REPUBLIC ENERGY COMMITTEE OF SR SLOVENIA
LJUBLJANA, YUGOSLAVIA

NUCLEAR SAFETY ACTIVITIES in SR SLOVENIA in 1985

Ljubljana, September 1986

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Abstract

Currently Yugoslavia has one 632 MWe nuclear power plant of PWR design, located at Krško in the Socialist Republic of Slovenia. NPP Krško, which is a two-loop plant, started power operation in 1981. In general, reactor safety activities in SR Slovenia are mostly related to upgrading the safety of our NPP Krško and to develop capabilities to be used for the future units.

This report presents safety related organizations in SR Slovenia and their activities performed in 1985.

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A. ORGANIZATIONS RELATED TO NUCLEAR SAFETY

With the coming into force of the federal "Act on Radiation Protection and the Safe Use of Nuclear Energy" (Federal Official Gazette No. 62/84, referred hereinafter as the 1984 Act), Yugoslavia has a partly new organizational structure of the regulatory body, competent for nuclear safety. This competence is divided between the federal and the republic (and autonomous province) authorities.

1) Federal organization

a) Regulations:

Since nuclear safety is a matter of importance for the whole country, federal authorities regulate this field of activities. Thus, the FEDERAL ENERGY AND INDUSTRY COMMITTEE is authorized to pass four very important regulations for carrying into effect the nuclear safety provisions of the above mentioned 1984 Act, i.e.:

- Regulation on the conditions for siting, design, construction, commissioning and operation of nuclear facilities;

- Regulation on the format and contents of safety analysis reports for nuclear facilities;

- Regulation on qualifications, experience and training of personnel in nuclear facilities;

- Regulation on accounting and control of nuclear materials.

The FEDERAL COMMITTEE FOR LABOUR, HEALTH AND SOCIAL WELFARE is authorized to adopt several regulations concerning radiation protection in all fields where radiation sources are being applied (e.g. regulations on a national monitoring system for environmental radioactivity, on the disposal of radioactive waste, on the application of sources of ionizing radiations for medical purposes, etc.).

b) Licensing:

Responsibility for licensing nuclear facilities in Yugoslavia lies with the authorities in the republics or autonomous provinces where the plant is to be alocated. However, to assure an assessment and overall control of the nuclear safety questions important for the whole country, a federal COMMISSION FOR THE SAFETY OF NUCLEAR FACILITIES is established at the FEDERAL ENERGY AND INDUSTRY COMMITTEE. The competent authority in republics or provinces may issue a license for the site, construction, commissioning and operation of a nuclear facility only if the Federal Commission has assessed, that all the prescribed safety conditions had been met.

c) inspections:

The inspections and enforcement of the 1984 Act is carried out by the competent bodies in the republics or autonomous provinces. However, in some cases, as e.g. the implementation of international agreements, the use of standards and quality norms etc., a federal body has the right to provide binding instructions to the competent republic or provincial bodies or even perform an activity which they failed to carry out.

2) Regulatory structure in the SR of Slovenia

The regulatory authorities acting on matters related to nuclear safety in SR Slovenia are shown in Figure 1.

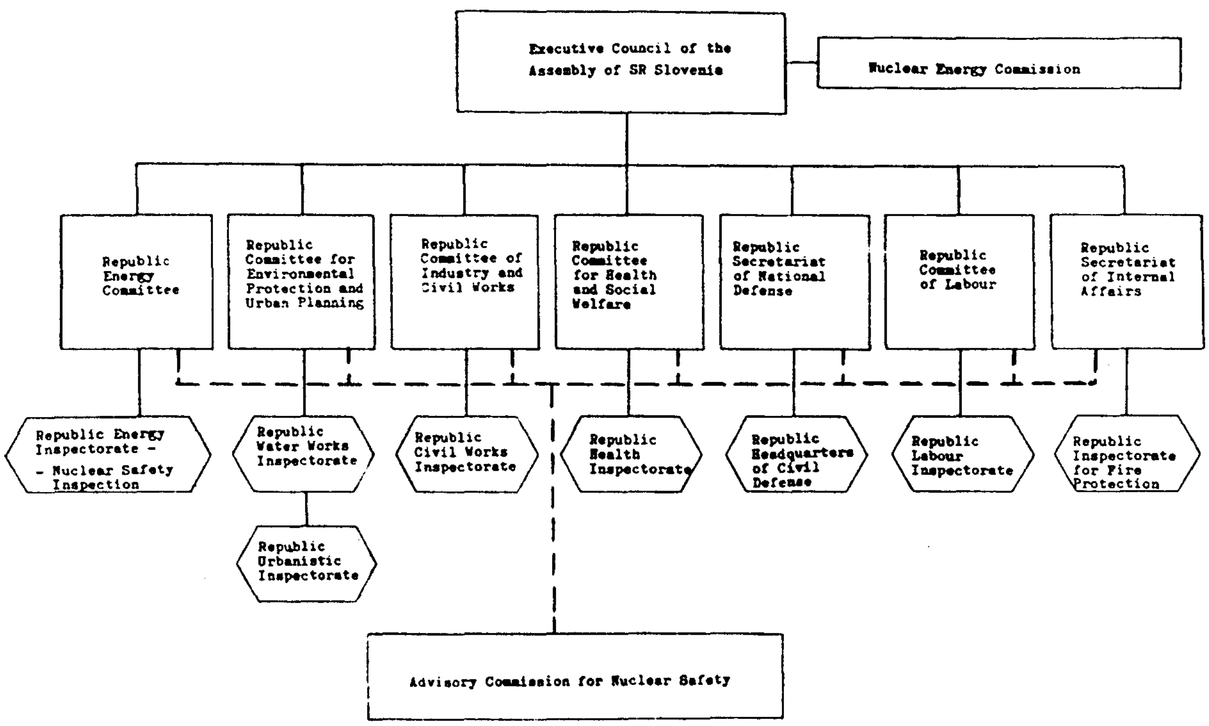


Figure 1: Governmental organization in SR Slovenia

The competence to pass regulations, for licensing and for inspection, is described within the presentation of the various organs and organizations. Generally speaking, nuclear safety in the SR of Slovenia is regulated with the republic (1980) "Act on the Execution of Radiation Protection and Measures for the Safety of Nuclear Facilities" (Republic Official Gazette No. 28/80). Due to the comprehensive and detailed provisions of the federal 1984 Act and Regulations, passed pursuant to it, there is little room left for the Republic's legislative activity. The most important republic legislative competence is the determination of the regulatory structure for the licensing and inspection activities. Furthermore, in detailing the general safety measures, prescribed by the federal 1984 Act, the SR of Slovenia adopts every 5 years a "Programme of Measures for Radiation Protection and Nuclear Safety". On this basis the competent administrative bodies of the SR of Slovenia, each for its field of activity, by the end of every year bring a detailed programme of general activities to be performed in the coming year. In the field of nuclear safety, this annual pogramme of general measures is financed by a special "Fond for nuclear safety" to which the State budget of Slovenia and the 3 greatest owners of nuclear facilities in Slovenia contribute on the basis of a social compact, signed in 1984. In this way general safety measures of interest for the whole republic of Slovenia are assured. Safety measures in each nuclear facility remain, of course, the responsibility of their operators.

The EXECUTIVE COUNCIL of the Assembly of the SR of Slovenia, i.e. the government, has very few direct functions related to nuclear safety. It adopts the already mentioned "Programme of Measures for Radiation Protection and Nuclear Safety" for a period of 5 years. It is also his direct competence to order the evacuation of the population in case of a nuclear accident or radiological emergency. Otherwise the various republic administrative authorities are acting within its structure.

Before describing the administrative authorities bearing responsibilities related to nuclear safety three important special republic bodies have to be mentioned.

1) NUCLEAR ENERGY COMMISSION is advising the Executive Council on questions related to energy policy, development of the national nuclear programme and other general matters.

2) ADVISORY COMMISSION FOR NUCLEAR SAFETY is the central experts' group in Slovenia, dealing with safety related questions and coordination among different governmental organs. It consists of representatives of governmental bodies and various research institutes. All questions concerning radiation protection and nuclear safety are passed to this commission. In the course of a licensing procedure, the competent administrative organs have to obtain an opinion of the commission, before their decision is taken.

3) The REPUBLIC HEADQUARTERS of CIVIL DEFENCE is responsible for planning and executing the civil protective measures in case of national disasters and other significant emergencies, including nuclear accidents and radiation emergencies.

The REPUBLIC ENERGY COMMITTEE is, within the limits of the federal regulations, authorized to adopt various regulations related also to nuclear safety (e.g. on regular reports on the operation of a nuclear facility etc.). Acting within its legal framework the REPUBLIC ENERGY INSPECTORATE is, according to the existing republic 1980 Act, authorized to issue the commissioning permits for nuclear facilities. The REPUBLIC ENERGY INSPECTORATE has a NUCLEAR SAFETY INSPECTION which is responsible for inspecting the nuclear facility during construction and operation. In discharging their responsibilities, this inspection may, among other, discontinue the operation of a nuclear facility, if not all prescribed conditions have been met.

The REPUBLIC COMMITTEE FOR ENVIRONMENTAL PROTECTION AND URBAN PLANNING is authorized for issuing a site license for a nuclear facility. Through its REPUBLIC WATER WORKS INSPECTORATE and REPUBLIC URBANISTIC INSPECTORATE control over this part of the administrative procedure is being executed.

The REPUBLIC COMMITTEE FOR INDUSTRY AND CIVIL WORKS is competent for the rest of the licensing procedure. It issues the licenses for construction and for the operation of a nuclear facility, if all the prescribed conditions are met. The REPUBLIC CIVIL WORKS INSPECTORATE has an authorization for inspections during the construction. The REPUBLIC COMMITTEE OF HEALTH AND SOCIAL WELFARE is competent for the control of environmental radioactivity and the control of workers exposed to radiation. These tasks are realized through the REPUBLIC HEALTH INSPECTORATE.

The REPUBLIC COMMITTEE OF LABOUR, the REPUBLIC SECRETARIAT OF INTERNAL AFFAIRS, and the REPUBLIC SECRETARIAT OF NATIONAL DEFENSE perform actions relating to their competences.

These administrative bodies, in discharging their responsibilities, rely on the professional support of authorized organizations in technical matters. The AUTHORIZED ORGANIZATIONS which are listed in the Official Gazette perform important technical tasks related to nuclear safety and report annually to the competent administrative bodies.

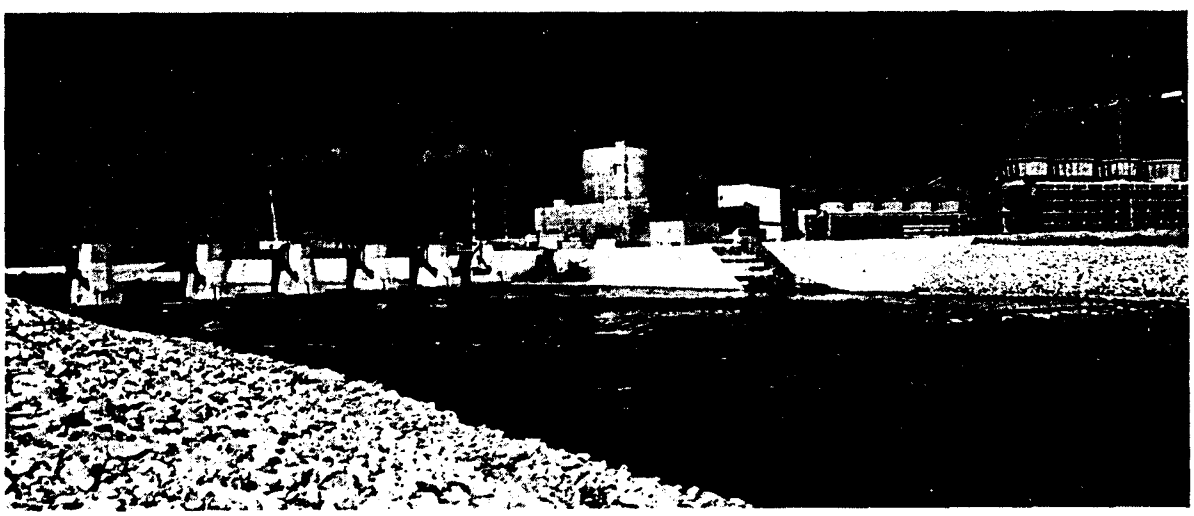
B. NUCLEAR SAFETY ACTIVITIES

I. NUCLEAR POWER PLANT KRŠKO OPERATION IN 1985

Nuclear power plant Krško started power operation in 1981.

The power production and availability data for 1985 are given below.

Availability Data:	hours	%
Time availability	6420	73.3
Refuelling, surveillance and maintenance	1751	20
Planned shutdown	18	0.2
Forced outage	593	6.8



Krško Nuclear Power Plant

FORCED SHUTDOWNS IN 1985

No.	Date	Duration (hours)	Cause	Mode	Remarks
1	Jan. 1-3	49	A	manual	Event occurred on Dec. 29, 1984. Repair took 53 hrs in 1984 and 49 hrs in 1985. See description.
2	Mar. 7	143	A	manual	See description.
3	Apr. 5	1	A,B	automatic	See description.
4	May 15	81	A,B	automatic	See description.
5	Aug. 26	3	A	manual	See description.
6	Aug. 29	1	A	automatic	See description.
7	Oct. 26	12	A	manual	See description.
8	Dec. 13	303	A,F	manual	See description.

Symbols:
A - equipment failure
B - maintenance or testing
C - refuelling
D - Regulatory Body limitations
E - operator training, exams
F - administrative measures
G - operational error
H - other

SHORT DESCRIPTION OF UNPLANNED SHUTDOWNS AND TRIPS IN 1985

Number	Date	Short event description
1	Jan.1-3	Steam pressure from a low pressure turbine feeding the preheaters 3B, 4B, 5B and 6B was abnormally low. The plant was manually shut down. The expansion joint on 3B preheater was found destroyed. Damages on other expansion joints were also found.
2	March 7	The plant was shutdown due to excessive leakage from primary reactor coolant system. The leakage occurred mostly on the pressurizer spray valve.
3	April 5	OT Δ T reactor trip during regular I&C testing. Trip was caused by the coincidental failure of one protection channel while the other was on test.
4	May 15	Inadvertent safety injection and reactor trip signal was initiated during regular testing of main steam isolation valves.
5	Aug. 26	Manual turbine trip due to DEH malfunction. Since reactor power was above 10%, reactor trip was automatically initiated.
6	Aug. 29	Reactor trip was on steam generator No.2 low-low level signal caused by inadvertent closure of FW isolation valve 21137.
7	Oct. 26	The plant was manually shutdown due to loss of heater drain flow, caused by malfunctioning of LCV 5126.
8	Dec. 13	In accordance with the Technical Specification the plant was shut down because of the loss of second independent source of outside power supply, which was not restored within 72 hours interval.

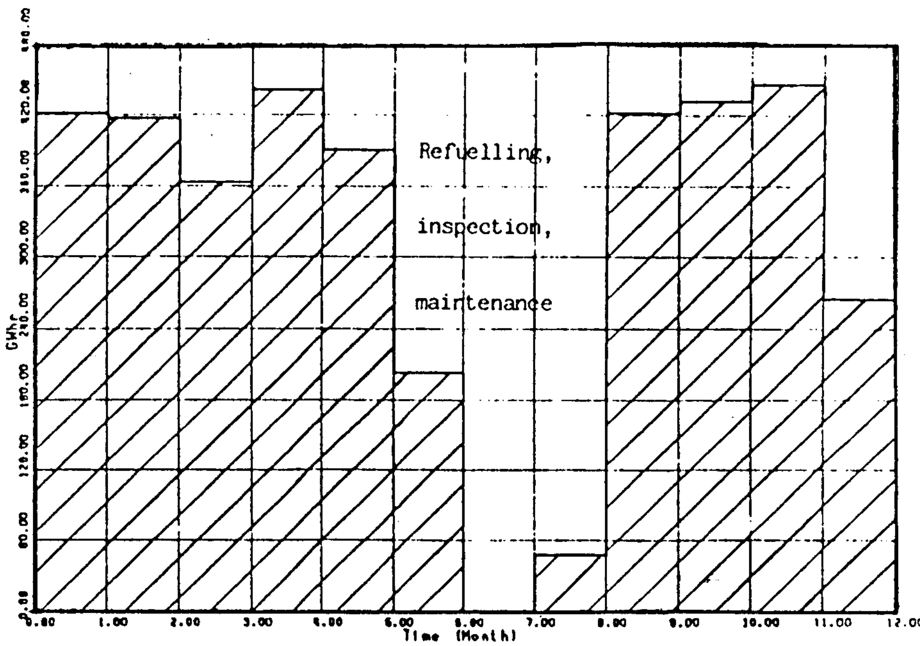


Figure 2: Electricity Production (3839.6 GWhr) in 1985

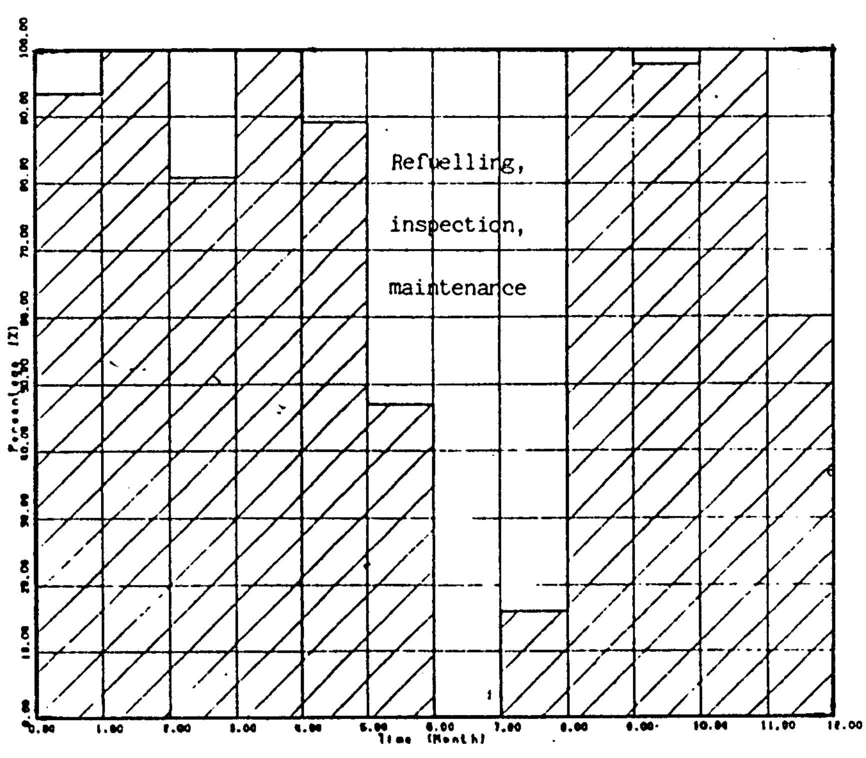


Figure 3: NPP Krško - Time Availability in 1985

II. SYSTEMATIC REVIEW AND RECORDING OF SAFETY RELATED ISSUES

1) Report on Safety Issues in 1985

Based on the "Programme of Measures for Radiation Protection and Nuclear Safety" the Regulatory Bodies of the Socialist Republic of Slovenia require a systematic review of selected safety related activities and independent evaluation of operational events in nuclear plants and facilities abroad and from NPP Krško to be conducted and reported to them. This work is done by "J.Stefan" Institute, located in Reactor Center at Podgorica, about 10 km from Ljubljana.

In the report prepared for 1985 a description is given of the present state of regulatory codes, new designs, research activities and operating experience as regards the nuclear safety abroad.

In the field of codes and regulations the report describes the "Symposium on IAEA Safety Codes and Guides in the light of current safety issues" (Vienna, October 1984), the revision of 10CFR, 50.109 "Backfitting" and the planned modifications of requirements from App. K to 10 CFR 50 concerning emergency core cooling system.

The new designs of the German KWU "Konvoi" and the status of the British project Sizewell - B which is improved Westinghouse standard project SNUPPS are discussed.

Summaries from the Specialist Meeting on Small Break LOCA in Pisa (1985), Loss of Fluid Test performed in USA (1984), Core Melting Test by KTG, Karlsruhe and Source Term Researches, are further reported.

As regards the operational events the following operational events were analysed: Virgil C. Summer-1 Event in USA, 1985 (Reactor Trip on High Neutron Flux), Davis-Besse 1 (Total Loss of Feedwater Event), auxiliary Diesel generators failures and the use of PSA methods in nuclear safety.

2) Safety Related Library

All documents collected by local institutions which are related to nuclear safety are centrally registered by the help of the IJS DIS program package. Records include the following items: date of publishing, language, signature, author, title, place of publishing, publisher, institution, type of document, keywords and remarks. In this way all documents can be found if only one of the above mentioned information is given to the computer. The list of documents is being updated monthly and the information on the latest documents is distributed to all parties of the Agreement on Exchange of Information. The list of documents presently contains 3500 records which are classified according to the institutions where they are located. At present the Safety Documentation Library covers publications collected by IJS, EIMV, IMK and partially by NEK and RKE.

III. REGULATIONS PREPARATION

As already mentioned, pursuant to the 1984 Act, the Federal Energy and Industry Committee is authorized to adopt the following four regulations important for nuclear safety:

- Regulation on the conditions for siting, construction, commissioning and operation of nuclear facilities;
- Regulation on the elaboration and contents of safety reports for nuclear facilities;
- Regulation on professional qualifications, experience and training of personnel in nuclear facilities;
- Regulation on accounting for and control of nuclear materials.

The drafts of all the four regulations are being studied and elaborated also by working groups from the SR of Slovenia. Through coordination by "Jožef Stefan" Institute from Ljubljana, the drafts of the "Regulation on professional qualifications, experience and training of personnel in nuclear facilities" and of the "Regulation on accounting for and control of nuclear materials" were completed and presented to the competent federal authority for adoption. Also the working drafts of the "Regulation on the conditions for the siting, design, construction, commissioning and operation of nuclear facilities" and of the "Regulation on the format and contents of safety analysis reports for nuclear facilities" are being prepared in collaboration with experts from Slovenia.

In the field of radiation protection the Federal Committee for Labour, Health and Social Welfare adopted nine regulations until now. In Slovenia a working group was set up which contributed many useful amendments during the drafting of the mentioned regulations.

IV. PROBABILISTIC SAFETY ANALYSIS (PSA) PROGRAMS

Probabilistic safety analysis (PSA) is defined as the application of probabilistic risk analysis to safety decisions. The PSA can be of use in various fields of investigation - standards and regulation development, siting of plants, operator training, risk comparison, design optimization, safety modifications (backfitting), operating procedures, test and maintenance procedures, safety goals and plant availability.

Probabilistic risk assessments can be performed at different levels, depending on the objectives of the study and the availability of time and manpower. These three discrete levels are the following:

Level 1: System analysis
Level 2: Systems and containment analysis
Level 3: Systems, containment and consequence analysis.

An analysis of external events may be included in any of these three levels. The external events that are selected for the analysis depend on the site, but they include such events as plant fires, internal and external floods and earthquakes.

1) Cooperation with IAEA on PSA projects

Yugoslavia has joined the Interregional IAEA project, INT/9/063, Probabilistic Safety Analysis in late 1985. This project, locally coordinated by IJS, will be performed jointly by different institutions from SR Slovenia and SR Croatia. Six institutions have been engaged altogether. The analysis will comprise the evaluation of importance and interaction of various plant systems and components, identification of accident sequences, deficiencies of design, of operating procedures and of test and maintenance work. The overall objective of this programme is to produce a probabilistic model of Krško NPP which can be used by the utility and regulators in both safety and operational analysis of the plant.

The project scope is a level 1 PSA (NUREG-2300). Specifically the project envisages:

- To determine the core melt frequency from a comprehensive set of accident initiators internal to the plant, including Loss of Offsite Power.
- To report dominant accident sequences, uncertainties, importance ranking of systems and failure modes.
- To report specific contributions of 1E category to the total core melt frequency.

In parallel J.Stefan Institute, Reactor Engineering

(c) Detailed evaluation and comparison of code results for Auxiliary Feed Water System reliability of NPP Krško

IAEA stimulates exchange of experiences in the area of PSA among the actively participating member states. Jožef Stefan Institute staff regularly participate in IAEA workshops.

2) Computer codes, data base and calculation of risk, reliability and availability of NPP systems

The program packages PREP/KITT, COMCAN II, FTA, FTAP/IMPORTANCE and MOCARS were installed on CDC computer CYBER 172 at the Republic Computer Center (RRC) in Ljubljana and on VAX-11/750 computer of the Reactor Center in Podgorica. The installed codes are regularly modified and updated.

Current data base uses generic values of component failures as specified by the foreign documentation (like US Reactor Safety Study WASH 1400), and NREP (National Reliability Evaluation Program) NRC documents. It is planned to substitute those values gradually by the specific operational data from NPP Krško.

Until now reliability was calculated of some NPP Krško systems like: Auxiliary Feedwater System (AFWS), Main Feedwater System (MFWS), Containment Spray System (CSS) etc. using data from NPP Krško. Draft was prepared for reliability calculation of 1E electrical supply system with diesel generators.

CRAC-2 (Calculation of Reactor Accident Consequences) is the program package for calculating risk and environmental effects due to finite probability of severe core melt accidents in NPPs. It was developed within Rasmussen's Reactor Safety Study (WASH 1400). For a given NPP location site specific data are required, as well as meteorological and population data etc. The application of the program includes the model of meteorological dispersion of radioactive cloud. The program calculates health effects on population close to the NPP site and at great distances (more than 1000 km) and provides economic consequences, too (costs of evacuation and interdiction of products).

It also calculates doses from the expanded radioactive cloud and the chronic and long term exposition due to deposited radioactive materials.

A part of the input data required for the application of CRAC-2 the NPP Krško specific data were prepared partly with the help of data from the Final Safety Analysis Report. A file of meteorological data from the one year on-site measurements were prepared, too.

V. PARTICIPATION IN IAEA INCIDENT REPORTING SYSTEM (IRS) AND SAFETY ASSESSMENT OF EVENTS IN NUCLEAR FACILITIES

With the rapidly increasing number of cumulative reactor years, the feedback of experience is becoming a valuable tool for enhancing safety and reliability of nuclear power plants. Systematic reporting and evaluation of safety-related events can lead to the identification of necessary plant modifications and the development of improved plant procedures. To facilitate the exchange of experience, both the Nuclear Energy Agency of the OECD (OECD/NEA) and the IAEA have established Incident Reporting Systems (IRS) to collect and examine events submitted by national organizations. National coordinators screen all events, passing on the most significant. Yugoslavia has joined IRS, the national coordinator being Republic Energy Inspectorate of SR Slovenia.

The IAEA form contains report number, title, event date, original report number, follow-up report number, plant name, licensee, type of reactor and manufacturer, reactor power, commencement of operation date, abstract, basis for reporting, information whether the report is urgent or not, narrative description of the incident, safety assessment and corrective actions taken or planned.

In establishing the national reporting system the Republic Energy Inspectorate is being assisted by "Jožef Stefan" Institute which is planning to use a computer aided data base on incidents in nuclear plants. A simplified form will be used at the beginning and later on it will be upgraded by the IAEA form.

This year 78 events from IAEA IRS library were analysed, 47 of these occurred in PWR, 23 in BWR, 2 in gas-cooled and 6 in HWR. Incidents were caused by technical failures and by human factor. Especially BWR and PWR events were initialized by human errors during maintenance, testing and installation. This indicates that more attention will have to be paid to operating procedures and instructions for maintenance, testing and installation and to additional training of the staff.

A special study of events which occurred in NPPs similar to NPP Krško covered the following two-loop PWR plants: Doel 2 (Belgium, Westinghouse), Borselle (Netherlands, KWU), Davis-Besse (USA, B and W), Cruas (France, Framatome), Mihama 2 (Japan, MNI/Westinghouse), Angra 1 (Brasil, Westinghouse). Though the number of events studied was small (10) the conclusion was again that more attention has to be paid to operating procedures and instructions for maintenance, testing and installation and to additional training of the staff.

Occurrences in Krško Nuclear Power Plant were evaluated on request by the regulatory body. The following events which take place in the period from February 1983 to December 1985 were analysed:

SRT-433 - Decrease of pressure in auxiliary cooling system below Technical Specifications limit
SRT-495 - Uncorrect operation of certain protective parts in Diesel generators DG-1 and DG-2
SRT-555 - Leaking of inner seal on reactor vessel flange
SRT-47 - Containment pressure increase over the Technical Specifications limits due to compressed instrument air leakage
- Loss of the second independent off-site power source (fault on T3 110/6,5 kV transformer)

All events are described on forms according to IAEA IRS. Safety assessment and categorization are made using American National Standards (ANS) and considering IAEA recommendations. ANS classifciation from the Final Safety Analysis Report having four categories of incidents, according to their frequency and probability of radiation exposure to the environment) and IAEA Guide to a National System for Collecting, Assessing and Disseminating Information on Safety Related Events in NPPs classifies seven categories of incidents was used. Depending on the category the incidents are then selected for reports to regulatory bodies.

LOSS OF THE SECOND OFF-SITE POWER SOURCE AT NPP KRŠKO

On December 9, 1985 the malfunction of the auxiliary transformer T3 (110 kV/6.3 kV) at NPP Krško was discovered. This transformer is in a stand-by position during normal operation and connects the NPP Krško with the second independent off-site power source at SPP Brestanica. (See Figure 4.)

Following the event, the NPP Krško submitted a request for a temporary change of Technical Specifications. The valid Technical Specifications allow power operation to continue for 72 hours and then require to bring the NPP to a cold shutdown state within the next 36 hours.

NPP Krško obtained the assurance for the increased reliability of 380 kV off-site power supply from the dispatcher service and after forming a special team capable of disconnecting any one out of four remaining transformers within one hour in case a fault occurs on it.

The influence of the proposed improvements was estimated. Values for probabilities for the loss of electric supply and frequencies of initiating events were calculated in order to obtain the expected final reliabilities. The conclusions of the analysis showed that:

- The loss of power supply from the SPP Brestanica is of extreme importance, so that for each of the initial events probability of failure increases for three or more orders of magnitude.

- All introduced improvements which are realisable in a comparatively short time can reduce the probability of the loss of electric power for less than one order of magnitude.

- Among all the assumed improvements the generator removal from the production level to the level of self-consumption has a dominant influence.

- The assumed probability that a plant can remain in its house load in case of disintegration of 380 kV network was 50%. It was then varied from 25% to 75%.

- Figure 5 on which two curves are compared (the basic configuration without Brestanica plant and with the introduced improvements) shows the time interval in which NPP Krško could still operate (in spite of SPP Brestanica unavailability) within the risk limits defined by Technical Specifications.

As a result the temporary change of Technical Specifications was not granted and the plant went into a cold shutdown.

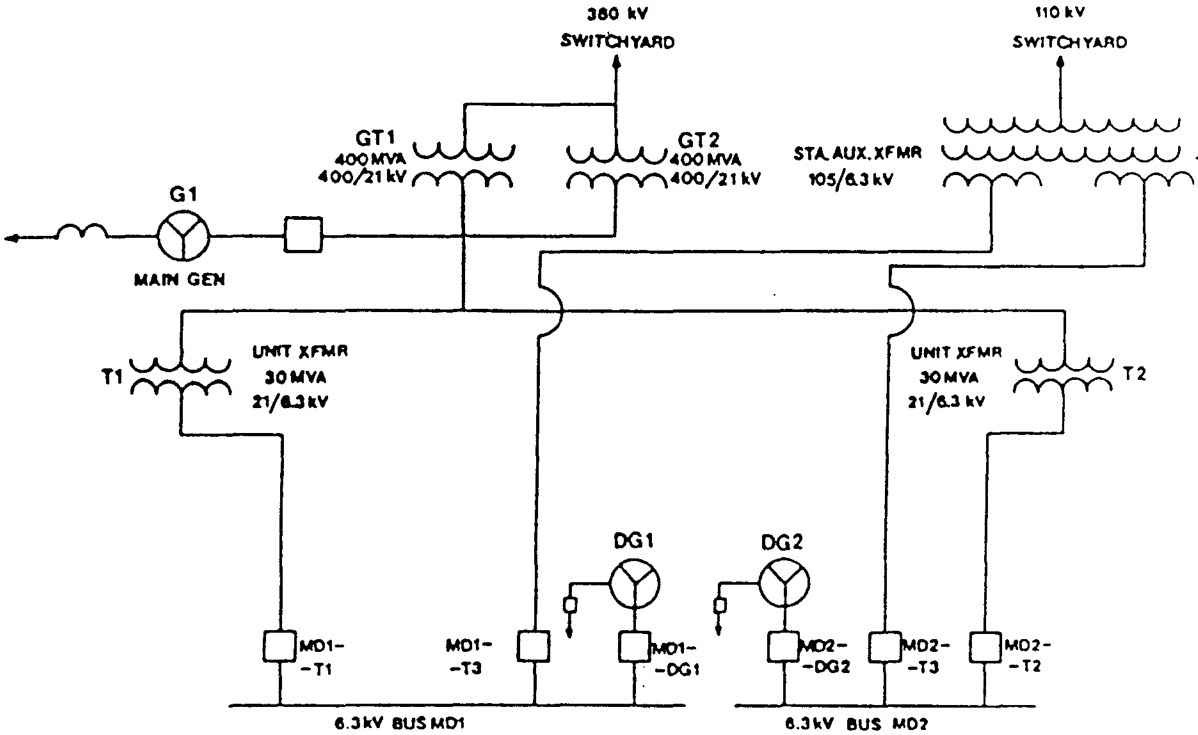
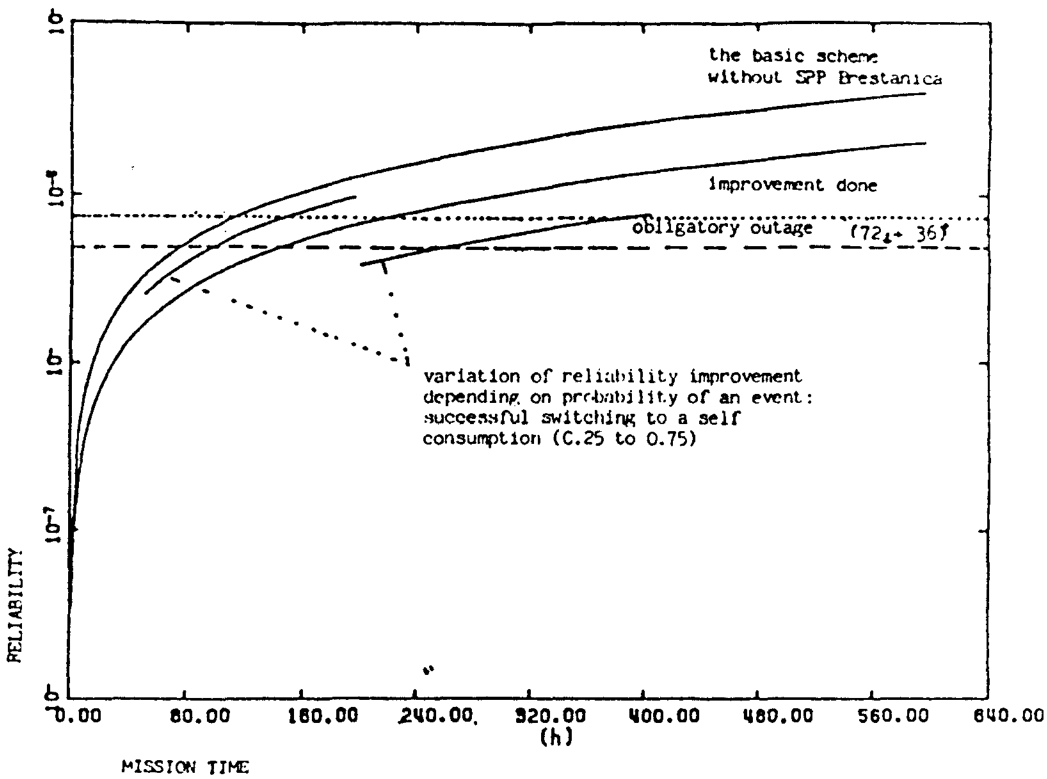


Figure 4: Electric Supply to 6.3 KV Buses



VI. DEVELOPMENT AND MAINTENANCE OF THE COMPUTER CODES FOR DETERMINISTIC SAFETY ANALYSES

Reactor safety research activities in Yugoslavia is conducted in the three national research centers: "J.Stefan" Institute in Ljubljana, "B.Kidrič" Institute in Belgrade and "R.Bošković" Institute in Zagreb which is, in the field of nuclear safety, closely connected to the Faculty of Electrical Engineering at Zagreb University. The group in Belgrade is predominantly engaged with experimental test loop facility for heat and mass transfer research, while the other groups are mostly analytically oriented. This report covers safety related research and applied studies done in SR Slovenia in the IJS Reactor Engineering Division connected to the NPP Krško.

The work has been carried out on the following topics:

- accident analysis,
- transient analysis,
- containment behaviour,
- core calculations

ALMOD 3.4 transient computer code was developed in GRS, Garching, Federal Republic of Germany, for the analysis of PWR plant response to outer disturbances and transients lasting from seconds to minutes. The program satisfactorily analyses transients with a reactor trip system failure.

Since ALMOD 3.4 is adapted to specific requirements of the KWU type plants some modifications had to be done for the analysis of NPP Krško, especially concerning the control of primary coolant temperature (power) through signals of temperature deviations from the setpoint, pressurizer pressure and level control, safety systems and U Tube Steam Generator (UTSG) program.

The program was installed on VAX-11/750 computer by the Reactor Engineering Division of the J.Stefan Institute. In the initial run with input from NPP Krško good results were obtained.

With input data prepared for NPP Krško the following transients were analysed:

- with ALMOD 3.4: test case, pump trip, testing of the steam generator level control,
- with UTSG1: pump trip, small break LOCA (input from RELAP5) and comparisons of the results with RELAP5 calculations,
- the transients with 50% load rejection and 5% load reduction with rod drop were calculated for the comparison of ALMOD4 and ALMOD5 versions.

Coupling of the new UTSG version named UTSG2 to ALMOD 3.4 was successfully completed and test case calculations were performed. Two new versions of ALMOD 3.4 are presently operational. ALMOD4 (with UTSG2) and ALMOD5 (with UTSG1). Both were added complete control and protection systems for the two loop PWR NPP Krško.

RELAP5/MOD1 Transient Code is one of the most important program packages we are using at present. It is a very useful tool for calculating small break LOCAs and transients in light water reactors. When trying to convert it to VAX-11 from CDC computer, some difficulties were encountered due to differences in Fortran compilers, to the use of assembler subroutines, to the differences in operational systems and to the use of specific program packages and tools.

Because of these difficulties during the installation some basic changes had to be done as regards precision and stability, calling procedures, corrections of algorithms etc. These changes were performed by the program package CDC/VAX which is now being developed and tested. The most important functions of the package are: the ability to change the precision of variables, constants and of all intrinsic functions, the ability to show the incompatibility of argument lenghts in calling parameters and the incompatibility of COMMON lenghts and the ability to store all changes on various levels of organization.

The CDC/VAX package is being improved and it is hoped that the final version will be of much help to other users as well since the general trend is directed from CDC to VAX-11.

In 1985 three types of transients for NPP Krško were calculated with RELAP5/MOD1 code: small break LOCA with various break sizes, loss of feedwater flow to both steam generators and increase of steam generator main feedwater flow. In small break calculations, sizes and locations of breaks were varied. The transients were calculated until the setpoint of the accumulator injection was reached. Loss of feedwater accident was calculated for the case with no auxiliary feedwater available. Transient with sudden increase of main feedwater was calculated until stabilization of steam generator level was identified.

In addition to what has been described in previous sections, the following deterministic safety studies have been conducted for NPP Krško:

The large LOCA analysis was performed using RELAP4/MOD6 computer code for blowdown, refill and reflood phase of the accident. This case was initially selected since the safety analysis included in FSAR was based only on the generic four-loop plant and the results presented were limited. Following the evaluation mode analysis parametric best estimate large break LOCA calculations were done. This sensitivity analysis was performed in three directions:

1. double-ended breaks at various break locations (cold leg at the pump discharge, cold leg at the pump suction side and hot leg).

2. various break sizes. The worst break location was found to be the pump discharge side with the critical size between 30% and 40%. See Figure 6.

3. various faults in ECCS operation. In case of failure of the intact loop accumulator, the calculations indicated that a severe core damage could occur. The role of RHR and SI during blowdown and refill was found to be less essential. With no SI operation, only 50% RHR operation, the temperature limits during the accident are not exceeded. If no RHR is available, the flood rate is much slower and damage to the hottest rods may occur.

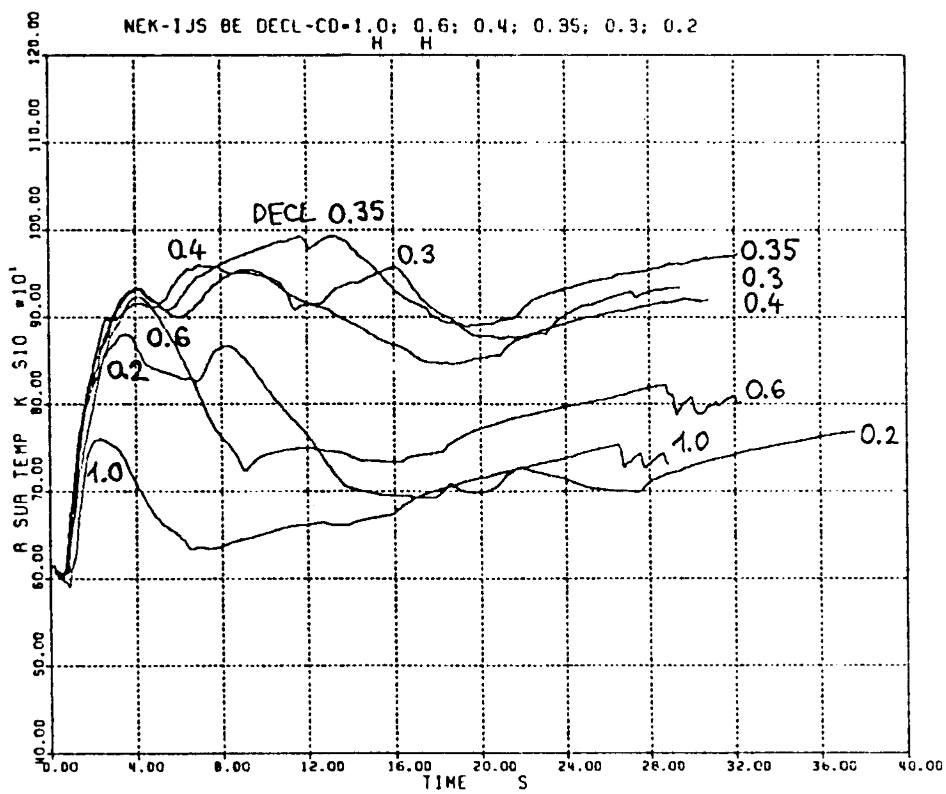


Figure 6: Average Rod Cladding Temperature (DECL 0.2, 0.3, 0.35, 0.4, 0.6, 1.0)

Due to problems associated with NPP Krško steam generators and subsequent tube pluggings the parametric analysis of large LOCA was started, taking into account 5%, 10%, and 15% steam generator tube plugging. The results are expected in early September 1986.

RELAP4 calculations were supplemented by a detailed analysis of core and containment conditions. The CONTEMPT-LT/126 was used to calculate the containment response to LOCA spectrum of various breaks on all significant RCS locations. The time scale of the analysis was synchronized with the time scale after the LOCA until the core reflood

VII. CONTACTS, COOPERATION AND EXCHANGE OF INFORMATION WITH IAEA AND WITH NRC

Contacts with IAEA

As it is well known the IAEA accepted the sponsorship for the construction of NPP Krško as an IAEA project. All Slovene organizations working in the nuclear field have close contacts with IAEA, especially in the field of nuclear safety. The cooperation is emphasized also by IAEA technical assistance in developing and training for an independent activity in the field of nuclear safety.

Information on IAEA activities is distributed in Yugoslavia by the Federal Energy and Industry Committee in Belgrade (SKEI) and through the Republic Institution for International Scientific, Technical and Cultural Cooperation (ZAMTES). On a working level, the exchange of information is going on through individual Yugoslav participants in various Agency projects and programs.

This procedure takes a considerable amount of time so current information is mainly exchanged directly through professional contacts. Publications are officially not easily available and they are usually obtained through regular contacts with IAEA. Information system therefore needs improvements which would enable a larger number of our work organizations to join in the activities performed by IAEA.

Contacts with NRC

In September 1985 USNRC from Washington and SKEI from Belgrade signed an "Agreement on Information Exchange and Cooperation Related to Nuclear Safety between the Yugoslav Federal Energy and Industry Committee and the American NRC". This agreement extended contacts between USNRC and IJS which were previously related mostly to a safe startup and operation of NPP Krško. Cooperation between IJS and NRC continued or completed in 1985 includes:

a) Training in Brookhaven National Laboratory

b) Participation in NRC Courses for Westinghouse PWR in USA

c) Expert assistance

Compilation, ordering and classification of NRC documents was focussed on documents related to computer safety analyses, operating events, source terms, PSA, releases into the environment, problems concerning steam generators and

For the first time we started with a systematic classification and distribution of the compiled documentation. As a result of this work a systematic list of safety related documents on "J.Stefan" Institute, "Electric Institute Milan Vidmar" and "Institute for Metal Constructions" was sent to parties of the Agreement and to some other interested work organizations.

Compared to information received from NRC our contribution to the exchange was very small. It comprised mainly copies of papers presented at international conferences and meetings, especially at IAEA. As assumed by the Agreement between SKEI and NRC this activity will have to be extended and systematically continued.

Based on Agreement signed between USNRC and SKEI it was suggested that through NUKLIN the "J.Stefan" Institute coordinates the execution of the Agreement for all who participate in the Yugoslav nuclear program and who need information on NPP safety according to the scheme in Figure 7.

Professional contacts which are going on for a number of years are indispensable in order to preserve current information concerning nuclear safety. The present scope of cooperation, though small, still presents a fair basis for continuation, extension and deepening.

Good information is one of the basic conditions for a safe operation of our nuclear power plant so only an adequate information system that will include all participants in the nuclear program will give satisfactory results.

A special attention has to be paid to availability of information distributed by NRC. Considering its extent and significance it is the principal source of information related to the safety of NPPs.

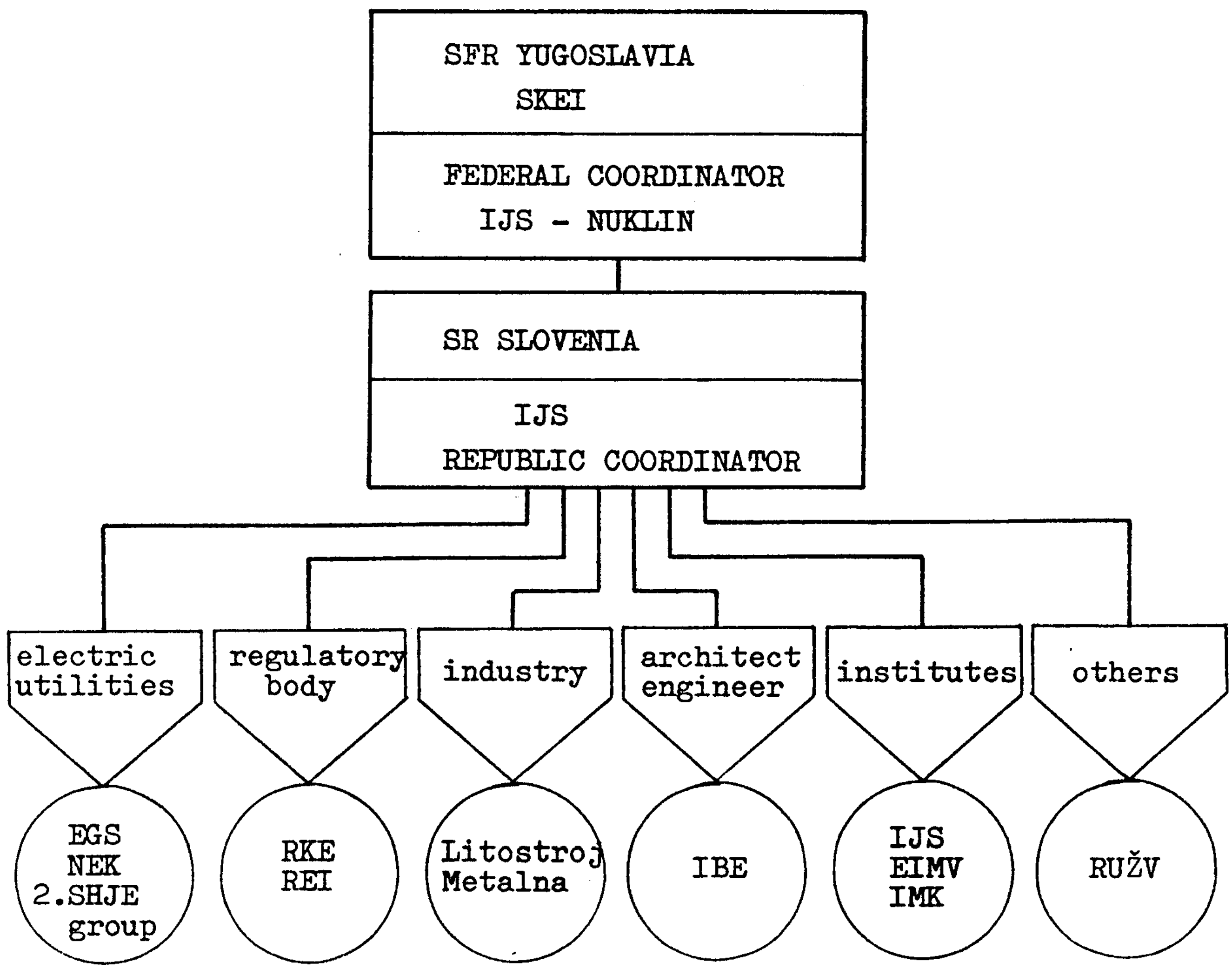


Figure 7: Organizational scheme for cooperation with US NRC and coordination in SR Slovenia

ABBREVIATIONS USED:

EGS .... Elektrogospodarstvo Slovenije (Electricity Generating Board of Slovenia)

EIMV .... Electric institute "Milan Vidmar"

IAEA .... International Atomic Energy Agency

IBE .... Inženirski biro Elektroprojekt

IJS .... "Jožef Stefan" Institute

IJS - RED .... IJS Reactor Engineering Division

IMK .... Institute for metal constructions

IRS .... Incident Reporting System

NEK .... Nuclear Power Plant Krško

NUKLIN .... NUKLearni INstituti (Managing Community for the Research, Development and Peaceful Uses of Atomic Energy)

PRA .... Probabilistic Risk Assessment

PSA .... Probabilistic Safety Analysis

REI .... Republiški energetski inšpektorat (Republic Energy Inspectorate)

RKE .... Republic Energy Committee

RUŽV .... Rudnik urana Žirovski vrh (Uranium Mine Žirovski vrh)

SKEI .... (Yugoslav) Federal Energy and Industry Committee

(US)NRC .... (United States) Nuclear Regulatory Commission

2.SHJE group ...... working group preparing the second Slovene-Croatian nuclear power plant

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