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NUCLEAR AND RADIOLOGICAL SAFETY IN SLOVENIA

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SLOVENIAN NUCLEAR SAFETY ADMINISTRATION

RUJV-RP-020

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SUMMARY

The Slovenian Nuclear Safety Administration (SNSA) in cooperation with the Health Inspectorate, prepared the Report on Nuclear and Radiological Safety in the Republic of Slovenia for 1994 as part of its regular practice of reporting on its activities to the Government and the Parliament of the Republic of Slovenia. The Report is divided into seven thematic chapters covering the activities of the SNSA, the operation of nuclear facilities in Slovenia, the activities of the Agency for Radwaste Management (ARAO), the activities of international safety missions in Slovenia, Environmental radioactivity monitoring in Slovenia, Ionizing radiation sources control by Slovenian Health Inspectorate and review of the operation of nuclear facilities around the world.

At the legislative level, the SNSA in 1994 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 senior operators at nuclear power plant).

In carrying out its administrative duties, the SNSA in 1994 issued a total of 16 administrative decisions 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 1994, and the Expert Commission for Testing the Qualifications of Krško Operators, which organized two examination periods in 1994.

The international activities of the SNSA markedly expanded in 1994. 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 accident, and proposed similar bilateral agreements to the nuclear safety administration agencies of other neighbours (Italy, Hungary, Croatia). The agreement on the exchange of technical information and cooperation in the field of nuclear safety between governments of Slovenia and Canada is almost completed.

Cooperation with the International Atomic Energy Agency (IAEA) is particularly intensive. SNSA staff and other Slovenian experts participated in the preparation of IAEA documents such as Basic Safety Standards for Protection against Ionizing Radiation and for the Safety of Radiation Sources and the Nuclear Safety Convention.The most intensive collaboration was in the field of technical cooperation and safeguards.

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

The inspections carried out in the Krško nuclear power plant in 1994 included 63 routine inspections, eleven quality system inspections, four non routine inspections, two joint inspections with other

inspectorates. Furthermore, there were two inspections of the TRIGA research reactor, as well as the regular inspection of the Žirovski Vrh Mine with the participation of the Slovenian Health Inspectorate. The inspection services established that the repair work, the functional and start-up tests of the plant systems and components following "refueling '93/94 and steam generators inspection 94" were performed correctly and the results of the functional tests of the plant systems and components complied with the operational limits and conditions. During the shutdowns, the causes were examined, measures were proposed and the implementations of the adopted measures were supervised. All safety systems for safe shutdown operated according to the design and safety was assured.

In 1994, the Krško nuclear power plant generated 4 609 150 MWh (4.6 TWh) of gross electric power at the generator output, or 4 403 528 MWh (4.4 TWh) of net electric power. The generator was connected to the grid for 7401.2 hours, 84.49 % of the total number of hours in that year. The production was 9.05 % higher than planned. The reactor was critical for 7427.2 hours, 84.79 % of the total number of hours, and the thermal energy produced totaled 13 422 033 MWh. The scheduled and unplanned shutdowns of NPP Krško, and the reactor power reductions in excess of 10 % of the rated power for over 4 hours, included seven power reductions, one automatic reactor trip and two manual shutdowns. The trip occurred due to the human error while performing corrective maintenance activity. The manual shutdowns were applied for refueling and service work. Operating at reduced power is the regulatory requirement to control thermal pollution of the Sava river. The steam generators are emerging problem because of the large number of plugged tubes, and should be replaced in the near future. Number of the plugged tubes is approaching safety analyses limit for full power operation. The Krško nuclear power plant made twelve modifications approved by the SNSA, as well as other 69 modifications.

The environmental-impact monitoring of Krško in 1994 proceeded according to the established programme. Based on 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 1994 was assessed at less than 10 microsieverts. The dose represents less than 0.5 % of the dose that an individual receives from natural or from other artificial sources of radiation. The Sava river and ground water monitoring showed no negative effect from the operation of NPP Krško.

The radioactivity monitoring of the human environment in Slovenia indicates that the effect of iodine from hospitals is greater in real terms than the contribution of iodine from NPP Krško.

The 250 kW thermal power research reactor TRIGA produced 324.1 MWh of heat. There were seven unplanned shutdowns - four because of a voltage cutout, the other because of a defect on high voltage feeder, alarm system and one because of ventilation unit. The radioactive waste storage in the Podgorica reactor center remained uncontaminated, and only the dose rate in the rear of the storage increased. None of the facilities represents a perceptible additional radiological impact on the environment. Radioactive releases from the Podgorica reactor center in 1994 were approximately equal to the releases in 1991, 1992 and 1993, 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 dose to the reference-man in the vicinity of the Reactor center in 1994 was modeled using the measured emissions and estimated at 1 microsievert, therefore impact to the environment from the Podgorica reactor center is negligible.

In April 1994 The Government of Republic of Slovenia accepted the programme for the permanent shutdown of the uranium mine and the milling facility and the elimination of consequences of mining in the Žirovski Vrh Uranium Mine. 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 1994 was assessed at 350 μSv. Main contribution to the additional load comes from radon and its doughters (80%).

The radioactive waste that was collected after the 1961 accident at the Oncological institute, from 10 mg of Ra-226 spill is stored near the village Zavratec in the old Italian army bunker. In 1994 the Ad-hoc group appointed by Nuclear Safety Expert Commission studied all the available materials and concluded that the Ra-226 needle is hermetically closed or is not present in storage at all. The Ad-hoc group suggested new measurements on which the sanification of the storage would be made. At the moment, for few decades, the storage seems not problematic for the environment.

Agency for Radwaste Management (ARAO), was established for final and safe management of radioactive waste disposal. After the public rejection of the possible final disposal locations for low and medium radioactive waste the new criteria for underground location are being made. Simultaneously the agency is collecting the data on old and abandon mines. The new concept for site selection will be introduced. First, the local population acceptance is achieved by tender (public competition), and then the actual work with site selection is starting. That way the public is actively involved in all stages of location selection.

In 1993, three international nuclear safety expert missions were active in Slovenia. In the reports they presented 252 recommendations and suggestions for improvement, although their unanimous conclusion was that nuclear safety in Slovenia was on satisfactory level. At the end of 1994 40% of the recommendations were implemented, 40% were in satisfactory progress, and others will be finished by the 1997. Some of them are dependent of the steam generator's replacement. OSART follow-up mission was in 1994 in Slovenia and concluded that the progress at implementing the OSART suggestions and recommendations is good.

In the framework of PHARE program for nuclear safety, European Union and Italian regulatory body ANPA, as program coordinator, signed agreement for assistance to the SNSA at seven different fields. First part of the program will be completed in 1995.

The monitoring of radioactivity in the human environment in Slovenia shows similar results as in 1992 and 1993 and the annual intake was below the established limits. Annual equivalent doses for ingestion and annual doses for outdoor gamma radiation are in the frame of world average recorded in the UNSCEAR report 1988.

From 1975 till 1985 Institute Jožef Stefan measured radon concentrations in karst caves, health resorts, some mines and in the surface and underground waters. The radon concentration in tourists caves were found to be between 20 and 7000 Bq/m^3. Concentrations of radon in thermal and mineral waters of health resorts in general are not high, with few exceptions. Among the mines, two had high concentrations of radon (non occupational place) up to 76000 Bq/m^3. Radon concentrations in surface water were found to be between 95 and till 5370 Bq/m^3, and between 50 and 7500 Bq/m^3 for underground waters. Radium concentrations ranged from 0.5 to 7.1 Bq/m^3 at surface waters and 0.5 to 510 Bq/m^3 in underground waters. Radioactivity of surface waters is higher at areas of uranium ore, phosphate industry areas and areas rich with thermal and mineral waters.

Radon concentrations in Slovenian dwellings are typical for Central Europe, 40 - 60 Bq/m^3, and corresoond to Slovenian climatic conditions and Slovenian geological configuration. Radon concentrations in 730 kindergartens and 888 elementary and high schools are predominantly low; 69% of school buidings show radon below 100 Bq/m^3 and only 2% of schools show radon above 1000 Bq/m^3. Assessed effective equivalent doses for children in kindergartens and schools are low. Two kindergartens with highest radon concentration were re-mediated.

Potential impact of fly ash dumps on environment are relatively small and can be controlled. Re-mediation of gravel pits at water protected areas is questionable.

The Slovenian Health inspectorate Slovenia is competent for the Ionizing Radiation source's control and oversees around 100 industrial, health, research and educational organizations. The Sloveniana Health Inspectorate also has controls radioactive material transport in Slovenia and at the Slovenian international borders and caried out 7 inspections at the NPP Krško, one at TRIGA researc reactor and four at Uranium mine Žirovski vrh.

In 1994 there were 2600 workers who work with sources of ionizing radiation and no one exceeded the dose limit of 50 milisieverts. The biggest problem is at the lead and zinc mine Mežica where in spite of rotating of workers, because of high radon daughters content it is still possible to get more than 15 mSv annually.

The Slovenian Health Inspectorate in 1994 carried out 22 inspections of 240 diagnostic X-ray machines units (RTG). 14 units lost their licence, 23 have to improve and 61 new licences were obtained.

All eleven inspections of unsealed sources were performed in seven medical institutions. In all nuclear medical departments were found out some irregularities, and at the one hospital for time being the licence was abolished.

Sealed sources in medicin are used only at the Oncological institute. The safety of industrial radioactive sealed sources was found acceptable in all 12 inspected institutions.

Nuclear and radiological safety in the Republic of Slovenia in 1994 was assured.

ABBREVIATIONS

ANPA	Italian Regulatory Body
ARAO	Agency for Radwaste Management
ASCOT	Assessment of Safety Culture in Organizations Team (IAEA)
ASSET	Assessment of Safety Significant Events Team (IAEA)
BIT	Boron Injection Tank
COSYMA	"Code System for Maria", Methods for Assessing the Radiological Impact of Accidents
CRAC2	Calculations of Reactor Accident Consequences, Version 2
CSAU	Code Assessment, Applicability and Uncertainty Analysis (NRC)
CZ	Civil Defense
EC	European Community
ECT	Eddy Currents Testing
EIS	Ecological Information System
ELME	Ecological Mobile Unit Laboratory
ERDS	Emergency Response Data System
GIS	Geographical Information System
HLW	High Level Radioactive Waste
IAEA	International Atomic Energy Agency
ICISA	International Commission for Independent Safety Analysis
IJS	Institute Jožef Stefan
INES	International Nuclear Event Scale (IAEA)
INIS	International Nuclear Information System (IAEA)
INSARR	Integrated Safety Assessment of Research Reactors (IAEA)
IR93	Unplanned Outage 93
IRS	Incident Reporting System (IAEA)
ISI	In service Inspection
LAN	Local Area Network
LILW	Low and Intermediate Level Radioactive Waste
LOCA	Lost of Coolant Accident
MOP	Ministry of Environment and Physical Planning
NEA	Nuclear Energy Agency of the OECD
NPA	Nuclear Plant Analyzer
NPP	Nuclear Power Plant
NRPB	National Radiological Protection Board
NSRAO	Medium and Low Level Radioactive Waste
NUID	Plan of Measures for Emergency Event
OECD	Organization for Economic Co-operation and Development
OSART	Operational Safety Review Team (IAEA)
PHARE	European Community Programmes for Economic Assistance to Central and Eastern European States
PSAPACK	IAEA - Probabilistic Safety Assessment Computer Code
RAMG	Regulatory Assistance Management Group (of EU)
RAMS	Radiological Alarm Measuring System
RS	Republic of Slovenia
RASCAL	Radiological Assessment System for Consequence Analysis (NRC)
RŠČZ	Republic Civil-Defense Headquarters
RTG	X ray machine
SFRY	Socialist Federative Republic of Yugoslavia
SKJV	Nuclear Safety Expert Commission (of SNSA)
SNSA	Slovenian Nuclear Safety Administration
STCP	Source Term Code Package (NRC)
TLD	Thermoluminescent Dosimetry
US NRC	US Nuclear Regulatory Commission
WMS	Weather Monitoring System
ZVD	Occupational Health Institute of Republic of Slovenia

INTRODUCTION

SLOVENIA

Slovenia as a central European country is located along the foothills of the eastern end of the Alps, at the very tip of the most northerly Mediterranean bay, open towards Hungary.

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 with Austria to the North, Italy to the West and Croatia to the South.

Basic data on Slovenia:
Area: 20,251 km^2
Population (1992): 2,020,000
Number of households (1991): 641,000
Population density: 99 inhab./km^2
Political system: parliamentary democracy
Capital: Ljubljana,
Ethnic composition: Slovene 87.8%, Hungarian 0.43%, Italian 0.16%
Official language: Slovene, in mixed regions also Hungarian and Italian
Religion: mostly Roman Catholic, in some areas Protestant
Currency: Slovene tolar (1 SIT = 100 stotin)
Annual population growth (1991): 1.1 per thousand
Birthrate (1994): 9,9 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 (280,200), 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 (1994): 7,181 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 (1994): primary 821, secondary 145, faculties (IAEA)(IAEA) and colleges 30
Number of teachers per 1000 inhabitants (1991): primary school 113, secondary school 46, universities and colleges 17
Number of books published (1992): 11 per 10,000 inhabitants

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. According to the new Slovenian Constitution, Slovenia is a democratic republic and social state governed by law.

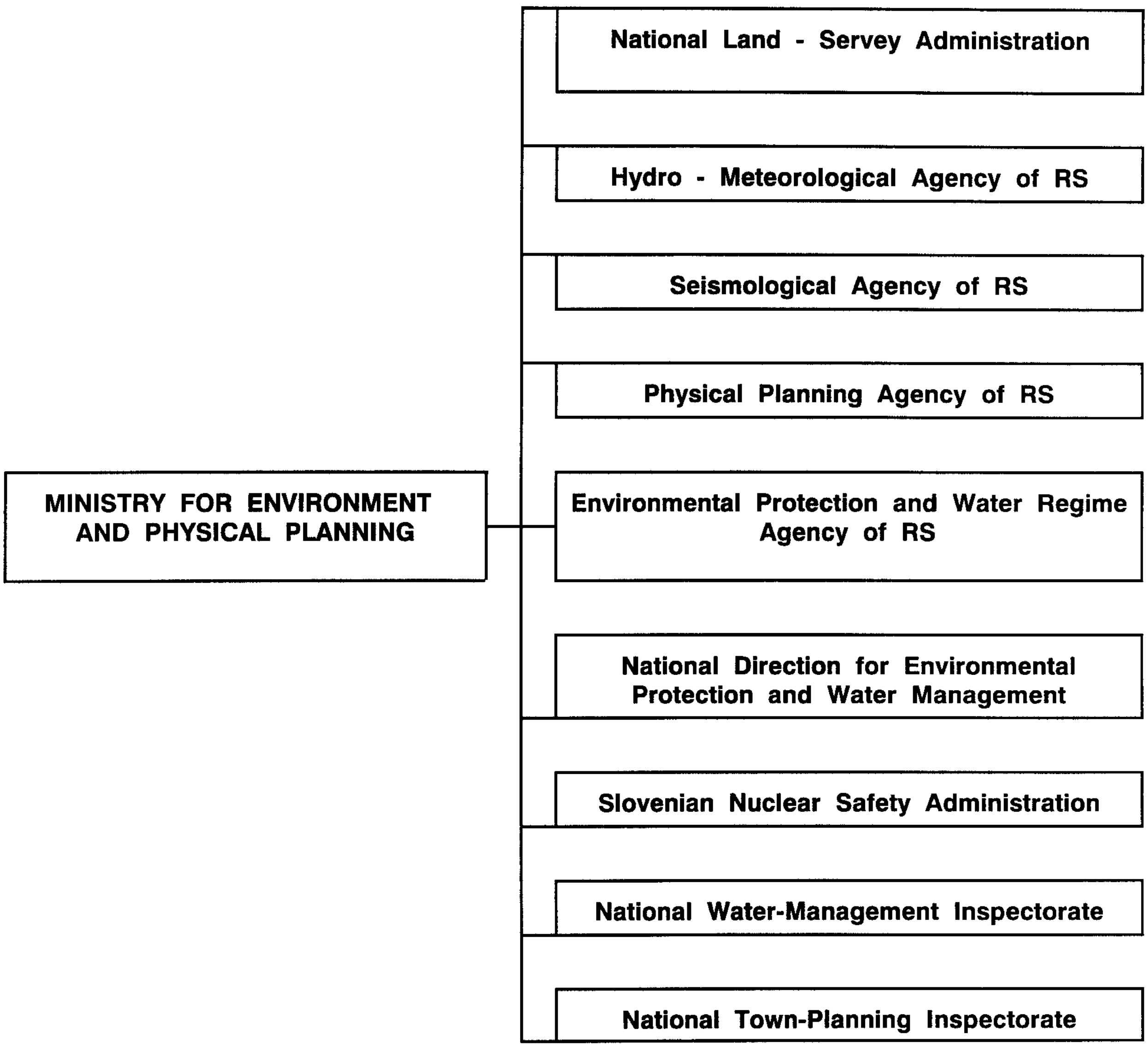
In accordance with the new Slovenian Constitution, the highest legislative authority is the parliament. It is a single-chamber parliament with 90 deputies elected for a four-year term of office. The National Council with 40 deputies performs an advisory role. It is composed of representatives of social,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

The President of the Republic represents Slovenia and is at the same time the supreme commander of the defense forces. The president calls elections to the Parliament, proclaims laws adopted by the Parliament, proposes a candidate for the prime minister to the Parliament 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 Parliament.

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
  Mining Inspectorate
- Ministry of Agriculture and Forestry
- Ministry of Culture
- Ministry of Internal Affairs
- Ministry of Defense
  Fire Protection Inspectorate
  Administration for Civil Protection and Rescue
- 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
  Slovenian Health Inspectorate
- Ministry of Science and Technology
- Ministry of Foreign Affairs


MINISTRY FOR ENVIRONMENT AND PHYSICAL PLANNING
National Land - Servey Administration
Hydro - Meteorological Agency of RS
Seismological Agency of RS
Physical Planning Agency of RS
Environmental Protection and Water Regime Agency of RS
National Direction for Environmental Protection and Water Management
Slovenian Nuclear Safety Administration
National Water-Management Inspectorate
National Town-Planning Inspectorate

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 that 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 in the Republic of Slovenia until adequate laws are passed by the Slovenian Parliament.

Among other acts and laws that were adopted in the Slovenian legal system the most important one related to nuclear safety is the ex-Yugoslav Act on Protection Against Ionizing 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 utilization of radioactive materials,
- qualification of persons who work with ionizing radiation sources,
- the dose limits for the members of the public and for occupational exposure,
- application of sources of ionizing radiation for medicine,
- limits of activity for trade of a foodstuff,
- limits of activity for radioactive contamination and decontamination,
- records and accounting of sources, doses to population and workers.

Other regulations define,

- conditions for siting, construction, commissioning, testing and operation of nuclear facilities,
- format and scope of safety reports,
- qualifications and tests required for operators,
- nuclear material accounting.

There are several other acts from the nuclear and radiological safety field that are used in our legal system:

- Act on Implementing Protection from Ionizing Radiation and Measures for the Safety of Nuclear Facilities and Equipment (Official Gazette SRS, 28/80),
- Act on Liability for Nuclear Damage (Official Gazette SFRY, 22/78 and 34/79),
- Act on Insurance of Liability for Nuclear Damage (Official Gazette SRS, 27/80),
- Act on Funds for Decommissioning of NPP Krško (Official Gazette RS, 75/94),
- Act on Transportation of Dangerous Goods (Official Gazette SFRY 27/90).

Some "nuclear" provisions can be find also in other acts, for example Act on Defense and Protection (Official Gazette RS 15/91) and Act on Protection Against Natural and Other Disasters (Official Gazette RS 46/94).

INTERNATIONAL TREATIES

The Republic of Slovenia in the field of nuclear and radiological safety accepted succession of the following multilateral 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.

Furthermore the Republic of Slovenia accepted succession of bilateral agreements with many countries in the world.

SLOVENIAN NUCLEAR SAFETY ADMINISTRATION

With the new Act on Organization and Field of Activity of the Administration, the Slovenian Nuclear Safety Administration (SNSA) performs administrative and technical duties, in the field of: nuclear and radiological safety of nuclear facilities; trade, transport and handling of nuclear and radioactive materials; safeguards; liability for nuclear damage; qualification and training of operators of nuclear facilities; assuring radiological monitoring; early notification of a nuclear and radiological accident; international cooperation on the SNSA activity field; inspection of nuclear facilities and control the fulfilment of laws that cover nuclear safety.

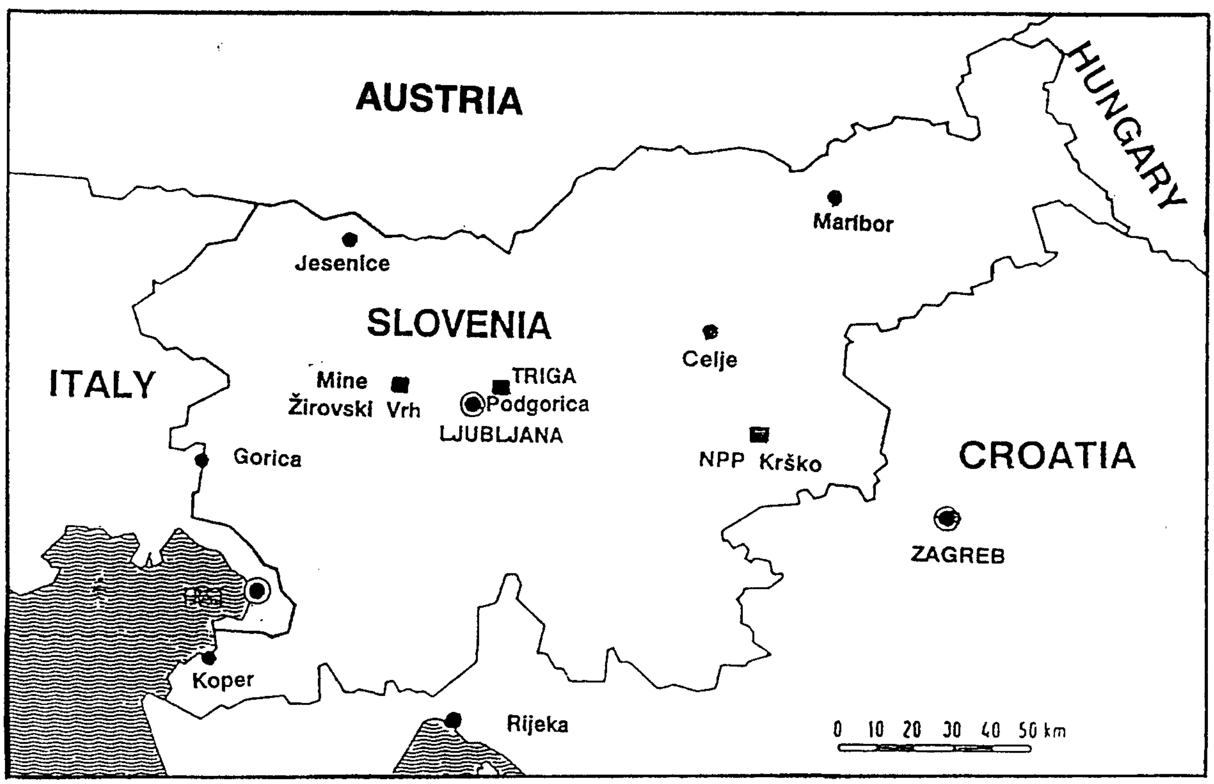
The Slovenian Nuclear Safety Administration is a part of the Ministry for Environment and Physical Planning. In accordance with the recommendations of the International Atomic Energy Agency, the SNSA is not supposed to promote nuclear power, therefore it is independent from the Ministry of Economic Affairs which is responsible for energy sector.

The major nuclear facility inspected by the SNSA is the Nuclear Power Plant in Krško with a pressurized 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, which is in phase of decommissioning, is supervised by the SNSA.

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

- Act on Organization and Field of Activity of the Administration
- Act on Government of the Republic of Slovenia
- Act on Administration
- Act on Administrative Procedures
- Act on Protection Against Ionizing Radiation and Special Safety Measures in the Use of Nuclear Energy,
- Act on Implementing Protection from Ionizing Radiation and Measures for the Safety of Nuclear Facilities and Equipment
- Constitutional law on the Enforcement of the Basic Constitutional Charter on the Autonomy and Independence of the Republic Slovenia
- Regulations for carrying into effect the nuclear safety provisions
- Ratified international treaties that regulate nuclear safety

ACTIVITY OF THE SLOVENIAN NUCLEAR SAFETY ADMINISTRATION



■ Nuclear Facilities in Slovenia

ACTIVITY OF THE SLOVENIAN NUCLEAR SAFETY ADMINISTRATION

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

- legal issues and international cooperation
- nuclear safety
- radiological safety in the nuclear facilities
- nuclear materials
- inspection

In view of the markedly interdisciplinary nature of the SNSA fields of activity, cooperation with other administrative bodies in 1994 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 Defense and the Ministry of Science and Technology. This cooperation is manifested in the issuing of administrative decisions, inspection and supervision, the preparation of answers to members of the Parliament questions and initiatives, the preparation of materials for sessions of the Government and its working bodies, and in the work of interdisciplinary expert commissions.

Legislation

At the legislative level, the SNSA has been 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 proposals for the revision of the Vienna Convention on Civil Liability for Nuclear Damage and proposals for Supplementary Funding for compensation of nuclear damage. The results of the above mentioned activities together with new International Basic Safety Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources will doubtless also influence the Slovenian legislation, which is under preparation.

Convention on Nuclear Safety was signed by republic of Slovenia in September 1994.

Inspection of nuclear facilities

The SNSA division for inspection of nuclear facilities supervises, in accordance with its competence, the operation 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 startup tests, testing, 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, outages and safety related 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 in 1996 (head of the division for inspection of nuclear facilities and three inspectors).

THE KRŠKO NUCLEAR POWER PLANT

There were 63 routine inspections and four non-routine inspections in the Krško nuclear power plant in 1994, plus eleven special inspections of the "Quality System Department" of the Krško NPP. There were also two joint inspections with the inspectors of Ministry of Interior and of the Power and Energy Inspectorate. The regular inspections of Krško in 1993, which took place on average once a week, covered:

- the status of internal audits in the Krško NPP required by the Quality Assurance Programme
- the plan, procedures and the protective actions in case of a radiological emergency
- the modification of the essential service water system
- the installation and testing of the safety parameter display system
- the operability of the post accident radiological monitoring system
- the planned modifications in 1994
- the fire protection programme
- emergency shutdown panels and the related procedures
- chemical parameters of the secondary systems
- the nuclear fuel leakage
- the physical protection
- the control of radioactive releases and the implementation of the radiological monitoring programme
- the training programme for the Krško NPP personnel in case of an emergency
- the training and examination of the licensed personnel
- the observation and assessment of the internal general exercise for all the emergency personnel
- maintenance procedures
- the results of the Probabilistic Safety Assessment Study
- the containment atmosphere sampling system and the steam generator blowdown
- storage and accounting of the low and intermediate level radioactive waste
- preparation for the supercompaction of the low and medium radioactive waste
- the operating experience feedback system
- the program of meteorological monitoring in the vicinity of the Krško NPP
- the status of the programme of In service testing (ISI)
- surveillance testing of the safety related equipment
- the surveillance testing of the chemical parameters
- the testing of the emergency communication equipment
- the evaluation of the auxiliary feed water system

Eleven special inspections of the "Quality System Department" of the Krško NPP were performed in the period from February 15 to December 8, 1994. These inspections covered:

- the status of the "Quality Assurance Plan",
- internal and external audits,
- non-conformance reports,
- organization and implementation of the Quality Control,
- training of the Quality Assurance and Quality Control Personnel,
- special issues (surveillance testing, fire protection, In service inspection, nuclear fuel).

The non-routine inspections were related to:

- manual shutdown of the reactor due to the leakage of the venting line of the pressurizer instrumentation,
- the automatic reactor scram due to inadvertent triggering of the turbine-generator protection during the measurement of the current in the protection circuit.

THE REFUELING OUTAGE 93/94 OF THE KRŠKO NUCLEAR POWER PLANT

The refueling outage took place from December 18, 1993, to January 12, 1994. The refueling only was finished and the reactor vessel head was closed on December 31, 1993. The "refueling outage 93/94" and the "forced outage 93" shall be considered as one normal outage, therefore the work performed during these two outages can be compared with the outage in the 1992. The refueling and the planned outage activities were performed as scheduled except for four modifications that were postponed to the next outage with the previous consent of the SNSA. These modifications were: installation of the chlorine monitors, installation of the post accident sampling system, modification of the essential service water system and the upgrade of the seismic system.

STEAM GENERATOR INSPECTION

After the forced outage due to the steam generator leakage and the 100 % inspection of the U-tubes, plugging and sleeving of the steam generators in 1993, the steam generator inspection was scheduled and performed from August 20 to September 30, 1994. The nuclear safety inspectors mainly supervised the steam generator inspection and the installation of the modifications rescheduled from the previous outage (refueling 93/94).

THE TRIGA RESEARCH REACTOR

Two inspections of the TRIGA Mark II research reactor were carried out in 1994.

The inspections covered the physical protection, dose measurement during the reactor pulse, procedures for experimental work with the reactor, modification of the reactor hall crane, personal dosimetry and the walkdown of the interim storage of low and intermediate radioactive waste.

THE ŽIROVSKI VRH MINE

The first regular inspection of the Žirovski Vrh mine was made together with the Slovenian Health Inspectorate on July 6, 1994. The inspection examined the instrumentation and the measurement of the radioactivity and contamination, the Jazbec mine pit waste disposal site, the Boršt hydro metallurgical waste disposal site and the measurements of sliding of the Boršt waste disposal site.

COOPERATION WITH OTHER INSPECTORATES

Division for inspection of nuclear installations organized the joint inspections with:

- the Power and Energy Inspectorate to inspect electrical equipment and wiring in the Krško NPP,
- the Ministry of Interior to verify the status of physical protection and the implementation of the actions requested by the Ministry of Interior,
- the Slovenian Health Inspectorate at the inspection of the research reactor TRIGA Mark II, the interim storage of the low and intermediate level radioactive waste at the research reactor site, and the Žirovski Vrh uranium mine.

Inspection's conclusion

By 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 jeopardized.

The operation of the TRIGA Mark II research reactor at the Jožef Stefan Institute Podgorica Reactor Center in 1994 complied with the operating conditions and limits.

The radioactive waste in the storage facility for low and medium radioactive waste at the Krško nuclear power plant and interim storage facility at the Reactor Center Podgorica is stored in accordance with the law, and the records are kept correctly and consistently.

The radiological monitoring programme in the Žirovski Vrh mine is running continuously and was modified to reflect the current status of the mine (the production is stopped). The program of the decommissioning of the uranium mine was approved, but it is not detailed enough to include the methods of decommissioning of the hydro metallurgical waste disposal site or the mine pit.

Safeguards

IAEA performed the control of nuclear material in Slovenia according to the Agreement Between the Socialistic Federal Republic of Yugoslavia and the IAEA for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons. New agreement between Slovenia and IAEA was accepted by Board of Governors and will be probably signed in 1995.

In 1994 the IAEA safeguards inspectors performed 5 inspections of nuclear materials into the NPP Krško and 1 inspections into the research reactor TRIGA Mark II.
Summary statement of conclusions for materials balance of NPP Krško and TRIGA Mark II:

- The Reports to the Agency satisfy the Agency's requirements with regard to their timeliness within the time period specified in the Agreement,
- Records are kept in accordance with the Facility Attachment,
- The nuclear material accountancy measures could be adequately complemented by containment and surveillance measures
- The inventory changes and the physical inventory as stated by the operator are accepted by the Agency.

During routine inspections of IAEA safeguards inspectors no defects were found.

The Issued Administrative Decisions

In discharging its administrative duties, the SNSA in 1994 issued to the Krško nuclear power plant 16 decisions relating to:

- professional training
- control room operator protection against chlorine accidental discharge
- updating the seismic monitoring system
- measures following the accident in the Three Mile Island NPP
- meteorological measurements in the vicinity of the NPP Krško
- radiological monitoring of the Krško nuclear power plant
- modification of essential service water
- change of the technical specifications

Authorization for the work on the field of nuclear safety was given to the Institute of Metals and Technologies.

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 1994. The Commission has 22 members. Ten members are selected 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 1994 also dealt with:

- the report on the safety of operation of nuclear facilities in 1993
- report on programme realization of ionizing radiation protection and nuclear safety in 1993.
- the report on the 1993/94 outage and refueling
- the report on the 1994 outage
- the report on the results of OSART, ICISA and EU missions
- analyses of emergency exercise Posavje 93
- financial transformation of NPP Krško
- the report on the temporary radwaste storage at Zavratec
- the report on the 38th IAEA General conference
- the report on the IAEA and PHARE projects

In 1994, the Expert Commission for Operators Exams organized two exams. Eight candidates for senior operator took the test to renew their licences, four senior reactor operator candidates took the test for the first time, seven candidates for reactor operator took the test to renew the licence. All candidates passed the test successfully and, on the proposal of the Commission, the SNSA granted or extended their licences.

Expertise and research

SNSA has ordered and financed following studies from the seismo-tectonic characteristics of the NPP Krško site:

- Neotectonic Research in the Vicinity of the Krško NPP (Ljubljana, 1994)

The report presents the results of the first phase of the research. The purpose of the research is to establish the existence of possible active tectonic faults in the vicinity of the nuclear power plant.
Geophysical research encompassed seismic and geoelectric profiling. The overall length of seismic profiles was about 5 km and that of geoelectric was about 3 km. Seismic profiles showed good contrasts in neogenic sedimentary formations that can be a sign of possible faulting into the quaternary layers. Quaternary layers of younger Pleistocene and Holocene in the vicinity of the NPP Krško (1-2 km) have no signs of tectonic destruction.
Geo-electric sonding has also revealed good contrasts with the same tectonic features in the neogenic - quaternary formation.

Geological data from different sources have been evaluated again. In the Krško basin field work has been performed, reexamination and charting of quaternary sediments in particular. The samples collected in the field have been studied in the laboratory. The results of the research revealed slight tectonic or non-tectonic bending of older Pleistocene formations. Study will be continued in 1995.

- Observations of tectonic movements in the surroundings of Krško NPP with geodetical measurements (Ljubljana, August 1994)
The report of the research concluded from the results of measurements that there are smaller tectonic movements in the Krško basin. It is necessary to continue with occasional measurements and with detailed measurements after any stronger earthquake. The results could be used by geologists for better understanding of neotectonics, for public hearing and in communication with neighbouring countries.

- Preparation of procedure for analysis the response of building and structures of NPP Krško at registered earthquakes (Ljubljana, May 1994)
The work presents the first phase of the project with the aim to produce the computer program that will have on-line connection with seismic measuring stations of NPP Krško. The system will allows to reveal the dynamic response of structures and equipment in the NPP and to determine the critical points, where the damage is most likely. The software will enable direct calculation of floor response spectra of buildings and equipment. In the first phase the software has been developed for the seperate phases of analyse, limited to reactor building only.

- Determination of floor response spectra for the NPP Krško (Maribor, 1993)
The authors have calculated the eigen frequencies, eigen vibration modes, displacement in time, speed, acceleration and acceleration spectra on different floors of NPP Krško. It has been concluded from the results of measurements that equipment that had been designed on the basis of floor spectra, is seismically safe.

In accordance with annual programme of protection against ionizing radiation and nuclear safety SNSA ordered, financed and accepted the following studies from the Research Institute "Jožef Stefan" :

- Maintenance, development, expertise and checking of computer programs for probabilistic safety analysis. For MELCOR, input model has been improved and some transitients have been calculated.

- Examination of the station black out accident with the software STCP. All three phases of the accident scenario have been studied.

- Application of CSAU method (probabilistic safety risk assessment) by means of computer program RELAP5/MOD3.1 in case of LOCA accident.

- Application of possible use of computer program RASCAL2A for the calculation of the consequences of the severe radiological accident.

- Calculation of severe nuclear accidents consequences at level 3 of probabilistic safety analysis with computer codes CRAC2 and PC COSYMA.

- Partial safety analysis of criticality of spent fuel pool in Krško NPP with PC version of computer package MCNP4A for neutronic/gama calculations with Monte Carlo method.

- Development of Passive neutronic dosimeter for thermic neutron measurements.

- Measurements of C-14 in different locations of NPP Krško.

Training

During 1994 SNSA devoted a lot of attention to further education of staff members. The emphasis was on state administrative exams, foreign languages, computer efficiency, and in nuclear and radiological safety in perticular. Two of the staff members completed the course " Basic Technology of NPP" and one "Basic Theory of Power Reactors" organized and carried out by Educational Center for Nuclear Technologies at "Jožef Stefan" Institute. Very intesive training was carried out abroad, since this is the only way to keep competentcy in the field.

Employment

Until the end of 1994 SNSA increased staff members to 20 employees. In spite of good trend it is a fact that international guidelines (IAEA NUSS program) suggest 80 up to 100 members and mission of the European Union - RAMG after careful study of Slovenian situation suggested at least 40 employees. The biggest problem beside the administrative ban on new employment is reeducation of new staff members which takes a long time and is costly.

International Cooperation

Cooperation with the International Atomic Energy Agency

Slovenia was admitted too full membership of the IAEA in 1992. Cooperation with the IAEA covers an extremely wide range of activities.

Seminars, Courses and Workshops Organized by the IAEA

Last year SNSA staff successfully participated in various seminars, courses and workshops organized by the Agency itself or in association with other organizations.

Also other Slovenian experts from organizations such as the Jožef Stefan Institute, the Krško nuclear power plant, the University Medical Center, Slovenian Health Inspectorate, IBE Elektroprojekt, the "Milan Vidmar" Electroinstitute, the Faculty of Natural Sciences and Technology, the Velenje lignite mine etc. participated in IAEA-organized seminars, courses and technical committees.

Scholarships and scientific visits

Another area of SNSA-IAEA collaboration in the frame of technical assistance and cooperation covers scholarships and scientific visits. In 1994 Slovenian Institutes were asked to accept 11 foreign experts as fellowship or scientific visitors in the following fields:

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

Technical assistance

For the 95/96 research period the SNSA sent to the Agency 6 applications from which four were accepted and additional three were prolonged from previous years. The most of the projects were prepared by the Jožef Stefan Institute, University Medical Center, Faculty of Architecture and Civil Engineering and SNSA.

Cooperation with other international organizations and administrative agencies

The Slovenian Nuclear Safety Administration also cooperates with international organizations and agencies other than the IAEA, in particular with the EU Commission. SNSA applied for projects within the regional programmes of the PHARE Nuclear Safety group. The PHARE-RAMG (Regulatory Assistance Management Group) programme (intended primarily for the former Soviet Union and eastern and central European countries) in general 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 organization of the body competent for nuclear safety. In 1994 SNSA staff members participated in more than 20 seminars, workshops and visits to the competent nuclear safety bodies in European Union.

Conclusion of New Agreements

Bilateral Agreements under preparation:

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

- Agreement on the Early Exchange of Information in the Event of radiological-Emergency between the Republic of Slovenia and Neighbouring Countries (Hungary, Italy, Croatia)

- The Agreement between SNSA and Slovak Nuclear Regulatory Authority on Exchange of Information

- The Agreement between the SNSA and Czech Nuclear Regulatory Authority on on Exchange of Information

- The Agreement between the Government of Slovenia and the Government of Canada on Cooperation in the Field of Peaceful Use of Nuclear Energy.

- The Agreement between Slovenia and IAEA for the Application of Safeguards in Connection with the Treaty on the Non-Proliferation of Nuclear Weapons.

Multilateral agreements

Preparations are in progress within the IAEA for the adoption of several important conventions in the field of nuclear and radiological safety. The experts from Slovenia actively participated at the working bodies. Here are some of them:

- Convention on Nuclear Safety, which was signed by Slovenian delegation on General conference in September. By the end of 1994 the ratification of it was in progress.
- Revision of the Vienna Convention on Civil Liability for Nuclear Damage
- Joint Protocol for use of Vienna and Paris Convention on Civil Liability for Nuclear Damage. Slovenian Parliament had ratified Joint Protocol in December 1994.

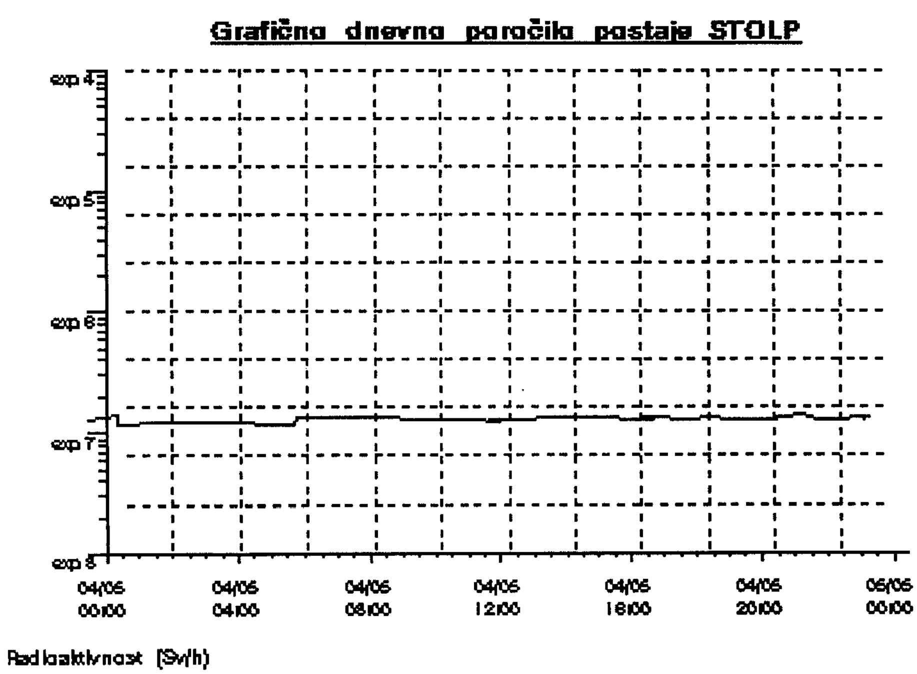
INFORMATION SYSTEMS

Computer information systems help SNSA at evaluation and decision making during accident situations. During the NPP operation the systems helps train personnel. The following systems are running or are being developed:

Information system EIS

Ecological Information System (**EIS**) is designed to monitor the environmental impact of the nuclear power plant and to provide the adequate statistical and emergency data on the radiological pollution. System consists of a number of automated stations measuring meteorological conditions and gamma dose rate. Central unit is a PC connected to the SNSA local area network, which is connected to two units, IJS and NPP Krško computer, on which indoor monitors at several points inside the power plant, as well as in the surrounding areas in the towns of Brežice, Cerklje and Krško are connected. In the 1995 the system will be connected to other facilities, as well.

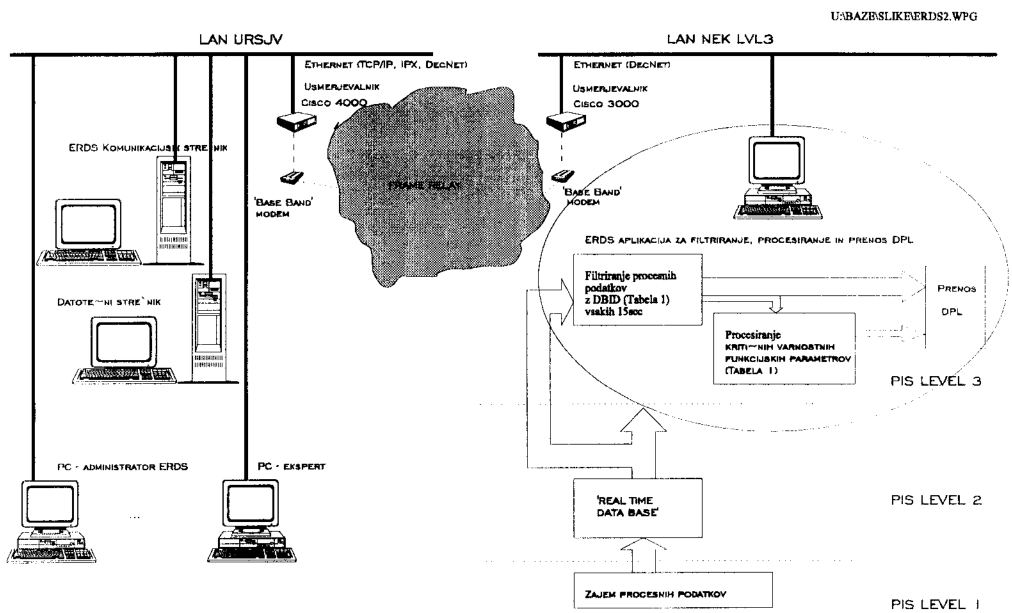
Figure 1: An Example od daily radioactivity report on measuring point NPP-Stolp



Information system **ERDS**

SNSA is developing the information system **ERDS** (**E**mergency **R**esponse **D**ata **S**ystem) for accurate and punctual transfer of NPP Krško safety operation data to the SNSA in the case of emergency. ERDS would automatically alarm the SNSA staff. System is at testing stage, and will probably in 1995 connect NPP and SNSA local networks.

Figure 2: Configuration of planed ERDS system



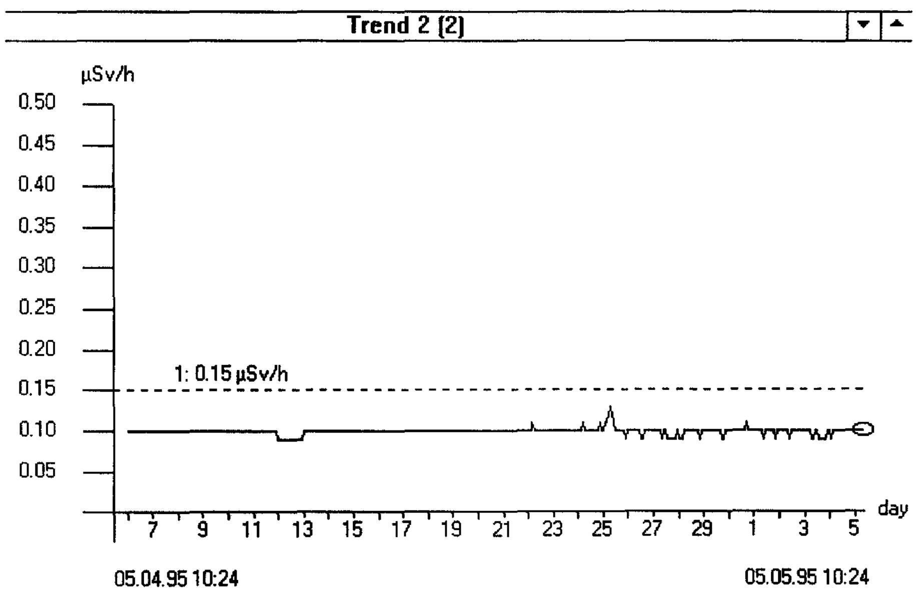
Geographical **I**nformation **S**ystem - **GIS**

SNSA is together with Administration for Civil Protection and Disaster Relief, developing a GIS-NPP Krško system to assist planning the action during nuclear accidents. Data bases cover topography, telephone, road, railway, and water work system network. Additionally position of spacious elements is in graphical part and properties in attribute files. Optimization of evacuations routes is planned in 1995.

Radiological Alarm Measuring System (RAMS)

Radiological Alarm Measuring System (RAMS) is designed for after accident stage, with purpose of alarming and measuring in conditions of increased radioactivity. Two Alnor gama dose rate units are connected to RAMS and in 1995 radioactive measuring points at nuclear facilities will be connected too. System allows data viewing on "client" PC units at SNSA.

Figure 3: An Example of RAMS system monthly graphical readout



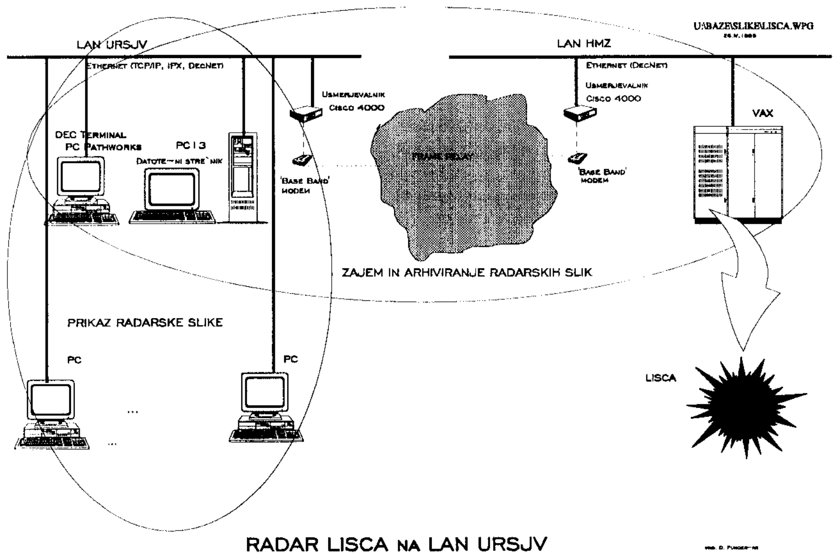
PC COSYMA

Program COSYMA "Methods for Assessing the Radiological Impact of Accidents") is for probabilistic analyses of severe nuclear accident consequences. Results obtained with incorporating local data give good results for planning and for managing protection, evacuation, iodide profilaxis, decontamination and food banning.

Weather Monitoring System - WMS

Information system for weather monitoring - **WMS**, makes it possible to view weather radar pictures. Direct weather data capturing takes place at Hydro meteorological institute from its radar center at Lisca. SNSA PC communication computer indirectly collect the radar picture trough the government fast communication bone as it is shown on the picture. The data are saved on a server and are available for SNSA 'client' PC users. In 1995 the satellite pictures should be included in the system.

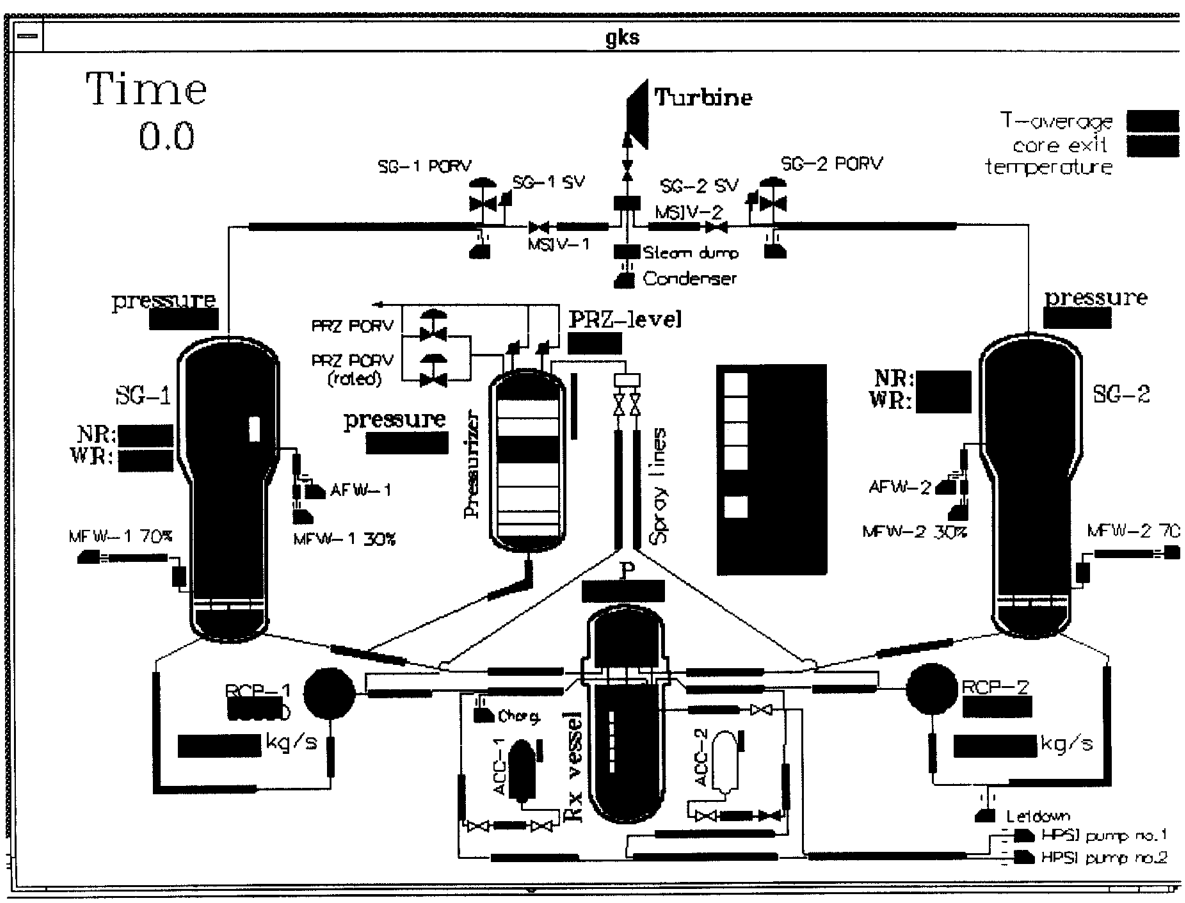
Figure 4: **W**eather **M**onitoring **Information S**ystem



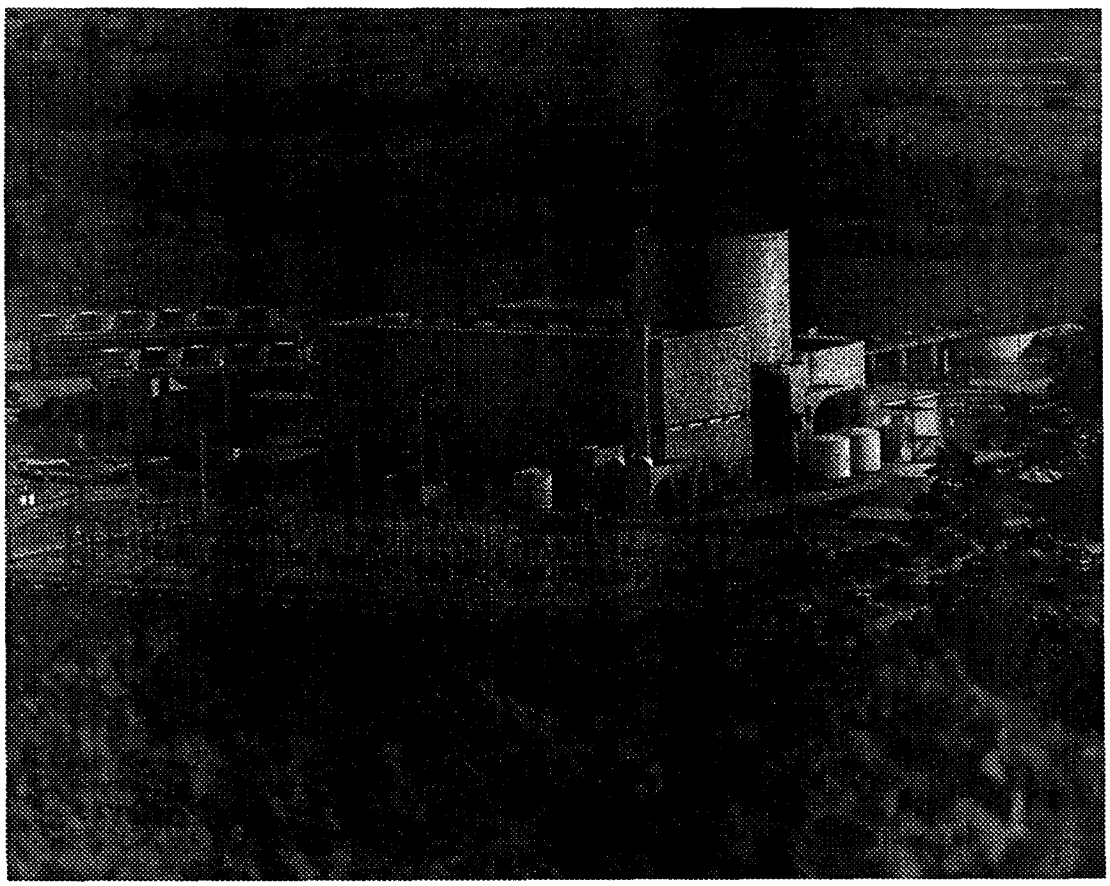
Nuclear Power Plant Krško Analyzer - **NPA**

Nuclear Power Plant Krško Analyzer - **NPA** (**N**uclear **P**lant **A**nalyzer) for training and support for emergency action. It simulates simplified accident situations with different speed simulation. It is possible to give orders simulating the operator interactions and to give false working conditions simulating the failing of system or components. It also can help in emergency planing during the exercises. At the moment, the demo version is finished.

Figure 5. Demo version of NPP Krško Analyzer



OPERATION OF NUCLEAR FACILITIES



NPP KRŠKO

KRŠKO NUCLEAR POWER PLANT

Main Operational Data

In 1994 the Krško NPP generated 4,609,150 MWh of electrical energy at the output the generator, or. 4,403,528 MWh net.

The generator was connected to the electrical grid 7401.2 hours or 84,49 % of the total number of hours in the year. The electrical production was 9,05 % higher than planned. Table 1 shows the energy output compared to the planned one.

Table 1: NPP Krško net electrical energy generation in 1994

Month	Planned Output (GWh)	Actual Output (GWh)	Difference (%)**
JAN	238	238.7	0.3
FEB	350	415.8	18.8
MAR	400	418.6	4.6
APR	400	445.3	11.3
MAY	400	450.2	12.5
JUN	400	440.4	10.1
JUL	350	407.0	16.3
AUG	250	258.5	3.4
SEP	50	1.7	- 96.5
OCT	400	427.3	6.8
NOV	400	441.1	10.2
DEC	400	458.5	14.6
Total	4038	4403.5	9

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

In 1994 the generation of thermal energy amounted to 13,422,033 MWh. The whole production of the electrical energy in Slovenia was 11,902 GWh, the share of the nuclear energy production being 36,9 %. Slovenia used 9,955 GWh of produced electrical energy and nuclear share was 22% as half of of production NPP Krško was transmitted to Croatia.

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 synchronized 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 1994.

Table 2: Reliability indicators of operation of the NPP Krško in 1994

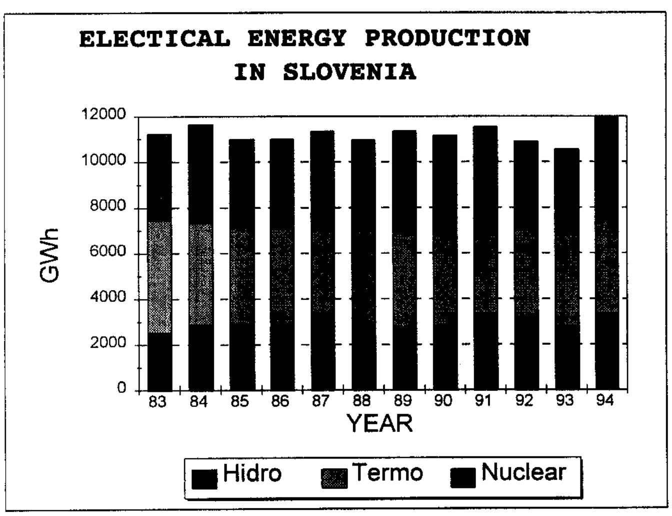
	Year 1994 (%)	Average (%) 1983 - 1994
Availability factor	84.49	80.48
Load factor	81.08	75.64
Forced outage factor	0.9	1.77

Table 3: NPP Krško time consumption in 1994 relevant to output

Time analysis of output	Hours	Percentage (%)
total available time	8,760	100
plant operating time	7,401.2	84.49
total outage time	1,358.8	15.51
maintenance	1,280.1	14.61
planned shutdowns	0	0
unplanned shutdowns'	78.7	0.90

Figure 6. shows the total electrical energy production in Slovenia for the past 12 years. Figure 7. shows the NPP Krško operating diagram for 1994. Figures 8 to 13 show the main operational data for the whole period of the NPP Krško operation (1983 - 1994). The Load factor (Figure 8) is frequently used for estimation of the efficiency of the NPP operation. The important factor is also the plant availability (Figure 9), because some plants intentionally decrease the power due to changes in electrical energy consumption which causes that the load factor is decreased. Figure 10 shows the electrical energy production along the whole period of the NPP Krško operation. Figures 11 - 13 show the number of plant shutdowns, forced outage factors and the number of incident reports per year and through the commercial operation of the plant. The availability of the NPP Krško in 1994 was 84,49 %.

Figure 6: Electrical energy production in Slovenia



NE KRSKO OPERATING DIAGRAM FOR 1994

Proizvedena energija na generatorju: 4.609.150 MWh

Proizvedena energija na pragu: 4.403.528 MWh

Gross produced energy: 4.609.150 MWh

Net produced energy: 4.403.528 MWh

Razpolozljivost (Availability Factor): 84.49%

Izkoristek (Capacitiy Factor): 81.08%

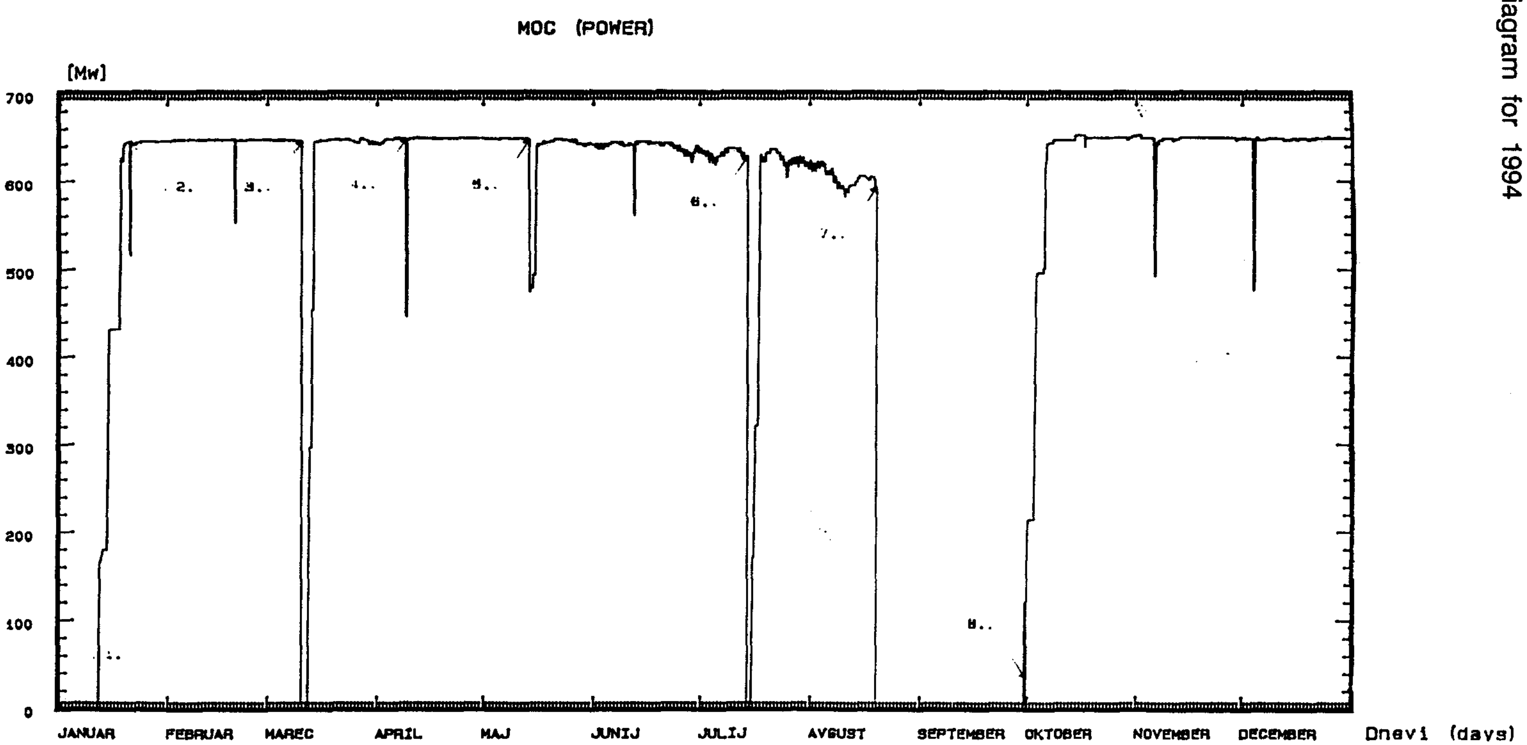


Figure 7: NPP Krško operating diagram for 1994

Figure 8: NPP Krško load factor

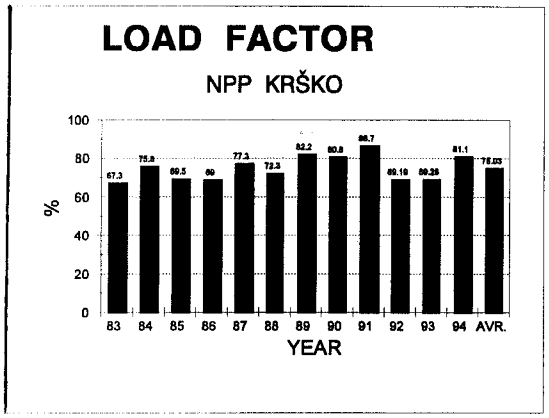


Figure 9: NPP Krško availability factor

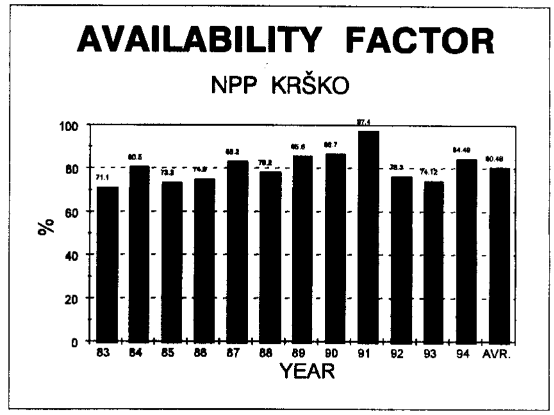


Figure 10: NPP Krško net electrical energy production per year

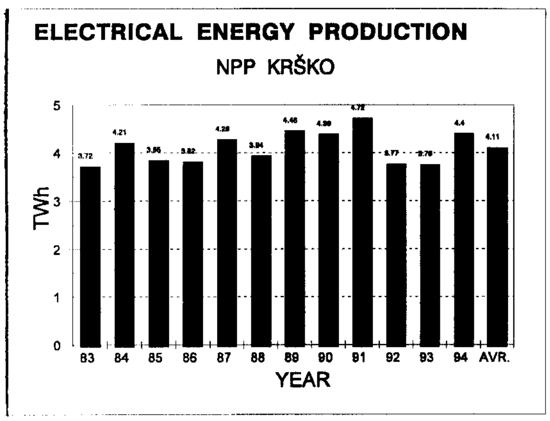


Figure 11: NPP Krško reactor shutdowns

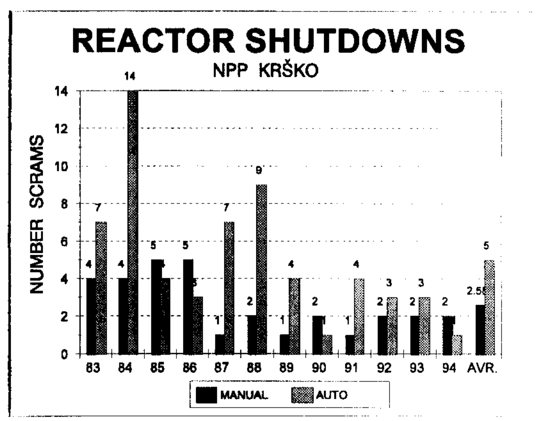


Figure 12: NPP Krško forced outage factor

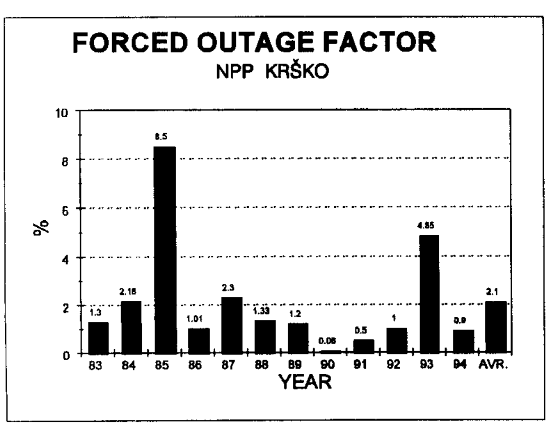
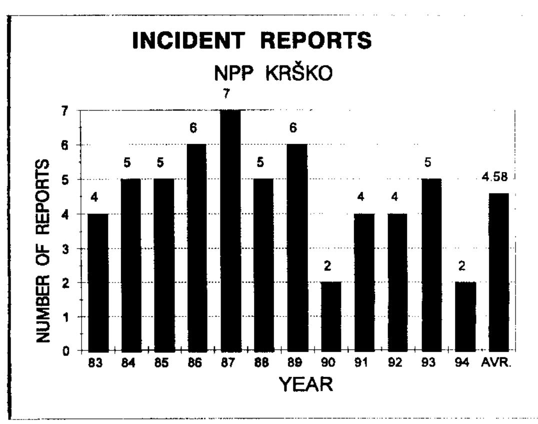


Figure 13: NPP Krško incident reports



Shutdowns and load reduction

Table 4. shows the date and duration of events for which NPP Krško was shutdown or during which the power was reduced for more than 10% and more than 4 hours. Short description of the events is given below:

Tab. 4: Shutdowns and reduction of power in 1994

Date	Hours of duration	Outages type	Short description
1.1.*	280.3	Planned Manual	**Planned Outage**, continuing from 1993.
21.1.	1	Planned Manual	Operating at **reduced power** (80%) due to maintenance works on the high pressure turbine.
20.2.	4	Planned Manual	Operating at **reduced power** (90%) due to testing of the turbine valves.
10.3.	45.1	Unplanned Manual	**Shutdown** because of leakage on pressurizer instrumentation line
9.4.	15	Planned Manual	Operating at **reduced power** (70%) due to maintenance works on the condenser and testing of the turbine valves.
13.5	34	Planned Manual	Operating at **reduced power** (75%) due to maintenance works on the condenser and testing of the turbine valves.
12.6.	8	Planned Manual	Operating at **reduced power** (90%) due totesting of the turbine valves.
14.7.	33.6	Unplanned Automatic	**Shutdown** because of activation of generator protection.
19.8.	999.8	Planned Manual	**Outage 94,** Steam generator inspection and maintenance work
6.11.	15	Planned Manual	Operating at **reduced power** (77%) due to testing of the turbine valves.
4.12.	20	Planned Manual	Operating at **reduced power** (77%) due to testing of the turbine valves.

* Shutdown and outage started on Dec. 18. 1993

Integrity of Reactor Fuel in 1994

In the process of electricity generation, fuel integrity depends on reactor operation history. This year the 11th fuel cycle was going on. It started on January 12. 1994 and will last approximately till April 1995. The core consists of 121 fuel assemblies. Each fuel assembly contains 16 x 16 rod arrays composed of 235 fuel rods Vantage 5 type with enrichment 4.3 % of U 235. The fuel is 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 11th cycle, including a comparison with other cycles are shown in Table 5. From iodine specific activity in 1994 we can conclude that in the reactor there are some open type damages. Control results during 1994 shows a continued decreasing of fuel integrity.

The majority of the leaking fuel assemblies will be removed from the core with refueling in 1995.

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	cycle 11	
					stable conditions	all measures
I - 131	0.08	0.03	0.101	0.111	0.201	1.495
I - 133	0.55	0.34	0.254	1.095	0.647	1.491
I - 134	2.22	1.22	0.681	0.618	1.557	1.543
Xe - 133	23.3	7.40	16.835	6.105	9.213	13.32
Xe - 135	2.96	0.89	5.809	3.200	5.957	5.402
Xe - 138	0.93	0.52	0.906	0.414	2.364	2.312
Kr - 85	1.11	0.26	1.539	0.733	1.05	1.061
Kr - 87	0.48	0.19	0.928	0.474	1.165	1.121
Kr - 88	1.11	0.32	2.361	1.125	2.234	2.356

Spent Nuclear Fuel

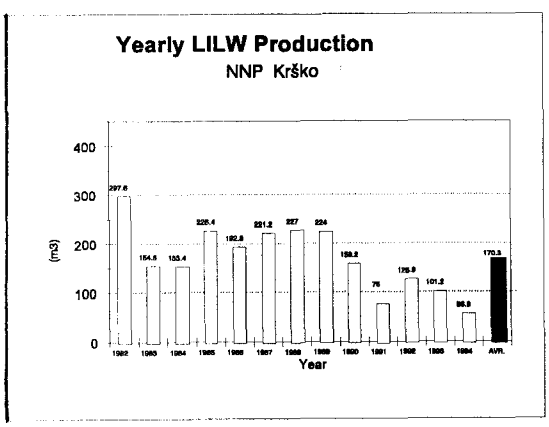
Spent fuel elements are stored at the power plant in the spent fuel pool which has enough space for 17 refuelings and for the entire reactor core (121 fuel assembles) as a permanent available reserve if, for any reason, it was necessary to empty the reactor core. The capacity of the spent fuel pool is 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 till the 2004. In 1994, no additional fuel elements were stored, which means that in total, there were 406 spent fuel assembles in the pool by December 31, 1994.

Radioactive Waste

All radioactive waste is packed in the power plant in 200 litter drums: low radioactive compressible waste without additional protection, other more active waste with additional protection which consists of a concrete cylindrical liner inside the drums. The LILW is located in the on-site interim storage.

In twelve years of power plant operation 1932 m^3 of LIL waste have been accumulated. The average specific activity in drums is 30 Gbq/m^3 ranging from 1 to 235 Gbq/m^3.

Figure 14: 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 drums containing evaporator bottoms. These activities should be carried out by using a mobile Westinghouse super-compactor unit, late in 1994 but because of supercompactor damage at the beginning of campaign it was postponed into 1995. The lifetime of the existing LILW interim storage on the NPP site will thus be significantly increased without any additional environmental impact.

Table 6: Radioactive waste in the Krško NPP according to the type and activity on 31 December, 1994

Type of waste	Number of Drums	Activity (GBq)	Volume (m^3)	Avg. Specific Act. GBq/m^3
SR	952	44680	190,4	235
CW	1116	962	223,2	4
EB	6739	8934	1347,8	7
F	125	2497	25	100
O	111	20	22,2	1
SC	617	531	123,4	4
TOTAL	9660	57624	1932	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

Dose data for 1994 indicate that doses received by workers have remained at the very low levels achieved over recent years. The average dose was 1,11 mSv and total collective dose was 0,844 manSv. The reduction of the doses from the previous year is a result of improving personnel training and a better practice during refueling and maintenance.

Table 7 shows the distribution of effective doses for workers of the Krško NPP from 1981 to 1994. Beside power plant personnel, subcontractors are also included in the table. The table shows that no employee received an annual dose exceeding 15 mSv and only 34 persons have received the annual dose above 5 mSv in the 1994. The workers are mostly exposed during the time of refueling and maintenance.

Table 8 shows collective and average doses in 1994. The annual collective effective dose per unit of electrical power generated in 1994 was 1.60 manSv/GWyear. It decreased for more than half compared to the previous year.

Table 7: Distribution of effective doses for all workers at the Krško NPP during years 1981 to 1994

range of doses mSv/year - ----------- year	0 - 1	1 - 5	5 - 10	10-15	15-20	20-25	over 25	Total number 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
1994	536	187	32	2	0	0	0	757

Figure 15 shows collective dose for all workers at NPP Krško for the past 12 years. For 1994 collective dose was 0.844 manSV which is half of the long term average at 1.6 manSv.

Figure 15: Collective effective doses for all workers at (NPP Krško)

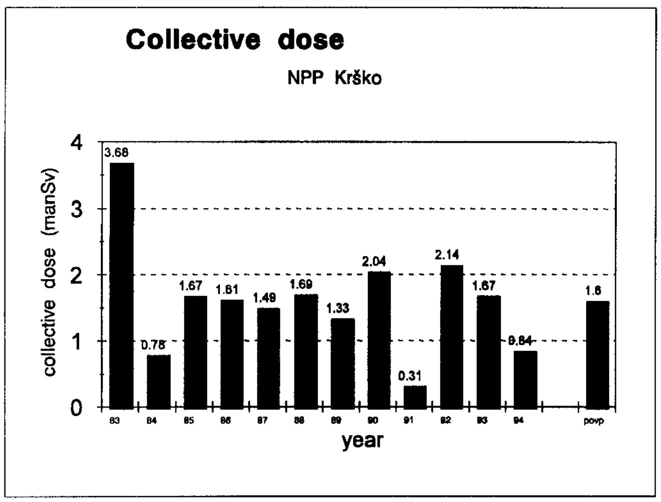


Table 8: Collective and average effective doses for all workers in 1994

Employees	Collective doses (man SV)	No. of workers	Average Dose (mSv)
Krško NPP	0.202	314	0.64
Subcontractors	0.642	449	1.43
Total	0.844	763	1.11

Radioactive Emissions to the Environment

Radioactive Discharges 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 Republic Energy Inspection Authority.

Competent administrative authorities are informed about the emissions in regular and special reports by the Krško NPP. Regular reports are made on a weekly, monthly and yearly basis. In daily reports the NPP Krško informs competent administration bodies in regular operation reports about the type and activity of emissions into the air and the Sava river. Special reports are mostly relevant to planned gas emissions from the gas storage tanks and for the containment before its venting.

In the liquid discharges into the Sava river, dominating radio nuclide is tritium. Annual emitted activity was 10,5 TBq, what is approximately 53 % of the limiting value 20 TBq stated in the licence. The activity of all other radio nuclides is 1000 times lower and is at the level of a few percentage of limiting values of the licence.

Radioactive discharges to the atmosphere come mainly from the reactor building stack. The majority of radioactivity in atmospheric discharges represent noble gases, about 99% of all activity. In 1994 total discharged activity was 10 TBq, what is approximately 17% of the limiting value 110 TBq. The value slightly increased from the previous year due to decreasing fuel cladding integrity.

Released tritium activity and released liquid activity during past years, respectively, is depicted in Figures 16. and 17.

Figure 16: Activity in liquid discharges without tritium (Krško NPP). Annual limit is 200 GBq.

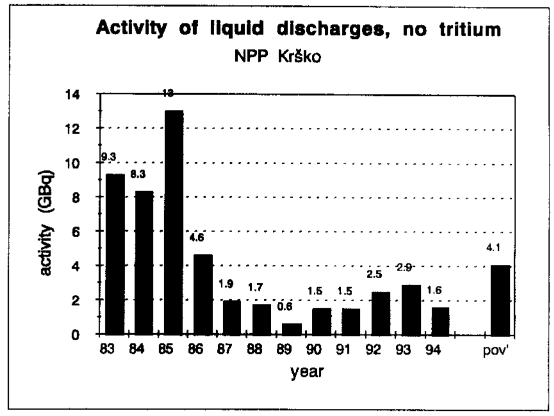


Figure 17. Activity of tritium in liquid effluents (Krško NPP). Annual limit is 20 TBq.

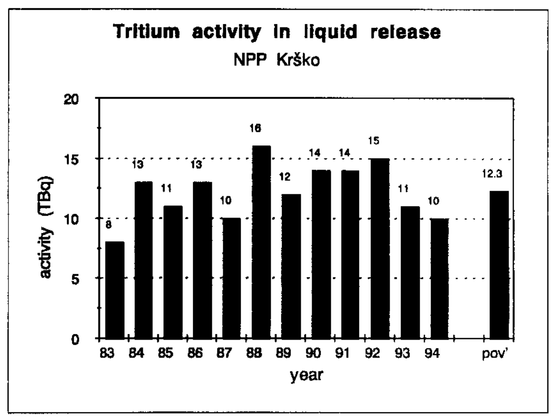
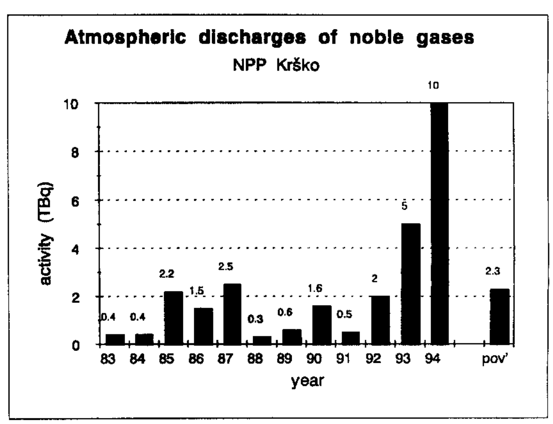


Figure 18 : Atmospheric discharges of noble gases from the NPP Krško. Annual limit is 110 TBq



Steam Generators

NPP Krško has two steam generators with vertical U-tubes and has the same problems with corrosion, like similar steam generators in the world.

During the 94 outage the following operations were performed in No.1 steam generator:

- 79 tubes were plugged, from that 8 have been already sleeved and 4 were plugged with Westinghouse plugs made of Inconnel 600 and had to be replaced according to new NRC regulations.
- 22 tubes with Westinghouse plugs were unplugged, and 49 tubes with ABB plugs were unplugged. The plugging in steam generator No.1 increased after the 94 outage from 17.95% to 18.13% or to 18.21% if sleeving is taken into account.

During the 94 outage the following operations were performed in steam generator No.2:

- 50 tubes were plugged, from that 6 were plugged with Westinghouse plugs made of Inconnel 600 and had to be replaced according the NRC regulations.

The plugging in steam generator No.2 increased after the 94 outage from 13.31 % to 14.40 %.

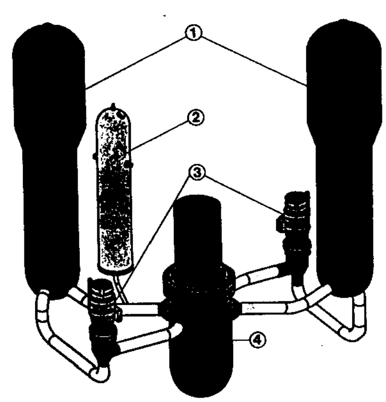
Table 9: Steam Generators tube plugging

Steam generators characteristics	SG 1	SG 2
Plugged tubes	828 (18,1%)	659 (14,4%)
Plugging considering sleeving	832 (18,2%)	
average plugging	16.31%	
sleeved tubes in operation	158	

The average plugging of both steam generators is 16.31%

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 was 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 that allowed the pH up to 8.8. The new condenser is made of stainless steel and can operate at a higher pH value, which substantially reduces the corrosion rate.

Figure 19: Reactor cooling system

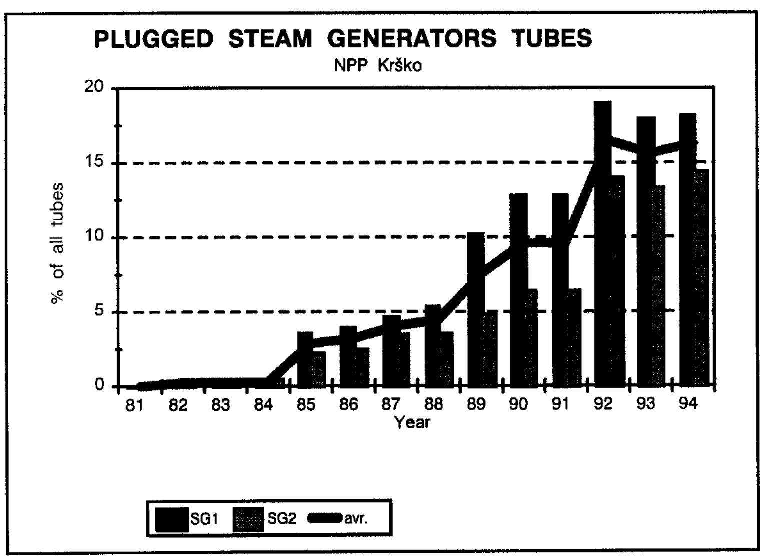


1. Steam Generators
2. Pressurizer
3. Reactor Coolant Pumps
4. Reactor

Table 10: Number and percent of plugged tubes in steam generators

Year	Steam Generator 1		Steam Generator 2	
	Tubes plugged	%	Tubes plugged	%
1982	4	0.088	17	0.370
1983	4	0.088	17	0.370
1984	6	0.130	21	0.460
1985	161	3.520	100	2.190
1986	179	3.920	112	2.450
1987	212	4.640	159	3.480
1988	246	5.390	162	3.540
1989	465	10.180	220	4.810
1990	584	12.780	293	6.400
1992	868	19.02	639	13.97
1993	820	17.95	608	13.31
1994	828	18.13	659	14.40

Figure 20: Plugged steam generators tubes



NE Krško Plant Modifications in 1994

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), which had been started or were completed in 1994, were the following:

1. Modification 001-ER-S, "Meteorological System Upgrades"
   Status: NNSR, had not been completed until the end of 1994.

2. Modification 007-SS-L, "Post Accident Sampling System"
   Status: NSR, completed.

3. Modification 009-VA-L, "Chlorine Monitoring System"
   Status: NSR, completed.

4. Modification 011-SW-L, "SW-Strainer Modification Taprogge Replacement"
   Status: NSR, completed.

5. Modification 015-AB-S, "Physical Protection-PARMS Wall"
   Status: NNSR, completed.

6. Modification 020-RP-L, "AMSAC"
   Status: NSR, in progress.

7. Modification 026-FP-L, "Fire Protection Upgrade"
   Status: NNSR, in progress.

8. Modification 032-SE-S, "Seismic Equipment Installation Low Earthquake Intensity Measurement"
   Status: NNSR, completed.

9. Modification 046-HC-L, "Containment Hydrogen Monitoring"
   Status: NSR, will be completed during the outage in 1996.

10. Modification 047-SI-L, "Containment Wide Range Pressure Monitoring"
    Status: NSR, will be completed during the outage in 1996.

11. Modification 076-TZ-L, "Physical Security Systems"
    Status: NNSR, in progress.

12. Modification 085-RH-S, "Installations of Ammeters for RHR Pumps"

    Status: NSR, has been initiated.

Acronyms:

NSR - Nuclear Safety Related
NNSR - Non Nuclear Safety Related

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 personnel skills for specific jobs and tasks. This is stipulated by 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 that takes care of annual training programs. As there is no nuclear power plant simulator in Slovenia, the Krško NPP training department organizes obligatory annual simulator training and retraining abroad, mostly in the USA. All personnel that require the operator licence or senior reactor operator licence took part in refreshment courses in 1994 on a simulator of the GINA NPP, Rochester, N.Y., USA. NPP personnel participated also in permanent training in the 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.

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

Radiological monitoring

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

Members of the public may incur additional radiation dose due to the liquid and atmospheric discharges from NPP Krško. All doses to members of the public were within regulatory limits. Evaluation is made on the basis of a model considering results of monitoring in environment, activity of liquid and gaseous releases and meteorological data. The additional annual effective dose for critical group in 1994 was smaller than 10 microSv.

Nonradiological Monitoring

The "Programme of nonradiological monitoring to determine the effects of the Krško nuclear power plant on the water quality of the river Sava and ground waters", decreed by the Ministry of Environment and Physical Planning, is incorporated in national program of surface waters monitoring.

Monitoring is provided by Hydro-Meteorogical Agency of Slovenia and Public Health Institute of Maribor. Monitored were more than 100 nonradiological water quality parameters and the conclusion is that from 1980 till 1994 there were not any noticeable impact on Sava river water quality from NPP Krško.

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

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 analyzed indicators, the quality of the groundwater had not deteriorated since 1981, when the Krško nuclear power plant went into operation. Results show 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). From the report of Hydro-Meteorological Agency of RS (4), we can conclude that still the higher pollutant concentrations are due to agricultural activities, the composition of the soil (iron) and, partly, the influence of the river Sava water.

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^3/sec 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 ground waters in connection with the operation of the Krško nuclear power plant in 1993, Croatian Water Management, Zagreb, March 1993.

4. Hydro-Meteorological Agency of RS, No. 935-122/95.

TRIGA RESEARCH REACTOR

Jožef Stefan Institute's TRIGA Mark II research reactor at Podgorica near Ljubljana with power of 250 kW has been operating for more than 25 years. The reactor scientists produce radioactive isotopes, mostly short-lived used in medicine, science and industry, deal with neutrons and gamma research, activation analyses, irradiation of materials for manufacturing of semiconductors and training of personnel.

No one from personnel exceeded external annual gamma dose of 0.4 mSv and effective dose of 1 mSv from neutron radiation.

Interim Storage of Radioactive Waste in the Reactor Center Podgorica

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

In 1994 the following activities were going on:

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

There are three types of radioactive waste in the storage:

closed barrels with contaminated items (paper, plastics, glassware, etc.) and materials with induced activity due to irradiation in TRIGA reactor,
other waste - bigger contaminated or active items which due to their size cannot be stored in barrels and are therefore stored separately,
sealed sources out of use, 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 11. In 1994 the number of drums increased by 5, number of sealed sources by 35.

Table 11: Radioactive Waste in the Interim Storage at the Reactor Center Podgorica in 1994

Type	Total (1994)	Isotopes *	Activity (GBq)
Barrels	142 (7)**	Co-60, Cs-137, Eu-152, Ra-226	3 - 20
Special	90 (5)	Co-60/Ra-226/Am-241	6100
Closed	165 (35)	Co-60, Sr-90	1000

* - isotopes providing the majority of activity are only quoted
** - Barrels stored in 1994

Radioactive discharges and environmental data

The monitoring of radioactive discharges in 1994 was made on the basis of the Program of regulation of radioactivity in the environment of the Reactor Center at Podgorica. The main discharges into the environment are the discharge of Ar-41 into the atmosphere (ventilation system of reactor confinement) and the discharge of liquid substances in to the Sava river from the Department for Nuclear Chemistry.

The conservative estimated annual effective dose for a person "living" close to the Reactor Center in Podgorica is: 0.2 microSv due to Ar-41 inhalation and 0.2 microSv due to drinking water from the Sava river.

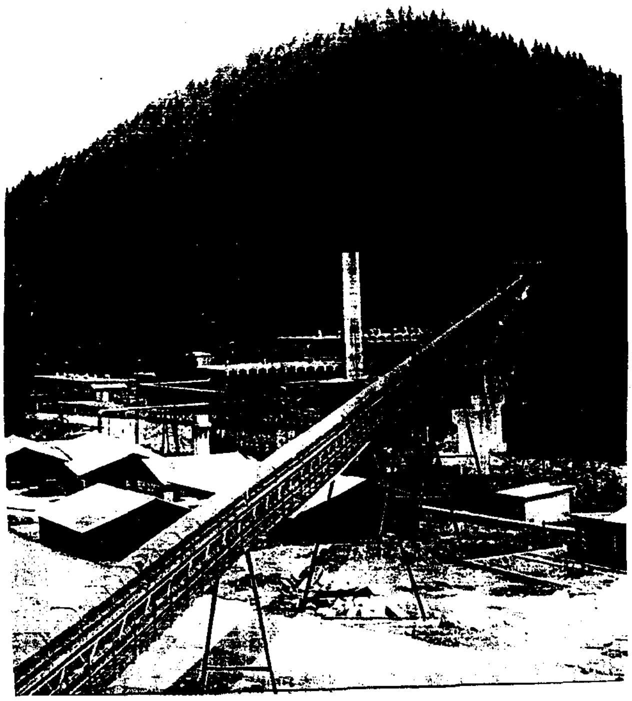
URANIUM MINE ŽIROVSKI VRH

In April 1994 The Slovenian Government accepted program for closure of the uranium mine. That way, the financial construction for the mine decommissioning was accepted.

During 1994 the main work was on:

- maintaining existing facilities
- amelioration the site of hydro metallurgical tailing Boršt,
- obtaining all permissions and plans for work in 1995

The concentrations of long-lived radio nuclides 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 as in the year 1991 and was not essentially lower after the production of yellow cake and mining was stopped. Also the radioactivity of sediments from the banks of Brebovščica and Todraščica and the concentration of uranium in surface waters did not change since 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. The main dose contributor is radon (80%).

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).

TEMPORARY STORAGE ZAVRATEC

Temporary storage for radioactive waste from Oncology Institute is located in the old Italian army bunker near village Zavratec. In 1961 10 mg of Ra-226 needle was accidentally broken and the content spilt at the Oncologist Institute. Contaminated material was stored at Zavratec, and almost forgotten as it was initially under the Yu-Army control. After independence public was alarmed and concerned because of radioactive waste in their surroundings.

Studies shoved that in the storage there are 69 drums, few cases, boards, and some containers. Concentration of radon was measured and amounts 30 kBq/m^3, what is not problematic from entering point of vie. In 1994 the Ad-hoc group, appointed by Nuclear Safety Expert Commission, studied all the available documents and concluded based on equilibrium Rn/Ra concentrations that the Ra-226 needle is hermetically closed or is not present in storage at all. The Ad-hoc group suggested new measurements as a basis for sanitation of the storage.

AGENCY FOR RADWASTE MANAGEMENT

(Agency RAO)

Agency RAO was established with the main objective to take care about the safe disposal of radioactive wastes in Republic of Slovenia. The primary task of the Agency is to find the location and to construct the repository for low and intermediate level radioactive waste (LILW) and to prepare the expert basis for the decision to be made concerning the management of the spent fuel elements in the future.

The siting procedure for surface LILW disposal started in late eighties. So far five locations that have met all the technical criteria for surface repository type were selected. Nevertheless, the opposition of the local communities caused the interruption of the project. The siting project was extended by considering the underground type of repository. In 1994 the preliminary siting criteria for an underground facility were prepared. Comparing the surface and underground siting criteria some differences concerning the geological criteria can be found while others are quite the same, therefore it will not be necessary to repeat the whole siting procedure. In parallel with the underground disposal siting criteria a new approach to the repository siting with the public invitation for bids is being examined. In this approach the local communities will be invited to offer the location for the repository. This way the Agency RAO hopes to reverse the siting procedure in such a manner that at the beginning the public acceptance is reached and afterwards the evaluation of the site suitability will be examined by applying the geological and other technical criteria.

On the basis of the overview of the geological and technical solutions concerning the spent fuel management in foreign countries it was found that no final solution for high-level waste disposal exists in the world. There are no examples of the successful solution of this problem and because there is still enough place in the spent fuel pit on the Krško NPP location it was proposed that so far the best solution is deferred decision. Meanwhile, the possibilities, of the preparation of an interim storage will be examined. This solution allows reprocessing of the spent fuel to be considered in the future if it turns out to be interesting.

Tab. 12.. Projects sponsored by ARAO

Year	Project	Prepared by
1993	LILW Management in Slovenia - Communication Aspects Survey	PRISTOP Communication Group, Ljubljana
1993	The Site Selection of the LILW Repository in the Republic of Slovenia, Step 3	Elektroprojekt Ljubljana, Consulting Engineers
1993	A Fundamental Study on the Strategy for the HLW Management in Republic of Slovenia	Elektroprojekt Ljubljana, Consulting Engineers
1994	Proposal of the Time Schedule for the Construction of the LILW Repository in Republic of Slovenia	Elektroprojekt Ljubljana, Consulting Engineers
1994	Preparation of the Basis for the Construction of LILW Repository	Elektroprojekt Ljubljana, Consulting Engineers
1994	Preliminary Acceptance Criteria for Low and Intermediate Level Radioactive Wastes	EGS, Maribor
1994	Initial Proposal for the Environmental Impact Statement Preparation	Elektroprojekt Ljubljana, Consulting Engineers
1994	Remediation Project for the Temporary Storage near Zavratec	Elektroprojekt Ljubljana, Consulting Engineers
1994	Survey of the Abandoned Mines and Prospection Drilling in Republic of Slovenia.	Geological Survey Ljubljana, Institute of Geology, Geotechnics and Geophysics
1994	Geological Guidelines for Site Selection of an Underground Disposal of LILW	Geological Survey Ljubljana, Institute of Geology, Geotechnics and Geophysics
1994	Development of Criteria for Site Selection of an Underground LILW Disposal in Republic of Slovenia	Elektroprojekt Ljubljana, Consulting Engineers
1994	Synopsis of International Experience With Spent Fuel and Draft Proposal for Republic of Slovenia High Level Radioactive Waste Management Program	"Jozef Stefan" Institute, Ljubljana
1994	Overview of the International Practice Concerning the Deep Geological Disposal of HLW	Geological Survey Ljubljana, Institute of Geology, Geotechnics and Geophysics
1994	Public Relations and Informing Strategy of Agency RAO	PRISTOP Communication Group, Ljubljana and "Jozef Stefan" Institute, Ljubljana
1994	Transportation of LILW	Elektroprojekt Ljubljana, Consulting Engineers
1994	Transportation of HLW and Spent Fuel	Elektroprojekt Ljubljana, Consulting Engineers
1994	Natural Radioactivity - Program of Initial State Measurements	"Jozef Stefan" Institute, Ljubljana
1994	Overview of Materials Suitable for Engineered Barriers in LILW Repository	EGS, Maribor
1994/95	Evaluation of the Possibilities for Radioactive Waste Storage or Disposal in Abandoned Mines or Other Underground Objects	Geological Survey Ljubljana, Institute of Geology, Geotechnics and Geophysics
1994/95	The site Selection of LILW Repository - the Basic Approach to Volunteer Siting	Elektroprojekt Ljubljana, Consulting Engineers
1994/95	Public Relations: Presentation of the Agency for Radwaste Management and Basic Principles Concerning the Radioactive Waste Management	PRISTOP Communication Group, Ljubljana
1994/95	Public Relations: Presentation of the Agency for Radwaste Management and Main Principles Concerning the Radioactive Waste Management	"Jozef Stefan" Institute, Ljubljana
1994/95	Initial State of the Environment - Preliminary Determination of Hydrological and Hydrogeological Parameters	Geological Survey Ljubljana, Institute of Geology, Geotechnics and Geophysics
1994/95	The Site Selection of the LILW Repository - the Program of Field Works within Step 4	Geological Survey Ljubljana, Institute of Geology, Geotechnics and Geophysics

INTERNATIONAL MISSIONS

IMPLEMENTATION OF THE RECOMMENDATIONS 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
- the ICISA mission (International Commission for Independent Safety Analysis) established by Slovenian Government
- and the Exploratory Mission of the European Commission within PHARE Programme

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 improvement in the plant. The European Commission performed an assessment of abilities and activities of the regulatory body for nuclear safety.

Table 13: Overview of Recommendations and their Implementation on 31.dec.1994.

Missions	Number of recommendations	Percent %
OSART		
Implemented, resolved	69	41
Satisfactory progress	72	43
Little or no progress	24	15
Withdrawn	2	1
TOTAL	167	100
ICISA		
Implemented or considered	31	42
Implementation scheduled by the end of 1995	25	34
Implementation scheduled by the end of 1996	1	1
Implementation scheduled by the end of 1997	1	1
Dependent on steam generator replacement schedule	2	3
SNSA responsibility		
Implemented	4	5
In the stage of implementation	10	14
TOTAL	74	100

OSART follow-up Mission

Upon the invitation from the Government of the Republic of Slovenia, an IAEA, OSART Follow-up visit was carried out from 24 to 28 October 1994. The team comprised one expert from the United Kingdom, two from the United States and one IAEA staff member. The purpose of the visit was to discuss the action taken in response to the recommendations and suggestions of the OSART mission, to comment on the appropriateness of actions and to make judgements on the degree of progress.

The follow-up review consisted of a step by step evaluation of the actions taken to each recommendation and suggestion given in the official report of Krško OSART mission. The team made technical comments on the response to each recommendation, suggested and provided a broad categorization for indicating whether the issue could be regarded as "resolved", whether "satisfactory progress" or " little progress" had been made in resolving the issue or whether the recommendation or suggestion should be withdrawn.

PHARE programme, RAMG assistance to Nuclear Safety Authority of Slovenia

In order to improve the organisation, the capability and performance of the SNSA, based on findings and recommendations raised by the exploratory mission of western regulators from May 1993 the contract between European Union as financing organisation and ANPA as executant was signed. The three-year program started in the middle of 1994 with participation of: France, Italy, Great Britain, Belgium, Spain and Germany. The first year items included:

1. Technical review of the proposed text for the new regulations on nuclear and radiological safety.
2. Establishing SNSA internal organizational and administrative procedures.
3. Assistance in the development of technique for public and media information.
4. Develop inspection guidelines and inspection programmes and provide training on working practice for site inspectors.
5. Develop capability for integrated systems analysis and use of PSA for regulatory purposes.
6. Assist SNSA in developing regulatory approach and practice for radwaste management.
7. Develop SNSA internal emergency plan and capability to assess the progress of environmental impact after a radioactive release.

Table 14.: An overview of responses effectiveness in each OSART review area by October 1994. R-recommendations, Ssuggestions.

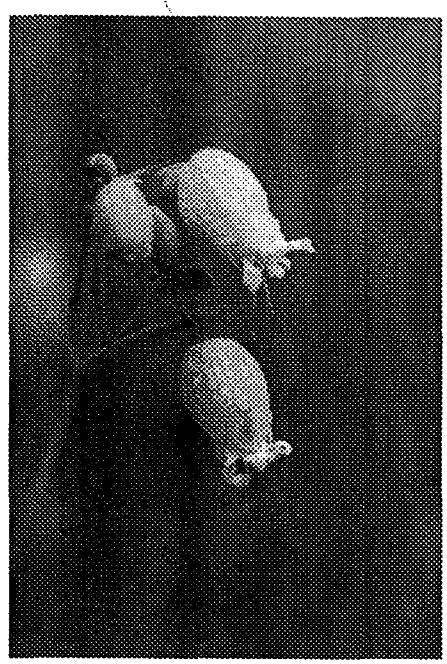
	Resolved	Satisfactory Progress	Little or No Progress	Withdrawn	TOTAL
Management Organisation Administration	4R 2S	8R 1S	5R -	- 1S	17R 4S
Training and Qualification	1R 2S	10R 3S	2R 1S	- -	13R 6S
Operations	6R 5S	5R 3S	2R 2S	- -	13R 10S
Maintenance	5R 2S	2R 5S	3R -	- -	10R 7S
Technical Support	1R 9S	1R 4S	- 2S	- -	2R 15S
Radiation Protection	5R 6S	5R 5S	2R 1S	- -	12R 12S
Chemistry	11R -	9R 4S	2R -	1R -	23R 4S
Emergency Planning and Preparedness	10R 1S	4R 3S	- 1S	- -	14R 5S
TOTAL	43R 27S 41%R 43%S	44R 28S 42%R 44%S	16R 7S 16%R 11%S	1R 1S 1%R 2%S	104R 63S 100%R 100%S
Overall	70 42%	72 43%	23 14%	2 1%	167 100%

RADIOACTIVITY

MONITORING

IN

SLOVENIA



NATURAL RADIOACTIVITY MAP OF SLOVENIA

At the Institute for Geology, Geotechnics and Geophysics they made the first Natural Radioactivity Map of Slovenia where the distribution of natural radioelement potassium K-40, uranium (U-238) and thorium (Th) is shown.

Five gamma-ray measurements were taken at each of 816 locations. Samples of the upper 10 cm of soil profile were collected for laboratory analysis. Uranium in samples was determined by delayed neutron activation method (DNC). Other 35 elements: Ag, Al, As, Au, Ba, Be, Bi, Ca, Co, Cr, Cu, Fe, K, La, Mg, Mn, Mo, Nb, Ni, P, Pb, Sb, Sc, Sn, Sr, Th, Ti, U, V, W, Y, Zn, and Zr were analysed by plasma emission spectrometry (ICP). The field gamma-ray measurements were converted to ground concentrations of potassium, uranium and thorium.

Concentrations of potassium in Slovenia vary between 0.05 and 4.63%, with a mean of 1.23%. The highest potassium contents were measured in the Idrija-Škofja Loka territory in which predominantly clastic are exposed, and in the eastern part of the Sava Hills, consisting of similar rock, as well as in the Pohorje Mountain built mostly of igneous and metamorphic rocks. Higher potassium abundances occur further in the Panonian basin where tops of elevations consist mainly of clastic rocks, and in lowlands the broad river valleys are filled with alluvial deposits. All these areas are covered with rich soils on which a dense vegetation grows. The potassium abundances are much lower in the territory of the Dinarides and the Julian Alps which consist mainly of carbonate rocks.

Uranium in Slovenia soils varies form 0.11 to 16.79 μg/g with an average of 3.23 μg/g. Higher values of uranium in soil occur in the Idrija-Škofja Loka area where occurrences of uranium ore are frequent, and in the Dinaric region on carbonate rocks for which the karstic relief is typical. Higher uranium abundances were measured also on Pohorje. The lowest values were measured in the Julian Alps region where the carbonate rocks are also karstified, but due to high mountain erosion most of the territory has a very thin soil cover.

Occurrence of thorium in Slovenia is found to be in the range between 0.31 and 21.86 μg/g, on the average 8.47 μg/g. Thorium is the most abundant in soil in the Northwestern part of the Outer Dinarides, in the Idrija-Škofja Loka region and on Pohorje. The lowest values were measured in the flysch basins of the Outer Dinarides, and in the Julian Alps where the weathering crust is very thin.

Comparison of results with absorbed dose rates elsewhere in Europe and in the world, indicates the gamma radiation in Slovenia being close to the world average 45 nGy/h (Grasty, 1984). In calculation of the absorbed dose rate also climatic factors need to be taken into consideration, especially the seasonal variation of moisture in the soil. In the samples collected for comparison the average humidity in soil was estimated at 22%.

Generally it appears that the elemental averages in soils in Slovenia exceed the world averages.

The map is a good basis for study of possible radiation hazards as a consequence of radioactive pollution, and beside that, a contribution of Slovenia to the construction of the Geochemical map of the world which is in elaboration under a common project of UNESCO and IAEA.

Source: Results of Radiometric and geochemical measurement for natural radioactivity map of Slovenia, Geologija, 36, 223-248, Ljubljana 1994.

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. The programme is executed by the Occupational Health 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. Radioactivity control 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 1994, the content, both of the 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, 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 samples from 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 1994 do not point to a significant reduction compared to 1992 and 1993.

The measurement of the external gamma radiation dose rate shows that the Chernobyl contribution still accounts for an average 17% - 30% of the total external dose measured in Slovenia. The average annual dose of external gamma radiation measured by thermoluminescent dosimeters amounts to 888 μSv.

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 all layers as in 1992 and 1993. Ljubljana and Kobarid have practically uniform distribution Cs-134/Cs-137 between all three layers but in Murska Sobota 70% of contamination is in the first layer because of local hydrometeorological and pedological characteristics. Sr-90 is same as in 1993 uniformly distributed between all three layers.

In 1994 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, and it was in 1994 either negligible or none-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 1994 was at the level of the preceding year.

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. In Ljubljana the dose measured by TLD is 876 μSv, the Chernobyl disaster being responsible for 146 μSv.

In 1994, based on these measurements, the implementors of the Program have established that the annual ingestion of artificial radionuclides was in the limits 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 1994 report (2), deal with the "iodine problem" in the water of the river 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. 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.

Table 15: Radioactivity in Slovenia - Annual average activity of Sr-90 (Bq/m^2) soil layer from 0 to 5 cm (grass surface)

Year	LJUBLJANA	KOBARID	MURSKA SOBOTA
1982	126	222	69
1983	157	161	43
1984	102	161	48
1985	107	154	56
1986*	123	680	115
1987	115	465	90
1988	120	395	84
1989	129	384	89
1990	130	335	81
1991	80	240 +	73
1992	82	255	71
1993	93	280	54
1994	77	230	70

+ Sampling site changed

* Measurements, because of presence of other short lived gama emitters from Chernobyl are not reliable

Table 16: Radioactivity in Slovenia - Sr-90 activity monitoring in milk and rainfall

	Milk Sr-90(Bq/kg)		Rainfall Sr-90(Bq/m³)		Rainfall (mm)	
Year	Ljubljana	Kobarid	Ljubljana	Bovec	Ljubljana	Bovec
1984	0.17	0.33	1.1	2	1423	2792
1985	0.19	0.33	0.9	1.9	1611	2855
1986*	0.28	0.81	450	630	1264	2137
1987	0.40	0,87	6.1	12	1528	3316
1988	0.22	0.53	1.8	5.3	1179	2498
1989	0.17	0.38	1.2	3.6	1212	2125
1990	0.19	0.43	0.38	1.1	1334	2865
1991	0.16	0.36	0.48	1.8	1178	2340+
1992	0.22	0.32	0.65	1.2	1434	3164
1993	0.15	0.3	1.4	1.1	1178	2343
1994	0.14	0.22	1.1	1.4	1397	2282

+ Measurement for May not included

* Measurements, because of presence of other short lived beta emitters from Chernobyl are not reliable

Table 17: Radioactivity in Slovenia - External gamma radiation, Ljubljana

Year	External gamma radiation (μSv)	Chernobyl contribution (μSv)
1988	1080	360
1989	1131	280
1990	994	220
1991	966	190
1992	975	190
1993	904	180
1994	876	146

Source: 1. Radioaktivnost v življenjskem okolju Slovenije za leto 1994, ZVD, Ljubljana, maj 1995,

2.. Meritve radioaktivnosti v okolici NE Krško, Poročilo za leto 1994, IJS-DP-6957, Ljubljana, marec 1995 IJS

Radon measurements in Slovenia

First radon-222 measurements in Slovenia were connected to uranium mine Žirovski vrh in 1969. From that time the Institute Jožef Stefan developed its own measuring method and now they are very active in indoor and outdoor radon measurements.

From 1975 till 1985 radon measurements were done in Karst caves, health resorts, mines and radon-radium measurements in surface and ground waters. Radon concentrations in karst caves (12 tourist caves and 26 others) was in concentration range from 20 to 20000 Bq/m^3. Radon and radium concentrations, in thermal and mineral waters of Slovenia health resorts, in general were not high, with few exceptions. Tuhinjska Dolina, Dolenjske Toplice had high radon content and Moravci high radium. Among mines Mežica, Idrija, Velenje-Preloge, Trbovlje,

Zagorje, Hrastnik, Laško and Senovo the hightest content of radon was in Idrija and Mežica. Radon concentrations in surface waters were between 95 and 5370 Bq/m^3, and in underground waters between 50 and 75000 Bq/m^3. Radium concentrations were between 0,5 and 7,1 Bq/m^3 for surface waters and between 0,5 and 510 Bq/m^3 for underground water respectively. Radioactivity of surface waters is higher at the uranium ore deposit region, locations of phosphate industry, thermal and mineral water regions.

The first preliminary study of radon in dwellings was done in 1985, and since 1990 systematic research sponsored by the Ministry of Health has been carried out.

Table 18: Tourist caves - some touristic features, calculated activities of inhaled Rn-222, and estimated bronchial doses due to Rn-222 and products received by visitor during a guided tour in the cave (summer time), (6), 1987.

Cave	Total length	Show length	Duration of visit	Number of visitors	Inhaled Rn-222	Estimated bronchial dose due to Rn+prod.s	Estimated effective dose
	m	m	min	vis./year	Bq/per.	μSv/pers.	μSv/pers.
Postojna	16500	5000	80	800 000	2500	135	8
Pivka	2500	1500	60	5 500	< 98	< 5	< 0.3
Planina	6000	900	60	1 400	190	10	0.6
Škocjan	5100	2300	120	37 500	480	26	1.6
Vilenice	1300	1000	60	8 000	< 260	< 14	< 0.8
Dimnice	1200	800	60	800	< 235	< 13	< 0.8
Kostanjevica	438	300	30	1 200	< 100	< 5	< 0.3
Pekel	1200	400	45	26 000	< 50	< 3	< 0.2
Tabor	360	327	60	8 600	10000	540	32
Železna	120	100	15	1 400	150	8	0.5
Francetova	20	20	10	1 200	270	15	0.9
Križ	8200	800	60	300	595	32	1.9

Table 19: Radon-222 concentrations in the air of Slovene underground mines (7).

Mine	Range Bq/m^3	Average Bq/m^3
Mežica -Graben (lead)	590 - 76900	1419±498*
Idrija (mercury)	185 - 1050	658±254
Velenje - Preloge (coal)	70 - 655	171±160
Trbovlje (coal)	30 - 400	129±126
Zagorje (coal)	100 - 445	264±151
Hrastnik (coal)	50 - 135	102±35
Laško (coal)	95 - 455	281±118
Senovo (coal)	250 - 465	334±94

* value 76900 Bq/m^3 not considered

Table 20: Radium and radon concentrations in drinking, mineral and thermal waters(2,3,4,)

Water	Radium conc. (Bq/m^3)	Radium conc. (Bq/m^3)	Data from (year)	Reference
Mineral water Radenci	215		1986	2
Bathing water Radenci	240		1986	2
Thermal water Podčetrtek	140		1984	3
Waterworks Ljubljana	0.68		1994	14
Waterworks Maribor	5.5		1994	14
Waterworks Celje	3.4		1994	14
Waterworks Kranj	1.9		1994	14
Waterworks Škofja Loka	1.6		1994	14
Hotel Toplice, Bled	7.4	4800	1974	13
Hotavje	11.1	18000	1974	13
Pirniče	7.4	13000	1974	13
Tuhinjska dolina			1973	13
New well	7.4	63000		
New well	11.1	23000		
Spring near road	7.4	27000		
Medijske toplice	25.9	5500	1992	13
Kotlje	129.5	5500	1974	13
Topolščica			1974	13
Spring		15000		
Pool		12000		
Dolenjske toplice	114.7	51000	1977	13
Rimske toplice	29.6	600	1972	13
Šmarješke toplice			1972	13
Pool 1	70.3	9000		
Pool 2	92.5	6000		
Laško, pool	125.8	5300	1972	13
Laško, pool	55.5	14000	1976	13
Laško				13
New spring	37	9500	1973	
Main well	48.1	5200	1972	
South well	29	7400	1972	

Water	Radium conc. (Bq/m^3)	Radium conc. (Bq/m^3)	Data from (year)	Reference
Dobrna			1977	13
Spring	18.5	1000		
Pool	29.6	8200		
Frankolovo			1977	13
Pool	37	28000		
Pool	14.7	11700		
Bušeča vas	37	5500	1972	13
Dobrna 1	14.7	8732	1975	13
Dobrna 2	18.5	10360	1975	
Toplice	11.1	4366	1975	
Hanjsko	11.1	12950	1975	13
Podčetrtek	62.9	29230	1975	13
Rogaška slatina	125.8	185	1972	13
Čatež				13
Pool	29.6	29415	1975	
Spring	44.6	13542	1976	
Radenci	210	7700	1976	13
Petanjci	44.6	1295	1976	13
Banovci	170.6	851	1976	13
Moravci, pool	614.2	4625	1976	13

Table 21: Natural radioactivity of Slovene surface waters (15)

Surface water (river), sampling site	Radon - 222 Bq/m^3	Radium - 226 Bq/m^3	Sampled in
The Sava			1975
Waterfall Savica	110	1,1	
Outlet of Bohinj lake	100		
Lesce/Bled	190	< 0,5	

Surface water (river), sampling site	Radon - 222 Bq/m^3	Radium - 226 Bq/m^3	Sampled in
Zelenci	5400		
Hrušica/Jesenice	740	< 0,5	
Posavec/Otoče	230	< 0,5	
Breg/Kranj	290	< 0,5	
Medvode, before inflow of the Sora river	740	< 0,5	
Šentjakob/Ljubljana	480	< 0,5	
Sava, after inflow of the Ljubljanica	790	1,2	
Zidani most	1400	25	
Krško	740	4,8	
Krško, NPP	530	4,0	
Brežice	300	2,2	
Jesenice/ Dolenjskem	580	2,5	
The Poljanska Sora			1977
Gorenja vas, above uranium mine	740	1,9	
Poljane, below uranium mine	850	10	
The Ljubljanica			1974
Pivka river / Pivka	3400	1,5	
Pivka, before inflow in Postojna cave	870	7,1	
Unica rive / Planina	710	2,6	
Ljubljanica / Vrhnika	480	1,9	
Ljubljanica river before Ljubljana	1300	< 0,5	
Ljubljanica river before inflow into Sava	370	< 0,5	
The Krka			1975
Spring	3700	< 0,5	
Krka village	1600	3,1	
Žužemberk	590	1,9	
Straža	520		
Muhaber pod Turško goro	590	< 0,5	
before inflow into Savo river	590	1,2	
The Mura			1986
Gornja Radgona		28	

Surface water (river), sampling site	Radon - 222 Bq/m³	Radium - 226 Bq/m³	Sampled in
Radenci		23	
Veržej		32	
Razkrižje		19	
The Soča			1974
Spring	250	< 0,5	
Žaga / Bovec	290	1,9	
Idrsko / Kobarid	350	1,2	
Tolmin	340	1,5	
Plave	280	1,1	
Solkan	240	1,5	
The Idrijca			1974
Spodnja Idrijca, below mercury mine	1300	2,3	
Bača / Modrej, above inflow into Soča	820	1,5	
The Vipava			1986
Spring		5,9	
Miren	150	2,3	
The Hubelj			1986
Spring		7,1	
The Rižana			
Spring		8,5	
before inflow into the see		8,4	
The Dragonja			1986
Spring		17	
The Reka			1978
Above Škocjan caves	70	< 0,5	
Trieste (as Timava river)		6,5	
The Kolpa			1974
Sečje / Vinica	480	3,3	
Radoviči / Rosalnica	910	4,5	
The Kokra			1974
Jezersko	410	< 0,5	

Surface water (river), sampling site	Radon - 222 Bq/m^3	Radium - 226 Bq/m^3	Sampled in
Preddvor	1300	1,1	
Above Oljarica / Britof	340	1,7	
Below Oljarica / Britof	95	< 0,5	
before inflow into Sava	95	< 0,5	
The Savinja			1974
Above the inflow of Paka river	150	1,1	
Polzela	280	1,5	
Megojnica	200	1,5	
Below Celje	730	< 0,5	
Below Laško	440	1,5	
Zidani most, before inflow into Sava	370	1,5	
The Sotla			1974
Rogatec	220	1,9	
Podčetrtek (Atomic Spa)	1500	4,1	
The Drava			1975
Dravograd	1200	1,5	
Maribor Island	300	2,6	
Zgornji Duplek	1700	1,9	
Borl	3800	2,2	
Središče	450	2,2	
The Dravinja			1974
Zreče above	450	1,9	
Zreče below	340	1,5	
Slovenske Konjice	200	2,2	
Majšperk	340	1,5	
Stagovice	360	1,5	

RADON MEASUREMENTS IN KINDERGARTENS AND SCHOOLS

Systematic measurements of radon concentrations were carried out in the 730 kindergartens and 888 elementary and high schools. Instantaneous air concentrations were obtained under closed conditions in winter time in the rooms which were closed 12 hours before the measurement. In 69% of the buildings the values were below 100 Bq/m^3 and in 33 buildings (2%) they exceeded 1000 Bq/m^{-3}. Geometric means of 58 and 82 Bq/m^{-3} were obtained in kindergartens and schools, respectively. All the buildings with indoor radon concentrations of about 1000 Bq/m^{-3} and more were further investigated. In the majority of these buildings, the main reason for a high indoor radon content was the geological structure of soil. Estimated effective equivalent doses for children in schools are in general low, about 5 to 10 % of total dose. In the future more attention should be devoted to the cases with high radon concentrations. Remedial action in three kindergartens with extremely high radon concentrations (around 6000 Bq/m^3) were successfully done (11).

Figure 21: Radon concentrations in kindergartens, Bq/m^3 (9)

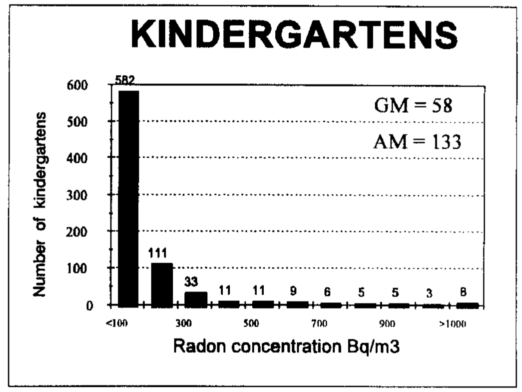


Figure 22: Radon concentrations in schools, Bq/m^3 (9)

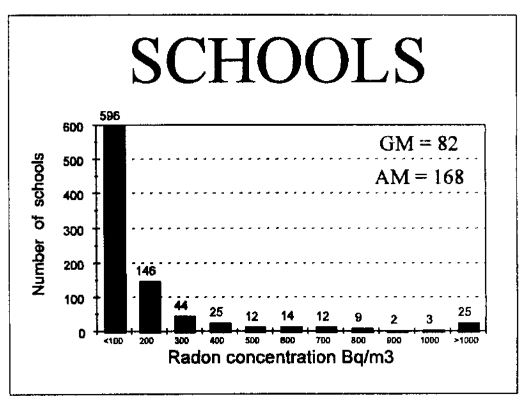


Table. 22: Mean radon concentrations and gamma dose rates in kindergartens and schools in different regions of Slovenia (8, 12)

Kindergartens					Schools				
Place (no.kindergart. : no. children)	Radon Bq/m^{-3}				Place (no. school.: no. children)	Radon Bq/m^{-3}			
	min	max	arit.m.	geo.m.		min	max	arit.m.	geo.m.
Ljubljana 193:22900	10	5606	194	74	Ljubljana 224:83054	20	3595	231	102
Maribor 160:10800	10	945	91	53	Maribor 151:47284	20	1286	97	63
Celje 120:9750	7	514	63	43	Celje 137:46798	14	1787	125	70
Kranj 53:4950	8	1089	149	69	Kranj 79:23193	33	1468	203	112
Nova Gorica 32:2850	9	1539	130	49	Nova Gorica 80:16640	10	3504	164	82
Koper 31:3350	17	208	44	35	Koper 32:12807	37	255	73	65
Postojna 24:1850	23	5750	518	156	Postojna 38:8386	26	3224	318	171
Novo mesto 62:5350	10	939	136	72	Novo mesto 86:26227	17	4690	226	95
Murska Sobota 55:3800	10	270	56	41	Murska Sobota 61:14246	12	343	67	48

Sources:

1. Atmospheric radon Concentrations in Dwellings in Slovenia, Yugoslavia, Sci. Total Environ., Vol. 70, 1988.
2. Radiation Doses at the Radenci Health Resort, RPD, Vol. 20, No. 4, 1987,
3. Radioactivity of the Atomic Spa at Podčetrtek, HP, Vol. 53, No. 3, 1987,
4. Natural Radioactivity of Fresh Waters in Slovenia, EL, Vol. 16, 1990,
5. Radionuclides in Effluent from Coal Mines, a Coal-fired Power Plant, and Phosphate Processing Plant in Zasavje, HP, Vol. 58, No 1, 1990,6.Atmospheric Rn in Tourist Caves of Slovenia, HP, Vol. 52, No. 4, 1987 in
7. Radon Concentrations in the Air of Slovene underground Mines, EL, Vol. 16, 1990.
8. Koncentracije radona v vrtcih in šolah Slovenije, IJS-DP-7236, 1994.
9. Meritve radona v Sloveniji, Vaupotič, Kobal, 1995.
10. Koncentracija radona v bivalnem okolju Slovenije, IJS-DP-7164, 1995.
11. Radon level reduction in two kindergartens in Slovenia, HP, Vol. 66, No.5, 1994.
12. Systematic indoor radon and Gamma Measurements in Kindergartens and Play Schools in Slovenia, HP, Vol. 66, No. 5, 1994
13. Radioactivity of Thermal and Mineral Springs in Slovenia, HP, Vol. 37, 1979.
14. Radioaktivnost v življenjskem okolju Slovenije za leto 1994, ZVD, Ljubljana, maj 1995
15. Natural Radioactivity of Fresh Waters in Slovenia, Yugoslavia, El, Vol. 16, 1990.

INDOOR RADON CONCENTRATIONS IN SLOVENIA

Programme for measuring indoor radon concentrations in Slovenia was sponsored by Ministry of Health and was carried out by Institute Jožef Stefan.

Between December 1993 and February 1994 concentrations of indoor radon were measured in 892 randomly selected dwellings in Slovenia (0.2% of 463 000), utilizing CR-39 etched track detectors. Results were statistically evaluated and the median approximate annual average concentration was found to be 54 Bq/m^{-3}. Maps of indoor radon concentrations in Slovenia were constructed and average annual concentrations in communities are presented in fig. 25 and tab. 23, 24.

Measurements were done in winter time when radon concentrations in closed, indoor space is in general the highest. Results are extrapolated on all year average.

Table 23: Radon concentrations in Slovenia, winter time measurements 1993/1994.

	Number of measure-ments	Concentrations (Bq/m^3)			
		Average (arithmetic)	Minimal	Maximal	Median
SLOVENIA	892	121.0	7.4	1889	74.2

Table 24: Radon concentrations in Slovenia, calculated medium "adjusted" value

	Number of measure-ments	Concentration (Bq/m^3), medium value		
		Arithmetic	Geometric	Median
SLOVENIA	892	87	59.6	54

Indoor radon map of Slovenia fig. 23 shows big similarity with map of radon daughters and uranium in the surface layers of the karst region that is south part of Slovenia. The highest concentrations of radon are found in houses in (Sežana 280 Bq/m^3), Logatec in Vrhnika 160 Bq/m^3, Cerknica 120 Bq/m^3, Kočevje 160 Bq/m^3 and Ribnica 210 Bq/m^3. At the karst regions, stronger faults as Idrija, Predjamski and Savski, there are higher radon concentrations than in a regions with impermeable layers.

Slightly higher radon concentration are in smaller areas of:

- in eastern part of Prekmurje
- in west part of Štajerska (Mozirje 140 Bq/m^3)
- in east Haloze
- in regions south of Ptuj (Ptuj 123 Bq/m^3)
- Kranj area 140 Bq/m^3
- Jesenice area 100 Bq/m^3
- regions of Idrija in Škofja Loka 110 Bq/m^3

Radon concentration in the highly urbanised areas are lower than at the country side. The highest concentrations were found in one family houses and lowest in big apartment buildings like in Ljubljana where the concentrations in the centre of the city were below the average and at the same time suburbs had highest values (Ljubljana, from 53 to 96 Bq/m^3). In general we can expect more radon in older houses. Radon concentration in houses made from fly ash in bigger cities (Celje, Maribor, Velenje, 68 Bq/m^3) were slightly above the average.

Indoor radon concentrations in Slovenia are typical for middle European regions with concentrations between 40 and 60 Bq/m^3.

Source: Koncentracija radona v bivalnem okolju Slovenije (zaključno poročilo), Institute "Jožef Stefan", IJS-DP-7164, januar 1995.

FLY ASH

Uranium, Thorium and Potassium-40 natural radionuclides are more or less present in coals depending on the type of coal. Process of burning coal gives ash as a by product in which the natural radionuclides get concentrated 2.5 to 6 times on mass unit. Uncontrolled damping of such material and specially of fly ash which is collected in filters of big energy producers can be a potential source of environmental radioactive contamination. Studies at Institute "Jožef Stefan" and Ljubljana University have concluded that:

- The measurements of gamma radiation directly on the surface of fly ash dump site shows 2 to 3 - times natural background or 1.5 to 2 - times the "after Chernobyl" dose rate of external gamma radiation. Dose rate is decreasing with the distance from a dump site and after some 10 m it is neglectable. Further more if Fly ash is covered with enough ground layer the influence is neglectable.

- Open dumps surfaces covered with fly ash do not represent additional source of dust in environment. Fly ash with water makes a hard surface crust which is protecting environment from the dust. Potential problem for polluting air is bad transport handling and manipulation with fly ash.

- Resident people around the dump site are not exposed to additional radiation if the dumps are covered with ground layer above the fly ash and if they are living at list 30 - 50 metres from the site.

- Potential influence on environment from leaching can be controlled specially for filling up at road construction. Filling up of ditches can be problematic, on water protected areas, and it is suggestible to locate them out of drinking water aquifers.

Sources:

- Vplivi sevanja na okolje iz odlagališč premogovega pepela iz TE-TO Ljubljana, IJS, 1989 in
- Kemijska karakterizacija in kinetika izluževanja EFP, FNT, 1988.

Figure 23: RADON MAP OF SLOVENIA

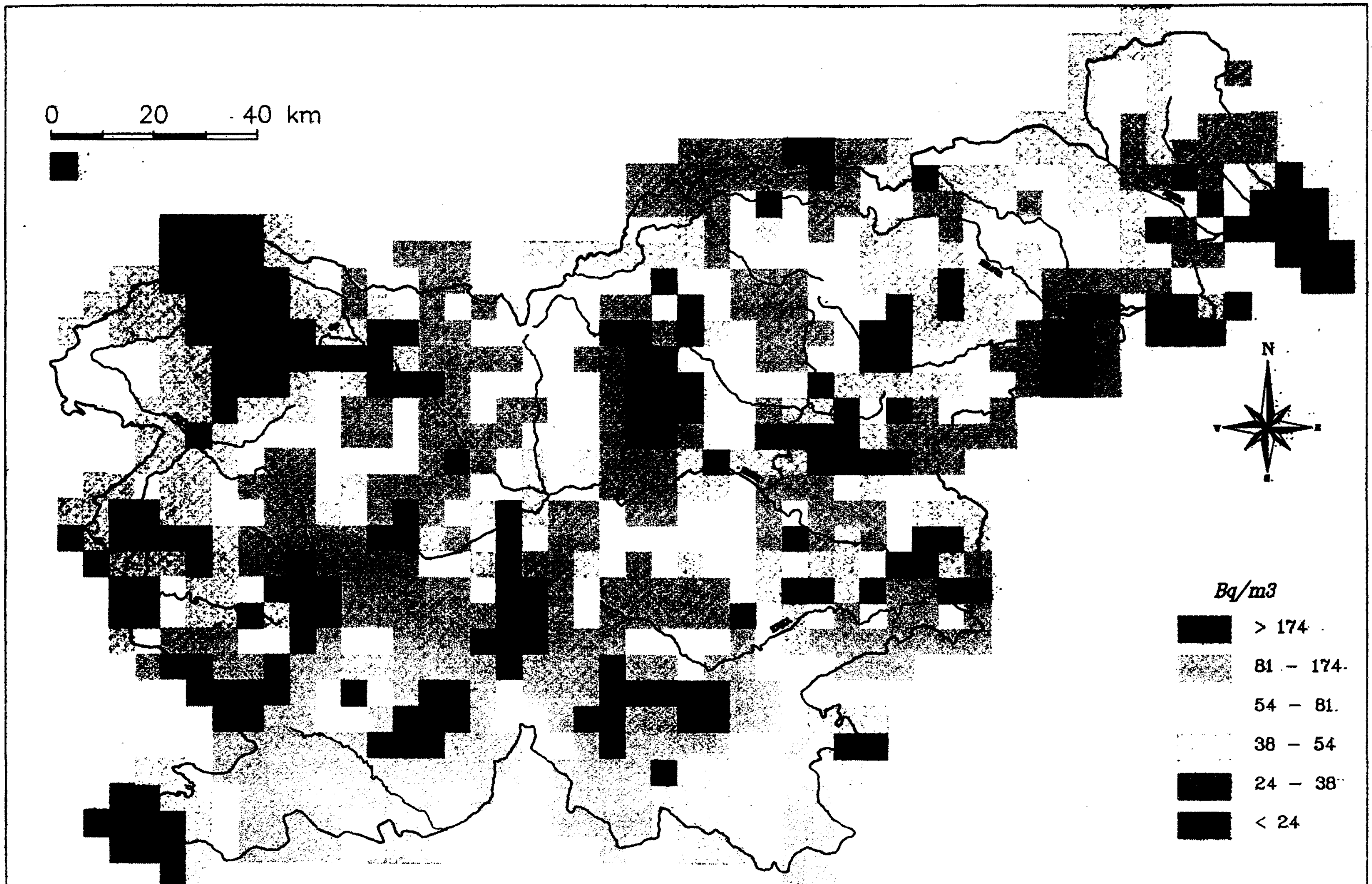


Figure 24: Sampling points locations for indoor radon measurements

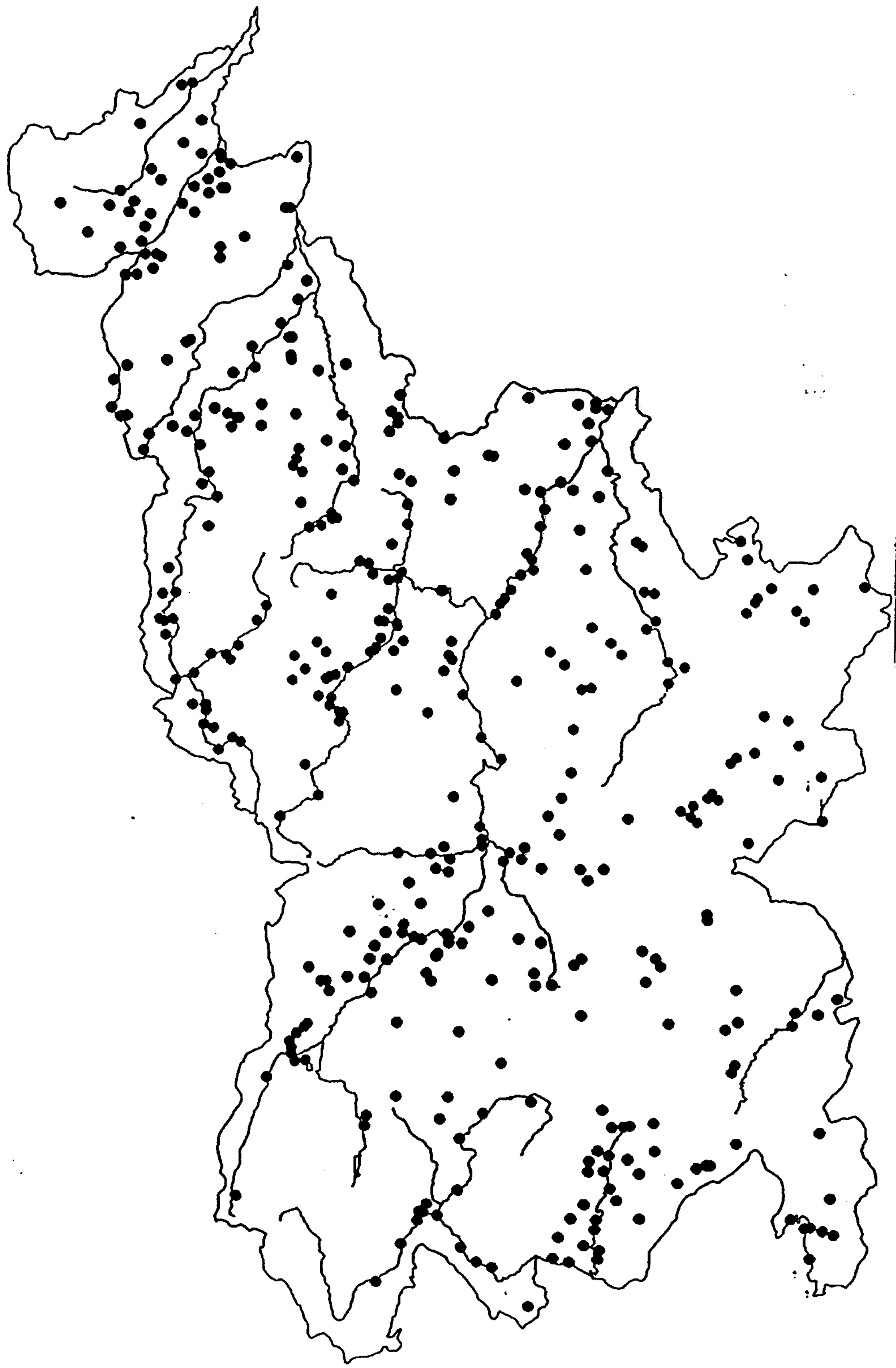
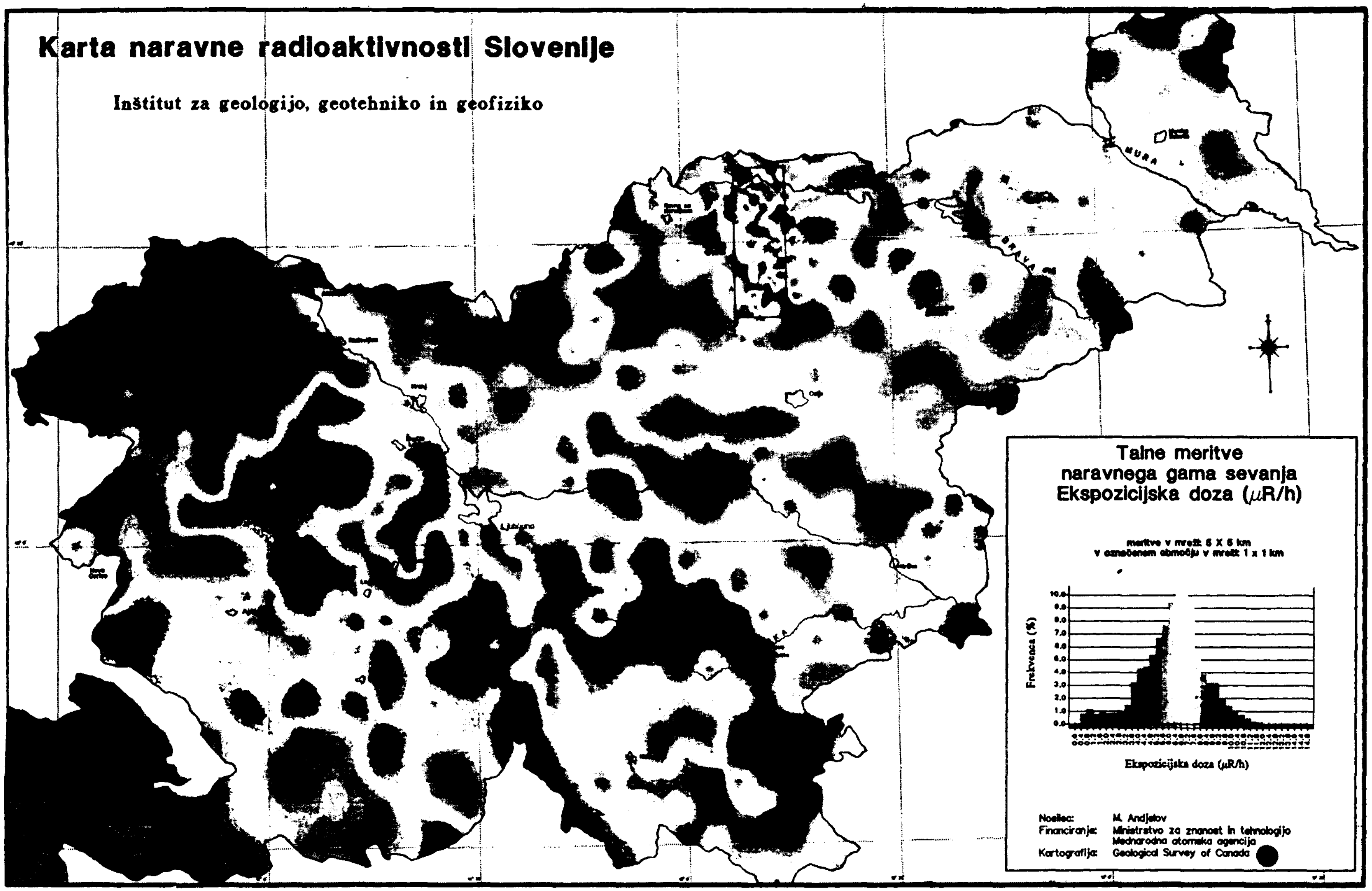
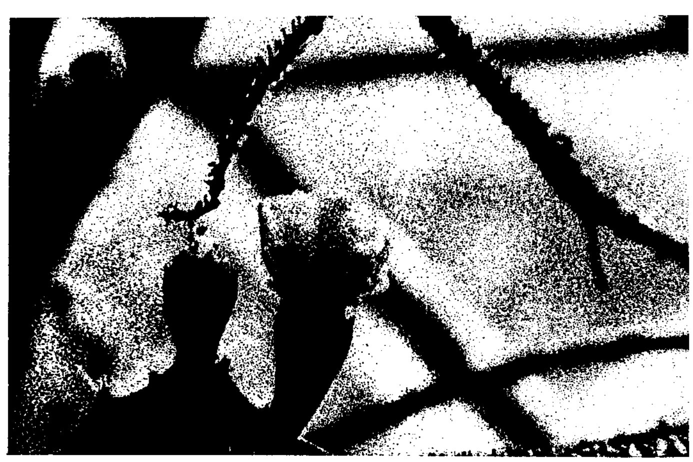


Figure 25: NATURAL RADIOACTIVITY MAP OF SLOVENIA



CONTROL OF IONIZING RADIATION SOURCES



CONTROL OF IONIZING RADIATION SOURCES

Health inspectorate of Slovenia controls ionizing radioactive sources and work with them. Under the control were besides nuclear facilities also a lead-zinc mine Mežice, about 100 production and research organizations and all medical institutions. Under control are also radioactive materials which are crossing the Slovenian border, domestic transport and fire detectors. The work includes also licensing procedures.

Technical control of the Ionizing Radiation sources is held by licensed organisations such as Institute Jožef Stefan and Occupational Health Institute of Slovenia.

Dosimetry

In Slovenia there are 2600 registered workers dealing with Ionizing radiation sources. Personal dosimetry is done by Institute Jožef Stefan and Occupational Health Institute of Slovenia on celluloid or thermoluminescent dosimeters. The effective received dose in 1994 was below the limit value of 50 mSv. In general 98 % of workers received less than 0.1 mSv per month, about 1 % workers received between 0.1 and 2 mSv, and less than 0.5% received between 2 and 4 mSv per month, mostly during the outage and supercompacting at NPP Krško. Special problem is at Lead and Zinc mine Mežica where the radon concentrations are high and workers have to rotate their workplace. The preliminary studies for 1994 shoves that 42 miners out of 182 received dose between 50 and 70 mSv considering conservative relation between measured values and dose (1 WLM = 10 mSv).

RTG Control in medical institutions

645 RTG's are registered at Health inspectorate in Slovenia from which 120 private dental service. They are located on 80 medical institutions locations plus 120 private dentist locations.

The Slovenian Health Inspectorate in 1994 carried out 22 inspections of 240 diagnostic X-ray machines units (RTG). 14 units lost their licence, 23 have to improve and 61 new licences were obtained.

According to their use we can divide them :

1. for radiography (80 units)
2. for computer tomography (6)
3. for radiography and radioscopy (19)
4. for mamographic radiography (15)
5. for surgery rooms (37 mobile units)
6. for lung radiography in PA protection with ODDELCA camera (34)
7. for radiography with TV camera (121)
8. for therapeutic irradiation (5)
9. for intraoral tooth radiography (296)
10. for panoramic tooth photography (32)

Regular quality control shoves that there are:

- 10 % new units
- 35 % units in good condition
- 40 % units needed to be serviced
- 5 % could be used only temporary as a replacement.
- 10 % should be abounded

Control of sealed and unsealed radiation sources in the medical institutions

With sealed radiation sources are dealing only at Oncological institute in Ljubljana using two cobalt-60 sources with 327 and 325 TBQ activity, two linear accelerators, iridium-192, cesium-137, ruthenium-106 and strontium-90.

With unsealed radiation sources are dealing in seven medical institutions in Ljubljana, Maribor, Celje, Slovenj Gradec, Šempeter near Nova Gorica and Izola. The mostly used isotopes are: technetium-99, iodine-131, thallium-201, Xenon-133, yttrium-90, gallium-67, indium-111, strontium-89, cobalt-57.

Complete supply of iodine in 1994 was about 700 GBq (average 15 GBq per week), and consumption was 500 GBq. Technetium delivery was about 3 TBQ (up to 70 GBq per week). Other important isotopes are: Xenon (up to 3.7 GBq per week), thallium (up to 2 GBq per week) and oidium-125 (up to 10 GBq per week).

Beside the medical institutions the open radiation sources are used at research institutions: Chemical Institute, Institute Jožef Stefan, Pharmaceutical Industry Lek, Veterinary Faculty, Institute for Biology and some smaller units.

Control of closed radiation sources in industry

In industry are generally used:

- iridium-192 and cobalt-60 with activity up to 2 TBQ for industrial radiography,

- cesium-137 and americium/beryllium with activity 0.3 respectively 1.5 GBq for density and humidity measurements in construction work,

- krypton-85, strontium-90, americium-241 with activity up to 20 GBq for thickness measurements in paper, wood and textile industry,

- europium-152 and 154 with activity up to 20 GBq for lighting rods,

- americium-241, cesium-137, cobalt-60 for level measurements in Iron industry up to 740 GBq, breweries up to 3.7 GBq, and food processing industry up to 10 GBq.

All radiation sources are registered and under regular annual control. Used sources are under the control transported and stored at the Podgorica Interim Storage.

Control of industrial RTG

At Health inspectorate there are registered 90 RTG in 65 organisations. The most of them are used by Customs for baggage control on ports of entry in the Slovenia.

Fire detectors

There are about 85000 ionizing fire alarm detectors in Slovenia which are under the control of Institutes for Occupational Health in Ljubljana and Maribor and institution Varnost from Maribor.

Licensed firms for fitting, unfitting and transporting ionizing fire alarm detectors to the Podgorica Interim Storage are Zarja Kamnik and Iskra Servis Ljubljana.

Transport of radioactive materials

For transport of radioactive materials in Slovenia there are licensed 14 companies among which the most work is done by JANIS Maribor, INTERTRANS Ljubljana and Institute Jožef Stefan.

Import of radioactive material is done generally by:

- IRIS, KRKA, PETROL, GENOS (radio-pharmaceutical)

- METALKA, MAŠINOIMPEX (equipment and tools for NPP Krško)

- LEK, IJS, SANOLABOR, EDITRADE (other sources)

In 1994 The Health Inspectorate issued 33 permissions for transporting the radioactive materials in Slovenia and 274 permissions for transporting the radioactive materials across the Slovenian borders.

Personnel training

Personnel dealing with the ionizing radiation materials are trained and controlled according the law. Training is organised by the Institute Jožef Stefan and Occupational Health Institute of Slovenia. In 1994 the special working group appointment by Ministry of Health prepared proposals for new training programs.

Medical control

Workers who deal with ionizing radioactive materials are regularly under the special medical examinations which are performed at Occupational Health Institute of Slovenia and Institute for Occupational Work, Transport and Sport.

Patients doses from medical intervention

Occupational Health Institute of Slovenia investigated Patients doses from medical intervention in Slovenia. In 1994 report they couldn't report the total patients dose in Slovenia because it is not exactly known the frequency of medical examination and therapy. For the time being it is possible to compare on the basis of incoming skin doze at use of RTG. The incoming skin doses at use of RTG are in average between 0.23 mGy (chest organs, PA projection) and 18.33 mGy (lumbar backbone, LAT projection) which is harmonized with guidelines of European Community and IAEA.

NUCLEAR

ELECTRICITY

GENERATION

NUCLEAR ENERGY GENERATION

At the end of 1994, there were 480 electric power reactors operating or being under the construction in the world with a combined output power of about 2130 TWH. They are operating in 29 countries, and the number of reactors in operation increased by four.

There were 51 reports on nuclear incidents sent to INES in 1994. Ten were assessed as second-degree incidents, 22 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 25: Nuclear Power Reactors in operation and under construction at the end of 1993

Country	Reactors in operation		Reactors under construction	
	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	3	2100		
Czech R	4	1648	2	1824
Finland	4	2310		
France	56	58498	4	5810
Germany	21	22559		
Hungary	4	1729		
India	9	1593	5	1010
Iran			2	2146
Japan	49	38875	5	4799
Kazahstan	1	70		
Korea RP	10	78170	6	4820
Lithuania	2	2370		
Mexico	2	1308		
Netherlands	2	504		
Pakistan	1	125	1	300
Romania			5	3250
Russia	29	19843	4	3375
S. Africa	2	1842		
Slovak R	4	1632	4	1552
Slovenia	**1**	**632**		
Spain	9	7105		
Sweden	12	10002		
Switzerland	5	2985		
UK	35	11702	1	1188
Ukraine	15	12679	6	5700
USA	109	98784	1	1165
Total*	432	340347	48	38876

* The total includes the data from Taiwan..
Ref.: IAEA, Press Release PR 95/9, 26.4.1995

Table 26: Total operating Experience and Electricity supplied by Nuclear Power Reactors

Country	Electricity supplied NPP in 1993		Total Operating Experience to end 1993	
	TWH	%	Years	Months
Argentina	7.68	13.77	32	7
Belgium	38.20	55.77	128	7
Brazil	0.04	0.01	12	9
Bulgaria	15.33	45.63	77	1
Canada	101.73	19.07	326	11
China	13.50	1.49	5	4
Czech R	12.13	28.22	34	8
Finland	18.33	29.51	63	4
France	341.80	75.29	822	10
Germany	145.00	29.33	490	1
Hungary	13.23	43.73	38	2
India	4.32	1.37	119	3
Japan	258.3	30.70	652	2
Kazahstan	0.38	0.58	21	6
Korea RP	55.92	35.48	90	4
Lithuania	6.63	76.37	18	6
Mexico	4.28	3.22	5	11
Netherlands	3.70	4.86	47	9
Pakistan	0.52	1.01	23	3
Russia	97.83	11.39	497	6
S. Africa	9.69	5.69	20	3
Slovak R	12.13	49.05	57	5
Slovenia	**4.39**	**38.01**	**13**	**3**
Spain	52.80	34.97	138	2
Sweden	70.20	51.30	205	2
Switzerland	22.98	36.84	98	10
UK	79.40	25.79	1028	5
Ukraine	68.85	34.20	158	11
USA	639.36	21.98	1819	8
total	2130.1		7230	8

* The total includes the data from Taiwan..
Ref.: IAEA, Press Release PR 95/9, 26.4.1995