STUK-B-VTO 38
OPERATION OF FINNISH NUCLEAR
POWER PLANTS

Quarterly Report
Third Quarter, 1986

Compiled by Pekka Lehtinen

May 1987

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ABSTRACT

These general reviews of the operation of the Finnish nuclear power plants concentrate on such events and discoveries related to reactor and radiation safety that the regulatory body, the Finnish Centre for Radiation and Nuclear Safety, regards as noteworthy. The report also includes a summary of the radiation safety of the personnel and the environment, as well as tabulated data on the production and load factors of the plants.

In the report period, no event essentially degraded plant safety nor posed a radiation hazard to the personnel or the environment. For remedying certain defects found in the administrative procedures concerning plant operation and maintenance, the Loviisa power plant was shut down for several days.

INDEX TERMS Reactor operation, PWR type reactors, BWR type reactors

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REGULATION OF NUCLEAR FACILITIES

The regulatory actions and inspections performed by the Finnish Centre for Radiation and Nuclear Safety concern the following areas (it is recommended that the licenses given in parentheses be granted when the inspections have been completed and no reason for withholding the license has been found):

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 and the safety analyses
- Safety classification of components and structures
- Quality assurance plan
- Plans concerning nuclear fuel and nuclear waste management
- Physical protection
  (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 organization
- Technical specifications
- Nuclear fuel management and safeguards
- Methods of nuclear waste management
- Physical protection and preparedness
  (Operating license)

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 organization
- Exceptional events
- Repairs and modifications
- Refuelling

- Nuclear fuel management and safeguards
- Nuclear waste management
- Radiation protection and environmental safety
- Physical protection and preparedness
- Observance of the quality assurance program

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 units in Loviisa and Teollisuuden Voima Oy the TVO I and II units in Olkiluoto, Eurajoki.

OPERATION OF THE NUCLEAR POWER PLANTS IN JULY - SEPTEMBER 1986

All units, i.e Loviisa 1 and 2 and TVO I and II were in commercial operation.

At Loviisa 1, during the start-up after the annual maintenance, one of the two turbines tripped due to empty pulse tubes in the level measurement of the condensate collector and, five days later, the other turbine tripped because of a broken pulse tube in the level control of the condensate collector. Furthermore, power had to be reduced for repairing the generator circuit-breaker. The unit was placed in cold shutdown for replacing the main circulation pump because of suspected damage in it. Due to the fact that certain administrative procedures were being corrected, the shutdown lasted approx. seven days (see Chapter 2 for Loviisa 2). The annual maintenance of the unit lasted from June 27 to July 20.

At Loviisa 2, during the start-up after the annual maintenance, a leakage occurred in the primary circuit through inadverdently opened valves. This lead to investigations and inspections and remedying of certain shortcomings in the administrative procedures on the basis of these actions. As a consequence, the start-up of the unit was delayed for approx. six days. Another reason for the delay of the start-up was leaking check valves in the main feedwater lines. The prolonged annual maintenance of the unit lasted from July 20 to September 13.

At TVO 1, power had to be reduced for repairing a turbine control valve and, in connection therewith, the unit was placed in cold shutdown for little less than 24 hours for repairing the vacuum breakers in two blowdown pipes of the primary circuit over-pressure protection system. In addition, a small reduction of power had to be made because of a main recirculation pump stoppage and for repairing a sealing weld in a flange of the low-pressure preheater.

At TVO II, during the start-up of the unit after the annual maintenance, power had to be reduced due a defective test relay of the low-pressure turbine control valve.

The amount of electricity produced by the Finnish nuclear power plants to the national grid in the report period totalled 4.07 TWh. According to the statistics compiled by the Finnish Association of Electricity Supply Undertakings, the net

production of electricity in Finland was at the same time 10.1 TWh. Nuclear power accounted for 40.3 % of the net production. The avarage load factor of the four units was 74.9 %. The production and availability figures are presented in more detail in Tables I and II. A general picture of the operation of the units can be obtained from the power diagrams (Figures 1-4). The most important events, discoveries and actions taken at the plant units are discussed in Chapters 2 and 3.

The radiation doses received by the personnel, as well as the releases of radioactive substances into the environment were considerably below the established limits. Radiation safety is discussed in Chapter 4.

2 INCIDENTS AND DISCOVERIES

Safety-related incidents at Loviisa 1

Inadvertently closed manually operated valves in the boron feed system

For increasing boron concentration in the primary circuit the boron system is equipped with two high-capacity centrifugal pumps and five smaller piston pumps. Of these pumps only two piston pumps can be controlled from the emergency control room. These two piston pumps are also needed in the event of a containment isolation for feeding sealing water to the main circulation pumps.

A decision was made to increase the boron concentration by means of the piston pumps on July 25, after the other turbine trip had caused a displacement of the control rods from the normal rod-position range. The both pumps stopped, however, immediately after the start. The stoppage was caused by high pressure in the pumping line due to closed manually operated shut-off valves, resulting in the actuation of the safety switch. The pumps had been tested on July 18, at which time the shut-off valves remained, contrary to the rules, in closed position in spite of having been acknowledged as open. The pumps were operated also on July 24 in connection with the testing of the emergency control room controls. During the tests an alarm indicating high pressure was neglected. The pumps did not stop because the pressure safety switch is automatically by-passed during the testing.

As a result of the occurrence, the positions of

all manually operated valves in the boron system were checked and the acknowledging prodecure was made more secure.

Inadvertent shut-off of the control room ventilation

The main ventilation system in the main control room comprises separate handling units for inlet and outlet air. Besides the main ventilation system, the control room is also equipped with an emergency ventilation system, intended for filtering the outside air before it is drawn into the control room and for obtaining a positive pressure in the control room relative to the surrounding areas and the outdoor air in the event of an accident.

The exhaust fan in the main ventilation system was stopped for replacing an electric motor bearing on September 5. At the time the work was started, the plant unit was in cold shutdown and, therefore, the work was not given the status "restricted operation" defined in the Technical Specifications. The unit was made critical on September 11. In the inspection of the conditions for criticality set forth in the Technical Specifications for the start-up of the plant units, it was not discovered that the fan was out of working order. Over-pressurizing of the control room in the event of an accident by means of the emergency ventilation system would have been uncertain, because the outlet valve in the main ventilation system had without work permission locked open in order to intensify the control room ventilation.

The situation was discovered in an occasional inspection on September 19 and the fan was mounted in place. As further measures, the power company has stated that it will increase training in the interpretation of the Technical Specifications, clarify the present form of the Technical Specifications as regards to the ventilation systems and develop the work order practices.

Other incidents at Loviisa 1

Inspection of the main circulation pump due to abnormal operating noise

The unit was placed in cold shutdown on September 5 because of abnormal operating noise from one of the six main circulation pumps. The pump and its motor was disassembled and it was discovered that the abnormal operating noise was due to

loosened clamping of the motor's mechanical oil pump gearing. The widening of the cog clearance would have caused an accelerated wear of the gearing, but probably no other damages. The dismantled motor was replaced by a reserve motor. The defect had no relevance to safety.

Sea water leakage into the lower parts of the turbine hall

In connection with the annual maintenance, inspections and modifications were made on the inner parts of the main sea water pipes. The safety precautions were removed without making sure that the work was in all parts completed. The sea water intake was opened while a mechanician was still working inside the pipe. Injuries were, nevertheless, avoided. Water flooded the lower parts of the turbine hall through an open pipe for two minutes time up to the level of 20 cm. Due to the incident, the work supervisors and the control room personnel were given additional training.

Annual maintenance

The ninth refuelling and annual maintenance outage of Loviisa 1 unit was accomplished from June 27 to July 20. The electricity production of the unit was interrupted for 22 days.

The most important operations included:

- The reactor was loaded with 102 new fuel bundles and 12 new fuel extensions. The Finnish Centre for Radiation and Nuclear Safety accepted the highest permissible linear power of 325 W/cm for the fuel rods of the new type (the same is also true for Loviisa 2). The highest linear power of the old rods is 285 W/cm.

- Nine control rod drives were replaced.

- In order to reduce thermal and pressure transients affecting the reactor pressure vessel in the event of a malfunction or an accident, the high-pressure emergency make-up water system was modified to restrict the capacity of the system. Analyzing the leak patterns of the primary circuit, the capacity restriction was found to be feasible. In addition, vibrations of the pumps and pipe lines were reduced by replacing valves and chokes.

- New shut-off valves were added to both lines in the primary circuit purification system, because the tightness of the control valves in the lines was found to be insufficient for shut-off valve operation. The lines are now equipped with two shut-off valves in series.

- Non-return valves in the low-pressure emergency core cooling system were serviced for removing the leaks detected in them.

- Corrosive wear had been discovered in the Cu/Ni tubes of the turbine condenser. For this reason, the old condenser of one turbine was replaced by a new titanium-tube condenser.

- An extensive modification was made in the plant protective system in terms of, among other things, improving the function of the isolation signals to the steam and feed water lines.

- The make-up pumps in the primary circuit were provided with protective tripping at high pressure in the primary circuit, because the pressure head of the pumps is sufficient to open the safety valve of the pressurizer.

- Some pressure and differential pressure transmitters in the reactor protective system were replaced.

- In order to ensure their accident resistance, the electric and instrumentation components were provided with additional protection, mainly in the turbine hall. Fire protection of the cables in the lower space of the control room and the actuator cables of the pumps and valves in the secondary circuit was improved.

- The main transformers were equipped with automatic sprinkler-systems.

- The old hydrogen leak analysers were replaced by a new 8-canal analyser.

- 25 pressure vessels underwent periodical inspections.

- The primary circuit was subjected to

non-destructive and visual inspections according to ASME XI program.

The collective radiation dose ensuing from the outage was 0,48 manSv.

Safety-related incidents at Loviisa 2

Cross-connected extension stems in two valves

The primary circuit purification system underwent periodic inspections on July 20 during the rundown of the unit for the annual maintenance. During the tests it was found out that the extension stems of two motor-driven shut-off valves had been cross-connected, resulting in closing or opening of a wrong valve.

The valves are located in pipe lines which connect the purification system to each of the six primary circuit loops.

During similar tests conducted a year earlier, it was found out that water was not getting through one of the pipe lines. In a renewed test, water, however, passed the pipe line. At the time the renewed test was performed, the plant unit was, due to the annual maintenance, in a different state of operation and the erroneus installation of the stems was not detected, because the other, normally closed valve, had been opened. The installation fault had been made during the annual maintenance in 1984. The valves were located close to each other, their stems looked alike, bearing no identification, and the actuators were located far away from the valves.

As a remedy, the annual process system tests will be, in the future, performed after the annual maintenance and the competency of the test methods will be surveyed. In addition, it will be studied if it is possible to mark those extension stems that are located close to each other, for example, with different colours. The extension stem valves stayed for two years in a position contrary to the Technical Specifications. The incident could have had relevance to safety in case of isolating a pipe leakage in the primary circuit purification system.

Leak in the primary circuit during start-up

At Loviisa 2 unit, during the start-up after the annual maintenance, a leak occurred in the primary circuit on August 3 as a consequence of improper

valve positions. The half an hour long leakage occurred through the deaeration system into the primary circuit discharge system. The major part of the leaked water (volume 17 m^3) run into the drain tank of the primary circuit. However, about 3 m^3 of the water got through the safety valve in the primary circuit discharge system to the containment air space and floor. At the beginning of the leak, work was still being carried on in the steam generator room. The leak was stopped by closing the valve that had been in inproper position.

A safety valve in the primary circuit discharge line had been under repair on the previous day. The line had been taken into service, even though the precautions concerning the work had not yet been restored. For this reason, two of the manually operated valves in the drainage system were in inproper positions, as the leak started, even though these two valves alone were not enough to form the leakage path. One has not been able to unequivocally define the cause of the leak, but the probable causes are considered to be inproper opening of or inadvertently opened valve in the drainage or deaeration system. In the inspections carried out immediately after the incident, five more inproperly opened valves were detected in the primary circuit purification system. These valves, however, had no relevance to the course of events in question.

The Finnish Centre for Radiation and Nuclear Safety required the following measures to be taken before the start-up of the plant units, referring to the human errors made in connection with the above incident and to the other human errors made during the annual maintenance periods.

> It had to be ensured that the work order practices function in practice (the work supervisors had often informed of the completion of the work only by telephone). The prodecures followed in performing electric connections had to be clarified. Training sessions in the administrative procedures had to be arranged for the operating personnel. The positions and identifications of the valves in all systems important to safety had to be checked.

During the valve inspections, a few valves were found in positions that were not in accordance with the list of specified valve positions. The

detected inproper valve positions would, however, not have been a significant hindrance to the function of any system. Incorrect and missing valve identifications were also found, and it was noticed that, during operation, the systems had been provided with a number of small alterations, not entered in the process and instrumentation diagrams. The defects were corrected and the diagrams were modified to comply with the real construction of the unit.

The Finnish Centre for Radiation and Nuclear Safety gave on September 9 permission to start both plant units after having received the required reports on and results of the accomplished inspections.

Leaks in check valves in the main feed water lines

Feed water can be pumped into the steam generators by means of both the main and the emergency feed water system. In case neither of these systems is available, water can be supplied by means of primary circuit make-up pumps via a separate pumping line. The main feed water line to each steam generator is equipped with two shut-off valves and one control valve located before the check valve.

In the tightness tests carried out after the annual maintenance on September 12, it was detected that the check valves in the main feed water lines were leaking in reverse flow. The leaks are of importance in the event of loosing the main feed water system, e. g. due to a pipe rupture. In such a case, part of the emergency feed water flows through leaking check valves into the main feed water system instead of the steam generators, in case one of the valves in the line in question is not closed.

Due to the detected leaks, the emergency guide concerning the loss of the main feed water was revised so that special attention will be paid to the possibility of a leak in the check valves concerned. All shifts were given simulator training in view of loosing the feed water. A strenghtened manning was maintained in the control room of Loviisa 2 unit until the above-mentioned corrective actions were implemented. In addition, STUK required the power company to review the testing and preventive maintenance procedures concerning the other check valves important to safety and, when necessary, improve the procedures.

Other incidents at Loviisa 2

Annual maintenance

The fifth refuelling and annual maintenance outage of Loviisa 2 unit was accomplished from July 20 to September 13. The electricity production of the plant unit was interrupted for 55 days.

The primary circuit underwent a water pressure test at 17.8 MPa pressure. The behaviour of the pressure vessel was followed by means of acoustic emission. After the pressure test, the reactor pressure vessel coating was subjected to eddy current and ultra-sonic tests. The coating has remained unchanged compared to its condition in 1982. After the reassembly of the reactor inner parts, the reactor was loaded with 102 new fuel bundles, 13 new fuel extension and 36 new steel elements. The following modifications correspond to the operations conducted at Loviisa 1 unit:

- Modifications in the high-pressure emergency core cooling system.
- Providing the primary circuit purification system with additional shut-off valves.
- Servicing the non-return valves in the low-pressure emergency core cooling system.
- Providing the make-up pumps in the primary system with a protective tripping.
- Replacing pressure and differential pressure transmitters in the reactor protection systems.
- Improving the protection of the electric and instrumentation components in view of accident conditions.
- Installing an automatic sprinkler-system for the main transformers.

Other important operations included:

- Structural modifications of the ends of the level measuring tubes in the lower space of the steam generators in order to prevent impurities from flowing down the measuring tubes.
- In the steam generator room, removing

the blowdown pipes deemed as unnecessary from the blowndown system of the steam generators.

- Replacement of the upper ends (2 pieces) of the temperature measurement channels located in the upper space of the reactor pressure vessel.

- Periodical inspections of 62 pressure vessels.

- Water pressure testing of 60 pressure vessels.

The collective radiation dose ensuing from the outage was 2.04 manSv. The exceptionally great dose was due to the great amount of work in which the workers were exposed to radiation.

During the water pressure test of the secondary circuit a great quantity of water leaked through leaking seals into the turbine hall and to the control room roof (the control building is located inside the turbine hall). There were cracks in the control room roof due to concrete shrinkage and the water got through the cracks into rooms containing electrical apparatus. As an immediate result of the leaks, two actuator motors of the feed water control valves burned. After the incident, the power company checked the actuators and the instrumentation that could have got damp. The control room roof was also sealed up.

Safety-related incidents at TVO I

Leak in a non-return valve in the containment pressure suppression system

In order to suppress the containment pressure in the event of a steam leak, the containment building is divided into drywell and wetwell. The steam discharged into the drywell in the event of a pipe rupture, is routed through 16 blowdown pipes to the condensation pool in the wetwell, driven by the pressure difference between the wells. The steam condensates completely in the pool. An overpressure is built up also in the wetwell, because part of the gas in the drywell is drawn there with the steam. Later, as the steam leak stops and the remaining steam in the drywell condensates, a vacuum is built up in the drywell. The pressure difference between the wells is then equalized through non-return valves located at the side of the blowdown pipes. There are 16

non-return valves comprising eight two-valve groups. A sufficient equalizing of the pressure differences is attained by means of seven valve groups. In addition, these vacuum breakers shall close tightly so as to prevent bypass leaks between the drywell and the wetwell of the containment.

During the tightness test conducted in connection with the annual maintenance in the summer of 1986, a minor leak was detected in one non-return valve, the other valve of the valve group being tight. The leak was caused by valve parts dropped on the lower valve from a ruptured guide sleeve of the stem of the upper valve.

As a remedy, the guide sleeve was replaced and both valves were tested. The non-return valves were not shown in the system flow diagrams, due to their passive role. The scope of the repair work and modifications performed on the valve was not accurately specified. As further measures, the flow diagrams will be completed and the safety importance of the valves in question will be emphasized in the personnel training. During the next annual maintenance, all corresponding guide sleeves of the non-return valves in both plant units will be checked.

Other incidents at TVO I

Overflow of low-active water in the radioactive waste building

The used filter compound of the filters and the flushing water in the condensate clean-up system is pumped in the liquid waste collecting tanks located in the radioactive waste building. After replacing the filter compound on July 27, a general alarm from the radioactive waste building was received in the main control room. In addition, an alarm was received from the tank room floor level measurement. It was found out that the tanks were full and water was flowing on the floor via the owerflow pipe of the other tank. The water was coming from the condensate clean-up system through a leaking butterfly valve. The leak stopped when the other valves in the line were closed. The quantity of the flooded water and compound was 4 m^3 and it was pumped back in the waste treatment system and the room was cleaned up.

As further measures, the failed butterfly valve which caused the owerlow will be replaced by a valve of a more reliable type at both plant units. Because a signal had, already earlier during the

flushing, been received for an abnormally high level in the preselected tank, the operating personnel will be pointed out that the incoming alarm signals shall not only be acknowledged but also their origin, cause and actions needed cleared up.

Safety-related incidents at TVO II

Nothing reportable.

Other incidents at TVO II

Nothing reportable.

3 OTHER MATTERS

Transport of used fuel from the Loviisa nuclear power plant to the Soviet Union

Imatra Power Company Ltd. transported between 30 September and 2 August the fourth consigment of used nuclear fuel from Loviisa 1 unit to the Soviet Union. Four containers, in other words 120 bundles, of used nuclear fuel removed from the reactor between 1979 and 1981 were transported by road and rail. The transportation was accepted to be made with special arrangements and it was carried out as the earlier transports. The transportation passed off without incident.

4 RADIATION SAFETY

Individual doses of the personnel

The individual doses of the nuclear power plant personnel in the the report period remained clearly below the quarterly dose limit of 25 mSv. The highest individual dose was 20.2 mSv; it was received at the Loviisa units.

The individual radiation doses of the personnel in the first nine months of 1986 were clearly below the annual dose limit of 50 mSv. The highest dose was 20.2 mSv and it was received at the Loviisa units.

The dose limits of the persons who are exposed to radiation in their work are included in the legislation on radiation protection and they are based on the recommendations of the International Commission on Radiological Protection (ICRP). The limits are set so that the health risk due to radiation is comparable to other work-related risks in occupations regarded as safe.

The distributions of the individual doses of the nuclear power plant personnel in the report period and from the beginning of the year till the end of the report period (Tables III and IV) specify the number of persons in each dose range and at each plant site. In addition, the table shows a distribution which is the total number of workers in each dose range. The distributions comprise the doses of persons who have been entered in the central dose database of the Finnish Centre for Radiation Protection and Nuclear Safety as nuclear power plant workers.

Collective radiation exposure of the personnel

In the report period, the collective radiation dose of the nuclear power plant personnel at the Loviisa 1 and 2 units totalled 2.438 manSv and at the Olkiluoto units 0.055 manSv.

The cumulative collective dose of the personnel in the first nine months of 1986 was 2.467 manSv at the Loviisa units and 1.284 manSv at the Olkiluoto units.

The dose limit recommended in the guides of the Finnish Centre for Radiation and Nuclear Safety is 0.005 manSv/MW(e) in one year, which would be in total 4.4 manSv/year for the Loviisa units and 7.1 manSv/year for the Olkiluoto units.

Releases and radiation doses in the environment

The releases of radioactive substances into the environment in the report period were considerably below the guide release limits (Table V).

In accordance with the Resolution of the Ministry of Trade and Industry, the release limits are determined so that for the persons with the highest exposure the annual whole-body radiation dose is no more than 0.1 manSv. This is less than one tenth of the dose received from natural background radiation and 1/50 of the dose limit given in the legislation.

Thus, the radiation doses calculated on the basis of the release reports are very small.

Radiation safety of the environment

The fallout caused by the nuclear accident at Chernobyl contained plenty of the same radionuclides that the nuclear power plants normally release

into the environment. Of the nuclides detected earlier in the surroundings of the Finnish nuclear power plants, only ^{51} Cr, ^{59} Fe, ^{58} Co, ^{60} Co, ^{65} Zn and ^{124} Sb were not found in the fallout. From the amounts and interrelations of some other nuclides typical of releases, such as ^{3} H, ^{54} Mn, ^{110} Ag, ^{131} J, ^{134} Cs and ^{137} Cs, it is possible to estimate how much comes from the nuclear power plants and how much from the fallout. For making these estimates, one needs data on the spreading and deposition of the releases before the Chernobyl accident, as well as results from the analyses of environmental samples taken elsewhere in the country after the accident.

The total amount of samples taken in the surroundings of both plant sites in accordance with the measurement program of environmental samples was in this quarter 240. Substances originating from nuclear power plants could be detected in certainty only in about nine per cent of the total amount of samples taken in this quarter.

All the ^{60} Co detected in the samples of sedimenting matter, algae and bivalve and in the second sample of perch in Olkiluoto, came from the power plant. The same is true for ^{58} Co and ^{65} Zn in the samples of bladder wrack and ^{58} Co in the samples of common mussel. All the ^{58} Co, ^{60} Co and ^{124} Zb detected in the samples of algae in Loviisa came from the power plant, as well as ^{60} Co detected in the samples of sedimenting matter and ^{60} Co and ^{124} Sb detected in the samples of rain water. Part of the ^{110m} Ag which was detected in the above-mentioned samples from Loviisa, originated from the power plant and part from the fallout caused by the accident in Chernobyl. Of the ^{3} H that was detected in sea water samples from Loviisa, part came from the power plant, part from Chernobyl and part from an older fallout.

In addition to the above-mentioned radioactive substances originating from nuclear power plants and the accident in Chernobyl, the environmental samples contained, in general, also nature's own radioactive substances (natural decay series and ^{7} Be and ^{40} K). The concentrations measured in the samples do not give rise to any actions.

As regards the nuclide composition, the results obtained from the measurement of environmental samples containing radioactive substances originating from power plants are consistent with the release reports of the power companies from this and the previous quarters. In doing this compa-

rison, one must take into account the behaviour of nuclides in nature and their detection limits in measurements. In this quarter, however, some of the nuclides from the power plants were hidden by the fallout from Chernobyl.

Table I Electricity production and availability of the units

	Electricity production (gross, TWh)			Availability factor %	Load factor %		
	Third quarter	Since beginning of 1986	Since start-up	Third quarter	Third quarter	Since beginning of 1986	1985
Loviisa 1	0.70 frz	2.68	30.7	72	68.5	88.0	93.0
Loviisa 2	0.38 fmz	2.36	20.0	40	37.1	77.5	91.7
TVO I	1.57	4.06	38.4	99	96.8	84.2	87.4
TVO II	1.57	4.28	29.8	100	97.1	92.4	87.4

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

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

Symbols (if needed)

- c modifications
- f refuelling
- m maintenance and inspections
- r repairs
- z power restriction

Table II Nuclear energy in the Finnish production of electricity

	Third quarter	Since beginning of 1986	1985	1984
Production of nuclear electricity (net, TWh)	4.07	13.0	18.0	17.8
Total production of electricity in Finland (net, TWh)	10.1	33.6	47.1	43.3
Percentage of nuclear electricity of total production	40.3	38.6	38.2	41.1
Load factor averages of the Finnish plant units %	74.9	85.5	89.9	89.3

Table III Dose distribution of the personnel in the report period

Dose range (mSv)	Number of persons in the dose range		
	Loviisa	Olkiluoto	Total [a]
< 0.5	199	867	988
0.5 - 1	103	26	153
1 - 2	112	8	146
2 - 3	54	3	66
3 - 4	35	-	35
4 - 5	38	-	39
5 - 6	36	-	39
6 - 7	24	-	27
7 - 8	26	-	28
8 - 9	12	-	12
9 - 10	21	-	21
10 - 11	18	-	18
11 - 12	10	-	10
12 - 13	15	-	15
13 - 14	6	-	6
14 - 15	7	-	7
15 - 16	4	-	6
16 - 17	3	-	3
17 - 18	1	-	1
18 - 19	6	-	6
19 - 20	5	-	5
20 - 21	1	-	1
21 - 22	-	-	-
22 - 23	-	-	-
-	-	-	-
- 25	-	-	-

[a] This column also includes the data on 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.

Table IV Dose distribution of the personnel from the beginning of the year till the end of the report period

Dose range (mSv)	Number of persons in the dose range		
	Loviisa	Olkiluoto	Total *
< 0.5	193	382	565
0.5 - 1	105	207	310
1 - 2	113	173	277
2 - 3	58	72	127
3 - 4	35	54	82
4 - 5	36	24	56
5 - 6	35	19	54
6 - 7	27	15	42
7 - 8	25	6	30
8 - 9	13	2	17
9 - 10	18	3	29
10 - 11	21	3	31
11 - 12	18	3	14
12 - 13	17	1	19
13 - 14	6	-	8
14 - 15	6	-	6
15 - 16	5	-	6
16 - 17	3	-	4
17 - 18	1	-	1
18 - 19	5	-	6
19 - 20	4	-	5
20 - 21	3	-	3
21 - 22	-	-	-
22 - 23	-	-	-
23 - 24	-	-	-
24 - 25	-	-	-
25 - 26	-	-	-
26 - 27	-	-	-
-	-	-	-
- 50	-	-	-

* These columns also include the data on 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.

Table V Releases of radioactive substances into the environment at each plant site

Plant site	Gaseous effluents		Liquid effluents	
	Noble gases (^{87}Kr-equiv., TBq)	Iodines (^{131}I-equiv., MBq)	Tritium (TBq)	Other nuclides (GBq)
Loviisa				
Report period	[a]	[a]	3.4	0.17
In the first nine months of 1986	[a]	[a]	10	0.24
Olkiluoto				
Report period	0.09	4.2	0.27	8.4
In the first nine months of 1986	0.65	78	1.1	33
Annual release limits				
Loviisa	22,000[b]	220,000[b]	150	890[b]
Olkiluoto	17,000	120,000	19	300

[a] Below detection limit. The calculatory release of ^{41}Ar from the Loviisa 1 and 2 units expressed as ^{87}Kr-equivalents was 0.23 TBq in the report period and 1.1 TBq in the first nine months of 1986.

[b] The figure shows the release limit of the plant site on the presumption that there will be no releases of other release types. The guide release limit is set in such a way that the sum of the release limit shares of the various types is equal to or smaller than 1.

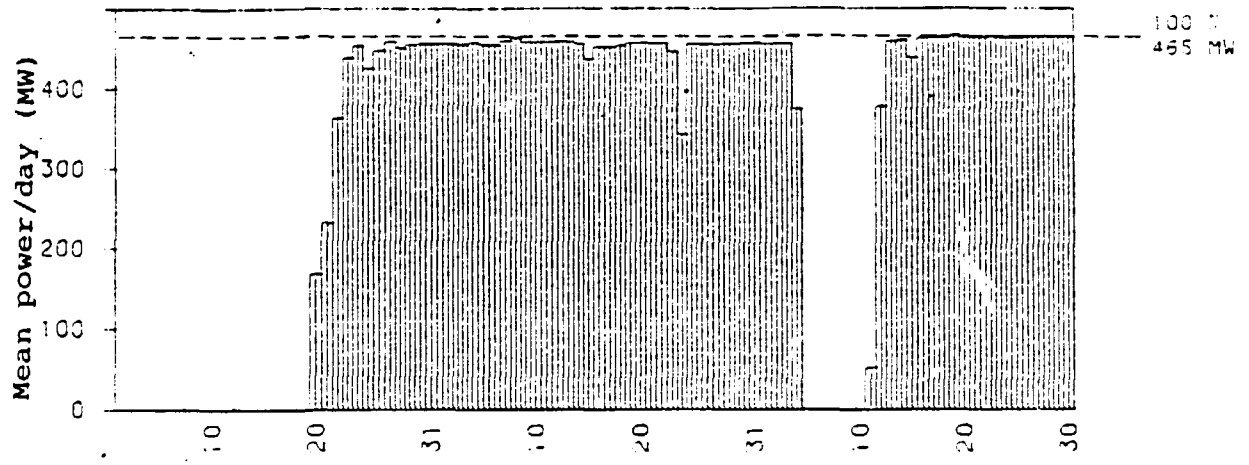

Figure 1 Daily gross power of Loviisa 1 plant unit in July - September 1986

1 Annual maintenance

2 Trip of one turbine

3 Repair of a generator circuit-breaker

4 Replacement of a main circulation pump. Correction of administrative procedures

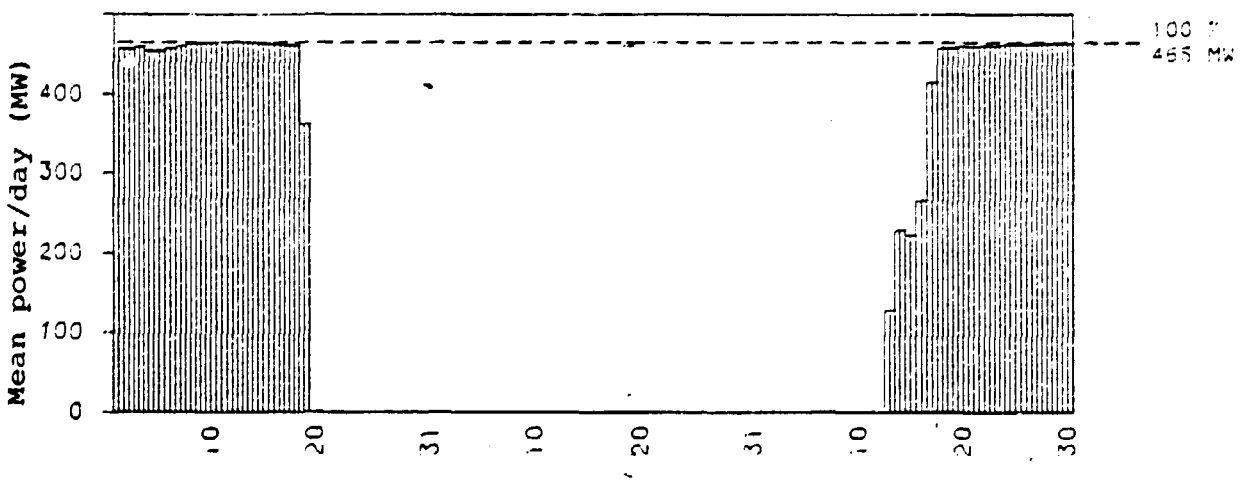

Figure 2 Daily gross power of Loviisa 2 plant unit in July - September 1986

1 Annual maintenance

2 Correction of administrative procedures

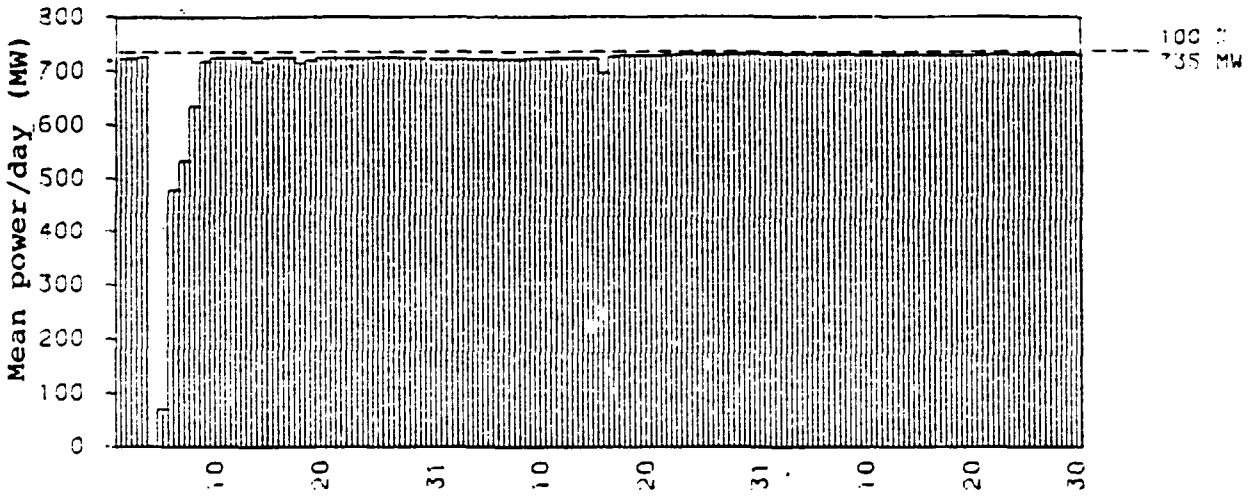

Figure 3 Daily gross power of TVO I plant unit in July - September 1986

1 Repair of a turbine control valve. Repair of the vacuum breakers in two blowdown pipes in the relief system

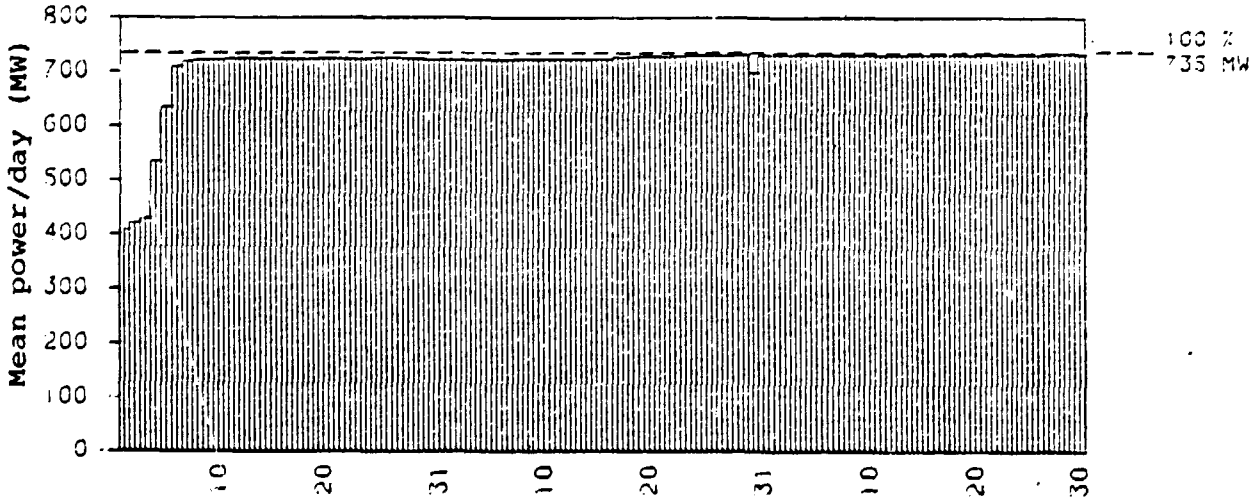

Figure 4 Daily gross power of TVO II plant unit in July - September 1986

1 Start-up after the annual maintenance

2 Repair of the test relay of a low-pressure turbine control valve