



XA0300591

REGIONAL WORKSHOP ON MODELLING OF EXTERNAL HAZARDS IN PSA

Sofia, November 6.-10., 2000

SNSA PRESENTATION

J. Obreza

Division for Nuclear Safety

TIME:

- 16:00 - 16:15 (Thursday, November 9)

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TOPICS:

- **Seismic characterization of the NPP Krško site**

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CONTENT OF THE PRESENTATION

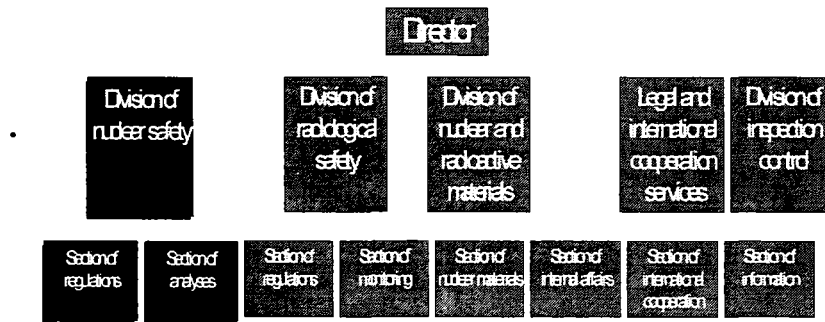
- SNSA - intro
- **NPP Krško Probabilistic Safety Assessment**
- INTRODUCTION (seismics)
- **NPP KRŠKO SEISMIC DESIGN BASES**
- **SEISMIC PSA ANALYSIS (IPEEE)**
 - Steps in process
 - Fragility analysis - results
 - Risk quantification - results
 - Conclusions of seismic PSA
- **ONGOING SITE GEOLOGICAL AND GEOPHYSICAL INVESTIGATION**
- **CONCLUSIONS**

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SNSA Organization



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NPP Krško PSA

NPP Krško Level 1 Initial Project Model Risk Profile over Initiators

Internal Events	Result CDF
– Total of 16 initiating events categories	5,44E-05/yr (23,7%)
External Events	
– Seismic events analysis	6,03E-05/yr (26,3%)
– Internal flooding analysis	4,62E-06/yr (2%)
– Internal Fire analysis	9,78E-05/yr (42,5%)
– Other external events analysis	1,26E-05/yr (5,5%)
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NPP KRŠKO CDF	2,30E-04/yr (100%)

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NPP Krško PSA

NPP Krško PSA Project Update

- **Goal**
 - Inclusion of plant changes (i.e. configuration/operational related) through the period January 1, 1993 till the OUTAGE99 (April 1999) into the integrated Internal/External Level 1/Level 2 NPP Krško PSA RISK SPECTRUM model
- **Achievements**
 - Reviewed and assessed changes and implemented the changes to the NPP Krško PSA model where it impacts the model
 - Resulting in new RISC SPECTRUM based NPP Krško PSA model “NEK 98”, that represents the initial project model plus implemented changes on the plant till end OUTAGE99, as well as plant OE till then
 - Documented update of the PSA model, and re-quantified results (ISA NPP Krško Stage 1 Phase)

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INTRODUCTION

- NPP Krško is located on seismotectonic plate
- Highest earthquake was recorded in 1917 with magnitude 5.8 at a distance of 7-9 km.
- Site (founded) on Pliocene sediments which are as deep as several hundred meters.
- No surface faulting at the Krško site has been observed and thus it is not to be expected
- NPP Krško is equipped with seismic instrumentation, which allows it to complete OBE (SSE) analysis within 5 minutes.

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NPP Krško seismic design bases

- Long term investigation (domestic and international experts involved - , started 1964 intensive from 1971 - 1975 - Geophysical, geomechanical, hydrogeological and engineering seismological investigations)
- Suggested SSE - 0.22 g, at the end conservatively adopted SSE=0.3 g, OBE= 0.15g;
- Free field response spectrum according to RG 1.60;
- Soil structure interaction analysis - SAP IV (6 blocks, soil springs and dumping values developed by - D` Apolonia Consulting Engineers);
- All components and systems qualified based on US standards and regulations

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Seismic PSA - IPEEE

- Per IPE (GL 88-20) and SNSA licensing amendment NEK decided for seismic PSA to evaluate plant vulnerabilities on seismic events
- Methodology developed in USNRC sponsored Seismic Safety Margin Research Program (SSMRP)
- First required step:
 - Development of free-field ground motions
 - Probabilistic hazard curves and uniform hazard response spectra
 - Work started in 1991 with all available domestic earth science experts under leadership of FAGG Ljubljana)
 - Work was reviewed by IAEA international expert teams (IPERS)
 - Results were published in 1994 - local earthquakes addressed separately (PSHA analyses was performed by FAGG Ljubljana)
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Seismic PSA - IPEEE

Steps in process are:

- **PSHA analysis** - Probabilistic hazard curves and uniform hazard response spectra
- **Perform probabilistic response analysis** (development of structural and soil model, foundation impedance and foundation input motion)
- **Seismic walkdown(s)** (equipment categorized into generic versus specific designs for subsequent fragility analysis)
- **Fragility analysis**
- **Risk quantification** (event and fault trees modified from internal events IPE)
- **Relay chatter evaluation** (deterministic)
- **Local earthquakes** treated separately - deterministic approach
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Seismic PSA - Fragility analysis - results

- Fragility analysis was performed for 3 structures and 37 equipment items
- Screening level adopted based on negligible effect on CDF ($A=2.0g$ PGA, $HCLPF=0.74$ PGA) - majority of structures and equipment were screened out
- Fixes recommended based on fragility analysis
 - main control room ceiling support
 - leg supported tank (CCW surge tank)
 - cabinets poorly welded through shims
 - (ALL IMPLEMENTED)
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Seismic PSA - Conclusions of seismic PSA

- Plant structures and equipment are generally very rugged
- Fixes defined based on walkdown and fragility analysis - all of them were performed
- CDF dominated by LOOP and random failures (DG)
- Seismic contribution to CDF dominated by few “low-fragility” (lack of documentation to higher qualification level for electrical components)
- The seismic PSA successfully demonstrated high seismic margin at NEK
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Seismic PSA - Risk quantification - results

Results:	Hazard Frequency	Conditional Core Melt Probability	Core Melt Frequency
Int. 1	2,54E-3	3,311E-3	8,433E-6
Int. 2	7,32E-4	1,100E-2	8,111E-6
Int. 3	3,11E-5	3,133E-2	9,766E-6
Int. 4	8,20E-5	1,588E-1	1,300E-5
Int. 5	2,00E-5	5,533E-1	1,100E-5
Int. 6	3,60E-6	8,855E-1	3,188E-6
> 6	1,40E-6	1,000E+0	1,400E-6
Total			5,500E-5

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Ongoing site seismic investigation

- During PSHA experts pointed out that due to lack of knowledge - very conservative estimations have been given.
- IAEA review recommended additional investigation
- Phase 1 - 1994-95 domestic institutions
 - additional geological and seismological investigation
 - geophysical investigation - first additional seismic profile measured
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- Work reviewed by IAEA expert team;
- Conclusion: additional 4 seismic lines shall be measured (square around NPP Krško)
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Ongoing site seismic investigation

In phase 2 (1997 - 2000) additional investigation:

- **Continuation of seismological and geological investigation** of Krško valley conducted by domestic institutions (geological map, ...)
- **Geophysical investigation** founded through PHARE program
 - Field measurements and data collection (additional 45 km of profiles to be recorded with seismic reflection method)
 - Data processing and data interpretation
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Conclusions

- NPP Krško seismic design based on US regulations and standards
- Seismic PSA successfully demonstrated high seismic margin (analysis done for 2 time SSE value) - risk comparable with internal initiators;

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