OPERATION OF NUCLEAR FACILITIES IN SLOVENIA

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Republic of Slovenia
Ministry of Environment and Regional Planning

SLOVENIAN NUCLEAR SAFETY ADMINISTRATION

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Republic of Slovenia
Ministry of Environment and Regional Planning

SLOVENIAN NUCLEAR SAFETY ADMINISTRATION

REPORT

ON THE

OPERATION OF NUCLEAR FACILITIES

IN SLOVENIA IN 1993

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SUMMARY

The Slovenian Nuclear Safety Administration (SNSA) prepared a Report on Nuclear Safety in the Republic of Slovenia in 1993 as part of its regular practice of reporting on its work to the Government and the National Assembly of the Republic of Slovenia. The Report is divided into five thematic chapters covering the activities of the SNSA, the operation of nuclear facilities in Slovenia, the activity of international missions in Slovenia, the Posavje - 93 exercise, and the operation of nuclear facilities around the world.

At the legislative level, the Administration in 1993 continued its work on preparing new Slovenian legislation (the law on nuclear and radiological safety, the law on liability for nuclear damage) and on preparing two draft regulations (on ensuring nuclear safety from the human standpoint - the so-called fitness for duty - and on professional education, work experience and testing of knowledge for the acquisition, extension and renewal of licences for reactor operators and chief operators in the Krško nuclear power plant).

In carrying out its administrative duties, the SNSA in 1993 issued a total of 27 administrative decrees, 22 of which applied to the Krško nuclear power plant.

The SNSA has two associated expert commissions - the Nuclear Safety Expert Commission, which met three times during 1993, and the Expert Commission for Testing the Qualifications of Krško Operators, which organised two examination periods in 1993.

The international activities of the SNSA markedly expanded in 1993. The Administration took part in the negotiations on the agreement between the Republic of Slovenia and the Republic of Austria on the early exchange of information in the event of radiological danger, and proposed similar bilateral agreements to the nuclear safety administration agencies of other neighbours (Italy, Hungary, Croatia). In December 1993, the SNSA and the US Nuclear Regulatory Commission signed an agreement on the exchange of technical information and cooperation in the field of nuclear safety.

Cooperation with the International Atomic Energy Agency (IAEA) is particularly intensive. SNSA workers and other Slovenian experts participated in the preparation of IAEA documents such as Basic Safety Standards, the Nuclear Safety Convention, the revision of the Vienna Convention on civil responsibility for nuclear damage, etc. The SNSA also collaborates with the IAEA missions (OSART, ASSET, ASCOT) and other systems (INES, IRS, INIS).

The SNSA personnel and other Slovenian experts in nuclear safety and radiation protection participated in many seminars, courses and workshops organised by the IAEA.

The IAEA also conducts a technical assistance and cooperation programme which includes programmes for scholarships, scientific visits, research contracts and concrete technical-assistance projects. Slovenia actively participates in all these programmes.

The inspections carried out in the Krško nuclear power plant in 1993 included 58 regular inspections, nine extraordinary inspections, four joint inspections with the authorised organisations related to the aggregate expert assessment upon completion of the "outage '92", four other inspections after the "extraordinary outage '93", and o joint inspection with the Fire Inspectorate of the Republic of Slovenia (RS). Furthermore, there were three inspections of the TRIGA research reactor, as well as the regular inspection of the Žirovski Vrh Mine with the participation of the Sanitary Inspectorate of RS. The inspection services established that the repair work and the functional and driving tests of the plant systems and components following the "extraordinary overhaul '93" complied with the operational

conditions and limits. During the shutdowns, the causes were examined, measures was proposed and the implementation of the adopted measures were supervised.

In 1993, the Krško nuclear power plant generated 3,956,662 MWh (3.96 TWh) of gross electric power at the generator output, or 3,762,780 MWh (3.76 TWh) of net electric power. The generator was connected to the grid for 6,492.8 hours, 74.1% of the total number of hours in that year. The production was 7.78% lower than planned. The reactor was critical for 6,518.51 hours, 74.41 % of the total number of hours, and the thermal energy produced totalled 11,471,831 MWh. The scheduled and unplanned shutdowns of Krško, and the reactor power reductions in excess of 10 % of the rated power for over 4 hours, included three automatic shutdowns and two manual shutdowns. The automatic shutdowns occurred due to the cut-out of voltage of the reactor pump inverter, the stoppage of the steam flow from the steam generator caused by irregularities in the sequence of testing of the main steam line bypass valve, and during the planned halting of the reactor after oscillations in the turbine power occurred and caused automatic shutdown of the reactor. The manual shutdown occurred because of a leak in the steam generator pipe, which necessitated the extraordinary overhaul. The steam generators are problematic because of the large number of clogged pipes, which will have to be replaced in the foreseeable future. The Krško nuclear power plant made eight modifications ordered by the SNSA, as well as other 17 modifications.

The environmental-impact monitoring of Krško in 1993 proceeded according to the established programme. On the basis of measurements of emissions and imissions, and on the basis of conservative assumptions, the contribution of the Krško nuclear power plant to the effective reference-man dose in the vicinity of the plant in 1993 was assessed at less than 10 μSv. The dose represents less than 0.5 % of the dose that an individual receives from natural or from other artificial sources of radiation.

The non-radiological monitoring to establish the effect of the nuclear power plant on the river Sava and on groundwater shows that the operation of the plant has no negative effect on the water and fauna of the river Sava at Brežice.

The monitoring of radioactivity in the human environment in Slovenia compared with the measurement of radioactivity in the surroundings of the Krško nuclear power plant shows that the effect of iodine from hospitals is greater in real terms than the contribution of Krško.

In 1993, the 250 kW thermal power research reactor TRIGA produced 257.45 MWh of heat. There were two unplanned shutdowns - one because of a voltage cut-out, the other because of a defect in the radiological protection instrumentation. The provisional radioactive waste storage in the Podgorica reactor centre remained uncontaminated, and only the dose rate in the rear of the storage increased. None of the facilites represents a perceptible additional radiological impact on the environment. Radioactive leaks from the Podgorica reactor centre in 1993 were approximately equal to the leaks in 1991 and 1992, the period when they reached their lowest in the entire period of operation of the TRIGA research reactor. The imission values were below the detection threshold. The effective reference-man dose in the vicinity of the Reactor centre in 1993 was modelled using the measured emissions and estimated at 1 μSv.

In April 1993, the programme for the permanent shutdown of production of uranium ore and the elimination of consequences of mining in the Žirovski Vrh Uranium Mine was completed. A supplemented programme will be drawn up in 1994. The additional load per individual in the critical group due to the mining was calculated on the basis of the results of imission in the surroundings of the Žirovski Vrh Mine. The contribution to the effective dose in 1993 was assessed at 290 μSv, which is several times lower than in previous years. The main contribution to the additional load comes from radon and its descendants (227 μSv). The termination of the working of the ore deposit has not resulted in any significant reduction in the gas and liquid emissions of radionuclides. A significant reduction is expected only after the rehabilitation of the mine and its waste products have been completed.

In 1993, three international nuclear safety expert missions were active in Slovenia. They found out 252 deficiencies, but their unanimous assessment was that nuclear safety in Slovenia was not threatened. Their recommendations relate to the organisation and management, education, operation, maintenance, technical support, radiological protection, chemistry, emergency preparedness, power plant systems, fuel and waste, geology - seismology, analyses and studies, managing bodies, legislation and regulations. Up to date, 72 recommendations have been implemented in practice, 113 will be implemented in 1994, and further 63 ones in 1995. Only six recommendations do not have a fixed deadline. None of the commissions' reports indicated critical deficiencies that would require the shutdown of the Krško power plant.

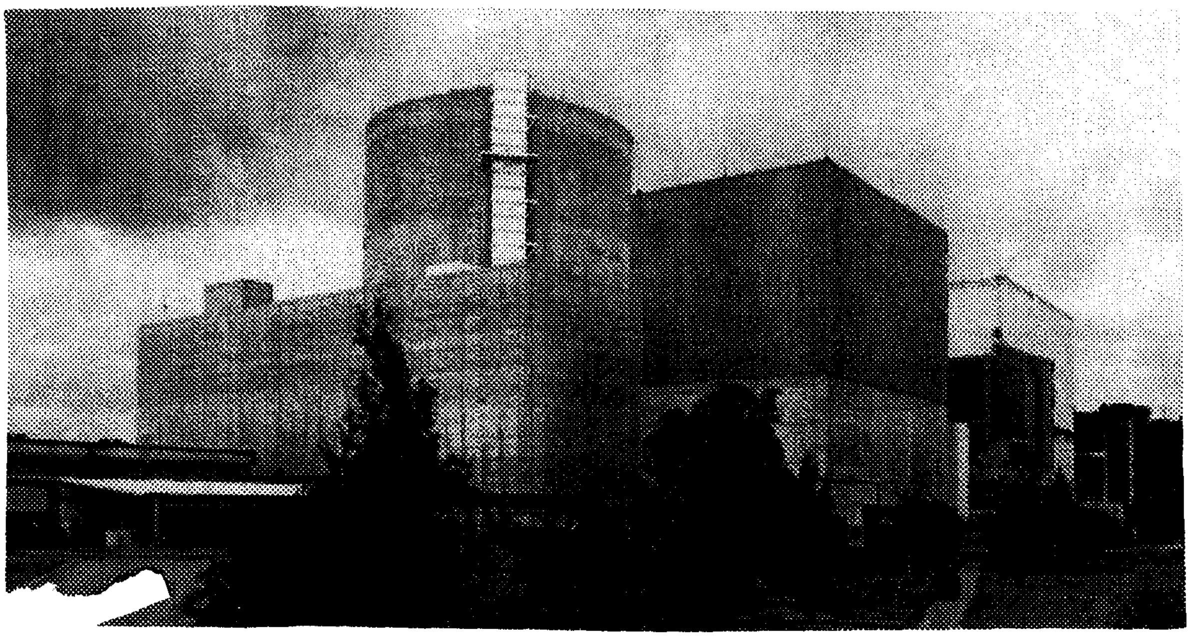
In 1993, the "Posavje 93" exercise was held as part of training for emergency situations. The analysis of the exercise points to the great commitment and professional ability of all the participants. It was established that more attention ought to be paid to technical connections between the participants, and that emergency preparedness exercises in the Krško nuclear power plant should be held more frequently.

Nuclear safety in the Republic of Slovenia in 1993 was assured.

ABBREVIATIONS

SNSA	Slovenian Nuclear Safety Adninistration
IAEA	International Atomic Energy Agency
OSART	Operational Safety Review Team
ASSET	Assessment of Safety Significant Events Team
ASCOT	Assessment of Safety Culture in Organizations Team
INES	International Nuclear Event Scale
IRS	Incident Reporting System
INIS	International Nuclear Information System
MOP	Ministry of Environment and Physical Planning
EC	European Community
BIT	Boran Injection Tank
NSRAO	Medium and Low Level Radioactive Waste
PSAPACK	IAEO - Probabilistics Safety Assessment Computer Code
OECD	Organisation for Economic Co-operation and Development
NEA	Nuclear Energy Agency of the OECD
NRPB	National Radiological Protection Board
PHARE	European Community Programmes for Economic Assistance to Central and Eastern European States
RAMG	Regulatory Assistance Management Group
NPP	Nuclear Power Plant
ISI	Inservice Inspection
IR93	Unplanned Outage 93
ECT	Eddy Currents Technique
INSARR	Intergrated Safety Assessment of Research Reactors
SKJV	Nuclear Safety Expert Commission
SFRY	Socialist Federative Republic of Yugoslavia
RS	Republic of Slovenia
US NRC	US Nuclear Regulatory Commission
ICISA	International Commission for Independent Safety Analysis
ELMA	Ecological Mobile Unit Laboratory
RŠČZ	Republic Civil-Defence Headquarters
CZ	Civil Defence
NUID	Plan of Measures for Emergency Event
IJS	Institute Jožef Stefan
ZVD	Work Safety Institute of Republic of Slovenia

INTRODUCTION



NPP KRŠKO

SLOVENIA

Slovenia as a central European country is located along the foothills of the eastern end of the chain of the Alps, at the very tip of the most northerly Mediterranean ba., Open towards Hungary and the south, it is a natural hub of European routes from the north to the south and from the west to the east. Besides Hungary it borders Austria, Italy and Croatia.

Basic data on Slovenia:
Area: 20,256 km^2
Population (1992): 2,020,000
Number of households (1991): 641,000
Population density: 99 inhab./km^2
Constitution order: parliamentary republic
Capital: Ljubljana
Ethnic composition: Slovene 87.8%, Hungarian 0.43%, Italian 0.16%
Official language: Slovene, in mixed regions also Hungarian and Italian
Currency: Slovene tolar (1 SIT = 100 stotin)
Annual population growth (1991): 1.1 per thousand
Birthrate (1990): 10.8 per thousand
Life expectancy (1989-90): 69.43 years for men, 77.28 years for women
Urban population (1991): 50.5%
Major towns (1991): Ljubljana (276,200), Maribor (108,100), Celje (41,300), Kranj (37,300), Velenje (27,700), Koper (25,300), Novo mesto (22,800),
Gross domestic product (1992 - estimate): 12.1 billion USD
Gross domestic product (1992): 6050 USD
Main farm products (1990): potatoes (426,000 t), corn (336,000 t), wheat (181,000 t), hops (3,800 t), apples (73,000 t), grapes (108,000 t), wine (516,000 hl), meat (173,300 t), milk (6,25 mill hl)
Main industrial sectors (By share of social product in industry and mining, 1990): Metal working with machine construction and industrial traffic instruments (13.3%), electrical equipment (12%), chemicals (10.2%), textiles (9.9%), timber (6.1%) etc.
Exports (1992): 6681 million USD
Imports (1992): 6141 million USD
Number of tourists (1992): 1,367,000, no. of overnight stays: 5,100,000
Number of schools (1991): primary 842, secondary 149, universities and colleges 28
Number of teachers per 1000 inhabitants (1991): primary school 113, secondary school 46, universities and colleges 17
Number of books published (1991): 2459

SLOVENIAN LEGAL SYSTEM

The constitution of the Republic of Slovenia was adopted on December 23, 1991, exactly a year after the plebiscite for an independent state. In accordance with the new Slovenian Constitution, Slovenia is a democratic republic and a law and socially governed state.

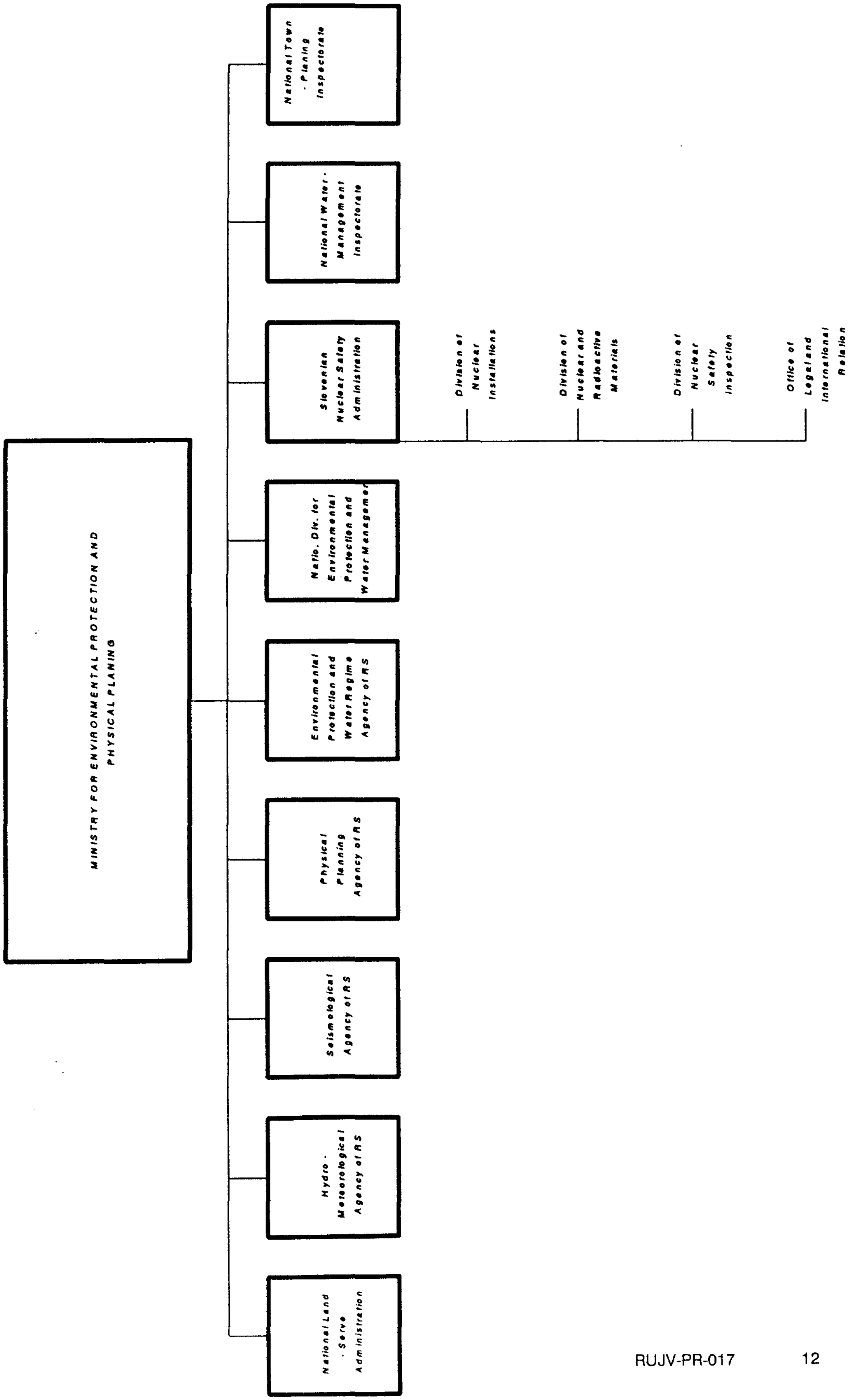
In accordance with the new Slovenian Constitution, the highest legislative authority is the SlovenIAN parliament, called the National Assembly. It is a single-chamber parliament with 90 deputies elected for a four-year term of office. The National Council with 40 deputies performs an advisory role. It is composed of representatives of social, economic, professional and local interests. The National Council may propose laws to the National Assembly, give opinions on all matters within its competence and may demand that the National Assembly review its decision on a law before its promulgation.

The President of the Republic represents Slovenia and is at the same time the supreme commander of the defence forces. The president calls elections to the National Assembly, proclaims laws adopted by the National Assembly, proposes a candidate for prime minister to the National Assembly and performs other duties defined by the Constitution. The President of the Republic is elected for a term of five years and may serve no more than two consecutive terms.

The government is the highest executive body, independent within the framework of its competence and responsible to the National Assembly.

GOVERNMENT

- Ministry of Labour, Family and Social Affairs - Labour Inspectorate
- Ministry of Economic Relations and Development
- Ministry of Finance
- Ministry of Economic Affairs
Energy Inspectorate
- Ministry of Agriculture and Forestry
- Ministry of Culture
- Ministry of Internal Affairs
- Ministry of Defence
Fire Protection Inspectorate
- Ministry of Environment and Physical Planing
Slovenian Nuclear Safety Administration
- Ministry of Justice
- Ministry of Transport and Communications
- Ministry of Education and Sport
- Ministry of Health
Sanitary Inspectorate
- Ministry of Science and Technology
- Ministry of Foreign Affairs


MINISTRY FOR ENVIRONMENTAL PROTECTION AND PHYSICAL PLANING
National Town - Planing Inspectorate
National Water - Management Inspectorate
Slovenian Nuclear Safety Administration
Division of Nuclear Installations
Division of Nuclear and Radioactive Materials
Division of Nuclear Safety Inspection
Office of Legal and International Relation
Natio. Div. for Environmental Protection and Water Managemen
Environmental Protection and Water Regime Agency of RS
Physical Planning Agency of RS
Seismological Agency of RS
Hydro - Meteorological Agency of RS
National Land - Serve Administration

SLOVENIAN NUCLEAR LEGISLATION

In the process of establishing sovereign and independent state the Constitutional Law on the Enforcement of the Basic Constitutional Charter on the Autonomy and Independence of the Republic of Slovenia was passed, which provides that all those laws which in the past had been passed by the former Yugoslav (federal) authorities, and which do not conflict with the Slovenian legal system, remain in force also in the Republic of Slovenia until adequate laws are passed by the Slovenian Parliament.

Among other acts and laws which were adopted in the Slovenian legal system the most important one related to nuclear safety is the ex-Yugoslav Act on Protection Against Ionising Radiation and Special Safety Measures in the Use of Nuclear Energy, (referred to hereafter as the 1984 Act) and 15 regulations based upon this law.

Since the 1984 Act was adopted, several very important regulations for carrying into effect the nuclear safety provisions of this act have been prepared and adopted. Most of them concern radiation protection:

- monitoring of radioactivity in the environment,
- monitoring of radioactivity around nuclear facilities,
- storage and disposal of radioactive waste,
- trading and utilisation of radioactive materials,
- qualification of persons who work with ionising radiation sources,
- dose limits for the members of the public and for occupational exposure,
- application of sources of ionising radiation for medicine,
- limiting activities for trade of foodstuff,
- limiting activities for radioactive contamination and decontamination,
- records and accounting of sources, doses to population and workers.
- Other regulations define,
- conditions for siting, construction, commissioning,
- trial operation and operation of nuclear facilities,
- format and scope of safety reports,
- qualifications and tests required for operators,

INTERNATIONAL TREATIES

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 Socialist 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.

SLOVENIAN NUCLEAR SAFETY ADMINISTRATION

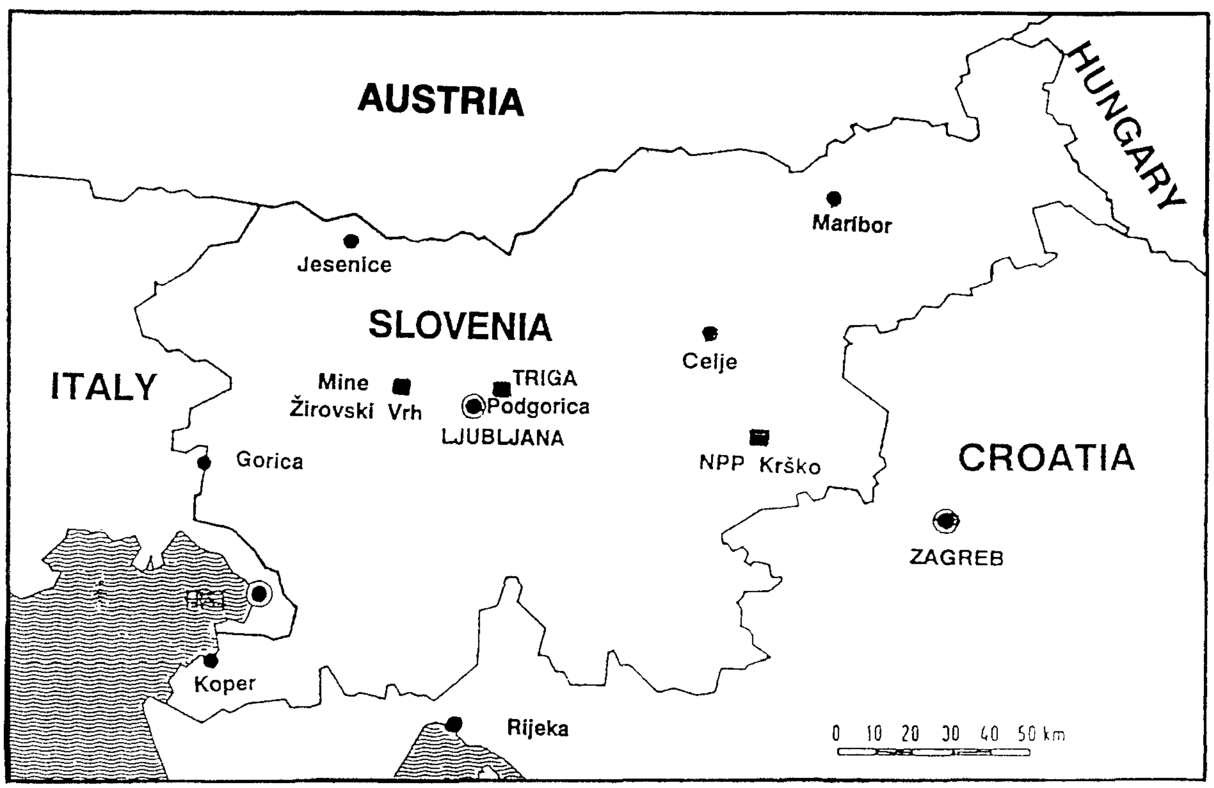
The Slovenian Nuclear Safety Administration (SNSA) is responsible for: nuclear safety, trade of nuclear and radioactive materials, safeguarding nuclear materials and conducting regulatory process related to liability for nuclear damage, qualification and training of operators at nuclear facilities, quality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

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

The legal basis for regulating frame work in the field of nuclear safety and inspection control (function) on nuclear installation are given by:

- Act on Organisation and Field of Activity of the Administration
- Act on Government of the Republic of Slovenia
- Act on Energy Economy
- Act on Protection Against Ionising Radiation and the Special Safety Measures in the Use of Nuclear Energy (1984 Act)
- Constitutional law on the Enforcement of the Basic Constitutional Charter on the Autonomy and Independence of the Republic Slovenia
- Regulations based on 1984 Act

ACTIVITY OF THE SLOVENIAN NUCLEAR SAFETY ADMINISTRATION



■ Nuclear Facilities in Slovenia

ACTIVITY OF THE SLOVENIAN SAFETY NUCLEAR ADMINISTRATION

The activities of the Slovenian Nuclear Safety Administration (SNSA) fall under four areas:

- systemic issues and international relations
- nuclear safety
- nuclear materials
- inspection

In view of the markedly interdisciplinary nature of the SNSA fields of activity, cooperation with other administrative bodies in 1993 was very intensive, especially with the Ministry of Economic Affairs, the Ministry of Labour, Family and Social Affairs, the Ministry of Health, the Ministry of Foreign Affairs, the Ministry of Internal Affairs, the Ministry of Defence and the Ministry of Science and Technology. This cooperation is manifested in the issuing of administrative regulations, inspection and supervision, the preparation of answers to deputies' questions and initiatives, the preparation of materials for sessions of the Government and its working bodies, and the work of interdisciplinary expert commissions (the work of international commissions is presented on pages 52-54 of the Report).

Legislation

At the legislative level, the SNSA continued working on the preparation of a new Slovenian law on nuclear and radiological safety and a new Slovenian law on liability for nuclear damage.

A standing committee set up by the IAEA is preparing draft changes to the Vienna Convention, and work intended to provide additional funding once the compensation avaible from the liable operators financial sccurity is exhausted The results of the activity of the standing committee, i.e. the adopted changes, will doubtless also influence the Slovenian legislation.

At the invitation of the SNSA, an EC Commission mission for assistance to administrative agencies visited Ljubljana from May 24 to 28, 1993. The Mission, inter alia, looked into the effective legislation and the draft new legislation. The Mission assessed that the effective legislation may serve as a solid basis for new legislation.

Inspection of nuclear facilities

The SNSA sector for inspection of nuclear facilities supervises, in accordance with its competence, the management of nuclear facilities. It abides by the effective legislation, standards, technical specifications and other regulations relating to the enforcement of all nuclear safety measures regarding the siting, design and construction, the installation of systems and components, functional and drive tests, trial run, operation, the verification of the quality of works and built-in material, emergency planning and preparedness, the qualification of personnel responsible for the operation of the plant, maintenance, audits, overhauls and safety equipment modifications, the accounting of nuclear materials and the responsibility for nuclear damage.

Under the SNSA job scheme, four posts for inspectors of nuclear facilities were planned, but two were still vacant at the end of 1993.

THE KRŠKO NUCLEAR POWER PLANT

There were 58 regular inspections in the Krško nuclear power plant in 1993, plus nine extraordinary inspections, four joint inspections with the authorised organisations relating to the aggregate expert assessment upon completion of the "overhaul 92", four other after the "extraordinary overhaul '93", and one in conjunction with the Republic Fire Inspectorate. The regular inspections of Krško in 1993, which took place on average once a week, covered:

- the status of emergency implementation procedures and abnormal operating procedures
- the status and course of audits of all operating procedures
- the procedures, plans and measures for unusual incidents
- the failure of the condenser's cooling-water pump
- water remaining in the cooling system of the emergency supply diesel generator
- the status of the implementation of modifications in 1993
- maintenance procedures
- the operation of inverters
- storage space inspection
- the storage and documentation of low- and medium-level waste
- the supervisory testing of safety systems and components
- findings in connection with the fire hazard study
- the review of the NPP Krško meteorological monitoring programme
- preparations for the "Posavje '93" exercise
- preparations for NSRAO super-compacting
- the modification "the reduction of concentration in the boron injection tank"
- the course of supervisory chemical testing
- the system status of post-accident sampling and measuring of radioactivity
- modification of the vital feedwater system
- measuring of the moderator's temperature coefficient after
- the end of the tenth cycle
- the status of planned modifications in 1993
- the status of the programme of testing during operation (ISI)
- preparation of a new revision of the "Plan of measures in the event of unusual incidents"
- preparations for the "refuelling 93"
- the status of measures implemented after the accident in the US
- electric power plant TMI-2

THE UNPLANNED OUTAGE OF THE KRŠKO NUCLEAR POWER PLANT

Following a SNSA decision, the Krško nuclear power plant was shut down again on May 26, 1993 after about a day's operation following the unsuccessful recovery of the no. 1 steam generator. On that day, "The Unplanned Outage 1993" (IR93) began and lasted until July 29, 1993 when, at 4 a.m., the reactor of the power plant again went critical. The examination of U-pipes in the two steam generators was the immediate reason for starting of the IR93.

During the IR93, there were 16 regular inspections and two extraordinary inspections made at the beginning and at the end of the overhaul.

The first inspections during the IR93 dealt with the course of preparations for repair works, since the overhaul was not scheduled and there was no time for thorough preparations. The regular overhaul was scheduled for November 5th, 1993.

Among the priorities during the IR93 there were the recovery of steam generators, the overhaul of the main generator, the inspection of the no. 2 reactor pump engine and the overhaul of the no. 1 reactor pump engine.

During the regular inspections, special attention was paid to measuring the indications in U-pipes in both steam generators, the plugging of steam generators and the mounting of bushings in damaged pipes, the on-site inspecting of repair works and supervisory testing using the eddy currents technique (ECT). Details about the operation and control of the steam generators are given on page 50.

THE TRIGA RESEARCH REACTOR

Three inspections of the TRIGA Mark II research reactor were carried out in 1993.

The inspections covered the programme of implementation of the INSARR recommendations, the preparation of the Plan of measures for the reactor centre in Podgorica, and physical protection. The inspection included the renewal of power current installations and was made in conjunction with the Electric Power Inspectorate of the RS, and one inspection was made in conjunction with the Sanitary Inspectorate of the RS.

THE ŽIROVSKI VRH MINE

The first regular inspection of the Žirovski Vrh mine was made in conjunction with the Sanitary Inspectorate of the RS on November 30, 1993. The inspection examined the environment control programme for 1993, the mine pit and the Boršt hydrometallurgical waste disposal site.

Inspections conclusion

On the basis of experience and facts up to date, it can be established that:
all systems for the safe shutdown of the nuclear power plant operated in accordance with design parameters, and nuclear safety was not jeopardised.

The operation of the TRIGA Mark II research reactor at the Jožef Stefan Institute Podgorica Reactor Centre in 1993 complied with the operating conditions and limits.

The radioactive waste in the temporary storage site for low- and medium-level radioactive waste at the Krško nuclear power plant and at the Podgorica Reactor Centre's transitional storage site for radioactive waste is stored in accordance with the law, and the records are kept correctly and consistently.

The Issued Administrative Enactments

In discharging its administrative duties, the SNSA in 1993 issued to the Krško nuclear power plant 22 enactments relating to:

- professional training
- supplementing the final safety report, chapter 15, with the analysis of the minor leak accident
- building the 3rd phase of the business complex - the storehouse for spare parts and equipment
- streamlining the seismic monitoring system
- measures following the accident in the Three Mile Island NNP
- probability analysis of the power plant's safety in the event of internal and external initial events
- shutdown of the power plant because of the repeated leakage in the steam generator pipe
- mounting of bushings in steam generators
- the system of post-accident sampling of processes and changing operational conditions and limits
- execution of the radioactive waste supercompacting procedure
- changing and supplementing the standard format of Operational Conditions and Limits relating to the recovery of pipes in steam generators (mounting of bushings and criteria for plugging)
- meteorological measurements in the vicinity of the NPP Krško in 1993
- radiological monitoring of the Krško nuclear power plant in 1993
- changing operational conditions and limits regarding the intake of the Sava water to cool the power plant
- decision to suspend procedure for extending the deadline for the final report on the 1st stage of the probability safety analysis for the NPP Krško
- the change to the operational conditions and limits in connection with the change of control bundle shutdown thresholds dependent on the reactor power percentage.

Expert Commissions

There are two expert commissions attached to the Slovenian Nuclear Safety Administration:

The Nuclear Safety Expert Commission (SKJV), which met three times in 1993. The Commission has 22 members. Ten members are seconded from administrative bodies and 12 members are experts in individual fields of nuclear safety and radiological protection.

In addition to the standard item, i.e. "operational safety of nuclear facilities in the period since the last meeting", the SKJV in 1993 also dealt with:

- the report on the safety of operation of nuclear facilities in 1992
- the proposal for the programme of additional geological/geotectonic and seismological research
- intervention thresholds in the event of nuclear or radiological accidents
- proposal for enacting the criminal code of the Republic of Slovenia - penal provisions in the field of nuclear and radiological safety
- the report on the 1993 extraordinary overhaul of the Krško nuclear power plant
- the report on the 1992 overhaul and refuelling
- the proposal for the 1994 annual programme of ionising radiation protection and nuclear safety.

In 1993, the Expert Commission for the Testing of Qualifications of Operators of the Krško nuclear power plant organised two examination dates for 23 candidates. Fifteen candidates for chief operator took the ability test to renew their licences, three chief operator candidates took the test for the first time, one candidate for reactor operator took the test to renew the licence, and 4 candidates for reactor operator took the test to obtain the first licence. All candidates passed the test successfully and, at the proposal of the Commission, the SNSA granted or extended their licences. The Commission noted that the level of competence of candidates was constantly improving, as was evident from the results of the examination and the length of the extension of licences.

International Cooperation

Conclusion of New Agreements

> The Agreement between the Republic of Slovenia and the International Atomic Energy Agency for the Application of Safeguards in conection with the Treaty on the Non-Proliferation of Nuclear Weapons

On the initiative of the SNSA, in 1993 the Ministry of Foreign Affairs launched the procedure for the conclusion of the aforementioned agreement.
On the basis of a special note addressed to the IAEA, the agreement between the former SFRY and the IAEA is still applied on the territory of the Slovenia, and with the conclusion of the Slovenian-IAEA bilateral agreement, yet another tie with the SFRY will be severed.

> The Agreement between the Republic of Slovenia and the Republic of Austria on Early Notification in the Event of a Radiological Emergency

The initiative by the SNSA was adopted by the Government of the Slovenia on 4 March 1993 and ratified by the National Assembly Committee for International Relations and the Committee for Infrastructure and the Environment.
On the basis of this initiative, three rounds of negotiations with the Austrian side were held in 1993 (in Vienna, on July 13 and 14; in Ljubljana, on October 18 and 19; in Vienna, on November 30 and December 1).

Agreement on the Early Exchange of Information in the Event of Radiological Danger Concluded between the Republic of Slovenia and Neighbouring Countries (Hungary, Italy, Croatia)

At the end of 1993, the SNSA proposed to the nuclear safety authorities of neighbouring countries the conclusion of bilateral intergovernmental agreements on the exchange of information in the event of radiological emergency.

The Agreement between the SNSA and the US Nuclear Regulatory Commission (US NRC) on the Exchange of Technical Information and Cooperation in the Field of Nuclear Safety

Almost a year of work on the aforementioned agreement, which is of special importance for Slovenia, was brought to a close by the signing of the agreement in December 1993.

Cooperation with the International Atomic Energy Agency

Slovenia was admitted to full membership of the IAEA in 1992. Cooperation with the IAEA covers an extremely wide range of activities, of which we cite only a few:

Preparation of International Conventions

Preparations are in progress within the IAEA for the adoption of several important conventions in the field of nuclear and radiological safety. Here are some of them:

- Basic Safety Standards
- Convention on Nuclear Safety
- Revision of the Vienna Convention on Civil Liability for Nuclear Damage

IAEA Missions

There are several missions operating within the IAEA. At the request of IAEA member countries, the missions organise advisory visits. Thus:

- The OSART (Operational Safety Review Team) mission visited the Krško nuclear power plant from July 5 to 23, 1993. Two SNSA experts participated in the OSART mission's activities in Mochovce and Gravelin.
- In 1993, the SNSA asked the Agency to organise an ASSET seminar on "Accident Prevention" in Slovenia in 1994.
- Slovenia asked the Agency to organise an ASCOT seminar in Slovenia in 1994.

Other important systems operating within the Agency include, for example, IRS (Incident Reporting System) and INIS (International Nuclear Information System). The SNSA cooperates with them and has its representatives in the Agency's working bodies.

Seminars, Courses and Workshops Organised by the IAEA

Last year SNSA employees successfully participated in various seminars, courses and workshops organised by the Agency itself or in association with other organisations:

- The interregional course on "Operational Safety Evaluation Techniques", Madrid, April 12-30, 1993
- The international course on "Physical Protection of Nuclear Facilities and Materials", Albuquerque, New Mexico, April 11-29, 1993
- The expert seminar on "The Application of the Probability Safety Assessment in the Administrative Procedure", Vienna, April 26-29, 1993
- The expert seminar on "Difficulties Concerning Steam Generators and Their Replacement", Madrid, Dec. 13-17, 1993
- The technical committee for INIS members: "The Review of Experience and Feedback Information Present in the Public and the Media", Vienna, October 27-29, 1993

- The technical committee on "Basic Safety Standards", Vienna, December 13-17, 1993
- The technical committee on "Accident Procedures and System Requirements", Vienna, October 4-8, 1993
- The technical committee on "Probability Safety Assessment Application Procedures for Establishing Optimal Operating Conditions and Limits for Nuclear Power Plants", Barcelona, September 20-23, 1993
- The "Accident Notification System", IRS, Paris, September 27-29, 1993
- The interregional course on "Nuclear Materials Record-Keeping and Supervision", St. Petersburg, October 4-13, 1993
- The expert seminar on "Upgrading Nuclear and Radiation Instrumentation; he Influence of Experience and New Technologies", Saclay, October 18-20, 1993
- The expert seminar on the "PSAPACK Probability Safety Assessment", Vienna, November 29 - December 3, 1993.

The SNSA staff members also attended seminars organised by other institutions, such as OECD/NEA, NRPB (National Radiological Protection Board), the European Union, etc.
Slovenian experts from organisations such as the Jožef Stefan Institute, the Krško nuclear power plant, the Medical Centre, IBE Elektroprojekt, the "Milan Vidmar" Electroinstitute, the Faculty of Natural Sciences and Technology, the Velenje lignite mine etc. participated as sponsors, advisors or lecturers in IAEA-organised seminars, courses and technical committees.

Scholarships and scientific visits

Another area of SNSA-IAEA collaboration in technical assistance and cooperation covers scholarships and scientific visits. In 1993 foreign experts attended training courses in Slovenia in the following fields:

- nuclear instrumentation, electronics, reactor control, materials analysis
- reactor physics
- research reactors
- safety assessment
- radiation protection.

Research Contracts: In 1993 the SNSA sent to the Agency three applications for the renewal of research contracts, prepared by the Jožef Stefan Institute:

- Analytic quality control in studies on the exposure of the environment to quicksilver
- The study of the monitoring of trace element air pollution in Slovenia using the nuclear analysis technique
- Modern library project - Scientific coordination and preparation of database.

In addition to applications for the renewal of contracts, the SNSA sent 6 new draft research contracts prepared by the Jožef Stefan Institute and the Medical Centre:

- Experimental analysis of low-frequency instability in magnetised discharged plasma
- The method of shutting down in order to assess the condition of control rods
- Modelling the influence of man on system efficacy
- The development of the gamma camera interface card and the appropriate software package
- The comparative development of efficacy and toxicity in the oral application of phosphorus (P-32) and intravenous application of strontium
- The expansion of the IBM computer equipment and processing system for radioisotopic scintillography

Technical Assistance and Cooperation Projects

Within the framework of the IAEA technical assistance and cooperation programme for 1993/94, the Agency accepted seven Slovenian proposals for technical assistance. The proposals were made by the Jožef Stefan Institute and the SNSA as follows:

- analysis of the nuclear power plant
- upgrading intercalibration equipment
- streamlining the Krško nuclear power plant
- radiation protection during decommissioning of the uranium mine
- the OSART mission
- the early notification system
- enhancing operational safety at the Krško nuclear power plant.

In late December, six proposals were submitted for the year 1995/96.

The Jožef Stefan Institute prepared proposals for:

- Nuclear spectrometry laboratory
- Radon laboratory
- Ensuring safety through personnel education and expert missions.

The Ljubljana Geological Institute prepared a project for:
- a map of natural radioactivity in Slovenia.

The Medical Centre prepared the project:
- The organisation of active and accident health protection for personnel in nuclear facilities.

Uranium Mine Žirovski Vrh:
- Uranium and Radium Removal by Ecological Engineering.

<u>Cooperation with other international organisations and administrative agencies</u>

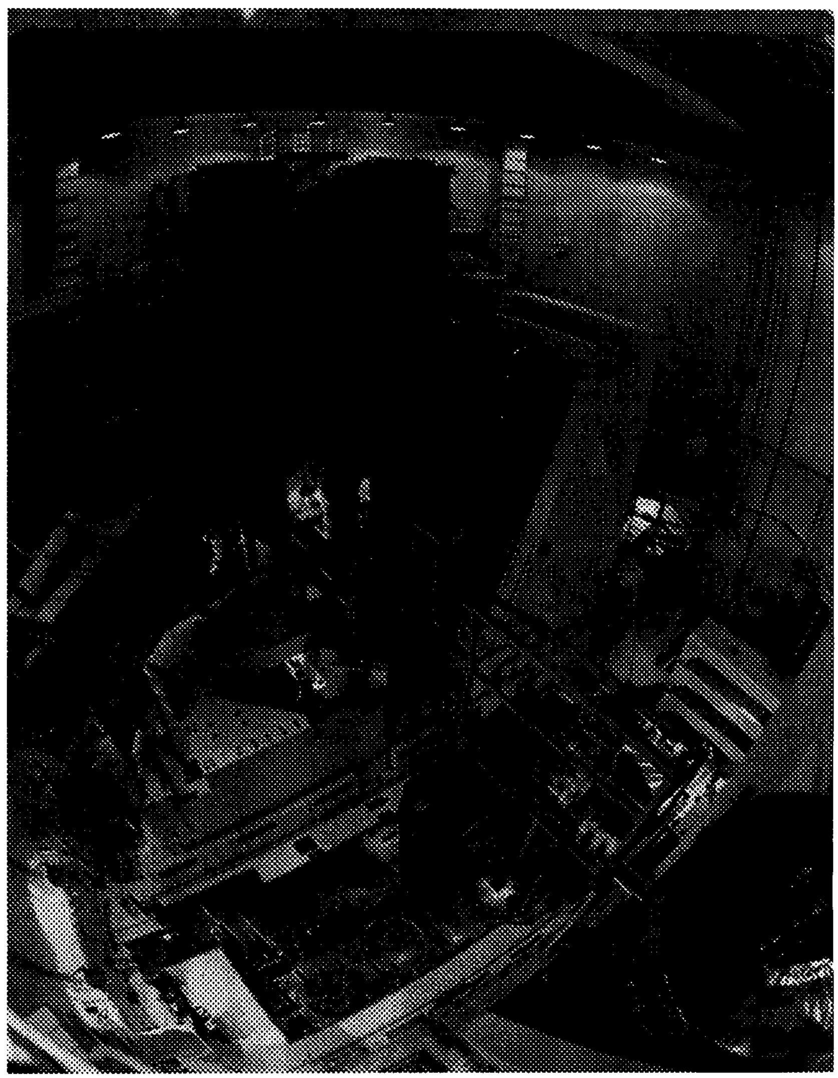
The Slovenian Nuclear Safety Administration also cooperates with international organisations and agencies other than the IAEA, in particular as part of the EU Commission's PHARE programme. Through the SNSA, Slovenia applied for projects within the regional programmes of the DGI/E/S-PHARE Nuclear Safety group. The PHARE regional nuclear safety programme (intended primarily for the former Soviet Union and eastern and central European countries) covers four areas:

- operational safety improvement
- short-term technical improvements
- improvements in the operation of administrative bodies
- nuclear fuel cycle and waste management.

At the invitation of the Slovenian Nuclear Safety Administration, an EC Mission, as part of the Regulatory Assistance Management Group (RAMG), visited Slovenia in May 1993 to assess the qualification and organisation of the body competent for nuclear safety in the Republic of Slovenia. The report on the results of the mission will be sent to the Government and the Parliament. On the basis of the Mission's findings, a programme of assistance was prepared and ratified by the RAMG in October 1993. The programme is to be implemented in the coming years through a comprehensive mutual agreement.

The Slovenian Nuclear Safety Administration intensively cooperates with the OECD Nuclear Energy Agency and with national administrative agencies for nuclear and radiological protection and the use of nuclear energy. All these well-established channels, coupled with personal contacts, provide for faster transfer of foreign administrative agencies' information and experience into our working procedures, although such experience is not always directly applicable to our situation.

OPERATION OF NUCLEAR FACILITIES



NPP KRŠKO - Core Loading

KRŠKO NUCLEAR POWER PLANT

Main Operational Data

In 1992 the Krško NPP generated 3,956,662 MWh of electrical energy at the outlet of the generator, i.e. 3,762,780 MWh net.

The generator was connected to the national grid, 6492.8 hours or 74.1 % of the total number of hours in the year. The electrical production was 7.78 % lower than planned. Table 1 shows the pace of output compared to the planned one.

Table 1: NPP Krško net electrical energy generation in 1993

Month	Planned Output (GWh)	Actual Output (GWh)	Difference (%)**
JAN	400	461,368	15.34
FEB	380	396,308	4.29
MAR	400	394,224	- 1.44
APR	400	443,392	10.85
MAY	400	143,536	- 64.12
JUN	400	0.0	- 100
JUL	400	5,776	- 98.56
AUG	400	368,152	- 7.96
SEP	400	441,778	10.45
OCT	400	454,232	13.56
NOV	60	403,644	909.11
DEC	40	250,360	317.27
Total	4080	3,762,780	- 7.78

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

In 1992 the reactor was critical for 6,518,51 hours or 74.41 % of the total number of hours in that year. The generation of thermal energy amounted to 11,471,831 MWh. The whole production of the electrical energy in Slovenia was 11,266 TWh, the share of the nuclear energy production being 33.3 %.

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

The Availability factor tells how long the plant has been connected to the network in a certain period of time. This factor is determined by the quotient between the number of hours in which the electrical generator is sinchronized with the network (regardless of reactor power) and the whole number of hours in the same period of time.

The Load factor represents the amount of electrical energy produced by the plant in comparison to the whole amount of electrical energy which could theoretically be produced in a certain period, i.e. The quotient between the yielded electrical energy and the electrical energy which could be produced theoretically (the product of power on el. generator terminals and the number of hours) in that period of time.

The Forced outage factor in a certain period of time is determined by the quotient of forced outage duration (in hours) and duration of plant operation (in hours) in that period of time.

Tables 2 and 3 show the performance indicators and the time consumption of the NPP Krško in 1993.

Table 2: Reliability indicators of operation of the NPP Krško in 1993

	Year 1993 (%)	Average (%) 1983 - 1992
Availability factor	74.12	80.12
Load factor	69.28	75.15
Forced outage factor	4.50	1.85

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

Time analysis of output	Hours	Percentage (%)
total available time	8,760	100
plant operating time	6,492.8	74.12
total outage time	2,267.2	25.88
maintenance	335.5	3.83
planned shutdowns	0	0
unplanned shutdowns	394	4.5

Figure 1. shows the electrical energy production in Slovenia. Figure 2. shows the level of operated power of NPP Krško through 1993. Diagrams on Figures 3 to 8 show the main operational data for whole period of NPP Krško operation (1983 - 1993). Load factor (Figure 3) is frequently used for a estimation of the efficiency of the NPP operation. Important factor is also the plant availability (Figure 4), because some plants intentionally decrease the power due to changes in electrical energy consumption which causes that the load factor is decreased. Figure 5 shows the electrical energy production along the whole period of NPP Krško operation. Figures 6 - 8 show the number of plant shutdowns, forced outage factors and number of incident reports, per year and through the commercial operation of the plant. The availability of NPP Krško in 1993 was 74.12 %.

Figure 1: Electrical energy production in Slovenia

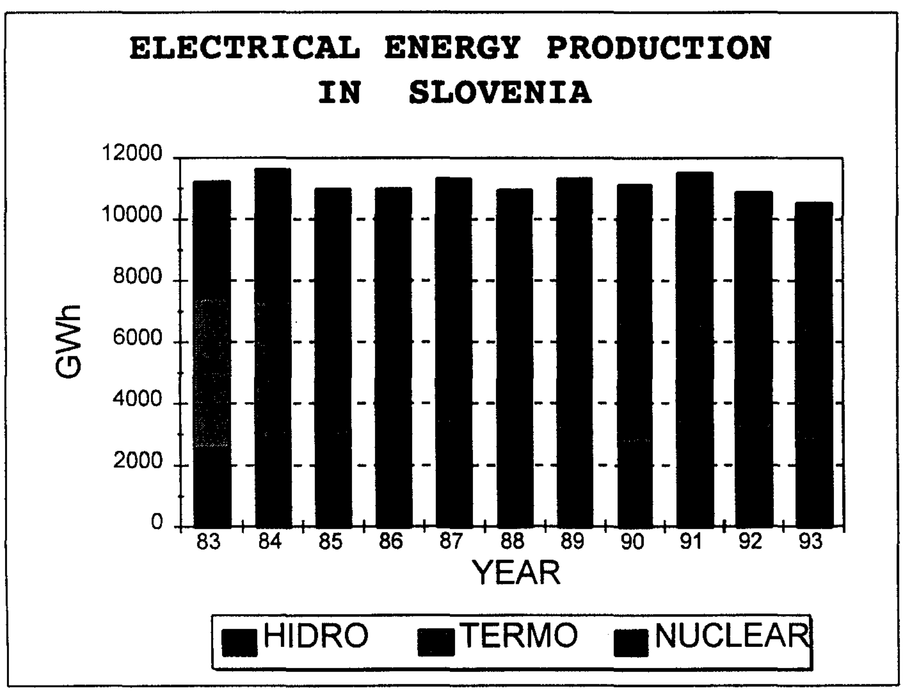


Figure 2:

NPP Krško operating diagram for 1993

Gross produced energy: 3,956,662 Mwh
Net produced energy: 3,762,780 Mwh
Availability Factor: 74.12%
Capacity Factor: 69.28%

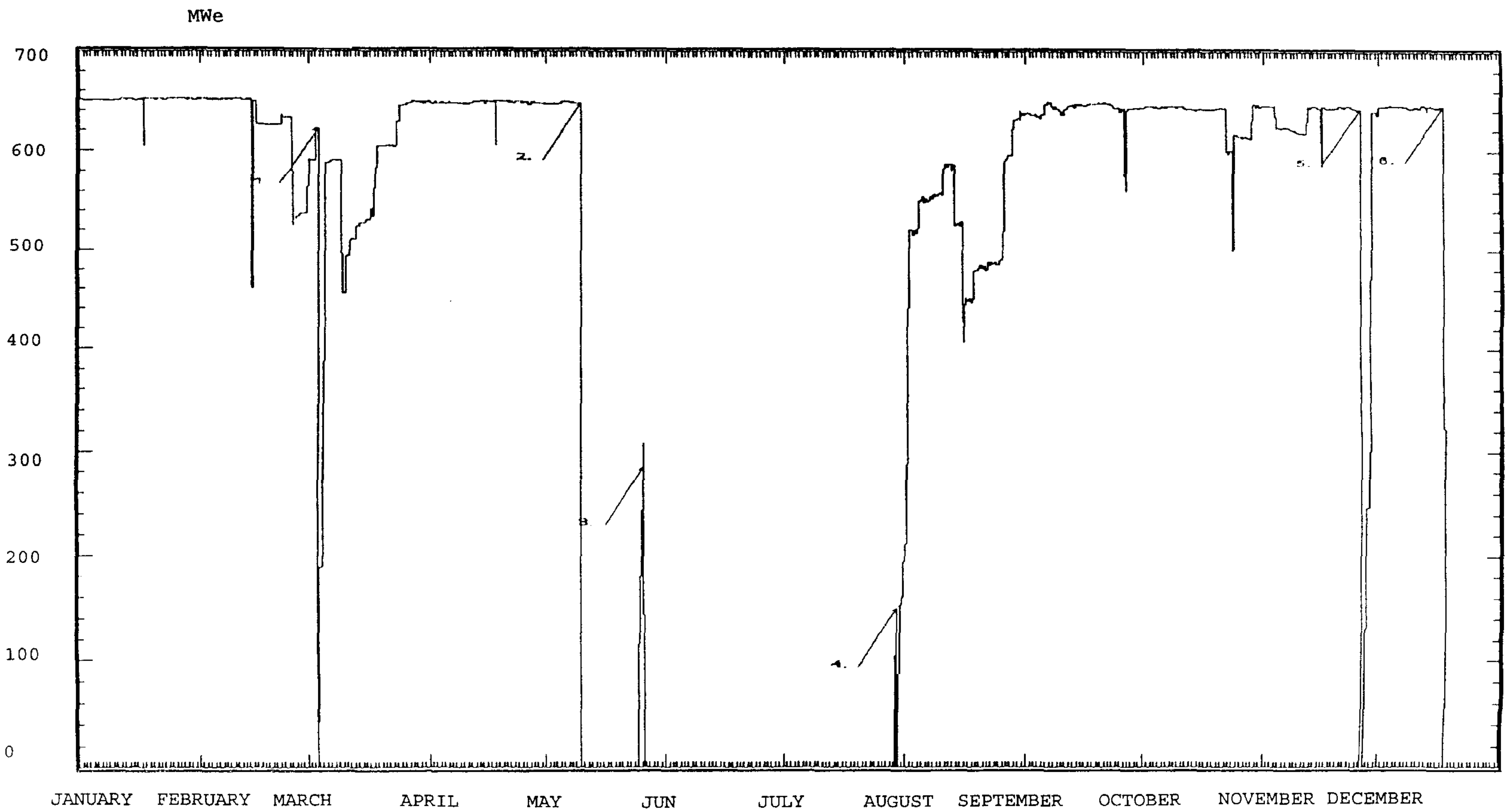


Figure 3: NPP Krško load factor

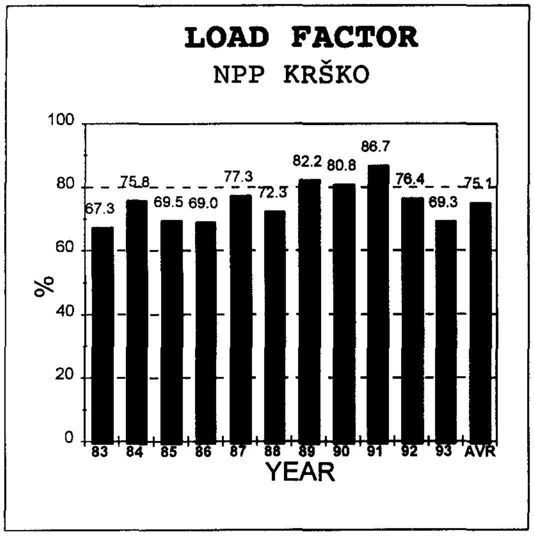


Figure 4: NPP Krško availability factor

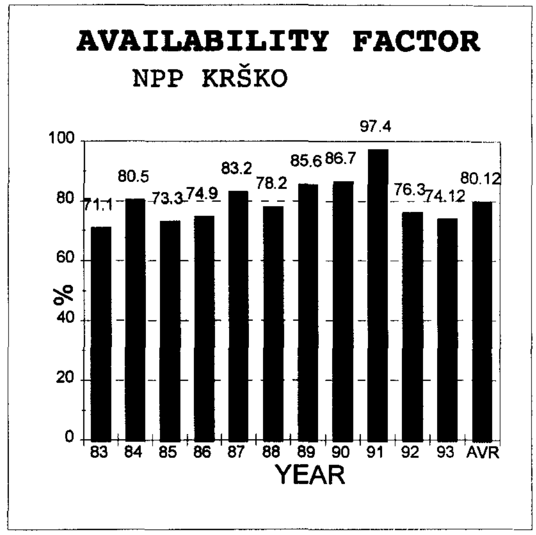


Figure 5: NPP Krško net electrical energy production

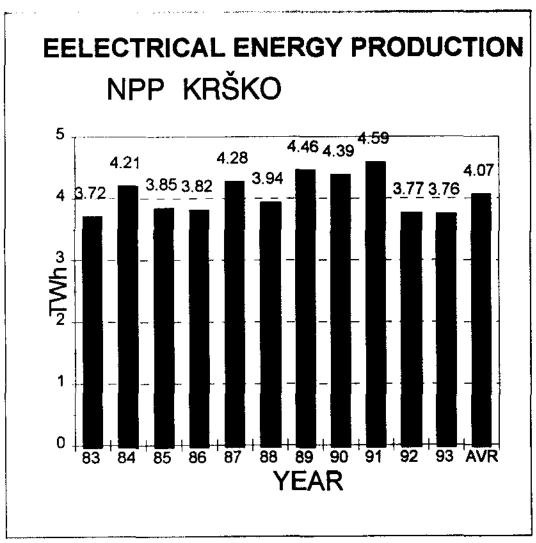


Figure 6: NPP Krško reactor scrams

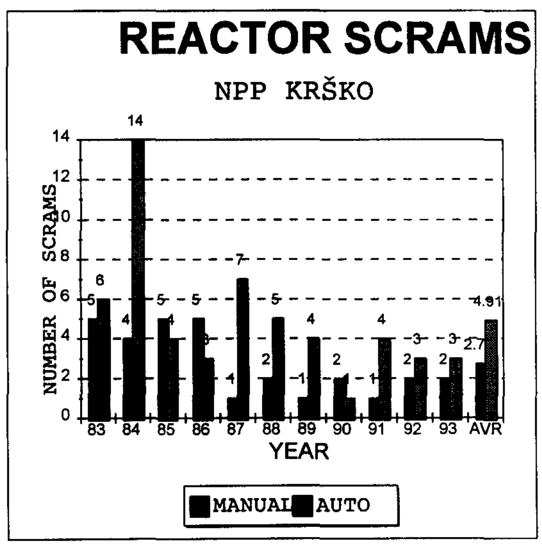


Figure 7: NPP Krško forced outage factor

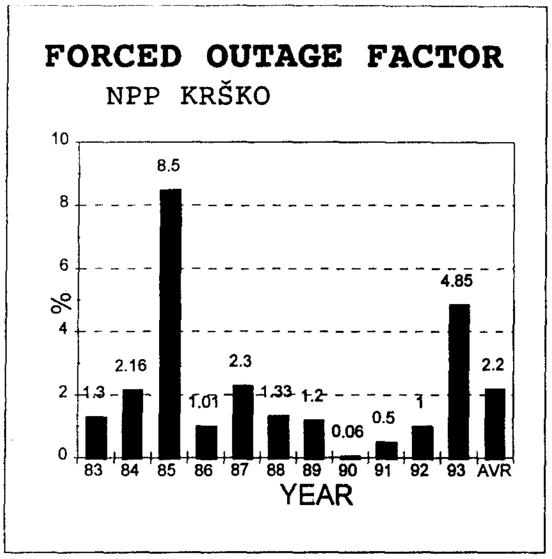
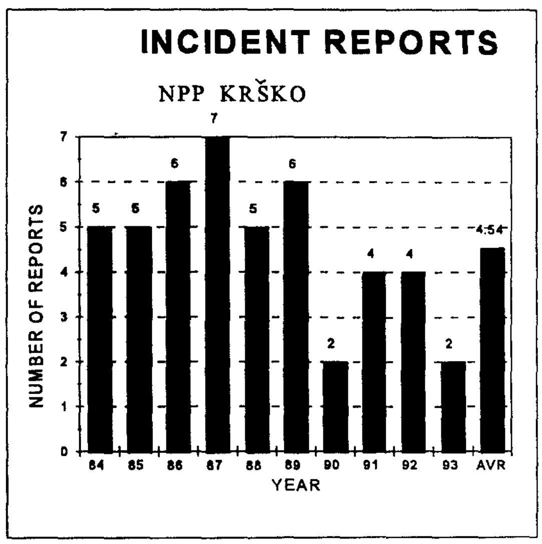


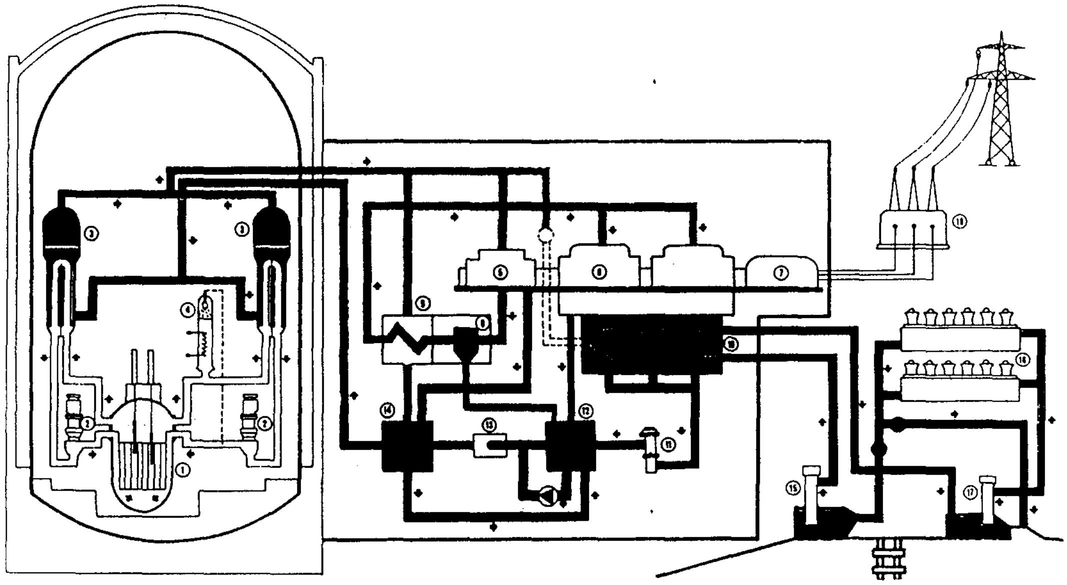
Figure 8: NPP Krško incident reports



Tab. 4: Planned and unplanned shutdowns in 1993

Date	Hours of duration	Short description
14.02.1993	6.5	Power reduction to 75% because of testing the turbine valves and maintenance works on the condenser
24.02.1993	150	Operating at reduced power (80-90%) because of the low River Sava flow
03.03.1993	352	Operating at reduced power (70-90%) because of the low River Sava flow
10.05.1993	356.6	Manual shutdown because of jump leakage on U-tube in steam generator no.1
26.05.1993	1537.6	Unplanned Outage 93
01.08.1993	643	Operating at reduced power (70-90%) because of the low River Sava flow
26.09.1993	2	Power reduction to 90% because of testing the turbine valves
22.10.1993	38	Power reduction to 90% because of the high River Sava flow
23.10.1993	13	Power reduction to 80% because of maintenance works on the condenser
26.11.1993	25	Automatic reactor trip initiated by stoppage of steam flow from stem generator no.1, which was caused by irregularity in test sequence on bypass valve of main steamline no.1.
18.12.1993	335.5*	Planned Outage 1993. During the reactor shutdown process, oscillations occurred on power turbine and caused automatic reactor trip. (*duration of Outage)

NPP KRŠKO - FUNCTIONAL DIAGRAM



1. *Reactor*
2. *Reactor Coolant Pumps*
3. *Steam Generators*
4. *Pressurizer*
5. *High Pressure Turbine*
6. *Low Pressure Turbine*
7. *Generator*
8. *Moisture Separator*
9. *Reheater*
10. *Condensers*
11. *Condensate Pumps*
12. *Low pressure Heater*
13. *Feedwater Pumps*
14. *High Pressure Feedwater Heater*
15. *Circulating Water Pumps*
16. *Cooling Towers*
17. *Cooling Tower Circulating Pumps*
18. *Transformer*

Integrity of Reactor Fuel in 1993

In the process of electricity generation fuel integrity depends on reactor operation history. This year the 10th fuel cycle was going on. The 10th fuel cycle ended on December 17, 1993. In the middle of the year 1993 there was a two-month shut down due to steam generators tubes plugging.
The core consists of 121 fuel assemblies. Each fuel assembly contains 16 x 16 rod array composed of 235 fuel rods Vantage 5 type with enrichment 4.3 % of U 235, made by Westinghouse.

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 following isotopes are analyzed in the Krško NPP: xenon 133,
135 and 138, krypton 85m, 87 and 88, iodine 131, 133, 134 and 135, cesium 134 and 137. The measurements are done daily, during the transients at least every four hours.

The characteristic values for isotopes (the average values of the concentrations at full power) for the 10th cycle, including a comparison with other cycles are shown in Table 5. The fuel quality of the fuel integrity for the 10th cycle was very good, the dispersed uranium of former cycles, which pollutes the coolant, prevails and the leakage of fuel is under the limit specified in Technical specifications.
T
The majority of the leaking fuel assemblies will probably be removed from the core with refuelling of the 48 fuel assemblies, which will be deposited in the spent fuel pit in the reactor building. All fuel elements which will be used in the 11th cycle from the spent fuel pit will be verified for their mechanical integrity.

Table 5: Isotope composition and activity of the primary coolant for 7th, 8th, 9th and 10th cycle.

ISOTOPE	ACTIVITY (GBq/m^3)			
	cycle 7	cycle 8	cycle 9	cycle 10
I - 131	0.08	0.03	0.101	0.111
I - 133	0.55	0.34	0.254	1.095
I - 134	2.22	1.22	0.681	0.618
Xe - 133	23.3	7.40	16.835	6.105
Xe - 135	2.96	0.89	5.809	3.200
Xe - 138	0.93	0.52	0.906	0.414
Kr - 85m	1.11	0.26	1.539	0.733
Kr - 87	0.48	0.19	0.928	0.474
Kr - 88	1.11	0.32	2.361	1.125

Spent Nuclear Fuel

Spent fuel elements are stored at the power plant in the spent fuel pool which has enough space for 17 refuellings and for the entire reactor core (121 fuel elements) as a permanent available reserve if, for any reason, it was necessary to empty the reactor core. The capacity of the spent fuel pool is therefore sufficient for the storage of used fuel elements at least until the year 2000. The plant operator is making great efforts to increase the duration of the fuel cycle and to achieve better efficiency by improving the nuclear core design. This would make it possible to use the existing spent fuel pool even after the year of the 2000. In 1993, 48 additional fuel elements were stored, which means that in total, there were 406 spent fuel elements in the pool by December 31, 1993.

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 whichconsists of a concrete cylindrical liner inside the drums. It is located in the on-site LILW interim storage.

In the eleven years of power plant operation 1875 m^3 of LIL waste have accumulated. The average specific activity in barrels (drums) is 30 Gbq/m3.

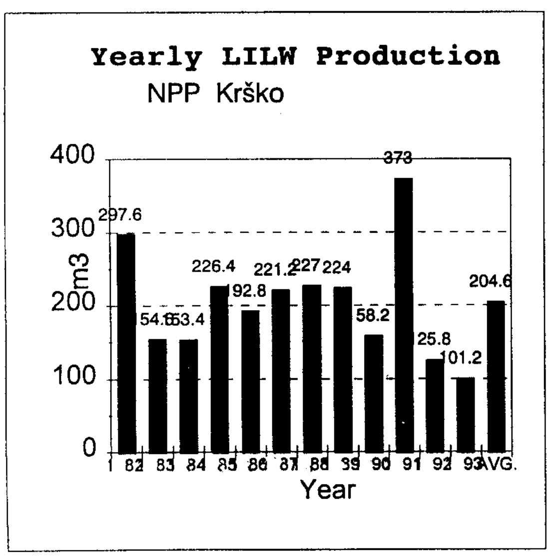


Figure 9: Yearly LILW production in the NPP Krško

In of 1993 the Slovenian Nuclear Safety Administration issued a licence to the plant operator for supercompaction of barrels containing evaporator bottoms. These activities will be carried out by using a mobile Westinghouse super-compactor unit, in 1994. The lifetime of the existing LILW interim storage on the NPP site will thus be significantly increased without any additional environmental impact above the limits specified by the regulations.

Table 6: Radioactive waste in the Krško NPP according to the type and activity on 31 December, 1993

Type of waste	Number of Drums	Activity (GBq)	Volume (m^3)	Avg. Specific Act. GBq/m^3
SR	952	44680	190	235
CW	984	860	197	4
EB	6606	8797	1321	7
F	106	2112	21	100
O	111	20	22	1
SC	617	531	123	4
TOTAL	9376	57000	1875	30

Type of waste:

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

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 normal operation. The dose limits for nuclear power plant and contractor workers were complied with, and the received doses were even below the latest ICRP recommendations as well.

Table 8 shows the distribution of effective doses for the personnel that worked in 1992 within the Krško NPP from 1981 to 1993. Besides the power plant personnel, subcontractors are also included in the table. The table shows that 123 people in 1993 received the annual effective dose above 5 millisieverts (mSv).

The collective effective dose of the plant personnel was 0.45 man Sv. For other people including the personnel of the main contractor the effective dose in 1993 was 1.22 man Sv and the total for all workers was 1.67 man Sv. The annual collective effective dose per unit of electrical power generated was 3.89 manSv/GWyear (UNSCEAR 1988 sets the average for west European power plants at 4 man Sv/GW year). Table 7 shows collective and average doses in 1993.

Table 7: Collective and average effective doses for all workers in 1993

Employees	Collective doses (man SV)	No. of workers	Average Dose (mSv)
Krško NPP	0.448	288	1.55
Subcontractors	1.223	419	2.92
Total	1.671	707	2.36

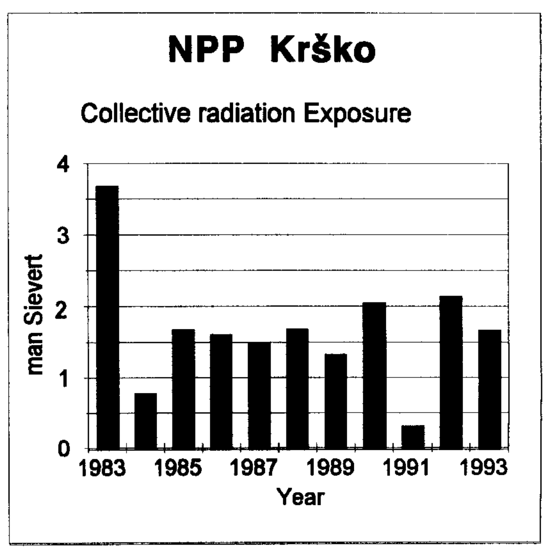


Figure 10: Collective effective doses (NPP Krško)

Table 8: Distribution of effective doses for all workers at the Krško NPP during years 1981 to 1993

range of doses mSv/year - ---------- year	0 - 1	1 - 5	5 - 10	10-15	15-20	20-25	nad 25	Total nomber of workers
1981	475	45	0	0	0	0	0	520
1982	275	313	9	13	10	1	1	622
1983	462	206	53	45	34	27	4	831
1984	375	205	15	3	2	0	0	600
1985	517	277	79	17	2	0	0	892
1986	524	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	354
1992	448	219	0	127	22	1	0	817
1993	401	183	87	26	9	1	0	707

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 only a few percent of limiting values for all radionuclides, except for tritium for which the annual emitted activity was approximately 70 %.. The same holds for air emissions for the Krško NPP. The limiting values for tritium are considerably lower than those stipulated or enforced in licences issued for nuclear power plants in other European countries.

The relevant administrative authorities are regularly informed about the emissions in regular and special reports by the Krško NPP. Regular reports are made on a weekly, 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 9 and 10 show released tritium activity and released liquid activity during the past 11 years.

Figure 9: Released activity in liquid effluents without tritium (Krško NPP), limiting value is 200 GBq/year

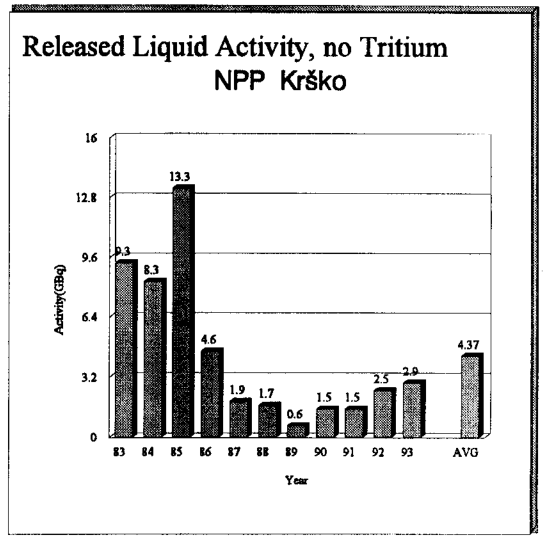


Figure 10: Released tritium activity in liquid effluents (Krško NPP), limiting value is 20 TBq/year

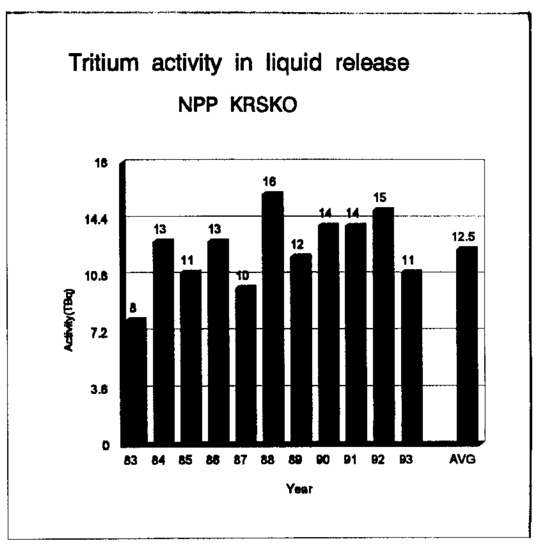


Figure 11: Released noble gases activity in effluents (NPP Krško)

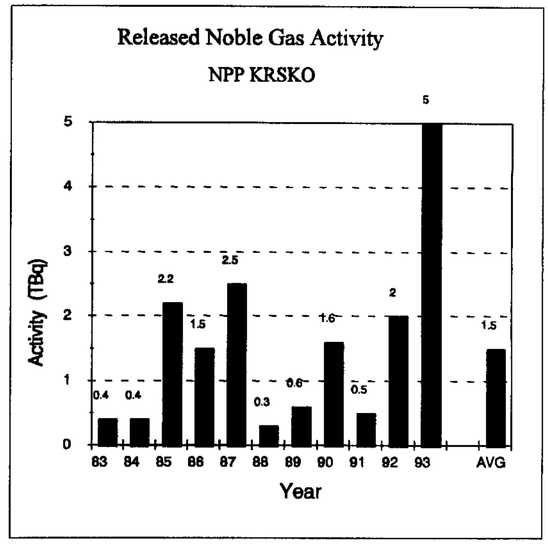
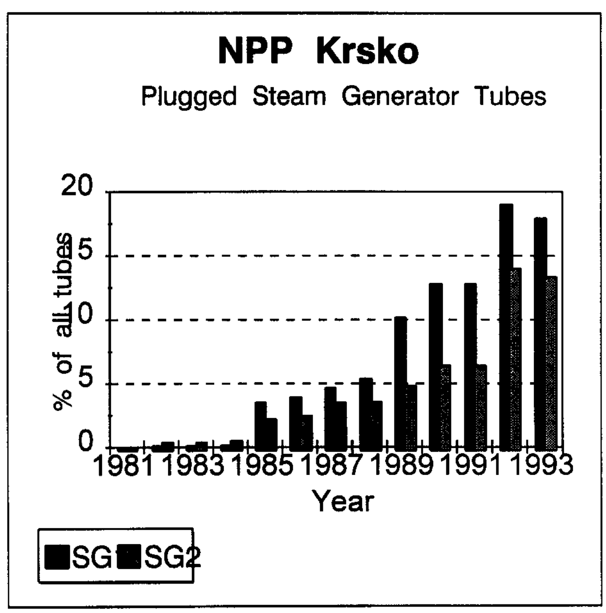


Figure 12: Plugged Steam Generator Tubes



Steam Generators

During the unplanned maintenance in 1993 both steam generators (SGs) were checked with eddy current procedure. After analysis at the SG No. 1 additionaly 193 of the total 820 tubes were plugged, which is 17,95 %. Therefore the equivalent plugging of the SG No. 1 is 824 tubes or 18.04%. In SG No. 2 149 of the total 609 were plugged, which is 13.31 %. The average plugging of both SGs 15.68%. The safety analysis performed for 18% average plugging does not allow more than 5% asymmetry between steam generators, which is the reason for the difference between the projected and the actually plugged SG tubes. In addition, 2 more tubes were extracted from SG No. 2 for testing. Because of the situation concerning the steam generators, the plant had to start with preparations for tube sanation and the replacement of steam generators.

During the 93 outage the following operations were performed in No.1 steam generator:

- 110 tubes plugged (they were in operation before the 93 outage),
- 245 tubes were unplugged, of which 83 were plugged again, 139 were successfully sleeved, 23 were reactivated without sleeving The plugging in steam generator No.1 decreased after the 93 outage from 19.02% to 17.95%.

During the 93 outage the following operations were performed in steam generator No.2:

- 87 tubes plugged (they were in operation before the 93 outage),
- 179 tubes were unplugged; these were mainly plugged during the 92 outage to reach the prescribed assimetry (the difference in plugging between the two steam generators should be less than 5%, if one of the steam generators is plugged more than 18%). 62 of them were plugged and 117 were reactivated without sleeving.

The plugging in steam generator No.2 decreased after the 93 outage from 13.97% to 13.31%.

The data about the region of U-tubes, where indications, that plugging was required, were found, give evidence about processes in the steam generators. Until 1987 the prevailing process was stress corrosion in the tube sheet region and in the transition region, after 1987 the degradation process is caused by intergranular corrosion in the tube support plate region. It is expected that after 1992, when the new condenser was installed, the conditions will improve due to changed secondary chemistry. The previous condenser was manufactured of a bronze alloy which allowed the pH up to 8.8. The new codenser is made of stainless steel and can operate at a higher pH value, which substantially reduces the corrosion rate.

After all the sleeves had been installed (July 16,1993) the leak on one of the sleeves was discovered during the test. The test was carried out with the steam generator filled with water on the secondary side. The sleeve was installed in the tube sheet region. The Krško NPP requested the experts from Combustion Engineering, USA, which is the conctractor for sleeving to come on the spot and to investigate why this had happened.

The Combustion Engineering experts (CE) prepared written answers to the questions raised by the SNSA representatives on the meeting between the Krško NPP, CE and SNSA staff. The conclusions were:

- the sleeve which leaked had been installed in the last batch of nineteen sleeves
- the inspection was discontinued and it was estimated that all the sleeve welds were unacceptable, because they did not want to moisten all other welds due to inspection. For rewelding the sleeves should be dry.
- the decision was made to reweld all the sleeves
- at rewelding the welding machine became lodged in the tube sheet at the weld area of the last weld of this set. This sleeved tube was plugged.
- the welding machine burnt a small hole through the sleeve and the U - tube ("blowhole"), a few tenths of millimeter in diameter. The defect was later on observed with a boroscope and a water jet was detected coming out of the hole.
- it was requested to find out why the hole was not discovered through inspection of the welds:

♦ the Eddy current measurements are done at four frequencies, since the highest frequency is screened, no indication was observed at this frequency

♦ later screening (when CE came back to the Krško NPP) revealed that this type of defect can be seen at lower frequencies

♦ CE started with the reanalysis of the Eddy current measurements

♦ CE recommended further seven tubes with sleeves to be plugged, because as the indications revealed, they could not reliably be interpreted as "passed"

♦ the Krško NPP accepted the recommendation and plugged these tubes

♦ another pressure test (secondary side of SG filled with water) was performed and leak on one unsleeved tube was detected (1droplet/75seconds). This tube had indication in the tube sheet region and was later plugged.

NE Krško Plant Modifications in 1993

An extensive programme for upgrading the NPP Krško is in progress. It was initiated to increase the safety of the plant. Modifications are also part of this programme.

A. Modifications in accordance with decrees issued by the Slovenian Nuclear Safety Administration (SNSA) carried out in 1993 were the following:

1. Modifcation 001-ER-S, "Metrological System Upgrades"
   Status: NNSR, will be completed during the outage in 1994.

2. Modifcation 007-SS-L, "Post Accident Sampling System"
   Status: NSR, will be completed during the outage in 1994.

3. Modifcation 009-VA-L, "Chlorine Monitoring System"
   Status: NSR, will be completed during the outage in 1994.

4. Modifcation 011-SW-L, "SW-Strainer Modification Taprogge Replacement"
   Status: NSR, will be completed during the outage in 1994.

5. Modifcation 015-AB-S, "Physical Protection-Parms Wall"
   Status: NNSR, completed.

6. Modifcation 032-SE-S, "Seismic Equipment Installation Now Eartg. Intensity Meas Seismic" Status: NNSR, phase I completed.

7. Modifcation 033-SE-S, "Seismic Station LO EQ Intensity Measurement (civil)"
   Status: NNSR, completed.

8. Modifcation 034-SE-L, "(Old DMP-L001) Seismic System Upgrade"
   Status: NNSR, completed.

Abbreviations:

NSR - Nuclear Safety Related
NNSR - Non Nuclear Safety Related

B. Modifications carried out in 1993 not ordered by SNSA decree were the following:

1. Modifcation 004-TU-L, "Turbine Trip Control System Power Source Upgrade"
Status: NNSR, completed.

2. Modifcation 005-EE-L, "Inverter Replacement"
Status: NSR, will be completed during the outage in 1994.

3. Modifcation 006-FH-L, "Fuel Handling Machine Upgrades"
Status: NNSR, will be completed during the outage in 1994.

4. Modifcation 008-DG-S, "Diesel 2A Cooling Water Vent Piping and Water Level Alarm Modification" Status: NSR, completed.

5. Modifcation 010-CW-L, "Exchange Traveling Water Screens-CW System"
Status: NNSR, will be completed during the outage in 1994.

6. Modifcation 012-FW-S, "FW-Oil Pumps Alarm"
Status: NNSR, will be completed during the outage in 1994.

7. Modifcation 013-Cy-L, "Condensate Polishing Pumps Seal Water"
Status: NNSR, completed.

8. Modifcation 014-PG-S, "Low Pressure H2 Manifold Removal"
Status: NNSR, completed.

9. Modifcation 018-CW-S, "TE Wiring"
Status: NNSR, completed.

10. Modifcation 023-DG-S, "2B Diesel Cooling Alarms"
Status: NSR, completed.

11. Modifcation 024.DG-.S, "1B DG Cooling Vent"
Status: NSR, completed.

12. Modifcation 025-DG-S, "1A Diesel Cooling Alarms"
Status: NSR, completed.

13. Modifcation 027-NI-S, "NI PWR DWR rewire"
Status: NNSR, completed.

14. Modifcation 030-PG-S, "Plant Gas Supply to Chem Lab"
Status: NNSR, will be completed during the outage in 1994.

15. Modifcation 035-G-L, "DG Speed and Load Control Upgrades"
Status: NSR, will be completed during the outage in 1994.

16. Modifcation 036-DG-S, "DG Governer Position Differential Alarm Control Unit Upgrade" Status: NSR, will be completed during the outage in 1994.

17. Modifcation 039-SI-S, "SI Accumulator Nozzle Liner Leaking"
Status: NSR, completed.

Personnel Training

Regulations require a highly trained personnel for peaceful use of nuclear energy. Not only is the level of education 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.

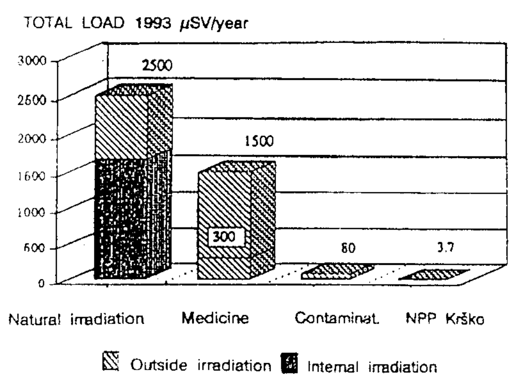
The Krško NPP has its own training department which takes care of annual training programs. As there is no simulator of nuclear power plant in Slovenia, the Krško NPP training department organises obligatory annual courses on a simulator abroad, mostly in the USA. All personnel that require the permit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

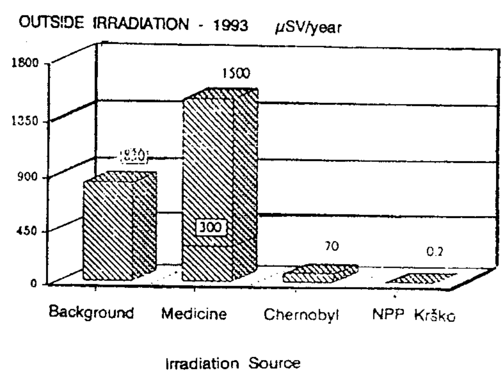
Expenses for personnel training are approximately 2.5 % of the plant working expenses.

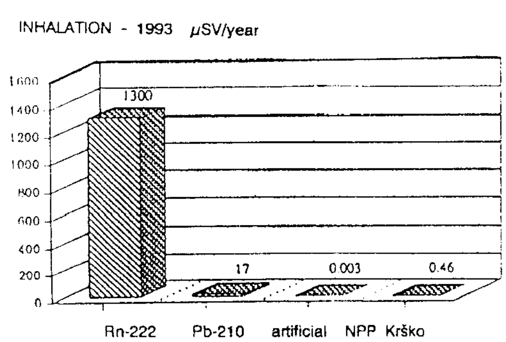
Radiological monitoring

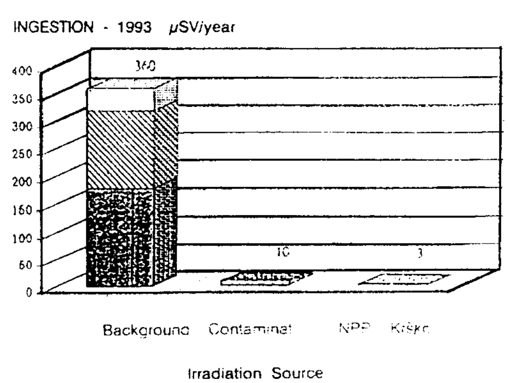
Regular radiological monitoring to determine the effects of the NPP Krško on the quality of surrounding area decreed by the SNSA is monitored by Institute Jožef Stefan from Ljubljana, Institute Rudjer Bošković and Institute for Medical Research and Occupational Health bouth from Zagreb. Emissions and imissions are measured in the circle of 12 km of the area around the NPP Krško and reference measurements are taken in the distance of 45 km.

The load on the environment from the NPP Krško was under the regulated the acceptable values. On the basis of evaluated public load compared to the reference public load from imission values, the values for effective dose are derived. These are lower than 10 μSv/year and smaller than the 0.5% from the average dose in normal environment.









Nonradiological Monitoring

The "Programme of nonradiological monitoring to determine the effects of the Krško nuclear power plant on the quality of the river Sava water and groundwaters", decreed by the Ministry of Environment and Physical Planning, is executed by the Ljubljana Chemical Institute in association with the Health Protection Institute of Novo Mesto and the Meteorological Office of the Republic of Slovenia (1).

In the "Analysis of the effects of operation of the Krško nuclear power plant on the ecological-biocenological changes in the river Sava and groundwaters" (2) for the year 1992, prepared by the Zagreb University Faculty of Natural Science and Mathematics and the Chemical Institute of Ljubljana, it was established that during the observed period, the quality of the water in the river Sava at Brežice was as good as, or better than, the quality in the section between the Videm Krško cellulose and paper factory and the Krško nuclear power plant. The comparison of the results with the zero state recorded between 1977 and 1980 indicated that the quality of the river Sava remained practically unchanged. Lignin concentration was somewhat lower, suspended matter was within the same limits, organic matter was slightly higher for KPKd, BPK5 and KPKb in the Sava section before the Krško nuclear power plant, whereas at Brežice it was slightly lower. The study of the fish community in the Krško nuclear power plant area of influence indicated that, in view of diseases and their incidence, the situation in the region did not differ from the situation in other watercourses. On the basis of the fact that the operation of the Krško nuclear power plant had no adverse effects on the river Sava, and on the basis of experience, a new, less comprehensive regime of nonradiological monitoring was adopted. The regime contains only the essential parameters for the determination of possible adverse effects on the river Sava (1).

The programme of nonradiological monitoring in 1993 (2) provides for the following sampling sites:

1 Krško, the bridge in Krško, the right bank
2a. Section between the Videm Krško cellulose and paper factory and the influx of vital feedwater into the Krško nuclear power plant, right bank
2b Section between the Videm Krško cellulose and paper factory and the influx of vital feedwater into the Krško nuclear power plant, left bank
3 The Brežice bridge, left bank
4 Jesenice na Dolenjskem, right bank.

Indicators of environmental effects and sampling frequency:

- The chemical need for oxygen is determined weekly by the dichromate method (KPK)
- The complexing capacity and surfactants are determined monthly
- Samples of the river bed fauna for biological analysis are taken every three months
- Degradability is determined semi-annually (in summer and winter).

In terms of quality degrees and classes and of the burden on the Sava along the Krško-Brežice section in 1993, determined on the basis of biological analyses of macrozoobenthic communities, and taking the lowest quality into consideration, the Sava water on the right bank in Krško before the dam at the Krško nuclear power plant is in the 3rd quality class, i.e. it is highly polluted. On the right bank before the Krško nuclear power plant, and on the right bank in Brežice, the water is in the 4th quality class. The saprobiological analysis did not reveal any adverse effect of thermal pollution on the Sava that would be traceable to the Krško nuclear power plant. The study showed that no adverse effects of the operation of the Krško nuclear power plant on the water and macrozoobenthos of the river Sava in Brežice were observed in 1993.(1)

The measurements to determine the impact of the Krško nuclear power plant on the quality of groundwater were performed by the Novo Mesto Health Protection Institute (1). Samples were taken twice a year at seven points: Vrbina, Spodnji Stari Grad, Šentlenart, Žadovinek, Brege, Skopica and Boršt.

In the study "Analysis of the effects of operation of the Krško nuclear power plant on the ecological-biocenological changes in the river Sava and groundwater" (2) for the year 1992, it was established that, according to the analysed indicators, the quality of the groundwater had not deteriorated since 1978, when the Krško nuclear power plant went into operation. Data for 1993 have not yet been processed. The study on "Nonradiological monitoring to determine the effects of the Krško nuclear power plant on the quality of the river Sava water and groundwater" (1) shows that in certain underground wells, the concentrations of nitrates, ammonia and iron and the traces of pesticides and chlorinated solvents, are higher than those prescribed by the rules on the quality of drinking water (Official Gazette of the SFRY, No. 33/87). Higher concentrations of ammonia, phosphates and nitrates and the biological needs for oxygen were determined in studies carried out between 1978 and 1981(1). We believe that the higher concentrations are due to agricultural activities, the composition of the soil (iron) and, partly, the influence of the river Sava water.
As part of the non-radiological monitoring in the vicinity of the Krško nuclear power plant, additional weekly measurements of temperatures and levels of groundwater were taken at 13 locations: Žadovinek V-1, Žadovinek V-2, Žadovinek V-3, Drnovo V-5, Brege V-5, Vihre V-6, Skopice V-7, Skopice V-8, Boršt V-9, Vrbina V-10, Spodnji Stari Grad V-11, Pesje V-12, Šentlenart V-13 (1).

The "Analysis of the effects of operation of the Krško nuclear power plant on the ecological-biocenological changes in the river Sava and groundwater" (2) establishes that, during dry weather in summer a rise in the temperature of the groundwater was observed, particularly in the wells near the river. The study further establishes that any rise of the river Sava temperature of more than 3 degrees centigrade at a flow rate below 60 m/sec and a load identical to that from 1992 would cause a critical state, with the possibility of oxygen concentrations dropping below 5 mg/l.

Sources:

1. Non-radiological monitoring to determine the effects of the Krško nuclear power plant on the quality of the river Sava water and groundwater, Chemical Institute, Ljubljana, 1994.

2. "Analysis of the effects of operation of the Krško nuclear power plant on the ecological-biocenological changes in the river Sava and groundwater", Zagreb University, Faculty of Natural Science and Mathematics and the Chemical Institute of Ljubljana, Zagreb - Ljubljana, 1993.

3. The monitoring of the quality of surface and groundwaters in connection with the operation of the Krško nuclear power plant in 1993, Croatian Water Management, Zagreb, March 1993.

TRIGA RESEARCH REACTOR

Jožef Stefan Institute's TRIGA Mark II research reactor at Podgorica in Ljubljana with the 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 the year 1993 there were 2 unplanned shutdowns. The first one was due to cutting out of the electricity circuit, the second one was due to malfunction on the instrumentation for radiological protection.

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.

Head operator of the reactor, five operators and service for protection against ionizing radiation are in charge of the reactor operation.

Reactor operators received effective equivalent doses of irradiation of gamma from 0.71 to 1.36 mSv. Neutron doses were below 1 mSv.

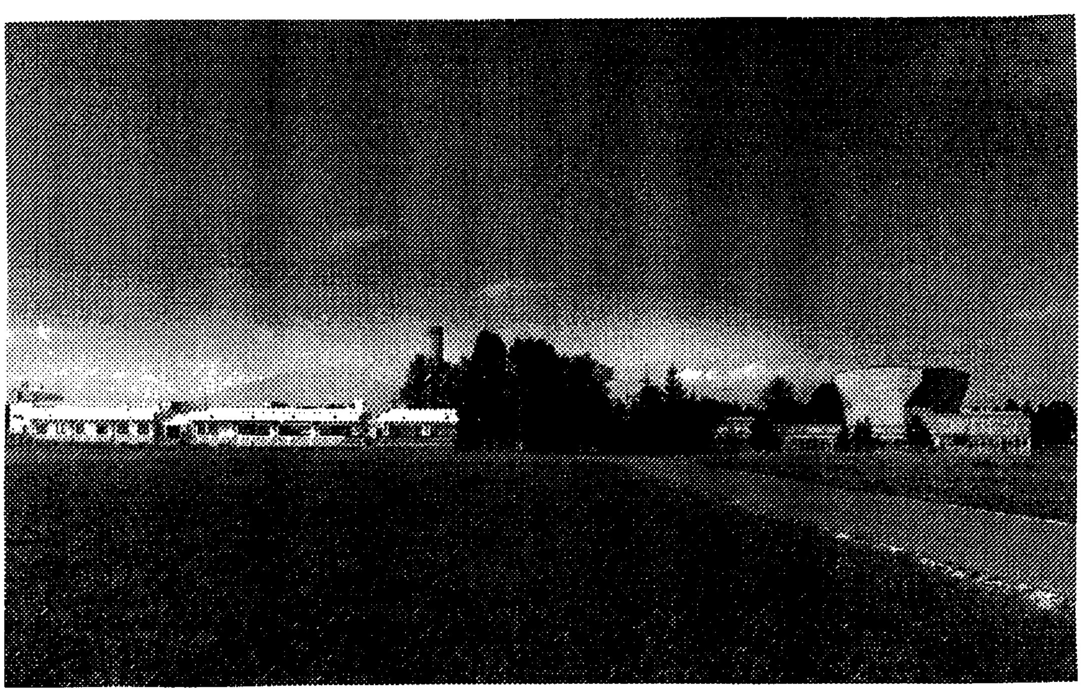
In the year 1993 the whole electric supply system in the reactor area and the climate for the control room was renewed.

Interim Storage of Radioactive Waste in the Reactor Center Podgorica

The 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.

In 1993 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, glass-ware, etc.) and materials with induced activity due to irradiation in the TRIGA reactor,
- special 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.

The quantity and the activity of different types of radioactive waste are given in Table 13. In 1993 the number of drums (barrels) increased by 2, the number of special waste by 6, the number of closed sources by 32.

Table 13: Radioactive Waste in the Transition Storage in the Reactor Center Podgorica for 1993

Type	Amount Total (1993)	Isotopes *	Activity (GBq)
Barrels	135 (2)	Co-60, Cs-137, Eu-152/U, Ra-226	3 - 20
Special waste	85 (6)	Co-60/Ra-226/Am-241	7000
Closed sources	130 (32)	Co-60, Cs-137	1000

* - isotopes providing the majority of activity are only quoted

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

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

- the discharge of Ar-41 into the atmosphere (ventilation system of the reactor hall)
- the discharge of radioactive substances in the Sava river with liquid waste from the Department for Nuclear Chemistry.

The estimated yearly effective dose per person due to Ar-41 in the air is 300 nanoSv, which is 0.03 % of the permissible annual value according to the regulations.
The estimated yearly effective dose per person due to the 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.

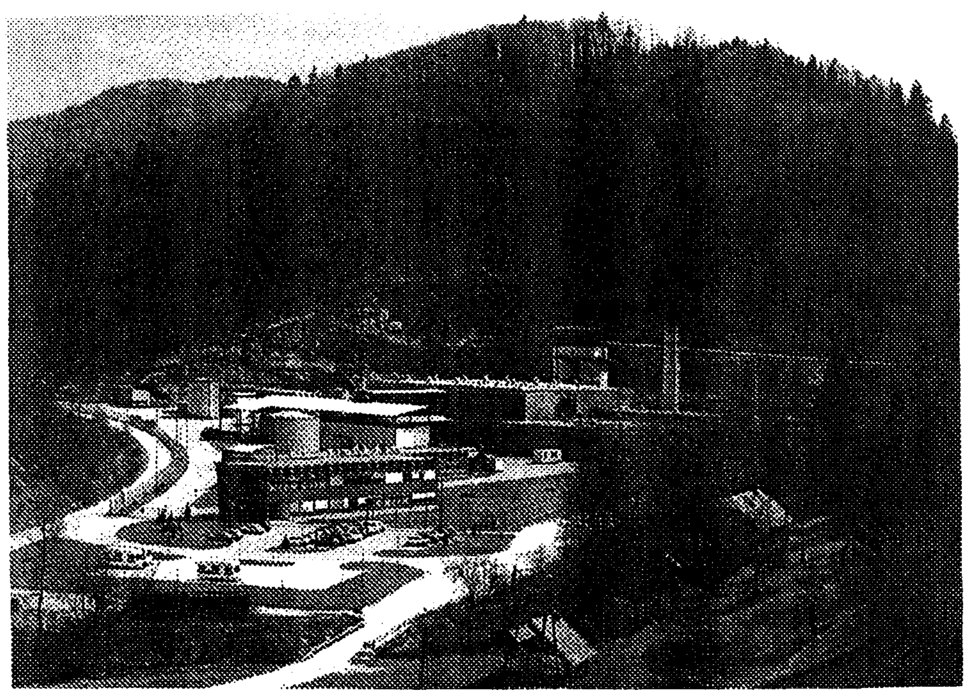
URANIUM MINE ŽIROVSKI VRH

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

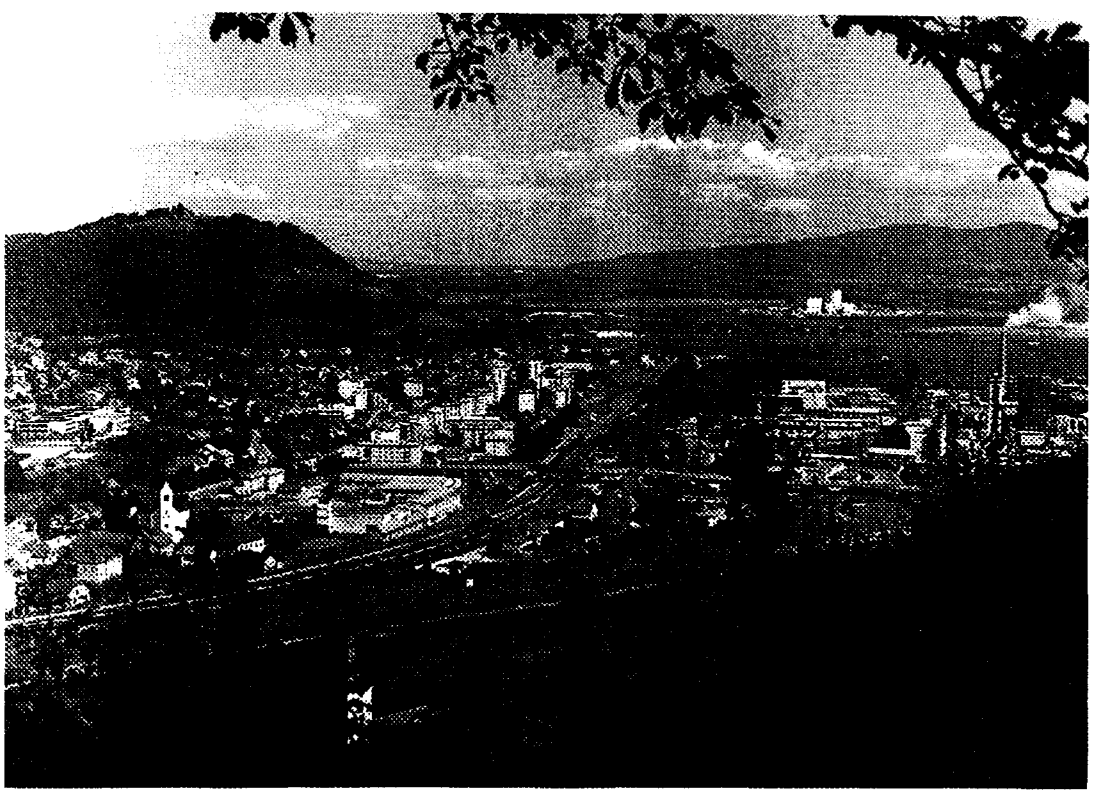
The concentrations of long-lived radionuclides from aerosols in the surrounding environment were equal to the reference concentrations and were not higher than the background ones. The average radon concentration was nearly the same in the year 1991 and was not essentially lower after closing down. Also the radioactivity of sediments from the brooks Bretovščica and Todraščica and the 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, additional dose was calculated for the critical group and it was 0.34 mSv. For individuals, the value is the same as in 1991.

The effective dose of an individual was lower than the limit dose of 1 mSv per year, per lifetime which is regulated by the Act (Off. Gaz. SFRY, No. 31/87) and recommended by International Guidelines ICRP 60 (1990).



INTERNATIONAL MISSIONS



KRŠKO

REPORTS OF THE INTERNATIONAL SAFETY EXPERT MISSIONS

There were three expert missions working on nuclear safety in Slovenia in the year 1993:

- the International Atomic Energy Agency OSART mission (Operational Safety Review Team) took place from 5 to 23 July 1993
- the ICISA mission (International Commission for Independent Safety Analysis) proceeded its work from 1992 and released the final report at the end of October
- the Exploratory Mission of the Commission of the European
- Communities took place from 24 to 28 May, analysing the ability of the regulatory bodies which are committed to inspecting the Krško NPP.

The OSART and ICISA reports are very similar. While the OSART mission followed the codes based on world experiences evaluating the quality of operational safety, the ICISA mission worked on the design assessment.
The OSART recommendations and proposals refer to particular corrective activities and enhancement in the operation and maintenance of the plant. The ICISA recommendations and proposals require larger studies that will confirm the safety of the chosen design solutions and their impruvmentations in the plant. The European Commission performed an assessment of abilities and activities of the regulatory body for nuclear safety.

The reports recommend certain corrections, enhancement and modifications of equipment, systems, operations and accompanying activities. They do not find any serious defects which would require a shutdown. According to the missions' findings and recommendations, the Krško NPP follows the technology, environmental impact , staffing, operation management and emergency planning of western NPP's. These reports will provide support and activity guidance for the enhancement of the on-going activities in the plant and in the SNSA. All the missions found out that the plant is in deep financial difficulties.

The OSART mission team was composed of twelve experts from seven different countries and IAEA staff members with three observers. From 5 to 23 July the mission performed the review and assessment of all power plant areas essential to operational safety:

1 Management, organization and administration
2 Training and qualification
3 Operations
4 Maintenance
5 Technical support
6 Radiation protection
7 Chemistry
8 Emergency planning and preparedness.

The OSART mission report presents assessments of these activity areas, and includes recommendations and suggestions for further enhancement of operational safety. In its report, the OSART mission presented also examples of good experience in terms of good performance or good practice. The report includes 95 recommendations, 62 suggestions, 20 good performances and 11 good practices.

The ICISA Commission which was established by the Slovenian Government in April 1992 was composed of the president (who was Slovenian) and representatives from Slovenia, Italy and Austria. The Commission invited 41 experts from nine different countries to cooperate in three working groups:

WG1: Technology and plant system
WG2: Geology, seismology and earthquake engineering
WG3: Environmental issues.

At the end of October, ICISA submitted its final report to the Government of the Republic of Slovenia. It presents the safety assessment of the power plant. The report includes:

- Introduction
- ICISA safety evaluation
- Nuclear power generation company and safety authority in Slovenia
- ICISA plant related findings
- ICISA conclusions and recommendations
- Abbreviations
- References
- List of attachments

In the report there are 77 recommendations for the enhancement of the Krško NPP safety.

The Exploratory Mission of the Commission of the European Communities is the group committed to providing technical assistance to regulatory bodies. Its visit took place from 24 to 28 May 1993. The group was composed of six members of regulatory bodies from Belgium, Italy, the United Kingdom and Spain, an IAEA consultant and an observer from Croatia. The mission performed an assessment of legislation related to nuclear safety and radiation protection, the organization, ability and activities of the SNSA in order to provide assistance to the regulatory body for the enhancement of its activity. The report makes 26 recommendations which should be considered by the Government and the Parliament of the Republic of Slovenia to in order improve the governmental organization and activity on nuclear safety. The report includes:

- Introduction
- Governmental organization and nuclear safety legislation
- Role and responsibility of the regulatory body
- Organization and staffing of the regulatory body
- Regulatory approach and licensing system
- Regulatory inspection and enforcement activities
- Nuclear safety regulations, codes and standards
- Assessment and technical support resources
- Radioactive waste management
- Emergency planning
- Radiological inspection
- Equipment needs
- Conclusions
- Annexes
- Index of abbreviations.

On the basis of this report the experts of the Commission of the European Community formulated an assistance program for the Slovenian regulatory body which will start to be implemented in the first quarter of 1994.

Table 14: Overview of Recommendations and their Implementation

No.	Review Area	No. of Recommendations				Implementation Schedule					
		OSART	ICISA	CEC	Over-lapping	Already Implemented	1994	1995	1996	1997	No Schedule
1	Management, Organization and Administration	21	9	/	2	11	13	5	1	/	/
2	Training and Qualification	19	1	/	1	6	13	/	/	/	1
3	Operations	23	6	/	5	6	13	7	2	1	/
4	Maintenance	17	3	/	1	10	6	4	/	/	/
5	Technical Support	17	3	/	1	7	7	4	2	/	/
6	Radiation Protection	24	6	/	2	11	12	4	2	1	/
7	Chemistry	27	1	/	/	7	13	7	/	1	/
8	Emergency Planning and Preparedness	19	3	/	1	6	14	2	/	/	/
9	Plant Systems	/	9	/	/	1	1	6	/	1	/
10	Fuel and Wastes	/	4	/	/	2	1	1	/	/	/
11	Geology/Seismology	/	8	/	/	1	3	2	/	/	2
12	Analyses and Studies	/	11	/	1	2	3	5	1	/	/
13	Regulatory Body	6*	10	26	1	2	14	16	1	/	3
TOTAL		167	74	26	15	72	113	63	9	4	6

* Already contained in other chapters

EMERGENCY PREPAREDENESS EXERCISE

"POSAVJE 93"

THE "POSAVJE 93" EXERCISE

The "Posavje 93" exercise, one of the forms of exercise provided for by the "Plan of Measures for Emergency Event" (NUID) was held on Saturday, 23 October 1993.

Participants in the operational part of the exercise included members of the Civil-Defence Headquarters of the RS (RŠCZ), representatives of all ministries and of the municipal civil defence (CZ) headquarters of Krško and Brežice, and the personnel of the Krško nuclear power plant. The demonstration part of the exercise included as participants members of the Krško CZ headquarters, municipal CZ units and the ecological mobile unit laboratory (ELME).

All vital decisions and the supervision of the exercise were in the hands of the Civil Defence Headquarters of the RS which, on the basis of its members' expert opinions, proposed measures to the Government, which issued orders to governmental bodies (ministries and agencies in their formation). The RŠCZ, as required, received from governmental bodies information and recommendations needed for taking decisions. The Slovenian Nuclear Safety Administration had in its formation three expert groups - for accident analysis, for dose computation and for information and support. These groups received information from the Krško nuclear power plant, evaluated it, worked out forecasts of further developments and prepared information for the public, thereby supporting the work of the RŠCZ. The bulk of information was transmitted over the telephone network (telephone, telefax, computer transmission). The transmission of information was in the hands of the state and municipal information centres, so that the RŠCZ had direct contact with the municipal CZ headquarters.

The internal supervision of the exercise was carried out by the staff of the Krško nuclear power plant. They communicated with the superintendents of the exercise, appointed from the power plant's staff, using telephone and radio communications. The internal leaders of the exercise and the superintendents attended to the coordination and smooth running of the exercise, in accordance with the scenario. The exercise was attended by the observers appointed by the RUZR director; their duty was to assess the activity of the direct participants.

The plan for the operational part of the exercise in the Krško nuclear power plant provided for the following activities:

a) activities that were carried out in entirety: detection and classification of threat, notification of external organisations, mobilisation of the technical support centre, assessment of the situation and suggestions for corrective measures, radiological control in the power plant, radiological control in the environment, control of admission to the power plant, provision of first aid, decontamination, radiological assessment of the hazard and suggestions for protective measures;

b) activities which were carried out in part: mobilisation of the Krško nuclear power plant organisation for emergency event, mobilisation of the operational support centre, review of attendance, transportation of injured persons to the medical centre, notification of the public, announcement of the end of the state of emergency;

c) simulation of certain activities: corrective measures applied to inoperable equipment and components;

d) activities that were not carried out: public alert inside the power plant and within the exclusion zone, evacuation of the power plant and of the exclusion zone, operational measures in the control room, change of the shift or replacement of individuals in specific workposts by those from the emergency reserve staff of the Krško nuclear plant.

The demonstration part of the exercise took place in a village farm at Brod pri Podbočju. The demonstration included preparation of the living space inside houses, sealing the windows and doors, protecting water pumps and milk vats with polyvinyl and other expedients to hand, preparing a two-day supply of water and animal feed, sending reconnaissance and dosimetric teams to the field, and decontaminating people, vehicles and buildings.

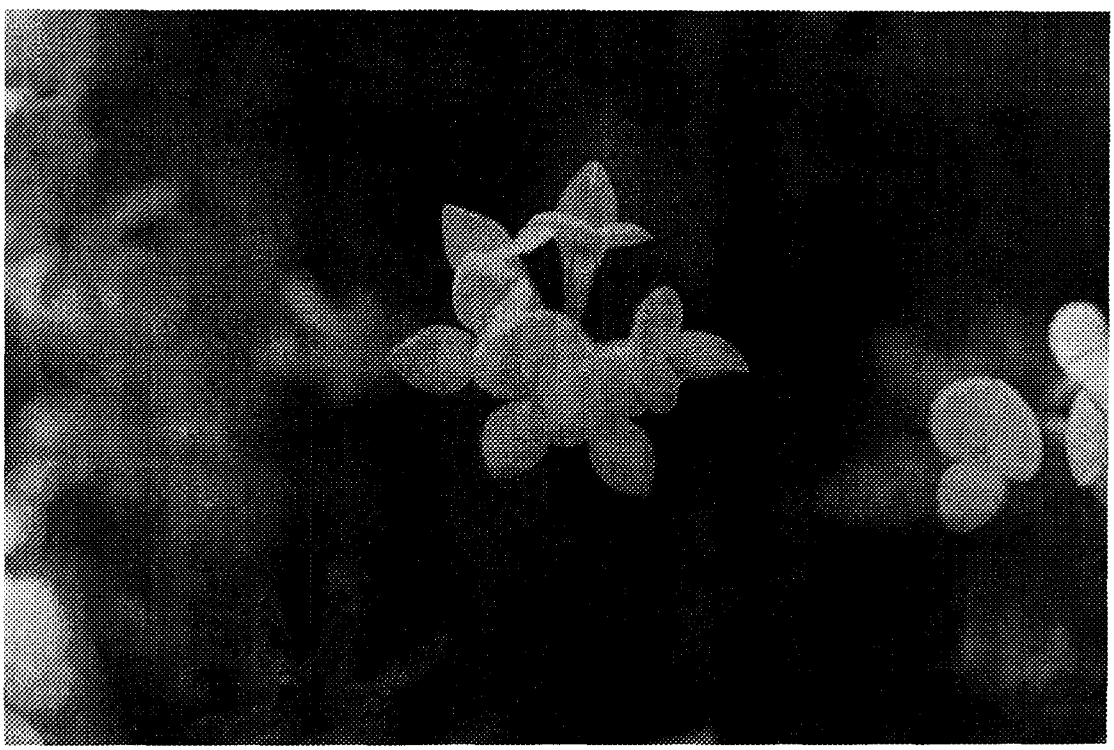
The aim of the "Posavje 93" exercise was twofold:

a) through preparations for the exercise, which started in spring 1992, to achieve as high a level of personnel preparedness as possible, to prepare the equipment, to adapt the necessary buildings and to supplement the documentation
b) to verify the functioning of the equipment and the competence and coordination of the participants in the event of an emergency at the Krško nuclear power plant.

Analysis of the course of the exercise points to the high level of commitment and professional competence of all the participants. It was established that more attention ought to be paid to communication between participants.

It was also suggested that exercises to test the preparedness for taking measures in case of an emergency event at the Krško nuclear power plant should be organised more frequently, since the last similar exercise had been carried out in 1992.

RADIOACTIVITY MONITORING IN SLOVENIA



RADIOACTIVITY IN THE HUMAN ENVIRONMENT IN SLOVENIA

The program for measuring and monitoring radioactivity in the human environment in the Republic of Slovenia is determined by the regulation on the locations, methods and time limits for the examination of contamination with radioactive substances (Official Gazette of the SFRY, No. 40/86), and on the basis of expert opinions adopted after the Chernobyl accident and included in the regulation on the locations and time intervals for systematic examinations of the content of radionuclides in the human environment (Official Gazette of the SFRY, No. 84/91). The programme is executed by the Work Safety Institute of the Republic of Slovenia and the Jožef Stefan Institute.

The Program encompasses:

1. Monitoring with immediate control of the degree of radioactive contamination, such as, for example, daily measurements of radioactivity of samples (air, precipitations) and continuous measuring of the external gamma radiation dose rate.

2. Measurements at 50 locations in Slovenia of daily and monthly doses received from the external gamma radiation.

3. Control of radioactivity in food from animal and plant sources - seasonal measurements as the basis for the calculation of doses received through ingestion.

The first two segments of the programme are essential for the early detection of environmental contamination, and the third one serves to monitor long-term trends in environmental contamination from artificial sources. In 1993, the content, both of artificial and of the most important natural radionuclides, in the samples was determined.

The scope of the Programme:

1. Rivers - Two samplings annually in the rivers Sava at Ljubljana (Laze-Jevnica), Drava at Maribor and Soča below Anhovo. The content of gamma emitters and H-3 were analysed.

2. Air - Daily sampling in Ljubljana, Jezersko and Predmeja. Monthly high-resolution isotopic analyses of gamma emitters were also made. The measuring will be extended to include Celje after an air pump has been installed there.

3. Earth - two samplings (May and October) at three depth levels, viz. 0-5 cm, 5-10 cm and 10-15 cm, on grassland (uncultivated land) in Ljubljana, Kobarid and Murska Sobota. The external gamma radiation dose rate was measured in Ljubljana, Maribor, Novo Mesto, Celje, Nova Gorica, Portorož, Murska Sobota, Kredarica and Lesce. In addition, monthly doses from external radiation were measured at 50 locations.

4. Precipitations - Continuous sampling of solid and liquid particles in Ljubljana (IJS and ZVD), Kobarid, Murska Sobota and Novo Mesto. In Ljubljana, measurements using high-resolution isotopic analysis of gamma emitters and Sr-90 were based on composite monthly samples, and in other towns on composite three-monthly samples.

5. Drinking water - Quarterly isotopic analyses of gamma emitters and specific analyses of Sr-90 and H-3 were made in Ljubljana, Celje, Maribor, Koper, Škofja Loka and Kranj (Krvavec).

6. Food - Measurements of the content of gamma emitters and Sr-90 in food from plant and animal sources were made at locations in Ljubljana, Novo Mesto, Koper, Celje, Murska Sobota, Maribor and Slovenj Gradec.
The analyses of milk as a staple diet were made on a monthly basis in Ljubljana, Bohinjska Bistrica, Kobarid and Murska Sobota.

7. Animal feed, grass - The programme provides for the analysis of grass, hay, feeds, manure and phosphates, particularly in the areas in which milk is

controlled. Due to limited funds, only a few analyses for the content of gamma emitters and Sr-90 were made.

The results of the measurements of activity concentration in the principal elements of the biosphere: the earth, the air and the precipitations in 1993 do not point to a significant reduction compared to 1992.

The measurement of the external gamma radiation dose rate shows that the Chernobyl contribution still accounts for an average 20% of the total external dose measured in Slovenia. The average annual dose of external gamma radiation measured by the dosimeter amounts to 1096 μSv, or 904 μSv when measured by thermoluminiscent dosimeters.

The results of measurements of specific activity on the samples of untilled land taken in Ljubljana, Murska Sobota and Kobarid show a similar distribution of Cs-134/Cs-137 between the first two layers and that from 1992, whereas the third layer contains only 10-15% of total contamination. This can be accounted for by the quantity and activity of precipitations in individual areas, the pedological properties of the soil and the greater mobility of Sr-90 relative to Cs-134/Cs-137.

In 1993 the measuring of the specific activity of gamma emitters in the samples of food of vegetable origin did not show a significant decline in activity. The activity of fruit samples practically remained at the level of the previous year. The contamination of vegetables with Cs-134/Cs-137 is the foliar deposit, was in 1993 either negligible or non-existent. Sr-90, due to its mobility, may nevertheless contaminate vegetables via the roots. The activity of gamma emitters and Sr-90 in fruit samples is, with a few exceptions, the same as in the preceding year.

The measurement of specific activity of gamma emitters and Sr-90 in samples of food of animal origin showed that contamination with Sr-90 in 1993 was at the level of the preceding year, whereas contamination with Cs-134/Cs-137 was by 25% lower.

On the basis of measured concentrations of artificial and natural radionuclides in food samples, the expected effective equivalent doses of radiation from ingestion were computed. In addition, the annual dose from external gamma radiation was measured in larger towns in Slovenia. The dose amounts to 904 μSv, the Chernobyl disaster being responsible for 180 μSv.

On the basis of these measurements, the implementors of the Program have established that the annual ingestion of artificial radionuclides was not in excess of the limit prescribed by the regulations on the maximum contamination of human environment and on decontamination (Official Gazette of the SFRY, No. 8/87).

The implementors have further established that the annual effective equivalent doses due to ingestion of natural nuclides, and the annual doses due to exposure to the external gamma radiation, are both within the average values in the world as given in the UNSCEAR 1988 report.

Radioactivity measurements in the surroundings of the Krško nuclear power plant, the 1993 report (2), deal with the "iodine problem" in the water of the river Sava. Comparisons for the iodine I-131 concentration were made at the following locations: Ljubljana's sewage treatment plant at Zalog on the river Ljubljanica, near confluence of the rivers Ljubljanica and Sava; at Laze, the right bank of the Sava, approx. 3 km downstream from the mouth of the Ljubljanica; in Krško; at Brežice; at Jesenice. Table 15 shows, in addition to the maximum and average concentrations of iodine, the potential doses that the reference-man would receive in 1993 solely from I-131 if he drank water from the Sava. In view of the river Sava's high contamination from hospitals, the contribution of I-131 and of other isotopes from the Krško nuclear power plant is quite negligible.

Table 15: Concentration of I-131 in the years 1990, 1991, 1992 and 1993 in the river Sava water, obtained from individual samples of unfiltered water (IJS). The Table gives the maximum measured values and the average values (in parenthesis) of larger samples.

Year	Specific activity Bq/m3					
	LJ-Zalog Sewage T. Plant	Laze	Krško before paper P.	Krško after Paper P.	Brežice	Jesenice in Dolenjska
1990			30 (19)	35 (21)	34 (17)	48 (19)
1991			41 (20)	62 (26)	57 (20)	32 (18)
1992		34 (25)	79 (28)	90 (31)	56 (22)	14 (7)
1993	1680	750 (350)	21 (16)	21 (14)	18 (13)	13 (10)
H_{E50} uSv/year	67	30 (14)	0.8 (0.6)	0.8 (0.6)	0.7 (0.5)	0.5 (0.4)

Except for the contributions of I-131, the total loads are, due to the predominant contributions of natural radionuclides, virtually similar to the pre-Chernobyl levels.

It will be necessary to start preparing a programme to control radioactive waste from hospitals.

Tritium appears in nature in trace amounts, but since the 1952 nuclear tests, its concentration has greatly increased. On the basis of the concentration of tritium in groundwater, it is possible to infer the age of the water or whether the aquifer is fed from surface water. Already, traces of tritium in groundwater point to the link with surface water.

Allowing for measuring errors, the periodic individual sampling of tap water at the Krško pumping stations, primarily with the aim of determining the presence of short-lived isotopes, did not show excessive values. At Brežice, during the periods of larger consumption of water it is necessary to include in the water supply system, in addition to the new pumping station which has low tritium content, the old pumping station, which has a higher tritium content. This is why mixed water from the waterworks was separately controlled on a monthly basis. The annual average in the mixed water in 1993 was 0.7 kBq/m3 and, on the whole, corresponds to the results of the preceding year, when the annual average was about 0.62 kBq/m3.

In the Medsave and Šibice control wells in the region of Samobor, the average annual concentrations in individual monthly samples of tritium were 4.3 kBq/m3, the individual sample ranging between 1.9 and 8 kBq/m3. These values approximate to the values of tritium in 1992; they are lower than the values in the Sava at Brežice (8.4 kBq/m3), and considerably lower than the average values measured by the IJS in the Sava at Jesenice (17 kBq/m3).

The values of tritium in Slovenia in 1993, and a comparison with the pumping stations in the Krško plant are shown in Table 16.

Table 16: Tritium in drinking water

Waterworks Catchment	Specific activity kBq/m3
Ljubljana*	1.2 1.2
Maribor*	3.1 2.8
Celje*	2.4 3.0
Kranj*	1.1 1.3
Škofja Loka*	1.8 1.8
Koper*	1.1 1.8
Krško**	1.8
Brežice**	0.96
Drnovo***	2
Brege***	2.3
Dolenja vas***	1.9

* individual semiannual samples
** individual quarterly samples
*** monthly composite samples

Sources: 1. Radioactivity in the human environment in Slovenia in 1993, ZVD, Ljubljana, May 1994
2. Radioactivity measuring in the vicinity of the Krško nuclear power plant, IJS, IJS-DP-6957, Ljubljana, March 1994

NUCLEAR ELECTRICITY GENERATION

TRIGA RESEARCH REACTOR

At the end of 1993, there were 430 electric power reactors with a combined output power of about 337,718 MW operating in 29 countries, and the number of reactors in operation was increased by seven.

There were 81 reports on nuclear incidents sent to INES in 1993. Four were assessed as third-degree incidents, twelve as second-degree incidents, 21 as first-degree incidents and others were below or outside the scale. The developed western countries show particular concern for the quality of nuclear safety in the central and eastern European countries, and provide programmes for improving the safety mechanisms of nuclear power plants and the rehabilitation of the existing facilities.

Table 17: Nuclear Power Reactors in operation and under construction at the end of 1993

Country	Reactors in operation		Reactors under constraction	
	No of units	Total MW	No of units	Total MW
Argentina	2	935	1	692
Belgium	7	5527		
Brazil	1	626	1	1245
Bulgaria	6	3538		
Canada	22	15755		
China	2	1194	1	906
Cuba			2	816
Czech R	4	1648	2	1824
Finland	4	2310		
France	57	59033	4	5815
Germany	21	22559		
Hungary	4	1729		
India	9	1593	5	1010
Iran			2	2392
Japan	48	38029	6	5645
Kazahstan	1	70		
Korea RP	9	7220	7	5770
Lithuania	2	2370		
Mexico	1	654	1	645
Netherlands	2	504		
Pakistan	1	125	1	300
Romania			5	3155
Russia	29	19843	4	3375
S. Africa	2	1842		
Slovak R	4	1632	4	1552
Slovenia	**1**	**632**		
Spain	9	7101		
Sweden	12	10002		
Switzerland	5	2985		
UK	35	11909	1	1188
Ukraine	15	12679	6	5700
USA	109	98784	2	2330
Total*	430	337718	55	44369

* The total includes the data from Taiwan..

Ref.: Nucleonics Week, Dec. 1993

Table 18: Total operating Experience and Electricity supplied by Nuclear Power Reactors

Country	Electricity supplied NPR in 1993		Total Operating Experience to end 1993	
	TWh	%	Years	Months
Argentina	7.2	14.2	30	7
Belgium	39.5	58.9	121	7
Brazil	0.4	0.2	11	9
Bulgaria	14	36.9	71	1
Canada	88.6	17.3	304	11
China	2.5	0.3	2	5
Cuba				
Czech R	12.6	29.2	30	8
Finland	18.8	32.4	59	4
France	350.2	77.7	766	5
Germany	145.0	29.7	469	1
Hungary	13.0	43.3	34	2
India	5.4	1.9	110	3
Iran				
Japan	246.3	30.9	603	7
Kazahstan	0.4	0.5	20	6
Korea RP	55.4	40.3	81	1
Lithuania	12.3	87.2	16	6
Mexico	3.7	3.0	4	9
Netherlands	3.7	5.1	45	9
Pakistan	0.4	0.9	22	3
Russia	119.2	12.5	468	6
S. Africa	7.2	4.5	18	3
Slovak R	11.0	53.6	53	5
Slovenia	**3.8**	**35.6**	**12**	**3**
Spain	53.6	36.0	128	8
Sweden	58.9	42.0	195	2
Switzerland	22.0	37.9	93	10
UK	79.8	26.3	994	2
Ukraine	75.2	32.9	143	11
USA	610.3	21.2	1810	8
Skupno	2093.4		6902	2

* The total includes the data from Taiwan..

Ref.: Nucleonics Week, Dec. 1993