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Operation of Finnish nuclear power plants

Quarterly report 1st quarter, 1992

Kirsti Tossavainen (Ed.)

SEPTEMBER 1992

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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 all the time in the first quarter of 1992. The load factor average was 99.8 %. All the events which are classified on the International Nuclear Event Scale were level 0/below scale on the Scale.

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 the nuclear power plants, were detected in samples collected in the vicinity of the nuclear power 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 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 and inspections related to nuclear power plants are 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. The fourth Quarterly Report also contains a summary of the information reported in the year in question 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 on the observations made by the Finnish Centre for Radiation and Nuclear Safety during regulatory control. The events described in the report are classified on the International Nuclear Event Scale.

Apart from the 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 the nuclear power plants.

2 OPERATION OF NUCLEAR POWER PLANTS IN JANUARY–MARCH 1992

The Finnish nuclear power plants were in operation for almost all the time in the first quarter of 1992. A brief interruption in production was caused by the outage to repair a failed valve at Loviisa 2.

2.1 Production data

Nuclear electricity accounted for 32.1 % of total production in Finland in this annual quarter. The load factor average of the plant units was 99.8 %. Production and availability figures are presented in more detail in Tables I and II. Power diagrams describing electricity generation by the plant units and the 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 (%)	
	First quarter 1992	Whole year 1991	First quarter 1992	Whole year 1991	First quarter 1992	Whole year 1991
Loviisa 1	1.01	3.55	100.0	90.5	99.3	87.1
Loviisa 2	1.01	3.63	98.7	90.6	99.3	89.2
TVO I	1.61	6.10	100.0	95.6	100.5	94.7
TVO II	1.61	5.95	100.0	93.8	100.1	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.*

	First quarter 1992	Whole year 1991	1990
Production of nuclear electricity (net, TWh)[a]	5.0	18.4	18.1
Total production of electricity in Finland (net, TWh)[a]	15.6	55.2	51.7
Share of nuclear electricity of total production	32.1	33.3	35.0
Load factor averages of the Finnish plant units	99.8	90.9	89.1

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

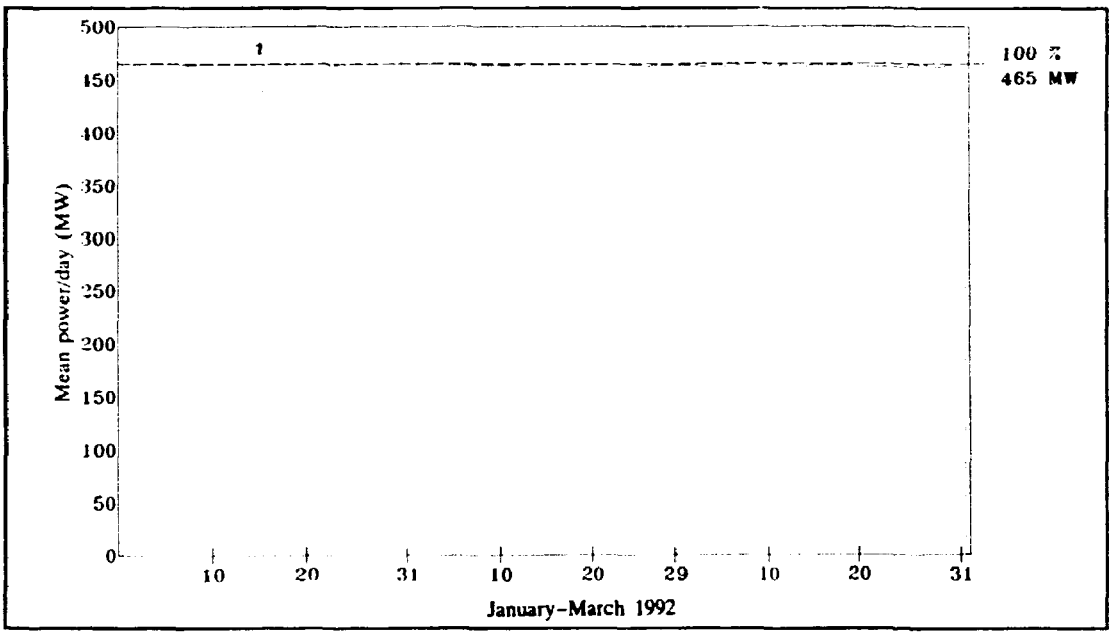

Fig 1. Average daily gross power of Loviisa 1 in January–March 1992.

1 Repair of a leak of a HP turbine bleeding point

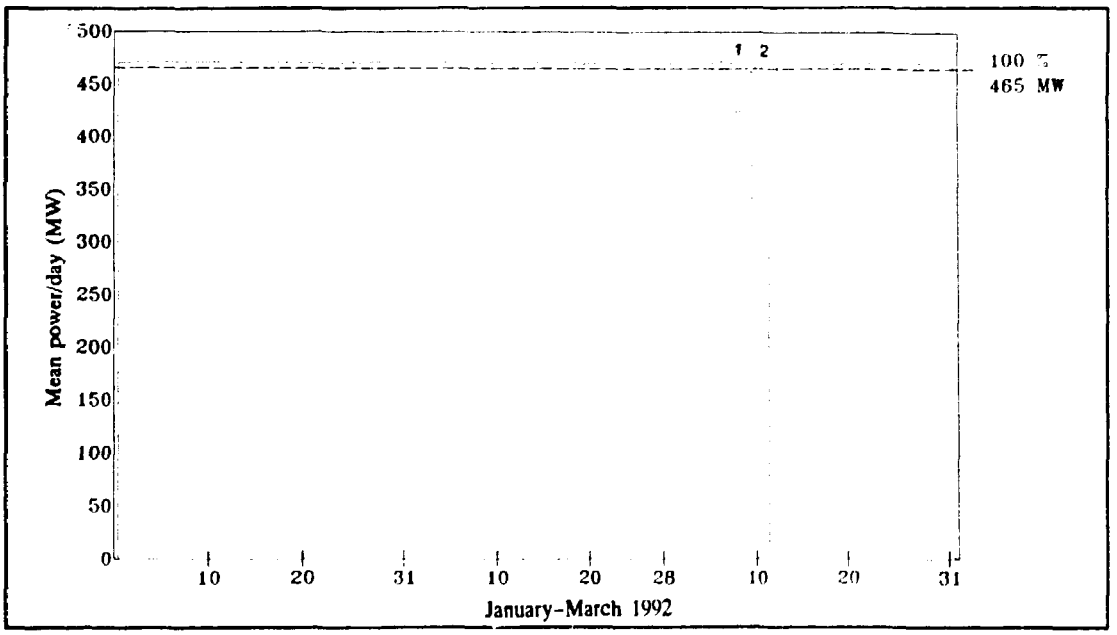

Fig 2. Average daily gross power of Loviisa 2 in January–March 1992.

1 One turbine tripped in connection with an adjustment of the lubricating oil system of the turbines, reactor to operate at 50 % power (see Chapter 2.2)
2 Hot shutdown to repair a feedwater system valve (see Chapter 2.2)

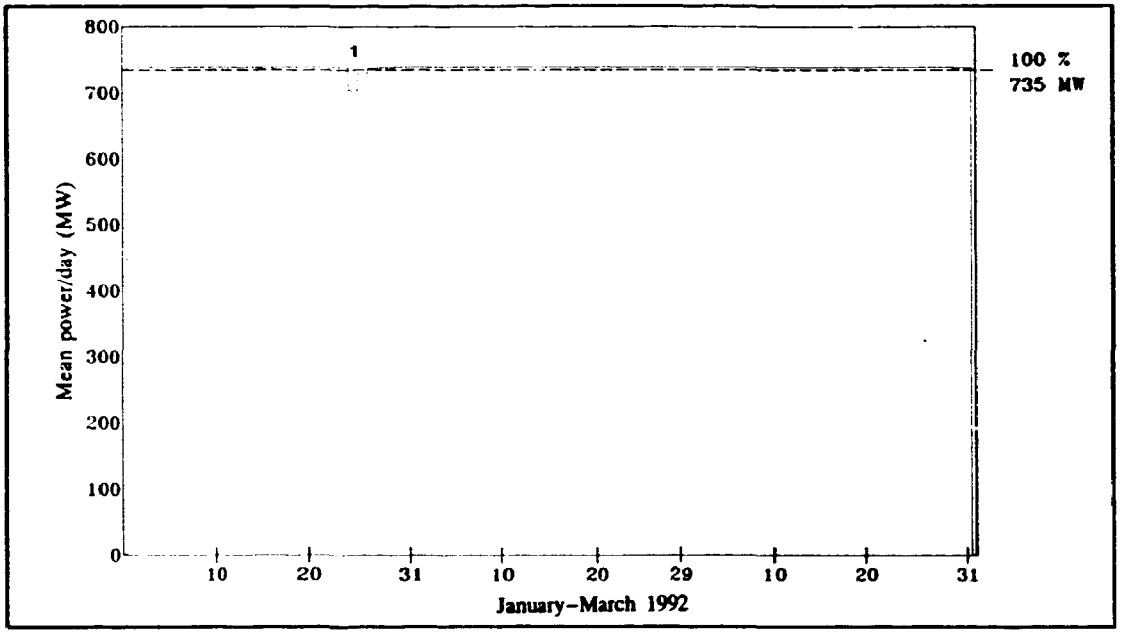

Fig 3. Average daily gross power of TVO I in January–March 1992.

1 Periodic tests, reactor operating at 65 % power

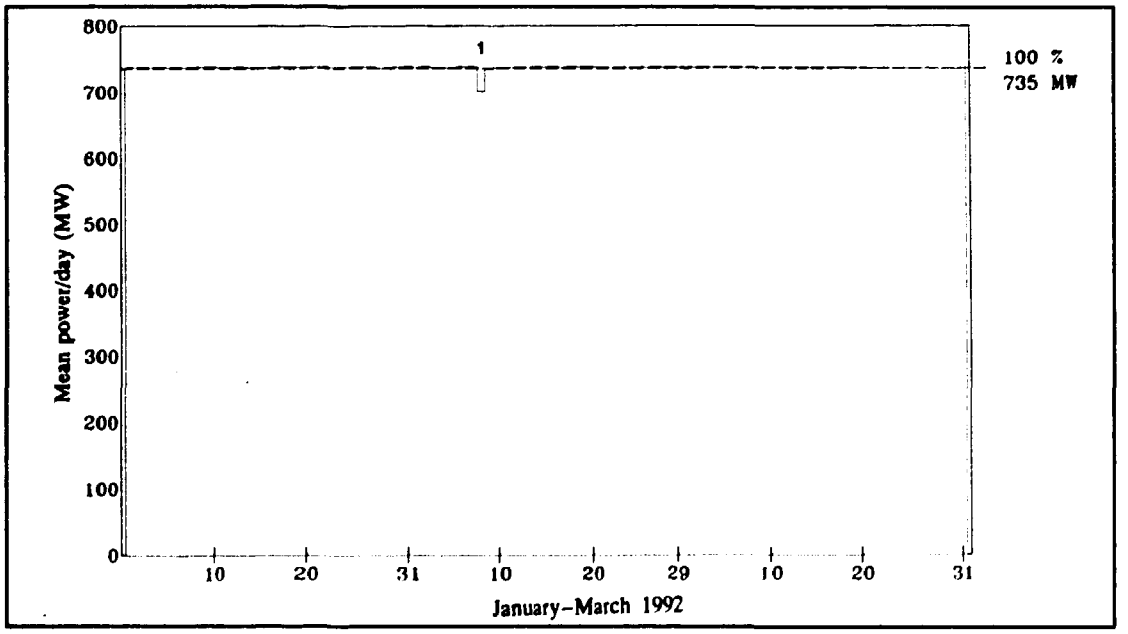

Fig 4. Average daily gross power of TVO II in January–March 1992.

1 Periodic tests, reactor operating at 70 % power

2.2 Hot shutdown at Loviisa 2

In connection with an adjustment of the lubriation system of the turbines of Loviisa 2 on 8.3. the level of oil tanks dropped below the protection limit because the adjustment measures were applied too quickly. One of the two turbines tripped in consequence. The turbine was placed back in full power the next morning. During restart a fault was observed in one gate valve of the feedwater system for the repair of which the plant unit was placed in hot shutdown on 11.3. A slide which was loose from the stem had prevented the valve's functioning. The valve was repaired and the plant unit was back on line on 12.3.

3 EVENTS AND OBSERVATIONS AT EACH PLANT UNIT

Loviisa 1

In connection with a modification work carried out in the ventilation system of the Loviisa 1 control room the permissible period of removal from service of a cooler was exceeded. The period allowed for repairing the failed component was mistakenly observed as the period for its removal from service. The event is classified as level 0/below scale on the International Nuclear Event Scale.

3.1 The permissible period of removal from service of an air cooling unit was exceeded in connection with a modification of the ventilation system

At Loviisa 1 modifications were made in the local control of two coolers of the ventilation system of the control building. The coolers had to be stopped for the repairs. The coolers cool the water which is required in the air conditioning of the control room and the instrumentation area important to safety.

For the repair of components important to safety the Technical Specifications determine the maximum period a component may be removed from service without the plant's operational state having to be changed (e.g. without shutting down the plant). An exemption from the Technical Specifications granted by the Finnish Centre for Radiation and Nuclear Safety is required for the removal from service of operable components.

Imatran Voima Oy obtained the necessary permit of exemption from the Technical Specifications for the modification work so that one cooler at a time was permitted to be removed from service for a working day (8 hrs). Cooler specific work orders were devised for the work according to regular procedure. In stead of the eight hours' removal from service permitted by the exemption from the Technical Specifications, three days and nights were determined in the work order as the period for which the cooler could, according to the Technical Specifications, be removed from service for repairs.

Modification work on the first cooler was started on 2.3. The next day an inspector of the Finnish Centre for Radiation and Nuclear Safety noted that the exemption from the Technical Specifications had not been complied with. After this the modification was accomplished without delay. The component was removed from service for about 32 hrs. In the work order of the other cooler the permissible period of removal from service was altered to gain conformity with the exemption from the Technical Specifications and the work was done according to it.

The cause for exceeding the permissible period of removal from service was a human error which occurred in the handling of the work order. The procedure of handling work orders has been changed since i.a. so that exemptions from the Technical Specifications are attached to work orders.

Loviisa 2

No reportable events occurred at Loviisa 2 in the first quarter of 1992.

TVO I and II

At the TVO plant units it was observed in test measurements made with a portable ultrasonic meter that the flow rate in the shut-down secondary cooling system was less than indicated by fixed meters. The event is classified as level 0/below scale on the International Nuclear Event Scale.

3.2 The heat transfer capacity of the shutdown cooling train was below the desingn value

At TVO I, in March, Teollisuuden Voima Oy made test measurements of the flow rates of various systems by a portable ultrasonic meter to assess the reliability of a new, ultrasound-based flow rate measurement system.

When making the test measurements in the shutdown secondary cooling system it was observed that the ultrasound meter gave indications ca. 20 kg/s less than the system's fixed flow meters. Based on several check measurements it was ascertained that the system's fixed measurement equipment erroneously gave indications higher than the actual flow rate. The flow rates have been adjusted based on the indications given by the fixed meters. Thus the system's actual flow rates were not according to the design value.

Teollisuuden Voima Oy continued the flow rate measurements. The flow rates of the shut-down secondary cooling system at TVO II were also ascertained as too low. The flow rates of other systems did not deviate from the flow indications given by the fixed meters.

The shut-down secondary cooling system is part of the heat transfer train by which the shut-down reactor's decay heat is transferred to the final heat sink i.e. the sea. Furthermore, the heat transfer train in question is used to cool the condensation pool of the containment building into which, in the event of transients and accidents, aqueous steam from the reactor pressure vessel is blown.

Teollisuuden Voima Oy carried out a safety review owing to the event. In the review the effect of the low flow rate ascertained in the shut-down secondary cooling system on the effectiveness of the whole shutdown cooling train was investigated. The review showed that the decrease in the heat transfer capacity of the cooling train was very small.

The flow rates in the shut-down secondary cooling systems both in TVO I and II were set to comply with the system's design values.

4 RADIATION SAFETY

Individual radiation doses of nuclear power plant workers remained well below the dose limit. Also releases of radioactive material off-site clearly remained 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 Occupational radiation exposure

The Finnish radiation legislation was revised at the beginning of the year 1992. Finland is among the first countries to apply the more stringent dose constraints recommended by the International Commission on Radiological Protection (ICRP). According to the Radiation Decree, the effective occupational radiation dose incurred in radiation work may not, in a period of five years, exceed the 20 mSv annual average. This will be monitored from the year 1992 onward. The radiation dose may not, during any one year, exceed 50 mSv.

The major part of the occupational radiation dose is generally incurred in work performed during annual maintenance outages. There were no annual maintenance outages in this quarter. The highest individual radiation dose in the report period was 8 mSv and it was received at the TVO nuclear power plant.

The distribution of individual radiation doses received by nuclear power plant workers in the report period compared with the distribution in the whole year 1991 is given in Table III which specifies the number of individuals in each dose range and at each plant site. The information given in the Table originates in the central dose file of the Finnish Centre for Radiation and Nuclear Safety.

In the report period, the collective occupational radiation dose at the Loviisa plant was 0.02 manSv and at the TVO plant 0.07 manSv. The dose limit given in a guide issued by 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.

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

Table IV presents the site-specific measured releases of radioactive materials. The Table also gives the annual release limits. Off-site releases in the report period clearly remained below the prescribed release limits.

4.3 Radiological monitoring of the environment

About 140 samples were analysed in this quarter the major part of which, according to the programmes of monitoring, were samples of air.

No radioactive material originating in the Loviisa nuclear power plant was detected in samples collected in the vicinity of the Loviisa nuclear power plant. Instead, radioactive materials which gained access to the environment in consequence of the

fuel channel failure at the Sosnovy Bor nuclear power plant on 24.3.1992 were detected in samples of air and, minor amounts, in samples of deposited material and sea water.

In a sample of air collected in Olkiluoto from 16.3. to 1.4. cobalt-60 originating in the Olkiluoto nuclear power plant was detected. Its concentration in the air was 4 $\mu Bq/m^3$.

Table III. *Occupational dose distribution in the report period and the year 1991.*

Dose range (mSv)	Number of persons in the dose range					
	First quarter 1992			Whole year 1991		
	Loviisa	TVO	Total[a]	Loviisa	TVO	Total[a]
<0,5	31	76	109	161	437	557
0,5 - 1	6	24	30	92	267	334
1 - 2	6	11	17	101	199	281
2 - 3	1	3	4	65	81	127
3 - 4	-	-	-	39	32	73
4 - 5	-	1	1	33	26	56
5 - 6	-	-	-	27	24	48
6 - 7	-	-	-	21	12	35
7 - 8	-	-	-	16	3	26
8 - 9	-	1	1	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	-	-	-	-	-	-

a These columns include also 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 nuclear power plants and in Sweden.

Table IV. External releases of radioactivity at each plant site, first quarter.

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) c)	b)	$1.6 \cdot 10^{6}$	$7.7 \cdot 10^{10}$	d)
1991	b) c)	$1.6 \cdot 10^{8}$	$1.8 \cdot 10^{6}$	$4.8 \cdot 10^{11}$	d)
Olkiluoto					
Report period	$2.0 \cdot 10^{11}$	$1.2 \cdot 10^{7}$	$5.1 \cdot 10^{7}$	$5.4 \cdot 10^{10}$	d)
1991	$7.1 \cdot 10^{12}$	$2.5 \cdot 10^{8}$	$7.3 \cdot 10^{6}$	$1.3 \cdot 10^{11}$	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	$4.4 \cdot 10^{12}$	$3.7 \cdot 10^{6}$
1991	$1.4 \cdot 10^{13}$	$5.2 \cdot 10^{9}$
Olkiluoto		
Report period	$3.7 \cdot 10^{11}$	$3.5 \cdot 10^{9}$
1991	$1.9 \cdot 10^{12}$	$2.2 \cdot 10^{10}$
Annual release limits		
Loviisa	$1.5 \cdot 10^{14}$	$8.9 \cdot 10^{11}$ 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 Below detection limit.
c The calculatory release of argon-41 from Loviisa 1 and 2 expressed as krypton-87 equivalents was $4.2 \cdot 10^{11}$ Bq during the report period. In 1991 the release was $1.5 \cdot 10^{12}$ Bq.
d The carbon-14 release estimate based on experimental data was $8.8 \cdot 10^{10}$ Bq in Loviisa and $1.7 \cdot 10^{11}$ Bq in Olkiluoto during the report period. The estimates for the year 1991 were $3.2 \cdot 10^{11}$ Bq in Loviisa and $6.4 \cdot 10^{11}$ Bq in Olkiluoto.
e The numerical value shows the release limit for the Loviisa plant site on the presumption that no releases of other release types will 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.

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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