

Twenty years of operation of WWER 440/230 Units in Jaslovské Bohunice.

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ABSTRACT

It is twenty years this year since the first unit WWER 440 of Slovak Nuclear Power Plant Jaslovské Bohunice was commissioned. There are four units WWER 440 in operation at Jaslovské Bohunice site. First two units of older soviet PWR design V-230 (also known as V-1) and other two units of newer V-213 type (also known as V-2). The goal of this presentation is to summarize and evaluate the operation of Unit 1 and 2 for this period of time and mainly to describe what has been done and what is planned to be done to increase the nuclear safety and operational reliability of both units. The operating organization and regulatory authority assume that an internationally acceptable level of safety will be reached by accomplishing of the upgrading programme.

1. General overview

The Slovenské elektrárne, joint stock company (SE) is the dominant electricity generator in the Slovak Republic (SR) with a total installed generating capacity of 6,147 MW at the end of 1997, which represents approximately 86% of the total installed capacity of power plants in the SR [Fig.1]. In the year 1997 SE generated in their own sources 21,170 GWh, from which 51 % at nuclear, 29 % at thermal and 20 % at hydro-electric power plants. The import of electricity represented 14% of total electricity consumption of Slovak Republic.

Figure 2 shows the power sources of SR including **two NPP sites**:

- four WWER 440 units in operation at **Jaslovské Bohunice** site. First two units of older soviet PWR design V-230 (also known as V-1) and other two units of newer V-213 type (also known as V-2).
- one unit in trial operation (full power reached in August 1998), one unit to be commissioned next year and two units under construction at **Mochovce** site (4 units WWER 440/V213),

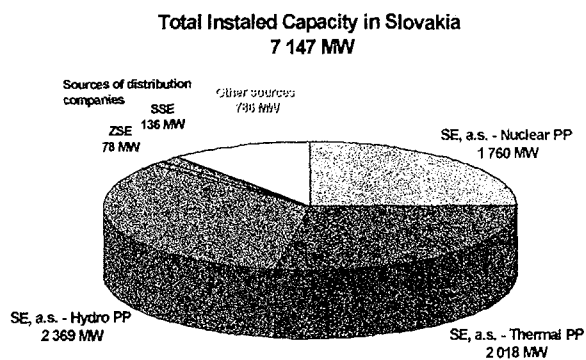


Fig. 1 Share of power sources in Slovakia

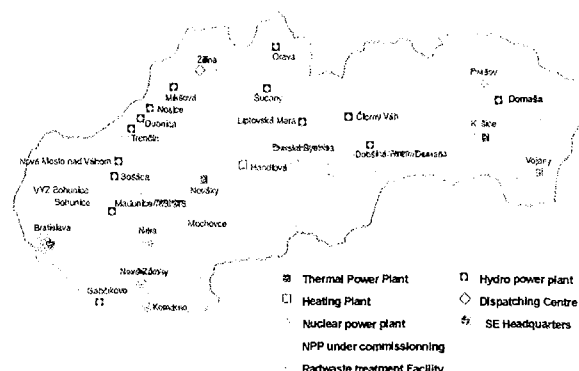


Fig. 2 Power sources of SR

1.1 Main goals of Slovenské elektrárne a.s.

Management of Slovenské elektrárne, aware of dominant position of company on Slovak energy market, declared the main company goals, which include following targets :

- safe, ecological, reliable and economical operation of electric and heat energy sources and power system
- ensure - in accordance with governmental program of economy development - *balanced* consumption and production of energy (do not exceed 15 % share of electricity import)
- increase safety of nuclear sources and keep them on an internationally acceptable level of nuclear safety
- apply *Least Cost Planning* methods in development plans and design energy sources with reasonable costs for future
- decrease long term *ecological impact* in according with international commitments of SR
- intensify co-operation between *UCPTE and CENTREL* countries and gradually integrate power system of EU and Slovak Republic

Among the most important power sources of SE, a.s. belong the WWER 440/230 units in Jaslovské Bohunice. In Table 1 the information of their commissioning schedule and the total electricity produced till 1997 is given.

Table 1

	Connection to the grid	Commercial operation start-up	Electric power production (by the end of 1997) [GWh]
Unit 1	17.12.1978	26.03.1980	52 335
Unit 2	01.04.1980	01.01.1981	50 348

The operation of these units has been safe and reliable since their commissioning. They provided by now a reliable contribution to the country's power supply without any accident or off-site impact (all reported operational events were reviewed by IAEA ASSET mission in 1990 and ranked according to the INES scale). This statement can be supported by the fact

that since 1990, when the ASSET operational event investigating methodology was adopted by the plant staff, no INES level 2 and above happened. Figure 3 shows the total number of operational events at both units evaluated as INES 1 for this period of time. Site management also adopted this parameter among its main safety and operational indicators. The target for this year is not to exceed the value one INES level 1 event per unit which corresponds with the decreasing tendency clearly visible on Fig. 3.

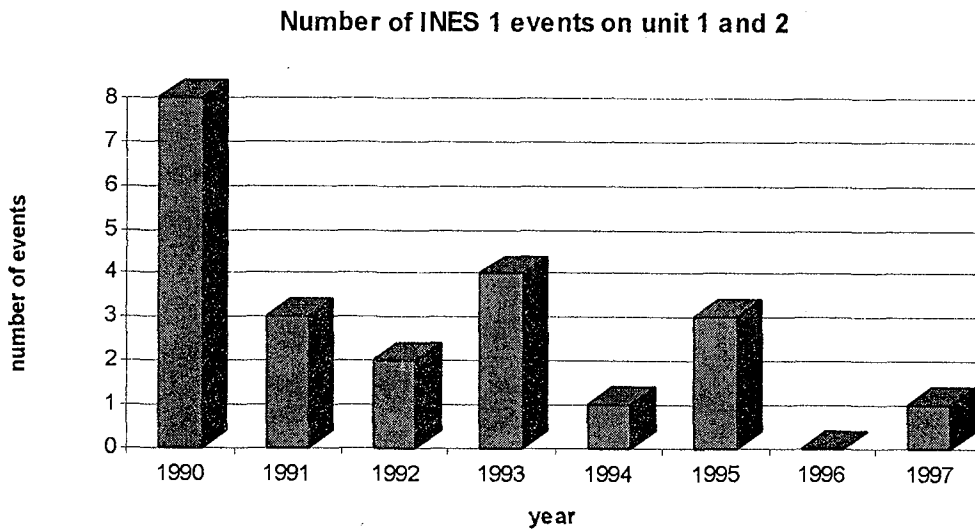


Fig. 3 Total number of operational events evaluated as INES level 1 on unit 1 and 2.

2. Bohunice V-1 Units Nuclear Safety Upgrading

Management and staff of the Bohunice NPP were always aware of their responsibility for the safe operation and understand the nuclear safety as a continuous process. Out of this reasons, safety improvements and equipment modifications have been performed just since the plant commissioning. More than 1200 minor or major modifications were implemented. Increased effort for safety upgrading of Unit 1 and 2 started in middle 80-ties, when the first backfitting programme, focused mainly on the RPV irradiation embrittlement decrease (installation of shielding assemblies around the core, using of so-called low-neutron-leakage fuel loading, measures to reduce thermal stress of the reactor pressure vessel during operational transients, etc.) and on improvements in fire protection area, was developed and executed.

After the political changes in former Czechoslovakia in 1989 the country opened for the cooperation with foreign bodies. Since 1990 twenty specific safety missions reviewed the status of the NPP both in the design and operational area. In 1990 IAEA initiated a programme to assist the countries of central and eastern Europe in evaluating the safety of the first generation WWER-440/230 NPP's. Major design and operational safety issues were identified and gathered in the document TECDOC-640 „Ranking of safety issues for WWER-440/230

NPP's". As a result of findings, recommendations and suggestions for further safety upgrading programmes were adopted.

According to decision No. 5/91 issued by the regulatory authority of former Czechoslovakia, so called „*Small reconstruction programme*“ was performed at Unit 1 and 2 between 1991 and 1993 with total investment of USD 67 million eighty-one improvements were performed within this programme both in design and operational field and considerably improved the safety of both units. The programme included:

- annealing of reactor pressure vessels of both units,
- validity verification of the LBB (Leak Before Break) method including the seismic upgrading of the equipment,
- improvement of confinement leaktightness,
- installation of fast-closing isolation valves at the steam generator steamlines,
- installation of diagnostic systems at the primary and secondary circuit equipment,
- reconstruction of the containment spray system delivery lines,
- interconnection of emergency core cooling systems of both units,
- reconstruction of pressurizer safety valves and installation of pressurizer relief valve,
- installation of emergency control room panels,
- reconstruction of the self consumption electric system including the installation of an additional diesel generator and an accumulator battery,
- replacement of the fire signalization system, extension of the stable fire extinguisher system and fire resistance upgrade - replacement of cables with fire-proof ones, covering of the fire protective walls and cables with non-flammable material,
- emergency operating procedures and surveillance programmes development,
- development of level 1 probabilistic safety assessment study,

Slovak regulatory authority issued decisions No. 1/1994 and 110/1994 based on the Safety Analysis Report elaborated in the frame of the „*Small reconstruction programme*“ and other technical sources listed below:

- Preliminary Safety Analyses Report for Gradual Reconstruction,
- “Ranking of Safety Issues for WWER 440 model V-230 NPP's” IAEA - TECDOC 640,
- “Bohunice V-1 Major Safety Upgrading” IAEA consultant's meeting report,
- IAEA report - “A common basis on which the safety of all operating nuclear power plants built to earlier standards can be judged”,
- Report of IAEA consultant's meeting “On containment and confinement performance in NPP's with WWER 440/213 and 440/230”,
- Report of the IAEA consultant's meeting “Major improvements for WWER 440/230 NPP's”,
- PSA level 1.

In decisions No. 1/1994 and 110/1994 requirements for further improving were expressed and the future operation of both units was conditioned by fulfillment of prescribed requirements. Only in case when they are met, the regulatory authority issues the license for operation which is valid one year. Basic Engineering for major reconstruction was prepared and so called „*Gradual reconstruction programme*“ started in 1996 and should be finished in 1999. The REKON consortium formed by Siemens KWU Group and the Slovak research institute VUJE a.s. is the main supplier of this reconstruction programme with total estimated cost of approximately USD 180 million. The Bohunice NPP intends to meet the following targets by the realization of this programme:

a) *deterministic targets:*

- to cope with the newly defined maximum Design Bases Accident LOCA 2 x ϕ 200 mm by a conservative approach and coping with Beyond Design Bases Accident LOCA 2 x ϕ 500 mm by best estimate method,
- the confinement leaktightness and accident localization systems must assure that the dose equivalent is less than 50 mSv for the whole body and 500 mSv for the thyroid in case of DBA and the dose equivalent is less than 250 mSv for the whole body and 1500 mSv for the thyroid in case of BDBA in the controlled area,

to finish the seismic upgrading of all safety and safety related systems and constructions to withstand 8°MSK-64 scale with horizontal acceleration 250 cm s^{-2} and vertical acceleration 130 cm s^{-2} .

b) *probabilistic targets:*

- the failure probability of safety systems 10^{-3} / per demand or less
- the failure probability of automatic reactor trip system 10^{-5} / per demand or less
- severe core damage probability (CDF) 10^{-4} / reactor year or less

The V-1 units safety upgrading process is carried out gradually during extended outages and general overhauls within 1996-1999 (this is why it is called „Gradual Reconstruction“), and includes, among others, the following safety improvements:

- increasing of reactor coolant system integrity,
- confinement leaktightness improvement and installation of isolation valves at the hermetic zone boundary pipes (the improvement brought about so far is evident from Fig. 4),

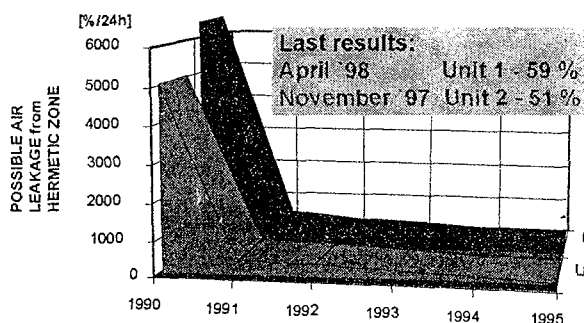


Fig. 4 Confinement of the Bohunice V-1 units leaktightness improvement

- strength improvement of the hermetic zone structures to withstand maximum overpressure during LOCA 2 x Φ 500 mm, backfitting of the accident localisation system to cope with accidents within the confinement,
- modifications of the emergency core cooling system including residual heat removal in case of a seismic event and provisions for a sufficient boric acid concentration in the reactor coolant

system (separation to 2 x 100 %) and possibility of primary side Bleed and Feed heat removal,

- spray systems modifications (separation to 2 x 100 %),
- secondary side Bleed and Feed introduction (improvements of emergency feed-water systems and installation of the steam generators steam dump stations),
- building up the essential service water system for safety related systems,
- installation of digital RTS, ESFAS, reactor power control and power limitation system, replacement of in-core temperature and neutron flux measurements,
- hydrogen detection system and hydrogen recombinators installation,
- implementation of safety improvements on electrical systems - motor generators replacement, diesel generators control and excitation system upgrading, emergency AC power supply possibility from Hydro plant Madunice (third grid)
- significant seismic upgrading of key safety equipment,
- implementation of measures in the fire protection area
- ventilation systems modifications and installation of new ones

Fig. 5 shows results of PSA Level 1 studies for the individual safety improvements stages of the initial project of V-1 units. After the gradual reconstruction including the implementation of symptom-oriented emergency procedures (SOEP), the CDF calculated value is 5,39 E-05 per reactor-year.

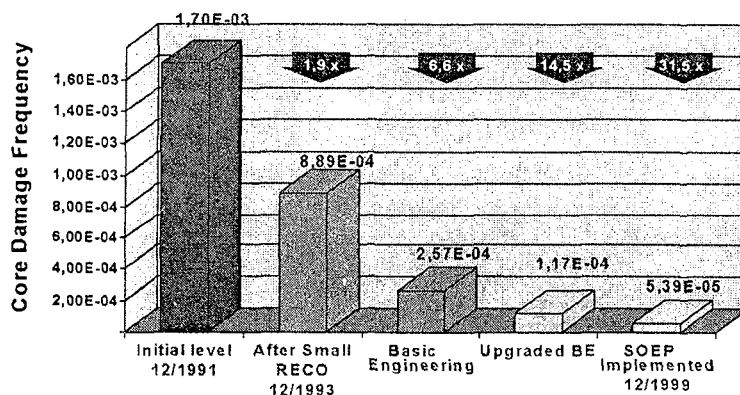


Fig. 5 Results of the PSA Level 1 studies of Bohunice V-1 units and reconstruction objectives

Certain projects have a general effect on the entire Bohunice site, as evident from the following implemented projects:

- Quality Assurance Program and Personal Training Program - in co-operation with the Nuclear Electric Plc. and funded by the UK government

- Multifunctional simulator - development of a simulator with international co-operation with CORYS, BELGATOM and Siemens, funded by the European Commission
- Installation of a number of diagnostic systems (evaluated as a „Good Practice“ by OSART 96) - Fig. 6
- AKOBOJE Site Security System - implemented by CEGELEC-TERMATOM
- Teledosimetric system - monitoring of the 15 km radius area around the Bohunice site (evaluated as a „Good Practice“ by OSART 96) - Fig. 7

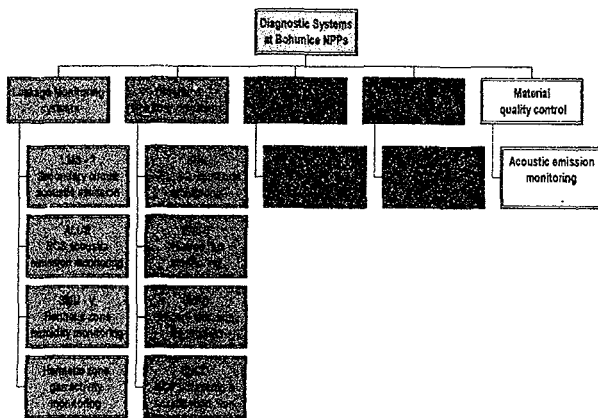


Fig. 6 Diagnostic systems at the NPP Bohunice

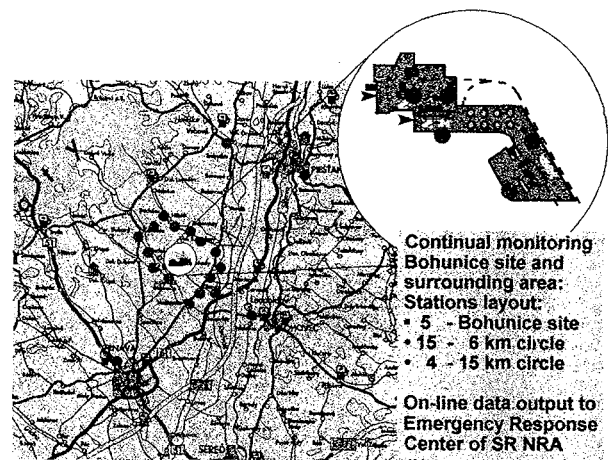


Fig. 7 Teledosimetric system at the NPP Bohunice

3. Conclusion

I would like to stress once again that the nuclear safety is the first priority of Slovenské elektrárne, a.s , which is expressed also in the „*Nuclear and Radiation Safety Policy*“. We assume that an internationally acceptable level of safety will be reached by accomplishing of this ambitious upgrading programme. This fact enables the operating organization to get the regulatory authority license for the operation of both units minimum till the end of the planed lifetime, that means till the year 2005.