REPUBLIC OF SLOVENIA
MINISTRY OF THE ENVIRONMENT AND SPATIAL PLANNING
SLOVENIAN NUCLEAR SAFETY ADMINISTRATION

Annual Report 2010 on Radiation and Nuclear Safety in the Republic of Slovenia

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June 2011

Prepared by the **Slovenian Nuclear Safety Administration** in cooperation with:

Slovenian Radiation Protection Administration,
Administration of the Republic of Slovenia for Civil Protection and Disaster Relief,
Ministry of the Economy,
Ministry of Agriculture, Forestry and Food,
Ministry of the Interior,
Agency for Radwaste Management,
Nuclear Pool GIZ,
Financial Fund for Decommissioning of the Nuclear Power Plant Krško,
Krško Nuclear Power Plant,
Jožef Stefan Institute and
Institute of Occupational Safety.

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Summary

In 2010, there were no events that posed a serious radiological threat to the population in Slovenia. There were also no particularities in relation to the services of radiation practices and operators of radiation facilities.

The Krško NPP operated without shutdowns and production was interrupted only for the annual outage. In 2010, the power plant produced 5.7 TWh in total and achieved 89.9% availability. The nuclear power plant had no major problems during the September floods, when the Sava river otherwise seriously threatened settlements in Posavje.

In the special laboratory, Hot Cell, which is part of the Jožef Stefan Reactor Infrastructure Centre in Brinje near Ljubljana, there was a slight fire in October. This was quickly extinguished by employees, and no radioactive discharges into the environment resulted.

In the former Žirovski Vrh uranium mine, the remediation of the Boršt mill tailing is still in process. It was prolonged due to additional works on the decontamination of areas near the tailing and reactivation of the landslide on which the tailings depository is situated. Ambient radiation is reducing each year because of the successful remediation.

The siting of the future repository for low- and intermediate-level waste in Vrbina near Krško was carried out very slowly. Unfortunately, the planned date of commencement of its operation is moving forward.

In November, a shipment of spent nuclear fuel was in transit through Slovenia from Serbia to Russia, and no difficulties were encountered. With this transit, several years of assistance offered by Slovenia to the international community in solving this shipment problem reached a successful conclusion.

The National Assembly of the Republic of Slovenia adopted a new Law on Liability for Nuclear Damage, with which Slovenia joined the list of countries with the best arrangements in this area.

The Slovenian Government has adopted an updated National Plan for Protection and Rescue in case of nuclear or radiological accident, in which improvements have been introduced on the basis of incidents in the past and international experience.

In August 2010, Slovenia applied for admission to the Nuclear Energy Agency (NEA), after it became a full member of the Organization for Economic Cooperation and Development (OECD).

The Slovenian Nuclear Safety Administration concluded an agreement with the Italian authorities for nuclear safety on early exchange of information in case of radiological emergency and cooperation in the field of nuclear safety. With this, Slovenia has concluded such agreements with all neighbouring countries.

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1 INTRODUCTION

This report is prepared annually in accordance with the provisions of the Ionizing Radiation Protection and Nuclear Safety Act. It has been issued since 1985 and summarizes all events in connection with ionizing radiation protection and nuclear safety for the previous year. The report is accepted by the Slovenian Government and is thereafter send to the National Assembly of Republic of Slovenia. It also represents the main way of communicating recent developments in the area of ionizing radiation protection and nuclear safety to the general public. This English version is the essential publication for the presentation of these activities in Slovenia to the international public.

In creating the report, the Slovenian Nuclear Safety Administration (SNSA) has the role of moderator, while content is also provided by other state bodies whose competences include ionizing radiation protection and nuclear safety, as well as other institutions in this area. Of these, the principal are the Slovenian Radiation Protection Administration (SRPA), the Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (ACPRD), the Ministry of the Economy, the Ministry of the Interior, the Ministry of Agriculture, Forestry and Food, the Agency for Radwaste Management (ARAO), the Nuclear Insurance and Reinsurance Pool, the Krško Nuclear Power Plant (Krško NPP), the Jožef Stefan Institute (JSI), the Institute of Occupational Safety (IOS), and the Fund for Financing Decommissioning of the Krško Nuclear Power Plant and Disposal of Radioactive Waste from the Krško NPP.

Together with this report, which is aimed at a wider interested public, an extended version in Slovene has been prepared. The extended report includes all details and data which might be of interest to the narrower group of professionals. It is available on the SNSA web page at http://www.ursjv.gov.si.

2 OPERATIONAL SAFETY

2.1 Operation of Nuclear Facilities

2.1.1 Krško Nuclear Power Plant

Operation and Performance Indicators

In 2010, the Krško Nuclear Power Plant (Krško NPP) produced 5,656,971.2 MWh (5.7 TWh) gross electrical energy on the output of the generator, which corresponds to 5,380,708.7 MWh net electrical energy delivered to the grid.

The Slovenian Nuclear Safety Administration (SNSA) performed 51 planned inspections in the Krško NPP, of which two were not announced. There were no unplanned inspections.

In general, the SNSA inspections established that the NPP operated safely without incidents which might pose a threat to the general public or the environment. The SNSA also assessed that the works carried out during a refuelling period were mostly performed professionally and in accordance with the high standards of radiation and nuclear safety expected. Nevertheless, in certain areas, such high standards were not achieved, and during on-site inspections the inspection team issued 55 requests related to irregularities found at the Krško NPP. Among these irregularities, 47 have already been addressed and 2 of them were delayed in 2010. The terms for the last 6 have not expired. The SNSA requires explanations for the delays.

The most important irregularities in the Krško NPP that the inspection team dealt with were as follows:

- the operator started works on the modification of seismic instrumentation which were planned to be implemented during the 2010 refuelling outage one month before the outage started, this before gaining authorisation from the SNSA. The SNSA inspector suppressed the works on the modification until such time as the SNSA issued an authorisation.
- The "Erection of Neutron Detectors" modification outside the reactor vessel was implemented in a different way from that approved in the authorisation issued by the SNSA. The operator was warned by the inspector that the authorisation had been violated. The operator was also warned to include contingency plans in the application for a modification approval.
- The Krško NPP did not inform the SNSA about a planned import of contaminated equipment by a Croatian contractor as is required under the terms of the SNSA permission on multiple import or export of contaminated equipment for use in controlled areas of the NPP. The reason for this discrepancy was improper communication between the NPP an the contractor. The Krško NPP has been obliged to implement suitable preventive actions to prevent a similar inconsistency being repeated.

Based on inspection reviews realized in 2010, the SNSA concludes that the operation of the Krško NPP in 2010 was safe, without significant incidents that could affect population or environment. The work of most of the NPP's organization units in 2010 was judged by SNSA inspectors to be good. The level of safety culture was found to be very high for most of the NPP's experts. This is reflected in the quality of performed activities where safety is considered a priority and in identifying possible difficulties based on operation experience and implementing of suitable corrective actions.

Comprehensive inspection of the Krško NPP during the 2010 outage showed that most jobs and tasks were carried out fully and well. Some deviations, however, have not been fully resolved, though these do not affect operational safety. The number of identified events and deviations compared to previous outages has not decreased. The reasons for this are human errors, high staff workload, aging and wear of equipment, and deficiencies in the preparation of certain modifications.

Based on the findings of inspections carried out in 2010 and earlier, the Krško NPP should seek improvements primarily in the preparation and implementation of design changes and the approach to the process of their approval by the administrative authority, as in these areas there was some minor violation during almost any outage.

In the field of radiation protection of exposed workers, the Krško NPP is also supervised by the Slovenian Radiation Protection Administration (SRPA). In 2010, the SRPA performed 4 inspection surveys relating to evaluation of the protection of exposed workers against radiation, listing of sealed sources, radiation protection operating procedures, planned releases of noble gases, preparations for outage, outage follow-up and dose trends analyses and organizational arrangements of the radiation protection unit during outage.

The most important performance indicators of the Krško NPP are shown in Tables 1 and 2, while their changes over time are described in the following parts of this report. The performance indicators confirm stable and safe operation of the power plant.

Table 1: The most important performance indicators in 2010

Safety and performance indicators	Year 2010	Average (1983–2010)
Availability [%]	89.9	86.0
Capacity factor [%]	92.2	83.7
Forced outage factor [%]	0	1.06
Gross realized production [GWh]	5,656.97	4,990.81
Fast shutdowns – automatic [Number of shutdowns]	0	2.57
Fast shutdowns – manual [Number of shutdowns]	0	0.14
Unplanned normal shutdowns [Number of shutdowns]	0	0.86
Planned normal shutdowns [Number of shutdowns]	1	0.83
Event reports [Number of reports]	3	4.5
Refuelling outage duration [Days]	36.8	45.6
Fuel reliability indicator (FRI) [GBq/m^3]	$3.70 \cdot 10^{-5}$	$7.28 \cdot 10^{-2}$

Table 2: Time analysis of Krško NPP operation in 2010

Time analysis of production	Hours	Percentage
Number of hours in a year	8,760	100
Duration of plant operation (on grid)	7,877	89.92
Duration of shutdowns	883	10.08
Duration of the refuelling outage	883	10.08
Duration of planned shutdowns	883	10.08
Duration of unplanned shutdowns	0	0

The operation of the Krško NPP in 2010 is shown in Figure 1. It can be seen that the operation of the power plant was stable. The plant had one shutdown for the regular refuelling outage. It operated at reduced power in January in accordance with the annual plan and due to the adjustment of the Circulating Water System pumps. There were no unplanned shutdowns.

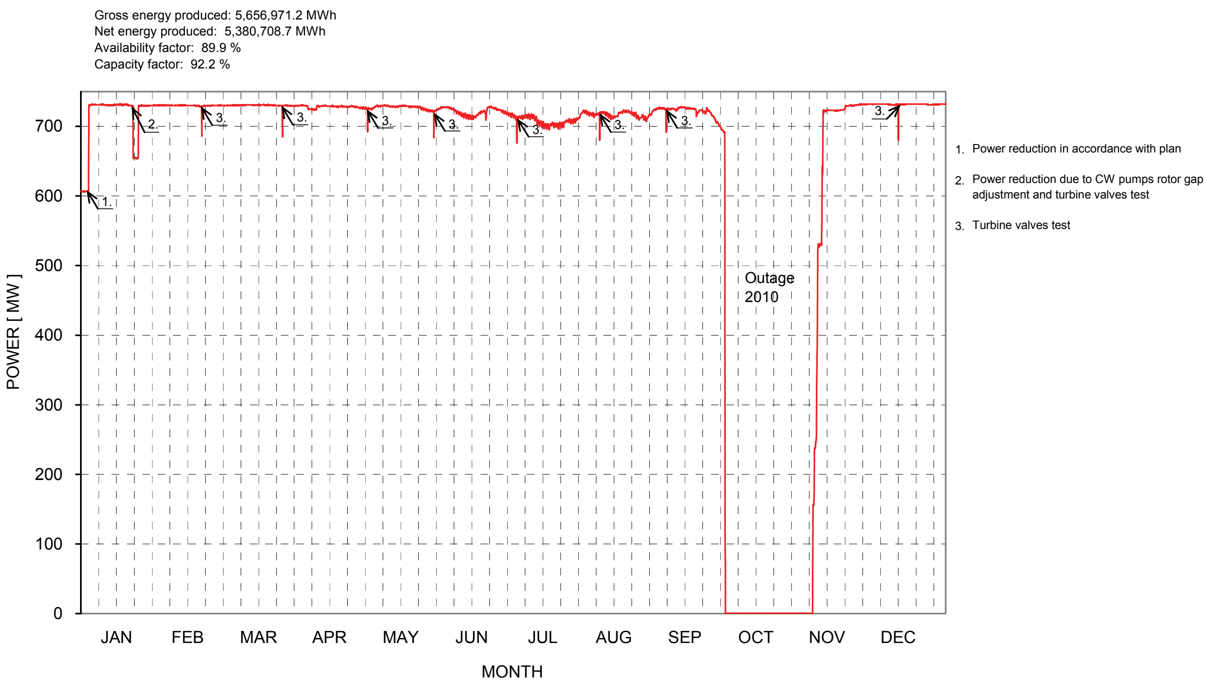

Figure 1: Operating power diagram for the Krško NPP in 2010

In Figures 2 and 3, the number of reactor shutdowns is shown.

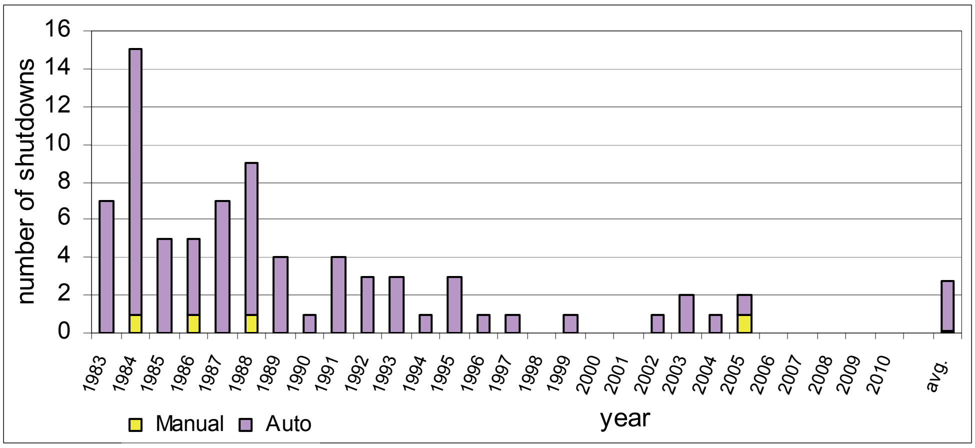

Figure 2: Fast reactor shutdowns – manual and automatic

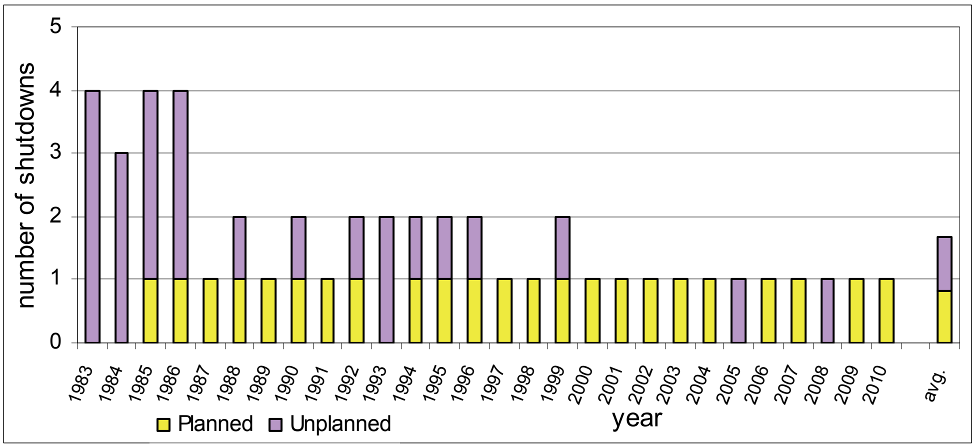

Figure 3: Normal reactor shutdowns – planned and unplanned

There are two types of reactor shutdowns, fast and normal. Fast reactor shutdowns are caused by the reactor protection system actuation, which can be activated manually or automatically. During normal reactor shutdowns, the reactor power reduces gradually. Normal shutdowns are divided into planned and unplanned. Outage is a special type of normal, planned gradual shutdown of a reactor.

Figure 4 shows the number of unplanned actuations of the high pressure injection system, which actuates automatically on low pressure in the primary or secondary cooling systems, on high pressure in the containment, or manually. In 2010, there were no unplanned actuations of this system, so the total number of actuations since the start of commercial operation remains at 10.

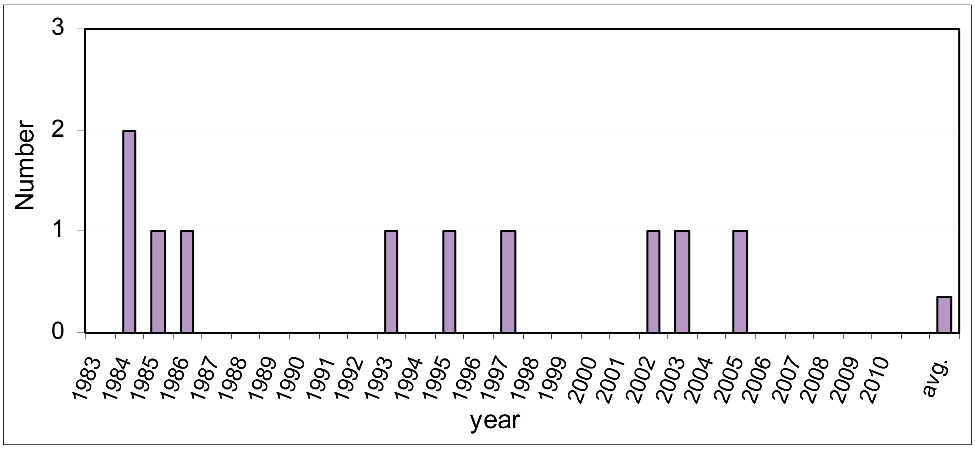

Figure 4: Number of unplanned safety injection system actuations

In Figure 5, the forced outage factor is shown. The factor is a ratio between the hours of duration of unplanned shutdowns and the number of hours in a year. In 2010, there were no unplanned shutdowns, thus this factor has a value of 0%.

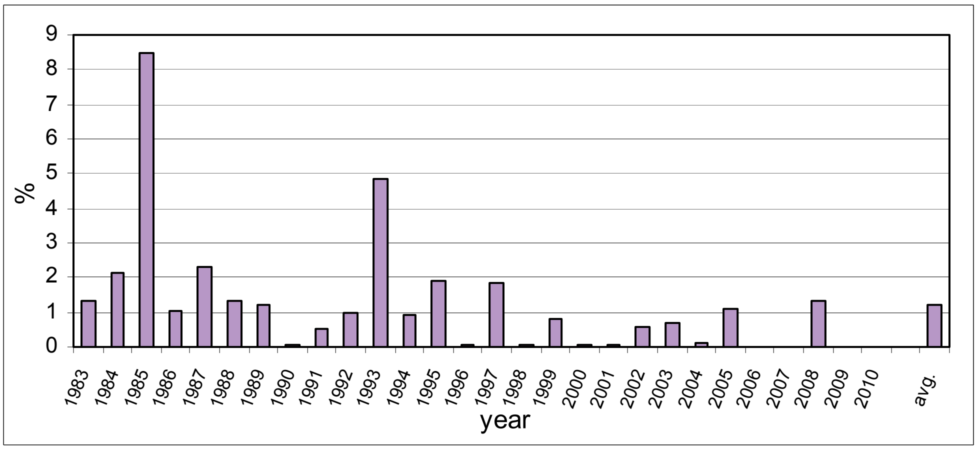

Figure 5: Forced outage factor

The collective exposure to radiation is shown in Figure 6. The low value of this factor indicates the high efficiency of radiation exposure control measures. Its value in 2010 is 851 man mSv. This factor has a higher value than in the previous two years due to additional activities which were performed during the outage (sludge lancing and other works in the steam generators, maintenance of reactor cooling systems and erection of a new construction platform in the reactor building).

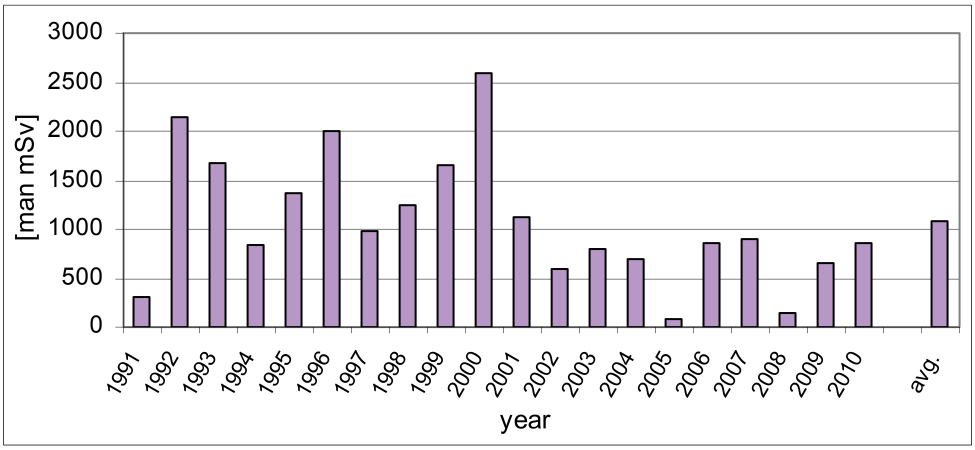

Figure 6: Collective exposure to radiation in the Krško NPP

Figure 7 presents data on the different means of electrical energy production in Slovenia, specifically the production in nuclear, hydro and thermal power plants. In 2010, the production of electrical energy exceeded 14 TWh for the third consecutive year, mostly due to favourable meteorological conditions, but also on account of the stable operation of the Krško NPP.

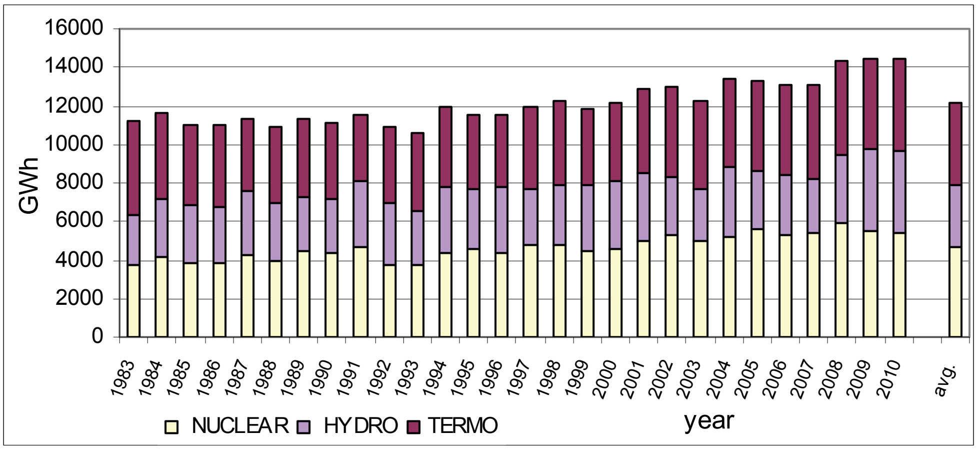

Figure 7: Production of electrical energy in Slovenia

Regulatory Oversight through Safety and Performance Indicators

At the end of 2007, the SNSA introduced its own set of safety and performance indicators (hereinafter SPI) to the surveillance of Krško NPP operations. In 2010, the set of SPI numbered 38. These include the changes of the SNSA thresholds for warnings and alarms. The Krško NPP has enough time to implement corrective measures before SNSA warning or alarm limits for the parameters are reached and consecutively increased regulatory inspection is enforced.

The SNSA sends monthly reports to the Krško NPP about indicators status and if necessary conducts thematic inspection.

Abnormal Events in the Krško NPP

Event reporting is defined by the Rules on Operational Safety of Radiation or Nuclear Facilities, which in Appendix Six lists events which have to specially reported by the operator of nuclear power plants. In 2010, the Krško NPP, in accordance with the above Rules, reported three events; none of these jeopardized nuclear and radiation safety or required stopping the plant.

All events were looked at by the SNSA, but due to the low safety significance of the events, detailed SNSA analyses were not required.

Trip of auxiliary feedwater pump due to high flow

Workers at the NPP Krško decided to measure the response of the control loop controller with the intention of eliminating periodic fluctuations in flow that occur during testing of the full flow auxiliary feedwater system.

This activity was started on 10 August 2010. In the first phase, in manual mode, the flow of the auxiliary feedwater system in the steam generator was established. The responses of all the parameters were as expected.

In the last phase of the response measurement, the flow into the steam generator in automatic mode was established. After fifteen seconds, due to high flow, a trip of auxiliary feedwater pump no. 1 occurred, resulting in the unavailability of safety train A of the auxiliary feedwater system (safety train B and the third auxiliary feedwater pump were available at all times).

The NEK commenced urgent work to diagnose the controller malfunction. It was found that the cause of the trip of the auxiliary feedwater pump was failure of the control card in the process cabinet. The card was replaced and tested on the same day.

Inoperability of safety trains A and B of the service water system

On 20 September 2010, at the time of September's high flow of the river Sava, safety train A of the service water system was operable. However, due to a failure of the coarse rake on the entry side of this safety train, the entire safety train A subsequently became inoperable. To clean the inlet side of safety train A, the safety train B pump was used. This entailed temporarily moving the flow path line B, which lasted 26 minutes. This situation was the reason for the announcement of inoperability of both safety trains, which is considered an abnormal event.

Multiple activation of false alarms in the seismic monitoring system

On 5 November 2010, the seismic alarm on the panel in the control room was triggered. The alarm was activated in a similar way on 8 November and 12 November 2010. In all cases it was found that these were false seismic alarms.

The Krško NPP investigated the events in detail and carried out analysis of the cause of the false triggering of the alarms. It was found that the seismic system had not been activated and that a seismic event (earthquake) had not occurred. False seismic alarms were activated after restart of the plant following the 2010 outage, suggesting that the possible cause of false seismic alarms was external electromagnetic interference. Optimization of the earthing cables was carried out, since which there have been no further seismic monitoring system alarms.

Preparation for Second Periodic Safety Review

The Krško NPP Periodic Safety Review (PSR 1) was carried out in 2001 to 2005 in accordance with European practice; this gave a good review of the plant's operational and design status and conformed that the plant was as safe as originally intended. This review did not reveal any major safety issue, but it did identify 122 actions to further enhance plant safety. The Krško NPP implemented most of corrective measures by the end of 2010.

The SNSA has allowed an extension of completion date for 28 actions. The decision was taken based on the review of work already accomplished, the status of the tasks, actual conditions and other limitations for completion and implementation of necessary changes. Most of the tasks whose deadlines were extended from the original plan had been mostly completed, lacking only the implementation of changes that will be possible to complete during the outage and refuelling in 2012. Extension of action implementation does not compromise operational safety of the NPP, but completing the planned changes will further improve the safety of the plant.

The 2nd PSR program for the Krško NPP was approved by the SNSA at the beginning of 2010. The review, prioritization and action plan will be completed by the end of 2013. The actions from the action plan will be completed in the next 5 years. In the second half of 2010, the NPP began with the preparation of technical specifications for individual programme tasks. The NEK is intensively working on a new, third revision of compliance with the new regulatory requirements in the U.S.A, the country from which the NPP was supplied. Initiation of a safety factors review according to the programme will start at the beginning of 2011.

Long-term operation of the Krško NPP

The Krško NPP should change their design bases to secure long-term operation after 2023. In 2009, the NPP requested the approval of its ageing management programme for systems and components. Implementing this programme is one of the prerequisites for the long-term operation of the plant. The Krško NPP suggested changes in safety documentation to match the assumption of the plant operating for 60 years. Comprehensive documentation was enclosed with the application, along with the detailed explanation of the Krško NPP's approach to ageing management and analyses.

An international group of experts has reviewed the submitted documentation and issued a positive expert opinion. The SNSA will review and assess the documentation and also the situation in the power plant in 2011. It will then consider the approval of the programme according to its findings. The possible extension of operation will depend on the owners of the plant and on successfully passing periodic safety reviews in 2013 and 2023.

Nuclear Fuel Integrity, Reactor Coolant Activities and Fuel Elements Inspections

The year 2010 comprised part of fuel cycle 24, which started on 2 May 2009 and ended on 30 September 2010 with the refuelling outage, and part of cycle 25, which started after the outage on 31 October 2010. Cycle 25 will last 18 months until the refuelling outage in April 2012.

The condition of fuel assemblies in the reactor (fuel cladding integrity) is monitored indirectly through measurements of specific properties of the reactor coolant. Fuel damage is indicated by isotopes of xenon, krypton and iodine. The level of fuel damage and contamination of the coolant can be determined from measuring iodine isotopes. There was no fuel rod leakage in the core in cycle 24, and by the end of 2010 there had been no fuel rod leakage in the core in cycle 25.

Fuel integrity is monitored by the Fuel Reliability Indicator (FRI), which shows fuel leakage and is used for comparison with nuclear power plants around the world. FRI values are determined from the specific activities of ^{131}I and ^{134}I and are normalized to a constant value of the reactor coolant purification rate. A FRI value below $2 \cdot 10^{-2}$ GBq/m³ represents fuel with no damage according to an internationally adopted criterion. The FRI values of $3.7 \cdot 10^{-5}$ GBq/m³ that were determined in fuel cycles 24 and 25 are the lowest possible and show good fuel rod integrity. The FRI values for last five fuel cycles are shown in Figure 8.

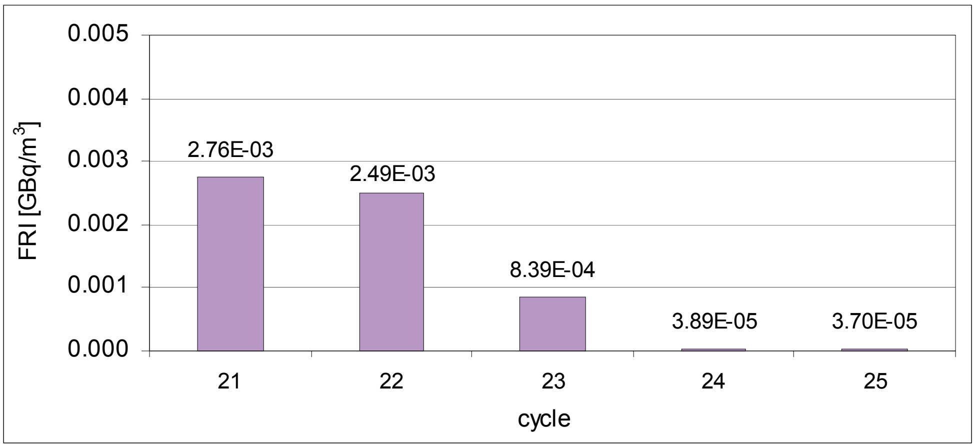

Figure 8: Fuel Reliability Indicator (FRI) values for last five fuel cycles

Refuelling Outage

A refuelling outage took place from 30 September till 5 November 2010. In the 24th fuel cycle plant operation was reliable. There were no major problems with the equipment, which is the result of well planned and carried out outage activities in 2009 and activities during plant operation.

The main activities during this year's outage were changing 56 fuel assemblies, preventative inspections, maintenance activities, and modifications and modernization of systems and equipment, prominent among which was the replacement of the electrical generator stator. There were 39 improvements in total, including pressurizer structural weld overlays, strong motion seismic system retrofit and ex-vessel neutron dosimetry system setup. In the field of preventive maintenance, inspection and renewal of secondary pipelines, switching equipment, pumps, motor drives and valves were important. Due to wear, the replacement of 125 V DC batteries on safety line B was carried out. There was an outage of the main generator BBC switch and replacement of the electromotor of reactor pump no. 2 with a refurbished spare electromotor. In accordance with the ten-year programme of in-service inspection for the period from 2002 to 2012, there was inspection of the reactor vessel, visual inspection of the bottom of the reactor vessel from the outside, and visual inspection of the lower fuel cartridge of the reactor vessel.

The entire length of the outage was 36 days and 17 hours, which is 134 hours more than planned. The main contributions to the delay were problems with the main generator rotor, vibration on the auxiliary feedwater pumps and problems with the temperature in the turbine bearing.

During the outage, virtually all the major planned works were completed, and needs for additional or increased volume of work were identified. Events or larger deviations were mostly eliminated successfully. Restarting the plant in the 25th fuel cycle, no major unresolved issues were transmitted into the next outage or the plant operation. Nevertheless, some technical problems are present which are not fully resolved, and there will be appropriate solutions for these prepared in the next fuel cycle, which will be implemented during the next outage. Faults are noted on the main generator rotor, in some actions from the action programme of the first periodic review, in the incomplete range of ultrasonic inspection of the reactor vessel, in the low capacity of 125 V DC batteries and in obsolete power cables. These pending activities or open issues have no significant direct impact on safety, but the possibility is not entirely excluded that there will be further deterioration, which could create the conditions for operational and partly also safety difficulties.

Problems and deviations from plans that occurred during the outage show that more attention should be given to checking of the actual status of systems and components, with the aim of timely detecting of deviations and anomalies. This is a prerequisite for the more real planning of outages, timely purchase of equipment and spare parts, and so on. However, it must also be noted that the outage was successful and that activities were well planned and professionally performed.

Modifications in the Krško NPP

According to the Ionizing Radiation Protection and Nuclear Safety Act (paragraph 83), the SNSA approved 8 modifications and agreed to 35 modifications. During the preliminary safety evaluation, the Krško NPP found out that there was no open safety issue for 33 modifications. Therefore the NPP only informed the SNSA about the changes. There were 7 implemented modifications to which the SNSA agreed or that were approved in previous years and 16 temporary modifications. In 2010, the Krško NPP issued the 17th revision of the Updated Safety Analysis Report, considering all modifications confirmed until 22 December 2010.

High river flow in September

During floods in September that occurred in most of Slovenia, the level of the Sava river rose fast on the 17th. When the Sava river flow at the Krško NPP reached 2,792 m^3/s and the river level reached 154.1 meters, on 18 September at 23:58, the Krško NPP announced an emergency of the lowest level, that is an unusual event. The plant staff controlled the conditions on the Sava river, while the plant was able to continue with power operation. The Krško NPP regularly reported to the SNSA on the emergency. The highest flow at the NPP during the emergency reached 3,155 m^3/s on 19 September at noon. When the Sava river flow and level decreased below the criteria for an emergency, on 19 September at 23:01, the plant ended the emergency and continued with normal operation.

External influences on the operational safety of the Krško NPP

In 2010, several spatial plans, projects for acquiring building permits and studies were prepared in parallel. It was necessary to coordinate these projects with each other and to take into account the results of studies or technical bases. The project for the Brežice HPP had to be adapted because of its influence on the Krško NPP. The road from Krško to Brežice on the flood protection dyke of the Krško NPP had to be adapted with the projects for the upgrade of the dyke and the new bridge across the river Sava in Krško. Other important external influences on the Krško NPP in 2010 were the construction of a new Krško HPP, the preparation of spatial plans for the Mokrice HPP and Feniks economic centre, and the preparation of the Krško municipality spatial plan.

National spatial plan for the Brežice HPP

The most important influence on the Krško NPP will be the construction of a new Brežice HPP, because of raised level of the Sava river at the Krško NPP, and planned construction of new energetic levees along the Sava river banks. In January 2010, the Krško NPP delivered an independent study of influences of the Brežice HPP on nuclear safety, systems and operation of the Krško NPP, which included recommendations for preparation of additional analyses on impacts on the mechanical equipment of the NPP, on the levels of groundwater, on the warming up of the Sava river and on Krško NPP operations. The investor in the Brežice HPP commissioned a study on the corrective measures of the HPP impacts on the NPP, along with an expert opinion on the impacts on the safety of the NPP. Implementation of measures for mitigation of the HPP impacts on the NPP should be implemented during the refuelling outages in 2012, 2013 and 2015. The study and the expert opinion will be completed in 2011. Experts will also review the implementation of SNSA guidelines for the preparation of a national spatial plan for the Brežice HPP.

National spatial plan for the HPP Mokrice

In January 2010, the SNSA issued guidelines for preparation of a national spatial plan for the Mokrice HPP. The guidelines specified conditions for flood protection of the Krško NPP and for measurement points and sampling points for monitoring NPP emissions into the environment. The guidelines also included recommendations by the Krško NPP concerning the influences on the area's flood protection and seismic stability.

National spatial plan for the connecting road from Krško to Brežice

A planned connecting road from Krško to Brežice that lies within the area of limited use around the Krško NPP has an important impact to the nuclear safety of the NPP. The road also influences the flood protection of the NPP, since a part of its route runs over the NPP flood protection dykes along the Sava river. In January 2010, the Krško NPP provided data for the elevation of protection against the probable maximum flood and for the required elevation of two bridges across the Potočnica stream and the Sava river in Krško. In October 2010, the SNSA issued an amendment to the guidelines for the national spatial plan for the road from Krško to Brežice, with detailed conditions for the construction of the road on the Krško NPP flood protection dykes according to the project for the dykes' upgrade.

Other spatial plans

In August 2010, the SNSA issued a positive opinion on the national spatial plan for construction of the Feniks economic centre in Posavje, since the SNSA guidelines have been taken into account appropriately.

In December 2010, the SNSA issued guidelines for a Krško municipality draft spatial plan. The spatial plan anticipates encroachments into the area of limited use around the Krško NPP and influences the safety analyses of the NPP. The SNSA guidelines determine the conditions for flood protection, for impacts on the Krško NPP radiological emergency response plan, for planned industrial activities and energetics, and for the planned Radwaste repository and the site of possible new NPP at Krško.

Flooding hazard studies and upgrade of the Krško NPP flood protection

Analyses of probable maximum flood have shown that the flows in such a case would exceed the current flood protection of the Krško NPP. Therefore a new study was prepared in 2009 and 2010 to determine the probable maximum flood and to propose a new concept for the Krško NPP flood protection. Based on the flooding hazard studies, including hydrologic and hydraulic calculations, projects for upgrade of the flood protection dykes along the Potočnica stream and Sava river and for the reconstruction of the road on the flood protection dyke have been prepared. The results of the study were also used as input parameters for the project of a bridge across the Sava river in Krško.

In April 2010, the SNSA issued design conditions that determined the requirements for the seismic design of the dykes, for applying the standards for flood protection facilities, for ensuring the proper safety margin in dyke height, for dyke endurance in case of overflow, for water-tightness of the dykes and for influences to the Krško NPP in the course of construction works. Projects for acquiring the necessary building permits were prepared and the SNSA issued approvals in June and July 2010. The upgrade of the dykes along the Sava river is foreseen for 2011.

Project for a new bridge across the Sava river in Krško

In July 2010, the SNSA issued design conditions for a new bridge across the Sava river in Krško, including requirements for seismic safety, for ensuring a proper height for sufficient river flow in the case of flood and for project harmonisation with other projects that are planned in this area.

2.1.2 TRIGA Mark II Research Reactor in Brinje

In 2010, the TRIGA research reactor of the Jožef Stefan Institute operated for 106 days and released 139 MWh of heat. The reactor operated only in stationary mode. The TRIGA reactor was mostly used as a neutron source for neutron activation analysis and for educational purposes. A total of 792 samples were irradiated in the carrousel or the channels (624) and in the pneumatic post (168).

In 2010, the hot cell was used for education and to perform a project of treatment and preparation of the radioactive waste of small producers for the Agency for Radwaste Management.

There were six forced shutdowns of the reactor in 2010, four of which during practical exercises and two caused by a disturbance in the fuel temperature monitor. Forced shutdowns during the performance of practical exercises were anticipated since they are a part of educational process. The cause of the disturbances in the fuel temperature monitor was a measuring transmitter that has since been repaired.

There were no violations of the operational limits and conditions of the Safety Analysis Report in 2010, and there were no modifications of the Safety Analysis Report for the TRIGA reactor.

Operational indicators for the collective dose of operators and experimenters reached are far below the regulatory limits. The collective dose was 42 man μSv for operators and 161 man μSv for the personnel that performed works at the reactor (operators, radiation protection service and experimenters).

In 2010, a total of 84 fuel elements were located on the reactor site. There were no spent fuel elements. All fuel elements were of the standard type with 12 percent of uranium content and 20 percent enrichment. The radiation monitoring system in the reactor building and the reactor coolant activity measurements showed that there were no leaking fuel elements. The institute reported monthly on the fuel balance with a special form to Euratom and the SNSA.

In 2010, a new worker was employed who shall in future perform the duties of TRIGA reactor operator. In 2010 he started a qualification course to gain an operator’s licence.

Regular periodic examinations and control of important systems, structures and components showed that these are adequate. Based on recommendations for improvements and refurbishments, in 2010 the following modifications were implemented: reconstruction of the ventilation system of the reactor hall and reactor control room, reconstruction of the main control point of entrance of staff to the reactor’s controlled area, and replacement of all valves of the external water supply network from the water tower to the reactor hall.

The reactor management prepared a programme for a periodic safety review of the TRIGA reactor.

Report of an emergency

On 17 October 2010 in a special dryer located in the hot cell facility, a small fire started that was extinguished by the staff. At the time of the fire, a project of treatment and preparation of radioactive waste for the Agency for Radwaste Management was in course. The cause of fire was a failure of the dryer sterilizer that was used for solidification of liquid radioactive waste. As a result of the fire, there was a local contamination with uranium of part of a room in the hot cell facility, but there were no radioactive releases to the environment. The fire did not threaten the reactor. Using appropriate protection equipment prevented the contamination of staff or spread of contamination out of the rooms where the event occurred. The event was classified as a level 1 event according to the INES scale, based on the criteria for such fires where small and intermediate radioactive waste is burnt.

Following notification on the emergency from the institute, the SNSA inspected the facility. The institute later delivered to the SNSA a report on the event which included a root cause analysis. The report determined several causes that contributed to the emergency occurrence, linked to inappropriate equipment and wrong assessment of fire hazard, emergency actions and preparations of notes on the emergency. The institute also prepared an action plan for corrective measures to review the event, mitigation of the emergency consequences and suppression of the causes. The decontamination of the facility was performed by the institute staff by 27 October 2010 and resulted in three barrels of radioactive waste.

2.1.3 The Central Storage for Radioactive Waste at Brinje

The Central Storage for Radioactive Waste at Brinje (CSRW) is operated by the Agency for Radwaste Management (ARAO).

In 2010, special attention was given to assurance and implementation of operational and maintenance works, modernization of equipment and preparation of the basis for a unified method of storage which will consider existing ground floor capacity, external packaging of the radioactive waste packages and the possibility to access and verify the radioactive waste packages as defined by the Rules on Radioactive Waste and Spent Fuel Management.

Among the most important improvements, there were maintenance works on the system for fire detection, notification and alarming (Figure 9). The project basis for upgrade of existing storage method was prepared, enabling larger utilisation of storage area and uniformity of the storage system.

Figure 9: New independent fire alarm, located in the storage entrance hall

In 2010, solidification of liquid radioactive waste was performed. Implementation of these works was carried out in cooperation with the Jožef Stefan Institute in a room adjacent to the hot cell. Spent ion exchange resins were treated with drying procedures. Figure 10 presents the first phase of the drying procedure – filtration of spent ion exchange resins.

Figure 10: Filtration of spent ion exchange resins

Newly produced packages meet waste acceptance criteria for storage, while their overall volume has reduced to approximately half. With the introduction of a technology for processing radioactive waste for storage, a platform to sign the contract between the ARAO and the Jožef Stefan Institute on the common use of a hot cell object was prepared.

In a framework of a bilateral programme on cooperation with the Belgian government, a project entitled "The Management of Medical Radioactive Waste in Slovenia", in which Belgian experts from the IRE and Leniko companies cooperated, was completed. The purpose of the project was to review the formation and management of waste produced by the use of radioactive material in medicine.

The ARAO reported on the waste stored to the Central Registry of Radioactive Waste (CERAO), which is maintained by the SNSA. The ARAO maintains the system for accountancy and the control of nuclear material and regularly reports to the European Commission (EURATOM) in Luxembourg, which carries out a safeguard inspection of the nuclear material stored in Central Storage together with the IAEA.

In 2010, the ARAO accepted into the CSRW the radioactive waste from 60 generators. There were 27 packages of solid wastes, 15 packages containing sealed sources, and 60 packages containing spent ionization smoke detectors (Figure 11). The total volume of the waste was 6.3 m^3. At the end of 2010, there were 629 packaging units: 399 packages of solid wastes, 114 packages with sealed sources and 116 packages with ionization smoke detectors. At the end of 2010, the total activity of the 86.4 m^3 waste stored is estimated at 3.2 TBq.

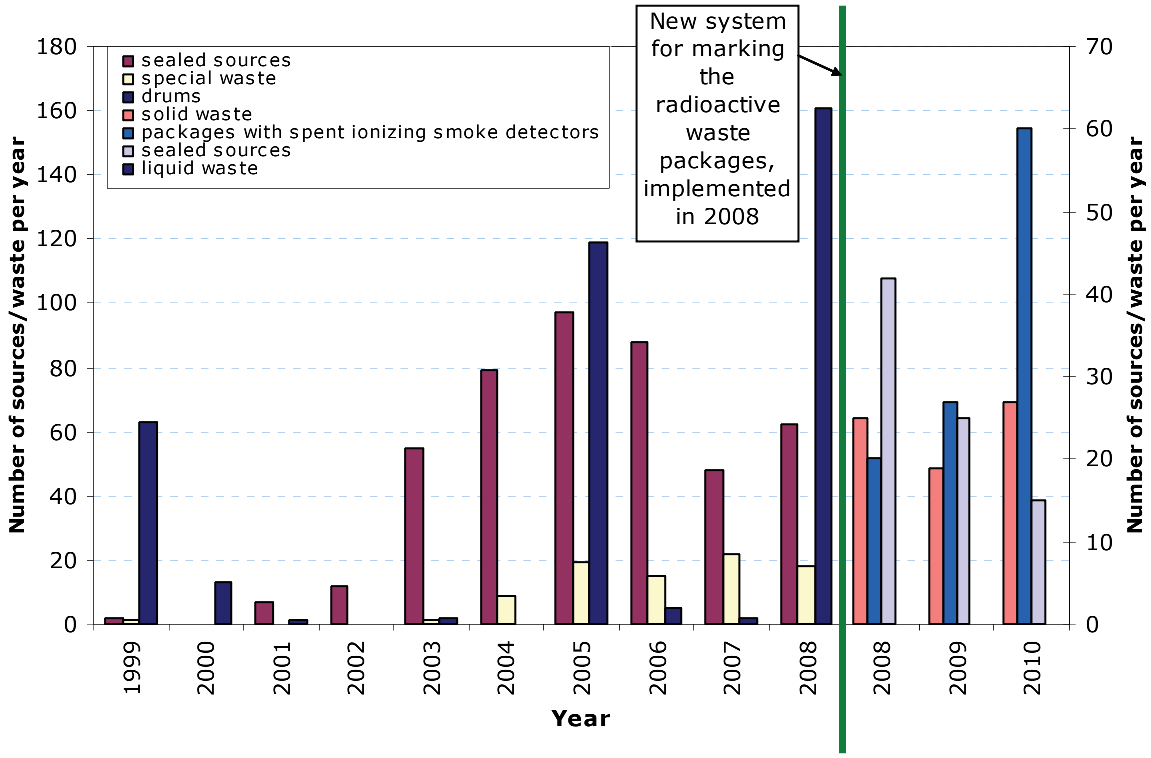

Figure 11: Types and quantities of radioactive waste annually accepted in the Central Storage at Brinje

Notes:

- In 2001, 1 drum was accepted as a result of repacking of radium sources.
- In 2003, 2 drums were accepted as a result of repacking of cobalt sources.
- In 2005, 95 drums were accepted as a result of the Phare project "Characterization of Institutional Low and Intermediate Level Radioactive Waste in the Central Storage Facility for Waste from Small Producers in Slovenia at Brinje"; 24 drums were accepted from other users.
- In 2008, 154 drums were accepted as a result of the project "Improvement of the Management of Institutional Radioactive Waste in Slovenia" and 7 drums were accepted from other users.
- In 2008, the new system for marking the radioactive waste packages was implemented. For easier comparison of the distribution of the accepted waste packages, the figure presents the distribution of the waste packages accepted in 2008 as shown by both old and new marking systems.

2.2 Radiation Practices and the Use of Sources

The Ionizing Radiation Protection and Nuclear Safety Act stipulates advanced notification of intention to carry out radiation practice or intended use of a radiation source, the evaluation of radiation exposure of workers and a mandatory licence to carry out a radiation practice and a licence for use of a radiation source. The competent authority for licensing in an area of industry and research is the SNSA, while in an area of medicine and veterinary medicine the competent authority is the Slovenian Radiation Protection Administration (SRPA).

One of the licensing documents is an evaluation of radiation exposure of workers, which has to be approved by the SRPA. In the document, the nature and extent of radiation risk for exposed workers, apprentices and students are assessed in advance. In addition, based on this assessment, a programme for optimization of radiation protection measures in all working conditions is made. The document must be prepared by the applicant, who is obliged to consult an authorized radiation protection expert. The assessment can also be prepared by an authorized expert in this field. In 2010, the SRPA approved 219 assessments. Authorized radiation protection experts perform examination of radiation sources according to the legislation. In 2010, the Institute of Occupational Safety examined a total of 1,252 radiation sources (799 in medicine and veterinary medicine and 453 in industry and research), while the Jožef Stefan Institute examined 14 radiation sources.

2.2.1 Use of Ionizing Sources in Industry and Research

In 2010, 47 licences to carry out radiation practices, 79 licences for the use of a radiation source, 2 certificates of registration of radiation sources and 11 approvals to the external operators of radiation practices were issued by the SNSA.

At the end of 2010, 102 organizations in industry, research and state administration in the Republic of Slovenia were using 209 X-ray devices, most of them for cargo and luggage inspection; 1,093 sealed sources were used in 88 organizations, mostly for the calibration and testing of instruments; and 41 sources stored at 18 organizations were to be handed over to the ARAO. The users will retain 13 empty shielding containers with depleted uranium. The distribution of application of radioactive sources according to their purpose and mode of use, excluding X-ray devices and ionization smoke detectors, is shown in Figure 12.

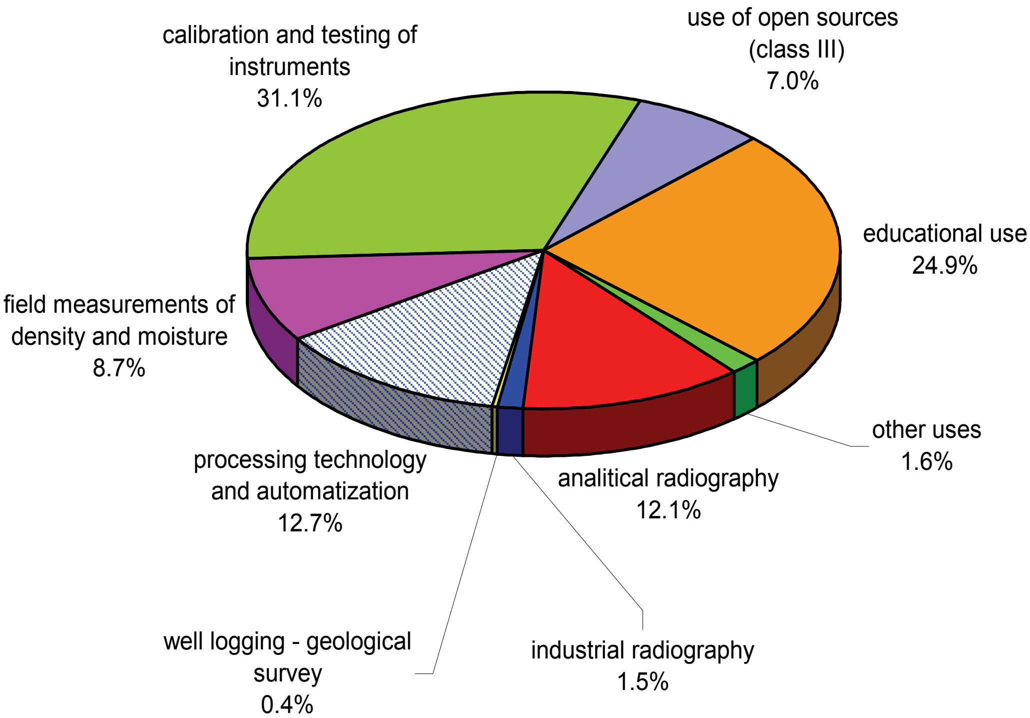

Figure 12: Distribution of application of radioactive sources according to their purpose and mode of use

According to the registry of radiation sources, there were 28,760 ionization smoke detectors used at 313 organizations by the end of 2010. In addition, 13,345 ionization smoke detectors were stored at users' premises, most of them at a company dealing with systems for early fire detection and alarm.

The SNSA has put a lot of effort in the last few years into registering all ionization smoke detectors, and now calls on all users to notify their use. The success of this effort can be seen in the increasing number of detectors registered and of those transferred to the Central Storage Facility for radioactive waste. 3,752 ionization smoke detectors were newly registered by the SNSA in 2010, among them 2,925 still in use. Based on the analysis, 13 proposals for inspections were given. Increased activities in this area will continue in 2011.

Inspection Control of Radiation Sources

In 2010, altogether 35 regular inspections, one ad hoc inspection, and 20 interventions at 49 organizations or institutions were performed by the SNSA Inspectorate. A series of inspections intended for identification of objects that users do not recognize as radiation sources continued. Among the organizations where an inspection was carried out, there were a few that provide radioactivity measurements of secondary metal raw material shipments. At the latter, the inspection found in some cases that there were no properly arranged statuses for the use of X-ray spectroscopy devices and that the producer instructions on the calibration of such devices were not being followed.

No major violations were found during the SNSA inspections. Most of the deviations related to safety culture, implementation of safety measures while using high activity sources and record keeping. In a few cases, the licensees did not have proper written procedures for the use of sources or, especially, for emergency situations. In addition, some deviations and inconsistency in marking of radiation sources still appear.

The SNSA inspections systematically inspected organizations that were commercially involved with servicing of ionization smoke detectors. The SNSA found that in the past, when control over ionization smoke detectors was not sufficient, many organizations performed their dismantling and preparation of radioactive waste without sufficient safety measures or approvals. It was also discovered that some organizations stored disused smoke detectors and did not transfer them to the Central Storage Facility by the defined deadline. This was often related to the high costs of acceptance of the waste by the ARAO.

During SNSA inspections of the Slovenian Museum of Natural History and the National Museum of Slovenia, many objects, mainly minerals and stones, with elevated dose rate on contact were identified, posing an unacceptable risk of exposure to the public and contamination of the environment. A part of a mastodon tusk with enhanced concentration of natural radionuclides found in the Slovenian Museum of Natural History is shown in Figure 13. The inspection also dealt with a finding of smoke detectors in a scrap metal cargo, a contamination with tritium and a use of a mobile X-ray unit without the required licences.

Figure 13: A part of a mastodon tusk with elevated concentration of natural radionuclides found in the Slovenian Museum of Natural History

In 2010 two interventions were related to a transport and a suspicion that a cargo contained a radioactive source. A ^{226}Ra source was identified at the Port of Koper in iron scrap and a ^{232}Th source was identified at Dinos d.d. Ljubljana. In both cases the sources were returned to their country of origin, Bosnia and Herzegovina. In addition, several interventions were carried out where suspicions about breaking the rules on safety measures were not proved. This means that companies are becoming more aware of the special safety measures required when handling ionizing radiation sources or radioactive waste.

During the summer, interventions were also triggered by a newly installed portal monitor at the Snaga d.o.o. waste facility at Barje in Ljubljana (Figure 14). These were related to radioactive waste from hospitals in Ljubljana. With the cooperation of the Slovenian Radiation Protection Administration, a systematic solution for handling such waste was put in place (see also following chapters).

Figure 14: Portal monitors at Barje waste facility

2.2.2 Use of Radiation Sources in Medicine and Veterinary Medicine

X-ray Devices in Medicine and Veterinary Medicine

According to data from the register of the Slovenian Radiation Protection Administration (SRPA), 858 X-ray devices were used in medicine and veterinary medicine by the end of 2010. The categorization of the X-ray devices based on their purpose is given in Table 3.

Table 3: Number of X-ray devices in medicine and veterinary medicine, by purpose

Purpose	Status 2009	New	Written off	Status 2010
Dental	440	41	49	432
Diagnostic	265	24	32	257
Therapeutic	9	1	0	10
Simulator	2	0	1	1
Mammography	35	4	3	36
Computer Tomography CT	29	3	4	28
Densitometers	44	2	2	44
Veterinary	50	7	7	50
Total	**874**	**82**	**98**	**858**

In the use of X-ray devices in medicine and veterinary medicine in 2010, the SRPA granted 134 licences to carry out a radiation practice, 228 licences to use X-ray devices, 156 confirmations of the programmes of radiological procedures, and 143 confirmations of the evaluation of protection of exposed workers against radiation. In medicine, 406 X-ray devices were used in private dispensaries and 402 in public hospitals and institutions. The average age of the X-ray devices was 8.7 years in the public sector (up from 9.4 years in 2009) and 8.3 years in the private sector (up from 8.1 years in 2009). In veterinary medicine, 39 devices were used in private dispensaries and 11 in public institutions. The average age of the X-ray devices was 11.8 years in the public sector and 6.6 years in the private sector. A detailed classification of X-ray devices in medicine and veterinary medicine, according to their ownership, is given in Table 4.

Table 4: Number of X-ray devices in medicine and veterinary medicine, by ownership

Ownership	Diagnostic		Dental		Therapeutic		Veterinary		Total	
	No. (%)	Age (y)	No. (%)	Age (y)	No. (%)	Age (y)	No. (%)	Age (y)	No. (%)	Age (y)
Public	294 (81)	8.7	97 (23)	8.8	11 (100)	8.1	11 (22)	11.8	413 (48)	8.8
Private	71 (19)	8.7	335 (77)	8.2	0	0	39 (78)	6.6	445 (52)	8.1
Total	**365**	**8.7**	**432**	**8.4**	**11**	**8.1**	**50**	**7.8**	**858**	**8.5**

All X-ray devices are examined by approved radiation protection experts at least once a year. The devices are classified, with regard to their quality, into the following groups: "perfect", "service required", "disuse proposed" and "out of order". The analysis of data for recent years is presented in Figure 15. It shows that more than 90% were classified as "perfect devices" in the last five years.

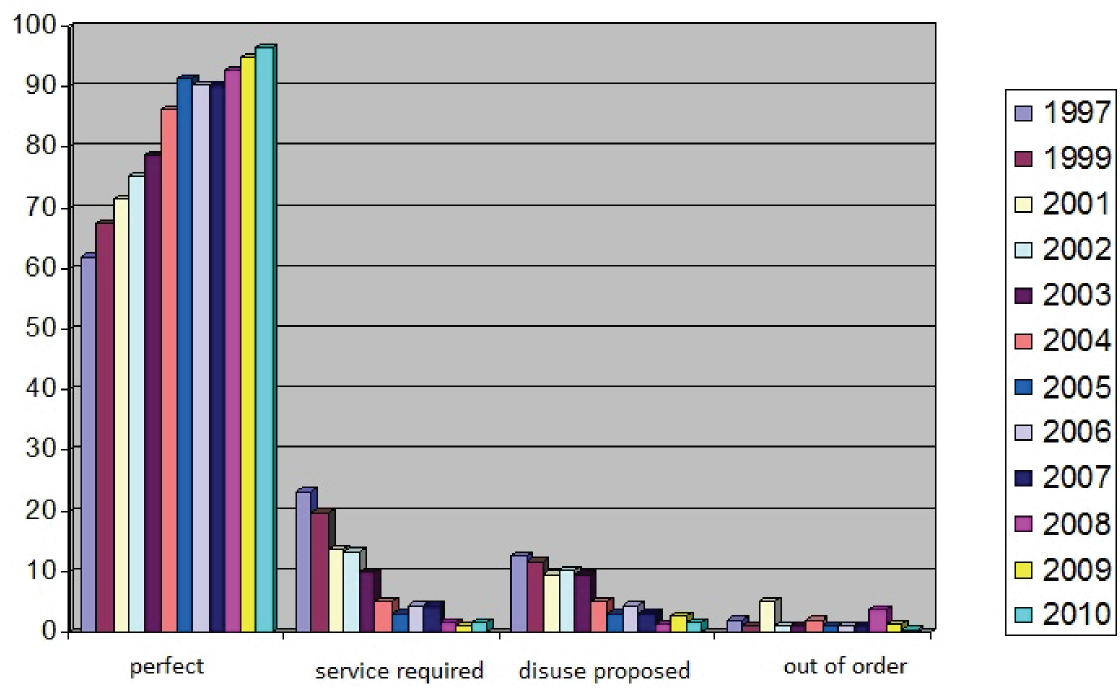

Figure 15: Percentage of diagnostic X-ray devices according to their quality for the period 1997–2010

In 2010, nine in-depth inspections of the use of X-ray devices in medicine and veterinary medicine were carried out. On the basis of the inspection findings, a decision was issued demanding compliance with existing regulations in five cases. One inspection was related to the control of technical adequacy of X-ray devices. In five cases, the inspected devices were sealed to prevent use as a back-up. Two inspections were related to the control of the use of X-ray devices in veterinary medicine. In four out of nine cases the procedure is continuing in 2011.

Unsealed and Sealed Sources in Medicine and Veterinary Medicine

Seven hospitals and clinics in Slovenia use unsealed sources (radiopharmaceuticals) for diagnostics and therapy in nuclear medicine departments: the University Medical Centre Ljubljana's Clinic for Nuclear Medicine, the Institute of Oncology, the University Medical Centre Maribor and the general hospitals in Celje, Izola, Slovenj Gradec and Šempeter near Gorica. In nuclear medicine departments, altogether 5,473 GBq of isotope ^{99}Mo, 3,529 GBq of isotope ^{18}F, 1,034 GBq of isotope ^{131}I and minor activities of isotopes ^{177}Lu,

^{123}I, ^{201}Tl, ^{90}Y and ^{111}In were applied for diagnostics and therapy. Isotope ^{99}Mo is used as a generator for isotope technetium ^{99m}Tc, which is extracted at nuclear medicine departments and used for diagnostics. From the initial activity of ^{99}Mo, approximately three times higher activity of ^{99m}Te can be extracted in one week.

Sealed sources for therapy are used at the Institute of Oncology and the Clinic of Ophthalmology, and for irradiation of blood components at the Blood Transfusion Centre of Slovenia. At the Institute of Oncology several sources of ^{192}Ir and ^{90}Sr are used. At the Clinic of Ophthalmology 6 sources of ^{106}Ru with initial activities up to 37 MBq for eye tumours therapy were used, and at the Blood Transfusion Centre of Slovenia a device with ^{137}Cs with the initial activity of 49.2 TBq was used for irradiation of blood components. A THERATRON device for teleradiotherapy with a cobalt ^{60}Co sealed source with initial activity of 290 TBq was suspended from use and the source was shipped to Germany.

Sealed sources of minor activities (mostly ^{57}Co with typical activities from a few MBq up to a few hundred MBq) are used for the operational testing of various devices and measurement equipment at some nuclear medicine departments. Most of them are used for calibration.

The SRPA register shows that there are still 2,486 ionization smoke detectors with ^{241}Am in 22 medical facilities. For most of them, the activity is about 30 kBq, while some have higher activity (up to 2.67 MBq).

In 2010, 8 licences to carry out radiation practice, 8 licences to use radiation sources in medicine, 8 confirmations of the evaluation of protection of exposed workers against radiation, 3 confirmations of the programmes of radiological procedures, 1 permission for the import of radioactive materials, and 18 statements about the shipments of radioactive materials from EU member states were granted with reference to the use of unsealed and sealed source in medicine.

The medical departments with unsealed and sealed radiation sources were surveyed by the approved experts for radiation protection. No major deficiencies were found. The SRPA inspectorate also made four inspections, two at the Institute of Oncology and two at the Clinic for Nuclear Medicine.

The inspections at the Institute of Oncology were focused on the dismantling of the THERATRON teleradiotherapy unit and transfer of the ^{60}Co sealed source with activity of around 110 TBq to transport container and to transport vehicle. No faults were found, doses received by radiation workers were very low – below 0.1 mSv. A decision was issued to suspend the licence to use this radiation source.

The inspections at the Clinic for Nuclear Medicine were focused on medical surveillance of exposed workers, maximum doses received by workers in the period October 2009–May 2010, and arrangements regarding licensing of new SPECT/CT and PET/CT devices. Some faults were found regarding expired medical exam certificates for some workers, exceeding the dose constraint for one worker and the shielding of the PET/CT diagnostics room. A decision was issued to ban three workers from work with radiation sources until they provide valid medical certificate. An evaluation of protection of exposed workers against radiation had not been confirmed due to inadequate shielding of the PET/CT diagnostic room. The confirmation was issued when the radiation protection expert provided a consensual report. Likewise, programmes of radiological procedures were confirmed when the medical physics expert in the field of computational tomography provided adequate amendments.

In 2010 contaminated waste from Clinic for Nuclear Medicine and Institute of Oncology were detected at the facility for disposal of non-dangerous waste at Barje. In all cases the contamination levels were low and there was no health threat to humans. In this respect inspections were carried out at the Clinic for Nuclear Medicine and Institute of Oncology. The Jožef Stefan Institute elaborated a study on isotope determination methodology and on health impacts. Dealing with the issue is continued in 2011.

3 RADIOACTIVITY IN THE ENVIRONMENT

Protection against ionizing radiation is implemented for three categories: radiation workers, patients in medical diagnostics that use radiation and the general population. Protection of the population is managed by the competent authorities through measurements of radioactivity throughout Slovenia, with special attention to the protection of populations living in the vicinity of nuclear and radiation facilities. Ways of protecting the population against radiation in the environment are provided by the Ionizing Radiation Protection and Nuclear Safety Act (Official Gazette RS, No. 102/2004) for both normal conditions (Art. 123 and 124) and the case of an emergency where there is contamination of the environment (Art. 90) and the Rules on Monitoring of Radioactivity (Official Gazette RS, No. 20/2007).

The main purposes of radioactivity monitoring in the environment are monitoring the levels of radioactive contamination, to follow trends in concentrations of radionuclides in the environment and to provide timely warning in case of sudden increases in radiation levels in Slovenia.

Radiation protection of the population is ensured through the ongoing monitoring of the levels of external radiation and radioactivity in the environment, and continuous monitoring of radioactivity in drinking water, food, feed and products in general use. Monitoring of radioactive contamination is provided by the competent authorities.

Control of nuclear and radiation facilities is carried out through operational monitoring, the programme determined by the competent authority. The operator is liable for the implementation of this programme. It covers the control of emissions from all facilities and the extent of radioactivity in the surrounding areas. Sampling and measurement of samples is carried out by accredited technical support organizations, which are in turn authorized by competent administrative authorities.

Radioactivity released into the environment by nuclear power plant in Krško, the former uranium mine in Žirovski Vrh, the TRIGA research reactor and the temporary storage of radioactive waste, both in Brinje near Ljubljana, is controlled. Monitoring of radioactivity in the environment produces results which are used to assess and evaluate environmental impacts and to monitor trends of radioactive contamination. Doses to the population are estimated on the basis of measured or modelled data, either for the population as a whole or for individuals in the reference groups who reside in the vicinity of nuclear and radiation facilities which emit radioactive substances into the environment. Doses for the population should be lower than the dose constraints set by the competent administrative authority.

Monitoring of radioactivity in the environment as a result of global contamination from the Chernobyl nuclear accident and past nuclear testing has been carried out for over five decades and consists mainly of tracking the long-lived fission track radionuclides ^{137}Cs and ^{90}Sr by different transmission paths.

This chapter contains a summary of reports on the state of radioactivity in the environment in Slovenia in 2010. First, it presents an automatic warning system, which enables immediate detection of elevated radiation levels in Slovenia due to a nuclear or radiological emergency, followed by summary reports on measurements of radioactivity and environmental impact assessments.

3.1 Early Warning System for Radiation in the Environment

Slovenia established an automatic on-line warning system for environmental radioactivity at the beginning of the last decade. It is designed for immediate detection of elevated levels of radiation in the environment and is one of the key elements of the warning and emergency response. In such a case, levels of external radiation and concentrations of radioactive particles in the air are elevated, and their subsequent deposition and rinsing on the ground causes contamination of drinking water, food and feed. Automatic probes for real-time measurements of external radiation are positioned around Slovenia, managed by the Slovenian Nuclear Safety Administration (SNSA), the Environmental Agency of Slovenia (EARS), the Krško Nuclear Power Plant and Slovenian thermal power plants. Data are collected at the EARS and the SNSA, where they are constantly being analysed, archived and displayed on the internet for the public. In the event of elevated values, an automatic alarm is sent to the officer on duty.

In 2010, there were no events that would trigger an alarm due to increased radiation in the environment.

Since 1997 the SNSA has been sending data from the warning system to the European system EURDEP, with its centre at the Joint Research Centre in Ispra, Italy, where data are collected from a majority of European national networks. Through this arrangement, Slovenia has also gained access to real-time data on external radiation from other participating countries. Additionally, Slovenian data are daily exchanged with the Austrian centre in Vienna, the Croatian centre in Zagreb and the Hungarian centre in Budapest.

3.2 Monitoring of Environmental Radioactivity

Monitoring of the global radioactive contamination due to atmospheric nuclear bomb tests (1951–1980) and the Chernobyl accident (1986) has been carried out in Slovenia for almost five decades. Primarily, two long-lived fission radionuclides, ^{137}Cs and ^{90}Sr, have been followed in the atmosphere, water, soil and drinking water and in foodstuffs and feedstuffs. The radionuclide ^{14}C, which is another product of nuclear tests, is not monitored, just like in most other European countries. A part of the monitoring programme related to the radioactivity of surface waters is river water contamination with ^{131}I due to the medical use of this radionuclide. Other natural gamma emitters are also measured in all samples, and additionally tritium ^{3}H in drinking water and in precipitation.

The results for 2010 showed that concentrations of both long-lived fission products in samples of air, precipitation, soil, milk, foodstuffs of vegetal and animal origin, and feedstuffs continued to decrease slowly and were mostly lower than before the Chernobyl accident. The only exception is the specific surface activity of ^{137}Cs in the upper layer of uncultivated soil, which is still much enhanced. At the time of the Chernobyl accident, approximately five-times higher contamination (20–25 kBq/m^2) was measured on average in Slovenia, compared to the total contribution of all nuclear bomb tests in the past. The highest contamination of the ground was measured in the Alpine and forest regions. This feature indirectly contributes to the enhancement of the contents of this radionuclide in forest produce (forest fruits, mushrooms and game) and produce from Alpine pastures (milk and cheese). The concentrations of tritium in liquid samples (surface waters, precipitation and drinking water) decrease very slowly, by only a couple of percent per year. In 2010, the monitoring teams detected no radioactive contamination of the environment related to any new nuclear or radiation event.

The biggest contribution to the radiation exposure of the public comes from external radiation and from food ingestion, while the inhalation dose due to aerosols with fission radionuclides is negligible. In 2010, the effective dose for an adult from external radiation of ^{137}Cs (mainly from the Chernobyl accident) was estimated at about 7.7 µSv, which is 0.87% of the dose received by an average Slovenian from natural background radiation. This value is quite similar as to the one that was measured and calculated for the previous year (7.6 µSv).

The annual dose from the ingestion pathway (food and drinking water consumption) was 2.0 µSv, which is similar to the estimation for 2009 (2.1 µSv). The dose for 2008 was higher (3.1 µSv) due to the higher average values of the radionuclide ^{90}Sr in the selected samples of vegetables sampled in regions with higher Chernobyl contamination. The contribution to the annual dose of the ^{90}Sr due to ingestion is 68% and of ^{137}Cs 31%. The annual contribution due to inhalation of both radionuclides is only about 0.001 µSv, which is negligible compared with the radiation exposure from other transfer pathways. The effective dose for drinking water, taking into account artificial radionuclides, was also estimated. It turned out that this dose was on average around 0.036 μSv per year. The annual limit value of 0.1 mSv per year due to natural and artificial radionuclides in drinking water from local water supplies was not exceeded in any sample.

In 2010, the total effective dose of an adult individual in Slovenia arising from the global contamination of the environment with fission products was estimated at 9.7 μSv, as shown in Table 5. This is approximately 0.4% of the dose compared to the annual exposure of the adult Slovenian received from natural radiation in the environment (2,500–2,800 μSv). In the regions with lower radioactive contamination of the ground (Prekmurje and the Coastal-Karst region), the corresponding dose is lower, while it is much higher in the Slovenian Alpine region.

Considering all the doses specified in this chapter, it should be taken into account that these values are extremely low and cannot be measured directly. The final results are calculated using mathematical models and are based on measurable quantities. The measurement uncertainties are therefore considerable and they differ considerably from year to year in some cases. But what is most important is that these values are far below the limit values.

Table 5: Radiation exposure of the population in Slovenia due to global contamination of the environment in 2010

Transfer pathway	Effective dose [μSv per year]
Inhalation	0.001
Ingestion: drinking water food	 0.036 2.0
External radiation	7.7*
Total (rounded)	**9.7****

* Applies to central Slovenia; the value for the urban population is lower, for the rural population a bit higher.
** Radiation exposure from natural radiation is 2,500–2,800 μSv per year.

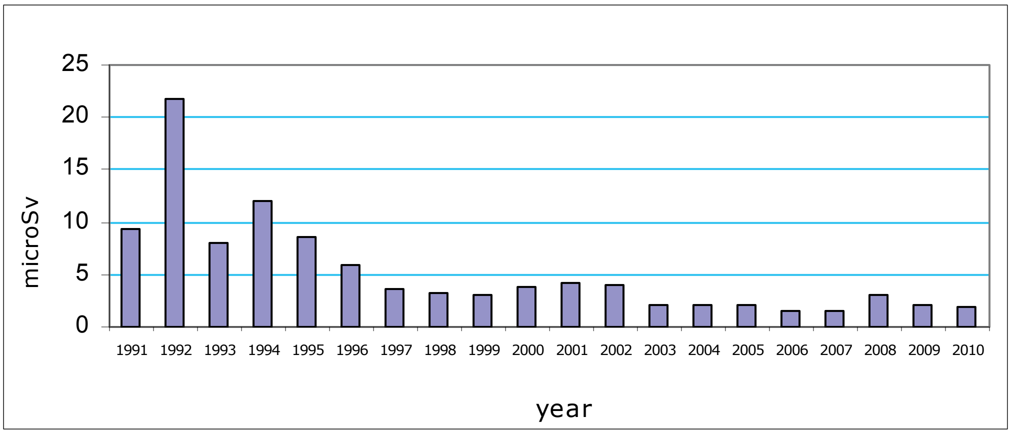

Figure 16: Annual effective doses to members of the public received by ingestion due to global radioactive contamination of the environment with the radionuclides ^{137}Cs and ^{90}Sr in Slovenia

The high value in 1992 (Figure 16) is due to the calculated dose estimation taking into account game foodstuffs. Without those samples, the effective dose for that year would have been lower than 10 μSv.

3.3 Operational Monitoring in Nuclear and Radiation Facilities

Each installation or facility that discharges radioactive substances into the environment is required to be the subject of control. Radioactivity measurements in the surroundings of the installations must be performed in the pre-operational period, during operation and for a certain period after ceasing operation. The goal of operational monitoring is to find out whether the discharged activities are within the authorized limits, whether environmental specific activities are inside the prescribed limits and whether population exposure is lower than the prescribed dose constraints or limits.

3.3.1 The Krško Nuclear Power Plant

The radiological situation in the surroundings of the nuclear power plant is monitored by the continuous measurements of gaseous and liquid radioactive discharges and by carrying out radioactivity measurements of environmental samples. The measured values of analysed radionuclides in environmental samples (in air, soil, surface and underground water, precipitation, drinking water, agriculture products, and feedstuffs) during normal operation of the plant are low, usually considerably lower than the detection limits of analytic procedures. The impacts of the nuclear power plant are therefore evaluated only on the basis of the data on gaseous and liquid discharges. Discharge data are used as an input for the modelling of dispersion of radionuclides to the environment. Low results of environmental measurements during normal operation are used as a confirmation that radioactive discharges into the atmosphere and in aquifers were low. In the event of an emergency, the established monitoring network enables immediate sampling and analysis of contaminated samples.

According to the recommendations of the European Verification Commission, the SNSA introduced an independent measurement control of the operational monitoring for the first time in 2008. The measurements were conducted in parallel with the regular measurements. Independent monitoring in 2010 confirmed that the measurements of discharges performed by the Krško NPP were in full accordance with the results of measurements carried out by the authorized performers of radioactivity monitoring, the Jožef Stefan Institute and the Institute of Occupational Health.

Radioactive discharges

In 2010, the total released activity of noble gases to the atmosphere was 0.171 TBq, which resulted in public exposure of 0.1 μSv, or 0.2% of the limit (set at 50 μSv per year). Calculated doses depend on dilution coefficients and composition of discharged noble gases. The released activities of iodine isotopes amounted to 0.00052% of the authorized limit, due to the lack of fuel leaks. Activity of the dust particles was 0.003% of the limit. The activity of alpha emitters was below the detection limit. Discharges of tritium into the atmosphere were within the expected values from recent years, as were ^{14}C discharges, which were approximately the same as in previous years; there are no prescribed limits for these two radionuclides.

In liquid discharges from the plant to the Sava river, the activity of tritium (^{3}H) in the water was highest, at 21.2 TBq, which represents 47.2% of the annual limit. This value is significantly higher then in 2009 (7.3 TBq) as a consequence of the nature of maintenance works performed during the year. Due to its low radiotoxicity, tritium is not as important a radioactive contaminant as other radionuclides. The total discharged activity of fission and activation products was lower than in 2009 and amounted to 37 MBq, which represents 0.037% of the operational limit value.

Environmental radioactivity

The monitoring programme of environmental radioactivity due to gaseous and liquid discharges comprises the following measurements of concentrations or contents of radionuclides in environmental samples:

- in air (aerosol and iodine filters),
- in dry and wet deposition (dry and wet precipitation),
- in the Sava river water, sediments and water biota (fish),
- in tap water (Krško and Brežice), wells and underground water,
- in food of agricultural and animal origin (including milk),
- in soil on cultivated and uncultivated areas, and
- measurements of ambient dose equivalent of external radiation at several locations.

Concerning the impact of the Krško NPP, it should be noted that the presence of the radionuclides ^{137}Cs and ^{90}Sr is a consequence of a global contamination and not a result of plant operations. The measurable contribution of the plant operations results in the higher concentrations of tritium in the Sava river downstream of the plant. An annual average concentration of tritium of 0.73 kBq/m^3 was measured at Krško, upstream of the plant, while at Brežice, downstream of the plant, the value of 5.9 kBq/m^3 was obtained. This value is higher than that in 2009 (2.3 kBq/m^3) due to a larger release. Elevated values of tritium concentration were also measured in underground water, sampled at the VOP-4 borehole on the left bank of the Sava river (average value 6.1 kBq/m^3), with highest values in July (15.6 kBq/m^3), August (21.5 kBq/m^3) and September (12.9 kBq/m^3), coinciding with the highest discharges. Those values are still lower then the limit for drinking water (100 kBq/m^3). The concentrations of other artificial radionuclides discharged to the Sava river (^{60}Co and others) were below the detection limits in all samples. The concentrations of radioisotope ^{131}I in the Sava river were caused by discharges from the clinics of nuclear medicine in Ljubljana and Celje, not by the operations of the nuclear power plant. Measurements of ^{14}C in vegetation samples (apples) repeatedly showed slightly elevated concentrations in the close vicinity of the Krško NPP.

Exposure of the public

The dose assessment of the public was based on model calculations. The calculated dispersion factors for atmospheric discharges, based on real meteorological data, showed that the most important pathways for public exposure were the ingestion of food with ^{14}C, external radiation from clouds and deposition, and the inhalation of air particles with tritium and ^{14}C. The highest annual dose was received by adult individuals due to ^{14}C intake from vegetable food ingestion (0.03 µSv of this figure belongs to ingestion of local apples), while a ten-fold lower dose was received due to inhalation of tritium. The dose assessment due to liquid discharges in 2010 showed their very low additional contribution to the population exposure, at 0.02 µSv per year. The levels of external radiation in the immediate vicinity of some structures on-site were higher than in the natural surroundings, but the plant's contribution is hardly measurable at the perimeter fence. It was estimated that the plant-related external exposure was less than 0.01 µSv per year. This estimation is similar to those in recent years and it is now based on more realistic data than in the first period of plant operation, when the estimated values of external dose were higher at least by one order of magnitude.

From Table 6, it is clear that the total effective dose for an individual who lives in the surroundings of the Krško NPP is less than 0.1 µSv per year. It is less than in 2009 chiefly because the contribution of ^{14}C ingestion is lower, due to the fact that the annual outage, when most of the releases occur, was performed after the vegetative period. This value represents about 0.2% of the authorized limit value (dose constraint of 50 µSv per year) or less than a ten thousandth of the effective dose received by an average Slovenian from natural background radiation (2,500–2,800 µSv per year).

Table 6: Assessment of partial exposures of adult member of the public due to atmospheric and liquid radioactive discharges from the Krško NPP in 2010

Type of exposure	Transfer pathway	Most important radionuclides	Effective dose [μSv per year]
External radiation	Cloud immersion Deposition	Noble gases: (^{41}Ar, ^{133}Xe, ^{131m}Xe) Particulates: (^{58}Co, ^{60}Co, ^{137}Cs …)	0.007 0.002
Inhalation	Cloud	^{3}H, ^{14}C	0.003
Ingestion (atmospheric discharges)	Vegetable food	^{14}C	0.03*
Ingestion (liquid discharges)	Drinking water (the Sava river)	^{3}H, ^{137}Cs, ^{89}Sr, ^{90}Sr, ^{131}I	< 0.02
Total Krško NPP			**< 0.1****

* Only seasonal consumption of local apples was taken into account.

** Single dose contributions from particular exposures are not additive, because different groups of the public were taken into consideration.

3.3.2 The TRIGA Research Reactor and the Central Storage of Radioactive Waste at Brinje

The TRIGA research reactor and the Central Storage of Radioactive Waste are both located at Brinje near Ljubljana. The samples irradiated in the reactor are analysed in the laboratories of the Department of Environmental Science of the Jožef Stefan Institute, which are located by the reactor. Potential radioactive discharges at this location arise from the reactor, from the waste storage and from the laboratories. The operation of the objects was stable and there were no incidents that would cause releases to the environment; thus the results of the operational monitoring for 2010 are essentially the same as for the previous year.

Environmental monitoring of the TRIGA research reactor comprises the measurements of atmospheric and liquid discharges and the measurements of radioactivity levels in the environment. The latter are performed to determine the environmental impact of the installation and comprise measurements of radioactivity in air and underground water, of external radiation, of radioactive contamination of the soil and of radioactivity of the Sava river sediments.

Measurements of radioactive aerosol discharges into the atmosphere again showed results below the detection limit. Discharges of ^{41}Ar to the atmosphere, calculated on the basis of the reactor operation time, were estimated close to 1 TBq, comparable with previous years. The measurements of the specific activities in the environment showed no radioactive contamination due to the operation of the reactor. The external dose due to radiation from the cloud on an individual because of the ^{41}Ar discharges was estimated at 0.02 μSv per year under the assumption that the individual spends 65 hours per year at a distance of 100 m from the reactor when mowing grass and ploughing snow and that he stays in the cloud only 10% of his time. An inhabitant of Pšata village who constantly lives at a distance of 500 m from the reactor receives 0.5 μSv per year. A conservative assumption was used for dose assessment for individuals of the population for liquid discharges. If the river water is ingested directly from the recipient river (Sava), the annual exposure is less than 0.01 μSv per year. The total annual dose for an individual, irrespective of the pathway, is still one hundred times lower than the authorized dose limit (50 μSv per year). The total annual dose for an individual from the public, irrespective of the model used, is still a thousand times lower than effective dose from the natural background in Slovenia (about 2,500–2,800 μSv per year).

The monitoring programme of environmental radioactivity of the Central Storage of Radioactive Waste at Brinje comprised control measurements of radioactive atmospheric discharges (radon and its short-lived progeny from the storage resulting from the stored ^{226}Ra sources), radioactive waste water (from the newly built drainage collector) and direct external radiation on the outside parts of the storage. Environmental concentrations of radionuclides were measured in the same way as in previous years (in the underground water from the two wells, as external radiation at several distances from the storage, and in dry deposition and soil near the storage).

After the reconstruction of the storage in 2004, radon releases to the environment gradually decreased from the annual average value of 75 Bq/s to 52 Bq/s in 2005, 35 Bq/s in 2006, 31 Bq/s in 2007, 24 Bq/s in 2008, and only 4 Bq/s in 2009 and 2010 (Figure 17). Enhancement of radon ^{222}Rn concentrations in the vicinity of the storage is not measurable and was estimated by a model for average weather conditions to be 0.2 Bq/m^3 at the fence of the reactor site. In the waste water from the new drainage collector, the only artificial radionuclide that was measured was ^{137}Cs, which is a consequence of global contamination and not due to storage operation. There were no other artificial radionuclides (^{241}Am, ^{134}Cs and ^{60}Co) detected. Concentrations of radionuclides were far lower than clearance levels and also lower than the derived concentrations for drinking water.

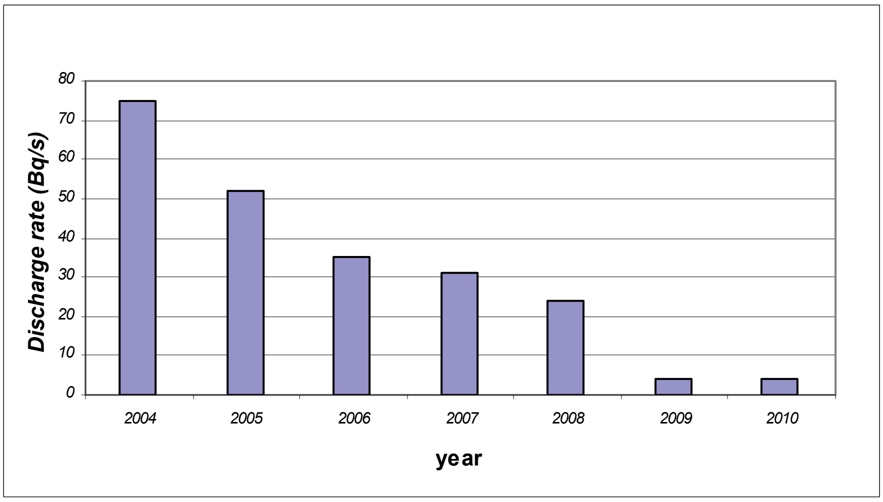

Figure 17: Emission rate of ^{222}Rn from the Central Storage of Radioactive Waste at Brinje

For the dose assessment of the most exposed members of the public, the inhalation of radon decay products and direct external radiation were taken into account. The most exposed members of the reference group are the employees of the reactor centre, who are potentially affected by radon releases from the storage. According to the model calculation, they received an estimated effective dose of 0.6 µSv in 2010. The security officer received about 0.3 µSv per year due to his regular rounds, while the annual dose to the farmer adjacent to the controlled reactor area was estimated to be only about 0.01 µSv. These values are the same as for 2009 and much lower than in previous years, mostly due to lower radon releases, and are much lower than the authorized dose limit for individuals from the reference group of the population (100 µSv per year). The annual dose collected by an individual from natural background is 2,500–2,800 µSv.

3.3.3 The Former Žirovski Vrh Uranium Mine

The monitoring of environmental radioactivity of the former uranium mine at Žirovski Vrh, which is currently in the post-operational phase, consists of the measurements of radon releases, liquid radioactive discharges and concentrations in the environment. An integrated programme of measurements is performed, including the radionuclide-specific activities of the uranium–radium decay chain in the environmental samples, the concentrations of radon and its decay products in the air, and external radiation. Measurement locations are set mainly in the settled areas in the valley, up to 3 km from the existing mine radiation sources; that is from the village of Gorenja vas to Todraž. For the evaluation of the impact of uranium mining and milling, the relevant measurements of radionuclides of natural origin have to be carried out at reference points, outside the influence of mine and repository discharges (as an approximation for natural radiation background). The net contribution of radioactive contamination is assessed such that the measured values are corrected with regard to the natural background of the measured examined radionuclides.

In recent years, the radioactivity of surface waters in both streams has been slowly but steadily decreasing, especially ^{226}Ra concentrations in the Brebovščica, the main recipient stream, where they are already close to the natural background level (3.5 Bq/m^3 in 2010). Only the concentrations of uranium ^{238}U in the Brebovščica stream (average monthly concentration 145 Bq/m^3) are still increased, as all liquid discharges from the mine and from disposal sites flow into it – mainly due to arranging works at the disposal sites. The radioactivity of sediments (^{238}U and ^{226}Ra) in the Brebovščica stream is not more than 50% higher than in the recipient river Poljanska Sora before the outflow of the Brebovščica stream. The average concentrations of radon ^{222}Rn in the surroundings of the mine (at Gorenja Dobrava) were still higher than a long-term average value at the reference point outside the mine influence (about 20 Bq/m^3). In 2010, the mine's contribution of radon ^{222}Rn from the repository sites and the mine to the concentrations in the environment is estimated at around 4 Bq/m^3.

The calculation of the effective dose for the population took into account the following exposure pathways: the inhalation of long-lived radionuclides, uranium, radon and its short-lived progeny, ingestion (intake of food and water) and external gamma radiation. Radiation exposure of an adult member of the public living in the vicinity of the mine was estimated at 0.118 mSv. The low exposure is a consequence of finishing the restoration at the mine repositories at the Jazbec and Boršt sites. It represents approximately one-third of the effective dose which was estimated in the last decade of the 20th century. However, the most important radioactive contaminant in the mine environment still remains radon ^{222}Rn with its short-lived progeny, which contribute two-thirds of the additional exposure (Table 7).

Table 7: Effective dose for an average individual living in the surroundings of the former uranium mine at Žirovski Vrh in 2010

Transfer pathway	Important radionuclides	Effective dose[mSv]
Inhalation	– aerosols with long-lived radionuclides (U, ^{226}Ra, ^{210}Pb) – only ^{222}Rn – Rn – short-lived progeny	0.0031 0.002 0.081
Ingestion	– drinking water (U, ^{226}Ra, ^{210}Pb, ^{230}Th) – fish (^{226}Ra, ^{210}Pb) – agricultural products (^{226}Ra in ^{210}Pb)	(0.0075)* 0.0006 < 0.03
External radiation	– immersion and deposition of radon progeny – deposition of long-lived radionuclides – direct gamma radiation from disposal sites	0.0012 / /
Total effective dose (rounded):		**0.118 mSv**

* Dose due to ingestion of water from the Brebovščica stream is not included in the dose assessment because the water is not used for drinking, watering of animals or irrigation.

The total effective dose for an adult individual in 2010 due to the contribution of the former uranium mine is 50% lower than in 2007 (0.23 mSv) and amounted to one-tenth of the general limit value for the population (1 mSv per year). Estimated doses for 10-year-old children were 0.142 mSv and for 1-year-olds 0.103 mSv. These values represent about 2% of the natural background dose in the Žirovski Vrh environment (5.5 mSv). Annual changes of effective doses due to the mine are shown in Figure 18.

Measurements and dose estimations for the last several years clearly show that because of the cessation of uranium mining and the restoration works already carried out, the environmental impacts and exposure of the population have decreased. The estimated dose exposure in the present restoration phase is already not more than one-third of the authorized dose limit of 300 μSv per year which will be in force after the termination of restoration works.

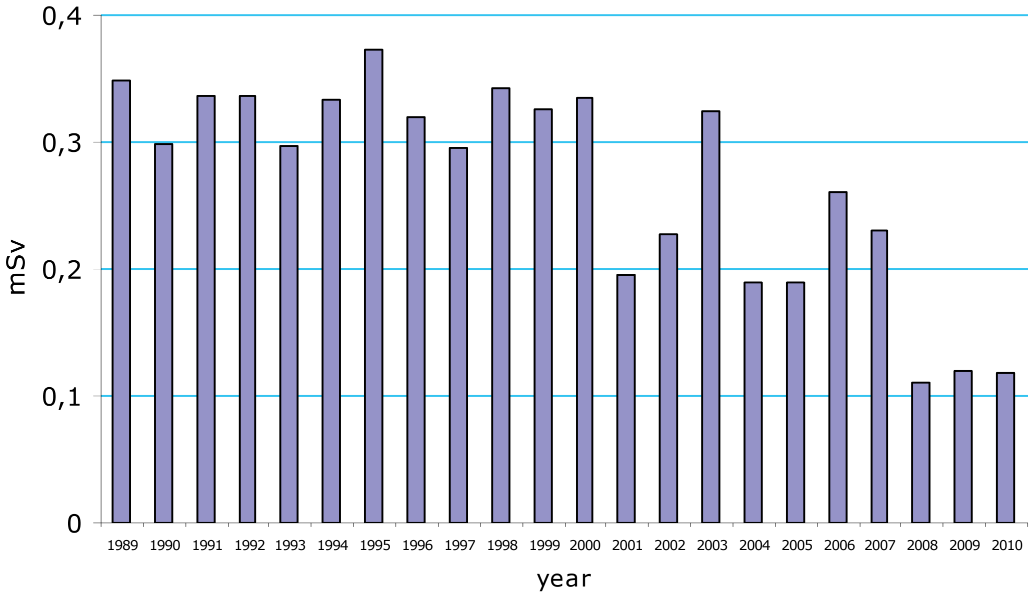

Figure 18: Annual contributions to the effective dose for an average adult member of the public due to the former Žirovski Vrh uranium mine in the period 1989–2010

3.4 Radiation Exposures of the Population in Slovenia

Every inhabitant of the Earth is exposed to natural and artificial radioactivity in the environment. A great part of the population receives radiation doses from radiological examinations in medicine, while only a small part of the population is exposed occupationally due to their work in radiation fields or with radiation sources. External radiation means that the source is located outside the body. Internal radiation occurs if radiation material enters the body by means of inhalation, ingestion of food, drinking or through the skin. The data on population exposure are presented below, while the occupational exposures (to artificial and natural sources) and medical exposures are presented in Chapter 4.

Exposure to natural radiation

The average annual effective dose from natural sources to a single individual on Earth is 2.4 mSv, varying according to different locations from only 1 mSv to up to 10 mSv. The average annual dose from natural radiation sources for an average member of the public in Slovenia is somewhat higher than the world average, about 2.5 to 2.8 mSv per year. From the existing data on external radiation and radon concentrations in dwellings and outdoors, it can be estimated that about 50% of this value is due to internal exposure as a consequence of inhalation of indoor radon and its progeny (1.2–1.5 mSv per year) in residential buildings. The annual dose due to the intake of radioactivity with food and water is about 0.4 mSv. The annual effective dose of external radiation originating from soil radioactivity, building materials in dwellings and cosmic radiation together was estimated at 0.8 to 1.1 mSv.

Radon measurements in dwellings

In 2010, the Slovenian Radiation Protection Administration (SRPA) continued with the implementation of the governmental programme of systematic examination of workplaces and dwellings. This programme comprised monitoring and informing the public about the measures for decreasing exposure due to the presence of natural radioactive sources and was approved in 2006. The highest priority was repeatedly given to radon exposure, since this radioactive noble gas is the main source of natural radiation in dwellings and at workplaces. On average, radon contributes to more than a half the effective dose received from all natural sources of ionising radiation. It penetrates into rooms from the ground, above all through various openings (shafts, outlets, gaps, cracks and so on).

In the scope of the programme, the measurements of concentrations of radon and its decay products were performed altogether in 73 premises of 53 objects and the estimated effective doses were assessed for both employees and children in schools and kindergartens. Based on the results of the measurements and the occupancy time in these buildings, the effective doses for employees and children were assessed. In 24 premises, the doses were lower than 1 mSv per year, in 10 between 1 and 2 mSv per year, in 18 between 2 and 6 mSv per year and in 21 higher than 6 mSv per year.

Population dose due to global contamination

People from the Northern Hemisphere in particular are still exposed to ionizing radiation from the global contamination of the environment resulting from past atmospheric nuclear bomb tests and the nuclear accident in Chernobyl. The average individual dose from long-term radionuclides ^{137}Cs and ^{90}Sr in Slovenia in 2010 was estimated at 9.7 µSv. External radiation contributed 7.7 µSv, while the effective exposure dose due to the intake of food and water was estimated at 2.0 µSv. Because of the lower contamination of the ground with ^{137}Cs, the population in urban areas is less exposed than the rural population.

Radiation exposure of population due to human activities

Additional radiation exposures due to the regular operation of nuclear and radiation facilities are usually attributed only to local populations. The exposures of particular groups of the population as a consequence of radioactive discharges from these facilities are described in the subchapter on operational monitoring. In Table 8, the annual individual doses are given for the maximum exposed adults from the reference groups for all objects in consideration. For comparison, an average annual dose for individuals related to global radioactive contamination of the environment (nuclear tests and the Chernobyl accident) is also shown. The highest exposures of the population are recorded for individuals living in the surroundings of the former uranium mine at Žirovski Vrh. These were estimated at a maximum of 5% of the exposure due to natural sources in Slovenia. In no case does the exposure of members of the public exceed the dose levels defined by the regulatory limits.

The population is also exposed to radiation because of other human activities. These exposures come from deposited materials with enhanced natural radioactivity and originate from past industrial or mine activities, related mostly to mining and processing of raw materials containing uranium or thorium.

Table 8: Exposures of adult individuals from the general population due to the operation of nuclear and radiation facilities and to general contamination in 2010

Source	Annual dose [mSv]	Regulatory limit [mSv]
Žirovski Vrh mine	0.118	0.300*
Chernobyl and nuclear weapon tests	0.0097	-
Krško NPP	< 0.0001	0.050**
TRIGA reactor	0.00052	0.050
Central Storage of Radioactive Waste	0.0006	0.100

* Limitation after the final restoration of disposal sites.
** Due to radioactive discharges.

4 RADIATION PROTECTION OF WORKERS AND MEDICAL EXPOSURES

Due to occupational exposure, individuals can receive a substantial dose of radiation. Therefore organizations that carry out radiation practices should optimize working activities so as to decrease the dose of ionizing radiation to a level as low as reasonably achievable (ALARA). Exposed workers are subject to a regular medical surveillance programme and suitable training. The employer has to assure that the dose of ionizing radiation is assessed for every worker performing specific activities.

The Slovenian Radiation Protection Administration (SRPA) manages the Central Records of Personal Doses (CRPD). All approved dosimetry services regularly report to the CRPD for all exposed workers on their external exposure on a monthly basis and for internal exposures due to radon semi-annually.

The approved dosimetry services in 2010 were the Institute of Occupational Safety (IOS), the Jožef Stefan Institute (JSI) and the Krško Nuclear Power Plant (Krško NPP). Additionally, approval was granted to the IOS to perform internal dosimetry for radon exposure in mines and Karst caves. Currently 10,728 persons have their records in the central register, including those who have ceased using sources of ionizing radiation. In 2010, the dosimetric service at the IOS performed measurements of individual exposures for 3,729 workers and the JSI monitored 881 radiation workers. The Krško NPP performed individual dosimetry for 412 plant personnel and 693 outside workers, who received an average[1] dose of ionizing radiation of 0.83 mSv. In other working sectors, the average annual effective dose due to external radiation was the highest for workers in industrial radiography, at 0.66 mSv, while the employees in medicine received on average 0.31 mSv. The highest average value among these, 0,88 mSv, was recorded for nuclear medicine workers.

The highest collective dose due to external radiation was received by radiation workers in the Krško NPP (810 man mSv), followed by workers in the medical sector (390 man mSv). Exposures in industry were 42 man mSv.

For 2010, the data on doses received by radiation workers who took part in NPP outages abroad and data on doses of Adria Airways flight personnel who are exposed to cosmic radiation have been included in the CRPD. The collective dose for 18 workers in foreign NPPs was 16.4 man mSv (average dose 0.91 mSv). During Adria flights, 148 workers were exposed, receiving an average dose of 1.02 mSv and a collective dose of 149 man mSv.

The highest doses are received by those workers exposed to radon and its progeny.

In 2010, 30 out of 150 tourist workers received an effective dose between 5 and 10 mSv, 15 workers received an effective dose between 10 and 15 mSv, while 2 workers received a dose exceeding 15 mSv. The highest individual dose was 16.3 mSv. The collective dose was 592 man mSv, with an average dose of 4.05 mSv. Tourism workers in Karst caves are the category of workers most exposed to ionising radiation.

The findings of a study on the exposure of individuals in Karst caves show that the doses that are assessed according to ICRP[2] 65 and received due to radon exposure are underestimated for tourism workers in Karst caves. Due to the high unattached fraction of radon progeny, an approximately two times higher dose factor should be taken into account, as described in the ICRP 32 model. Thus in this report, doses due to radon and its progeny are assessed according to the ICRP 32 model. Doses calculated in such a

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[1] All average doses in this section are calculated per number of workers who received a radiation dose above the minimum detection level.

[2] ICRP stands for the International Commission on Radiological Protection, which, among other tasks, periodically recommends methods for dose assessments.

manner are thus twice as high as those calculated according to ICRP 65, which was used in the past.

At the Žirovski Vrh mine, the highest annual individual dose was 1.32 mSv and the average for a group of 7 workers was 0.58 mSv. The collective dose was 4.1 man mSv.

The distribution of workers by dose intervals in different work sectors is shown in Table 9.

Table 9: Number of workers in different work sectors distributed according to dose intervals (mSv)

	0–MDL	MDL≤E<1	1≤E<5	5≤E<10	10≤E<15	15≤E<20	20≤E<30	E≥30	total
Krško NPP	132	696	266	11	0	0	0	0	1,105
Industry	352	95	9	1	0	0	0	0	457
Medicine and veterinary	2,180	1154	99	1	0	0	0	0	3,434
Air flights	4	44	100	0	0	0	0	0	148
Education, research and other	546	181	10	0	0	0	0	0	737
Radon	4	46	60	30	15	2	0	0	157
Total	**3,218**	**2,216**	**544**	**43**	**15**	**2**	**0**	**0**	**6,038**

MDL – minimum detection level
E – Effective dose in mSv received by an exposed worker.

Education of workers using sources of radiation is in accordance with regulations. Minor deficiencies were found regarding timely refreshment of knowledge and skills. Training, refreshment courses and tests were carried out by the approved technical support organizations, namely the IOS and the JSI. In 2010, a total of 2,167 participants attended courses on ionizing radiation protection.

In 2010, the medical surveillance of radiation workers was performed by five approved occupational health institutions:

- Clinical Institute of Occupational, Traffic and Sports Medicine, Ljubljana,
- IOS, Ljubljana,
- Aristotel Llc., Krško,
- Health Centre Krško and
- Health Centre Škofja Loka.

Altogether, 3,031 medical examinations were carried out. Among examined candidates, 2,681 fulfilled requirements for work with sources of ionising radiation, 315 fulfilled requirements with limitations, 9 temporarily did not fulfil requirements and one did not fulfil requirements at all. For one worker a different job was recommended and in 24 cases the evaluation was not possible.

Exposure of patients during radiological procedures

Since 2010 Slovenia has been included in the project Dose DataMed2. The project is running under the guidance of the European Commission and is coordinated by the Finnish regulatory authority. In the project framework, the contribution of patient doses during radiological procedures to the collective dose will be assessed.

Based on preliminary data for Slovenia, the average exposure of a person due to radiological procedures is assessed at approximately 1 mSv.

5 RADIOACTIVE WASTE MANAGEMENT AND MANAGEMENT OF NUCLEAR AND RADIOACTIVE MATERIALS

In Slovenia, the only high-level radioactive waste (HLW) is the spent nuclear fuel (SNF) from the Krško NPP. The greatest amount of low- and intermediate-level radioactive waste (over 95%) is generated from the operations of the Krško NPP. The rest is produced in medicine, industry and research activities. A special category of waste are spent sealed radioactive sources in the possession of small companies or are stored in the Central Storage for Radioactive Waste at Brinje.

5.1 Implementation of the National Programme on Radioactive Waste and Spent Nuclear Fuel Management

In 2006, the National Parliament of the Republic of Slovenia adopted the Resolution on the National Programme on Radioactive Waste and Spent Nuclear Fuel Management for the period 2006–2015 (ReNPROJG), which is part of the National Environment Protection Programme. ReNPROJG is setting goals and tasks in the field of radioactive waste and spent nuclear fuel management.

As part of the National Programme, activities on the construction of the low- and intermediate-level waste (LILW) repository took place in 2010 after acceptance of the Decree on the Detailed Plan of National Importance for Low and Intermediate Level Waste Repository in Vrbina in Krško municipality. Activities on amendments of the Krško NPP Decommissioning Programme and Disposal of LILW and SNF continued. The Central Storage for Radioactive Waste operated normally. Furthermore, the solidification of liquid waste in a hot cell facility was carried out. The closing works at the Jazbec mine waste pile and Boršt mill tailing site were finished. At the end of 2010, the beginning of the second phase of the final arrangement started: stabilization of the landslide where the hydrometallurgical tailings are disposed off.

The Operational Programmes for the Radioactive Waste and Spent Nuclear Fuel Management for a period from 2006 to 2009, which assures that all objectives from the Resolution are met, were prepared in the beginning of 2007. The document was revised in 2008. In 2009, the Agency for Radwaste Management (ARAO) prepared a new version of Operational Programmes for the period from 2010 to 2013, based on the review of planned and already implemented activities related to radioactive waste and spent fuel management. The last Operational Programmes are structured differently than in the previous versions and are in line with the provisions from the 2002 Act in the field of the state public company for radioactive waste management, the disposal of radioactive waste from power production nuclear facilities, and the long-term surveillance of the mine and hydrometallurgical tailings repositories, as well as commitments defined in the Agency's founding documents (Decree on the Transformation of the Public Company ARAO into a Public Institution, January 2010). The Operational Programmes were sent into approval procedure but were still not approved by the end of 2010.

Tasks dynamics related to construction of the LILW repository are behind the deadlines defined by the ReNPROJG. Operation of the LILW repository was scheduled for 2013. Therefore the respective part of the ReNPROJG should be revised, how the delay will influence operation of the NEK assessed and a new deadline for the start of repository operation set.

5.2 Radioactive Waste and Irradiated Fuel at the Krško NPP

In recent years, the volume of LILW radioactive waste was reduced by compression, super-compaction, drying, incineration, and melting. The total volume of waste accumu— lated by the end of 2010 amounted to 2,211 m^3. The total gamma and alpha activity of stored waste were $1.98 \cdot 10^{13}$ Bq and $2.54 \cdot 10^{10}$ Bq respectively. In 2010, 135 standard drums containing solid waste were stored with total gamma and alpha activity on 31 December of $7.28 \cdot 10^{11}$ Bq and $8.74 \cdot 10^{8}$ Bq respectively. Total activities decreased compared to 2009 due to transfer of a greater amount of waste to the decontamination building awaiting transport to Sweden as detailed below. The NEK notified that an optimization of storage capacity is planned.

5.2.1 Management of Low- and Intermediate-Level Waste

Figure 19 shows the accumulation of low- and intermediate-level radioactive waste in the Krško NPP storage. Periodical volume reductions with compression, super-compaction, incineration, and melting are marked. After 1995, the accumulation of waste volume was reduced as a result of a new in-drum drying system (IDDS) for evaporator concentrate and spent ion exchange resins.

In 2006, the super-compactor was installed in the storage facility at the Krško NPP, so the power plant started with the continuous super-compaction of radioactive waste. In 2010, there were 93 standard drums with compressible and other waste super-compacted.

In 2010, 154 standard drums with compressible waste were transferred to the decontamination building. As a result 194 packages of compressible waste and two packages with other waste are currently stored in the decontamination building; these will be transported to Sweden for incineration.

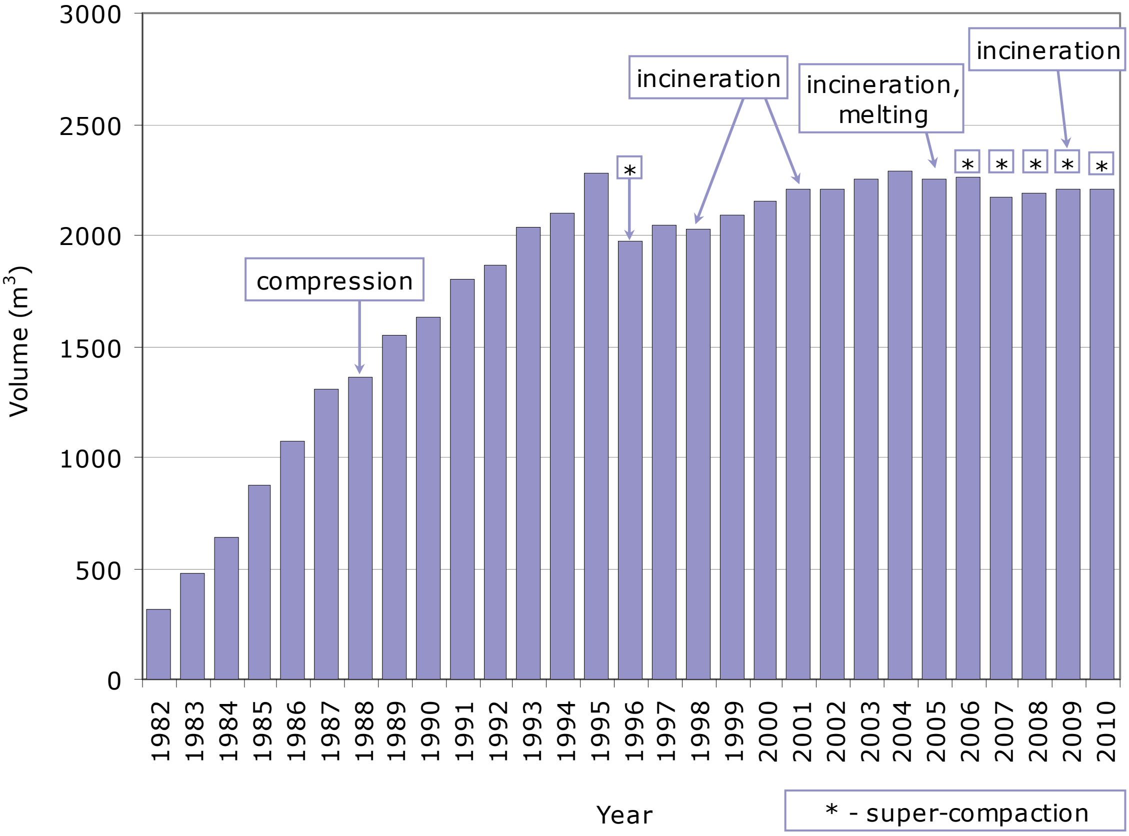

Figure 19: Accumulation of low- and intermediate-level radioactive waste at the storage in the Krško NPP

5.2.2 Management of Spent Nuclear Fuel

In 2004, the Krško NPP started with a longer fuel cycle, according to which outages take place every 18 months. In 2010, 56 fuel elements were replaced during the regular outage. At the end of 2010, there were 985 fuel elements stored in the spent fuel pool, including the container with fuel rods, removed from fuel elements due to the fuel leaking investigation. Figure 20 shows the accumulation of spent fuel at the Krško NPP.

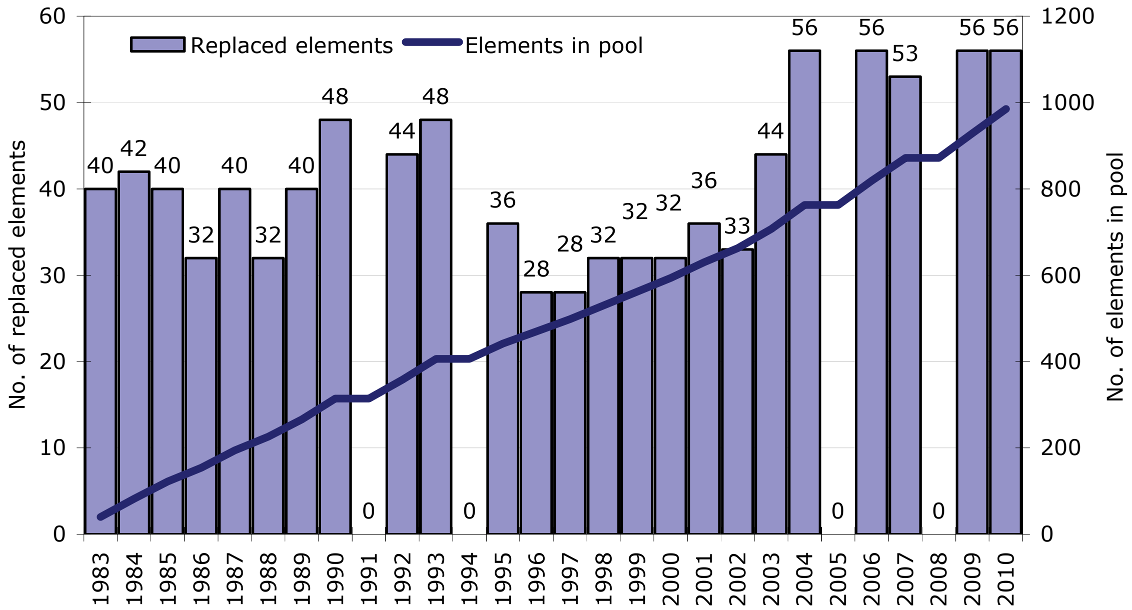

Figure 20: The annual production of spent assemblies and accumulation of spent fuel assemblies in the Krško NPP spent fuel pool

5.3 Radioactive Waste at the Jožef Stefan Institute

In 2010, approximately 0.15 m^3 of radioactive waste was produced during the operation of the reactor and from works in hot cells and controlled areas of the Department of Environmental Sciences and still stored in the hot cell facility at the end of 2010. After characterization, the Institute's Radiation Protection Unit will hand the waste over to the Central Storage for Radioactive Waste at Brinje.

The radioactive waste generated during the decontamination and decommissioning of buildings used for the processing of uranium in the past was, at the beginning of 2010, still temporarily stored in 31 drums on the site of the Reactor Center in Brinje. In February 2010 the Jožef Stefan Institute transferred 12 drums to the Central Storage Facility. Since the waste contains low concentrations of natural radionuclides, the institute prepared a dose estimation report and in autumn 2009 applied for the approval of the conditional clearance for the remaining 19 drums containing waste material. These drums contain building materials, scrap metal, wood, plastics and soil with a total mass of 3.7 tonnes, a volume of 4 m^3 and activity of ^{238+}U 8.73 MBq. During the administrative procedure the SNSA requested an additional independent activity assessment, which was than carried out by the IOS. The institute demonstrated that the maximum effective dose to a single member of the public and the collective dose will not exceed legal restrictions for approval of radioactive material clearance. In the middle of the year, the decision on conditional clearance, which is the first such decision in the Republic of Slovenia, was issued by the SNSA. This very low-level waste can be disposed off on a municipal landfill and covered with other waste material or overlay. By the end of 2010, the clearance of the material had not yet been implemented.

5.4 Radioactive Waste in Medicine

The Institute of Oncology in Ljubljana, as the biggest user of radioactive iodine ^{131}I, has appropriate hold-up tanks to facilitate decrease of the activity of waste liquids through decay. The tanks are emptied every four or more months after authorized radiation protection experts carry out preliminary measurements of specific activities. The new Oncological Institute has also arranged for the appropriate temporary storage for radioactive waste. Radioactive sources which are no longer in use were returned to the producer or handed over to the Central Storage. Short-lived solid radioactive waste is temporarily stored in a special place for decay until it is released as non-radioactive waste. On the other hand, the Clinic for Nuclear Medicine at the University Medical Centre in Ljubljana has not yet built a system for holding up liquid waste. In the course of renovation of the University Medical Center, the Clinic intends to build new premises with an appropriate system for holding up liquid waste. Since in other Slovenian hospitals only ambulant treatment is carried out and patients leave the hospital immediately after the application of a therapeutic dose, there hold-up tanks are not necessary.

5.5 Public Service for Radioactive Waste Management

5.5.1 Public Service for Radioactive Waste Management from Small Producers

The Agency for Radwaste Management (ARAO) is the responsible transactor of the public service for radioactive waste management. The public service includes:

- take-over of the radioactive waste from small producers, in cases of accidents and in cases where the holder of the waste can not be identified;
- transport, radioactive waste treatment for storage and disposal, storage and disposal;
- management of the accepted radioactive waste in a prescribed manner;
- management of the Central Storage Facility in Brinje.

Within the public service for radioactive waste management from small producers, the ARAO ensured regular and smooth take-over of the radioactive waste at its place of origin, its transport, treatment and preparation for storage and disposal, and manage—ment of the Central Storage Facility in 2010, as discussed in Chapter 2.1.3.

5.5.2 Disposal of Radioactive Waste

A success for the ARAO and indeed for the country was acceptance of the Decree on Detailed Plan of National Importance for the LILW repository in Vrbina in Krško municipality at the end of 2009. With its publication in the Official Gazette RS, No. 114/09 on 31 December 2009, the procedure for siting of the repository was finished.

Activities related to the preparatory phase prior to the construction licence application procedure were carried out in 2010. A framework plan of project activities, a schedule and a cost estimation for the implementation of the second phase of the project were prepared. The ARAO started to plan on buying land for realization of the LILW repository project.

Monitoring of the underground water in all wells that were made during field investigation took place in 2010. Additionally, sampling and geochemical analysis of underground water from wells made in Vrbina, Krško, were performed.

The conceptual design of the repository project was presented in a presentation film showing the disposal and other premises as well as foreseen technological procedures for preparation of the LILW and disposal itself.

International peer review of the conceptual project, involving two Slovenian and two foreign reviewers, was undertaken in 2010. For critical solutions derived from the conceptual design, an analysis of variant solutions or their optimization is in preparation.

Preparation of the solutions for disposal technology was commenced before the project documentation elaboration was continued.

In the framework of safety analysis and waste acceptance criteria projects a tender for implementation of safety analysis, recalculations and waste acceptance criteria for LILW repository was carried out. The provider was selected accordingly. The work started at the end of 2010 and the first revision of the Implementation Plan was prepared.

Due to the dynamics of the repository siting it looks that the repository for the Slovene part of the waste coming from the Krško NPP will not be in operation until 2013.

5.6 Remediation of the Žirovski Vrh Uranium Mine

The remediation of the Žirovski Vrh uranium mine has been in progress since 1992. Both the uranium processing plant and the mine, together with the various accompanying objects, have been successfully decommissioned.

The first phase (arrangements of the waste pile and surroundings) of the remediation of the Boršt hydrometallurgical tailings site was concluded in the first half of 2010. Due to renewed activation of the landslide in 2008, a report entitled "Hydrogeological and Geotechnological Conditions of the Boršt Site after Completion of the First Phase of the Remediation Measures" was prepared. The report suggested that an immediate approach towards intervention remediation measures should be taken, otherwise considerable damage to completed remediation works and consequent compromise of radiation safety could occur. Therefore, at the end of 2010 implementation of the second phase of remediation works – stabilization of the base of the waste pile – started at the site.

On the Jazbec mine waste pile, where the remediation is completed, activities within the scope of the five years transitional period plan were carried out, such as mowing, the strengthening of grassy vegetation, the removal of bushes on both sides of the fence, maintenance and cleaning of lateral channels and drainage trenches and control of the overall state of the waste pile.

While performing the work, all prescribed and necessary measures for appropriate working conditions for the staff and for the protection of the environment were followed. There were no incidents related to implementation of the works or due to weather conditions.

After completing the remediation at the Boršt and Jazbec sites, the SNSA will need to issue the licence for closure. This licence is a prerequisite to obtain a permit for the cessation of rights and obligations according to mining regulations and for the transfer of the sites into national infrastructure.

The financial resources needed for the planned activities and safe working conditions for the staff and external workers and for limiting the effects of the mine on the environment were fully assured in time.

5.7 Transboundary Movement of Radioactive and Nuclear Materials

The SNSA and the Slovenian Radiation Protection Administration (SRPA) issue permits for import and export of radioactive and nuclear materials and approvals for the shipment of radioactive material from other EU member states. In 2010, the SNSA approved 13 forms of consignees of the radioactive material from other EU member states. In addition, the SRPA approved 18 forms of consignees of the radioactive material. The standard document of declaration is also valid for multiple shipments, but only for a period up to three years.

The SNSA also issued one licence for multiple shipments according to special arrangement in 2010. All shipments in road transport should be performed according to the provisions of the European Agreement Concerning the International Carriage of Dangerous Goods by Road (ADR).

In 2010, the SNSA ran two administrative procedures for revalidation of package design which were used in transport of spent fuel from Vinča, Serbia. The packages were revalidated by the Minister of the Environment according to the Transport of Dangerous Goods Act.

The SNSA issued one licence for transit across the Republic of Slovenia in 2010; this was for transit of spent nuclear fuel from a research reactor in Vinča, Serbia (description in next chapter). For this particular transit, the consent for shipment according to EU legislation was also issued by the SNSA. Approval for this shipment was issued by the Hungarian competent authority which led the administrative process, as Hungary was the entry state for the particular consignment to the EU.

The SNSA also issued one licence for multiple import of radioactive material and one licence for import of nuclear material – fresh nuclear fuel for the Krško NPP. The SRPA issued one licence for import of radioactive material from non-European countries.

5.7.1 Transport of the fuel from Vinča

Under non-proliferation activities, return of highly enriched uranium or fresh or spent nuclear fuel to the countries or origin (USA or Russia) has been carried out for many years. Slovenia contributes to these efforts, allowing such shipments to pass through the country.

The last transit of spent fuel took place in November 2010. There were 6,656 fuel elements with low enriched uranium and 1,374 fuel elements with highly enriched uranium (total mass of uranium of 2.39 tones) from Vinča, Serbia. The fuel was transported in 14 containers (total of 32 casks).

Transport took place by rail from Serbia, through Hungary and Slovenia to the Port of Koper, and continued its journey by ship to Russia. Preparations for the shipment were highly coordinated and professionally involved many national authorities and companies: the SNSA, the Ministry for the Interior, the Jožef Stefan Institute, the SRPA, the Customs Administration, the Administration for Civil Protection and Disaster Relief, the Slovene Intelligence and Security Agency, Slovenian Railways Ltd, the Port of Koper and Transing Ltd, as the main organizer and performer. Transit was under the auspices of the IAEA and fully funded by the international community. Administrative procedures related to this shipment are described above.

5.8 The Fund for Decommissioning of the Krško NPP and for the Deposition of Radioactive Waste from the Krško NPP

The Slovenian Fund for decommissioning of the Krško NPP and for management of radioactive waste from the Krško NPP collects financial resources for decommissioning of the Krško NPP and for the safe disposal of LILW and spent nuclear fuel. In 2010, the Krško NPP delivered one half of electric power to the Slovenian and the other half to the Croatian utility. GEN Energija, Llc., was liable for the payment of the regular levy to the Fund in the amount of EUR 0.003 for every kWh of electric power received by Slovenia from the NPP. In 2010, a total of EUR 8,037,932 was paid into the Slovenian fund.

The safety of investments is assured by the structure of investments, as 82.47% of the total portfolio is invested in debit securities, deposits and CDs which have low credit risk and assure long-term stable incomes.

As of 31 December 2010, the fund managed EUR 149,977,300.45 of financial investments, 21.79% of which was invested in banks in the form of deposits and CDs, 40.91% in state securities, 20.05% in other bonds, 3.16% in mutual funds, 13.75% in investment funds which do not provide a guaranteed return and 0.33% in so-called controversial investments.

The yield of the entire portfolio of the fund for 2010 amounted to 2.23%, while the market yield of the portfolio amounted to 2.51%. The income from financing in 2010 amounted to EUR 5.7 million. In 2010, the fund realized EUR 0.65 million of capital profit. The entire income of EUR 14,946,249 from the funding in 2010 was 2.14% lower than planned. The expenses in 2010 were 43.24% lower than planned and amounted to EUR 7,703,818. The expenses of portfolio managing in relation to the entire portfolio amounted to 0.27%.

In all whole period of the existence of the Slovenian fund, a total of EUR 127.82 million was paid by the Krško NPP and GEN Energija, Llc. From 1998 until the end of 2010, a total of EUR 18.12 million was paid out by the fund to the ARAO for the purchase of studies and projects in the area of management of radioactive waste and spent fuel. Since 2004, the municipalities have received EUR 15.3 million as compensation for the limited use of land.

6 EMERGENCY PREPAREDNESS

Emergency planning and preparedness are important parts of the comprehensive system for ensuring a high level of nuclear and radiation safety. During an emergency, competent organizations must be prepared to take prompt action according to emergency plans that are prepared in advance.

Nuclear and radiological accidents are incidents that directly threaten people and the environment and require protective measures. But incidents are not necessarily accidents. They could also be, for example, reductions in nuclear or radiation safety, but this also requires an appropriate response from the relevant authorities.

6.1 The New National Plan

The Government of the Republic of Slovenia adopted the Protection and Rescue Plan in case of a Nuclear or Radiological Accident, version 3.0, on 22 July 2010.

The National Plan was prepared by the Administration for Civil Protection and Disaster Relief (ACPDR), in close cooperation with the Slovenian Nuclear Safety Administration (SNSA). Details have been coordinated by a special working group involving all levels of planning, including the Krško Nuclear Power Plant (NEK).

Fundamental innovations of the National Plan are:

– The plan deals with accidents at the Krško NPP and radiological emergencies and accidents in other nuclear and radiation facilities in Slovenia and abroad with potential impact on Slovenia.

– The Government shall appoint a special inter-ministerial committee to plan, coordinate and monitor implementation of the Plan, led by the SNSA.

– For communication between management bodies during an emergency, the Interministerial Emergency Communication System (MKSID) is used. The MKSID is provided by the SNSA.

– It is planned to combine all the capabilities for radiological monitoring under the unified leadership of the SNSA.

– A new concept of prior distribution of potassium iodide tablets, which is also associated with the new regulations on such tablets.

– Use of satellite communications.

6.2 The New Regulations on the Use of Potassium Iodide

New rules on the use of potassium iodide in a nuclear or radiological emergency, issued by the Minister for Health in agreement with the Minister for the Environment and Spatial Planning, the Minister for Defence and the Minister of Economy, were published in the Official Gazette RS on 23 July 2010.

The rules govern the use of potassium iodide (PI) for iodine prophylaxis – an effective and simple method of protection of the thyroid gland against radioactive iodine, which can be released in a nuclear accident.

The key points are as follows:

– Iodine prophylaxis is planned for the entire population of the RS up to 40 years of age.

– PI tablets will be pre-distributed for the population in an area 10 km around the Krško NPP; in other areas tablets will be held in hospitals and will be distributed on the introduction of iodine prophylaxis.

- Pre-distributed tablets are covered by the Krško NPP; the rest come from Institute for Commodity stocks.
- Iodine prophylaxis is suggested by the SNSA and ordered by the Commander of Civil Protection of the RS, according to the type and scale of the disaster.
- The dosage is precise, especially for infants and newborns, as are the number of doses.
- The provision of iodine prophylaxis is assured by introducing a process of checking and recharging, informing the population, training of competent authorities and carrying out iodine prophylaxis exercises.

6.3 Responsible Organizations

Slovenian Nuclear Safety Administration

Since March 2010, responsibility for preparedness to respond to emergencies at the SNSA falls to the Department for Emergency Preparedness, whose primary functions are:

- Providing training, staffing and response of the SNSA group for dealing with the incident (SID).
- Ensuring the timeliness and integrity of SID procedures.
- Assuring of the SID operational equipment and facilities.

The SNSA's capabilities to act are ensured by regular training of members of the SID, the response verification and exercises, regular checks of computer and other equipment, participation in international activities and through regular reviews of all associated organisational regulations and guidelines. In 2010, the SNSA conducted 27 training sessions running to a total of 84 hours, with 429 participants or 1,012 man-hours of training. The exercises are considered as part of training. The SNSA also participated in the 2010 annual Krško NPP exercise and in several international ConvEx and ECURIE exercises.

In the framework of international cooperation in the field of preparedness for emergencies, the SNSA chaired the EENCA (Eastern European National Competent Authorities) group, whose members represent the 31 East European countries, and thus guides cooperation in this field.

The SNSA is providing "The Communication System During an Emergency" (MKSID), a web tool for communication between the members of the SID and emergency response organizations at the national level (14 organizations).

The SNSA measures were partially activated because of a fire in the JSI hot cell. This event is described in detail in Chapter 2.1.2.

Administration of the RS for Civil Protection and Disaster Relief

In accordance with statutory powers, in 2010 the Administration for Civil Protection and Disaster Relief (ACPDR) maintained, developed and ensured preparedness for effective response to nuclear or radiological accident.

The Centre for Information of the Republic of Slovenia of the ACPDR is a national contact point for notification to the relevant state agencies and neighbouring and other countries and international institutions at a nuclear or radiological accident at the Krško NPP and other nuclear or radiation facilities in the RS and nuclear or radiological accidents abroad with possible impact on RS. The centre participated in the regular annual exercise called "the Krško NPP 2010 exercise".

Krško Nuclear Power Plant

In 2000, the activities of the Krško NPP in the area of preparedness for emergencies included:

- training, drills and exercises (annual NEK exercise 2010),
- maintenance of support centres, equipment and communications,
- updating the NEK protection and rescue plan, procedures and other documentation, and
- stuffing and replacement in the emergency organization.

Moreover, NEK staff actively collaborated with the planners and providers of protection and rescue tasks at the local and national levels and with the administrative authorities (SNSA and the ACPDR).

In 2010, the NEK mobile unit performed two tours with the mobile unit of the Institute of Occupational Safety and one tour with the IJS mobile radiological laboratory.

The NEK protection and rescue plan was activated on 18 September 2010, following an abnormal event due to high waters in the Sava river. The event is described in Chapter 2.1.1.

7 CONTROL OVER RADIATION AND NUCLEAR SAFETY

7.1 Legislation

The most important piece of legislation in the field of nuclear and radiation safety in the Republic of Slovenia is the Ionizing Radiation Protection and Nuclear Safety Act (ZVISJV, Official Gazette RS, No. 102/04 – official consolidated text).

Based on the ZVISJV, 28 implementing regulations were adopted by the end of 2009: seven governmental decrees, ten rules issued by the minister of the environment, nine issued by the minister of health and two issued by the minister of the interior.

In 2010, the following regulations were adopted and issued:

- Decree amending the Decree on the Implementation of Council Regulations (EC) and Commission Regulations (EC) on the Radioactive Contamination of Foodstuffs and Feedstuffs (Official Gazette RS, No. 38/10);
- Rules on the Use of Potassium Iodine in a Nuclear or Radiological Accident (Official Gazette RS, No. 59/10); on the date of entry into force of these Rules (7 August 2010) the Rules on the Use of Potassium Iodine (Official Gazette RS, No. 142/04) shall cease to apply.

Amendments to the Rules on Radiation and Nuclear Safety Factors and to the Rules on Operational Safety of Radiation and Nuclear Facilities were published in the Official Gazette RS, No. 9/10.

2010 also saw the preparation of the new Act on Third Party Liability for Nuclear Damage. After being adopted by the National Assembly at its 20th session on 22 September 2010, the Act was published in the Official Gazette RS, No. 77/10.

Based on this act, at the end of the year (30 December 2010), the government adopted the Decree on Establishment of the Amount of Limited Operator's Liability for Nuclear Damage and on Establishment of the Amount of Insurance for Liability for Nuclear Damage (Official Gazette RS, No. 110/10).

Preparation of amendments to the Act on Ionizing Radiation Protection and Nuclear Safety and to regulations issued on the basis of this act are also ongoing.

7.2 The Expert Council for Radiation and Nuclear Safety

The Expert Council for Radiation and Nuclear Safety provides expert advice to the Ministry of the Environment and Spatial Planning and to the Slovenian Nuclear Safety Administration in the field of radiation and nuclear safety, physical protection of nuclear materials and facilities, safeguards, radioactivity in the environment, radiation protection of the environment, intervention measures and mitigation of the consequences of emergencies and use of radiation sources other than those used in health and veterinary care.

The Expert Council convened four regular and two correspondence sessions in 2010. In addition to the regular reporting of the SNSA Director to the Council on the news and developments in the field of radiation and nuclear safety between the meetings, the Council considered the following subject areas: monitoring of the operation of nuclear facilities, drafts of new nuclear regulations and their status, the introduction of practical guidelines as a legally non-binding document of the SNSA, amendments to the Ionizing Radiation Protection and Nuclear Safety Act, a study on flood threats, taking into account the protection of the Krško NPP against hundred-year floods, and general questions on nuclear and radiation safety. The last session held in 2010 considered open questions on the implementation of the project on the LILW repository at Vrbina near Krško. At the end of 2009, a decree on national spatial planning was adopted by the Government of Slovenia approving the site of the repository. However, since the beginning of 2010 only slight progress has been made to fulfil further steps of the project. Members of the Council expressed their grave concern about the delay connected to the preparation of the LILW repository construction.

In 2010, the Expert Council also reviewed and adopted the following:

- the Annual Report 2009 on Radiation and Nuclear Safety in the Republic of Slovenia,
- the Slovenian 5th National Report on the Convention on Nuclear Safety,
- the 2010 refuelling outage of the Krško NPP report,
- the draft rules on conditions to be fulfilled by workers performing safety-significant tasks at nuclear or radiation facilities,
- the draft regulation on guarantee for financial means of nuclear and radiation facilities and users of a highly active source.

A new chairman of the Council, Gregor Omahen, Ph.D., was appointed in 2010 by the Minister of the Environment and Spatial Planning. At the end of 2010, the members of the Council were Prof. Borut Mavko, Božidar Krajnc, M.Sc., Tomaž Žagar, Ph.D., and Boštjan Duhovnik, M. Sc.

7.3 Slovenian Nuclear Safety Administration

The Slovenian Nuclear Safety Administration (SNSA) performs specialized technical and developmental administrative tasks and tasks of inspection in the following areas: radiation and nuclear safety; carrying out of practices involving radiation and the use of radiation sources, except in medicine and veterinary medicine; protection of the environment against ionizing radiation; physical protection of nuclear materials and facilities; non-proliferation of nuclear materials and safeguards; radiation monitoring; and liability for nuclear damage.

Legal bases for its administrative and expert tasks in the area of nuclear safety, radiation protection and inspection are provided by the legal framework presented in detail at the SNSA website, http://www.ursjv.gov.si.

At the end of 2010, the SNSA, an administrative body within the Ministry of Environment and Spatial Planning, had 41 employees, of whom 8 had a doctorate, 12 had a master’s degree, 20 had higher or university education and one had high-school education.

In November 2010, the SNSA successfully passed the external recertification audit of the management system. (The first external audit was in 2007, followed by the first control audit in 2008 and the second control audit in 2009, which forms the transition to the new version of the ISO standard, ISO 9001:2008.) During the recertification audit, no non-conformances were identified, thus the external auditor concluded that the SNSA management system complied with ISO 9001:2008.

The SNSA pays special attention to qualification in the area of nuclear safety and radiation protection. A number of its employees passed a special training course within the educational programme of the US NRC or at the Nuclear Training Centre at Brinje near Ljubljana. Furthermore, SNSA employees regularly participate at the seminars and workshops organized by the International Atomic Energy Agency, the European Commission and other international organizations.

For the specific skills and knowledge required for the narrower scope of its work, the SNSA has also organized internal education and training. Such education and training is especially suitable in areas where the contractor programme adjusts to the needs and requirements of the customer (the SNSA); the programme is performed mostly at the SNSA’s premises, which allows wilder participation of SNSA students.

In 2009, the average SNSA employee spent 7 days in different kind of training.

The SNSA website offers general information about the SNSA, information for the public, legislation, agreements and standards in this field, annual and other reports, information on meetings, information on workshops, projects and invitations for tenders co-financed by the International Atomic Energy Agency, data on radiation monitoring, INES events, and links to the websites of other regulatory authorities, organizations and research centres. On the site's pages, all relevant information as required by the Act on the Access to Information of a Public Nature is also available. The website is constantly updated by the SNSA, which tries to ensure that the level of information is interesting for the general public as well as for experts.

The Expert Commission for the Verification of Professional Competence and Fulfilment of other Requirements in Respect of Workers Performing Duties and Tasks in Nuclear and Radiation Facilities (the Commission) performed examinations of Senior Reactor Operators and Reactor Operators. In 2010 no examinations were organized for the Shift Engineer of the Krško NPP.

In 2010, eight candidates successfully acquired their Reactor Operator licence for the first time, four candidates acquired Senior Reactor Operator licence extensions, three candidates acquired Reactor Operator license extensions and four candidates successfully acquired their Senior Reactor Operator license for the first time. The licences were all granted by the SNSA.

No examinations for licence extension for operators at the TRIGA research reactor at the Jožef Stefan Institute were preformed in 2010, nor were there any examinations for shift engineers.

7.4 Slovenian Radiation Protection Administration

The Slovenian Radiation Protection Administration (SRPA), an agency within the Ministry of Health, performs specialized technical, administrative and developmental tasks and tasks of inspection related to carrying out practices involving radiation and the use of radiation sources in medicine and veterinary medicine, protection of public health against the harmful effects of ionizing radiation, systematic survey of exposure at workplaces and in the living environment due to the exposure of humans to natural ionizing radiation sources, monitoring of radioactive contamination of foodstuffs and drinking water, restriction, reduction and prevention of health problems resulting from non-ionizing radiation, and auditing and approval of radiation protection experts.

As a special operational unit within the SRPA, the Inspectorate for Radiation Protection is competent for the surveillance of sources of ionizing radiation used in medicine and veterinary medicine and for the implementation of legislation in the field of protection of people against ionizing radiation. In 2010, the SRPA had five employees.

The activities of the administration were focused on performing duties in the field of radiation protection and on strengthening of the system for health safety against the harmful impacts of radiation in the Republic of Slovenia. Within this framework, the activities of the SRPA comprised issuing of permits and certificates as prescribed by the Act, issuing of approval to radiation protection experts, performing inspections, informing and increasing public awareness about procedures of health protection against the harmful effects of radiation, and co-operation with international institutions involved in radiation protection.

In 2010, the SRPA focused on assuring the quality of teletherapeutic radiological procedures and diagnostic procedures in nuclear medicine. The administration provided financial means for the technical operation check of three teleradiotherapeutic irradiation facilities at the Institute of Oncology in Ljubljana and of three gamma cameras at the nuclear medicine departments. Furthermore, the SRPA assured the implementation of the national programme for the systematic examination of the working and living environment and raising public awareness about the ways of reducing exposure to natural radiation sources. The means were also assured for the surveillance and monitoring of radioactivity in foodstuffs and drinking water in the Slovenia.

The SRPA supervised radiation practices in medicine and veterinary medicine and the use of radiation sources in these activities, protection of exposed workers in nuclear and radiation facilities and radon exposure. Altogether 142 permits to carry out a radiation practice, 236 permits to use radiation sources and 1 permit to import radioactive sources, 149 confirmations of programmes of radiological procedures, 18 statements of consignees of radioactive materials and 219 evaluations of protection of exposed workers were granted. Of these, 143 were for the use of X-ray devices in medicine, 8 for the use of open and sealed sources in medicine, 7 for performing a radiation practice in nuclear and radiation facilities, 2 for air flights, 2 for transport of nuclear fuel and 57 for industrial, research and other activities. In 2010, the SRPA issued three approvals for radiation protection experts (two natural persons and one legal entity) and provided its opinion on fulfilment of conditions to perform medical checks for six medical practitioners.

Altogether, 215 inspections were carried out. Of these, there were 13 in-depth inspections in medicine and veterinary medicine, with 7 decisions requiring correction of established deficiencies issued and 5 decisions requiring sealing of X-ray devices.

With respect to radiation protection of exposed workers, in 2010 the SRPA surveyed the Krško NPP, JSI and ARAO. Altogether, 7 inspections were performed in these institutions. The SRPA also supervised the Žirovski Vrh mine, the Postojna Cave, the Škocjan Caves, and primary schools, kindergartens, hospitals and other public buildings with increased radon concentrations. Inspection was carried out in the Žirovski Vrh mine.

In the field of other natural sources of ionizing radiation, the SRPA supervised flight operator Adria Airways and carried out an inspection.

7.5 Authorized Experts

Authorized experts for radiation and nuclear safety

The Ionizing Radiation Protection and Nuclear Safety Act lays down the requirement that the operators of radiation or nuclear facilities consult authorized experts or acquire their expert opinion on specific interventions in the facilities.

From the reports of authorized experts, it can be concluded that there were no major changes in their operations in comparison to previous years. Their staff have maintained their level of competence and the equipment used was well kept and updated. The organizations established the Quality Management Programmes certificated in compliance with ISO 9001:2000. The authorized experts provided professional support to the Krško NPP by preparation of independent expertise. An important part of their work focused on an independent review and assessment of plant modifications. They also provided professional support to the administrative procedures related to the remediation of the mining waste sites of the Žirovski Vrh mine and to the activities of the Agency for Radwaste Management.

Research and development activities are an important part of their work. Certain organizations successfully participated in international research projects.

On the basis of the Ionizing Radiation Protection and Nuclear Safety Act, by the end of 2010, the SNSA had authorized 12 legal entities and 3 natural persons as Authorized Experts for Radiation and Nuclear Safety for a period of five years.

In accordance with Rules on Authorised Experts on Radiation and Nuclear Safety, the Commission for the Verification of Compliance with Requirements of Authorised Experts considered seven applications for authorisation of legal persons. One candidate for authorised expert fulfilled the criteria for extension of authorisation; the commission gave a favourable opinion and the SNSA issued an extended authorisation.

Authorized radiation protection experts

Approved radiation protection experts co-operate with employers in drawing up evaluations of the protection of exposed workers against radiation; give advice on the working conditions of exposed workers, on the extent of implementation of radiation protection measures in supervised and controlled areas, on the examination of the effectiveness thereof, on the regular calibration of measuring equipment, and on the control of usefulness of protective equipment; and perform training of exposed workers in radiation protection. Approved radiation protection experts regularly monitor the levels of ionizing radiation, contamination of the working environment and working conditions in supervised and controlled areas. The approval can be granted to individuals (for giving expert opinions and for presentation of topics relating to training on radiation protection) and to legal entities (for giving expert opinions, performance of control measurements, inspection of radiation sources and protective equipment and for performance of training on radiation protection). Individuals can acquire approval if they have appropriate formal education, working experience and expert skills, and legal entities if they employ appropriate experts and have at their disposal appropriate measuring methods accredited according to the standard SIST EN ISO/IEC 17025. Authorizations are limited to specific expert areas.

In 2010, the SRPA issued thee approvals to radiation protection experts. Approvals were obtained by two natural persons and one legal entity (the Institute of Occupational Safety, IOS). Approvals were granted by the SRPA based on the opinion of a special commission which assess the fulfilment of requirements. The IOS obtained approval for the following expert areas:

- practices in medicine and veterinary care where sources of radiation are used which emit ionizing radiation as a consequence of particle acceleration, and
- practice in medicine and veterinary care where opened and sealed sources of ionizing radiation are used.

The IOS obtained the approval in 2007, but for a shorter period and under condition that the technical examinations of radiation sources they perform will be harmonised with legislative requirements. It was ascertained that the IOS had made noticeable progress in the aforementioned fields, especially in quality assurance in teleradiotherapy and for gamma cameras and SPECT devices. Technical examinations are performed according to legislative requirements.

Authorized dosimetric services

Authorised dosimetric services perform tasks related to the monitoring of individual exposure to ionizing radiation. An approval can be granted only to legal entities employing appropriate experts and which have at their disposal appropriate measuring methods accredited to the standard SIST EN ISO/IEC 17025.

In 2010, the SRPA did not issue any approval for dosimetric services.

Authorized medical physics experts

Approved medical physics experts give advice on the optimization, measurement and evaluation of irradiation of patients, the development, planning and use of radiological procedures and equipment, and ensuring and verifying the quality of radiological procedures in medicine. Only natural persons can become approved medical physics experts.

In 2010, the SRPA issued two such approvals.

Authorized medical practitioners

Approved medical practitioners carry out the medical surveillance of exposed workers. An approval is issued by the Minister of Health on the recommendation of the SRPA and the Expanded Professional Collegium for Occupational Medicine.

In 2010, the SRPA recommended six medical practitioners.

7.6 The Nuclear Pool GIZ

The Pool for the Insurance and Reinsurance of Nuclear Risks GIZ (Nuclear Pool GIZ) is a special type of insurance company dealing with insurance and reinsurance of nuclear risks.

The Nuclear Pool GIZ has been operating since 1994 and at the moment includes eight members. The insurance company Triglav, Ltd., the reinsurance company Sava, Ltd., Adriatic Slovenica, Ltd., and the reinsurance company Triglav have the biggest shares in the pool.

The Krško NPP third-party liability cover is insured by the Nuclear Pool GIZ in the amount of 150 million SDR, in Euro equivalent (approx. EUR 173.9 million).

The Nuclear Pool GIZ participates in the third-party liability insurance risk up to its capacity level, while the rest of the risk is reinsured in 19 foreign pools. The most important are the British, Japanese, German, French, and Nordic (Swedish and Finnish) pools.

The TRIGA Research Reactor third-party liability cover is also insured by the Nuclear Pool GIZ in the amount of 5 million SDR.

In 2010, a new Act on Insurance for Nuclear Damage Liability was adopted. Since the Republic of Slovenia is a signatory to the Paris Convention, the act will set the highest standards for the protection of potential injured parties in the event of nuclear accident, providing higher guarantee limits and new requested contents of guarantee (e.g. environmental damage).

8 NUCLEAR NON-PROLIFERATION AND SECURITY OF RADIOACTIVE MATERIALS

The international community has increased its attention to nuclear non-proliferation in the last few years. A violation of the Treaty on Non-Proliferation of Nuclear Weapons has been discovered as a result of the Gulf crisis, as have clandestine activities in North Korea. A few countries which are not contracting parties continue with their nuclear weapons programmes (India, Pakistan, North Korea and Israel). The situation in Iran shows that their civil nuclear programme is not always transparently presented. The United Nations Security Council has adopted the additional resolution 1929 (2010), and the Board of Governors of the IAEA has considered the report of the General Director about the implementation of the safeguards agreement (for Iran as well as for Syria).

Between 3 and 28 May 2010, the eighth Review Conference on the Treaty on Non-Proliferation of Nuclear Weapons (NPT) was held in New York. The conference ended with the agreement on the final document, which includes an action plan in the sphere of nuclear disarmament, nuclear non-proliferation and peaceful use of nuclear energy.

Slovenia completely fulfils its obligations under the adopted international agreements and treaties. Together with other countries, it tries to prevent further expansion of nuclear weapons. Due to potential misuse of radioactive sources, the international community, including Slovenia, has increased the control of these sources with significant activity.

Nuclear safeguards

Nuclear safeguards are regulated at the international level with the Treaty on Non-Proliferation of Nuclear Weapons and the Treaty Establishing the European Atomic Energy Community. In the process of accession to the EU, the legal frameworks had to be rearranged. Slovenia now completely fulfils its obligations regarding nuclear safeguards.

In Slovenia, all nuclear material (fresh and spent fuel) at the Krško NPP, at the Jožef Stefan Institute, at the Central Storage for Radioactive Waste in Brinje and at the other eleven holders of small quantities of nuclear material is under the supervision of international inspection.

All holders of nuclear material report directly to the European Commission about their quantities and status of nuclear material, in accordance with Commission Regulation (EURATOM) No. 302/2005 on the application of EURATOM safeguards. The reports are sent in parallel to the SNSA, which maintains its registry on nuclear material, in accordance with Slovene legislation.

There were ten IAEA/EURATOM inspections in 2010; no anomalies were found. The Slovenian holders of nuclear material reported to EURATOM in accordance with legislation.

Due to the "non-side letter" application of the Additional Protocol, the SNSA continued reporting in accordance with the Protocol to the IAEA and in the defined scope to EURATOM.

The Comprehensive Nuclear-Test-Ban Treaty

One of the international legally binding instruments for combating proliferation of weapons of mass destruction is the Comprehensive Nuclear-Test-Ban Treaty (CTBT). Slovenia signed the treaty on 24 September 1996 and ratified it on 31 August 1999.

The Comprehensive Nuclear-Test-Ban Treaty Organisation (CTBTO) has been established based on the CTBT; the current tasks of the CTBTO are accomplished through the Preparatory Commission (PrepCom), which has set up an international supervisory system for detection of nuclear explosions. The CTBT commemorated its 14th anniversary at the 5th ministerial meeting in New York between 23 and 24 September 2010. Slovenia, as a CTBT signatory country, follows the work of the PrepCom. In 2010, several meetings and sessions of working groups took place. The SNSA, together with the Ministry of Foreign Affairs, considered the events in this area.

Export controls of dual-use goods

In the scope of international activities in this area, the SNSA and the Ministry of Foreign Affairs participate in the work of the Nuclear Suppliers Group (NSG) and the Zangger Committee. Slovene representatives regularly participate in the sessions of both organizations.

Jubilee 20th Plenary Week was held in June 2010. NSG Member States addressed, among other things, the situation since last Plenary Week, stressed the importance of export control of dual-use goods and their final use, agreed upon the continuation of seeking a way to strengthen the guidelines regarding enrichment and reprocessing, discussed the co-operation with India, stressed the support on diplomatic efforts to find a solution for Iran and the North Korea, and addressed the co-operation with non-NSG countries and organisations, aiming at continuous co-operations and efforts to found an effective export control and taking into consideration NSG guidelines and lists by adherent countries.

At the beginning of 2010, in the framework of its NSG chairmanship, Hungary organised a seminar on export control of nuclear dual-use items. Hungary invited several countries, including Slovenia, and expert organisations.

In 2010, the Act on Export Controls of Dual-Use Goods was amended.

On the basis of the Act on Export Controls of Dual-Use Goods, a special Commission for Export Controls of Dual-Use Goods was established at the Ministry of Economy. Dual-use goods are goods that can be used not only for civil but also for military purposes (including nuclear weapons and other weapons of mass destruction). Representatives of the Ministry of Economy, the Ministry of Foreign Affairs, the Ministry of Defence, the Ministry of the Interior, the Customs Administration, the SNSA, the Slovenian Intelligence and Security Agency and the National Chemicals Bureau constitute the membership of the commission. An exporter of dual-use goods must obtain a permit from the Ministry of Economy, issued following the opinion of the commission. In 2010, the commission had 7 regular and 18 correspondence sessions and one technical meeting.

Physical protection of nuclear material and facilities

The operators of nuclear facilities carried out physical protection in accordance with their plans on physical protection, which were approved by the Ministry of the Interior. The operators also checked if their plans were in line with the threat assessments (DBT) for 2010 issued by the police. Annual training sessions for guards of nuclear facilities and materials during transport were held. The systems of physical protection are supervised by the Ministry of the Interior and the SNSA. The Commission for Performing Expert Tasks in the Field of Physical Protection of Nuclear Facilities and Materials worked in compliance with its mission. Most important here was the co-ordination of work of all stakeholders in this field.

In the middle of April, following extensive preparations, the 2-week follow-up mission of the IAEA (IPPAS – the International Physical Protection Appraisal Service) was accomplished, addressing the area of physical protection of nuclear material and facilities. The mission’s experts prepared a special report on their findings, giving some recommendations and suggestions to further improve the situation. There were no significant deficiencies and the mission found many instances of good practice.

In the middle of the year, some changes and up-dates to the 2002 Act were prepared and harmonised, tackling the chapters of physical protection and inspection. The IPPAS recommendations which require amendments of legislation will be included in the revised act and regulations; other recommendations (suggestions) will be implemented later on.

At the end of August, the physical protection of the shipment of fresh nuclear fuel for the Krško NPP was accomplished. In November, the most challenging of nuclear material, the shipment of spent fuel from the Serbian research reactor Vinča, required extensive physical protection. The shipment entered Slovenian territory by rail (route Hodoš–Port of Koper) and continued its journey by ship bound for Murmansk in Russia. Both shipments took place without any security problems.

Illicit trafficking of nuclear and radioactive materials

The Decree on Checking the Radioactivity of Shipments of Metal Scrap has been in force since January 2008. This decree determines the requirements and rules on radiation safety provisions which have to be considered by the consignee and the organizer of transport in the case of import of scrap metal into the Republic of Slovenia. The purpose of the decree is to prevent overexposure of workers and the general public due to insufficient control over radiation sources of unknown origin, and to prevent the high costs of potential decontamination. Twenty-three organizations had been authorised for measurement of radioactivity in scrap metal shipments by the end of 2010. All these organisations sent their annual reports to the SNSA. According to the reports, 35,886 measurements of shipments were carried out. In four cases, the dose rates were elevated due to ^{226}Ra (twice), thorium and natural occurring radioactive materials. In the last-mentioned case, the shipment was not denied to the country of origin.

To enable assistance and consultation, the SNSA gave other state offices and private organizations (scrap recyclers and melting facilities) the phone number of a 24-hour on-duty officer. Thirteen calls were registered in 2010.

At the beginning of July 2010, the SNSA reported to the IAEA Illicit Trafficking Database about the loss of two lightning rods with ^{60}Co (from Gorišnica near Ptuj). The event occurred in 2005 and the regulatory body was acquainted with the first details in 2009. The lightning rods were mounted on the top of two poles without adequate markings. The poles were used for other purposes in 2005 and the upper parts were sawn off and discarded among scrap metal without knowledge of their radioactivity. The trace for the radioactive lightning rods has since been lost. The general public and users of radioactive sources were informed about the chronology of the events. No indications of criminal acts were observed in the loss of the lightning rods.

9 RESEARCH ACTIVITIES

In recent years, the Slovenian Nuclear Safety Administration has supported smaller research projects. With this, the Administration has aimed to obtain relevant data on specific technical issues and simultaneously direct and maintain scientific knowledge in Slovenia. Such research projects were meant to provide answers to specific technical questions. Unfortunately, due to cuts in financing, the possibility of funding such research had been radically reduced. Thus in 2010, there were no new studies and only the studies commissioned in 2008 were concluded.

The Competitive Position of Slovenia in 2006–2013 – Providing Radiation and Nuclear Safety targeted research programme

Back in 2005, the Slovenian Government approved the starting points for the sustainable assurance of supporting activities in the field of nuclear and radiation safety and appointed a working group to prepare the long-term programme on supporting activities in the field of nuclear and radiation safety. This programme was the basis of the targeted research programme Competitive Position of Slovenia in 2006–2013. A tender covering the following chapters was published in 2008:

- Safety questions on the technologies of nuclear and radiation facilities,
- Safe disposal of radioactive waste and spent fuel, and
- Radiation monitoring in the environment.

Three long-term joint projects of the Jožef Stefan Institute and the Institute of Occupational Safety were selected by tender. The research funds were provided by the SNSA and the Slovenian Research Agency. The selected projects are:

- Constructional properties of concrete and seepage of water through concrete structures,
- Developing the necessary skills to monitor, evaluate and control the management of aging nuclear facilities, and
- Determination of the relation between ^{129}I and ^{127}I in the marine and terrestrial environment in Slovenia.

In 2010, the projects were successfully completed and produced the expected results. The projects are briefly described below.

Constructional properties of concrete and seepage of water through concrete structures

The research on the constructional properties of concrete and seepage of water through concrete structure was carried out by the Institute of Occupational Safety, the Jožef Stefan Institute and the Faculty of Civil and Geodetic Engineering. The purpose of investigations within the project framework was to determine the principal mechanical characteristics of various compositions of concrete mixtures for reinforced concrete silos or packages in low and intermediate radioactive waste repositories. Additionally the teams investigated the impacts of defects, weak parts, non-optimal environmental conditions and cracks on water permeability of concrete and what can be expected due to the construction technologies for reinforced concrete elements in the repository. Tests were performed in accordance with valid Slovenian standards – standard groups SIST EN 12350, SIST EN 12390 and standard SIST 1026. The number of freeze/thaw cycles was increased to 550 (instead of the normal 100 to 150 cycles). Properties of fresh concrete for various concrete mixtures were determined, namely consistency, slump, unit weight and air content, as were hardened concrete mechanical properties, compressive strength after 7 days, compressive strength after 28 days, splitting tensile strength after 28 days, water penetration depth under pressure (resistance to water leakage PV-I) and water permeability coefficient.

In the framework of determination of increased depth of water penetration and permeability coefficient due to defects, weak points or nonoptimal curing they analised impacts of segregation, bug holes, cold joints, honeycombs, 2.3% reinforced bars, 2.7% reinforced bars, low temperatures (0°C), elevated temperatures (40°C) in 550 freeze/thaw cycles. Factors of increase at regard of ideal conditions varied up to 10, with the highest factor amounting to 22.6.

The performed investigations of impacts of defects, weak points or non-optimal concrete curing are in comparison with available data from literature almost certainly the first of its kind performed on concretes from domestic materials. In the available foreign literature, results of such investigations could not be found. The investigations performed also revealed some deficiencies in the project of investigations of reinforced concrete elements. It became evident that the formation of cracks should have been performed using bigger (more realistic) bending elements, i.e. plates, and out of these should be drilled cylinders for testing of the impact of cracks size on concrete permeability to water under pressure. The results indicate that cold joints can be especially critical when concrete is made of river gravel; hence such concrete should not be used in applications where isolative properties of engineered barriers are required, e.g. repositories, reservoirs and treatment plants.

The investigations performed have shown that the results of concrete testing in accordance with requirements of valid standards are often overoptimistic and do not reflect the actual state of concrete built in the structures. Therefore it would be logical to alter the standardization so that principal investigations would be performed on test samples taken from actual facilities, where possible in terms of safety. Thereby a realistic estimate of concrete quality in the structure would be obtained and premature defects in important public concrete infrastructures could be avoided.

Developing the necessary skills to monitor, evaluate and control the management of aging nuclear facilities

Jožef Stefan Institute has developed application of methods for ageing modelling within the probabilistic safety assessment (PSA). The primary interest was to compare the incorporation of ageing models in the initial events of the fault trees by incorporation of ageing models in the minimal cut sets, which are the results of the fault tree analysis. Ageing models were upgraded in the frame of PSA with the aim of optimization of testing and maintenance.

An method for improved modelling of safety systems was developed, by which combined models enable modelling of several configurations of same systems, several features of these systems and multiple operating modes of the plant. A realistic analysis of the Krško NPP was performed and was then used in modification of PSA.

The improved calculation of the human factor contribution to risk in complex systems was analysed, focusing on the impacts of interdependencies among human actions and the uncertainty propagation from deterministic analysis to PSA.

Determination of the relationship between ^{129}I and ^{127}I in the marine and terrestrial environment in Slovenia

^{129}I is formed in nature, but the main sources of ^{129}I are nuclear fuel reprocessing plants. Operational plants in Europe are located in England (Sellafield), France (La Hague) and Russia, and outside Europe in India and Japan (Tokaimura and Rakkasho).

^{129}I is gradually released in trace quantities into the atmosphere and aquatic environment from reprocessing plants. It is then physically transported in the air or water media under the influence of chemical and biological processes. Iodine is released from the marine and terrestrial environment to the atmosphere as organic iodine (mostly methyliodide) as a consequence of microbial activity. The emitted organic iodine is decomposed by sunlight into inorganic iodine compounds. Iodine enters the marine and terrestrial environment by processes of wet and dry deposition.

The United Nations Scientific Committee on the Effects of Atomic Radiation (UNSCEAR, 2000) identifies as globally dispersed radionuclides ^{3}H, ^{14}C and ^{129}I. Because of its very long half-life, ^{129}I is one of the most important radionuclides in long-term radiological assessment of discharges from nuclear fuel reprocessing plants.

In the project the content of ^{129}I in samples from the environment collected from 2008 to 2010 was investigated. From the marine environment, seawater and alga sampled at Žusterna, Portorož and Debeli Rtič, blue mussels sampled at Koper, Piran-Seča and Strunjan and sediment samples sampled in the Bay of Koper and Piran were analysed, from the terrestrial environment, precipitation, soil and pine needles sampled at Bovec, Bilje, Ljubljana and Iskrba. Bovec and Bilje were selected as sampling locations because according to statistical data the west part of Slovenia has the most precipitation. The Environmental Agency of the Republic of Slovenia chose Iskrba (Kočevje) as a reference sampling location.

^{129}I content in investigated precipitation and seawater samples was of the same order of magnitude, approximately $1·10^{-5}$ Bq/kg. Precipitation and seawater are probably the main carriers for ^{129}I exchange among the different compartments in the marine and terrestrial environments. ^{129}I levels in marine sediment and blue mussels were up to 100 and in alga up to 300 times higher than in seawater, meaning that ^{129}I accumulates in these compartments.

In the terrestrial environment, similar behaviour of ^{129}I was recorded. In investigated pine needles, the ^{129}I levels were up to 100 and in soil up to 500 (open field) and 800 (forest) higher than in precipitation. From all the investigated samples, soil samples collected in forest contained the highest levels of ^{129}I, at up to $85·10^{-4}$ Bq/kg, followed by marine algae with values up to $30·10^{-4}$ Bq/kg.

The method was found to be suitable to notice differences in ^{129}I and ^{127}I levels in soil. Soil samples collected in coniferous forest, where more organic matter is present, contained more ^{129}I and ^{127}I than soil from open fields at the same location. It is also evident that the impact of light in the open field promotes oxidation of iodine compounds via photochemical reactions.

This is the first study on the radionuclide ^{129}I in the marine and terrestrial environment in southeast Europe and makes an important contribution to the national and international databases.

10 International cooperation

10.1 International Atomic Energy Agency

During 2010, Slovenia successfully cooperated with the International Atomic Energy Agency (IAEA) in various fields. As usual, the Slovenian delegation attended the regular annual session of the General Conference. The most important Slovenian activities are as follows:

- Slovenia received 24 individual applications and two group applications for training of foreign experts in the country in 2010. Fourteen training programmes were implemented, one training application was rejected, while eight individual applications and one group application are waiting for implementation in 2011. Another five applications from 2009 were also realized in 2010.
- Slovenia submitted 3 new proposals for research contracts, which were prepared at the Jožef Stefan Institute and the Department for Nuclear Medicine. Twelve research contracts were in progress from previous years.
- Back in 2007, Slovenia submitted 4 new proposals of national technical assistance projects for the cycle 2009–2011. The Board of Governors approved 2 new technical assistance projects for the ongoing three-year period. The two national technical projects started in 2009. For the new cycle, which will start in 2012, Slovenia proposed concepts of six new national projects for technical co-operation in July 2010. The Board of Governors will decide about these new projects in November 2011.
- Slovenia continues with its active policy of hosting activities organised by the IAEA. In 2010, Slovenia hosted nine such events in the form of workshops, courses and meetings.
- In 2010, three Slovenian experts appointed to the Nuclear Standards Committee, Waste Standards Committee and Radiation Standards Committee actively participated in activities of the three committees.

At the invitation of the IAEA, in 2006 the Slovenian experts commenced co-operation in a national project of the Republic of Serbia called VIND (Vinča Institute Nuclear Decommissioning). Activities under the VIND project started in the 2003–2004 cycle of technical cooperation and assistance. The main activity under this project was completed by transporting a shipment of Serbian spent nuclear fuel to Russia. A detailed description of the transportation is given in Chapter 5.7.1. The shipment concluded another project among those of the international community's efforts to reduce the possibility of proliferation of nuclear weapons. Within the framework of the removal programme, highly enriched nuclear fuel, once no longer in use, is being returned to its countries of origin.

The Slovenian Radiation Protection Administration is involved in an IAEA project on the optimisation of the use of ionising radiation in health care, which has been going on for more than five years. The project is focused on radiation protection in intervention treatment, with an emphasis on intervention cardiology. The few years of the project have provided a good survey of the situation in this field in Slovenia. Items of medical apparatus that cause above average radiation doses to patients were identified. Consequently, adequate measures for the optimization of patient treatment using ionising radiation were taken where necessary. Good collaboration with relevant medical staff was also established within the project, contributing to better understanding of risks due to exposure of high doses to patients in this kind of treatment. During 2010 the SRPA's attention was also dedicated to the optimization of tomography examinations in pediatrics patients.

The Slovene representative was invited by Yuki Amano, Director General of the IAEA, to become a member of Standing Advisory Group on Nuclear Energy for the next three years. The group is assisting the Director General regarding IAEA activities in the fields of nuclear energy, nuclear fuel cycles, radioactive waste disposal technologies and the role of nuclear energy in sustainable development. The membership of the 20-member Group is an acknowledgment of the success of the Slovenian nuclear profession.

10.2 Organisation for Economic Co-operation and Development – Nuclear Energy Agency

In 2010, the Republic of Slovenia continued its well-developed co-operation with the Nuclear Energy Agency (NEA) of the Organization for Economic Co-operation and Development (OECD). The mission of the NEA is to assist its member countries in maintaining and further developing the scientific, technological and legal bases required for the safe, environmentally friendly and economical use of nuclear energy for peaceful purposes. The agency has a network of co-operation with the Atomic Energy Agency in Vienna and European Commission in Brussels and Luxembourg. The NEA implements specific scientific projects, including verification and benchmarking of scientific results, which will pave the way to further progress.

In terms of organisation, the agency has seven standing technical committees working under the auspices of the Steering Committee for Nuclear Energy – the governing body of the NEA –, which reports directly to the OECD Council. The standing technical committees are comprised of experts from member states and observers. The committees represent a specific international forum for exchange of experiences and knowledge regarding specific technical issues.

On 1 June 2010, Slovenia attained full membership in the OECD. In August 2010, Slovenia applied for membership of the Nuclear Energy Agency (NEA), which operates within this organization. It is expected that Slovenia will become an NEA member in 2011.

10.3 Cooperation with the European Union

Working Party on Atomic Questions (ATO)

In the first half of 2010, Sweden handed over the EU presidency to Spain. The main activity during Spain’s presidency in the Working Party on Atomic Questions (ATO) was discussion about the proposal for a negotiating mandate for the agreement between Euratom and Australia, along with their proposal for agreement with the Republic of South Africa. There was also a continuation of the follow-up negotiations on the agreements on co-operation between Euratom and Canada and Russia.

In the second part of 2010, Belgium took over the presidency. A presentation of the European Commission in connection with the provision of radioisotopes for nuclear medicine and the EU Council conclusions on the same topic was held. The main internal issue was the beginning of discussion of the draft Directive on radioactive waste and spent fuel, which started in November. The community administrative arrangements for transportation of radioactive materials were also considered among internal issues. The international issues included a complete report of Euratom for the fifth review meeting of the Parties of the Convention on Nuclear Safety, the definition of a negotiating mandate for the agreement with the Republic of South Africa and follow-up reports on negotiations with Russia, Canada and Australia. The ATO also monitored the ratification process in Member States of the Protocol, supplementary to the Paris Convention on civil liability for nuclear damage.

High-Level Group on Nuclear Safety and Waste Management (ENSREG)

In 2010, the High-Level Group on Nuclear Safety and Waste Management (ENSREG) had three meetings. It is chaired by Dr. Andrej Stritar, the SNSA Director, Besides the main group, the ENSREG has three working groups (for nuclear safety, radioactive waste management and transparency), which continued their activities in 2010. The ENSREG also first produced its website in that year. The main activities of the ENSREG were directed into three areas: implementation of the provisions of the Community Nuclear Safety Directive, with the future Directive on Radioactive Waste Management and Spent Fuel, which has been under discussion in the council working group of the ATO since November 2010, and with preparations for the forthcoming European conference on nuclear safety.

Consultative Committees under Euratom

Within the framework of the European Atomic Energy Community Treaty (Euratom), there are at present several technical and consultative committees dealing with different areas of the nuclear energy field. Representatives of the SNSA are active in the committees under Articles 31, 35/36 and 37.

The committee under Article 31 prepares recommendations for the European Commission regarding legal acts in the field of radiation protection and public health. In the June meeting, Dr. Helena Janžekovič, from the Slovenian Nuclear Safety Administration, was elected as chairperson of the committee. A key document which occupied the committee in 2010 was the amendment of the Directive on Basic Safety Standards for Radiation Protection (the BSS Directive). Euratom requires Member States to establish a system of radiation monitoring in the environment and consequently to report to the European Commission within the committee under Article 35. In 2010, there was no meeting of the committee under the Article 35. The European Commission can verify the existence and compliance of such systems with the community requirements (Article 36). Such verification took place in Slovenia in 2006. The main task of the committee under Article 37 is to prepare opinions for the European Commission regarding the impact of a certain nuclear object on adjacent Member States.

Consultative Committees of the European Commission

The Consultative Committee Instrument for Nuclear Safety Co-operation (INSC) advises the European Commission on issues with regard to assistance to third countries in the area of nuclear and radiation safety. In 2010, the INSC consultative committee discussed their annual programme, with proposals for projects of assistance to third countries and a report on the status of the programme related to the Chernobyl Fund. The history and the role of RAMG, Phare, TACIS and INSC were presented; this aimed to provide historical insight and serve as an input parameter for the future reorganization of the instrument.

The Consultative Committee Euratom-Fission (a body in the seventh Framework Programme) represents a group of experts advising the European Commission regarding nuclear research projects financed by the EU. In 2010, there were two meetings of the committee. Slovenian representative attended the first meeting, which was held in February. The main themes of the meetings were status of implementation of the Fission programme and the proposal of the work programme for 2011.

10.4 Cooperation with Other Associations

Western European Nuclear Regulator's Association (WENRA)

WENRA is an informal association consisting of representatives of nuclear regulatory authorities of European countries with nuclear power plants. The main objectives of WENRA are to develop a common approach to nuclear safety and to exchange experiences between the chief nuclear safety regulators in Europe.

In 2010, WENRA and its sub-committee dealt mainly with the safety requirements for new reactors and with the reference standards on safety of radioactive waste repositories. In 2010, Russia and Ukraine participated in WENRA as new observers for the first time. The proposal for establishing a new working group to harmonise the inspection systems, structures and components was supported. It was agreed that by the end of 2010 a questionnaire on research reactors would be prepared. The aim is the harmonisation of this area. At the November meeting, WENRA adopted a declaration on safety objectives for new nuclear power plants.

The International Nuclear Law Association (INLA)

The International Nuclear Law Association (INLA) is an international association of legal and other experts in the field of peaceful use of nuclear energy. INLA's objectives are to arrange and promote studies in and knowledge of legal problems related to the peaceful use of nuclear energy, focusing on the protection of people and their environment, on promoting exchange of information among its members and on cooperation, on a scientific basis, with similar associations and institutions. INLA has more than 500 members from more than 50 countries and international organizations.

After the 2009 conference, which was organized in Toronto, Canada (due to economical constraints, the SNSA did not send a representative), the next conference will be organized in 2011, in Bucharest, Romania.

Association of the Heads of European Radiological Protection Competent Authorities – HERCA

The SRPA collaborates with the Association of the Heads of European Radiological Protection Competent Authorities (HERCA). In 2010, an outline of the European Radiation Passport was prepared by HERCA in agreement with European Commission and a wide debate regarding its implementation was started.

European ALARA Network

As one of 20 European countries, Slovenia is participating in the European ALARA Network (EAN). The EAN is dedicated to optimisation of radiation protection and sharing good ALARA practice in industry, research and medicine. In the EAN framework, international workshops are organised in specific fields. In addition, the EAN issues a newsletter with information on practical implementation of the ALARA principle, examples of good practice and other news. The EAN has an active role in studies conducted by the European Commission and other international organisations in radiation protection. It is also involved in other aspects of implementation of the ALARA principle in practice. In the EAN framework several sub-networks are operational; the SRPA is active in the European Radioprotection Authorities Network, which is dedicated to operational informational exchange on surveillance and measures in radiation protection.

ESOREX

For several years the SRPA has been involved in the European Study of Occupational Radiation Exposure (ESOREX) project. The ESOREX project is dedicated to sampling, processing and comparison of individual occupational doses at the international level. In the project framework, countries share experience on organisations of individual monitoring and national data registry administration. The project is supported by the European Commission, but it is not confined only to EU Member States. In 2010, national coordinators and international organisation representatives (from the IAEA and UNSCEAR) met and stressed the need for co-operation in the field of individual data collection harmonisation.

10.5 Co-operation in the Framework of International Agreements

Slovenia is a party to numerous bilateral and multilateral agreements in the field of nuclear and radiation safety, safeguards of nuclear materials, notification and response during a nuclear accident, physical protection of nuclear objects, nuclear non-proliferation, and nuclear liability.

Bilateral Co-operation

In mid June 2010, a quadrilateral meeting with the Czech Republic, the Slovak Republic, and Hungary was organized in Balatonfüred, Hungary. The main topics of the meeting were activities and news related to the regulatory bodies themselves, events of interest in the nuclear power plants, and news in the area of regulations and international co-operation. Additional discussion included the planning meeting on the appropriateness of national rules, the necessity to prepare tender documentation for new nuclear power plants, and siting and determining the design basis of new power plants. The participants exchanged information about participation in international forums (WENRA and ENSREG).

In October 2010, the annual bilateral meeting between Austria and Slovenia took place in Vienna. During this twelfth bilateral meeting, both sides described the main developments in the field of legal frameworks and administration. The Slovenian side presented the adoption of a new Law on Third Party Liability. The Rules JV5 and JV7 were also presented. These refer to radiation and nuclear safety of installations before and during operation respectively. Austria reported on the transposition of EU Directive on Nuclear Safety in its legislation. Other topics included radiation monitoring, emergency preparedness and waste management. Slovenia presented the performance indicators for the NPP Krško, explained some of the operational events and described the implementation of the action plan after the first periodic review.

In May 2010, SNSA director Dr. Andrej Stritar and Commissioner Prefect Vincenzo Grimaldi, Head of the Italian Institute for Environmental Protection and Research, signed Arrangement on Early Exchange of Information in the Event of a Radiological Emergency and Co-operation in Nuclear Safety Matters, which has been in force since September 2010.

Multilateral Co-operation

In February 2010, the Slovenian Nuclear Safety Administration began with preparations for the fifth review meeting of the Parties of the Convention on Nuclear Safety (CNS). Since the last review meeting, held in 2008 in Vienna, the Krško NPP, SNSA, SRPA and Ministry of Economy have co-operated in preparing the report on compliance with the CNS in Slovenia. The report was finalized in June and the government adopted it in July. In late August, the report was sent to the International Atomic Energy Agency, which distributed it to other parties for review. By December, member states had reviewed the reports and shared questions. Slovenia raised 84 questions and received 40 questions.

Intergovernmental Agreement on the Co-ownership of the Krško NPP

NEK authorities – the Assembly, Supervisory Board and Management Board – co-exist on a parity basis and operate in accordance with the competences and responsibilities laid down the Intergovernmental Agreement.

In 2010, the Assembly of the NPP convened two times. On the basis of Article 49 of the Intergovernmental Agreement, the Assembly inter alia adopted the Krško NPP annual report and gave the consent for two agreements on servitudes.

The Assembly gave the Management Board two approvals to establish a servitude on two plots. On plot no. 1204/206 of the cadastral municipality of Leskovec for the constru–ction, installation, operation, maintenance and monitoring of water supply system in favour of the servitude beneficiary municipality of Krško, and on plot no. 1197/44, cadastral municipality of Leskovec, for the construction of public communications networks and access to built communications networks and associated infrastructure for the operation and maintenance servitude for the benefit of the beneficiary Telekom Slovenia.

In accordance with the adopted methodology of making monthly reports, the NPP has been sending information from its financial statements to the Supervisory Board.

In 2010, the Supervisory Board held five meetings and monitored the operation and supervised the management of the company. The basis for its work has been written materials prepared by the Management Board. At each meeting the Supervisory Board followed up the adopted decisions and views.

The Supervisory Board of the NPP has considered and adopted, in particular:

- information about economic operations,
- the long-term investment plan,
- monthly reports of the independent safety evaluation group (ISEG),
- economic plans.

It also expressed a positive opinion on the annual report.

On the basis of the fifth point of Article 40 of the Intergovernmental Agreement, the Supervisory Board gave the administration approval to issue a letter of intent for the supply of forgings for the replacement rotor of the main electric generator of the NPP and adopted an investment programme for raising embankments to protect the NPP against maximum possible floods.

The NPP Management Board has worked with the following composition:

- Stanislav Rožman, President of the Board and
- Hrvoje Perharić, Member of the Board.

The Management Board has represented and managed the business in accordance with the NPP operating partnership agreement and unanimously determined business policy, independently concluded legal transactions and conducted business activities. In addition, in different areas the board has adopted 69 individual decisions.

In accordance with the third point of Article 10 of the Intergovernmental Agreement, the professional organizations Agency for Radioactive Waste Management (ARAO) and Agency for Special Waste (APO) prepared the Krško NPP Decommissioning and Disposal of LILW and SNF Programme (the Decommissioning Programme). Project teams of both professional organizations should complete a short revision of the Decommissioning Programme, according to the comments of the Scientific Council, then a review will be made and the programme will be confirmed by the Interstate Commission for Supervising the Implementation of the Intergovernmental Agreement. On the Slovenian side, the Decommissioning Programme should be approved by the government and on the Croatian side by Sabor. Adoption of the Decommissioning Programme is the basis for calculating the contribution to be paid into separate funds for the decommissioning of the NPP in both countries, for every kWh of electricity received from the NPP. The Decommissioning Programme is updated every five years.

10.6 Use of Nuclear Energy in the World

At the end of 2010, there were 30 countries operating 441 nuclear reactors for electricity production. In 2010, five new nuclear power plants were put in operation, one in Russia, one in the Republic of Korea, one in India and two in China. The operation of the Phenix nuclear power plant in France was ended. The construction of 14 new nuclear power plants started in 2010, of which 9 were in China, two in Russia and one each in Japan, Brazil and India.

Detailed data on the number and installed power of reactors by countries is given in Table 10.

In Europe, there are nuclear power plants under construction in Finland, France and Slovakia. New builds are planned in Poland, Hungary, Czech Republic and Bulgaria.

Table 10: Number and installed power of reactors by countries

Country	Operational		Under construction	
	No.	Power [MW]	No.	Power [MW]
Belgium	7	5,934		
Bulgaria	2	1,906	2	1,906
Czech Republic	6	3,678		
Finland	4	2,721	1	1,600
France	58	63,130	1	1,600
Germany	4	1,889		
Great Britain	17	20,490		
Hungary	1	487		
Netherlands	2	1,300		
Romania	32	22,693	11	9,153
Russia	4	1,762	2	782
Slovakia	1	696		
Slovenia	8	7,516		
Spain	10	9,303		
Sweden	5	3,238		
Switzerland	15	13,107	2	1,900
Ukraine	19	10,137		
Europe total:	195	169,987	19	16,941
Argentina	2	935	1	692
Brazil	2	1,884	1	1,245
Canada	18	12,569		
Mexico	2	1,300		
USA	104	100,747	1	1,165
Americas total:	128	117,435	3	3,102
Armenia	1	375		
China	19	4,189	6	3,362
India			1	915
Iran	54	46,823	2	2,650
Japan	13	10,048	27	28,230
Korea, Republic of	21	18,665	5	5,560
Pakistan	2	425	1	300
Taiwan	6	4,980	2	2,600
Asia total:	116	85,505	44	43,617
South Africa	2	1,800		
World total	**441**	**374,727**	**66**	**63,660**

Reference: International Atomic Energy Agency

10.7 Radiation Protection and Nuclear Safety Worldwide

The International Nuclear and Radiological Event Scale (INES) is used worldwide as a tool for uniform notification of the public on the safety significance of nuclear and radiological events. The events are rated into seven levels: levels 1 to 3 for incidents and levels 4 to 7 for accidents.

International reporting is performed for more significant events: level 2 or above and those that have caught the interest of the international public. Since 2001, a Nuclear Events Web-Based System (NEWS) for publication of event reports has been established.

In 2010, there were 16 event reports published in the NEWS. Six reports were on events in nuclear power plants, three reports were on events with the use of radiation sources, and the other reports were on different types of events, e.g. mining, orphan sources in scrap metal shipments and use of radiation sources in research organizations.

The highest rated event – at level 4 – occurred in India. Because of a scattered radiation source (^{60}Co) in a scrap metal yard, seven persons were exposed to high radiation doses (0.4 to 3.7 Gy). One person died after being exposed.

There were ten events rated as level 2. The most interesting was an event at H. B. Robinson NPP, where several fires occurred because of electric power line failures. In spite of some malfunctions of safety-related equipment, the plant was shut down safely. There were no radiological consequences for personnel or the environment, and the level 2 rating for the event was based on degradation of defence-in-depth.

Five events were rated as level 2 due to exceeding of dose limits for workers with radiation sources in nuclear power plants of in industrial radiography practices. In some cases the workers' dosimeters were not in place or procedures for work with radiation sources were breached. With a proper use of radiation detectors and by adhering to the procedures, the exposures of workers could be avoided.

One event was reported on overexposure of a member of the population who has been in contact with a radioactive patient in a hospital and had breached the visiting time and the radiation shielding limitations. The patient was radioactive because of the radio—isotope implants being used for radiotherapy purposes.

One of the events was rated as level 2 because of degradation of defence-in-depth and contamination of workers with radioisotopes.

One event was rated as level 2 due to finding of an orphan source in an imported shipping container. None of the workers that were near the container had been overexposed.

In an event in a nuclear power plant, safety systems were activated. Operators shut down the plant safely and there was no exposure to the personnel or radioactive releases to the environment, but the event was still rated as level 2 due to the inappropriate safety culture that contributed to the event.

Three events were rated as level 1, one due to the discovery of damage to some nuclear power plant equipment, one due to inappropriate procedures in a nuclear power plant and one due to loss of control over several radioactive sources in an abandoned ironworks.

In 2010 Slovenia did not report to the NEWS, as there were no events fulfilling the criteria for international reporting. However, we rated for an emergency in a hot cell facility at the TRIGA research reactor, where a local fire occurred with spread of contamination within the facility (but without affecting the environment). The event was rated as level 1. More information on this event is given in Chapter 2.1.2.

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