RUJV-RP-015

R E P O R T

ON

OPERATION OF NUCLEAR FACILITIES

IN SLOVENIA IN 1992

Republic of Slovenia

Ministry of Environment and Regional Planing

SLOVENIAN NUCLEAR SAFETY ADMINISTRATION

A B S T R A C T

Slovenian Nuclear Safety Administration (SNSA) in 1992 was responsible for: nuclear safety, trade of nuclear and radioactive materials, safeguarding nuclear materials, and conducting regulatory process related to liability for nuclear damage, qualification and training of operators at nuclear facilities, quality assurance and inspection of nuclear facilities.

The major nuclear facility supervised by SNSA is the Nuclear Power Plant in Krško with a pressurised water reactor of 632 MW electric power. Beside the nuclear power plant, TRIGA Mark II Research Reactor of 250 kW thermal power operates within the Reactor Center of Jožef Stefan Institute. There is an interim storage of low and medium radioactive waste at the Reactor Center. Also the Uranium Mine Žirovski Vrh was supervised by SNSA.

All the nuclear power facilities in the Republic of Slovenia were operating safely in 1992. There were no significant events that could be evaluated as a safety problem or a breach of technical specifications.

A great part of activities of SNSA was focused on the international co-operation and finally Slovenia become a member of the IAEA. Next visit of the IAEA OSART team (Operational Safety Assessment Review Team) in the Krško Nuclear Power Plant was postponed in 1993. Visit of the INSARR mission (Integrated Safety Assessment of Research Reactors) for the TRIGA Mark II Research Reactor was in march 1992.

30.5.1994

1. INTRODUCTION

Slovenian Nuclear Safety Administration (SNSA) is responsible for: nuclear safety, trade of nuclear and radioactive materials, safeguarding nuclear materials, and conducting regulatory process related to liability for nuclear damage, qualification and training of operators at nuclear facilities, quality assurance and inspection of nuclear facilities.
Slovenian Nuclear Safety Administration is a part of Ministry for Environment and Regional Planning. In accordance with the recommendations of the International Atomic Energy Agency the SNSA is not supposed to promote nuclear power, therefore it is separate and independent from the Ministry of Energy which is in charge of power utilities.

The major nuclear facility supervised by SNSA is Nuclear Power Plant in Krško with a pressurised water reactor of 632 MW electric power. Beside the nuclear power plant, TRIGA Mark II Research Reactor of 250 Kw thermal power operates within the Reactor Center of Jožef Stefan Institute. There is an interim storage of low and medium radioactive waste at the Reactor Center. Also the Uranium Mine Žirovski Vrh was supervised by SNSA.

All the nuclear power facilities in the Republic of Slovenia were operating safely in 1992. There were no significant events that could be evaluated as a safety problem or a breach of technical specifications. There were three automatic and two manual shutdowns of the Krško Nuclear Power Plant. Two automatic shutdowns were because of high water level in steam generator in july and august and one was because of blown fuse on the turbine inverter. Manual shutdowns were because of steam leakage on the high pressure turbine and refuelling.

A great part of activities of SNSA was focused on the international co-operation and finally Slovenia become a member of the IAEA. Next visit of the IAEA OSART team (Operational Safety Assessment Review Team) in the Krško Nuclear Power Plant was postponed in 1993. Visit of the INSARR mission (Integrated Safety Assessment of Research Reactors) for the TRIGA Mark II Research Reactor was in march 1992.

The major competencies of SNSA stipulated by laws are relevant to safe operation of the Krško Nuclear Power Plant and the supervision over the operation of nuclear facilities in the Republic of Slovenia which represented the greatest part of activities of SNSA in 1992.

The Republic of Slovenia accepted succession of the following treaties to which the former Socialist Republic of Yugoslavia was a party:

- Treaty on the Non-Proliferation of Nuclear Weapons,
- Agreement Between the Socialistic Federal Republic of Yugoslavia and the International Atomic Energy Agency for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons,
- Statute of the International Atomic Energy Agency,
- Convention on the Physical Protection of Nuclear Material,
- Convention on the Early Notification of a Nuclear Accident,
- Convention on the Assistance in the Case of a Nuclear Accident or Radiological Emergency,
- Vienna Convention on Civil Liability for Nuclear Damage,
- Agreement on the Privileges and Immunities of the International Atomic Energy Agency,
- Treaty Banning Nuclear Weapons Tests in the Atmosphere, in the Outer Space and under Water,
- The IAEA Incident Reporting System (IAEA-IRS),
- Treaty on the Prohibition of the Emplacement of Nuclear Weapons and Other Weapons of Mass Destruction on the Sea-Bed and the Ocean Floor and in the Subsoil Thereof.

The operation of the Krško Nuclear Power Plant was supervised by nuclear safety inspection in accordance with regulations and licences.
Totally of 54 planned inspections in Nuclear Power Plant Krško and 2 planned inspections in TRIGA Mark II Research Reactor were performed by SNSA. Besides, two unplanned inspections were carried out at the Krško Nuclear Power Plant. They were performed either by the nuclear safety inspection or together with other inspectorates. This co-operation was successful and will continue also in the future, specially in the joint systematic inspection check-ups. At the Uranium Mine Žirovski Vrh there was one unplanned inspection carried out.

During the refueling outage of the Krško Nuclear Power Plant there were 17 planned inspections and SNSA inspectors joined the IAEA inspectors controlling the material ballance of nuclear materials.

In 1992 SNSA also issued operating license to the Reactor Center Podgorica for the TRIGA Mark II reactor whose operation licence expired.

In 1992 SNSA employed five new professionals (Adviser to Director, Nuclear Safety Inspector, Advisor I and two trainees). A lot of attention was given to the training of the staff.

Within SNSA there is an Advisory Commission on Nuclear Safety (22 members) which met three times in 1992 and treated most important matters in the field of radiation protection and nuclear safety related to the operation of nuclear facilities. The Advisory Commission on Nuclear Safety also treated the Krško NPP Outage Report for the year 1991, Krško NPP Refit Report for the year 1992 and Annual Operating Report for 1991 of the TRIGA Mark II Research Reactor and the Uranium Mine Žirovski Vrh.

The Commission for Reactor Operators Exams held three examinations. 29 candidates applied; 19 candidates for senior reactor operators and 10 for reactor operators. All candidates passed the tests successfully.

2. OPERATION OF NUCLEAR FACILITIES

2.1 KRŠKO NUCLEAR POWER PLANT

2.1.1 Main Operational Data

In 1992 the Krško NPP generated 3.970,718 MWh of electrical energy at the outlet of the generator, i.e. 3.768.088 MWh net. The generator was connected to the national grid 6698,7 hours or 76,26 % of the total number of hours in the year. The electrical production was 1,62 % lower than planned. Table 1 shows the pace of output compared to the planned one.

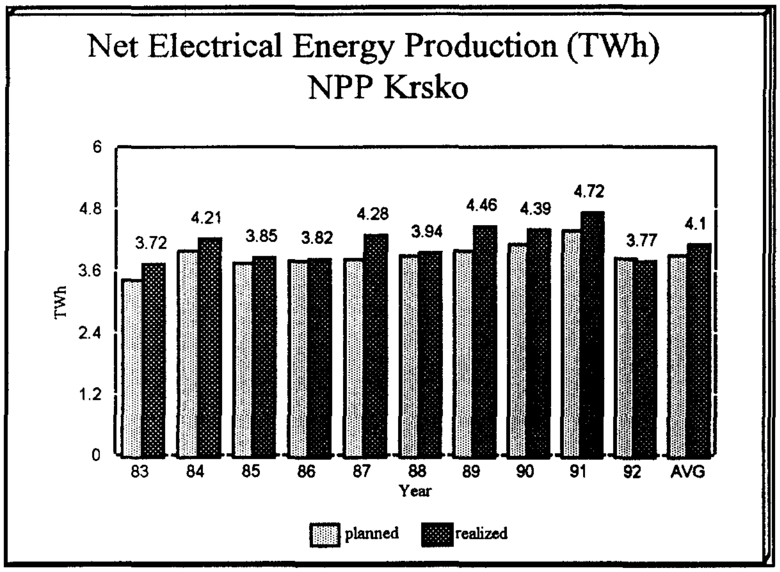
Table 1: NPP Krško net electrical energy generation in 1992

Month	Planned Output (GWh)	Actual Output (GWh)	Difference (%)**
JAN	400	450.9	12.73
FEB	380	405.2	6.67
MAR	400	445.2	11.29
APR	400	428.0	6.99
MAY	0	0.0	0
JUN	0	0.0	0
JUL	250	57.4	-77.04
AUG	400	322.8	-19.3
SEP	400	352.7	-11.83
OCT	400	426.8	6.68
NOV	400	416.6	4.15
DEC	400	462.6	15.65
Total	3830	3768.1	-1.62

* Krško NPP did not operate due to refuelling outage in May, June and started to operate on 23 July.

** (Actual Output - Planned Output)/(Actual Output) (%)

Figure 1: NPP Krško net electrical energy production (TWh)



In 1992 the reactor was critical 6714,3 hours or 76,44 % of the total number of hours in that year. The generation of thermal energy amounted to 11.614.766 MWh, the average burnout of fuel was 13.191 MWD/MTU.

Important performance indicators of the power plant are availability, capacity factor and number of forced shutdowns.

Table 2: Reliability indicators of operating of NPP Krško in 1992

	Year 1993 (%)	Average (%) 1983 - 1992
Availability factor	76.26	80.72
Capacity factor	69.19	75.74
Forced outage factor	0.97	1.79

Figure 2: NPP Krško availability factor

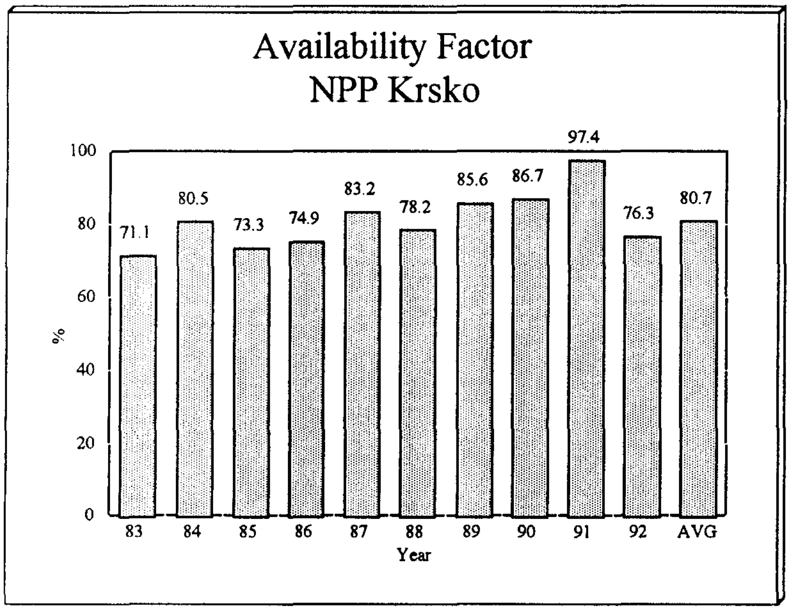


Table 3: NPP Krško time consumption in 1992 relevant to output

Time analyses of output	Hours	Percentage (%)
total available time	8784	100
plant operating time	6698.7	76.26
total outage time	2085.3	23.74
maintenance	2019.4	22.9
planned shutdowns	0	0
unplanned shutdowns	65.9	0.75

Table 4 shows the events due to which the Krško NPP was shutdown in 1992. It contains information on modes of shutdowns of power plant, causes of shutdowns and their duration.

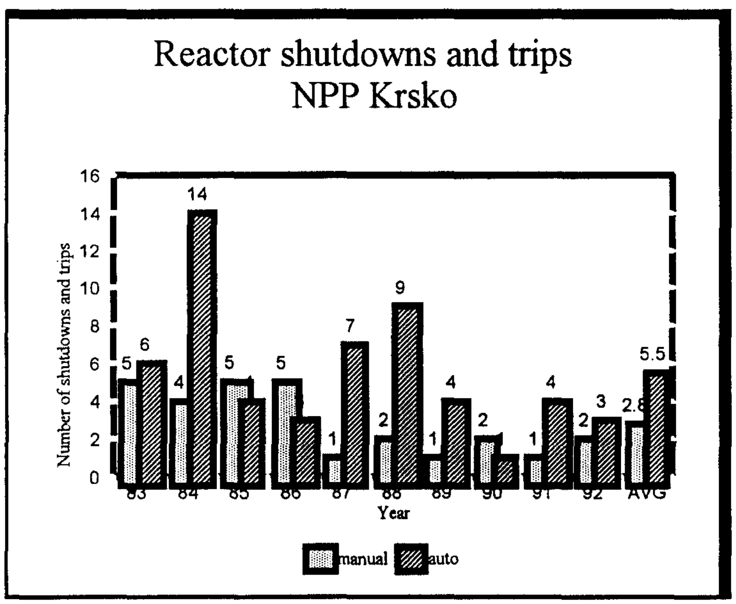
Table 4: Planned and unplanned shutdowns in 1992

DATE	HOURS	DESCRIPTION
26 JAN	9.5	Power reduction to 80 %. Testing of the turbine valves
5 FEB	28.4	Manual reactor trip due to steam leakage on the blind flange of the high pressure turbine. Cause: Erosion. No impact on the environment.
22 Mar	3.5	Power reduction to 90 %. Testing of the turbine valves
30 APR	2019.4	Manual reactor trip due to refuelling outage
24 JUL	3.3	Automatic reactor trip from 26% power. High level in steam generator No. 2. According to the planned testing of the turbine overspeed, power was reduced, turbine stopped and reactor power stabilised on 2 or 3 %. Later, because of uncontrolled opening turbine control valves, (P-13 signal generation, and loss of the signal P-7) in steam generator No. 2 the fast increase of the steam level swell cause reactor trip. The event did not cause any impact on the environment.
24 JUL	5.8	Automatic reactor trip from 25 % power on steam generator No 1. HI-HI level caused by inadvertent opening of feedwater control valve (due to electronic signal drift) during switchover from manual to automatic.
1 AUG	744	Operating at 70 % power because of the low River Sava flow. *
1 SEP	721	Operating at 78 % power because of the low River Sava flow. *
1 OCT	47	Reduction to 75 % power because of the low River Sava flow. This is according the Slovenian regulations.*

3 OCT	56	Reduction to 54 % power because of the condenser cleaning.
24 OCT	15	Reduction 75 % power because of the condenser cleaning.
10 NOV	31.8	Automatic reactor trip. Blown fuse on the inverter No. 6 caused turbine trip and reactor trip from 100 % power. The event did not cause any impact on the environment.

* Due to the very low Sava river flow and imposed regulatory power restrictions regarding thermal pollution of the Sava river, the plant had to operate at lower power levels.

Figure 3: NPP Krško reactor shutdowns and trips



2.1.2 Integrity of Reactor Fuel in 1992

In the process of electricity generation fuel integrity depends on reactor operation history. This year the 9th and 10 fuel cycle was going on. The 10 th fuel cycle ended in July 24, 1992.

The integrity of the fuel in the reactor is monitored indirectly by the reactor coolant activity. The specific activities of a greater number of isotopes are measured at stable operations as well as during transient phenomena.

The fuel quality for the 9th and 10 th cycles was very good, the dispersed uranium of former cycles, which pollutes the coolant, prevails and the leakage of fuel is under the detection limit.

2.1.3 Radioactive Emissions to the Environment

The limiting values of radioactive emissions into environment are stipulated by the licence to start operations of the Krško NPP No. 31-04/83-5 issued on February 6, 1984 by the Republican Energy Inspection Authority. The emissions of radioactive effluent into the Sava River are at the level of few percentage of limiting values of the licence for all radionuclides, except for tritium for which the annual emitted activity was approximately 70 % of the limiting value stated in the licence. The same is valid for air emissions for the Krško NPP. The limiting values for tritium are considerably lower from those stipulated or enforced in licences issued for nuclear power plants in other European countries.

Relevant administrative authorities are regularly informed about the emissions in regular and special reports by the Krško NPP. Regular reports are made on a monthly and yearly basis. Special reports are mostly relevant to planned emissions from containment before its venting. The Krško NPP daily informs relevant administration bodies in regular operation reports about the type and activity of emissions of radioactive waste into the Sava river.

Figures 4 and 5 show released tritium activity and released liquid activity during past years.

Figure 4: Released liquid activity (Krško NPP), limiting value is 200 GBq/year

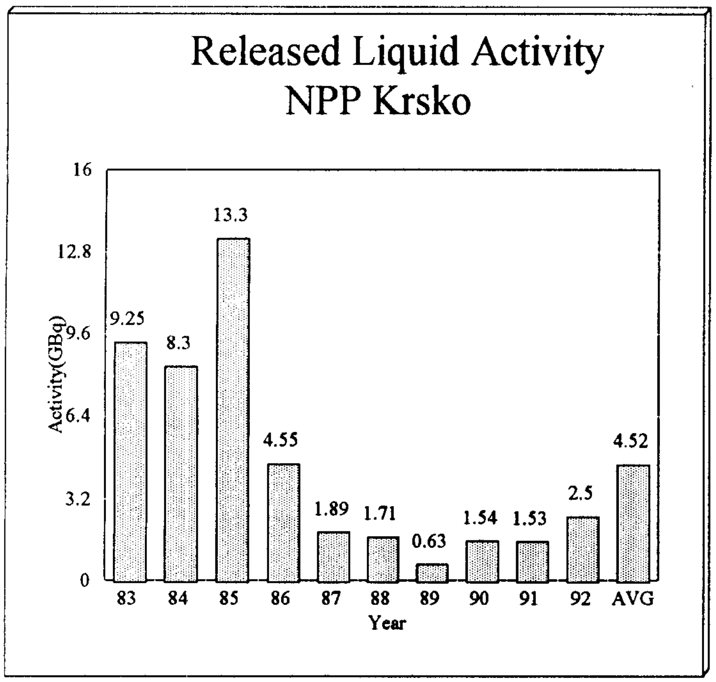


Figure 5: Released tritium activity (Krško NPP) in Krško, limiting value is 20 TBq/year

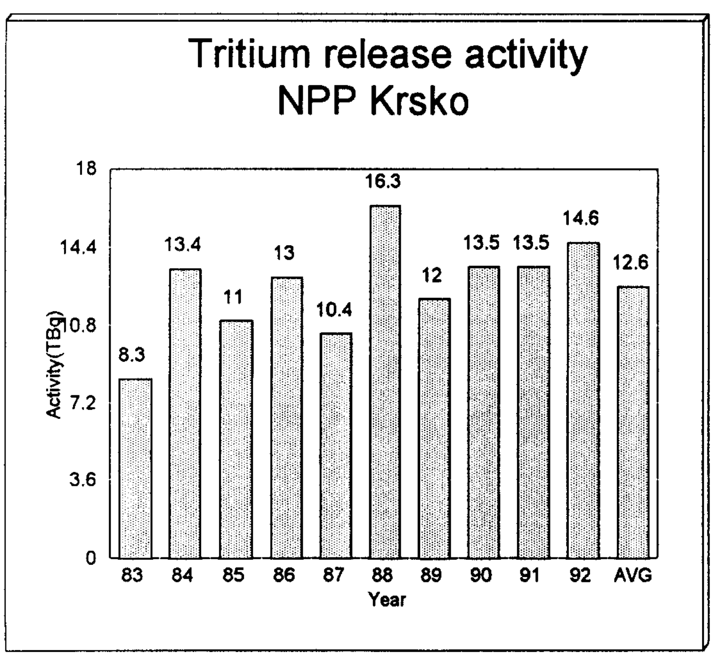
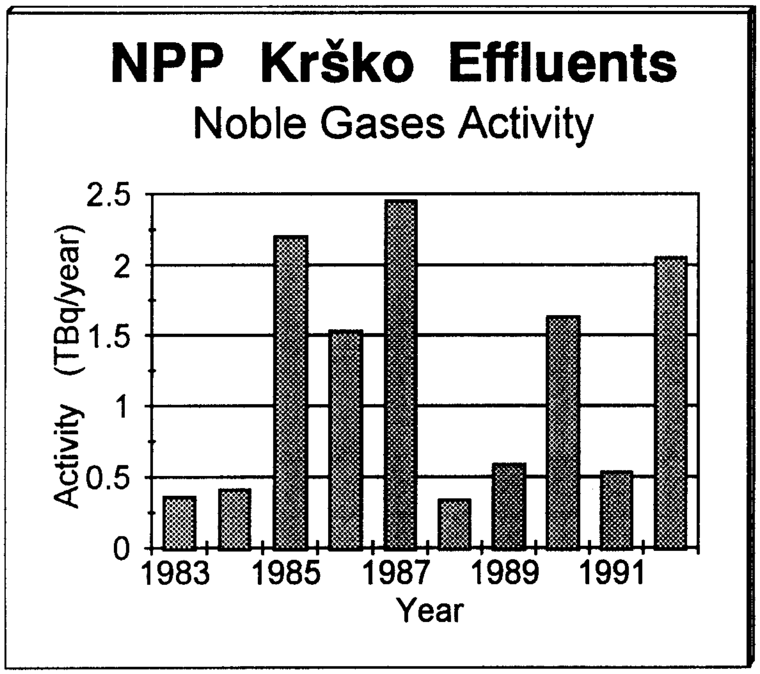


Figure : Noble Gases Activity, NPP Krško Effluents



2.1.4 Doses Received by Personnel

The average exposure of the personnel in the power plant is low and does not exceed 1/20 of the prescribed limiting value for professionals. The received doses are higher during refuelling and maintenance operation than during the normal operation. The dose limits for nuclear power plant and contractor workers were obeyed, and the received doses were even below the latest ICRP recommendations as well.

Table 2.6 shows the distribution of effective doses of personnel that worked in 1992 within the fence of the Krško NPP from 1981 to 1992. Beside power plant personnel, subcontractors are also included in the table. The table shows that 150 persons have received in 1992 the annual effective dose above 5 millisieverts (mSv).
The collective effective dose of the plant personnel was 0.425 manSv. For other people including the personnel of main contractor the effective dose in 1992 was 1.713 manSv and total for all workers was 2.14 manSv. The annual collective

effective dose per unit of electrical power generated was 4.85 manSv/GWyear (UNSCEAR 1988 sets the average for west European power plants at 4 man Sv/GW year). Table 7 shows collective effective doses at the Krško NPP in 1992 relevant to activities and Table 8 shows collective and average doses in 1992.

Table 6: Distribution of effective doses for all workers at the Krško NPP during years 1981 and 1992

Range of dosses mSv/year	0-1	1-5	5-10	10-15	15-20	20-25	25-30	Total
1981	475	45	0	0	0	0	0	520
1982	275	313	9	13	10	2	1	622
1983	462	206	53	45	34	31	4	831
1984	375	205	15	3	2	0	0	600
1985	517	277	79	17	2	0	0	892
1986	542	301	79	3	4	1	0	912
1987	486	242	65	16	6	1	0	816
1988	506	298	60	21	3	1	0	889
1989	443	200	66	19	3	0	0	731
1990	390	265	92	38	5	2	0	792
1991	257	89	8	0	0	0	0	345
1992	448	219	0	127	22	1	0	817

Table 7: Collective effective doses of irradiation at Krško in 1992

Activity	Doses (manSv)		
	Krško personnel	Subcontractors	All
regular maintenance	0.146	0.8271	0.9734
processing of red. waste	0.0486	-	0.0486
refuelling outage	0.2304	0.8862	1.1166
Total	0.4253	1.7133	2.1386

Figure 6: Collective effective doses (NPP Krško)

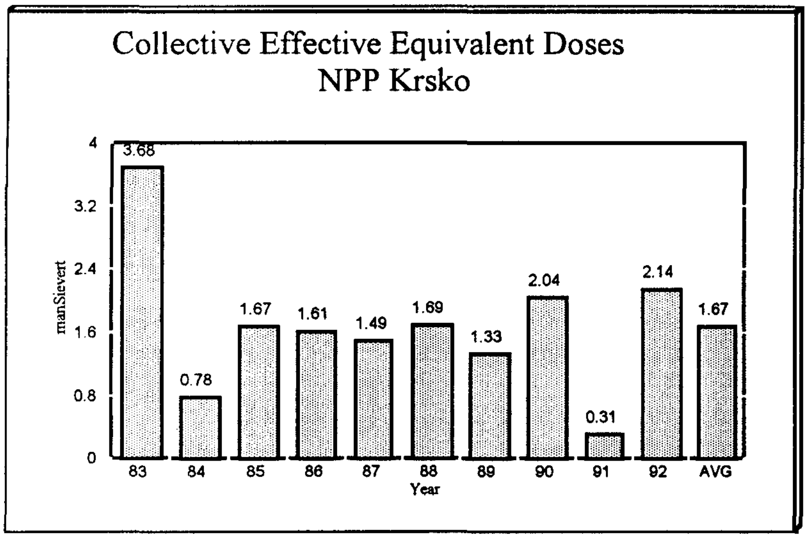


Table 8: Collective and average effective doses in 1992

Employees	Coll. doses (manSV)	No. of emp.	Average Dose (mSv)
Krško NPP	0.4253	295	1.44
Subcontractors	1.7133	522	3.28
Total	2.1386	817	2.61

2.1.5 Radioactive Waste

All radioactive waste is packed in the power plant in 200 litter drums: low radioactive compressible waste without additional protection, other more active waste with additional protection which consists of concrete cylindrical liner inside the drums.

In ten years of power plant operation 1774 m3 of LIL waste have accumulated.

Average specific activity in barrels (drums) is 21,6 GBq/m3.

Table 9: Radioactive waste in the Krško NPP according to the type and activity at 31/12/1992

Type of waste	Number of Drums	Activity (GBq)	Volume (m^3)	Specific Act. GBq/m^3
SR	870	27407	174.0	149
CW	792	650	158.0	4
EB	6393	7987	1278.6	6
F	87	1784	17.4	104
O	111	20	22.2	1
SC	617	531	123.4	4
TOTAL	8870	38376	1774.0	21

Type of waste:

SR - spent resin
CW - compressible waste
EB - evaporator bottom
F - filters
O - other waste
SC - super compacted waste

2.1.6 Spent Nuclear Fuel

In the power plant spent fuel elements are stored in the spent fuel pool which has enough space for 17 refuelling and for the entire reactor core (121 fuel elements) as a permanent available reserve, if for what so ever reason, it was necessary to empty the reactor core. The capacity of the spent fuel pool is therefore sufficient for storage of used fuel elements at least until the year 2000. The plant operator is making much effort in increasing the duration of fuel cycle and to achieve better efficiency by improving nuclear core design. That would make possible to use the existing spent fuel pool even after the year of 2000.

2.1.7 Personnel Training

Peaceful use of nuclear energy requires highly trained personnel which is required also by regulations. Not only the level of education is stipulated by regulations but also programs of initial and permanent training, as well as the system of checking of the skills of personnel for specific jobs and tasks. This is stipulated by Reactor regulations (Official Gazette SFRY, No.86/87; Off. Gaz. of SRS No. 9/81) for Krško Senior Reactor operators and Shift Engineers managers and department for protection against irradiation.

The Krško NPP has its own training department which takes care of annual training programs. As there is no simulator of nuclear power plant in Slovenia, Krško NPP training department organises obligatory annual courses on a simulator abroad, mostly in the USA. All personnel that require the permit of operator or senior reactor operator were on refreshment courses in 1992 on a simulator of NPP GINNA, Rochester, N.Y., USA. These people participated also at permanent training in spring and autumn according to the program which contains beside regular refreshment courses also studying of experiences from nuclear power plants in other countries and specialised topics like nuclear safety.

Above all, expenses for personnel training are approximately 2,5 % of plant working expenses.

2.1.8.Steam Generators

During the refuelling combined with general maintenance and repairs the steam generators (SG) were checked. At the SG No. 1 there were plugged 284 tubes in total 868, that is 19 %. In SG No. 2 there ware plugged 167 tubes in total 460 what is 10.1 %, but because of safety analysis which do not allowed more then 5 % asymmetry between steam generators there were actually plugged 639 or 14%. Because of situation with steam generators the plant has to start with preparations with tube sanation and replacement of steam generators. This is the activity which takes some years and big funds.

2.2 TRIGA RESEARCH REACTOR

Jožef Stefan Institute's TRIGA Mark II research reactor at Podgorica in Ljubljana with power of 250 kW has been operating for more than 20 years. The reactor produces radioactive isotopes, mostly short-lived used in medicine, science and industry, deals in neutrons and gamma research, activation analyses, irradiation of materials for manufacturing of semiconductors and training of personnel.
In accordance with regulations all the necessary services for protection against irradiation, storage of radioactive waste and records and storage of nuclear fuel are organised in the reactor centre where are in total 313 fuel elements.
In charge of reactor operation are head operator of reactor, five operators and service for protection against Ionizing radiation.
Reactor operators received effective equivalent doses of irradiation of gamma till 0.60 mSv. Neutron doses were below 0,5 mSv.

2..2.1 Interim Storage of Radioactive Waste in the Reactor Center Podgorica

Interim storage for solid low and medium radioactive waste for users in Slovenia (except for the Krško NPP and Žirovski Vrh Uranium Mine) has been functioning since 1987 on.

In 1992 the following activities were going on:

- receiving and recording of additional radioactive waste,
- regular weekly supervision of the storage (visual and radiological supervision).

There are three types of radioactive waste in the storage:

- closed barrels with contaminated items (paper, plastics, glassware, etc.) and materials with induced activity due to irradiation in TRIGA reactor,
- other waste - bigger contaminated or active items which due to their size cannot be stored in barrels and are therefore stored separately,
- closed sources - unusable closed sources of irradiation which are, as a rule, stored in original protected containers.

Quantity and activity of different types of radioactive waste are given in table 10. In 1992 the number of drums increased by 8, number of closed sources by 16, number of special waste 23.

Table 10: Radioactive Waste in the Transition Storage in the Reactor Center Podgorica at 31.12.1992 (cumulative)

Type	Amount	Isotopes *	Activity (GBg)
Barrels	133 (8)**	Co-60, Cs-137, Eu-152, Ra-226	3 - 20
Special	79 (16)	Co-60/Ra-226/Am-241	7700
Closed	98 (23)	Co-60, Sr-90	1000

* - isotopes providing the majority of activity are only quoted

** - Barrels stored in 1992

3. RELEASED RADIOACTIVITY IN THE VICINITY OF NUCLEAR INSTALLATION

In Slovenia radioactivity of environment is measured on the entire territory within the scope of the so-called Republican Program according to Regulations on Locations, Methods and Time Schedule for Testing of Contamination with Radioactive Substances (Off. Gaz. SFRY No. 40/86).

Radioactivity in the vicinity of nuclear installations is regulated by Regulations on Mode, Scope and Time Schedule of Systematic Testing of Contamination with Radioactive Materials in the Vicinity of Nuclear Facilities (Off. Gaz. SFRY No. 51/86)

3.1 KRŠKO NUCLEAR POWER PLANT

All detectable and quantitatively evaluated loading of environment due to emissions of the Krško NPP were under administratively allowed limiting values. Evaluated loading of persons and critical groups of population made as on the basis of evaluated emission values as on the basis of data of annual emissions of the Krško NPP by a computer model provides in 1992 values for the effective doses that are smaller than 10 microSv/year or smaller than 0.5 % of annual dose received in average by a man in normally loaded environment by natural and artificial sources.

3.2 REACTOR CENTER AT PODGORICA

Monitoring of radioactive releases in 1992 was made on the basis of Program of regulation of radioactivity in the environment of the Reactor Center at Podgorica.

One can derive from the measured data (emissions) that two most important effects on the environment were the following:

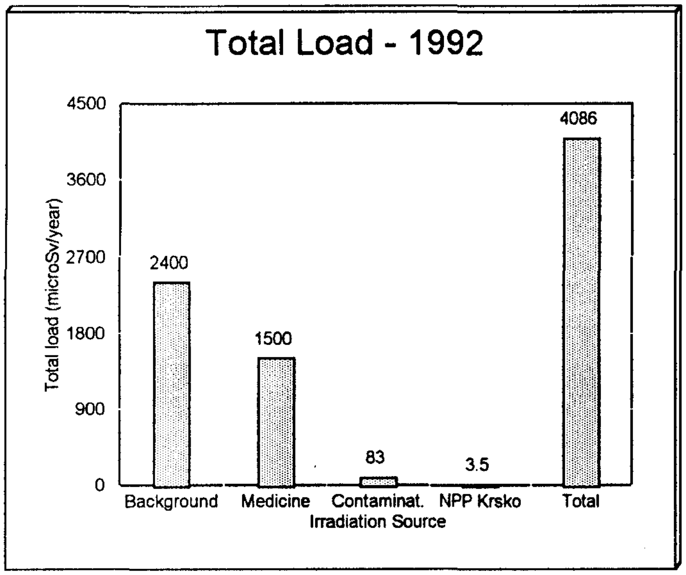
- discharge of Ar-41 into the atmosphere (ventilation system of reactor hall)

- discharge of radioactive substances in the Sava river with liquid waste from Department for Nuclear Chemistry.

Estimated yearly effective dose per person due to Ar-41 in the air is 300 nanoSv, what is 0.03 % of annual permissible value according to the regulations. Estimated yearly Effective dose per person due to discharge of radioactive substances in the Sava river is 1 microSv.

The dose was estimated on the basis of emission values, models of dispersion in the environment and dosimetric factors.

Figure 7: Annual Effective dose of persons in the vicinity of NP Krško



3.3 Uranium Mine Žirovski Vrh

In 1992 the Act for Closing The Uranium Mine Žirovski Vrh was passed (Off. Gaz. RS, No. 36/92). Because of limited founds the activities are restricted only on, environmental monitoring and basic research for the final closing of the mine.

Concentrations of long-lived radionuclides from aerosols in the surrounding environment were equal to the reference concentrations and were not higher than background one. Average radon concentration was nearly the same in the year 1991 and was not essentially lover after closing down. Also the radioactivity of sediments from brooks Bretovščica and Todraščica and concentration of uranium in surface waters did not change in 1992.

On the basis of monitoring and measurements in the environment around the uranium mine the additional dose was calculated for the critical group and was 0.34 mSv. For individuals that is the same value as in 1991.

Effective Dose of an individual was lover than limited Dose of 1 mSv per year, per lifetime which is regulated by Act (Off. Gaz. SFRY, No. 31/87) and recommended by International Guidelines ICRP 60 (1990).