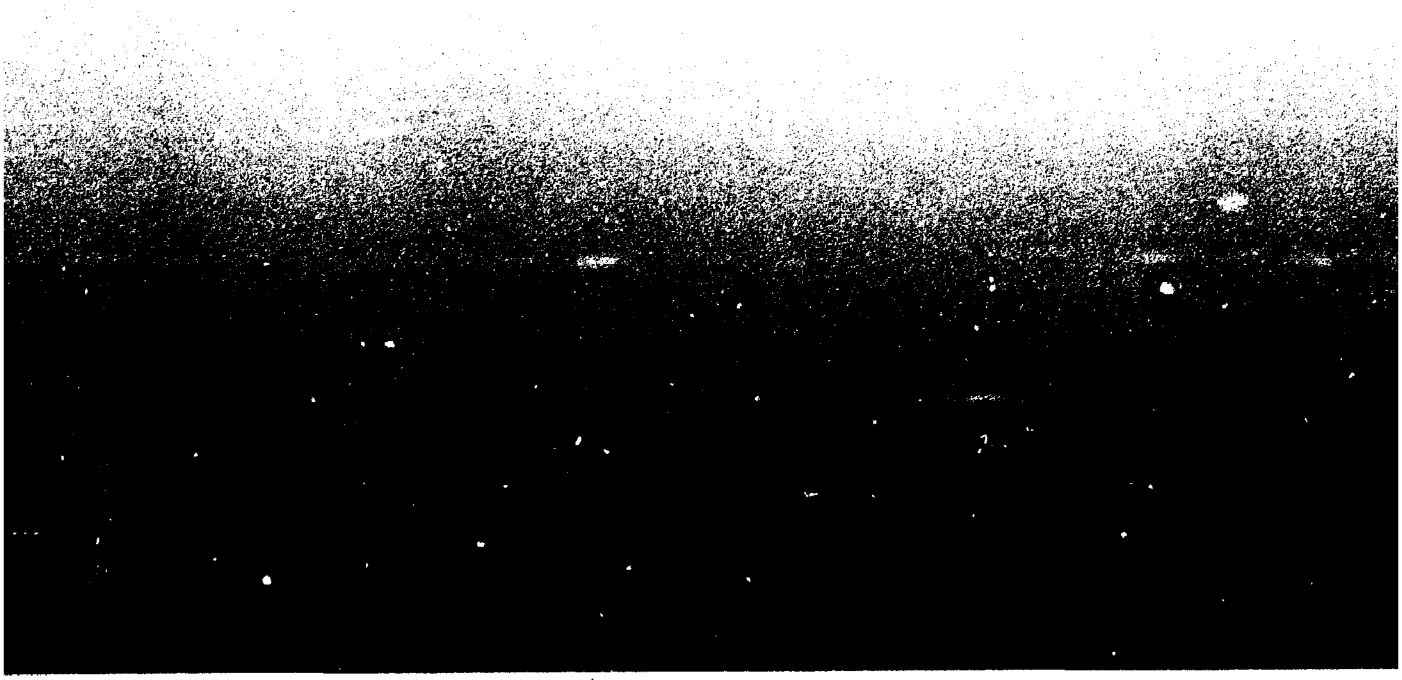
STUK-B-YTO 116

Operation of Finnish nuclear power plants

Quarterly report 3rd quarter, 1993

Kirsti Tossavainen (Ed.)

MARCH 1994



SÄTEILYTURVAKESKUS
Strålsäkerhetscentralen
Finnish Centre for Radiation and Nuclear Safety

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Quarterly report
3rd quarter, 1993

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ABSTRACT

Quarterly Reports on the operation of Finnish nuclear power plants describe nuclear and radiation safety related events and observations which the Finnish Centre for Radiation and Nuclear Safety considers safety significant. Safety improvements at the plant and matters of general interest relating to the use of nuclear energy are also reported. A summary of the radiation safety of plant personnel and the environment, and tabulated data on the plants' production and load factors are also given.

In the third quarter of 1993, all of Finland's four nuclear power plant units were in power operation, with the exception of the annual maintenance outages of the Loviisa units. The load factor average of the plant units was 83.6 %. None of the events which occurred during this annual quarter had any bearing on nuclear or radiation safety.

Emergency cooling system improvements continued at the Loviisa and TVO nuclear power plants since it had been considered possible that, in the event of a pipe break, dislodged piping thermal insulation material could block emergency cooling water circulation.

Occupational doses and radioactive releases off-site were below authorised limits. In samples collected around the plants, only quantities of radioactive material insignificant to radiation exposure were measurable which originated in the plants.

CONTENTS

1 INTRODUCTION

As prescribed by the Nuclear Energy Act (990/87), regulatory control of the use of nuclear energy rests with the Finnish Centre for Radiation and Nuclear Safety. The Centre's functions also include regulatory control of physical protection, emergency preparedness and nuclear material safeguards. The scope of nuclear power plant regulatory control and inspections is specified in Appendix 1. General information about the plants is given in Appendix 2.

The Finnish Centre for Radiation and Nuclear Safety publishes quarterly a report on the operation of Finnish nuclear power plants. The report gives a description of events and observations at the plants during each quarter, tabulated data on the plants' production and availability factors and a summary of the radiation safety of plant personnel and the environment. The report also describes safety improvements at the plants and matters of general interest relating to the use of nuclear energy. The fourth Quarterly Report also contains an annual summary of information reported earlier in the year.

The Report is based on information submitted to the Finnish Centre for Radiation and Nuclear Safety by the utilities and on the Centre's observations during its regulatory activities. The events described in the report are classified on the INES.

2 OPERATION OF NUCLEAR POWER PLANTS IN JULY-SEPTEMBER 1993

The annual maintenance outages of both Loviisa plant units were scheduled for this quarter. These outages excluded, the plant units were in operation for the whole quarter.

2.1 Production data

Nuclear power's share of total electricity production in Finland was 36.7 %. The load factor average of the plant units was 83.6 %.

Detailed production and availability figures are given in Tables I and II.

Power diagrams describing electricity generation by each plant unit and the causes of power reductions are given in Figs 1 - 4.

Table I. Electricity production by and availability of the units.

	Electricity production (gross, TWh)		Availability factor (%)		Load factor (%)	
	Thrid quarter 1993	From start of 1993	Thrid quarter 1993	From start of 1993	Thrid quarter 1993	From start of 1993
Loviisa 1	0.65	2.66	68.2	89.3	63.2	87.3
Loviisa 2	0.75	2.70	75.3	89.3	72.3	88.6
TVO I	1.62	4.54	100.0	95.0	99.7	94.2
TVO II	1.61	4.46	100.0	93.4	99.0	92.6

$$\text{Availability factor} = \frac{\text{generator synchronized (h)}}{\text{calendar time (h)}} \cdot 100\ \%$$

$$\text{Load factor} = \frac{\text{gross electricity production}}{\text{rated power} \cdot \text{calendar time (h)}} \cdot 100\ \%$$

Table II. Nuclear energy in Finnish electricity production.

	Third quarter 1993	From start of 1993	1992	1991
Nuclear electricity production (net, TWh)[a]	4.4	13.7	18.2	18.4
Total electricity production in Finland (net, TWh)[a]	12.0	41.1	54.7	55.2
Nuclear's share of total electricity production (%)	36.7	33.3	33.3	33.3
Load factor averages of Finnish plant units (%)	83.6	90.7	89.2	90.9

a Source: Statistics compiled by the Finnish Association of Electricity Supply Undertakings.

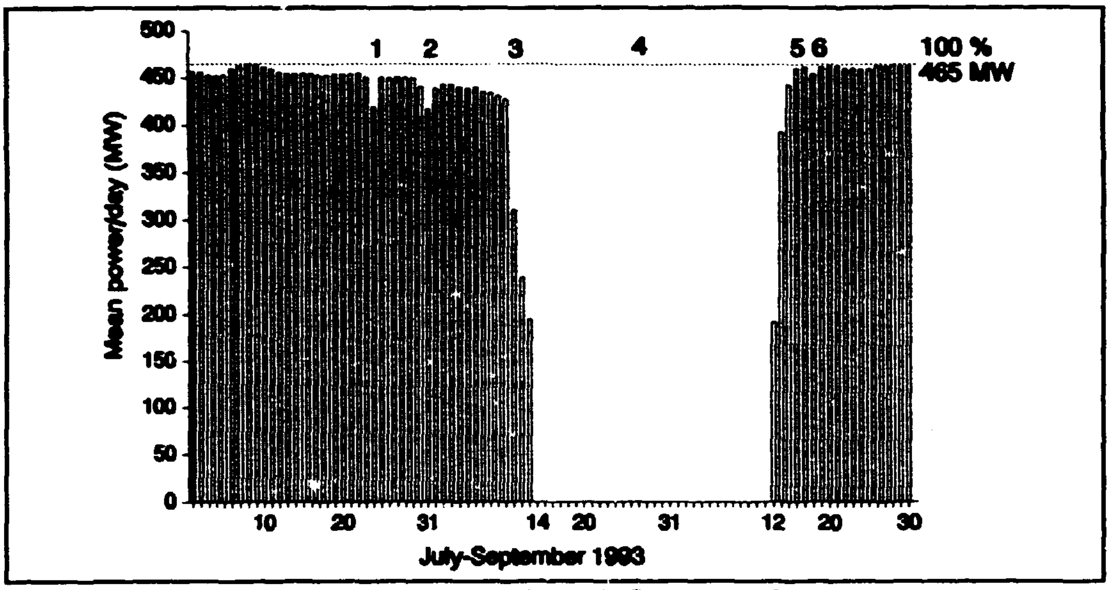

Fig 1. Daily average gross power of Loviisa 1 in July-September 1993.

1 Main steam line safety valve tests, the reactor at 80 % power.
2 One generator taken off the grid to replace a leaking generator breaker safety valve, the reactor at 60 % power.
3 One generator taken off the grid for balancing, the reactor at 50 % power.
4 Annual maintenance outage (see chapter 2.2).
5 Unreliable operation of a main steam line isolation valve clarified, the reactor at 80 % power.
6 Boron content of the primary circuit exceeded set limits, the reactor at 80 % power.

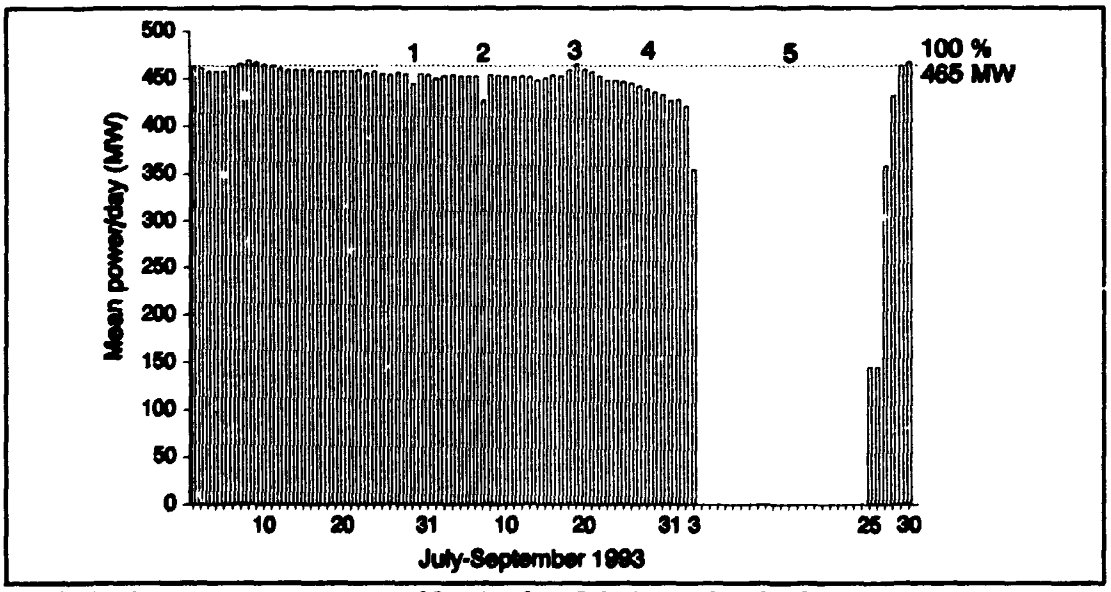

Fig 2. Daily average gross power of Loviisa 2 in July-September 1993.

1 One primary circulating pump stopped in consequence of a temperature measurement equipment malfunction, the reactor to 90% power.
2 Main steam line safety valve tests, the reactor at 80 % power.
3 One control rod dropped to the lowest position in consequence of a low-frequency converter failure, the reactor to 95 % power.
4 Operation in stretch-out mode.
5 Annual maintenance outage (see chapter 2.3).

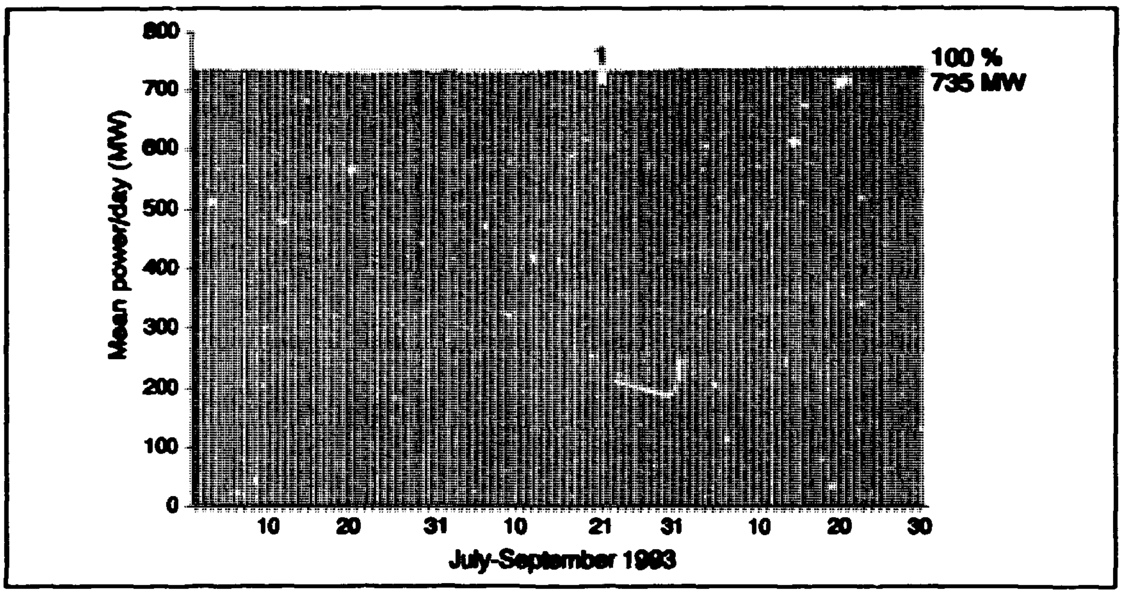

Fig 3. Daily average gross power of TVO I in July-September 1993.

1 Periodic tests, the reactor at 72 % power.

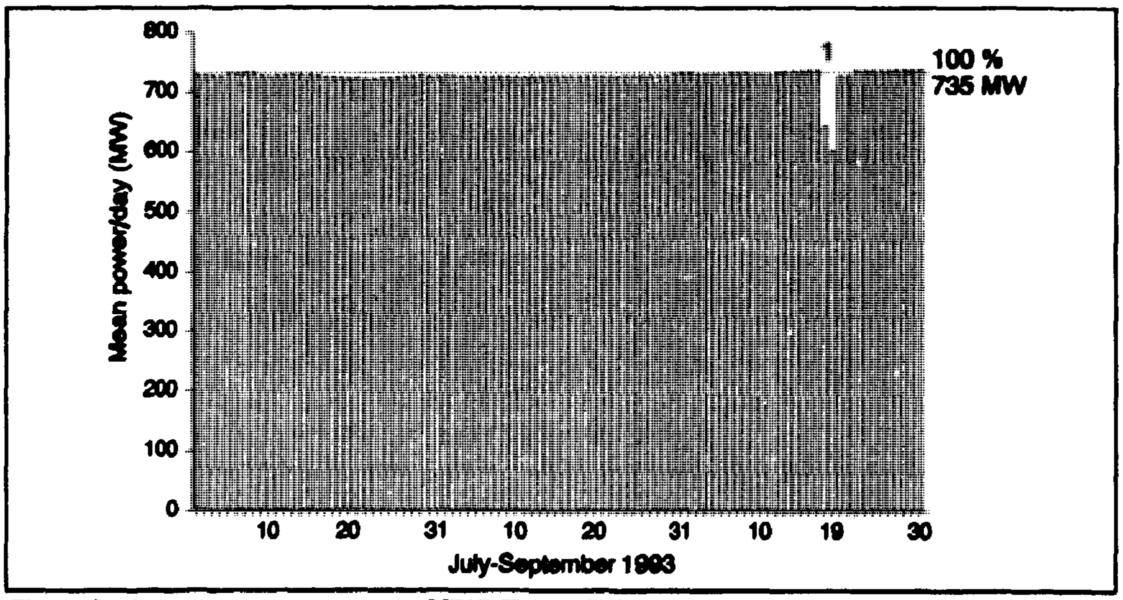

Fig 4. Daily average gross power of TVO II in July-September 1993.

1 Periodic tests, reactor stability measurements and localisation of a fuel leak which was detected on 8 July 1993 (see chapter 3.2), lowest reactor power was 50 %.

2.2 Annual maintenance outage of Loviisa 1

The 16th refuelling and maintenance outage of Loviisa 1 was from 14 August to 13 September, 1993. Emergency cooling systems modifications and problems during start-up relating to control rod drive mechanisms prolonged the outage by about ten days. The outage totalled 30 days.

Apart from Imatran Voima Oy's own staff, about 900 non-utility workers took part in the outage. Collective occupational radiation dose during outage work was 1.02 manSv, ca. 40 % of which was received during emergency cooling systems modifications.

During the outage, part of spent nuclear fuel was replaced by fresh fuel and plant safety improvements (see chapter 5) were made. A large number of inspections, repairs and maintenance operations were carried out; work assignments during the outage totalled 2993.

Scheduled primary circuit major components inspections and pressure vessel inservice inspections were conducted. Secodary circuit piping was subjected to extensive inspections to monitor erosion-corrosion. Based on the inspection results, parts of feedwater lines adjacent to steam generators and the intake ends of feedwater pump minimum flow circuits were replaced. The new portions of piping are made of material which better resists erosion-corrosion.

The purification system which connects to the primary circuit was fitted with a recirculation line to facilitate primary coolant water chemistry adjustments.

Operating licences for the reactor pressure vessels of the Loviisa plant units are granted for a fixed period of time since STUK prefers to monitor closely any neutron irradiation induced changes in pressure vessel material (STUK-B-YTO 103, 1992). For inspection purposes, four samples 120 mm in diameter and 6 - 9 mm thick were cut off the outer surface of the Loviisa 1 reactor pressure vessel.

2.3 Annual maintenance outage of Loviisa 2

The 13th refuelling and maintenance outage of Loviisa 2 was from 4 to 26 September, 1993. The outage totalled 22 days. Emergency cooling systems modifications proceeded according to schedule as experiences obtained at Loviisa 1 were utilized. Plant start-up was delayed by one day by a primary water filter lid seal repair.

Part of spent nuclear fuel was replaced with fresh fuel and safety improvements were made at the plant (see chapter 5). A number of repairs, inspections and maintenance operations were accomplished. Work assignments during the outage totalled 2628. Collective occupational radiation dose during outage work was 1.01 manSv, almost half of which was received during emergency cooling systems modifications.

Inservice inspections of primary circuit major components and of pressure vessels were conducted; portions of secondary circuit feedwater lines and of feedwater pump minimum flow circuits were replaced to enhance resistance to erosion-corrosion.

During spent fuel surveys in 1991, deformations were detected in fuel bundle uppermost spacing lattices (see STUK-B-YTO 90, 1991). The fuel manufacturer devised a new spacing lattice structure for the improved fuel bundle design. In 1992, six lead test fuel bundles with the new lattice design were loaded into the Loviisa 2 reactor. Measurements made during the 1993 outage indicate that, after the bundles have been one year in the core, the upper spacing lattice location has remained almost completely unchanged within the measurement range.

In the reactors of the Loviisa nuclear power plant, the service life of the absorbing part of the fuel follower type control rod has only been four years; at other corresponding reactors their service life limitations have been based on mechanical wear. The utility has started to examine the options of extending the service life of the absorbing part. Measurements are made during annual maintenance outages to monitor rod mechanical wear. These measurements were started at both plant units. To obtain, as soon as possible, information on wear in the long run, six control rods of the Loviisa 2 reactor were fitted with absorbing parts which have been in service for four years.

Elevated primary circuit radiation levels have been observed at Loviisa 2, and Imatran Voima Oy has looked into the options of reducing them (STUK-B-YTO 103, 1992). The primary circuit is due for decontamination in 1994 and in preparation for the assignment, small samples were taken during outages from the inner surfaces of the plant units' primary circuits to study oxidation layers.

3 EVENTS AND OBSERVATIONS

Loviisa 1 and 2

In the third quarter of 1993, Loviisa 1 and 2 emergency make-up pumps tripped a number of times during periodic performance testing. The event is rated on the INES at level 0.

3.1 Emergency cooling reliability was compromised due to problems in motor bearings of emergency make-up pumps

At the Loviisa plant units, the emergency make-up system injects water direct to the primary circuit during a loss-of-coolant accident (LOCA). The system has two parallel lines with two redundant pumps in each. One pump must be operational during accidents. According to the periodic testing programme of the plant units, each pump undergoes a test run every four weeks and, every week, one pump is tested.

In a test at Loviisa 1 on 27 July 1993, the temperature of one pump's motor bearings reached trip limit (75 °C) and the pump stopped. Both the ball and the roller bearing of the motor's dual bearing were replaced and aligned. In a new test run the pump performed flawlessly. Also the other three Loviisa 1 pumps were immediately subjected to testing and they functioned well.

At Loviisa 2, corresponding test runs were carried out on 29 July 1993. During the test runs, one pump stopped when the temperature of its motor bearings reached trip limit (85 °C) in about two hours. Also the bearings temperature of one pump motor began rising rapidly and the pump was stopped. The ball and roller bearings of both pumps were aligned and the pumps functioned flawlessly in a new test run. The system's two other pumps functioned as planned during a test run.

Since the testing time has only been half an hour, it has not been disclosed during earlier test runs that bearings temperatures could reach trip point. This time, the minimum test run period was planned to be two hours to allow for stabilization of the bearings temperatures prior to vibration measurements.

Temperature limits have been so set that pump motors are protected during testing. Where the material and structural characteristics of pump motors and bearings are concerned, these endure even higher temperatures. In an actual event, temperature-related trip limits would have been bypassed automatically, which would have ensured longer functioning of the pumps For conducting the test runs, the trip limits were raised to 100 °C at both plant units. The 75 °C in use at Loviisa 1 was taken as the alarm limit. The maintenance instructions have been revised accordingly.

In the future, emergency make-up pump test runs will take at least two hours. Special attention will be paid to alignment of pump motor bearings after replacement and maintenance.

In the annual maintenance outage of Loviisa 2 in September the bearings configuration of two emergency make-up pump motors was modified: the motors' dual bearings were replaced by a ball bearing. This modification solved problems related to alignment of the bearings. Test run protective trip limits for the pumps will be reset to 85 °C. Modifications to the bearings of two other Loviisa 2 pumps and to all of Loviisa 1 pumps are due in forthcoming annual maintenances.

TVO I

No reportable events in the third quarter of 1993.

TVO II

In the third quarter of 1993, a minor nuclear fuel cladding leak was observed at TVO II. The event is classified on the INES at level 0.

3.2 Nuclear fuel cladding leak

An insignificant increase in turbine steam condenser off-gas activity was observed at TVO II on 8 July 1993; the increase was due to a minor fuel leak which possibly started the day before. It was not until the following week that a minor leak was confirmed by off-gas laboratory measurements.

LWR nuclear fuel is composed of thin tubes made of zirconium alloy which form fuel assemblies; the tubes contain uranium dioxide pellets. The TVO II reactor houses about 500 fuel assemblies most of which encompass 64 fuel rods. Fuel rod walls form a gas-tight cladding which prevents fission products formed during reactor operation from being transferred from fuel to coolant. The concentrations of gaseous radioactive substances and of those dissolved in water are monitored regularly by laboratory measurements. The activity concentrations of reactor-to-turbine steam lines and off-gas lines are subject to continuous-operation radiation monitoring which quickest indicates potential fuel leaks.

This fuel rod cladding leak is negligible; only fission gases formed inside the rod are released into the primary circuit. Coolant has not been in contact with uranium dioxide since the activity concentrations of iodine-131 or actinides have not increased. The xenon-133 leak rate generally used for leak rate assessment, in August increased to 7 MBq/s, which is less than a tenth part of the maximum leak rate caused by one leaking rod. Measurements show that the sand tanks and carbon columns employed for off-gas delay and filtering have performed as normal and the activity concentration of air discharged via the main stack has not increased.

On 19 September 1993, with the plant operating at about 50 % power, the fuel leak was tentatively localised into an area of four fuel assemblies by control rod manoeuvring. Actual leak detection will take place in the next annual maintenance outage and the leaking assembly will be removed from service.

4 RADIATION SAFETY

Individual doses to nuclear power plant personnel were below the dose limit. Also environmental releases were well below the release limits. In samples collected in the vicinity of nuclear power plants, only quantities of radioactive material insignificant to radiation exposure were measurable which originate in the plants.

4.1 Occupational exposure

The highest individual dose at the Finnish nuclear power plants was 21.7 mSv and it was received at the Loviisa nuclear power plant. The Radiation Decree stipulates that the annual effective dose incurred in radiation work may not exceed 50 mSv. Averaged over a period of five years, the annual dose may not exceed 20 mSv. This monitoring started at the beginning of 1992 when the revised Radiation Decree took effect.

The individual dose distribution of nuclear power plant personnel during the third quarter of 1993 is given in Table III, which specifies the number of exposed individuals by dose range and plant site. The information given in the Table is taken from the central dose file of the Finnish Centre for Radiation and Nuclear Safety.

During the third quarter, collective occupational dose at the Loviisa and TVO plants totalled 2.04 manSv and 0.04 manSv, respectively. Most of the dose is incurred in annual maintenance outage work. The annual maintenance outages of both Loviisa plant units were scheduled for this quarter. A guide issued by the Finnish Centre for Radiation and Nuclear Safety, which came into force at the beginning of 1993, determines the collective dose limit for one plant unit at 2.5 manSv per one gigawatt of net electrical power averaged over two successive years; this means 1.11 manSv/year and 1.78 manSv/year collective dose per one unit for the Loviisa and TVO plants, respectively.

Imatran Voima Oy has submitted to the Finnish Centre for Radiation and Nuclear Safety a preliminary plan on the decontamination of the Loviisa 2 primary circuit and detailed reports pertaining to the matter. The decontamination is scheduled for the 1994 annual maintenance. The procedure significantly reduces the amount of radioactive cobalt-60 on primary circuit inner surfaces. Collective occupational radiation exposure is reduced subsequently.

4.2 Radioactive releases

Table IV gives the radioactive releases measured at each plant site. Also the annual release limits are given. Releases during the report period were well below authorized limits.

4.3 Environmental monitoring

In this quarter, a total of about 170 environmental samples were analysed in accordance with the monitoring programmes. Also 24 external radiation measurements were made.

Radioactive substances originating in the Loviisa nuclear power plant were measurable in two air samples, in three samples of deposited material, in three samples of bladder wrack and in three samples of sinking matter. Cobalt-60 and silver-110m dominated discharges from nuclear plants. Apart from this, the tritium concentration of three sea water samples was somewhat above normal.

In samples collected in the terrestrial environment of the TVO nuclear power plant, radioactive cobalt (cobalt-60) originating in the plant was detected in one sample of deposited material. In samples taken in the marine environment, radioactive substances were measurable in indicator samples (manganese-54, cobalt-58 and -60, chromium-51) and in one sea water sample (cobalt-60). In one samnle of sinking matter, an unusual cobalt-60 concentration was measurable. Further investigation showed that about 95 % of the activity was emitted by a particle having an activity of about 10 Bq.

All the measured concentrations were low and require no action.

In evironmental samples, radioactive caesium isotopes (caesium-134 and -137) which originate in the Chernobyl accident and also natural radioactive substances (such as potassium-40) are still measurable.

Table III. Occupational dose distribution in the report period and from start of 1993.

Dose range (mSv)	Number of persons by dose range					
	Third quarter 1993			From start of 1993		
	Loviisa	TVO	Total[a]	Loviisa	TVO	Total[a]
< 0.5	210	96	319	199	500	646
0.5 - 1	90	9	108	88	214	296
1 - 2	83	4	110	90	196	290
2 - 3	76	1	89	79	110	178
3 - 4	62	2	86	62	49	128
4 - 5	36	1	55	39	28	59
5 - 6	31	-	41	29	20	58
6 - 7	32	-	37	33	10	46
7 - 8	19	-	28	23	9	48
8 - 9	10	-	17	9	6	29
9 - 10	7	-	12	8	6	30
10 - 11	6	-	9	6	5	16
11 - 12	7	-	14	7	1	13
12 - 13	3	-	8	4	-	8
13 - 14	3	-	5	3	-	7
14 - 15	5	-	13	5	1	13
15 - 16	1	-	5	1	1	4
16 - 17	5	-	8	5	-	9
17 - 18	4	-	7	4	-	7
18 - 19	1	-	6	1	-	7
19 - 20	3	-	3	3	-	2
20 - 21	-	-	1	-	-	1
21 - 25	1	-	7	1	-	8
25 - 30	-	-	3	-	-	5
30 - 35	-	-	-	-	-	1
> 35	-	-	-	-	-	-

a This column also includes Finnish workers who have received doses at the Swedish nuclear power plants. The same individual may have worked at both Finnish nuclear power plants and in Sweden. From the beginning of 1993 the highest dose to a Finnish nuclear power plant worker, 30.8 mSv, was received while working in Sweden.

Table IV. Radioactive releases at each plant site, third quarter 1993.

Atmospheric releases (Bq)[a]

Plant site	Noble gases (Krypton-87 equivalents)	Iodines (Iodine-131 equivalents)	Aerosols	Tritium	Carbon 14
Loviisa					
Report period	$1.1 \cdot 10^{11}$ b)	$3.3 \cdot 10^{7}$	$7.5 \cdot 10^{7}$	$5.3 \cdot 10^{10}$	d)
Early 1993	$2.2 \cdot 10^{11}$ b)	$3.3 \cdot 10^{7}$	$8.1 \cdot 10^{7}$	$1.6 \cdot 10^{11}$	d)
Olkiluoto					
Report period	c)	$6.1 \cdot 10^{4}$	$2.5 \cdot 10^{6}$	$9.2 \cdot 10^{10}$	d)
Early 1993	$6.4 \cdot 10^{11}$	$8.1 \cdot 10^{7}$	$1.0 \cdot 10^{8}$	$3.9 \cdot 10^{11}$	d)
Annual release limits					
Loviisa	$2.2 \cdot 10^{16}$ e)	$2.2 \cdot 10^{11}$ e)			
Olkiluoto	$1.8 \cdot 10^{16}$	$1.1 \cdot 10^{11}$			

Releases into water (Bq)[a]

Plant site	Tritium	Other nuclides
Loviisa		
Report period	$2.1 \cdot 10^{12}$	$6.3 \cdot 10^{7}$
Early 1993	$9.9 \cdot 10^{12}$	$6.7 \cdot 10^{7}$
Olkiluoto		
Report period	$3.4 \cdot 10^{11}$	$1.9 \cdot 10^{9}$
Early 1993	$3.2 \cdot 10^{12}$	$7.9 \cdot 10^{9}$
Annual release limits		
Loviisa	$1.5 \cdot 10^{14}$	$8.9 \cdot 10^{11}$ e)
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 calculatory argon-41 release from Loviisa 1 and 2 in krypton-87 equivalents was $2.9 \cdot 10^{11}$ Bq in the report period and $1.1 \cdot 10^{11}$ Bq as of the beginning of 1993.

c Below the detection limit

d The carbon-14 release estimate based on experimental data was $6.0 \cdot 10^{10}$ Bq in Loviisa and $1.7 \cdot 10^{11}$ Bq in Olkiluoto in the report period. As of the beginning of 1993, the estimates were $2.3 \cdot 10^{11}$ Bq in Loviisa and $4.7 \cdot 10^{11}$ Bq in Olkiluoto.

e The figure shows the release limit for the Loviisa plant site, on the presumption that no releases of other release types occur. The release limit is set in such a way that the sum of the various types of release limit shares shall be smaller than or equal to 1.

5 SAFETY IMPROVEMENTS AT NUCLEAR POWER PLANTS

Emergency core cooling systems improvements have continued at the Loviisa and TVO nuclear power plants. The modifications ensure emergency cooling even under accident conditions during which dislodged piping thermal insulation could block coolant circulation. Also other modifications affecting safety were made at the Loviisa plant units during the annual maintenance outages scheduled for this quarter.

5.1 Emergency cooling improvements at the Loviisa plant

At the Loviisa nuclear power plant units, water from the emergency make-up water tank cools down the reactor core and the containment building during the early stages of a loss-of-coolant accident (LOCA). Water is injected direct to the primary circuit and to the spray nozzles of the containment building upper space. Water collecting in the containment building is directed to two sumps from which it is pumped back to the reactor and spray nozzles after the emergency make-up tank is drained. Coolant recirculation is required for the long-term assurance of reactor core and containment building cooling.

The entire sump structure of both Loviisa plant units has been re-designed. It is the sumps that are susceptible to clogging although they even originally had protective screens for collecting loose material. The sumps were now fitted with several hundreds of filtering units through which the flow to the sumps is passed. The sumps have now been divided into two compartments: water which cools down the containment building is recirculated via one compartment and water which cools down the reactor core via the other. Both coolant circulations have their own, independent filtering units. The filtering units are cleaned of crushed insulation material collecting on their surfaces by flushing with pressurized nitrogen. Performance of the new filtering units and of their cleaning flow has been examined experimentally. These modifications made the new filtering surface about 20 times larger than the old filtering arrangement.

New filtering units were installed at Loviisa 1 and 2 during the 1993 annual maintenance outages. Imatran Voima Oy intends to continue work on sump operation improvement i.a. by ensuring the performance of filtering units which assure reactor core cooling.

The emergency cooling system improvements were sparked off by an event in Sweden in July 1992. A safety valve erroneously opened during plant unit startup and steam from the valve dislodged piping thermal insulation which was transported to the condensation pool; consequently, the emergency cooling system intake strainers were blocked sooner than expected. Investigations after the event revealed that, when crushed, old mineral wool is brittle and easily water-logged, which adds to its blocking impact. Mineral wool insulation is widely used as piping thermal insulation also at Finnish nuclear power plants. Insulation behaviour tests during the construction phase of the Finnish plant units were made with new insulation material.

After the event in Sweden, a decision was promptly made to increase the screen surface of sumps at the Loviisa plant units. At Loviisa 2, the modifications were carried out in September-October, during the 1992 annual maintenance outage, and at Loviisa 1, from 1 to 2 November, 1992 (STUK-B-YTO 109, 1993).

5.2 Emergency cooling improvements at the TVO plant

In the event of a loss-of-coolant accident (LOCA), the reactor core and containment at the TVO plant units are mainly cooled with water from the condensation pool located in the reactor containment. Steam or water from the reactor is directed to the pool. Water is introduced into coolant circulation via condensation pool intake strainers. Supply of water from the condensation pool to coolant circulation is vital from the early stages of an accident.

At the TVO plant units, blocked condensation pool intake strainers would compromise emergency cooling. The hazard of strainer blockage has been reduced by replacing the mineral wool insulation of steam lines by mirror insulation and glass wool, thereby reducing the amount of material which could block the strainers. At both plant units, mirror insulation replacements were carried out on two out of four steam lines during the 1993 annual maintenance outages (STUK-B-YTO 112, 1993). Insulation on the rest of the steam lines will be replaced in the 1994 annual maintenance outages. Strainer capacity has also been upgraded by a new cleaning procedure and by permanently installed, more efficient flushing by pressurized nitrogen. Work relating to the flushing system improvement was accomplished in September.

Also the improvements implemented at the TVO nuclear power plant were sparked off by the event in Sweden. Preliminary investigations at the TVO plant units resulted in strainer cleaning preparedness improvements. The modifications were made in late 1992 (STUK-B-YTO 109, 1993).

5.3 Other safety improvements at the Loviisa and TVO plants

Apart from the emergency cooling improvements, also other safety improvements were made at the Loviisa plant units. Sumps in the reactor pit of the containment building were strengthened with an extra layer of concrete to provide against severe accidents. Monitoring of primary circuit water chemistry was improved by a new sampling line.

Fire protection of certain cable spaces at TVO II was improved by sprinkler extinguishing system extensions.

6 OTHER MATTERS RELATING TO THE USE OF NUCLEAR ENERGY

The Finnish Centre for Radiation and Nuclear Safety has issued a revision of Guide YVL 6.3 which is concerned with nuclear fuel design and control of fuel fabrication.

Nuclear fuel design and control of fuel fabrication help assure that fuel fulfills the requirements made of it under nuclear power plant normal operational conditions, anticipated operational transients and postulated accident conditions. Apart from nuclear fuel, the regulatory procedure presented in the Guide also applies to reactor control rods and shield elements in reactors.

APPENDIX 1

REGULATORY CONTROL OF NUCLEAR FACILITIES

The regulatory control performed by the Finnish Centre for Radiation and Nuclear Safety encompasses the following areas (the granting of the licenses mentioned in parentheses is recommended when the control activities have been completed and no reason for withholding the license has arisen):

Construction Phase

- Preliminary plans of the nuclear facility
- Location and environmental effects of the plant
- Arrangements for nuclear fuel and nuclear waste management
  (Decision in principle)

- Preliminary safety analysis report on the planned structure and operation of the plant as well as the preliminary safety analyses
- Safety classification of components and structures
- Quality assurance plan
- Plans concerning nuclear fuel and nuclear waste management
- Physical protection and emergency preparedness
  (Construction permit)

- Construction plans, manufacturers, final construction and installation of components and structures
- Performance tests of systems
- Final safety analysis report on the structure and operation of the plant and the final safety analyses
- Composition and competence of the operating organisation
- Technical specifications
- Nuclear fuel management and safeguards
- Methods of nuclear waste management
- Physical protection and emergency preparedness
  (Operating licence)

Operating Phase

- Start-up testing at various power levels
- Maintenance, inspections and testing of components and structures
- Operation of systems and the whole plant
- Operation and competence of the operating organisation
- Exceptional events
- Repairs and modifications
- Refuelling
- Nuclear fuel management and safeguards
- Nuclear waste management
- Radiation protection and safety of the environment
- Physical protection and emergency preparedness
- Observance of quality assurance programme

APPENDIX 2

PLANT DATA

Plant unit	Start-up	Commercial operation	Rated power (gross/net,MW)	Type, supplier
Loviisa 1	8 Feb. 1977	9 May 1977	465/445	Pressurized water reactor (PWR), Atomenergoexport
Loviisa 2	4 Nov. 1980	5 Jan. 1981	465/445	Pressurized water reactor (PWR), Atomenergoexport
TVO I	2 Sept. 1978	10 Oct. 1979	735/710	Boiling water reactor (BWR), Asea Atom
TVO II	18 Feb. 1980	1 July 1982	735/710	Boiling water reactor (BWR), Asea Atom

Imatran Voima Oy owns the Loviisa 1 and 2 plant units in Loviisa and Teollisuuden Voima Oy the TVO I and II plant units in Olkiluoto, Eurajoki.

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