STUK-B-YTO 97

Operation of Finnish nuclear power plants

Quarterly report 4th quarter, 1991 and annual summary

Kirsti Tossavainen (Ed.)
MAY 1992

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Strålsäkerhetscentralen
Finnish Centre for Radiation and Nuclear Safety

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ABSTRACT

In the Quarterly Reports on the operation of the Finnish nuclear power plants such events and observations are described relating to nuclear and radiation safety which the Finnish Centre for Radiation and Nuclear Safety considers safety significant. Also other events of general interest are reported. The report also includes a summary of the radiation safety of the plants' workers and the environment, as well as tabulated data on the production and load factors of the plants.

The Finnish nuclear power plant units Loviisa 1 and 2 as well as TVO I and II were in operation for almost the whole fourth quarter of 1991. The load factor average was 94.7 % (the whole year 90.9 %). All the events in the last annual quarter, which are classified on the International Nuclear Event Scale, were below scale/level 0. Also the events which occurred in the other quarters of the year 1991 were rated at the scale's lowest levels.

Occupational radiation doses and releases of radioactive material off-site remained well below authorised limits. Only quantities of radioactive material insignificant to radiation exposure originating in nuclear power plants were detected in the samples collected in the vicinity of the nuclear power plants.

CONTENTS

1 INTRODUCTION

As prescribed by the Nuclear Energy Act (990/07), regulatory control of the use of nuclear energy rests with the Finnish Centre for Radiation and Nuclear Safety. The functions of the Finnish Centre for Radiation and Nuclear Safety also include regulatory control of physical protection, emergency preparedness and nuclear material safeguards. The scope of regulatory control related to nuclear power plants is specified in Appendix 1. General information relating to the Finnish nuclear power plants is presented in Appendix 2.

The Finnish Centre for Radiation and Nuclear Safety publishes a quarterly report on the operation of the Finnish nuclear power plants. This report also contains a summary of the information reported in 1991 and background information on the principles of radiation protection. The report is based on the information reported to the Finnish Centre for Radiation and Nuclear Safety by the power companies and the observations made by the Finnish Centre for Radiation and Nuclear Safety during regulatory control. The events and observations described in the report are classified on the International Nuclear Event Scale.

Apart from event descriptions, the report contains a summary of the radiation safety of nuclear power plant workers and the environment and tabulated data on the production and load factors of nuclear power plants.

2 OPERATION OF NUCLEAR POWER PLANTS IN OCTOBER–DECEMBER 1991

The Finnish nuclear power plants were in operation for almost the whole fourth quarter of 1991. Brief interruptions in electricity generation were caused by the outages arranged at Loviisa 1 and TVO II to repair failed components.

2.1 Production data

Nuclear electricity accounted for 32.9 % of total production in Finland in this quarter. The load factor average of the plant units was 94.7 %.

Production and availability figures are presented in more detail in Tables I and II.

Power diagrams describing electicity generation by the plant units and causes of power reductions are presented in Figures 1 – 4.

Table I. Electricity production and availability of the units.

	Electricity production (gross, TWh)		Availability factor (%)		Load factor (%)	
	Fourth quarter 1991	Beginning of 1991	Fourth quarter 1991	Beginning of 1991	Fourth quarter 1991	Beginning of 1991
Loviisa 1	0.94	3.55	93.8	90.5	92.1	87.1
Loviisa 2	0.91	3.63	89.4	90.6	89.0	89.2
TVO I	1.63	6.10	100.0	95.6	100.2	94.7
TVO II	1.58	5.95	98.4	93.8	97.6	92.4

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

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

Table II. Nuclear energy in the Finnish production of electricity.

	Fourth quarter 1991	1991	1990	1989
Production of nuclear electricity (net, TWh)[a]	4.9	18.4	18.1	18.0
Total production of electricity in Finland (net, TWh)[a]	14.9	55.2	51.7	50.8
Share of nuclear electricity of total production	32.9	33.3	35.0	35.4
Load factor average of the Finnish plant units (%)	94.7	90.9	89.1	89.9

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

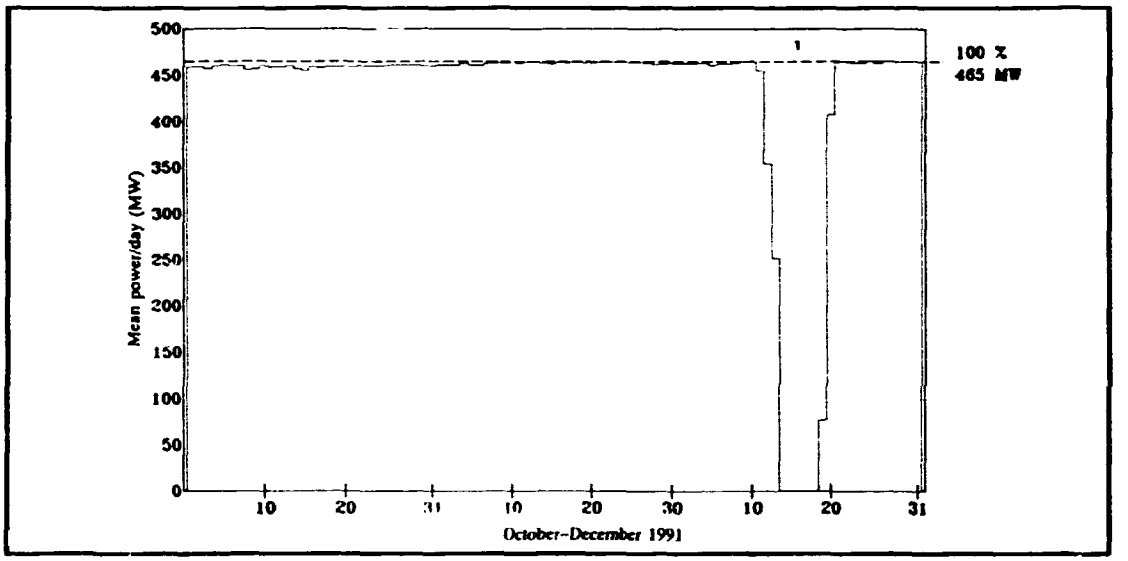

Fig 1. Average daily gross power of Loviisa 1 in October–December 1991.

1 Cold shutdown to replace a primary circulating pump unit (see chapter 2.2)

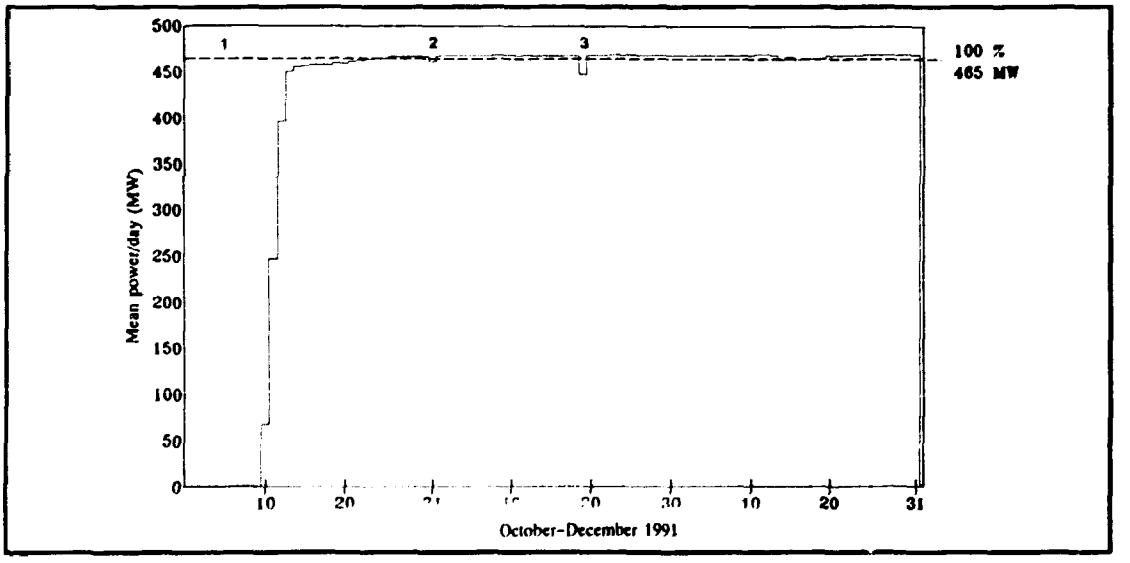

Fig 2. Average daily gross power of Loviisa 2 in October–December 1991.

1 Annual maintenance (see report STUK-B-YTO 92, chapter 2.3)
2 Control rod drop in consequence of a low frequency converter fault, reactor to operate at 89 % power)
3 Temporary repair of a leak in the cross-under pipeline of the steam reheater, reactor operating at 73 % power

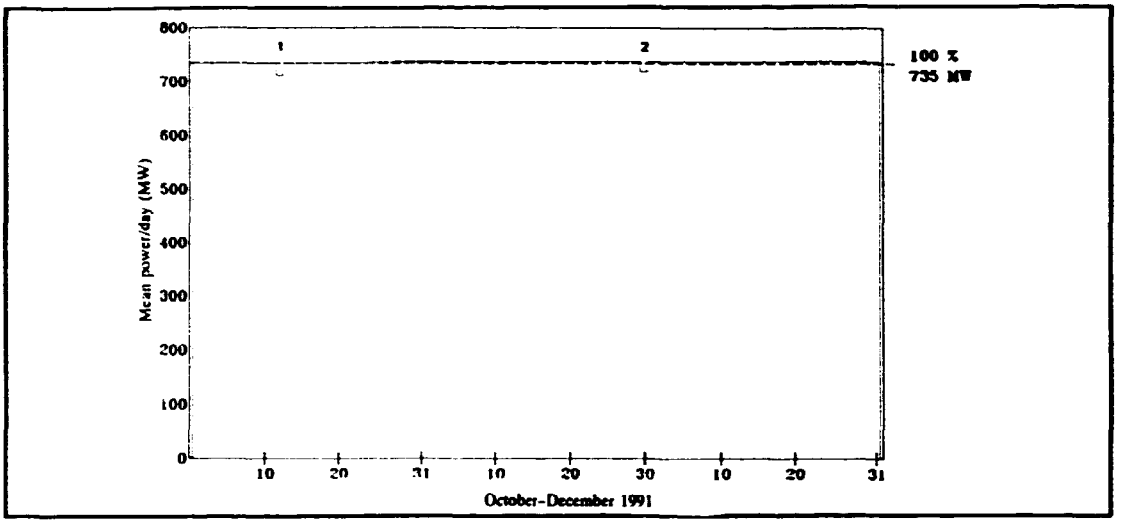

Fig 3. Average daily gross power of TVO I in October–December 1991.

1 Periodic tests, reactor operating at 60 % power 2 Periodic tests, reactor operating at 70 % power

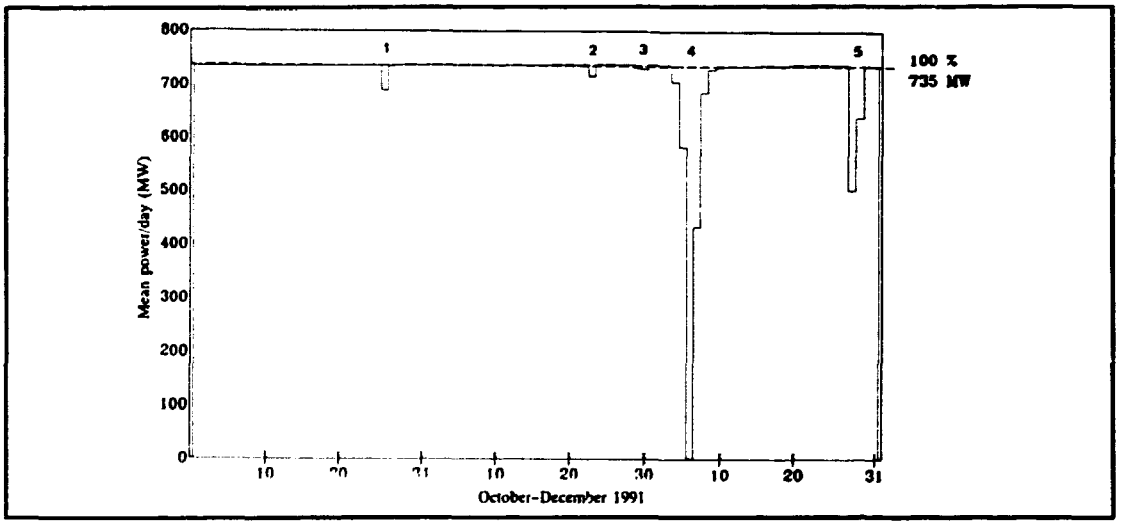

Fig 4. Average daily gross power of TVO II in October–December 1991.

1 Periodic tests, repair of a steam leak in the steam reheater drain tube, reactor operating at 60 % power
2 Repair of the steam reheater drain tube and testing of the reactor protection system, reactor operating at 60 %
3 Recirculation pump frequency converter tripped from overcurrent, reactor to operate at 73 % power
4 Cold shutdown to replace defective solenoid valves of the relief system and the main steam system (see chapters 2.3 and 3.2)
5 Turbine trip and partial scram, reactor to operate at 55 % power (see chapter 2.4)

2.2 Cold shutdown at Loviisa 1

One primary circulating pump of Loviisa 1 tripped on 12.12. in consequence of overheating of the bearing of the pump's motor. Owing to the tripping of the primary circulating pump, plant unit power settled at 75 %. The damaged bearing was changed on 13.12. Due to an installation error, the new bearing sustained damage right after the pump was started and the plant unit was placed in cold shutdown. The whole pump unit and its motor were changed during the shut-down. The plant unit resumed electricity generation on 19.12.

2.3 Cold shutdown at TVO II

In a test of relief system valves on 4.12. it was discovered that one of the system's quick-open valves opened too slowly (see chapter 3.2). A 95 % restriction on reactor power resulted. The plant unit was placed in cold shutdown on 6.12 to repair the failure. Also an earlier failed solenoid valve, which controls the steam line isolation valve, was repaired in the shutdown. During plant unit start-up, a reactor scram occurred due to malfunctions in the neutron flux measurement channels. The plant unit resumed electricity generation on 7.12.

2.4. Turbine trip and partial reactor scram at TVO II

In consequence of a malfunction in the generator's moisture measuring train, a turbine trip and a partial rector scram occurred at TVO II on 28.12. The malfunction was attributed to a failed measuring transformer of the measurement train. When re-started after the repair, the turbine tripped again. The plant unit's start-up was delayed also by a malfunction in the coolant pump's instrumentation. The plant unit resumed electricity generation on 29.12.

3 EVENTS AND OBSERVATIONS AT EACH PLANT UNIT

Loviisa 1

In a plant round which was part of the inspections carried out by the Finnish Centre for Radiation and Nuclear Safety, three open fire doors were observed in the cable spaces below the diesel generator rooms while the renovated diesel generator was undergoing trial run. The event is classified as below scale/level 0 on the International Nuclear Event Scale.

3.1 Diesel building fire doors were open during diesel generator trial run

At both Loviisa plant units four diesel generators ensure supply of electrical power for electrical components important to safety. One diesel's output is sufficient to ensure essential safety functions. The diesel generators are housed in a separate building in the site area and they are separated from each other both physically and function-wise. For reasons of fire safety the diesels and their cables are separated from each other by barriers which resist fire for three hours.

One generator's diesel motor had undergone basic renovation. The post-renovation trial run required the installation of temporary electrical loads. For this end, cables were installed which were routed to the diesel generators via partitioning fire doors. Thus, the doors could not be closed. With the doors open, a possible fire in one cable space could spread and damage the cables of the other diesel generators, too, if the automatic water sprinklers failed to operate. The installation of temporary cables was begun on 14.11. and they were removed on 1.12. The plant's engineer responsible for fire safety had orally consented to the operation.

During the event the work permit procedure was not complied with and, consequently, requirements relative to the integrity of fire zones were not taken into consideration. The doors may be kept open when substitute fire protection measures are implemented. In this event, however, fire guarding measures were ignored. Fire protection was otherwise appropriately taken care of. The fire detection and extinguishing systems were in normal standby. In addition, fire guarding was arranged for the duration of the welding operation and the plant fire brigade was present when the diesel was first started.

To prevent recurrence, Imatran Voima Oy will arrange for personnel training with emphasis on the practical meaning of the instructions relative to the integrity of the fire zones.

Loviisa 2

No reportable events occurred at Loviisa 2 in the last quarter of 1991.

TVO I and II

In the last quarter of 1991, various types of solenoid valve failures were detected in the periodic tests conducted at the TVO plant units. The failures are classified as below scale/level 0 on the International Nuclear Event Scale.

3.2 Failures of solenoid valves

Solenoid valves are small valves which serve at nuclear power plants as pilot valves to larger pressurized air or nitrogen operated valves. Solenoid valve state change (open–close movement) is attained by an electrical coil installed around valve stem. There are about 600 solenoid valves at both TVO plant units, 72 of which are inside the containment. The valves inside the containment cannot be repaired or serviced during operation. There are solenoid valves in safety important systems i.a. as pilot valves of hydraulic scram system actuating valves, main steam isolation valves and certain other containment isolation valves.

One main valve is usually guided by four solenoid valves and each solenoid valve functions as part of one of the four channels of the reactor protection system. The solenoid valves have a 2/4 operating logic which means that the change of state of two solenoid valves is required for the protective function, i.e. main valve state change, to take place.

At the TVO plant units, the coils of the reactor protection system solenoid valves are usually energized. A reactor protection system signal de–energizes the coil and the solenoid valve changes state (trips) by means of a coil spring. Solenoid valve functioning can be ascertained by measuring the pressure difference of the gas which controls the main valve. All the four solenoid valves share pressure difference measurement.

Depending on the manner of coupling of the solenoid valves, the failure of one solenoid valve may affect the functioning of a component controlled by the reactor protection system in two ways. If a solenoid valve fails into a tripped state, the protective function logic changes from a 2/4 logic to a 1/3 logic and the possibility of an inadvertent protective function increases. If a valve gets stuck i.e. if it does not trip although the current is switched off, the protective logic changes to a 2/3 logic and the reliability of the protective function is impaired.

The solenoid valve failures discovered in October–December 1991 are described below.

In a periodic test conducted at TVO I on 4.10. one solenoid valve which controls the steam line isolation valve inside the containment was ascertained inoperable. The solenoid valve had become stuck in such a way that when the coil's voltage was shut off the valve failed to trip, as should have been the case. It is also possible that the solenoid valve is operable but the pressure difference sensor is defective. About a week later, on 12.10., a solenoid valve which controls a steam isolation valve inside the containment failed also at TVO II. This time the failure was attributed to breakage of the solenoid valve's coil which tripped the valve. The failures were of minor safety significance. Immediate repair of the valves was not necessary but could be postponed to be done in forthcoming outages, as appropriate.

In a relief system testing conducted at TVO II on 4.12. the opening of the system's other quick–open valve was ascertained as delayed. Delayed functioning of the solenoid valve which functions as its pilot valve was suspected. In consequence of the inoperability of the quick–open valve, a 95 % limitation on the reactor power resulted, as prescribed in the Technical Specificantions. On 6.12. TVO II was placed in cold shutdown to repair the failure. The solenoid valves which function as pilot valves of the system's both quick–open valves, as well as the solenoid valve of the steam line isolation valve, which failed earlier, were changed in the outage. The failed solenoid valves were subjected to laboratory tests to establish the root cause of the failures.

It was discovered in a protection system test at TVO I on 10.12. that one solenoid valve controlling the actuating valves of the scram system failed to change state. Due to the failure of the valve in question, the protective function of one scram group consisting of control rods would have changed from a 2/4 logic to a 2/3 logic. In a later inspection it was discovered that the pressure diffrence sensor shared by the group of four solenoid valves in question, had failed.

Problems related to solenoid valves of the type of the failed valves were encountered in 1985 – 86. Due to the problems at that time, the coils of all solenoid valves of this type inside the containment were replaced. Due to the failures now detected, Teollisuuden Voima Oy decided that, in the 1992 annual maintenance outage, all the solenoid valves inside the containment, which have not been changed before, will be changed. Also all the old solenoid valves in systems parts external to the containment, which cannot be replaced during plant operation, will be changed.

4 RADIATION SAFETY

Individual occupational radiation doses remained well below the dose limit. Also releases of radioactive material off-site were considerably below the release limits. Only quantities of radioactive material insignificant to radiation exposure, originating in the nuclear power plants, were detected in the samples collected in the vicinity of the nuclear power plants.

4.1 Limitation of radiation exposure

Radiation exposure arising from the operation of nuclear power plants shall be kept as low as reasonably achievable. To accomplish this objective, the sum doses i.e. the collective radiation doses of individuals working in a nuclear power plant and the population in the vicinity of a nuclear power plant shall be monitored and measures accomplished to limit occupational radiation exposure and releases of radioactive material. Furthermore, individual radiation doses shall be limited below confirmed dose limits.

4.2 Occupational radiation exposure

The radiation safety of nuclear power plant workers is, on the one hand, dependent on plant layout and condition and, on the other hand, on the radiation protection measures applied at work. The major part of the radiation dose incurred is received in work performed during annual maintenance outages.

Individual occupational radiation doses in the report period remain below the dose limit for three months, 25 mSv. The highest individual radiation dose in the report period was 3.8 mSv and it was received at the Loviisa nuclear power plant.

The limit for individual occupational radiation dose has been set so that the health risk to workers from radiation is small and comparable to risks in occupations considered safe.

The distribution of individual occupational doses in the report period and from the beginning of 1991 until the end of the report period is given in Table III which specifies the number of individuals in each dose range and at each plant site. The Table also shows a distribution which is the total number of workers in each dose range. The distributions comprise the doses of persons who have been recorded as nuclear power plant workers in the central dose file of the Finnish Centre for Radiation and Nuclear Safety.

In the report period, the collective radiation dose at the Loviisa plant was 0.11 manSv and at the TVO plant 0.03 manSv. In this quarter, the last ten days from the end of the Loviisa 2 annual maintenance outage occurred. The dose limit given in the guides of the Finnish Centre for Radiation and Nuclear Safety is 5 manSv/GWe per installed electrical power in a year which means a collective radiation dose of 4.45 manSv/year for the Loviisa plant and 7.1 manSv/year for the TVO plant.

Table III. Occupational dose distribution in report period and from beginning of 1991 until end of report period.

Dose range (mSv)	Number of persons in the dose range					
	Fourth quarter 1991			From beginning of 1991		
	Loviisa	TVO	Total*	Loviisa	TVO	Total*
< 0.5	62	65	128	161	437	557
0.5 - 1	28	14	42	92	267	334
1 - 2	24	5	34	101	199	281
2 - 3	11	-	11	65	81	1[illegible]
3 - 4	5	-	5	39	32	73
4 - 5	-	-	-	33	26	56
5 - 6	-	-	-	27	24	48
6 - 7	-	-	-	21	12	35
7 - 8	-	-	-	16	3	26
8 - 9	-	-	-	13	2	25
9 - 10	-	-	-	8	1	11
10 - 11	-	-	-	10	2	15
11 - 12	-	-	-	5	4	11
12 - 13	-	-	-	9	2	12
13 - 14	-	-	-	4	2	8
14 - 15	-	-	-	2	1	4
15 - 16	-	-	-	1	1	3
16 - 17	-	-	-	-	-	-
17 - 18	-	-	-	1	-	-
18 - 19	-	-	-	-	-	-
19 - 20	-	-	-	-	-	1
20 - 21	-	-	-	-	-	-
20 - 25	-	-	-	-	-	-
> 25	-	-	-	-	-	-

* These columns also include the data of those Finnish workers who have received doses at the Swedish nuclear power plants. The same person may have worked at both Finnish plant sites as well as in Sweden.

4.3 Releases of radioactive material off-site and radiation exposure of the population

The radiation exposure of the population in the vicinity of a nuclear power plant arises from releases of radioactive material into the air and water during operation. The releases are restricted by technical means. Furthermore, the plant's operational condition and its releases are monitored continuously and compared with predetermined limits.

Releases of radioactive material off-site in the report period were much below prescribed release limits (Table IV).

The release limits have been determined in such a way that the annual radiation dose to the most exposed individuals is not more than 0.1 mSv. This is about a fiftieth part of the dose annually received from natural background radiation in Finland, radon in dwellings included. The release limits have been determined for nuclides and release pathways with associated significant potential for individual overexposure.

Radiation doses to individuals of the surrounding population, calculated on the basis on release reports are low and, at most, less than about a thousandth part of their annual radiation exposure.

The release from nuclear power plants of the long-lived carbon-14 nuclide causes a global collective dose approximately as high as the dose limit for a period of 500 years (5 manSv/GWe per installed electrical power) determined in a relevant guide issued by the Finnish Centre for Radiation and Nuclear Safety. This collective radiation dose limit is based on the definite limitation of annual dose arising from the widespread use of nuclear power below 0.1 mSv even for individuals living in the future. When defining the collective dose limit it was assumed that an average of 10 kW of electrical power per person will be generated by nuclear power in the whole world, truncated at 500 years. At present, the use of nuclear energy in Finland is about a twentieth part of the mentioned value.

4.4 Radiological monitoring of the environment

Radiation safety in the vicinity of the Finnish nuclear power plants is monitored by means of regular sampling and analysis programmes. The aim of the monitoring is to follow dispersion into the environment of radioactive discharges and to ensure that doses to the local population remain below set limits.

Annually, about 500 samples collected in the vicinity of both the Loviisa and Olkiluoto nuclear power plants are examined. Samples are taken i.a. of air, rain, sea water as well as foodstuffs such as milk, meat, grain, vegetables and fish. In this way the quantities of radioactive material possibly accumulating in man can be assessed. Also terrestrial and marine indicator organisms are analysed which effectively enrich radioactive material from their environment. By their help even very low quantities of radioactive material can be detected and their dispersion monitored. Nuclides most important for human exposure are determined from the samples.

About 150 samples were analysed in this quarter. Radioactive material originating in the Olkiluoto nuclear power plant was detected only in samples of sinking matter. These contained small quantities of manganese-54 and cobalt-60. The three samples of sinking matter from Loviisa contained cobalt-60 and silver-110 and one sample contained zirkonium-95. The samples collected in the large rain water collector on-site the Loviisa power plant in November and December contained silver-110m (0.29 and 0.10 Bq/m^2) and, in November, also cobalt-60 (0.13 Bq/m^2).

Table IV. Releases of radioactive material at each plant site, fourth quarter, 1991.

	Releases into the air (Bq)[a]				
Plant site	**Noble gases (Krypton-87 equivalents)**	**Iodines (Iodine-131 equivalents)**	**Aerosols**	**Tritium**	**Carbon 14**
Loviisa					
Report period	[b]	$4.8 \cdot 10^{6}$	$2.7 \cdot 10^{6}$	$6.0 \cdot 10^{10}$	[d]
In 1991	[b]	$1.6 \cdot 10^{8}$	$1.8 \cdot 10^{8}$	$4.8 \cdot 10^{11}$	[d]
Olkiluoto					
Report period	$1.9 \cdot 10^{11}$	$2.5 \cdot 10^{7}$	$1.8 \cdot 10^{8}$	$2.0 \cdot 10^{10}$	[d]
In 1991	$7.1 \cdot 10^{12}$	$2.5 \cdot 10^{8}$	$7.3 \cdot 10^{8}$	$1.3 \cdot 10^{11}$	[d]
Annual release limits					
Loviisa	$2.2 \cdot 10^{16}$[c]	$2.2 \cdot 10^{11}$[c]			
Olkiluoto	$1.8 \cdot 10^{16}$	$1.1 \cdot 10^{11}$			

	Releases into water (Bq)[a]	
Plant site	Tritium	Other nuclides
Loviisa		
Report period	$3.1 \cdot 10^{12}$	$5.2 \cdot 10^{9}$
In 1991	$1.4 \cdot 10^{13}$	$5.2 \cdot 10^{9}$
Olkiluoto		
Report period	$2.9 \cdot 10^{11}$	$2.4 \cdot 10^{9}$
In 1991	$1.9 \cdot 10^{12}$	$2.2 \cdot 10^{10}$
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] Below detection limit.
[c] The calculational release of argon-41 from Loviisa 1 and 2 expressed as krypton-87 equivalents was $3.9 \cdot 10^{11}$ Bq in the report period. As of beginning of 1991, the release was $1.5 \cdot 10^{12}$ Bq.
[d] The carbon-14 release estimate based on experimental data was $8.0 \cdot 10^{10}$ Bq in Loviisa and $1.7 \cdot 10^{11}$ Bq in Olkiluoto during the report period. The estimates in 1991 were $3.2 \cdot 10^{11}$ Bq and $6.4 \cdot 10^{11}$ Bq, respectively.
[e] The figure shows the release limit of the plant site on the presumption that there will be no releases of other release types. The release limit is so set that the sum of the various types of release limit shares is equal to or smaller than 1.

N.B.
There was an error in the Quarterly Report, 4th Quarter, 1990 (STUK-B-YTO 85) as regards the "Releases into water" part of Table IV. The correct figures are as follows:

Loviisa	Other nuclides
In the report period	$1.7 \cdot 10^{10}$ Bq
In 1990	$1.8 \cdot 10^{10}$ Bq

ANNUAL SUMMARY FOR 1991

The Finnish nuclear power plants were in operation for almost the whole year. Longer interruptions in production were due to annual maintenance operations. The Loviisa plant units were off the national grid for a total of 60 days for annual maintenance. The repairs and inspections of the sealing structure leaks of a main gate valve, detected towards the end of the Loviisa 2 outage, extended planned outage duration by about one week. The annual maintenance outages of the TVO plant units lasted 34 days in all. The outage to repair the damage caused by a switchplant fire was combined with the annual maintenance outage of TVO II.

The load factor average of the plant units was 90.9 %. The load factor indicates the relation of energy generated in a certain period of time to energy which could have been generated, if continuously operating the plant at full power. The load factor is one way of measuring the reliability of a nuclear power plant's operation. The number of scrams is another measure. In 1991 no scrams occurred at the Loviisa plant units. One scram occurred at both TVO plant units during power operation and one scram at TVO II during post-outage start-up.

Nuclear's share of all the power generated in Finland was 33.3 %. The power diagrams describing electricity generation by the Finnish plant units can be found in Figures 5 - 8.

The International Nuclear Event Scale is a means for communicating the safety significance of nuclear power plant events. Incidents and accidents are rated on a scale from 1 to 7. Events at level 7 are the severest. There is also below scale/level 0 rating for events with no safety significance. The events which occurred at the Finnish nuclear power plants in 1991 were rated as follows: one was level 2 and two were level 1 incidents and the rest were below scale/level 0.

The incidents and observations reported in the Quarterly Reports of the Finnish Centre for Radiation and Nuclear Safety at the various plant units were as follows:

Loviisa 1

- Fuel bundle spacing lattice failures (1st and 2nd Quarter). Level 1.
- Unsatisfactory functioning of the check valve of the discharge line of an emergency cooling system water tank (3rd Quarter). Level 1.
- Both service water system lines were out of operation simultaneously during annual maintenance (3rd Quarter). Level 0.
- Pressurizer control cubicles sustained damage in consequence of an erroneous test connection during annual maintenance (3rd Quarter). Level 0.
- Shortcomings in ensuring reactor sub-criticality during annual maintenance (3rd Quarter). Level 0.
- Diesel building fire doors were open during diesel generator trial run (4th Quarter). Level 0.

Loviisa 2

- Partial clogging of service water system throttles in consequence of an erroneous process coupling (3rd Quarter). Level 0.
- Leak of a main gate valve sealing structure (3rd Quarter). Level 0.

TVO I

- Doors of rooms containing auxiliary feedwater and emergency cooling systems were open (2nd Quarter). Level 0.
- Errors in handling of spent nuclear fuel transport cask (2nd Quarter). Level 0.
- Failures of solenoid valves (4th Quarter). Level 0.

TVO II

- Loss of external grids due to switchgear fire (2nd Quarter). Level 2.
- Errors during annual maintenance outage (2nd Quarter). Level 0.

Collective occupational radiation doses were still low by international comparison, 1.68 manSv at the Loviisa plant and 1.40 manSv at the TVO plant. The highest individual radiation dose was 17.7 mSv. The limit for three months is 25 mSv.

Releases of radioactive material off-site remained well below the release limits.

About 1000 samples collected in the vicinity of the Finnish nuclear power plants were analysed. As before, the environmental impact of the nuclear power plants was insignificant. The dominant radionuclide was caesium-137 which originates in the fallout from the Chernobyl accident.

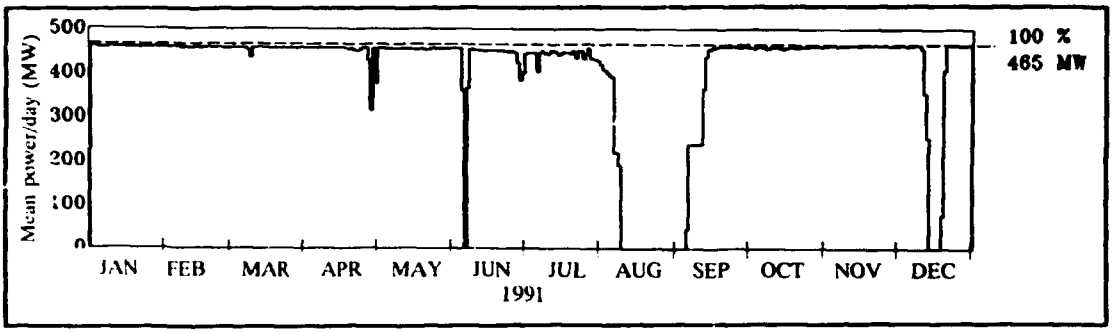

Fig 5. Average daily gross power of Loviisa 1 in 1991.

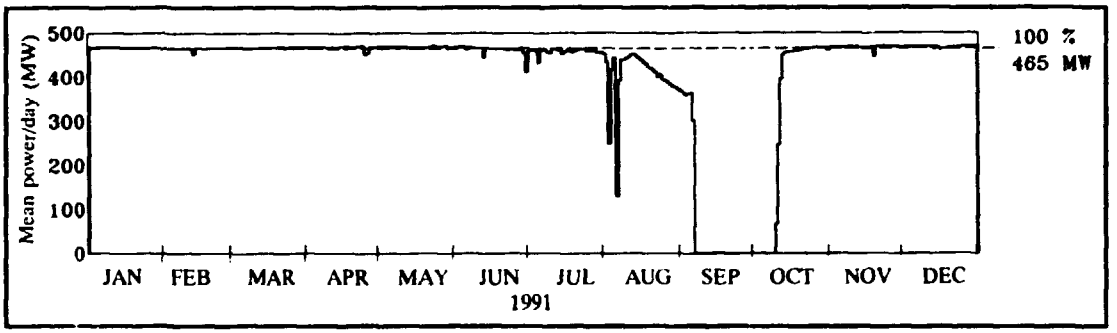

Fig 6. Average daily gross power of Loviisa 2 in 1991.

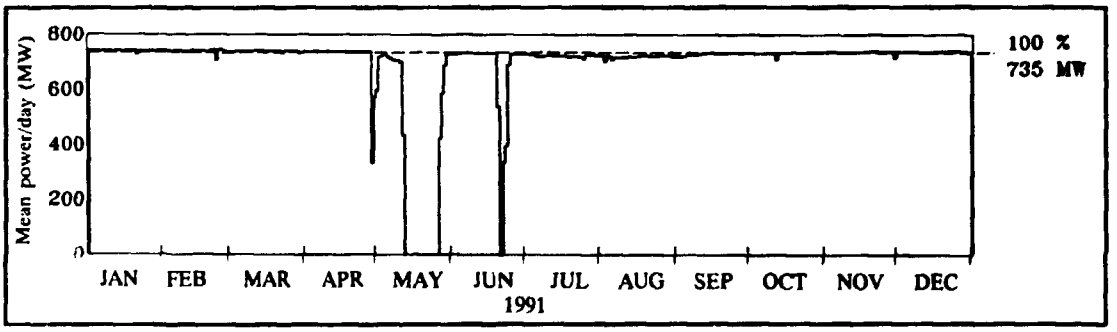

Fig 7. Average daily gross power of TVO I in 1991.

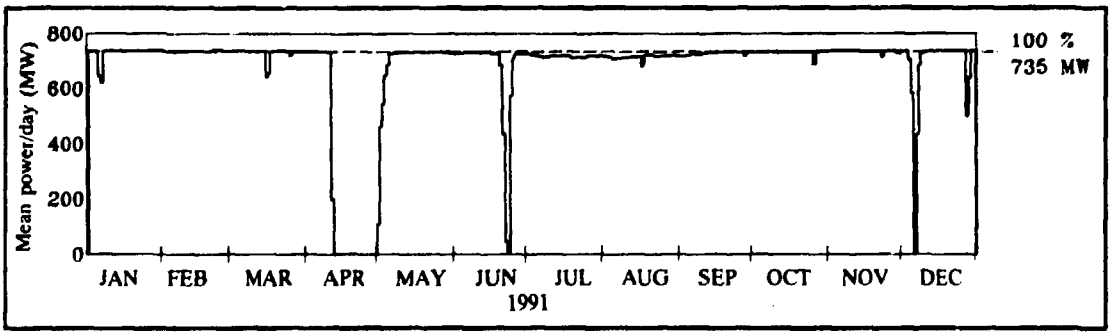

Fig 8. Average daily gross power of TVO II in 1991.

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	8.2.1977	9.5.1977	465/445	Pressurized water reactor (PWR), Atomenergoexport
Loviisa 2	4.11.1980	5.1.1981	465/445	Pressurized water reactor (PWR), Atomenergoexport
TVO I	2.9.1978	10.10.1979	735/710	Boiling water reactor (BWR), Asea Atom
TVO II	18.2.1980	1.7.1982	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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