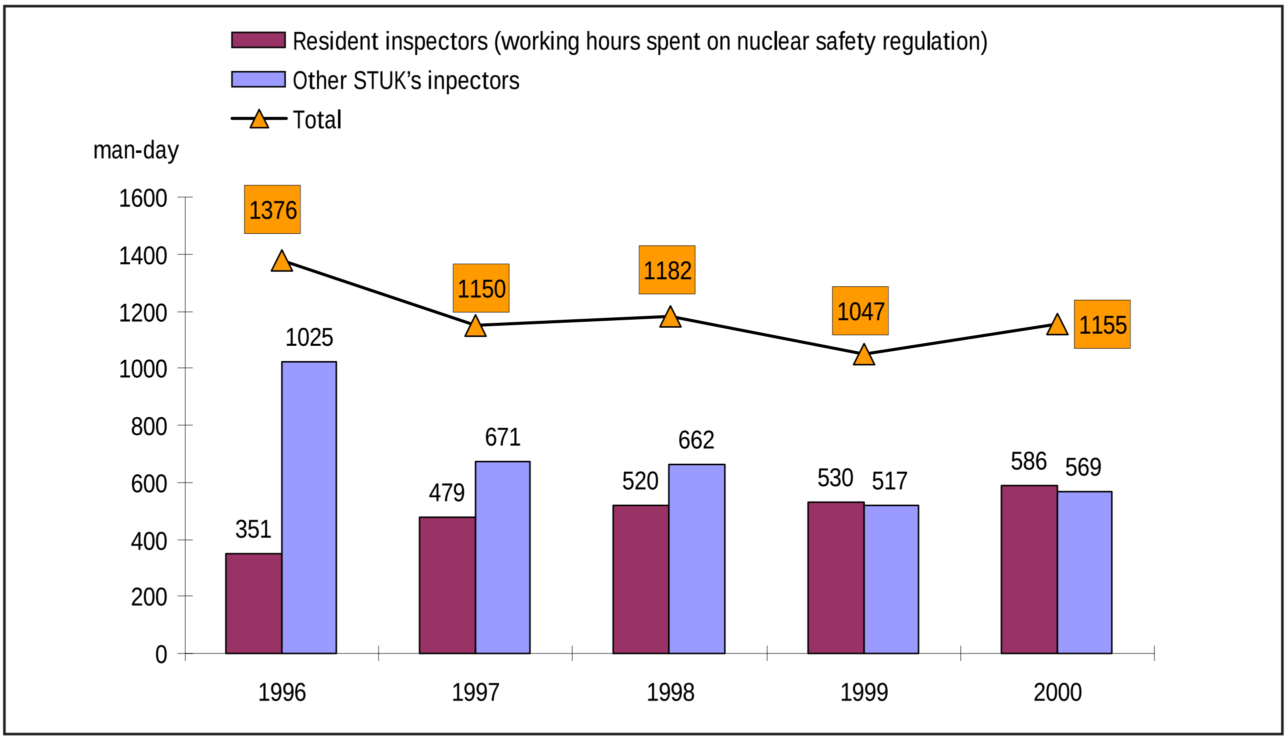

Fig 3. *Number of inspection days onsite and at component manufacturers' premises.*

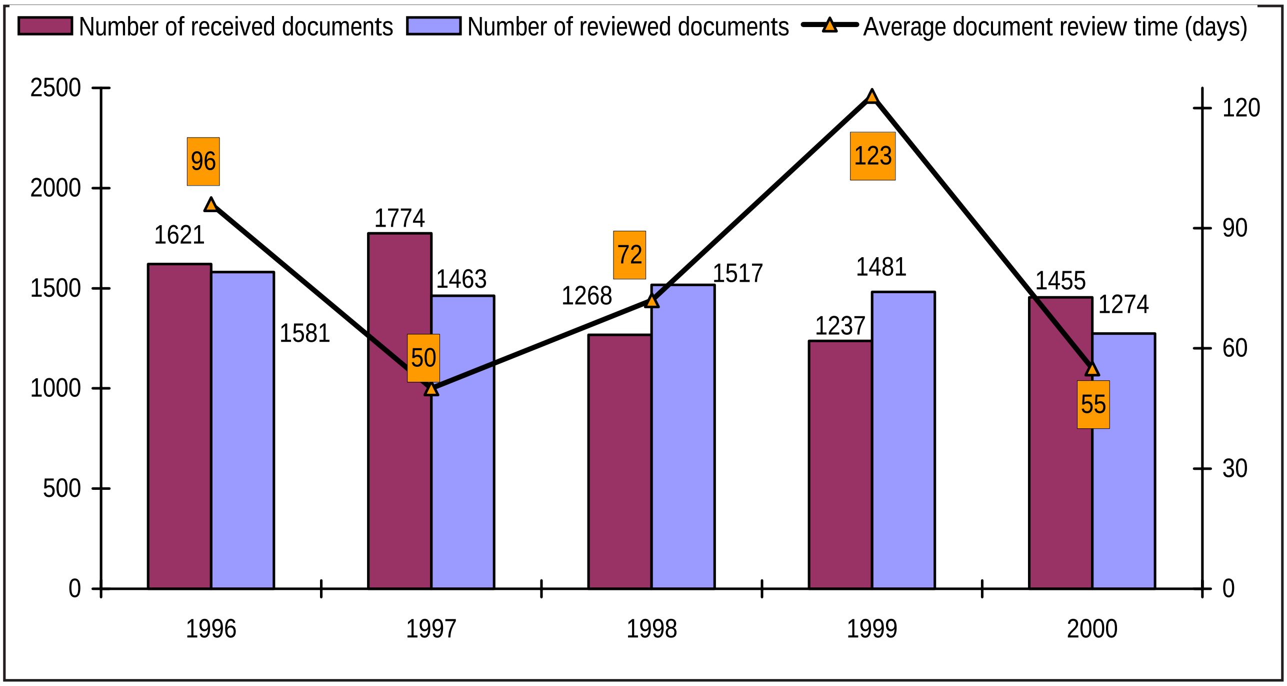

Fig 4. *Number of documents received and reviewed as well as the average document review time.*

times for documents concerning Loviisa and Olkiluoto plant units that were under review for approval. Reports for 25 events at Loviisa nuclear power plant and for six events at Olkiluoto nuclear power plant were submitted to STUK. The number of event reports over the past years is given in Fig 7. The licensees regularly submitted to STUK also the following reports: daily reports, quarterly reports, annual reports, outage reports, annual reports on environmental radiation safety, monthly reports on individual radiation doses, annual reports on operational experience feedback and safeguards reports.

The regulatory control proved that the Finnish nuclear power plants were operated in accordance with valid regulations. Nuclear waste management and the use of nuclear materials were in compliance with valid rules and regulations. On the basis of the inspections and reviews, additional documentation and measures were requested

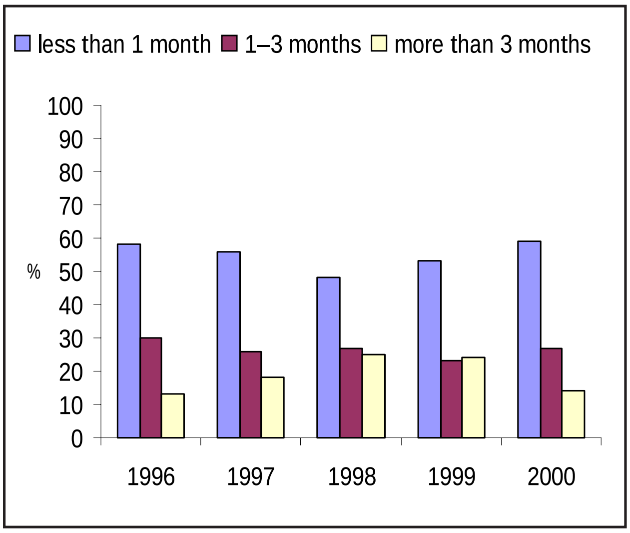

Fig 5. *Distribution of time spent on preparing decisions concerning the Loviisa plant units.*

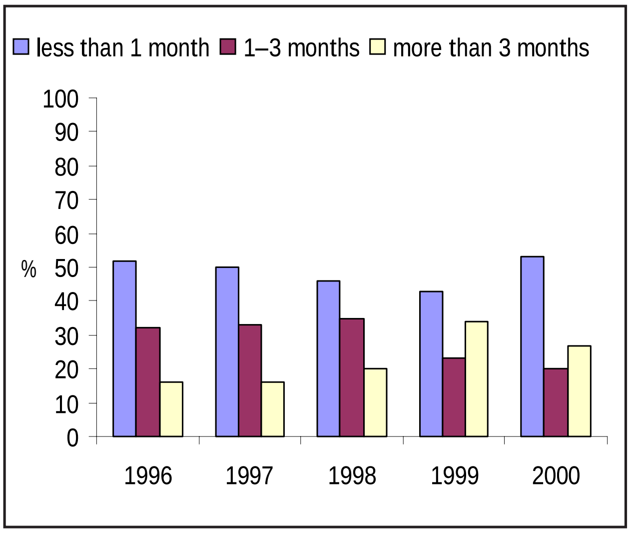

Fig 6. *Distribution of time spent on preparing decisions concerning the Olkiluoto plant units.*

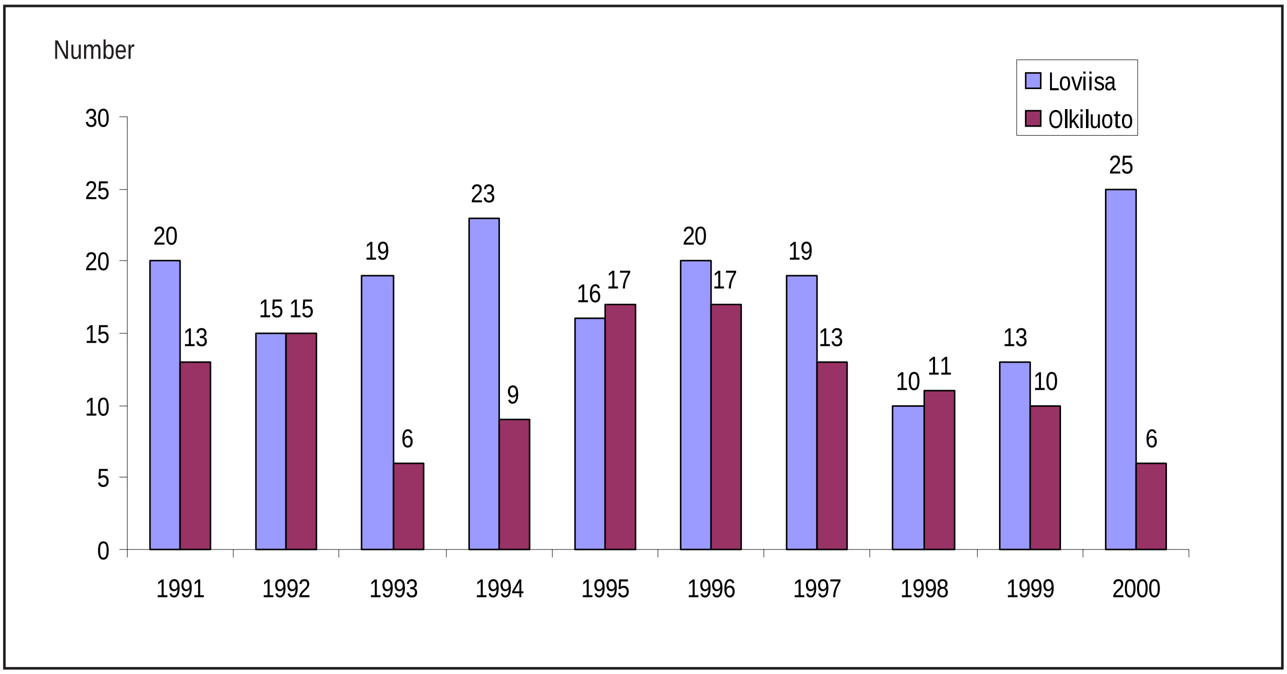

Fig 7. *Number of event reports submitted by Loviisa and Olkiluoto nuclear power plants.*

from the utilities to further enhance the safety of the plants.

3.3 Safety research

By means of research the safe use of nuclear energy is ensured and enhanced. STUK's experts controlled and monitored the ongoing, publicly financed FINNUS 1999–2002, a national nuclear power plant safety research programme, and the JYT 2001, a nuclear waste research programme. STUK ordered the majority of research made into nuclear power plant safety and waste management from external organisations (VTT, Technical Research Centre of Finland and GSF, Geological Survey of Finland).

The research topics of the FINNUS 1999–2002 programme in 2000 were nuclear power plant ageing, reactor accidents and various risks analysed in eleven research projects and numerous subprojects and tasks. A interim report on the FINNUS programme is available at *http://www.vtt.fi/ene/research/finnus/*. The research focus of JYT 2001 research programme in 2000 was the same as in 1999, that is geosciences, engineered barriers, mitigation of radioactive substances, safety analyses and engineered solutions. JYT 2001 also included societal research topics. An interim report of JYT 2001 (in Finnish) is available at *http://www.vtt.fi/ene/tutkimus/jyt2001/jytpvali.pdf*. English summaries are available at *http://www.vtt.fi/ene/tutkimus/jyt2001e*. The JYT 2001 research programme covers the period 1997–2001.

Appendix 5 lists STUK-financed safety research that was completed in 2000. Part of it closely relates to nuclear safety regulation and is kept separate from the FINNUS and JYT programmes. STUK's research programme includes projects dealing with the development and assessment of the procedures of the regulatory control. The annual cost of nuclear safety research is given in Fig 8.

For enhancement the utilisation of the results of the international research co-operation of the nuclear safety research and of other countries with nuclear power plants in operation, STUK has followed and participated in the co-operation in question. Co-operation in its traditional forms has continued through OECD, IAEA and EU working groups and projects. In 2000 STUK participated in safety research seminars arranged by the Swedish nuclear safety authority (SKI) and Det Norske Veritas. As a result, research reports of the OECD's Halden project and by the US safety authority NRC, among others, have become available to STUK. In addition, the use of the Internet to monitor safety research has been significantly intensified.

Publishing activities concerning nuclear safety research were intensified by improving, among others, the research information provided on STUK's Web site.

STUK purchases most safety research projects

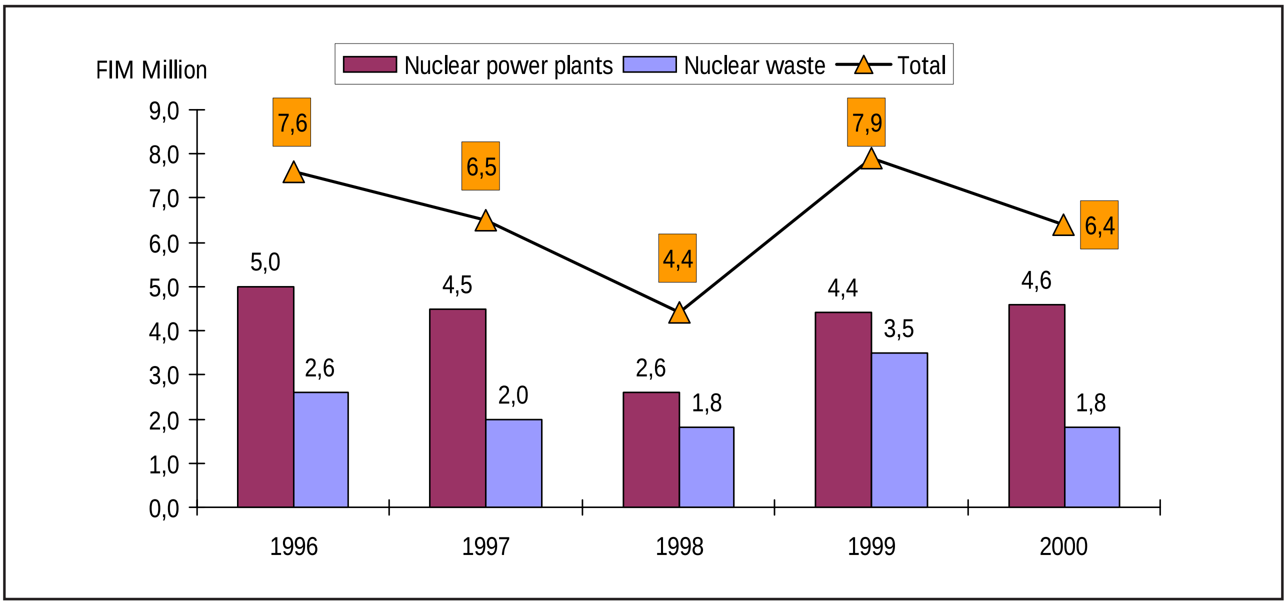

Fig 8. *The costs of nuclear safety research.*

from VTT. In order to assure the quality of research and its independence, STUK commissioned an audit of the quality systems of VTT's various research units to an external consult.

3.4 Emergency response

STUK oversees the preparedness of the operating organisations of nuclear power plants to act in unusual situations and maintains its own emergency preparedness. No such situations occurred in 2000.

Emergency response at nuclear power plants has been continuously developed 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 nuclear power plants and reviews every year the implementation of the emergency preparedness regime, including training and emergency exercises.

STUK arranged several training events and exercises to test and develop its emergency response. Emergency training was also arranged for experts from foreign authorities.

Various types of national emergency exercises were arranged in Finland in 2000 the most extensive of which was the VALHA exercise. Separate exercises began in March. An exercise arranged by the Council of State (VNH-2000) was held on 31 August 2000 and one involving local and district administration (APH-2000) on 5–7 September 2000. Practically all authorities at central administration level participated in the VALHA exercise. District and local government as well as numerous municipalities participated insofar as the events concerned them. In STUK's field of activity, two special situations were rehearsed: a nuclear explosion in the Barents Sea and an accident at Loviisa nuclear power plant. The highest number of STUK participants at one single time was 26. Some worked in protected rooms, some at STUK and some at Loviisa plant. Working under exceptional conditions was tested during the exercise. An objective was also to test management between central, district and local administrations as well as co-operation between authorities under exceptional circumstances. In addition, recommendations pertaining to decontamination and as well as questions relating to agriculture and forestry were discussed.

3.5 Communications

STUK took the initiative in communicating to the general public matters relating to safety, nuclear waste management and safeguards at nuclear power plants and also responded to questions made by the media. STUK issued information of over 20 different topics in the form of press releases and bulletins on the Teletext pages of YLE (the Finnish Broadcasting Company) and on its own Web site. In addition, the various subjects were discussed in the STUK publication ALARA that comes out four times a year. The media were provided with quarterly reports on the use of nuclear energy in Finland and in its neighbouring countries.

On STUK's Web site, under Reader's Link, citizens can make questions to STUK's experts. In 2000, 137 questions were made two of which were about nuclear safety regulation. Asked were how a disposal facility for spent fuel would affect the economy of host municipality and to what extent radiation emanating from high-level reactor waste would reduce with time.

Of the events at Finnish nuclear power plants, a leak of mildly radioactive water on 17 August 2000, which recurred the next day, attracted the most media attention. It was rated INES Level 1 because its recurrence. Information was also disseminated about other matters relating to safety regulation at Finnish plants, including the failure of a sewage collection tank in the medium-level waste storage onsite Olkiluoto plant, the annual maintenance outages of the plant units, and a brief production break for a repair work at Loviisa 2. In addition, a summary information bulletin was issued in early 2000 about most significant events at the Finnish plants. Information on specified requirements for application in the siting of nuclear power plants was also announced.

As regards nuclear waste management, STUK provided information about a preliminary safety analysis report submitted to the Ministry of Trade and Industry concerning Posiva Oy's application for a decision in principle on the final disposal of nuclear waste; STUK also provided information about its contribution to an international project to develop methods for the final disposal of nuclear fuel In addition, the safety assessment and those safety requirements applied to a final disposal facility for nuclear fuel were described to the Economic and Environmental Committees of parliament during their visit to STUK on 7 June 2000. As regards nuclear material safeguards, a summary report was issued on radioactive shipments turned back at Finland's eastern border in 2000.

On 14 August 2000 STUK issued a press release about the possible radiation hazards of the accident in the Barents Sea on 12 August 2000 that involved the nuclear submarine Kursk. According to the press release, even in the worst case, the accident would not cause in Finland a situation requiring protective measures. In connection with the accident, rumours circulated about elevated radiation levels in Finland. On 18 August 2000 a piece of news was broadcast in Greece about high levels of radioactivity having been measured in water in Finland and that they were due to the Kursk accident. The rumour might have been due to information simultaneously made public about a leak of mildly radioactive water at Loviisa 1. The rumour was dispelled on 18 August 2000 by a written announcement to the IAEA, the EU and the Nordic Countries as well as by a telephone call to the Greek radiation authority.

In connection with projects to improve nuclear safety in countries in Eastern Europe, information was disseminated, among others, about new radiation detection equipment that had been installed at Tallinn Airport and also about training that had been given to border control officers.

Information was published about issues relating to international co-operation, i.a. meetings hosted by STUK, an assessment of STUK drawn up by an IAEA group of experts (IRRT), and nuclear safety in EU applicant countries. The results of the IAEA assessment as well as the report about nuclear safety in the EU applicant countries were available in full on STUK's Web site.

3.6 Development projects

Organisational culture

Co-operation and the flow of information have been developed and working processes and roles have been clarified in order to strengthen the organisational culture of the Nuclear Reactor Regulation and to enhance work motivation. A survey was conducted in 1999–2000 to determine the situation and to list the development needs; it included, among others, interviews and a questionnaire. The results were processed in a seminar that discussed matters relating to the department's organisational culture. Five working groups were formed to find out how people perceive their work, in what way the results are assessed and feedback given, and how expertise is developed; also regulations, flexibility and values were analysed. The department's operations will be developed on the basis of the research results.

Data management

The Nuclear Reactor Regulation has launched a long-term development project to clarify data management relating to activities and processes associated with nuclear regulatory control. All data is currently contained in paper-based, localised archives and in the form of digital data in various databases, workstation hard disks and STUK's server, which makes its retrieval for use in decision-making or in the planning of inspections comparatively hard. Where data analysis or the monitoring of matters under review are concerned, the current data management facilities fall behind modern standards. A great part of the data remains undocumented, i.e. is in the form of employee proficiency and know-how.

In 2000, data management was examined and existing data archives were listed. During the project, the modelling of working practices identified in nuclear regulatory control was started. Also examined were the available software as well as communication through electronic means between STUK and the licensees.

The storage and electronic retrieval of research reports on nuclear waste management were developed to improve the traceability of reports, among others.

Development of safety control by means of PSA

Risk-informed regulatory control assures that onsite inspections and tests focus on objects essential to avoiding risks and that the prerequisites for safe plant operation are in place. STUK has extended risk-informed control by introducing new applications, i.e. risk-informed inservice inspection of piping (RI-ISI), inservice testing of components (IST), the Technical Specifications (TTKE), and plant event risk follow-up.

A risk-informed in-service inspection programme for piping

STUK has developed a risk-informed method for drawing up an in-service inspection programme for nuclear power plant piping. The objective is to better focus inspections on objects having a bearing on risk and to improve the periodic timing of the inspections. The licensees contributed by providing the necessary information about systems and materials, among others.

The piping inspections necessary in the shutdown cooling system and in the sea water circuit of the Olkiluoto plant units and in the high pressure emergency cooling system and the backup emergency coolant system of Loviisa plant have been analysed and the results are available. Expert panels combined risk-informed and deterministic data and specified the inspection priorities of various piping segments. The panel identified some piping segments whose inspection programme should be reassessed. The focusing of inspections under the current inspection programme was considered successful for the most part.

Risk-informed assessment of the testing of safety systems and components and of the Technical Specifications

STUK's method analysis evaluated three regulatory guides of the US regulatory authority USNRC, pertaining to risk-informed Technical Specifications, plant modifications and testing. In addition, STUK collected examples of relevant risk-informed decisions made by itself or by Finnish power plants. Risk-informed methods showed that the requirements contained in the Technical Specifications are not entirely mutually comparable. The allowable repair time of some systems specified in the Technical Specifications can lead to a ten-fold risk compared to certain other significant safety systems.

Risk-informed subsequent appraisal of plant events

STUK developed a risk-informed plant event analysis method. The PSA based method is used to assess the safety significance of incidents causing component unavailability without a realised initiating event. The results are utilised for example in regulatory work and in the assessment of onsite inspection focus. During 2000 this method has been made more specific, further clarifying assumptions and boundary conditions relating to computation. Along with this analysis, applications have been drawn up containing an analysis of the 1995–2000 plant events.

Nuclear material monitoring devices

As part of an IAEA support programme, STUK has contributed to the development of new, effective methods of nuclear material verification. By tomography, even one single rod missing in a fuel assembly can be detected. The previous measurement campaign was in Olkiluoto in December 1999. The next one will be at Ringhals nuclear power plant in 2001.

In addition, STUK has developed new data transfer methods for use by the IAEA in remote monitoring. Monitoring data collected by the IAEA can, in principle, be inexpensively transmitted via the Internet but uncrypted data transmission is problematic as regards data confidentiality and authenticity. VPN (virtual private network), new data security technology, offers a solution to this problem. VPN was submitted to a 6-month field test, utilising a connection from a STUK roof laboratory to the IAEA headquarters.

3.7 Finances

STUK has introduced a system of net budgeting as of the beginning of 2000, whereupon the costs of regulatory control of nuclear facilities subject to a charge are directly entered as income to STUK.

In 2000, the costs of nuclear regulatory control subject to a charge were FIM 31.1 million. The total costs of nuclear regulatory control were FIM 38.8 million. The share of activities subject to a charge was 80%.

The 2000 income from regulatory control was of nuclear facilities was FIM 31.2 million. Of this, FIM 12.9 million and FIM 14.7 million came from the regulatory control of Loviisa and Olkiluoto nuclear power plants, respectively. The control of Posiva Oy's operations yielded FIM 3.5 million. The income from other objects of regulation was FIM 0.1 million. Figure 9 gives the annual income and costs of regulatory control of nuclear facilities over the recent years.

3.8 The Advisory Committee On Nuclear Safety

In accordance with section 56 of the Nuclear Energy Act, the preliminary preparation of matters related to the safe use of nuclear energy is vested with the Advisory Committee on Nuclear Safety. The Council of State appoints the Committee that functions in conjunction with STUK. Its term of office is three years. The Committee was reappointed on 16 August 2000 and its term of office will end on 15 August 2003.

The new Committee's Chairman is Professor Pentti Lautala (Tampere University of Technology) and its Vice-Chairman is Head of Research Rauno Rintamaa (Technical Research Centre of Finland). The members of the Committee are Senior Researcher Riitta Kyrki-Rajamäki (Technical Research Centre of Finland), Professor Ulla Lähteenmäki (MIKES), Director Olli Pahkala (Ministry of the Environment), Professor Rainer Salomaa (Helsinki University of Technology) and Branch Manager Paavo Vuorela (Geological Survey of Finland). Professor Jukka Laaksonen, Director General of STUK, is a permanent expert to the Committee. Invited experts are Dr. Antti Vuorinen and Director Christer Viktorsson of the Swedish Nuclear Power Inspectorate. The Committee convened seven times in 2000; three of the meetings were by the new Committee.

For preparatory work, the Committee has set up 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.

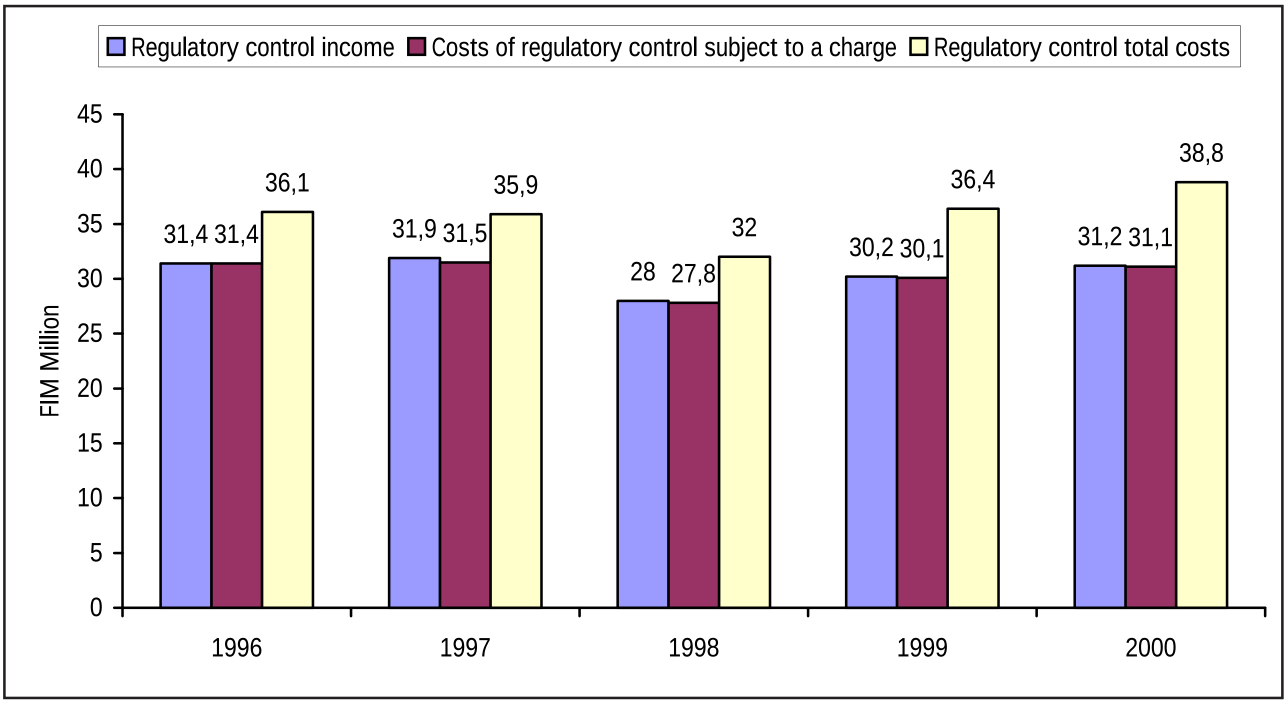

Fig 9. *Nuclear regulatory control income and costs.*

4 REGULATORY CONTROL OF NUCLEAR FACILITIES

4.1 Loviisa nuclear power plant

4.1.1 Operation

Both units of Loviisa nuclear power plant operated reliably. The load factor of Loviisa 1 was 84.8 % and that of Loviisa 2 was 91.0%. The duration of the annual maintenance outages was 44 days at Loviisa 1 and 19 days at Loviisa 2. The course of the outages and the actions taken during them are described in sub-section 4.1.2.

In addition to the annual maintenance outage, there was a brief interruption in electricity generation at Loviisa 2 to repair a leaking valve in the feedwater line of the secondary circuit; there were no other interruptions in electricity generation at Loviisa 1. No scrams occurred at either plant unit. Due to a reduction in electricity demand, power generation was reduced at Loviisa 1 and Loviisa 2. The power reductions took place around Easter and May Day as well as in May–July. Consequent production losses were 0.90% at Loviisa 1 and 1.8% at Loviisa 2. Production losses due to equipment failures were 0.1% at Loviisa 1 and 0.2% at Loviisa 2.

The Loviisa plant units had no computer-related problems on Y2K critical days, i.e. 29 February 2000 and 1 March 2000, or during the crossover from December 31, 2000 to January 1, 2001. No significant problems occurred either during the crossover from December 31, 1999 to January 1, 2000. STUK had required the licensee to prepare for possible computer problems caused by the dates in question and to report any deviations in computer operation.

Figure 10 gives the daily average gross powers of the Loviisa and Olkiluoto plant units in 2000. Load factors and reactor scrams over the past years are given in Figures 11 and 12.

4.1.2 Annual maintenance outages

The Loviisa 1 refuelling and maintenance outage was from 22 July until 4 September 2000 and that of Loviisa 2 from 28 August until 14 September. Reactor refuelling as well as maintenance of components, structures and systems were carried out. In addition, plant modifications were made relating to severe accident management. Those plant modifications most important to plant safety are described in sub-section 4.1.6. Radiation safety during the outages is described in sub-section 4.1.8.

The annual maintenance of Loviisa 1 was about two weeks longer than planned. This was mostly due to the unplanned identification and repair of leaks in an emergency make-up tank. The 1000 m^3 volume tank contains boric acid water to be injected to the primary circuit during an accident. During the outage the tank's leak detection line indicated a ca. 10 litres/h leak from the tank. Inspections revealed several defects in the tank's steel cladding, some of them penetrating the cladding. Defects and leak points were repaired and cladding samples were taken for detailed laboratory analysis. Startup was delayed in its early stages because the primary circuit had to be cooled down from warm-up to repair a steam line isolation valve.

STUK oversaw the annual maintenance outages. It gave permission for Loviisa 1 startup on 4 September 2000 and for Loviisa 2 startup on 14 September 2000. The licensee initiated the startups after STUK's inspectors had ascertained startup readiness onsite. Loviisa 1 started electricity generation on 4 September 2000 and Loviisa 2 on 14 September 2000.

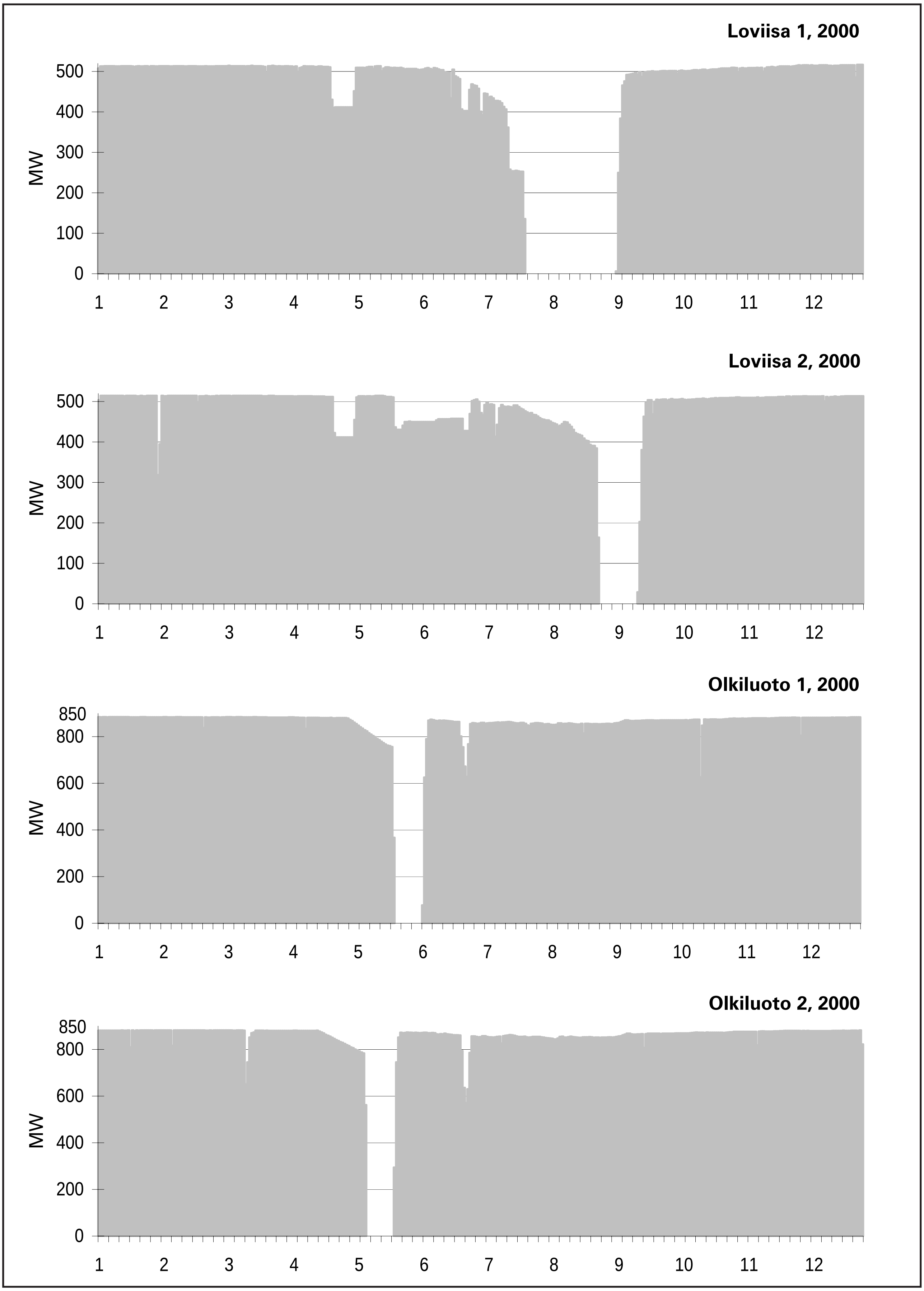

Fig 10. *Daily average gross power of the Loviisa and Olkiluoto plant units in 2000.*

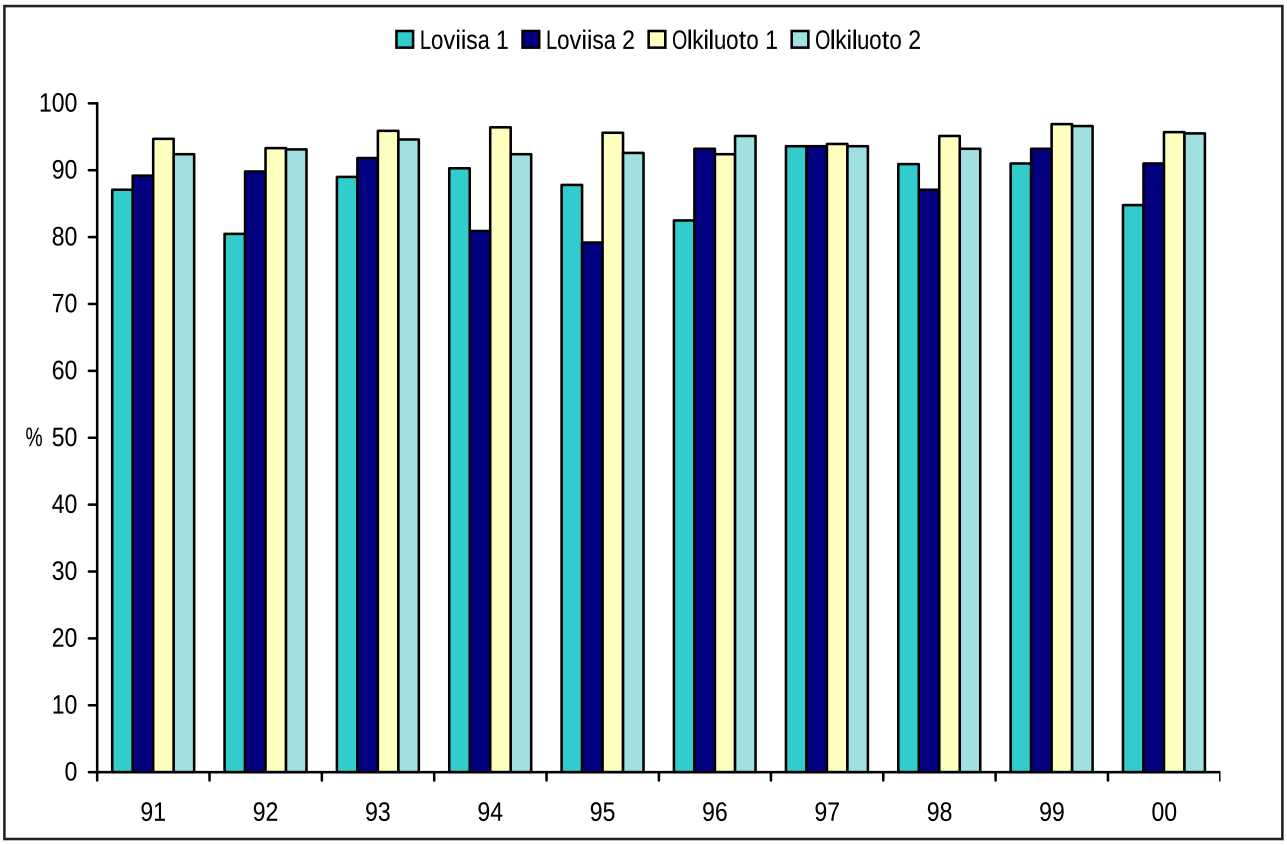

Fig 11. *Load factors of the Loviisa and Olkiluoto plant units.*

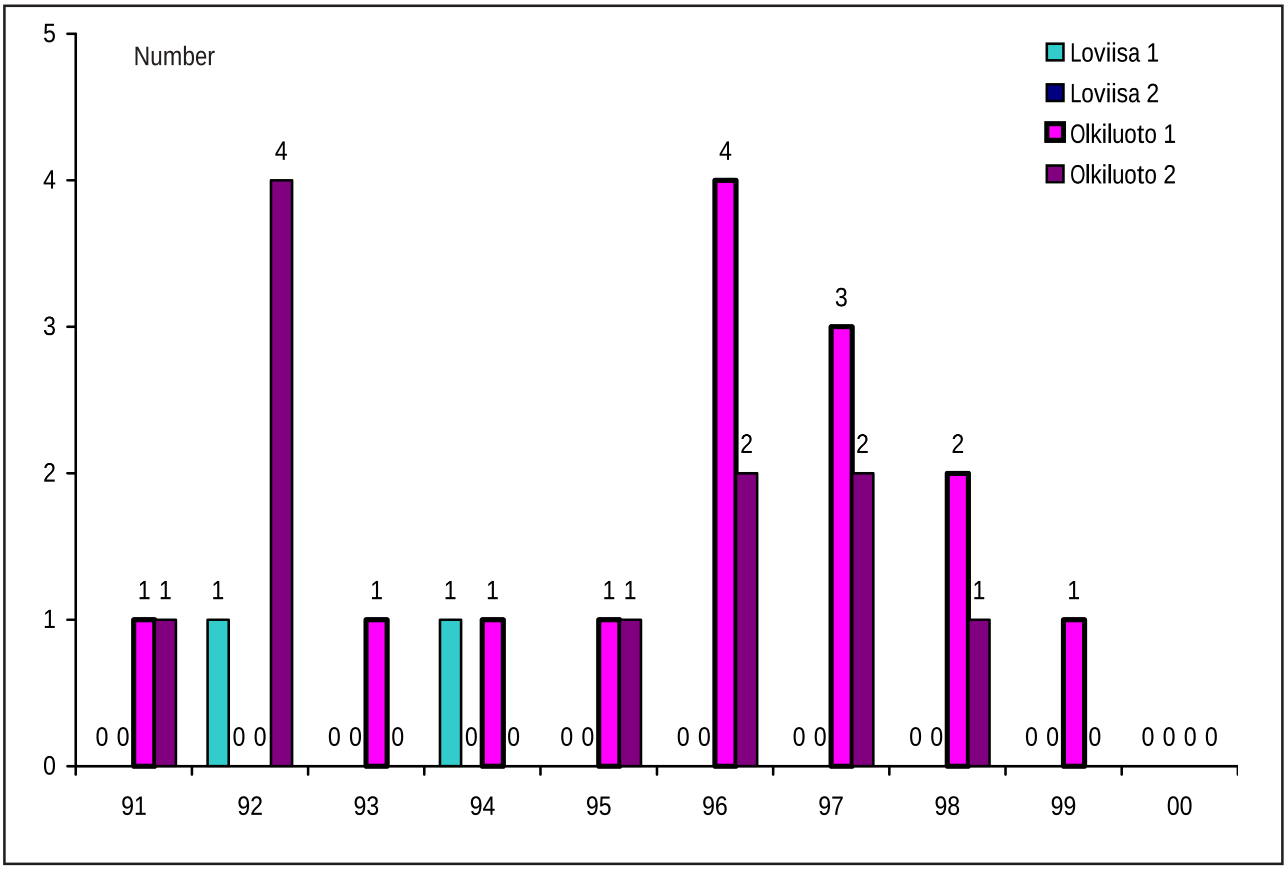

Fig 12. *Number of reactor scrams at the Loviisa and Olkiluoto units, scram tests excluded (reactor power exceeds 5%).*

4.1.3 Significant operational events

No event at the Loviisa plant units endangered safety in 2000. The highest level assigned to them was INES Level 1. A leak of mildly radioactive water during the Loviisa 1 annual maintenance outage was assigned Level 1 because its recurrence. The number of events at INES Level 1 and above at the Finnish plant units is given in Fig 13.

The lowering of an activity monitor's alarm limit was delayed at Loviisa 1

During the functional testing of activity monitors at Loviisa 1 on 9 February 2000, the sensitivity of a monitor that checks the secondary circuit for radioactive off-gases was found inadequate. The plant unit's Technical Specifications require its repair within eight hours. If this is not possible, the monitor's alarm limit must be lowered.

A work order was written to repair the monitor. Information about the work order did not reach the shift manager according to procedures, for him to have ordered the lowering of its alarm limit. Repair work began the next morning and, at the same time, this breakdown in communication was discovered. The monitor's alarm limit was immediately lowered, ca. 14 hours late.

The secondary side of the Loviisa plant normally contains no radioactive substances. Potential primary-to-secondary leaks are monitored for radioactivity in various process phases by activity monitors. On the day of the event, the monitors were in operating order with the exception of the non-sensitive monitor measuring the radioactivity of off-gases. The delay in the lowering of the alarm limit was of a brief duration and of minor significance.

The licensee informed STUK about the event in the daily report of 11 February 2000 and later sent STUK a report about it and about measures planned to prevent recurrence. In consequence of the event, the licensee emphasises accuracy in the processing of work orders and the importance of informing about different matters. The event was rated Level 0 on the INES scale.

A ventilation system disturbance in the instrumentation area of Loviisa 1 control building

On 19 April 2000, a cooling unit of the cooling water system of the Loviisa 1 control building ventilation system stopped due to a recirculating pump bearing failure. The reserve cooling unit did not automatically start because the pump motor safety switches were in an incorrect position. The plant unit was operating at full power. The Technical Specifications require the plant unit's shutdown in two hours if both cooling units are unavailable.

When the cooling unit in operation had stopped, its reserve unit was assumed to have automatically started as usual. About half an hour later, on examination of alarms received in the control room, both cooling units were observed to

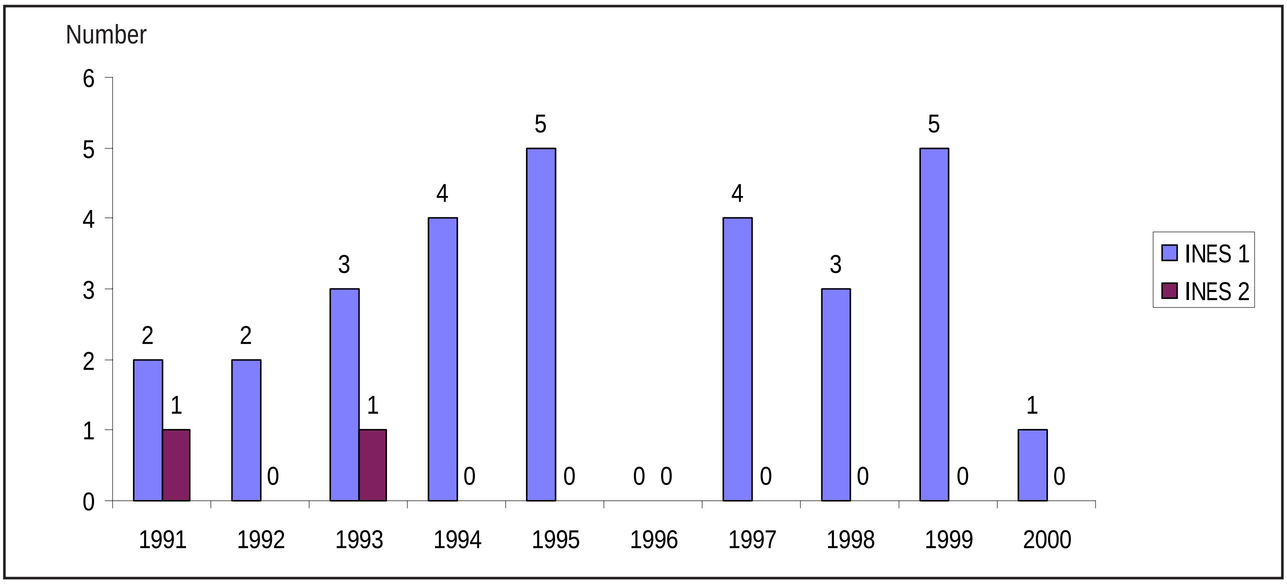

***Fig 13.** Events at INES Level 1 and above at the four Finnish plant units.*

have stopped. Ventilation system fans in the instrumentation area had automatically started at full speed. However, due to a temperature control system failure, the room temperatures had not decreased as designed and the control room received an alarm when the temperature in one room exceeded 24 degrees. A reserve fan was started to decrease the temperatures and the alarm signal disappeared in 30 minutes. The reserve cooling unit was started in about two hours from the start of the event. The recirculating pump of the cooling unit that had been in operation was replaced whereafter the device was brought back to operation.

The temperatures in the instrumentation area during the event did not exceed the limits of the Technical Specifications and the cooling units were simultaneously unavailable for less than two hours. The cause of the incorrect position of the safety switches of the cooling unit's motor remained unclear, as did the unit's time of inoperability.

Owing to the event, the interval of testing applied to the ventilation system of the control building's instrumentation area was stepped up and the control of the systems' availability was increased.

The licensee identified the event's safety significance based on the later analyses and informed STUK on 2 June 2000. Later in June it submitted a detailed report and what measures were planned to prevent recurrence. The event was assigned Level 0 on the INES Scale.

Primary circuit temperature measurement at Loviisa 2 was simulated to a protected state in violation of the Technical Specifications

Loviisa 2 was in power operation on 10 August 2000 when a primary circuit temperature measurement was found to display values in excess of actual temperatures. The plant unit's Technical Specifications require the repair of failures of this kind within three days. Unless the measurement function can be restored to operation within that time period, the plant unit must be brought to hot stanby for the repair.

It was found out the next day that the failure could not be repaired within the period allowed for restricted operation. The measurement was thus simulated to a protected state, i.e. a state where a measurement value would actuate its protective function. The procedure as such is appropriate and complies with the Technical Specifications of Loviisa 1. At the time of the event, a corresponding change to the Technical Specifications of Loviisa 2 was under review by STUK and the simulation was not yet an approved procedure. The licensee should have submitted to STUK, as a separate matter, this deviation from valid Technical Specifications. STUK has approved the change to the Technical Specifications on 13 September 2000.

The event surfaced during a periodic inspection conducted by STUK. It had no bearing on plant safety but the licensee's failure to closely follow administrative procedures, as required by STUK, was considered a deficiency. The event is rated Level 0 on the INES Scale.

A fresh fuel assembly sustained damage at Loviisa 1

On 15 August 2000, while fuel was being loaded into the reactor of Loviisa 1 during annual maintenance outage, defects were detected in the lower end piece of a fuel assembly. It was a fresh fuel assembly and no radioactive substances could be released from the rods. The damaged assembly was replaced in the reactor.

The damage sustained by the assembly was discovered when its insertion during loading failed, leaving it ca. 20 cm higher than other assemblies. An inspection conducted by a TV camera showed three dents in the assembly's lower end piece that had prevented full insertion into the reactor. Nothing out of the ordinary was found in the attempted insertion position in the reactor. Investigation revealed marks in the rack for internal transfer of fuel assemblies indicating that the assembly's lower end had hit the rack at an above-normal speed. After this the licensee considered it unnecessary to look for the cause of the damage inside the reactor and replaced the assembly with a fresh one. The damage sustained by the assembly prevents its further use in the reactor.

The dents had occurred during the lifting of the assembly from the storage pool. In the pool the assemblies are submerged in water in a transfer rack in which they are brought from the fresh fuel storage and from which they are transferred one by one by the refuelling machine to the reactor. The gripper of the refuelling machine had failed to grip the assembly. This was found out and the gripper was to be lifted up and the procedure was to be attempted again. The gripper had stuck onto the assembly, however, which started to be lifted along with the gripper, but fell from ca. 25 meters' height to the bottom of the rack. During the grip's lifting, insufficient attention was paid to the display of the weighing machine and it thus went unnoticed that the assembly was being lifted along with the grip. Under the transfer rack was a dosemeter, which had fallen into the storage pool, to which the event was attributed. It had caused the rack and the fuel assemblies therein to become slightly askew. During the lifting of assemblies, scratches on the gripper had increased assembly by assembly. During the lifting of the last assemblies, the one in question being among them, the gripper's scratches were so numerous that it failed to close and lock.

Refuelling guidelines are under review by the licensee. In case a gripper's attachment to a fuel assembly must be corrected, specific attention is to be paid to the readings of the scale's display and to the entering of the figures displayed on the refuelling's list of actions.

The licensee on 16 August 2000 notified STUK of the event and, later in the month, submitted a detailed report about it. In November it submitted a report about causes. The event was classified Level 0 on the INES Scale.

Leaks of mildly radioactive water during Loviisa 1 annual maintenance outage

Two leaks of mildly radioactive water occurred during the annual maintenance outage of Loviisa 1. The first occurred on 17 August 2000 during the emptying of an emergency cooling water tank. The tank contains non-radioactive boric acid water and was being emptied for inspections. The filling pump of the reactor pool was used whose suction line filled with air and prevented the pump's use. The suction line's refilling was attempted with mildly radioactive water from the reactor pool. After the filling, air was to be removed from the suction line and the pump's operation was to be tested.

The filling of the line was started by opening the isolation valves of a line coming from the reactor pool, which is not a regular operation. The control room staff on shift was not aware that an isolation valve in a line branching out from the main line was open when it should have been closed. The isolation valve had been opened in connection with a lowering of the reactor pool level, which procedure had been entered in the operating logs of the shift manager and of the reactor operator. Directly after the opening of the valves, water began to leak from the reactor pool via the open isolation valves outside the containment to rooms in the lower part of the reactor building.

The leaked water's temperature was ca. 30 degrees and it immediately triggered fire alarms. The leak was not detected at once because, in accordance with instructions, focus was placed on clarifying the fire alarms. The leak was noticed in about ten minutes from the receipt of the fire alarms and the open valve was closed. The water leak was ca. 20 m^3 in volume. The rooms affected have thresholds as well as floor drains designed for handling water leaks and radioactive water. The ventilation system of rooms located in the lower part of the reactor building, whose filters remove potential radioactive substances from air, was put on the filtering mode in about two hours after the event. Some unfinished maintenance work on the ventilation system prevented the filtering function's immediate activation.

Areas affected by the mildly radioactive water were isolated or marked out. Their activity concentrations were determined. The surface contamination measurement average of the most contaminated room was ca. 70 kBq/cm^2. Appropriate protective equipment were used when making the measurements and during decontamination. Workers received insignificant radiation doses from these measures. The collective radiation dose arising from the decontamination was ca. 2 mmanSv, which was only a minor part of the combined dose (collective dose 1670 mmanSv, see Fig.17) incurred from work done during the Loviisa 1 annual maintenance outage. After decontamination had been completed, the surface contamination of the rooms was below the limiting value of 4 Bq/cm^2, i.e. their activity concentration had been restored to pre-leak level.

The next day, i.e. on 18 August 2000, the reactor pool extraction pump test was continued. The pump was started without first checking the entire pipeline included in the pump start-up. Immediately after the pump's start-up, water began to discharge through the recirculation lines of the emergency cooling system to rooms inside the containment building. The leak volume was ca. 10 m^3. The leaked water did not contain the same radioactive nuclides that caused heavy surface contamination during the previous day's leak. The surface contamination of the leak area varied, maximum contamination being ca. 7 Bq/cm^2. The radiation exposure of workers during the decontamination did not deviate from those incurred during regular decontamination. The decontamination restored pre-leak activity concentration in the rooms.

The licensee informed STUK about the leak without delay and also sent in September a detailed description of the events and of the measures planned to prevent recurrence. The latter event was classified Level 1 on the INES Scale because this was a second occurrence.

In consequence of the events, the licensee reviewed and further specified the instructions for plant unit operation. In addition, it defined measures for those exceptional situations during annual maintenance outages not covered by procedures.

During post-leak decontamination it was found that the paintwork on the steam generator room floor was peeling. It was repaired during the annual maintenance outage. STUK requested from the licensee an analysis of how reactor cooling during an accident would be affected by the peeling. An analysis and experimental data showed that even the largest estimated amount of fine-grained, peeling paint would not substantially clog the plant's cooling water filters.

Back-up emergency feed water pump out of operational readiness in violation of the Technical Specifications of Loviisa 2

A pump of the back-up emergency feed water system shared by the Loviisa plant units was out of operational readiness in violation of the Technical Specifications. The situation occurred when the pump's servicing was started during the annual maintenance outage of Loviisa 1. Its out-of-service time is unlimited for a shutdown plant but during operation the pump must be serviced in 21 days. Work on the pump was started on 31 July 2000 and was finished on 22 August 2000. The allowable out-of-service time was exceeded by 43 hours.

The back-up emergency feed water system assures injection of water to the secondary side of the steam generators in case the operation of feed water pumps and emergency feed water pumps have been prevented by a turbine hall fire, for example. The system was installed in 1990 and comprises two diesel-operated pumps shared by the two plant units. The pumps inject water to the steam generators of either plant unit.

Progression of this work, as well as that of other work during which plant operation is restricted, was monitored at Loviisa 2. Owing to human error, the pump's maintenance was thought to have been completed and monitoring of the work was discontinued before its actual completion. Loviisa 1, responsible for the pump's maintenance, did not apply the period of limited operation that was in use at Loviisa 2. The pump's maintenance and testing were delayed due to other urgent outage work.

The licensee noticed only later that the time allowed for the pump's removal from operating readiness had been exceeded at Loviisa 2. It notified STUK about the matter on 25 August 2000 and in September sent STUK a detailed report on the event as well as a plan for measures to prevent recurrence. The exceeding of the allowable time of removal from operating readiness was of a brief duration and the event was thus assigned Level 0 on the INES Scale.

Concentration of boric acid in primary circuit water exceeded threshold limit at Loviisa 1

During a test conducted towards the end of the annual maintenance outage, the boric acid concentration of the primary circuit of Loviisa 1 exceeded the limit given in the Technical Specifications. The excess concentration was insignificant and lasted 18.5 hours.

In addition to control rods inserted into the reactor, boric acid assures reactor subcriticality during outages. The Technical Specifications state that the boric acid concentration is to be 13–14 g/kg of coolant during outages. The lower limit is so set that reactor subcriticality is maintained even if the control rods were withdrawn. The upper limit is set on the basis of the corrosion impact of the boric acid. The boric acid concentration is monitored by continuous-operation measurement and laboratory analyses. It is reduced during plant startup and during the operating cycle.

The allowable boric acid concentration was exceeded on 3 September 2000 during a testing of the plant unit's primary circuit make-up system. During the test, water containing strong boric acid solution is injected into the primary circuit. The test is conducted once a year, usually immediately after the plant unit has been stopped for annual maintenance. During the test, strong boric acid solution is injected into the primary circuit to increase its boric acid concentration to a value in compliance with the Technical Specifications. Due to a make-up system pump failure, however, the test had been moved to the startup phase.

The plant unit was in a post-revision hot standby state at the time of the event. The next phase in plant startup is startup state during which the reactor is made critical by dilution of the boric acid concentration of the primary circuit. It would have required the unlocking and restoration, while in hot standby, of the clean water feed lines in use during outages. The licensee therefore decided to move on to the next startup phase where the reduction of the primary circuit's boric acid concentration is begun according to normal procedures.

The exceeding of the allowable boric acid concentration of the primary circuit water was minor and did not adversely affect the fuel cladding. The event was affected by the make-up system test having been conducted, exceptionally, during plant unit startup. A shortcoming in the procedures followed by the licensee was that STUK's permission was not asked for the non-reduction of the boric acid concentration while in hot standby state and for the carrying out of the reduction in the next plant startup phase, i.e. startup state. The licensee informed STUK about the event on 6 September 2000 and sent a detailed report in September. The event was rated INES Level 0.

Partial inoperability of the sea water clean-up system of Loviisa 2 during annual maintenance outage

It was noticed at Loviisa 2 on 8 September 2000 that the sea water clean-up system was not fully operational in accordance with the Technical Specifications. The situation lasted for 18 hours. The plant unit was undergoing annual maintenance.

The sea water clean-up system comprises two parallel subsystems, with two lines to the turbine condensers in each. Before they reach the condensers, water is taken from the four lines for injection to the plant unit's service water system that cools the cooling circuits of systems and components important to safety, among others. It is essential that, during outages, the sea water system contains no impurities that could endanger the operation of the service water system. One sea water clean-up system line must be operational during outages.

One subsystem of the sea water system had been removed from service for maintenance and the filter baskets in one line of another subsystem were being replaced. The control room on 6 September 2000 authorised the inspection and repair of a filter in the operational line. The work was started on 8 September 2000; the filter was isolated from the sea water line and emptied. During the isolation as well as the issuance of the work permit, it went unnoticed that the replacement of the filter baskets in the other line had not yet been completed. According to original plans, it should have been completed by the time in question; however, the work was behind schedule. The filter in the second line was available, with the exception of the its back flushing function.

The back flushing function's unavailability was observed during inspections made before switching from refuelling shutdown to cold shutdown. The filter of the first line was easily made operational and measures were immediately taken to return it into service.

The sea water was relatively clean at the time of the event and the filter of the other line was in place. Had the sea water contained impurities, from a storm for example, the filter would have very slowly become clogged because of the sea water system's large volume and the small flow into the service water system. The service water system's cooling capacity thus was not significantly endangered.

The licensee informed STUK about the event without delay and in September submitted a detailed report about it. It was classified Level 0 on the INES Scale.

4.1.4 Event investigation

STUK appoints a team to investigate into a plant event especially when the licensee's organisation has not operated as planned or when an event is assessed to lead to significant modifications in the plant's technical structure or instructions. A STUK investigation team is set up also if the licensee has not investigated an event's root causes well enough.

The licensees assess events that have occurred at their plants, taking action, if necessary. STUK assesses these licensee measures as part of safety regulation. STUK also assesses its own activities in connection with the events.

In the year 2000 STUK investigated the below two events:

Deviations from the Technical Specifications

The number of plant operations in violation of the Technical Specifications in 1999, as compared to the previous years, had increased both at Loviisa and Olkiluoto plants. They have been described in the report STUK-B-YTO 202. Common causes underlying these events as well as causes that may have contributed to their increase were looked into.

No unambiguous common denominator for the increase was found. The process of defining events as being in violation of the Technical Specifications had been observed to be open to interpretation, which could have had a bearing on their increase. For example, an event used not to be considered in violation of the Technical Specifications if the plant situation was brought to comply with the requirements within a fixed period of time from the detection of a failure or a situation. At present an event is considered to be in non-compliance with the Technical Specifications if it has passed unobserved in tests required in the Technical Specifications.

Plant events violating the Technical Specifications generally involve underlying human and organisational factors. The most significant common denominator is management of situations involving change. The progress of five events into events in violation of the Technical Specifications has been essentially affected by changes in original plans and an insufficient consideration of changes in the replanning of work. The investigations have not revealed any shortcomings in the clarity of the Technical Specifications, or how well they are known or understood.

Shortcomings in the operating and maintenance instructions have been noted to have a bearing on the initiation of several events. The utilities have already implemented software modifications to correct the situation. During its own inspections STUK should pay attention specifically to the quality of the utilities' maintenance instructions in all fields of technology.

On the basis of the investigation, the utilities should re-evaluate their current procedures for recognising change. They should also find out how to avoid excessive routine and how to foster alertness of action, especially when pressed for time and during abnormal situations. In consequence of the events, the utilities have further developed procedures for validating system and component operability.

Delays and deficiencies in implementing of a risk reducing modification at Loviisa nuclear power plant

An investigation was made into a delay in the implementation of a modification to assure the injection of sealing water to cool the seals of the primary coolant pumps of Loviisa nuclear power plant. Mechanical seals require continuous cooling. If cooling is lost for several hours the seals could sustain damage leading to a small leak from the primary circuit. The importance of cooling water supply and its enhancement have been recognised based on the results of probabilistic safety analyses (PSA), among others. PSA results have shown that the loss of primary coolant sealing water significantly contributes to core melt risk, especially in case of the loss of the sea water system, among others.

The seals are cooled by primary coolant, which is cooled by water from the intermediate coolant circuit. The intermediate coolant circuit is cooled by water from the service water system. A service water system leak occurred at Loviisa 1 in 1998 and during its isolation a disturbance was caused in the operation of the intermediate cooling circuit. The temperature of the sealing water of the primary coolant pumps consequently increased, exceeding the limit set in the operating procedure (STUK-B-YTO 202, 2000).

The planned upgrade makes possible the cooling of the seals by water from the boric acid system. The system's water is cold enough to make its separate cooling unnecessary. Sealing water injection would be automatically switched to occur from the boric acid system if sealing water temperature exceeds 50 degrees. The mechanical seals of the primary circulation pumps withstand temperatures up to 70–80 degrees. The upgrade requires modifications to the protection and control systems as well as new temperature measurements.

The licensee had made a modification initiative in summer 1998 and a preliminary work plan was ordered the next year. The licensee decided to implement the modification in June 1999. It was due at Loviisa 2 in the annual maintenance outage of 2000. In spring 2000 STUK approved system pre-inspection documentation submitted by the licensee. In July the licensee submitted to STUK for approval pre-inspection documents for I & C systems. STUK reviewed them in August. The licensee informed STUK that, since it had not received STUK's approval of the documents in time, there would not be enough time to carry out the modification in the outage.

Investigation revealed shortcomings in the actions of both the licensee and STUK. One important reason for the licensee's belated accomplishment of plans was postponement of implementation decisions. The modification's implementation was put off because the time and human resources spent in its planning were insufficient and the number of necessary analyses was underestimated. In addition, the design criteria for the seals were insufficient and the seals' actual endurance had not been verified. The pre-inspection document for I & C systems included unjustified deficiencies from the regulatory requirements concerning the temperature measurements components.

Aware of the shortcomings, the licensee submitted the documents to STUK, assuming that STUK would approve them. A stringent schedule may have had a bearing in the matter.

STUK's review of the documents was belated because they arrived late and were reviewed during overlapping Loviisa 1 outage which was delayed by two weeks. There was not sufficient awareness of the modification's importance within STUK. In addition, STUK did not manage the entire modification in a centralised manner.

Regulatory procedures relating to modifications are under review by STUK to eliminate the shortcomings. In the co-ordination of extensive modifications important to safety, projects and early monitoring are to be preferred. The licensee is to ensure that, in the planning of modifications, the requirements of regulatory guides are observed and any deviations thereof justified.

4.1.5 Deviations from the Technical Specifications

The following five events, involving plant unit non-compliance with the Technical Specifications, occurred at the Loviisa plant units:

- The lowering of the alarm limit of an activity monitor was delayed at Loviisa 1
- A ventilation system malfunction occurred in the Loviisa 2 control building instrumentation room
- A back-up emergency feed water pump was not in operational readiness at Loviisa 2
- The allowable boric acid concentration of primary circuit water was exceeded at Loviisa 1
- A partial inoperability of the sea water clean-up system of Loviisa 2 during the annual maintenance outage.

Detailed descriptions of the events can be found in subsection 4.1.3.

The licensee has planned and partly implemented measures to prevent recurrence. Fig. 14 gives the number of plant events in violation of the Technical Specifications over the past years.

The Technical Specifications were deviated from also when the licensee applied for STUK's advance approval of a deviation. In the year 2000, STUK granted a total of six such exemptions for the Loviisa plant units; one application was turned down. The yearly number of exemptions is given in Fig. 15.

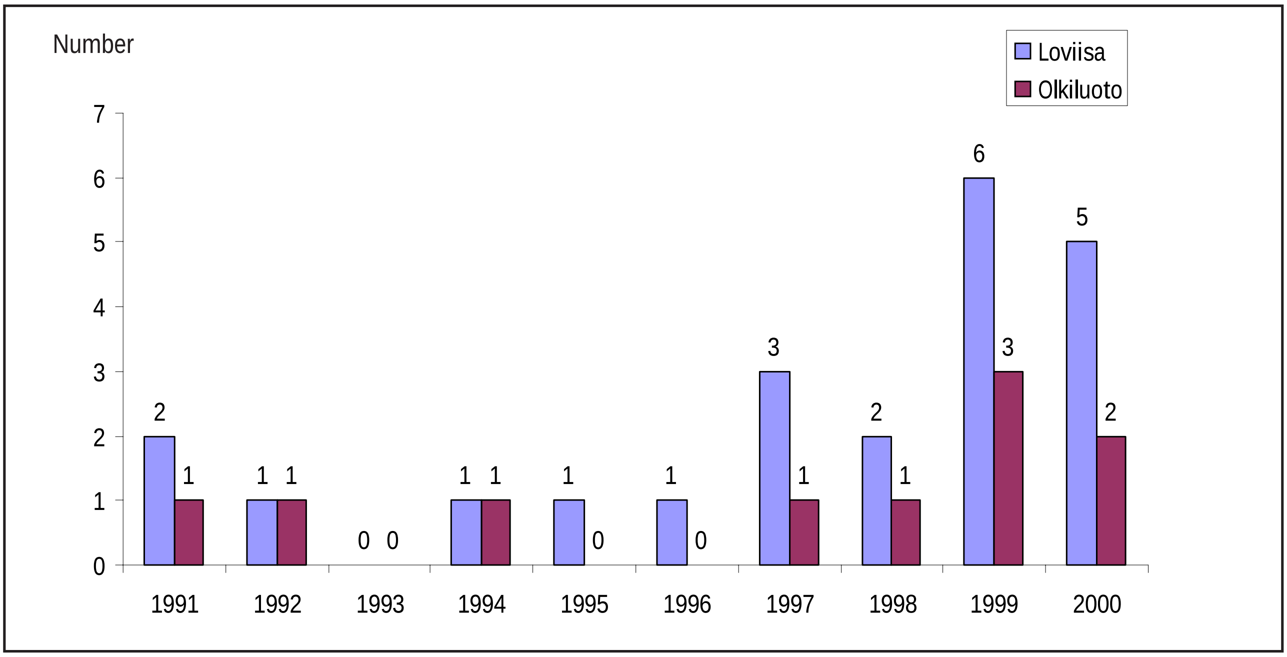

Fig. 14. *Number of onsite situations in violation of the Technical Specifications at Loviisa and Olkiluoto nuclear power plants.*

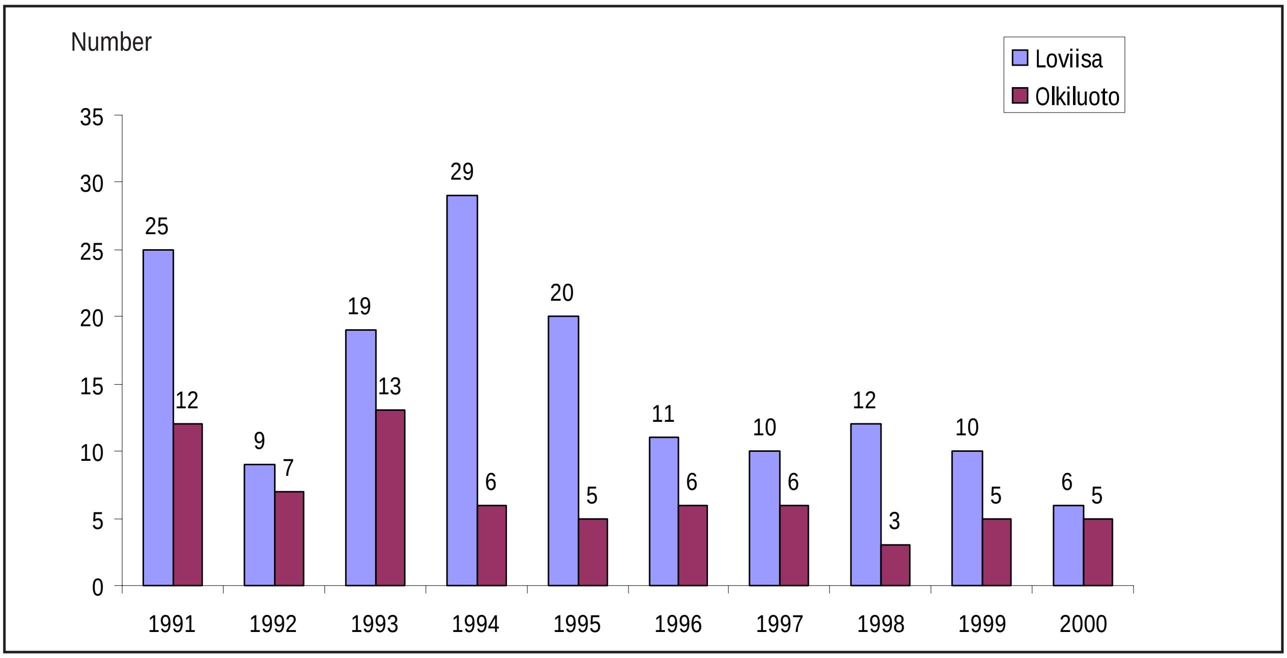

Fig. 15. *Number of exemptions from the the Technical Specifications at Loviisa and Olkiluoto nuclear power plants.*

4.1.6 Safety improvements

Mitigation of the consequences of severe accidents

In the Loviisa 1 annual maintenance outage of 2000, a number of measures to mitigate the consequences of severe accidents were implemented. The measures are part of the facility's ongoing project providing for severe accidents. Of the actions taken, the technically most far-reaching was the implementation of plant modifications required by the reactor pressure vessel's external cooling. For this purpose, flow routes between the steam generator room and the reactor pit were opened and configured; the lowering equipment of the reactor pressure vessel's heat shield was also fitted in place. STUK oversaw the modifications and the associated site acceptance tests. After the completion of these modifications, the hot corium melt that would form in a severe accident could be contained inside the reactor pressure vessel by externally cooling the vessel.

A separate control room for severe accident management, to be shared by the two units, was given the finishing touches. In addition, a number of modifications to automation technology was made and new I & C systems were installed, enabling centralised severe accident management. Among others, a manual trip alternative was provided for the actuation of special containment isolation signals necessary to maintain containment tightness. These manually tripped special functions assure containment tightness against possible leaks through systems.

Hydrogen is released inside the containment in severe accidents. For its burning in a controllable manner, and to avoid quick explosive hydrogen burns, the installation of catalytic recombiners in the containment has been planned as well as the installation of opening mechanisms for the doors of ice condenser compartmet located inside the containment. The opening mechanisms assure supply of air to all parts of the containment because air is needed in the catalytic burning of hydrogen. In addition, they also limit local hydrogen concentrations, making flaming unlikely. Both systems were due for installation at Loviisa 1 in 2000; however, their installation has lingered due to technical problems. Installation of the opening mechanisms of ice condenser doors was started during the annual maintenance. Work will continue both during operation and in the 2001 annual maintenance outage.

Removal of water seal cross-tie lines from the primary circuit of Loviisa 1

Water-seal cross-tie lines adjoining the primary circuit were removed at Loviisa 1 during the annual maintenance outage. This small-diameter piping was located in three of the plant unit's six loops between bends in the cold and hot legs of primary piping. The cross-tie lines were fitted in the early 80's when the so called water seal phenomenon was assumed to compromise reactor core cooling during a primary circuit leak. Current knowledge, based on experimental investigation and analyses, considers the cross-tie lines unnecessary. Their removal eliminated the possibility of a primary circuit leak through them.

The primary circuits of the Loviisa plant units have bends both in the hot leg leaving the reactor and the cold leg returning to the reactor. After the commissioning of the plant units, the bends were considered a possible safety hazard for reactor cooling in certain primary circuit leak situations. It was estimated, that a minor leak in the cold leg would cause a long-term drop in the reactor water level, which would partially expose the fuel and leave it without sufficient cooling. According to these analyses, when steam generated in the reactor flows to the leak point, it suppresses the reactor water to the level of the upper edge of primary circuit piping bends. Analyses indicated that this harmful phenomenon was made worse by two successive bends. With the calculation methods available it was demonstrated that when the bends of a loop's hot and cold legs are connected using relatively small-diameter piping, the drop in the reactor water level caused by the water seal phenomenon is reduced to a level not hazardous for reactor cooling. Three loops at both Loviisa plant units were fitted with cross-tie lines.

Cracks have been detected in the cross-tie lines and their valves, two of which have developed into small leaks into the containment. Because of the risk of a leak from the piping and their valves as well as the work load arising from their condition monitoring, the licensee investigated how necessary the cross-tie lines are in the light of current knowledge. After the lines were installed in the 80's, the water seal phenomenon of the reactor primary circuit has been quite extensively investigated. At the same time, the applicability and reliability of analysis methods have been improved. According to studies conducted by the licensee, the cross-tie lines only have a minor effect on the water seal phenomenon, which, even at its worst, is much milder than was estimated possible at the time of the lines' design.

STUK reviewed and approved documents submitted by the licensee for justification of the removal of the cross-tie lines, reviewed plans for the removal of the lines and the devices contained therein as well as supervised the work at Loviisa 1. Corresponding modifications will be made at Loviisa 2 in the 2002 annual maintenance outage.

Renewal of low pressure emergency coolant pumps

In the 2000 annual maintenance outage of Loviisa 1, two pumps of the low pressure emergency cooling system were replaced and the necessary piping modifications were made.

The low pressure emergency cooling system cools the reactor during emergencies. The system is divided into two parallel, independent subsystems with two parallel pumps (four pumps in all) in each. Either independent subsystem can alone handle the cooling function during an accident. Only one subsystem's pumps were now replaced.

The replacement pumps had proved necessary due to some structural weaknesses found in the old pumps. In connection with it, it was also possible to improve the reduction of mechanical stresses exerted on the pumps from the piping. The new pump type exceeds the original in efficiency, and the modification thus also improved the capacity of the low pressure emergency cooling system. STUK reviewed and approved the modification plans and supervised the pre-operational testing of the pumps. Plans are to install new pumps to the other Loviisa 1 subsystem and to the two Loviisa 2 subsystems in the year 2002.

Measures taken on account of elevated steam generator room temperatures

Based on temperature measurements made in the steam generator rooms of the Loviisa plant units it has been ascertained that, over the past years, the electrical and I&C components and cables located there have been exposed during operation to thermal loadings in excess of design basis values (STUK-B-YTO 190, 1999). High temperatures and radiation levels accelerate cable and component ageing.

The faster-than-expected ageing of the cables led to extensive cable inspections and replacements at both Loviisa plant units in the 1999 annual maintenance outages. In the annual maintenance outages of 2000 further measures were implemented in the steam generator rooms to assure the operability of the electric and I & C cabling and to reduce the temperatures. Further temperature measurements were made to identify items that might require upgrading. Electric and I & C cables were inspected both visually and by cable sample examinations. Cabling was replaced and installations were upgraded. Lighting plus their cabling in the steam generator room were replaced. Some aged thermal insulation of piping and of other hot structures was replaced and, on the basis of temperature measurements, additional insulation was installed to reduce heat emission from hot structures to the surrounding spaces. A reduction in the steam generator room temperatures during operation was aimed at by improving the efficiency of the ventilation systems.

This has given added assurance of the availability of electric and I & C components and cables needed during possible accident conditions. The licensee has also updated a condition monitoring programme assuring the long-term operability of the electric and I & C components located in the steam generator room. The upgrading measures in the steam generator room will be continued in future annual maintenance outages.

STUK inspected and approved all upgrades made on account of high steam generator room temperatures. In addition, STUK oversaw implementation of the upgrade projects in the 2000 annual maintenance outages.

Improvement of the temperature endurance of emergency coolant pumps at Loviisa facility

Safety analyses in connection with the modernisation and power uprating of Loviisa facility showed that the temperature endurance of the motors of containment spray system pumps needed upgrading. The motors' availability during a possible long-term undervoltage needed to be improved as well. The pumps spray the containment with water in the event of a large loss-of-coolant accident.

As a result of the analyses the licensee decided to modernise the electric motors of containment spray system pumps at both plant units. The modernisation was carried out by rewinding the old electric motors plus their auxiliary motors. The motors now meet more stringent requirements pertaining to operating and ambient conditions. The rewinding of the motors was started in 1999 and was completed in early 2000 at what time the last rewound pump motor was returned to service.

STUK has reviewed and approved documents relating to the renewal of the motors and supervised the installation of the motors and their preoperational testing.

4.1.7 Probabilistic safety analyses

Flood risk analysis

STUK has reviewed a flood risk analysis for Loviisa nuclear power plant that was updated in 1998. The previous flood risk analysis report of 1994 was reviewed by STUK in 1997. Flood risk analysis deals with flood events internal to the plant during power operation that could arise from tank and piping ruptures or component malfunctions, for example. The flood risk assessment for power operation is ca. 5% of assessed plant core melt frequency.

Flood events internal to the plant during outages are dealt with in outage risk analysis; floods due to external events are included in weather risk analysis. Certain flood events affect the adjacent plant unit as well. The analysis for Loviisa 1 includes such Loviisa 2 flood events.

The licensee has listed potential sources of flooding by comparing the location of components and systems important to safety to those of systems containing significant liquid volumes; also flood pathways were considered. After an onsite inspection in 1994, the licensee listed nine flood-initiating event groups. Flooding is caused by piping or tank ruptures, erroneous pump startups or incorrect valve positions, for example. Flood risk is strongly affected by the location and isolation of flood sources and, on the other hand, of components important to safety, particularly those needed in the removal of reactor decay heat.

The goal of the 1997 flood risk analysis by STUK was to assure that all potential sources and routes of flooding had been identified and that the effect of flooding on the functioning of the plant's safety systems had been appropriately evaluated. In addition, the objects and sufficiency of future modifications to reduce flood risk were evaluated. The new review by STUK of the 1998 flood risk analysis complemented the 1997 review because the licensee had made numerous changes to the 1994 version. A new flood-initiating event and the impact of a feed water tank level flooding, among others, had been included in the analysis; plant modifications were taken into account as well.

4.1.8 Radiation safety

The radiation doses of those who worked at Loviisa nuclear power plant in 2000 were below the 50 mSv annual limit. The distribution of individual doses in 2000 is given in Table II. The highest individual dose at Loviisa nuclar power plant was 18.4 mSv. It accumulated during the annual maintenance outages of Loviisa 1 and 2. The highest individual dose incurred in the Loviisa 1 annual maintenance outage was 16.5 mSv and that incurred in the Loviisa 2 outage was 7.9 mSv. Radiation doses may not exceed the dose limit of 100 mSv over any period of five years. The highest individual dose to a Finnish nuclear power plant worker in the 5-year period 1996–2000 is 93.2 mSv.

The collective occupational radiation dose for both Loviisa plant units in 2000 was 2.26 manSv. The collective occupational doses incurred over the past years are given in Fig. 16. The yearly collective dose is mostly incurred in outage work. The collective dose arising from work done during annual maintenance outages is 1.67 manSv at Loviisa 1 and 0.47 manSv at Loviisa 2. Figure 17 gives the collective occupational radiation doses incurred during the annual maintenance outages of the Loviisan plant units. The 2000 collective dose at Loviisa 1 exceeds that of the previous years owing to more scheduled work than usually, to unscheduled work and an extended annual maintenance. According to guidelines set by STUK, the threshold guideline for the collective dose for a Loviisa plant unit is 1.22 manSv averaged over two successive years. In 1999 the collective occupational dose was 0.80 manSv at Loviisa 1 and 0.56 manSv at Loviisa 2. The guideline value for two successive years was thus exceeded by 0.04 manSv at Loviisa 1. In a case such as this, the licensee must report to STUK what caused the value to be exceeded and any measures that may be needed to enhance radiation safety.

Radioactive releases into the environment from Loviisa nuclear power plant in 2000 were well below authorised limits. The releases of gaseous radioactive effluents were 0.03% of authorised limits. In the releases of radioactive noble gases, the activation product of argon-40, i.e. argon-41, originating in the air space between the reactor pressure vessel and the biological shield, dominated. The releases of radioactive iodine were below the detection limit. The tritium content of liquid effluents, 11 TBq, is ca. 7% of the release limit. The total activity of other radionuclides in liquid effluents was 0.1 GBq, i.e. ca. 0.01% of the release limit. Detailed information about the releases are given in Table III.

The purpose of the release limits is to keep annual individual exposure in the vicinity of nuclear power plants, arising from the operation of the plants, well below the 100 µSv threshold value given in the Council of State Decision (395/1991). The dose to the most exposed individual in the environment of the nuclear power plants, calculated on the basis of releases, was ca. 0.06% of the set limit. Calculated annual radiation doses are given in Fig. 18.

Table II. *Occupational radiation dose distribution at Loviisa and Olkiluoto plant units in 2000.*

Dose range (mSv)	Number of persons by dose range		
	Loviisa	Olkiluoto	total*
< 0.5	245	394	577
0.5–1	113	228	325
1–2	124	224	325
2–3	83	121	192
3–4	52	58	104
4–5	28	42	70
5–6	29	26	55
6–7	22	7	33
7–8	24	12	45
8–9	18	4	33
9–10	14	6	29
10–11	8	4	16
11–12	10	3	17
12–13	3	1	7
13–14	8	–	11
14–15	6	1	9
15–16	2	–	4
16–17	6	–	6
17–18	4	–	5
18–19	2	–	2
19–20	–	–	–
20–25	–	–	–
> 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 Finnnish nuclear power plants and in Sweden.

Radiation monitoring in the environment of nuclear power plants comprises onsite and offsite radiation measurements as well as the determination of radioactive substances to establish the population radiation exposure and radioactive substances present in the environment.

In the vicinity of Loviisa nuclear power plant, 324 samples were analysed in accordance with a monitoring programme. Radioactive substances originating in Loviisa plant were measurable in one sample of air, six samples of deposition, one sample of bottom fauna, 11 samples of aquatic plants, seven samples of sinking matter and five

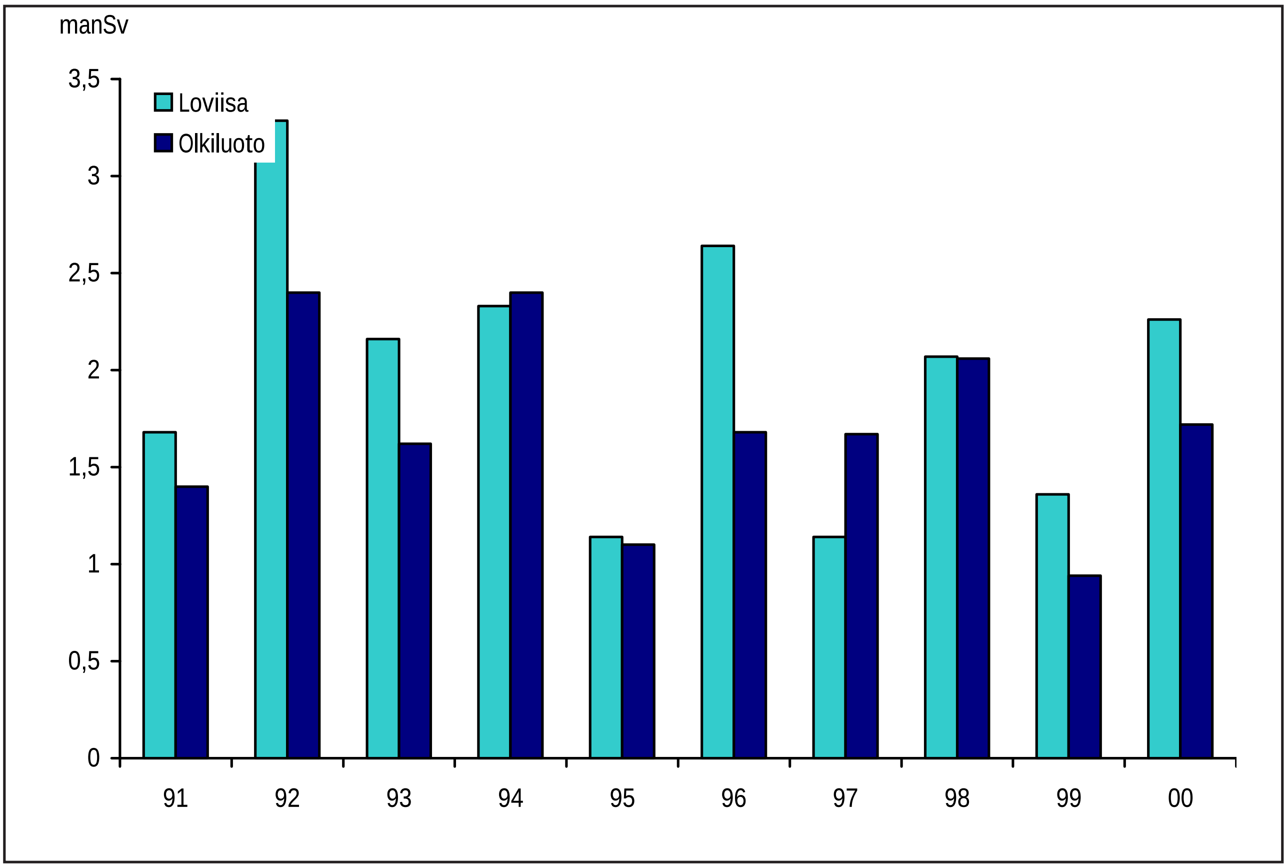

Fig 16. *Collective occupaational doses at Loviisa and Olkiluoto nuclear power plants.*

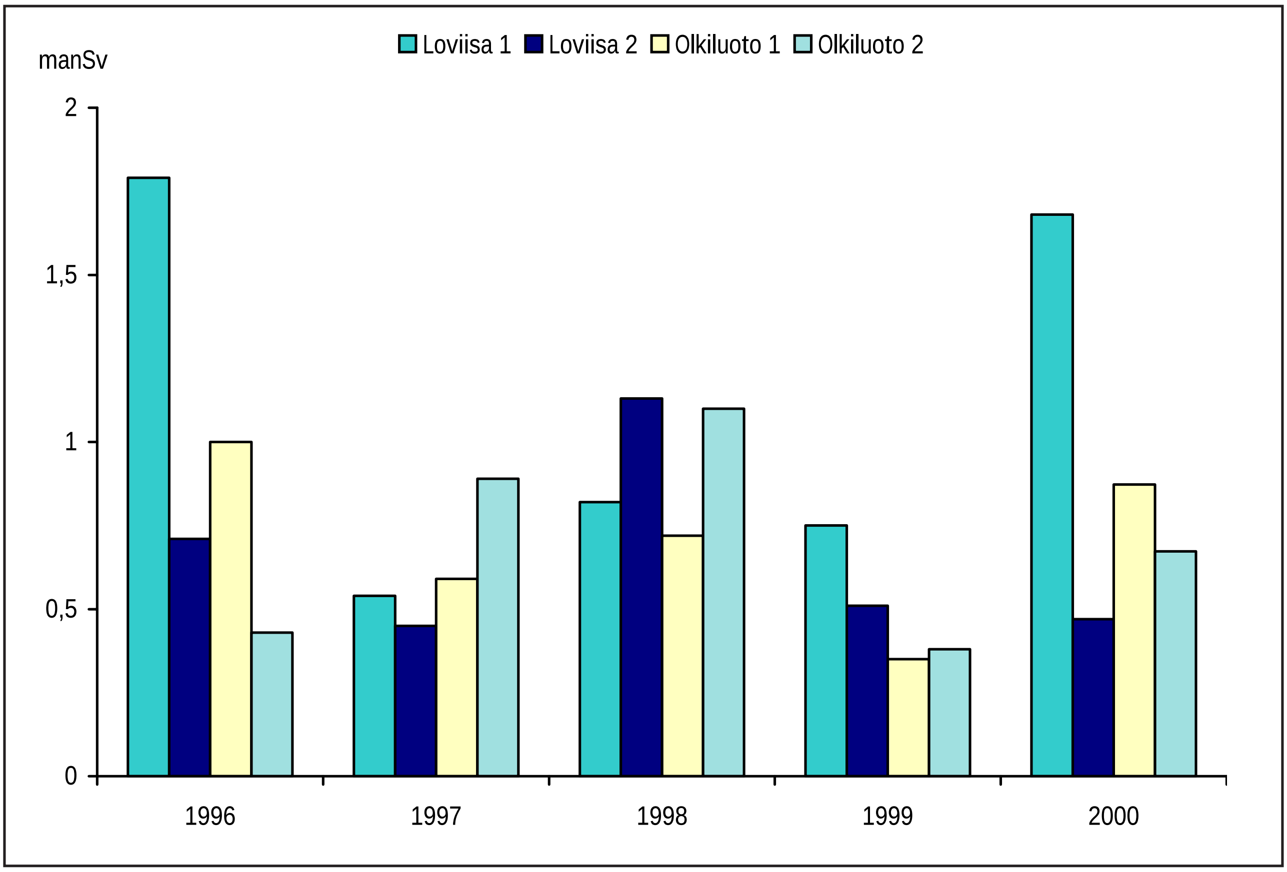

Fig 17. *Occupational radiation doses incurred in the annual maintenance outages of the Loviisa plant units.*

Table III. Measured radioactive releases from Loviisa and Olkiluoto plants in 2000.

Gaseous effluents by nuclide group (Bq) a)					
Plant site	**Noble gases (Krypton-87 equivalents)**	**Iodines (Iodine-131 equivalents)**	**Aerosols**	**Tritium**	**Carbon-14**
Loviisa					
In 2000	$5.4 \cdot 10^{12}$	$5.7 \cdot 10^{3}$	$6.2 \cdot 10^{7}$	$2.0 \cdot 10^{11}$	$2.8 \cdot 10^{11}$
Olkiluoto					
In 2000	$3.0 \cdot 10^{11}$	$7.9 \cdot 10^{7}$	$1.3 \cdot 10^{7}$	$4.6 \cdot 10^{11}$	b)
Annual release limits					
Loviisa	$2.2 \cdot 10^{16}$ c)	$2.2 \cdot 10^{11}$ c)			
Olkiluoto	$1.8 \cdot 10^{16}$	$1.1 \cdot 10^{11}$			

	Liquid effluents by nuclide group (Bq) a)	
Plant site	**Tritium**	**Other nuclides**
Loviisa		
In 2000	$1.1 \cdot 10^{13}$	$1.0 \cdot 10^{8}$
Olkiluoto		
In 2000	$1.0 \cdot 10^{12}$	$1.1 \cdot 10^{9}$
Annual release limits		
Loviisa	$1.5 \cdot 10^{14}$	$8.9 \cdot 10^{11}$ c)
Olkiluoto	$1.8 \cdot 10^{13}$	$3.0 \cdot 10^{11}$

a) The unit of radioactivity is Becquerel (Bq): 1 Bq = one nuclear transformation per second.
b) The carbon-14 release-estimate based on experimental data was $7.6 \cdot 10^{11}$ Bq in Olkiluoto in 2000.
c) The numerical value shows the release limit for the plant site by nuclide group assuming that other releases would not occur. The total release limit is calculated so that the sum of the various types of release limit shares does not exceed 1.

samples of sea water. Cobalt-60 was a dominating plant-based radionuclide measured in all of the aforementioned samples, except for the air sample. The total number of observations was 25. The next most common radioactive substances were the radioactive isotopes of manganese and silver (silver-110m, 16 observations and manganese-54, 12 observations). In some samples from the aquatic environment, also the following radioactive substances were detected (the number of observations in brackets): tritium (5), chromium-51 (1), cobalt-58 (7), strontium-89 (1), zirconium-95 (1), niobium-95 (2), tellurium-123m (3) and antimony-124 (5).

All the detected concentrations were low and have no bearing of radiation exposure.

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

Dosemeters measuring external radiation have been placed in the environment of Finnish nuclear power plants, in about 20 locations within a radius of 1–10 km from the plants as well as 25 continuously operating measurement stations within a 5-km radius from the plants. The measurement data yielded by the stations are transferred both to the plants' control rooms and the national radiation monitoring network. Monitoring is complemented by dose rate verification measurements and spectrometric measurements. In the environment of Loviisa plant, 12 such measurements verifying external radiation were made.

4.2 Olkiluoto nuclear power plant

4.2.1 Operation

Both units of Olkiluoto nuclear power plant operated reliably. The load factor of Olkiluoto 1 was 95.7 % and that of Olkiluoto 2 was 95.5%. The duration of the annual maintenance outages at both plant units was 14 days. The measures taken during the outages are described in subsection 4.2.2. Radiation safety during the outages is described in subsection 4.2.8.

No reactor scrams or other interruptions in electricity generation occurred at the plant units. Reactor power was limited in consequence of electricity demand. There were power limitations at Midsummer and consequent production losses were 0.2% at Olkiluoto 1 and 0.3% at Olkiluoto 2. Production losses caused by component malfunctions were 0.1% at Olkiluoto 1 and 0.04% at Olkiluoto 2.

No problems occurred at the Olkiluoto plant units on the days critical for computer software, i.e. 29 February 2000 and 1 March 2000. On the working day following the turn of the year 2000/2001, a computer running an administrative software application failed to start because it did not recognise the year 2001 during startup. Other computers of the same type failed in the same manner. The computer type in question can be found in certain process computer systems of the Olkiluoto plant units; the problem did not surface in them because they are never turned off. The problem was corrected and the computers' operation was tested. No other problems occurred at the turn of the year 2000/2001. Some minor problems at the turn of the year 1999/2000 were reported, the most significant of which was that the reading

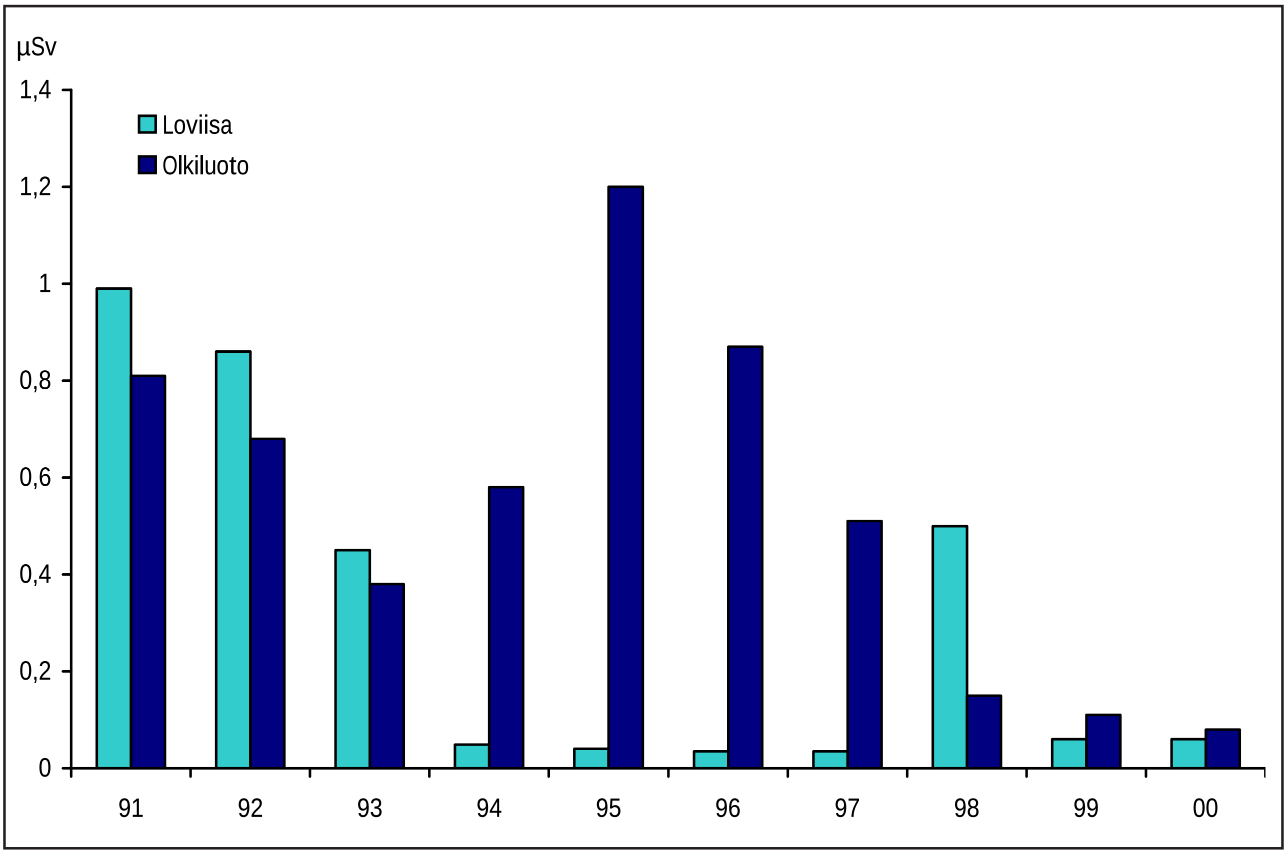

Fig 18. *Radiation dose estimates calculated for an individual of the most exposed population group in the vicinity of Loviisa and Olkiluoto nuclear power plants.*

devices of the real-time dose monitoring system were left on local operation mode. This hampered the use of dosemeters. STUK had requested the licensee to make provision for computer problems that might be caused by the dates in question and to report any deviations in computer operation.

Fig. 10 gives the daily average gross powers of the plant units in 2000. Load factors and the number of reactor scrams over the past years are given in Figs. 11 and 12.

4.2.2 Annual maintenance outages

The Olkiluoto 1 refuelling and maintenance outage was from 21 May to 4 June 2000 and that of Olkiluoto 2 from 7 to 21 May 2000.

It was waited at Olkiluoto 1 for 17 hours after reactor shutdown for the reactor water radioactivity to decrease enough to allow for the opening of the reactor. The higher-than-normal concentration of radioactive substances in the water was caused by two leaking fuel assemblies in the reactor. During the plant unit's startup after the 1999 annual maintenance outage on 25 July 1999 the licensee had detected a small nuclear fuel cladding leak (STUK-B-YTO 196, 1999). Activity monitoring during plant operation had indicated another fuel leak later. The leak was located to two fuel assemblies in a test prior to the reactor shutdown. They were removed from the reactor during the annual maintenance outage. Other fuel assemblies were subjected to leak detection to assure that no leaking fuel was left in the reactor. Despite the fuel leak, the concentration of radioactive iodine isotope (iodine-131) in the reactor coolant water had been less than one part per thousand of the threshold value given in the Technical Specifications for the entire operating period and since the previous annual maintenances; the value indicates when restrictions on reactor operation are necessary. The plant units have systems for radiation detection and decontamination for use in the event of fuel leaks.

In addition to refuelling, plant structures, systems and components were serviced during the annual maintenance outages.

At both Olkiluoto plant units, unplanned additional work was caused by the repair of emergency coolant system piping located inside the reactor pressure vessel. By means of the piping, cooling water is channelled to the upper plenum during accidents. In inspections conducted at both plant units in 1998 and 1999 (STUK-B-YTO 184, 1999 and STUK-B-YTO 196, 1999), cracks had been detected in the piping. In 1999 cracked piping was removed and replaced with new pipe segments fitted with heat shields. Piping with no cracks in it was fitted with heat shields only. Shifting of some of the new piping segments plus their heat shields was detected. Their proper positions were restored and their attachments improved. The repaired piping segments will be checked every year because of the risk of loose parts and thermal fatigue.

STUK oversaw the annual maintenance outages. STUK gave permission to start Olkiluoto 2 on 18 May 2000 after which STUK's inspectors ascertained the plant unit's startup readiness onsite the same day. The licensee began plant startup, which had to be discontinued twice. In the early stages of startup it was detected that a valve in the relief system was leaking. Plant startup was resumed after the valve had been repaired but it had to be discontinued when another valve in the same system failed to operate according to design in a periodic test. The fault was repaired and the plant unit was connected to the national grid on 21 May 2000.

STUK gave permission to start up Olkiluoto 1 on 2 June 2000. The licensee began startup after STUK's inspectors had ascertained the plant unit's startup readiness onsite. The plant unit was connected to the national grid on 4 June 2000 and was operating at full power on 7 June 2000.

4.2.3 Significant operational events

None of the events at the Olkiluoto plant units in 2000 endangered safety. The most significant plant operating events and related regulatory measures by STUK are described below. The number of INES Level 1 and above events at the Finnish plant units is given in Fig 13.

The volume of back-up diesel fuel in a storage tank went below the limit set in the Technical Specifications

It was found out at Olkiluoto 2 on 30 January 2000 that the volume of back-up diesel fuel in a storage tank was below the 230 m^3 limit of the Technical Specifications. For about two days, it was 2 m^3 below the minimum volume of the Technical Specifications. The amount of fuel had decreased during a diesel generator test.

Every operating shift checks and records the amount of fuel in the storage tank. The morning shift of 28 January had recorded 230 m^3 as the amount of fuel left and the evening shift had recorded 228 m^3. The morning shift did not notice that the fuel level was approaching the level of the Technical Specifications and the evening shift did not notice that it had gone below it. The amount of fuel recorded by the next four shifts was identical (228 m^3); the fact that the fuel level had decreased below authorised level went unnoticed. In a weekly checking, on 30 January, it was detected that the fuel level in the storage tank had decreased from 242 m^3 to 228 m^3 during the week, and that it was below the limit of the Technical Specifications.

Both plant units have four diesel generators generating reserve power for the plant units in case the off-site power is lost. The plant unit was operating at full power in this case and there was no need to start the diesel generators. The 230 m^3 of fuel in the storage tank suffices for seven days of generator operation, which has been a criterion in the plant's design. In addition to the storage tank, the diesel generators have their own day tanks, with ca. 4 m^3 fuel in each. The total amount of fuel would have lasted for seven days of operation.

The licensee informed STUK about the event in a daily report sent on 31 January 2000 and later submitted a report on it and the measures planned to prevent its recurrence. The deficiencies most significant for safety were found in limit value monitoring. The fuel level was below the limit of the Technical Specifications several times, unnoticed. This was because the measurement values recorded had not been compared with the set limit. That the limit value went undetected was because circulating written lists are used in the monitoring of the diesel fuel level and because the limit values are not automatically monitored. As a result of the event, the limit values were marked on the indicators. The licensee will also look into the modernisation of monitoring. The event was rated Level 0 on the INES Scale.

A liquid sewage collection tank broke at Olkiluoto

It was detected on 17 January 2000 that the liquid sewage collection tank of the medium-level waste storage onsite the Olkiluoto facility, i.e. the KAJ store, was leaking. The leak was detected during the tank's yearly emptying during which sewage from the tank is sucked into a transport container and taken to the facility's liquid sewage treatment unit.

In the KAJ store, radioactive waste and components are treated and temporarily stored. The 3 m^3 fibreglass tank was located beneath the floor of the storage, at ca. 1.5 meters' depth. It contained sewage from the storage building's sinks and floor washing water.

The tank was dug up and the radioactivity of the surrounding soil was measured. Ca. 5 m^3 of sand in the tank's immediate vicinity was mildly contaminated. No radioactivity in excess of natural background radiation was measured in core samples taken in the environment of the area.

The contaminated soil was placed in drums and handled as radioactive waste in accordance with regulatory guidelines. Plans are to replace the tank with a new one. Until that, a movable tank will be used.

The licensee reported the event to STUK. It had no bearing on the radiation safety of the personnel or the environment and was classified Level 0 on the INES Scale.

The connectors of boards in the neutron flux monitoring system had been incorrectly installed at the Olkiluoto plant units

Two unnecessary trippings of one reactor scram condition were observed at Olkiluoto 1 in 1999. Both took place during a periodic testing of the neutron flux monitoring system. No reactor scrams occurred since only one of the system's four channels was tested at a time. The two trippings were attributed to errors made during the installation of the receptacle connectors for electronics boards.

The neutron flux monitoring system of the reactor of Olkiluoto 1 was upgraded in 1997 and that of Olkiluoto 2 in 1998. The system, which uses programmable technology, trips the scram condition when the neutron flux exceeds a certain limit. All of the system's four channels have an electronics board with traditional hard-wired technology, to assure the functioning of protection limits that have been implemented using programmable technology. An unsuitable type of connection sleeve had been used in the assemblage of receptacle connectors on the back of the boards. In addition, the installation method was incorrect and the connecting wires were too thick. The incorrect installations caused a contact disturbance during testing and tripped a scram condition during the detachment of the testing device's connector from an electronics board. The problem was detected in periodic tests in 1999 after the boards to be inserted into receptacle connectors had been replaced with a card type having improved protection functions.

The installations at both plant units were corrected in the annual maintenance outages of 2000. During the outages the licensee also checked other connections in the neutron flux measuring system and ascertained them to be in order.

STUK reviewed the repair plan and work as well as documents containing the inspection results. The event has been assigned Level 0 on the INES Scale.

A heater in the off-gas filtering system of Olkiluoto 1 was isolated for preventive maintenance in violation of the Technical Specifications

A heater in the off-gas filtering system of Olkiluoto 1 was isolated for preventive maintenance during power operation on 26 July 2000, which is against the Technical Specifications. The heater is allowed to be unavailable during plant operation for three days owing to a failure but it may not be removed from service for maintenance. It was isolated for about three hours for calibration of the temperature detectors of its electrical heating elements.

The heater is located in the auxiliary ventilation section of the off-gas filtering system that contributes to the emergency ventilation function of the control building. The auxiliary ventilation section comprises four parallel sets of filters and four fans. The filter sets consist of a drop separator, a heater as well as particle and active carbon filters for separating mechanical impurities, iodine and methylic iodide. Air is warmed up before it enters the set of filters because humidity impairs the mechanical endurance of particle filters and reduces the separating capacity of active carbon filters.

Analyses by the licensee and STUK have ascertained that in 1999 all heaters of the off-gas filtering system of Olkiluoto 1 had been isolated in a corresponding way, in violation of the Technical Specifications. There have been brief isolations even on earlier occasions to allow for the measuring of the insulation resistance of heating resistors and the calibration of overheating protection. These isolations have been of minor safety significance only. The last event has been assigned Level 0 on the INES Scale.

The licensee informed STUK about the preventive maintenance of the heater in a daily report of 27 July 2000. STUK's resident inspector investigated the matter onsite and the licensee launched an investigation into these recurrent deviations from the Technical Specifications. The investigation attributed the event to both established practice and the inambiguity of the Technical Specifications. To prevent recurrence the licensee will amend the Technical Specifications and instructions. It also listed some preventive maintenance procedures applied to other systems, which could be against the Technical Specifications. A need to alter one preventive maintenance procedure was identified.

4.2.4 Event investigation

In 1999 the number of situations in violation of the Technical Specifications increased at Olkiluoto facility, as compared with the previous years. An investigation was conducted into the underlying common factors and their causes; both Loviisa and Olkiluoto nuclear power plants were looked into. The results are described in subsection 4.1.4.

The investigation at the Olkiluoto plant units also focused on common cause failures based on human error whose number was on the increase in comparison with the previous years. A common cause failure is a failure in mutually parallel subsystems, or their components, that is attributable to one cause. The following, among others, were considered human errors: design errors as well as incorrect working methods and installations. The investigation utilised the failure database of Olkiluoto nuclear power plant.

The aim was to find out why the number of events is growing and to assess the common cause analysis method used by the licensee as well as the way common cause failures have been considered in the plant units' probabilistic safety analyses (PSA).

These common cause failures have been of minor significance for the facility's operation since none of them have been assessed to have any bearing on plant operation. From the viewpoint of system operation, three failures had no significance, three would have resulted in incomplete or incorrect system operation (mostly measurement errors) and three rendered two or more subsystems unavailable.

The investigation showed that the growth in common cause failures was, at practical level, caused by the same reasons that had increased plant situations in violation of the Technical Specifications (subsection 4.1.4). From the viewpoint of common-cause failure analysis it was noted that, where PSA is concerned, the modelling of human-error based common-cause failures is particularly demanding. Operating experience from one facility is not sufficient to make a reliable database; world-wide data gathering is needed.

4.2.5 Deviations from the Technical Specifications

Two events occurred at Olkiluoto during which the plant unit's state was in violation of the Technical Specifications:

- The volume of back-up diesel fuel in the storage tank
- Isolation of a heater in the off-gas filtering system for preventive maintenance at Olkiluoto 1.

Descriptions of the events are given in subsection 4.2.3.

The licensee has planned, or has already implemented, measures to prevent recurrence, as described in subsection 4.2.3. Fig. 14 gives the number of plant situations in violation of the Technical Specifications over the past years.

The Technical Specifications were deviated from by virtue of exemptions granted by STUK. In 2000 STUK granted five such exemptions for the Olkiluoto plant units; two applications were refused. The yearly number of exemptions is given in Fig. 15.

4.2.6 Safety improvements

Provision for severe accidents

Several projects in provision for severe accidents (STUK-B-YTO 202, 2000) have been pending at both Olkiluoto plant units. Of these, those planned to the containment spray system were due for implementation in 2000. After their completion, the addition of lye to the spraying water during an accident will be possible to prevent evaporation of radioactive iodine from the containment pools. This is to ensure that no radioactive iodine escapes to the environment in connection with a containment pressure reduction, for example. STUK approved the documents for the modification in early 2001, whereafter the licensee will be able to begin work on the system modification.

Carbon-14 and tritium samplers commissioned at the Olkiluoto plant units

Continuous-operation carbon-14 and tritium samplers in the off-gas stacks of both units of Olkiluoto nuclear power plant have been commissioned. They improve the monitoring reliability of carbon-14 and tritium releases into the atmosphere.

Tritium, the heaviest hydrogen isotope, is formed in the reactor. Tritium generally combines with a water molecule. Carbon-14, i.e. a radioactive carbon isotope, is also formed in the reactor core. It mainly combines with carbon dioxide and certain hydrocarbons. Small amounts of these beta-active isotopes are measured in gaseous effluents.

The Olkiluoto plant units used to determine carbon-14 releases separately, using a calculatory method based on an earlier measurement campaign. A calculatory method could be used because carbon-14 formation in the reactor core is steady. The determination of tritium releases was based on regular sampling. With new continuous-operation samplers, release determination is based on information yielded by an air sample over the entire sampling period.

The new equipment collects exhaust air from the sampling line of the plant unit's exhaust air stack. To obtain a sample, the exhaust air to be analysed is circulated through sampling bottles containing cooled absorption solution. The samples are analysed in a laboratory for measurement of their carbon-14 and tritium content.

STUK reviewed design documents concerning the equipment and their installation and oversaw the commissioning of the equipment.

The measurement computer systems of Olkiluoto plant units were renewed

The measurement computer system of Olkiluoto 1 was renewed in the 2000 annual maintenance outage. This equipment facilitates the work of the operating and maintenance personnel in the monitoring and analysis of the course of plant events as well as makes possible the analysis of data thus gathered.

The old system has normally been in stand-by state and has been activated by specific alarm signals to collect data on important plant parameters during disturbances. The system has also been used to record plant unit operation during special events, such as important tests. It has collected data yielded by more than 200 analogue and 16 binary signals. The licensee decided to renew the system's data collection and handling equipment to enhance system availability and maintainability.

For measurement data collection the new system uses programmable logic processors whose sampling capacity far exceeds that of the old system. Data from the processors is transferred to individual workstations. The data is continuously gathered and the memory always contains an entire week's event history. For data analysis, there is access from the workstations to applicable analysis software.

The measurement computer system of Olkiluoto 2 is due for renewal in 2001.

The system only indirectly affects safety and the modifications have not been noted to be directly connected with safety systems. STUK's control thus mostly pertains to reviewing the description of the modified system after the modification's implementation.

4.2.7 Probabilistic safety analyses

Flood risk analysis

STUK has reviewed the flood risk analysis for the Olkiluoto plant units. The flood risk estimate for the plant, while in power operation, is ca. 1% of assessed plant core melt frequency.

Flood risk analysis deals with flood events internal to the plant during power operation arising from tank and piping ruptures or component malfunctions, for example. Flood events internal to the plant during outages are dealt with in outage risk analysis, and floods due to external events are included in weather risk analysis.

Apart from system failures arising from a flood-initiating event, the spreading of flooding to several subsystems important to safety is also a factor critical to the reliability of flood risk analysis. The most significant rooms important to safety at Olkiluoto facility are pump those located in the auxiliary building since the cooling systems needed in the removal of reactor decay heat are located in the auxiliary buildings. Flood events in the auxiliary buildings contribute to ca. 84% of the flood risk estimate.

No modifications have been implemented at the Olkiluoto facility on the basis of flood risk analysis so far because flood risk is small according to the licensee. The estimates made by STUK support this view.

4.2.8 Radiation safety

The radiation doses of those who worked at Olkiluoto nuclear power plant in 2000 were below the annual limit of 50 mSv. The distribution of individual doses in 2000 is given in Table II. The highest individual dose at Olkiluoto nuclear power plant was 14.9 mSv. It has been received while working at Olkiluoto 1 and 2 during their annual maintenance outages. The highest individual dose during the Olkiluoto 1 annual maintenance outage was 11.4 mSv and during that of Olkiluoto 2 it was 11.9 mSv. No individual dose exceeded the 100 mSv dose limit applied to any 5-year period.

The collective occupational exposure in 2000 was 1.72 manSv. Collective occupational dose over the past years is given in Fig. 16. It mainly

Table IV. Options for the new reactor.

Facility	Type	Output	Supplier
ABWR	BWR	1400 MW	General Electric, USA
BWR 90+	BWR	1500 MW	Westinghouse Atom, Sweden
SWR 1000	BWR	1000 MW	Framatome ANP, France (designed by former Siemens, Germany)
AP1000/EP1000	PWR	1000 MW	Westinghouse Electric, USA
EPR	PWR	1500 MW	Framatome ANP, France (designed by former Nuclear Power International, a Framatome/Siemens joint effort)
VVER 91/99	PWR	1000 MW	Atomstroyexport, Russia

accumulates in outage work. The collective radiation dose was 0.87 manSv during the Olkiluoto 1 annual maintenance outage and 0.67 manSv during that of Olkiluoto 2. Fig. 17 gives the collective occupational dose incurred in the annual maintenance outages of the Olkiluoto plant units. STUK guidelines state that the threshold for one plant unit's collective dose is 2.10 manSv, averaged over two successive years. In 1999 the collective occupational dose was 0.49 manSv at Olkiluoto 1 and 0.45 manSv at Olkiluoto 2.

Radioactive releases into the environment from Olkiluoto nuclear power plant in 2000 were well below authorised limits. The releases of gaseous radioactive effluents were 0.002% and iodine releases 0.07% of authorised limits. The total activity of liquid effluents was 1.0 GBq, i.e. ca. 6% of the release limit. The total activity of other liquid effluents was 1.1%, which is ca. 0.4% of the plant-specific release limit. Measured radioactive releases are given in Table III.

The radiation dose calculated for the most exposed individual in the environment of the plant on the basis of releases was ca. 0.08% of a limit (100 µSv) that has been established by a Council of State decision

Environmental radiation monitoring around a nuclear power plant comprises on- and offsite measurements as well as determination of radioactive substances to establish the population radiation exposure and the amount of radioactive substances present in the environment.

In the environment of Olkiluoto nuclear power plant, 295 samples were analysed in accordance with a monitoring programme. Radioactive substances originating in Olkiluoto plant were measurable in two samples of deposition, one sample of deposited material, one sample of lichen, two samples of bottom fauna, one sea water sample and 16 samples of aquatic plants and 15 samples of sinking matter. Cobalt-60 was a dominating radionuclide, originating in the plant, measured in all of the aforementioned samples, except for the sample of deposited material. The total number of observations was 37. The next most common radionuclide was manganese-54 of which there were nine observations in aquatic plants. In three samples of aquatic plants, also another radioactive cobalt isotope, cobalt-58, was detected. An elevated tritium concentration was observed in one sample of deposited material and in one sample of sea water.

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

In addition, 12 measurements were made to verify external radiation in the environment of Olkiluoto nuclear power plant.

4.3 Fifth reactor in planning

Teollisuuden Voima Oy on 15 November submitted to the Council of State an application for a decision in principle for the construction of a new nuclear power plant unit. The application is for a nuclear power plant unit that is either a boiling water (BWR) or a pressurised water (PWR) type of light water reactor. The plant unit's output would be 1000–1600 MW, depending on the plant type. Plans are to place the new unit either in Loviisa or Olkiluoto. Teollisuuden Voima Oy has clarified the technical and economic applicability to the Finnish circumstances of the six different plant alternatives listed in Table IV.

The Ministry of Trade and Industry requested from STUK a preliminary safety assessment of the application for the decision in principle. STUK had prepared for the issuance of the safety assessment by discussing with Teollisuuden Voima Oy and the plant suppliers the types of light water reactor available and how they would meet Finnish safety requirements. During the talks certain requirements in the Finnish regulatory guides, written down in fairly general terms, were made technically more detailed.

4.4 Other nuclear facilities

STUK regulates also the FiR 1 research reactor operated by the Technical Research Centre of Finland (VTT). 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 treatment of brain tumours by neutron irradiation (BNCT, Boron Neutron Capture Therapy).

STUK's regulatory work is focused on the reactor's QA, operation, radiation protection, radioactive releases, fire protection, emergency preparedness, physical protection and safeguards, among others. Out of the proposal of VTT Chemical Technology, STUK in March 2000 approved new operators for the reactor. No significant problems were observed in its operation in 2000. Occupational radiation doses and radioactive releases into the environment were clearly below set limits.

The performance figures of the BNCT irradiation unit of the reactor are good. However, in 2000 the FiR 1's operating organisation begun an investigation into a power uprate test to improve the performance figures and submitted to the Ministry of Trade and Industry a report on the licensing arrangements of a power uprate test. STUK has followed the power uprating project and handled certain safety questions related to it.

The regulation of nuclear facilities relating to nuclear waste management, e.g. storage space, are discussed in chapter 5.

5 NUCLEAR WASTE REGULATION

5.1 Spent nuclear fuel

STUK monitored the storage of spent nuclear fuel by regular inspections and by reviewing plans and witnessing work pertaining to storage equipment. No storage-related events occurred that would have endangered safety. The yearly volumes of spent fuel stored onsite are given in Figure 19.

Work on an extension to a pool storage for spent nuclear fuel was completed at Loviisa nuclear power plant. Owing to the new storage extension, the intermediate storage capacity onsite Loviisa plant increased to 610 tU. The storage extension will be subject to regular periodic inspections by STUK.

Posiva Oy, a company owned by Fortum Power and Heat Oy and Teollisuuden Voima Oy, carries out R&D and planning into spent fuel disposal and prepares for implementation at a later date. The company in May 1999 submitted an application for a decision in principle about the construction of a final disposal facility in Olkiluoto, approved by the Council of State in December 2000. In January 2000 STUK presented to the Ministry of Trade and Industry a preliminary safety appraisal on the application for the decision in principle.

Further main objects in the final disposal project are to start facility construction in early 2010 and to commission it in early 2020. During

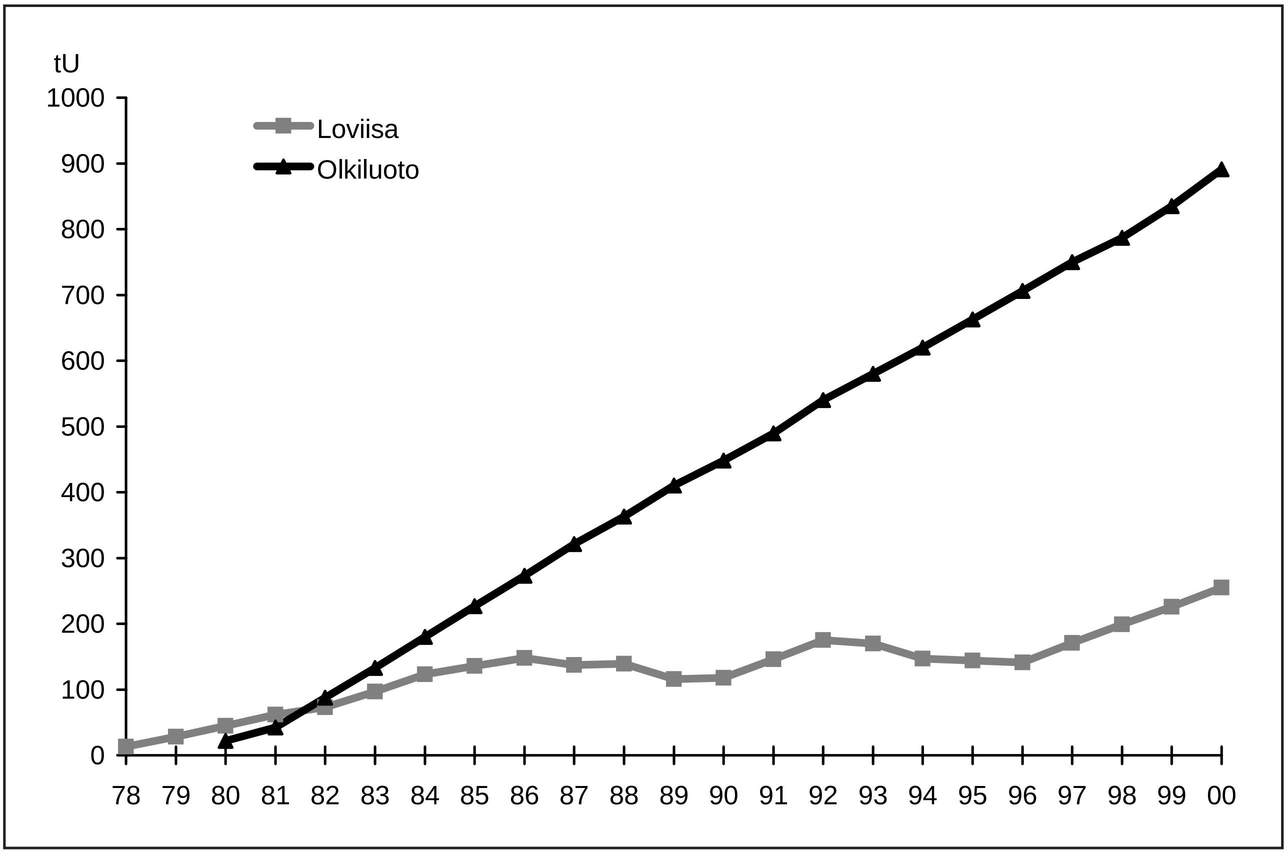

Fig 19. *The volume of spent nuclear fuel on plant sites at the end of the year.*

the next 10 years, Posiva plans to implement an extensive research, development and design programme to assure site suitability and to obtain research data ensuring safe final disposal. The research programme includes the construction of an underground research facility in Olkiluoto.

The focusing of research activities on one final disposal site means STUK's regulatory effort in this field will be stepped up. Posiva's research reports and bedrock investigations in Olkiluoto in particular have been followed in more detail than before. In a statement about the nuclear waste management programme of the licensees STUK gave its opinion about the R&D needs in the period between a possible decision in principle and an application for a construction licence. In addition, STUK completed a framework plan on nuclear waste research that supports the regulatory effort. STUK audited Posiva's quality system in 2000 and made some remarks to develop it.

5.2 Reactor waste

Fortum Power and Heat Oy plans to build on the site of Loviisa nuclear power plant a solidification facility for medium level waste, since the plant's onsite storages for liquid waste are nearly filled to capacity. A Preliminary Safety Analysis Report for the facility was submitted to STUK for review, which was completed by the end of the year.

During reactor waste handling and storage inspections, STUK made remarks on the safety classification of systems intended for the measurement of i.a. waste activity. An inspection of the final disposal of reactor waste gave no cause for remarks.

By STUK's permission, scrap metal, maintenance waste, waste oil, washing agent and sewage-saturated sand from nuclear power plants were cleared from regulatory control. The licences issued by STUK are listed in Appendix 3.

No safety-related problems occurred in the handling, storage and final disposal of reactor waste. Yearly waste volumes are given in Figure 20.

5.3 Decommissioning

By virtue of a 1991 decision by the Ministry of Trade and Industry, decommissioning plans for domestic nuclear power plants are to be maintained and updated plans are to be reported every five years. Such plans were last reported in late 1998 and STUK gave a statement about them to the Ministry in 1999. STUK's statement on the safety assessment concerning the final disposal of decommissioning waste was postponed, however, until a report on it by VTT Energy was available in early 2000. STUK in its statement considered that plans for the final disposal of decommissioning waste from Loviisa power plant could be based on the kind of policy decision presented in the 1998 decommissioning plan. STUK also made some remarks with an eye to the further planning of the final disposal concept and safety studies.

5.4 Other control activities

STUK gave to the Ministry of Trade and Industry a statement, as referred to in section 78 of the Nuclear Energy Decree, about the licensees' nuclear waste management measures and plans as well as a statement, as referred to in section 90 of the Nuclear Energy Decree, about making financial provision for the costs of nuclear waste management. These regular statements assess whether, in preparing for nuclear waste management, the licensees have proceeded according to goals set out by the government. At the same time, provision made for the future cost of nuclear waste is being assessed.

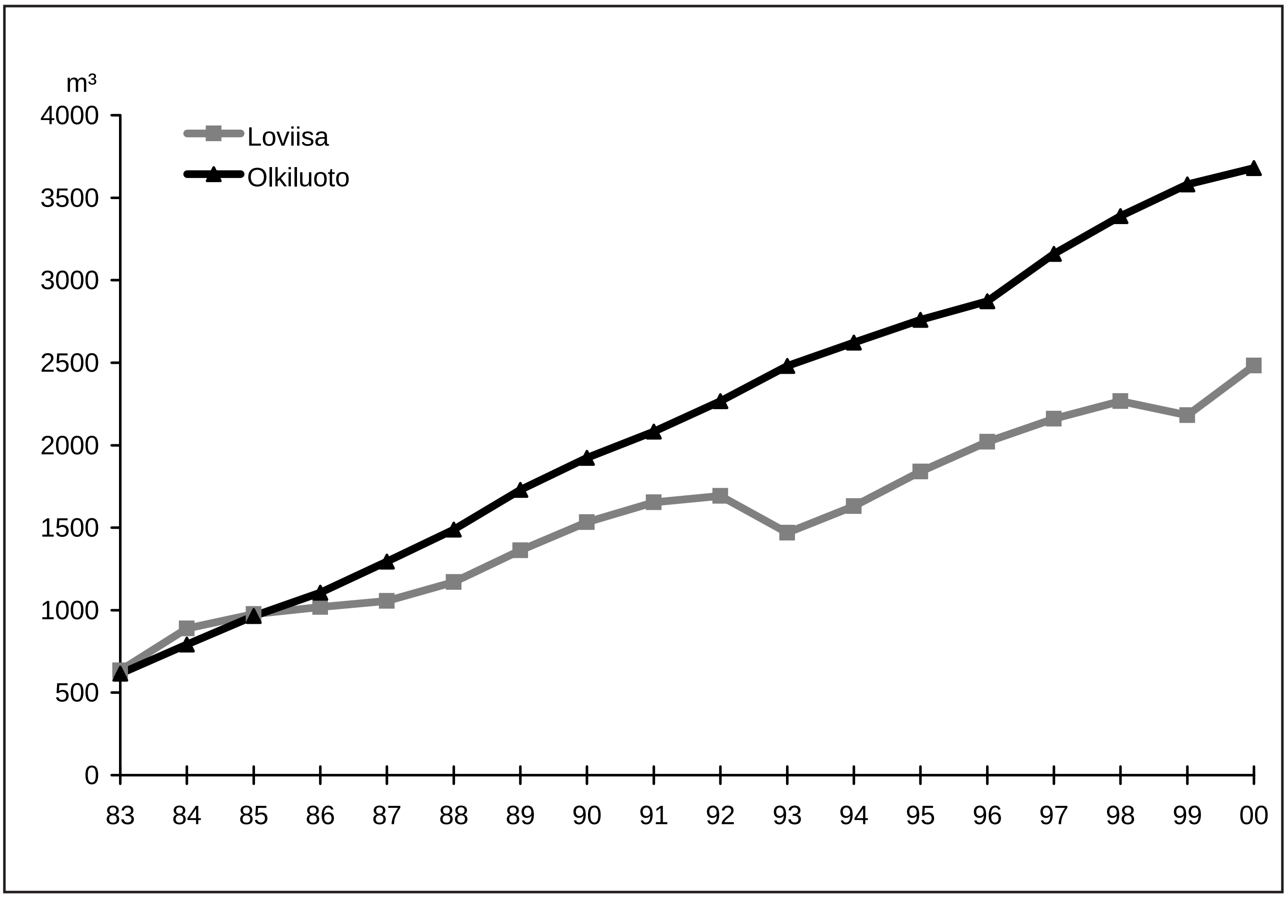

Fig 20. *The volume of reactor waste at the end of the year.*

6 NUCLEAR MATERIALS REGULATION

6.1 Safeguards at Finnish nuclear facilities

Nuclear material safeguards assure the safety of operations and that nuclear materials are not diverted from licensed, peaceful uses and also that operations comply with current rules and regulations as well as international agreements signed by Finland.

As regards nuclear power plants, STUK's safeguards focused on the import, storage, domestic transfer and reloading of fuel. The utilities submit to STUK the necessary annual plans, advance notices and reports in compliance with safeguards requirements.

The number of safeguards inspections at Loviisa nuclear power plant in 2000 was 13 and at Olkiluoto nuclear power plant it was 15. Euratom participated in 22 of them, using 26 man-days. The IAEA took part in 15 inspections, using 18 man-days. Both reactor units of Loviisa nuclear power plant, the fresh fuel storage and the two spent fuel storages comprise one unit in nuclear material accounting, i.e. a material balance area. Olkiluoto nuclear power plant has three material balance areas: Olkiluoto 1, Olkiluoto 2 and a spent fuel storage.

In addition to the nuclear power plants, minor amounts of nuclear material can be found at other facilities. The most significant of these is FiR 1, the research reactor operated by the VTT. Also the following are in possession of small amounts of nuclear materials: the Laboratory of Radiochemistry at the Department of Chemistry of the University of Helsinki, VTT Manufacturing Technology, the Laboratory of Isotope Geology of the Geological Survey of Finland and STUK. In 2000 one inspection was conducted on FiR 1.

Safeguards employs several verification methods to ascertain that the nuclear materials data given by the users, such as burn-out and cooling time, are correct and complete. Even other matters relating to nuclear safety, ranging from operational safety to final disposal, can be verified by measurements. In 2000 STUK verified by NDA (non-destructive assay) measurement 42 spent fuel assemblies at Olkiluoto nuclear power plant. At Loviisa nuclear power plant, 1199 spent fuel assemblies were verified. At Loviisa plant, the Scanning-SFAT method, developed by STUK, can be used that makes possible the verification of ca. 1000 fuel assemblies a day.

International safeguards is implemented by the IAEA and the Euratom Safeguards Office (Euratom). IAEA safeguards are based on the Non-Proliferation Treaty and the Safeguards Agreement signed by non-nuclear EU member states, Euratom and the IAEA (INFCIRC/193). Euratom safeguards are based on the Euratom Treaty and Commission Regulation 3227/76 given by virtue of the Treaty. STUK always takes part in inspections carried out by international organisations.

Euratom and the IAEA have agreed on co-operation in the field of inspections (New Partnership Approach, NPA). At practical level, Euratom and the IAEA co-operate in the conducting of inspections in all material balance areas. Euratom carries out routine inspections at Olkiluoto 1 and 2 but the inspections of the KPA storage, which are made at the same time, have participants from both Euratom and the IAEA.

Operation in all material balance areas was in accordance with manuals approved by STUK, facilitating the implementation by STUK of the obligations of international nuclear agreements signed by Finland. In 1999 Euratom and the IAEA delivered to STUK 28 Euratom inspection reports and IAEA reports. According to the reports national obligations had been fulfilled in compliance with INFCIRC/193.

After the disclosure of the Iraqi nuclear weapons programme, the IAEA launched an extensive programme to strengthen the safeguards system. Where administration is concerned, the programme is based on the Model Protocol Additional (INFCIRC/540). Finland ratified the Protocol on 30 June 2000 and is thus equipped to implement safeguards in accordance with it. The Protocol will simultaneously take effect in all non-nuclear EU member countries.

6.2 Control of radioactive materials transport

About 20 000 radioactive packages are transported in Finland every year. STUK is not aware of any transport accidents involving radioactive materials, or of any other safety hazards. The transport of nuclear materials requires a licence granted by STUK. A prerequisite for the licence is, among other things, that nuclear liability insurance and sufficient physical protection are in place. STUK did not grant any new nuclear transport licences in 2000 since those applied for earlier were still valid. STUK approved four transport plans. Three of them were for fresh nuclear fuel and one was for irradiated fuel rods for research purposes. STUK approved four package types for use in Finland. The most important form of nuclear material transport in 2000 was the import of fresh nuclear fuel (a total of 248 fuel assemblies) from Germany and Spain for use at the Finnish nuclear power plants and the export of two leaking fuel rods to Studsvik, Sweden, for examination.

The importation of radioactive and nuclear materials is subject to licence. No attempts at nuclear smuggling were observed at the Finnish borders in 2000 but a few, obviously inadvertent cases surfaced.

In 2000 three shipments containing radioactive material were turned back at the border. One of them contained scrap metal for industrial use and two were lumber carriages with a contaminated metal structure. In addition, minor radioactivity was detected in two consignments of scrap metal after their entry in Finland. According to current usage, consignments cannot be turned back once they have passed the customs.

Figure 21 gives the yearly number of consignments turned back at the border. Three consignments were turned back at the border in 2000. The number is smaller than in previous years, partly because consignors and consignees have, through training and experience, come to understand the possibility of radioactivity in consignments of scrap metal. Control at the borders has been enhanced as well.

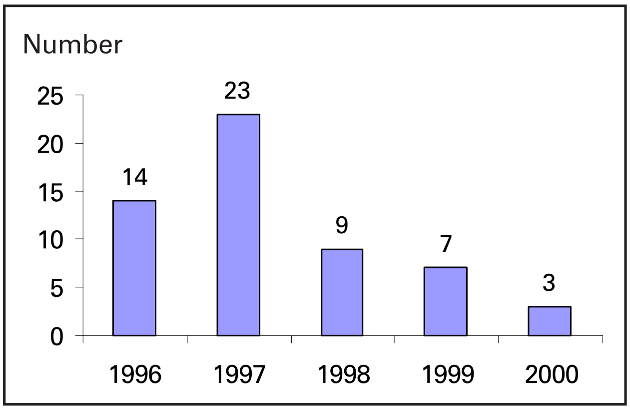

Fig 21. *The number of consignments containing radioactive materials turned back at the border.*

7 INTERNATIONAL CO-OPERATION

IRRT assessment by the IAEA

An IAEA team of experts visited STUK on 13–24 March 2000 to assess the efficiency of STUK's regulatory effort in ensuring nuclear and radiation safety. The inspection was commissioned by the Ministry of Social Affairs and Health and the Ministry of Trade and Industry. As a result of the assessment, recommendations and proposals for the development of STUK's operations were given. In addition, the team recorded proven STUK procedures. A report on the results of the inspection is available on STUK's Web site.

The team noted i.a. that STUK has no written policy of action to ensure a consistent line of action in dealing with factors endangering safety. According to current usage, action is considered case by case. It was also noted that STUK's inspection effort goes deep into detail and that the inspectors possess a thorough knowledge of the regulated nuclear facilities. The idea was brought forth that this could compromise independence of control.

The team recommended that the periodic inspection programme of nuclear power plants, currently for one year at a time, be revised to cover several years instead. Unannounced inspections were also considered necessary. According to current usage, all inspection dates are agreed upon with the licensee and inspection topics are announced in advance.

The team recommended that STUK be more involved in the control of R&D relating to the final disposal of nuclear waste, for example. Legislation now gives the Ministry of Trade and Ministry quite a leading role in the matter.

The team considered STUK's regulatory effort to be of high quality. The effort to continuously improve quality of operations, and nuclear waste management arrangements were considered especially noteworthy. STUK's procedures relating to a systematic organisation of operations, and a highly developed internal quality system were considered exemplary.

STUK has taken measures based on the IRRT team's recommendations.

Co-operation with the IAEA

The IAEA continues revision of its nuclear safety regulations (NUSS Guides). STUK prepared for the IAEA several statements on draft guides that had been requested from Finland (see Appendix 4). On request STUK’s experts participated in the preparation of the draft guides.

A report on how the obligations of the International Nuclear Safety Convention have been met is to be submitted every three years, according to the Convention. The first meeting to evaluate national reports was in 1999. STUK began preparation of the next report at the end of 2000.

A representative of STUK in 1998–1999 functioned as an advisor to the director general of the IAEA in safeguards-related matters. The director general invited the expert in question to continue for the period 2000–2001.

Via the nuclear power plant Incident Reporting System (IRS), maintained by the IAEA and the OECD/NEA, 73 reports were received. By means of the system, nuclear power plant operational events and observations that may give an impulse to safety improvements at other nuclear power plants are communicated to participating countries. STUK is the co-ordinating organisation in Finland. The reports are stored in a database (AIRS, Advanced Incident Reporting System) that contained ca. 2900 event reports at the end of 2000. In Finland, the database is available for use by STUK and the licensees. The reports were assessed by STUK and the licensees. The reports assessed 2000 did not give any reason for significant changes in plant structures or operational practices at Finnish nuclear power plants.

STUK is a contact organisation in an information exchange system maintained by the IAEA for the events at research reactor facilities (IRSRR, Incident Reporting System for Research Reactors). The system's operation is in it's early stages and in 2000 several countries submitted reports on the previous years' events. Finland reported an event, “Incorrect procedures during irradiation of a sample at FiR 1 reactor”, which occurred on 23 September 1994 at the FiR 1 reactor operated by the Technical Research Centre of Finland.

The IAEA communicated through the INES information exchange system (INES, International Nuclear Event Scale) information on 26 events, two of which pertained to the assignment of a final Level to two events in 1999. Events that are at least Level 2, or above, on the INES Scale or which are, or may be, of interest internationally are reported to the IAEA. STUK is the Finnish contact organisation for the INES system. Of the events that took place in 2000, 13 occurred at nuclear power plants. The severest of them was classified Level 2. An accident assigned to Level 4 (preliminary classification) occurred in Egypt in June during the handling of a radioactive source. The source, heavily emitting Ir-192, had fallen into wrong hands, resulting in the death of two and the significant exposure to radiation of five persons. Other events during the use of radiation or at places other than nuclear power plants involved losses of radiation sources. They were mostly classified Level 1. In 2000 Finland submitted no reports to the INES System, however, a STUK report on a leak of mildly radioactive water at Loviisa nuclear power plant on 17 August 2000 was disseminated through the INES system after STUK had submitted it to an IAEA emergency response unit.

STUK hosted an IAEA-financed 14-day international course on the use of nuclear power plant safety assessment as a tool in decision-making. The course was targeted at nuclear power plant employees and safety authorities in Eastern European Countries.

In IAEA expert capacity, STUK's representatives participated in the IRRT assessment of nuclear safety authorities in the Czech Republic, Hungary and China. A representative of STUK has also participated, as an IAEA expert, in training and assistance given to the Armenian nuclear safety authority.

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 between authorities about the need to develop nuclear safety regulations and the contents of individual regulations. STUK was represented in all of the organisation’s main committees:

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

A representative from STUK acted as the chairman of the CNRA. STUK took part in the work of working groups set up by the committees as well.

Co-operation with the EU

STUK participated in the work of Atomic Questions Group (AQG), a working group under the Council of Ministers of the EU, when it assessed nuclear safety in the EU applicant countries.

STUK participated in the work of the following EU working groups: Nuclear Regulators Working Group (NRWG), European Radioactive Waste Regulator's Forum (ERWR), European Nuclear Installations Group (ENIS-G) and the NRWG working group Safety Critical Software.

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

STUK's participated in the work of the Commission's expert group that handles documents submitted by the member states to fulfil their obligations under article 37 of the Euratom Treaty. The article obliges all member states to send to the Commission general information on their radioactive waste disposal plans. This enables the group to assess whether the implementation of the plans could lead to the contamination of water, soil or air within the territory of another member state.

NKS co-operation

The ongoing Nordic nuclear safety research programme (NKS), covers the years 1998–2001. The main research areas are nuclear safety and radiation protection (SOS), emergency response and environmental impacts (BOK) and projects dealing with nuclear threats and dissemination of information (SBA); these further divide into seven projects.

The most important tasks of the SOS programme are the assessment of risks and safety culture in the operation of nuclear power plants as well as severe accident management. The BOK programme and the SBA projects partly pertain to nuclear safety. STUK contributed to the work of steering groups and various study areas of the NKS programme.

Bilateral co-operation

A representative from STUK was a permanent member of the Reactor Safety Committee assisting 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 was continued through meetings during which current questions of nuclear power plant regulation were discussed. With the Swedish radiation safety authority SSI, information exchange was continued concerning doses to Finns who had worked at nuclear power plants in Sweden and to Swedes who had worked at Finnish plants. Liaison during emergency situations was developed in co-operation with SKI and the SSI.

Within the framework of an agreement of co-operation with the US NRC, a wealth of reports in written form were exchanged as in previous years.

The most important form of co-operation with the Belgian nuclear safety authority AIB Vincotte Nuclear (AVN) was participation in the work of an international nuclear safety committee that supports AVN.

Co-operation meetings on PSA and fire studies were arranged with the French nuclear safety authority (DSIN).

Co-operation between STUK and the Russian nuclear safety authority (GAN) in the field of nuclear material and waste control continued based on an arrangement signed in 1998.

Safeguards co-operation with the Australian authority (ASO) continued. In accordance with an established practice, STUK provided ASO with information about nuclear materials of Australian origin imported to and kept in Finland.

A permanent representative from STUK was nominated to the Advisory Committee on Nuclear Safety that assists the Lithuanian nuclear safety authority (VATESI). In addition, STUK's representatives participated in the Licensing Assistance Project (LAP) that supports VATESI in licensing relating to Ignalina nuclear power plant.

Assistance to Central and Eastern European safety authorities

STUK continued to participate in assistance given to radiation and nuclear safety authorities in Central and Eastern Europe under financing from the Ministry for Foreign Affairs and the European Union as well as through from the IAEA.

In association with other EU countries, STUK carries out EU programmes to assist the authorities in Lithuania, Slovakia, the Czech Republic, Ukraine, Hungary and Russia. Earlier programme phases were completed by 2000. The preparation of continuation projects aimed at all of these countries as well as of new projects aimed at Estonia and Lithuania are awaiting for a decision by the Commission of the European Communities. The Commission spent almost all of 2000 in establishing the final form of a comprehensive policy of administration that would include nuclear safety matters and related assistance programmes. At the beginning of 2001 the Commission is expected to be fully prepared again for decision-making pertaining to nuclear safety assistance programmes.

With funding for co-operation with the neighbouring areas from the Ministry for Foreign Affairs, bilateral co-operation programmes were maintained with the nuclear safety authorities of Russia, Estonia, Latvia, Lithuania and Ukraine. Close contacts were maintained with the resident inspectors at Leningrad and Kola nuclear power plants who regularly drew up quarterly reports on plant events, reporting to STUK the situation at the plants in question during their visits to Finland. Visitors from the technical support organisation of the Russian nuclear safety authority were advised on the making of comparative reactor analyses by offering training at the Lappeenranta University of Technology in Finland, in the application of a Finnish simulation programme to a new type of Russian reactor.

In the field of safeguards, there was close cooperation with Russia, Estonia, Latvia, Lithuania and Ukraine. Training offered to boarder control officers and customs officials as well as equipment provided for radioactive materials detection helps reduce the smuggling of radioactive materials.

Enhancement of safety at Easetern European nuclear facilities

STUK administered Finnish-Russian co-operation in the field of radiation and nuclear safety, funded from the Finnish government's budget for co-operation in neighbouring areas. Kola and Leningrad nuclear power plants as well as various radioactive waste storages are the objects of co-operation. STUK plans the projects together with the recipients, invites offers and participates in project control. In addition to work carried out by consultants, STUK's experts actively participate in the making of safety improvements at the plants in question.

These projects continue a long-term programme that emphasises quality of plant operations, fire safety and the integrity of safety-relevant piping as well emergency response and environmental radiation monitoring.

Further information on the projects can be found in the report "Finnish Support Programme for Nuclear Safety, Annual Summary 2000 (STUK 2001)".

STUK's representatives worked in expert groups of the EU and the European Bank for Reconstruction and Development (EBRD), which assessed the appropriateness of some nuclear safety improvement projects for which financing has been sought.

STUK worked in a team of experts (Contact Experts Group, CEG) co-ordinating international projects to improve nuclear waste management in Russia; it participated in the meetings and working groups of CEG as well as in its assessment and consultation work. One major CEG meeting was arranged in Finland. In direct bilateral cooperation with GAN and the Radon combine, STUK continued implementation of programmes to exchange nuclear waste management information and experience. STUK organised for Russian authorities various training events pertaining to nuclear waste and western technology. The specific aim of multilateral international co-operation was to make the assisting countries better informed of one another's nuclear waste projects.

Finland participated in an international project to develop a mobile storage cask for naval radioactive waste for use on the Kola Peninsula. The cask will be a prototype that meets modern safety requirements.

STUK participated in the work of the PIERG (Paldiski International Expert Reference Group) which supports the decommissioning of the nuclear reactors at Paldiski in Estonia and the handling of radioactive waste. Finland assisted the Estonian radiation safety authority by way of bilateral co-operation.

Radiation monitoring in the environment of Leningrad nuclear power plant was enhanced by the installation of additional automatic measurement stations. The network now comprises 25 measurement stations, making possible a nearly real-time monitoring of data by STUK. A corresponding system is being developed for Kola nuclear power plant. For the radiation monitoring network in the environment of Kola nuclear power plant, 15 automatic measurement stations have been installed and commissioned.

The transmission equipment for a satellite-based accident announcement system was renewed at Leningrad nuclear power plant. Both Leningrad and Kola nuclear power plants have this system available for use by the nuclear safety authority, making it possible to quickly relay a notification of an event or accident to STUK.

STUK co-operated with an emergency centre in St Petersburg subordinate to the Russian ministry of energy. In 2000 STUK participated i.a. in the procurement of a ventilation system for the emergency centre's new premises.

In the field of safeguards, there was close co-operation with Russia, Estonia, Latvia, Lithuania and Ukraine. The training and equipment provided by STUK aim at preventing radioactive materials smuggling.

The Comprehensive Nuclear Test Ban Treat (CTBT)

Finland ratified the Comprehensive Nuclear Test Ban Treaty on 15 January 1999. In Finland STUK was given the duties of a National Data Centre, i.e. a responsibility for the verification obligations of the treaty binding the national authority, the Ministry for Foreign Affairs, and for those binding the international authority, i.e. the nuclear test ban organisation (the Comprehensive Nuclear-Test-Ban Treaty Organization, CTBTO). The National Data Centre officially opened on 4 October 1999.

In 2000 the Centre participated in the setting up of an international verification system. Its own operation capabilities were developed: secure data communications and an automatic analysis system were completed. In addition, a description of the Centre's activities was completed. The Centre provided training to personnel from Nordic radiation monitoring stations.

Other forms of co-operation

STUK was active in the work of the Western European Nuclear Regulators' Association (WENRA). WENRA is a body of mutual co-operation set up by the nuclear safety authorities of Western Europe. In 2000 WENRA published a second report on nuclear safety in the EU membership applicant countries. Co-operation continued to establish a common European safety approach in the fields of both reactor safety and nuclear waste management.

STUK continued to contribute to NERS work (Network of Regulators of Countries with Small Nuclear Programmes) and hosted a NERS meeting in 2000. NERS is a body of co-operation set up by the safety authorities of countries with small-scale nuclear programmes. The authorities of the Argentine, Belgium, the Czech Republic, Finland, Hungary, Netherlands, Slovakia, Slovenia, South Africa and Switzerland are contributors to its work. NERS exchanges experiences and ideas on how authorities with small organisations could handle their duties appropriately and efficiently. Possible mutual assistance in regulatory control issues is discussed as well.

STUK has contributed to the VVER Forum, a form of co-operation among countries operating VVER-type nuclear power plants. Other participants were Armenia, Bulgaria, the Czech Republic, Hungary, Russia, Slovakia and Ukraine. Operating experiences from and safety improvements to VVER-type plants are discussed and experience exchanged. The VVER Forum held one meeting in 2000. It has launched a joint project into the service life management of components and buildings of VVER-type plants. It aims at promoting exchange of information on facility service life management among authorities regulating VVER plants as well as to drawing up recommendations for development of regulatory requirements pertaining to service life management. An inspector from STUK participated in the working group's start-up meeting in Kiova.

STUK participated in the preparatory meeting of the DOCUM project launched by the Loviisa Energy Centre. The project aims to develop normative documentation on lifetime management of Russian VVER plants in co-operation with the Russian International Nuclear Safety Center (RINSC) of the Russian Atomic Energy Ministry (MINATOM) and the Russian nuclear safety authority (GAN).

PERIODIC INSPECTION PROGRAMME

APPENDIX 1

A. Safety management

- Definition, maintenance and development of safety culture
- Quality management
- Verification of fulfilment of safety regulations
- Co-operation with authorities

B. Main functions

- Methods employed in working processes and their functionality
- Interfaces between the various stages of working processes
- Feedback contained in the functions and their utilisation
- Support functions, such as training, quality assurance and document administration, relating to the main function under inspection

B.1. Safety assessment and improvement

- Responding to changing safety requirements
- Utilisation of safety research
- Utilisation of operating experience feedback in safety assessment and development
- Modification process and its functionality

B.2. Operations

- Operation
- Supervision of operations
- Management of operational disturbances
- Periodic tests

B.3. Plant maintenance

- Maintenance
- Service life management
- Annual maintenance management
- Procurement
- Administrative work control

C. Inspections by functional unit and field of know-how

C.1. Plant safety functions
C.2. Electrical and I & C systems
C.3. Mechanical engineering
C.4. Construction engineering and structural engineering
C.5. PSA and utilisation of fault statistics
C.6. Information management
C.7. Chemistry
C.8. Nuclear waste
C.9. Radiation protection
C.10. Fire protection
C.11. Emergency preparedness
C.12. Physical protection
C.13. Training
C.14. Quality assurance

APPENDIX 2

TOPICAL INSPECTIONS

- Updates of safety documents
- Competence of personnel
- Abnormal events
- Outage planning and execution
- Reactor reloads
- Conduct and results of inservice inspections
- Inservice examinations of pressure equipment
- Modifications, repairs and preventive maintenance
- Post-outage plant start-up
- Nuclear fuel procurement
- Nuclear material safeguards
- Nuclear waste cleared from regulatory control

Licences and approvals in accordance with the Nuclear Energy Act, and decisions to implement YVL Guides

APPENDIX 3

Licences and approvals in accordance with the Nuclear Energy Act

- C214/219, 16 November 2000,
  Teollisuuden Voima Oy
  Exportation of two irradiated nuclear fuel rods to Studsvik, Sweden, for examination. Max. 30 g of plutonium and 4 kg of enriched uranium. Valid until 31 December 2000.

- C821/68, 17 November 2000,
  Teollisuuden Voima Oy
  The handing over to Ekokem Oy of a $9m^3$ batch of waste oil to be cleared from regulatory control. The oil is from Olkiluoto nuclear power plant and will be used for saw chain oil. Valid until 31 December 2001.

Decisions to implement YVL Guides

- 17/001/99, 15 February 2000,
  Teollisuuden Voima Oy
  Guide YVL 1.10, Requirements for the siting of nuclear power plants

- 17/001/99, 15 February 2000,
  Fortum Power and Heat Oy
  Guide YVL 1.10, Requirements for the siting of nuclear power plants

- 7/001/98, 23 March 2000,
  Teollisuuden Voima Oy
  Guide YVL 1.14, Mechanical equipment and structures of nuclear facilities. Control of manufacturing.

- 7/001/98, 23 March 2000,
  Fortum Power and Heat Oy
  Guide YVL 1.14, Mechanical equipment and structures of nuclear facilities. Control of manufacturing.

- 3/001/97, 30 March 2000,
  Teollisuuden Voima Oy
  Guide YVL 6.9, The national system of accounting for and control of nuclear material.

- 3/001/97, 30 March 2000,
  Fortum Power and Heat Oy
  Guide YVL 6.9, The national system of accounting for and control of nuclear material.

- 3/001/97, 30 March 2000,
  Teollisuuden Voima Oy
  Guide YVL 6.10, Reports to be submitted on nuclear materials

- 3/001/97, 30 March 2000,
  Fortum Power and Heat Oy
  Guide YVL 6.10, Reports to be submitted on nuclear materials

- 4/001/98, 27 April 2000,
  Teollisuuden Voima Oy
  Guide YVL 4.3, Fire protection at nuclear power plants

- 4/001/98, 27 April 2000,
  Fortum Power and Heat Oy
  Guide YVL 4.3, Fire protection at nuclear power plants

APPENDIX 3 Licences and approvals in accordance with the nuclear energy act, and decisions to implement YVL Guides

- 1/001/97, 28 April 2000,
  Teollisuuden Voima Oy
  Guide YVL 6.2, Design bases and general design criteria for nuclear fuel

- 1/001/97, 28 April 2000,
  Fortum Power and Heat Oy
  Guide YVL 6.2, Design bases and general design criteria for nuclear fuel

- 16/001/99, 27 September 2000,
  Teollisuuden Voima Oy
  Guide YVL 1.16, Control of nuclear liability insurance policies

- 16/001/99, 27 September 2000,
  Fortum Power and Heat Oy
  Guide YVL 1.16, Control of nuclear liability insurance policies

- 10/001/99, 27 December 2000,
  Teollisuuden Voima Oy
  Guide YVL 2.1, Nuclear power plant systems, structures and components and their safety classification

- 10/001/99, 27 December 2000,
  Fortum Power and Heat Oy
  Guide YVl 2.1, Nuclear power plant systems, structures and components and their safety classification.

Statements and decisions pertaining to personnel of nuclear power plants

APPENDIX 4

Statements

- Y811/29, 12 January 2000
  A preliminary safety evaluation submitted by STUK to the Ministry of Trade and Industry pertaining to the application by Posiva Oy for a decision in principle on a nuclear fuel repository

- 2 February 2000
  OECD/NEA/CNRA questionnaire on plant upgrading and life extension; Finnish response.

- Y811/23, 4 February 2000
  A statement to the Ministry of Trade and Industry about the licensees' waste management programme for 2000

- 2/000/00, 13 April 2000
  A statement to the Ministry of Trade and Industry about a Council of State decree to modify the Nuclear Energy Decree

- 4/750/00, 27 April 2000
  A statement to the IAEA about the Safety Guide Draft “Organisation and staffing of the regulatory body for nuclear facilities”

- 4/750/00, 27 April 2000
  A statement to the IAEA about the Safety Guide Draft “Regulatory inspection of nuclear facilities and enforcement by the regulatory body”

- 4/750/00, 27 April 2000
  A statement to the IAEA about the Safety Guide Draft “Review and assessment by the regulatory body for nuclear facilities”

- 4/750/00, 27 April 2000
  A statement to the IAEA on the Safety Guide Draft “Documentation produced and required in regulating nuclear facilities”

- A814/8, 12 June 2000
  A statement to the Ministry of Trade and Industry on the commissioning of Loviisa facility, an assessment of the safety of the final disposal of decommissioning waste

- 26/750/00, 30 June 2000
  A statement to the IAEA about the Safety Guide Draft “Dispersion of radioactive material in air and water and consideration of population distribution in site evaluation for nuclear power plants”

- 25/750/00, 24 July 2000
  A statement to the IAEA about the Safety Guide Draft “Maintenance, surveillance and inservice inspection in nuclear power plants”

- Y214/48, 3 September 2000
  A statement to the Ministry of Trade and Industry about VTT Chemistry's application for the exports of thorium-containing pyrochlorine concentrate

- C812/27, 18 October 2000
  A statement to the Ministry of Trade and Industry about the financial provision for nuclear waste management made by Teollisuuden Voima Oy

APPENDIX 4

- A812/26, 19 October 2000
  A statement to the Ministry of Trade and Industry about the financial provision for nuclear waste management made by Fortum Power and Heat Oy

- 35/750/00, 23 October 2000
  A statement to the IAEA about the Safety Guide Draft "Safety of nuclear power plants. Operation: Core management and fuel handling"

- F812/21, 11 December 2000
  A statement to the Ministry of Trade and Industry about the financial provision made by VTT for the management of nuclear waste generated by the research reactor FiR 1

Decisions pertaining to personnel of nuclear power plants

- F113/8, 8 February 2000
  On the application of VTT Chemistry, new operators have been approved for the FiR 1 research reactor, expiry date 31 December 2002.

- A113/100, 23 February 2000; A113/102, 26 April 2000; A113/104, 30 October 2000; A113/105, 20 December 2000
  On the application of Fortum Power and Heat Oy, individuals employed by the applicant have been approved as shift managers or operators

- C113/164, 16 February 2000; C113/165, 24 March 2000; C113/166, 31 March 2000; C113/167, 15 May 2000; C113/170, 26 October 2000
  On the application of Teollisuuden Voima Oy, individuals employed by the applicant have been approved as shift managers or operators

- T121-2/8, 25 April 2000
  On the application of Teollisuuden Voima Oy, individuals employed by Teollisuuden Voima Oy, Inspecta Oy and Huber Testing Oy have been approved to perform structural inspections of OL1/OL2 nuclear power plant components and structures.

- C114/23, 12 June 2000
  On the application of Teollisuuden Voima Oy, Mr Esa Unga, M.Sc. (Tech), has been approved a second substitute responsible manager, as referred to in section 79 of the Nuclear Energy Act (990/1987) and in sections 122–127 of the Nuclear Energy Decree (161/1988), at Olkiluoto nuclear power plant.

- A114/17, 4 July 2000
  On the application of Fortum Power and Heat Oy, Mr Markku Tiitinen, M.Sc (Tech), has been approved a second substitute responsible manager, as referred to in section 79 of the Nuclear Energy Act (990/1987) and in sections 122–127 of the Nuclear Energy Decree (161/1988), at Loviisa nuclear power plant.

- T121-1/29, 27 July 2000
  On the application of Fortum Power and Heat Oy, individuals employed by the applicant have been approved to perform structural, operational and periodic inspections on mechanical equipment and structures at Lo1/Lo2 nuclear facilities as well as to perform commissioning inspections of electrical and I & C systems after repairs and modifications.

Safety research accomplished in 2000

APPENDIX 5

Nuclear power plant safety

Application of the Monte Carlo technique to complex geometries

The TRAB-PLIM computer code; verification of the TRAB-3D code

The HEXTRAN-PLIM computer code; completion of the code using a primary circuit model based on the PLIM solution method

Evaluation of the characteristics and applicability of importance measures for use in risk-informed regulatory control of nuclear power plants

Development of NDT systems qualification; Qualification variables

FNNUS/AGE/FUELI—fuel cladding corrosion mechanism and its modelling, year 1999

FINNUS/AGE/OXI—Modelling of oxide film behaviour and its significance for activity build-up and various corrosion phenomena in nuclear power plants

FINNUS/AGE/ENVI—environmental stress induced rupturing of nuclear power plant materials, year 1999

Development of fuel analysis facilities by utilisation of the FRAPCON-3/FRAPTRAN software package

Safety culture in practice

A cable fire model for a room; completion of the model

Studies in concrete technology for the construction, inspection and repair of bridges and nuclear power plant structures; studies 1999

Review of Loviisa level 2 PSA

Development and qualification of the SCANAIR programme

Development of NDT system qualification; qualification body documents

Development of NDT system qualification; qualification level documents

The effect of fuel burn-up on safety

Generation of organic iodine during severe accidents; paint experiments

Gathering of data via the meteorological towers of Loviisa and Olkiluoto nuclear power plants and data handling by the Finnish Meteorological Institute; a continuation project

Analysis of the Multiverter frequency converters

Modelling of fire situations for use in fire-PSA

The effect of smoke and heat on electronic equipment

An agreement to implement the PALOTUB fire safety project in 1997–98

Licensing of a programmable automation system

Licensing of a programmable automation system; Operating experience analysis

APPENDIX 5 SAFETY RESEARCH ACCOMPLISHED IN 2000

Analysis and combining of deterministic and probabilistic data for use as a basis for decision-making; Development and application of a multiple criteria decision model as part of a decision panel

Development of NDT system qualification; Co-operation in the qualification of NDT systems in Finland. Review of TVO/Siemens qualification documents; 16 October 2000

Nuclear waste management

Assessment of the characterisation of VLJ waste from Olkiluoto

Review of a safety analysis for final disposal of decommissioning waste from Loviisa facility

Palmottu natural analogue project; redox processes and migration 1999

Palmottu natural analogue project; geochemical evaluation 1999

Palmottu natural analogue project; performance assessment studies 1999

Radiation dose estimates from radionuclides released in mines

Geochemical barriers in nuclear waste repositories; the behaviour of high-FeO olivine rock and sorption mechanism of uranium

Groundwater flow paths; fractured rock observations from rock cuts

Natural geochemical concentrations and fluxes on the Baltic Shield in Finland as indicators of nuclear waste repository safety

Review of possible safeguards verification methods for final disposal of nuclear fuel

Calculational modelling of the mechanical and physical phenomena of final disposal in safety assessments

Uranium series research in the assessment of long-term safety

Modelling of the glacial loading

Electric and electrochemical properties of surface films formed on copper in the presence of chloride anions in groundwater

Presence and character study of fractured rock zones in a final repository environment