



Slovenian Nuclear
Safety Administration

Third Periodic Safety Review of the Krško NPP

Basis for Extension of Plant Operating License and Transition to Long-term Operation

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Slovenian nuclear facilities performing PSRs



NPP
Krško





Krško NPP

In commercial operation since 1983, Westinghouse PWR, 2000 MWt

Owners 50:50 Slovenian and Croatian utilities

Steam generators replacement and Power uprate in 2000

Aging management program, lifetime extension 2023→2043

1st PSR 2003, 2nd PSR 2013, **3rd PSR 2020-2023**

Stress tests 2011, Safety upgrade program 2013-2021, Spent fuel dry storage 2023



Legislation and practical guidelines for periodic safety reviews

- Ionising Radiation Protection and Nuclear Safety Act (2002, last revision 2019)
- Regulations and decrees
 - Rules on radiation and nuclear safety factors, JV5 (2009, 2016, 2024)
 - Rules on the safety assurance of radiation and nuclear facilities, JV9 (2009, 2016, 2024)
- SNSA Practical guideline PS 1.01, rev. 2, The content and scope of periodic safety review of radiation or nuclear facility (2009, 2021)
- IAEA SSG-25 Periodic Safety Review for NPPs (2013)
- WENRA SRL Issue P - Periodic Safety Review (2014, 2020)
- *2020 – WENRA SRL for Research Reactors, IAEA SRS 99 (2020)*



What is a PSR – definition in the regulation JV9

PSR means systematic verification of safety of radiation or nuclear facilities undertaken periodically in order to establish cumulative effects of

- ageing,
- modifications to the facility,
- operational experiences and
- technical development and
- changes at the facility site

and thereby to ensure a high level of safety throughout the radiation or nuclear facility service life.

PSR is a tool to supplement continuous safety verification intended for

- integral verification of the level of safety of a radiation or nuclear facility and
- for the demonstration of its capacity to operate safely in the next period



Periodic & Extraordinary Safety Reviews

- Act Art. 112 – **requirement for a PSR**
 - 40 months before operating license expires, licensee submits the content, scope and timetable of the PSR for SNSA approval
 - Act Art. 113 – **extraordinary safety review** – regulatory order (no appeal)
 - SNSA determines the content, scope and time limit for extraordinary safety review or measures implementation and method of reporting
 - Act Art. 114 – **report on PSR**
 - Action plan - changes to improve radiation or nuclear safety
 - opinion of an authorized radiation and nuclear safety expert on implementation and on the results of PSR
 - Action plan implementation – in 5 years (exceptions +3 years)
 - approved report on the PSR shall be the condition for renewing the licence for operating a facility
- Amendments to regulation JV9 (2016)
 - **NEW Safety Factors** radioactive waste and spent fuel, security, radiation protection
 - **NEW** scope of PSR for repository of radwaste and of spent fuel ([WENRA](#))



SNSA practical guideline on PSR

PS 1.01 rev. 2



- Revision 2 (2021) was significantly expanded and modernized
- Developed according to the requirements of the Act and the regulation JV9
- Mostly follows the IAEA standard **SSG-25** Periodic Safety Review for NPPs (2013)
- For new safety factors: *radioactive waste & spent fuel*, *security*, *radiation protection*
the contents were defined by SNSA according to requirement of Slovenian legislation and in some cases, different international references
- Defines the approach to global safety assessment
- Presents templates for different reports for all three phases of the PSR



Vsebina in obseg občasnega varnostnega pregleda sevalnega ali jedrskega objekta

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IAEA Safety Standards

for protecting people and the environment

Periodic Safety Review for Nuclear Power Plants

Specific Safety Guide

No. SSG-25



Three phases of a PSR process



- 1. Program**
- 2. Review**
- 3. Action plan**



1 – PSR program - Agreement on PSR scope and contents

PSR program is approved by regulator, application is submitted by licensee **3 years before the deadline** for preparation of the final PSR report

- Defines contents, scope and time schedule of the review, freeze date
- Organization and responsibilities for performing safety review
- Methodology for assessing safety significance of findings
- Reporting requirements: phase reports, topical reports, summary report

SNSA practical guideline PS 1.01, rev. 2 (2021)

- 18 safety factors
- Interfaces between safety factors, prioritization of findings
- PSR summary report, global safety assessment, evaluation for continued operation
- Action plan with timeframe for implementation
- Report on action plan completion and analysis of effects on the operational safety of the facility



PSR3 safety factors

Plant

- (1) Plant design,
- (2) Actual condition of structures, systems and components (SSCs) important to safety,
- (3) Equipment qualification,
- (4) Aging.

Safety analysis

- (5) Deterministic safety analysis,
- (6) Probabilistic safety analysis,
- (7) Hazard analysis.

Performance and feedback of experience

- (8) Safety performance,
- (9) Use of experience from other plants and research findings.

Management

- (10) Organization and the Management System
- (11) Safety culture,
- (12) Procedures,
- (13) Human factors,
- (14) Emergency planning.

Environment

- (15) Radiological impact on the environment
- (16) **Radioactive waste and spent fuel**

Security

- (17) **Security**

Radiation Protection

- (18) **Radiation Protection**



2 – safety review

- Operator reports every 6 months on PSR progress
- Every safety factor – a topical report
 - description of applied review methods, of the course of review, all the findings of the review and the final written assessment,
 - shall clearly state and explain detected deficiencies and propose modifications and improvements to remedy deficiencies and comply with criteria specified in the standards and international practice
- Topical reports reviewed and commented by regulator, final topical reports to comply with regulatory recommendations
 - **Deviations with high importance for safety must be promptly resolved**
- Interface between safety factors, impact on significance of such findings
- Prioritization – determination of safety significance of findings/actions: probabilistic, deterministic methods, engineering judgement
- Preparation of actions and timeframe for implementation



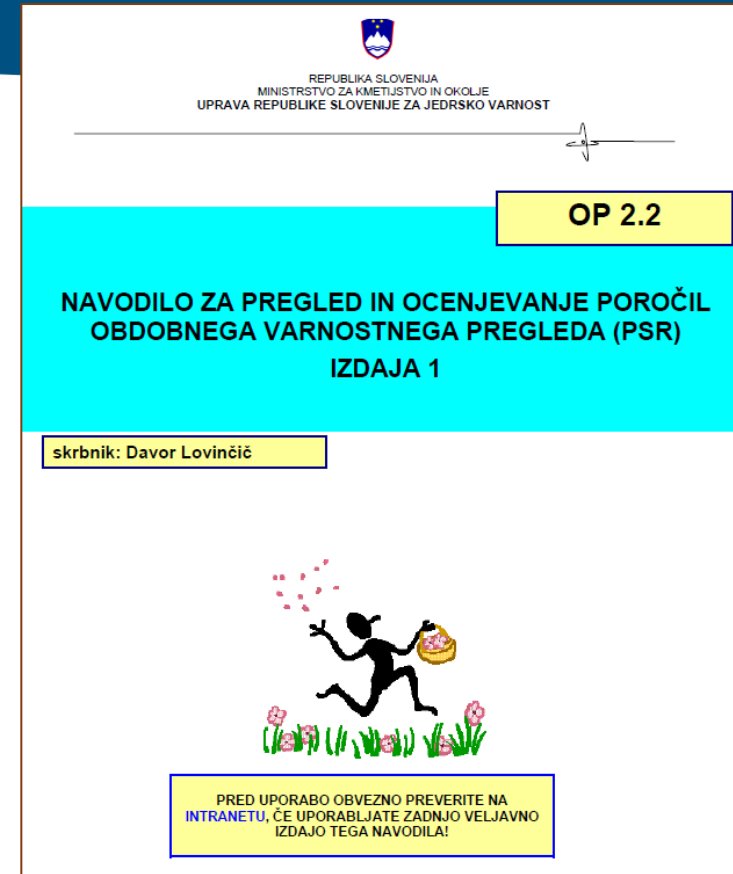
2 – PSR summary report and action plan

- Summary descriptions of applied methods, final assessment based on topical reports
- Global assessment of plant safety
- Action plan for improvements
- **Independent expert opinion** on the PSR report by an authorised expert shall confirm PSR implementation, the PSR results and conclusion on the impact of the proposed measures on radiation and nuclear safety of the facility
- PSR summary reported translated into Slovenian and published – to inform the public
- Action plan: modifications and improvements to remedy deficiencies and comply with criteria specified in standards and international practice
- Timeframe for action plan implementation: max 5 years, possible 3 years extension (with regulatory approval)



Regulatory role in the PSR process

- SNSA procedure for review and assessment of PSR reports
- Organization of review – distribution of work and responsibilities
- Format for PSR review report
- Assessing inputs, outputs, methodology, criteria
- Resolving disagreements with the licensee, meetings
- Approval of final PSR report
- PSR database: documents, review reports, PSR findings and actions



Organization of SNSA for the review of the PSR3

- „Everybody“ was involved, **all SNSA resources**: 24 experienced expert reviewers + SNSA director
- At least 2 reviewers for each SF, max 12 reviewers worked on SF1 Plant design
- 5 supervisors of 7 individual chapters
- Reporting by special forms



Pregled tematskih poročil PSR3

| Poglavja | Varnostne vsebine | Skrbnik poglavja | Pregledovalci za varnostno vsebino |
|---|--|------------------|------------------------------------|
| Objekt | 1. Projekt objekta | █ | █ |
| | 2. Dejansko stanje SSK | | █ |
| | 3. Kvalifikacija opreme | | █ |
| | 4. Staranje objekta | | █ |
| Varnostne analize | 5. Deterministične varnostne analize objekta | █ | █ |
| | 6. Verjetnostne varnostne analize objekta | | █ |
| | 7. Analize ogroženosti in možnih nevarnosti glede na jedrsko in sevalno varnost | | █ |
| Obratovanje in uporaba obratovalnih izkušenj | 8. Obratovalne izkušnje in obratovalni kazalniki lastnega objekta | █ | █ |
| | 9. Obratovalne izkušnje drugih objektov ter ugotovitve znanosti in tehnologije za obdobje pregleda | | █ |
| Vodenje | 10. Sistemi vodenja in organiziranost upravljavca | █ | █ |
| | 11. Varnostna kultura | | █ |
| | 12. Pisni postopki upravljavca | | █ |
| | 13. Vpliv dejavnosti osebja – človeški dejavnik | | █ |
| Okolje | 14. Načrt zaščite in reševanja | █ | █ |
| | 15. Radiološki vplivi na okolje | | █ |
| Fizično varovanje | 16. Radioaktivni odpadki in izrabljeno gorivo | █ | █ |
| | 17. Fizično varovanje | | █ |
| Varstvo pred sevanji | 18. Varstvo pred sevanji | █ | █ |

Regulatory experience - NEK PSR1

- First PSR at the Krško NPP – official decision based on the CNS recommendation
- **SNSA did not have a legal basis at the time of first PSR** – new law introduced PSR in 2002
- For PSR1 scope and process, draft IAEA standard was used, because more safety factors were defined in new (draft) revision
- IAEA assisted with review of the PSR1 program
- The PSR1 did not review deterministic safety analyses and design bases, because in 2000 plant modernization and power uprate was licensed
- **Methodology for safety prioritization of findings was not defined at the PSR1 start (in program) – at the end of PSR there were disagreements**
- **Safety prioritization – by use of PSA, mainly engineering judgment**
- Many relevant PSR1 findings not resolved – they were revisited in PSR2
- Important findings on external hazards – 6 years before Fukushima
- Action plan included unresolved RCP issues (compliance with NRC reg.) and RAMP mission recommendations – 124 actions for 5 years



Regulatory experience - NEK PSR2

- SNSA and NEK were better prepared, legislation was in place, practical guideline on PSR2 rev. 1
- Main disagreement on methodology of determining safety significance of findings, new methodology introduced based on: PSA, defence-in-depth, assessment of soft factors (organisational, procedures, human factor, safety culture)
- Organisation of work and reporting was improved
- Re-evaluation of all unresolved PSR1 findings
- Cross checking findings from different safety factors – interfaces
- Grouping of similar PSR2 findings
- Prioritisation and preparation of actions
- Fukushima accident – special reports on relevance for the PSR2 findings
- EU stress tests performed in parallel (extraordinary safety review) – resources were limited
- Extensive PSR2 action plan – SNSA justified for many additional actions to be included into final action plan – 255 actions to be implemented in 5 years
- Global safety assessment – overview based on prioritisation results, justification approach based on deterministic methods and expert judgment



PSR for evaluation of NPP long-term operation

- Review of safety factors
 - Plant design and actual conditions of SSC
 - Aging management program and equipment qualification
 - Safety analyses: deterministic, PSA, hazards
 - Plant performance (operational experience), foreign OPEX
- **PSR1** – aging management and equipment qualification scoping & screening (SSC, plant areas, environment)
- **PSR2** – review of new AMP and EQ programs/procedures
- **PSR3** – review of findings and corrective actions
 - Replacement of major systems/components
 - Generation changes – knowledge transfer, responsibilities
 - NEK safety upgrade program – post Fukushima improvements
 - Findings of IAEA pre-SALTO mission (2021)



Krško NPP Third PSR

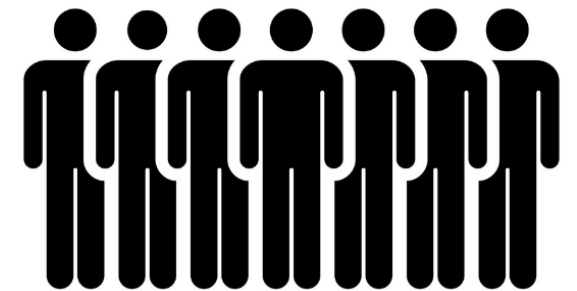


- PSR3 especially important
 - Operating license extension (+10 y)
 - Safety review to confirm safety of NPP at the end of operating lifetime (40 years)
 - PSR3 action plan implementation is condition for NEK long-term operation (+20 y)
- PSR3 specific features
 - SF17 - Physical Security – review was performed in a separate process
 - Impact of NEK Safety Upgrade Program to plant safety, implementation of DEC
 - Conformance with new regulatory requirements, e.g. WENRA SRL (2020), Regulatory Conformance Program (RCP)
 - Results of IAEA Pre-SALTO mission (2021) input to SF4 (Aging Management)
 - Findings of IAEA expert mission on fire PSA (2020) included in SF6 PSA and the IAP



Topical reports for every safety factor + PSR3 findings

- 2022 – NEK delivered topical reports on review of safety factors to the SNSA for review and comment. Safety review and the Topical reports were prepared by contractors.
- Meetings of SNSA with the NPP staff and reviewers (contractors) were performed to resolve comments. Final versions of topical reports were approved by SNSA in September 2022.
- Altogether, there were 180 PSR3 findings identified and remaining with many interfaces between safety factors to be considered.
- Most PSR3 findings were in safety factors Plant design, Actual conditions of SSC, Safety performance, Deterministic safety analysis and Emergency Planning
- The PSR3 findings were ranked based on their safety significance and prioritization of PSR3 actions was defined accordingly.

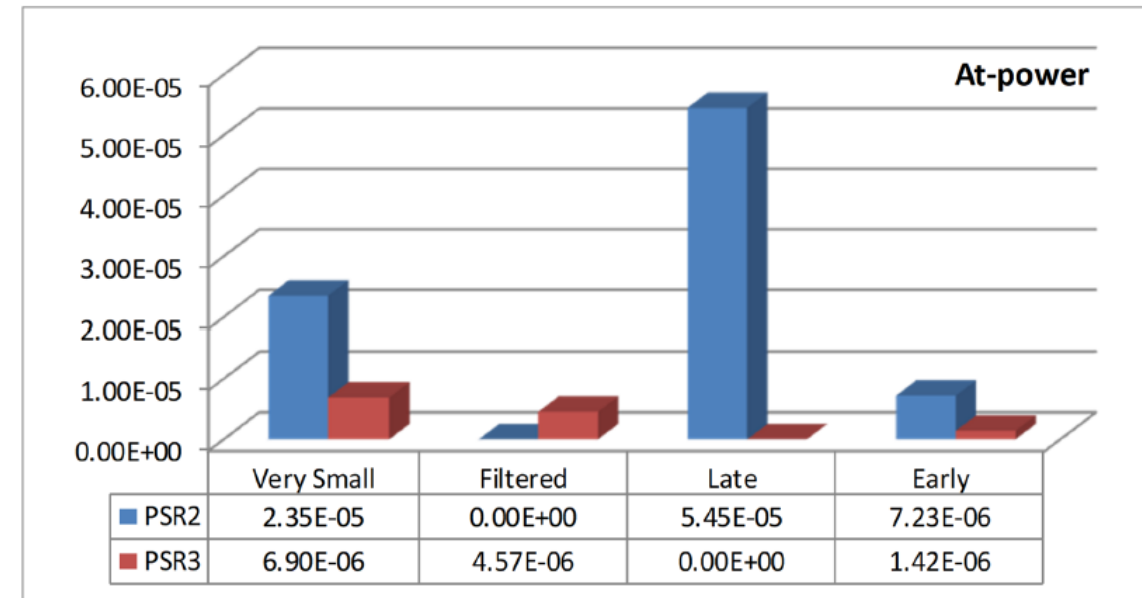




Global safety assessment

PSR3-NEK-9.3

- Depth of defence:
 - Internal Events, Seismic Events, Shutdown Modes
 - Reactor Safety, SFP Safety
- Risk Assessment:
 - Reactor Core Damage and Release of Radioactivity at Power and at Low Power or Shutdown Modes
 - Risk from Spent Fuel
- Consideration of PSR 3 Issues
- Conclusions Regarding Plant Status and Continued Operation
 - Global safety assessment showed significant increase of safety in the period since the PSR2 – the most important contribution was the completion of safety improvements in the course of NEK Safety upgrade program



Independent expert opinion by the TSO

- Independent expert opinion required in the process of approval of the PSR report:
- *An expert opinion on the report on implementation, application methodology, findings and conclusions of the periodic safety review and the impact of the proposed measures on radiation and nuclear safety of the facility shall be attached to the final report.*
- Independent expert review started at the prioritization process of PSR3 findings and preparation of the PSR3 action plan.
- Review of the PSR3 summary report included the review of global safety assessment.
- *Based on presented evidence, the independent evaluation can confirm that there are no issues which would prevent the plant to further operate safely or issues that have immediate impact on nuclear safety and therefore, conclude that NEK is safe and is capable for continuous safe operation.*



Regulatory approval of the PSR3 report

SNSA Decision on 4 December 2023

- Approval of the PSR3
 - summary report with global assessment of plant status
 - Implementation action plan (IAP)
 - Fulfilled condition for operating license extension for the next 10 years
- 5 years to complete the action plan
- Reporting on implementation of IAP to the SNSA every 6 months
- Separate implementation of the Security action plan is required (Security report and action plan approved separately on 16 August 2023)
- Summary of the PSR2 report and the IAP to be translated into Slovenian and published
- Final report on IAP completion shall be prepared and delivered to SNSA
- By 4 June 2033 the application for PSR4 program shall be submitted



Action plan implementation and reporting requirements

- *The report on a Periodic Safety Review shall include ... the implementation action plan of modifications and improvements in the facility with appropriate substantiations*
- *The implementation action plan shall contain a detailed description and deadlines for all measures specifically. The plan shall clearly indicate for each measure, which finding or recommendation of the Periodic Safety Review it is based on.*
- *The operator shall implement all the modifications and improvements indicated in the approved report on the Periodic Safety Review within **five years** from the approval of the report. This deadline may be extended, on an exceptional basis, to eight years from the approval of the report in cases of expensive and complex modifications.*
- From 254 PSR3 findings, many were resolved in the process, **102 actions are included into IAP** (51 by SNSA and 2 by TSO) and 74 findings will not be implemented but will be revisited in the PSR4 for their relevance
- Reporting on progress of action plan implementation every 6 months
- Regulator reviews reports and produced documentation, while modifications are licensed in separate processes
- At the end – Report on action plan completion and analysis of effects on the operational safety of the facility



Conclusions



- A **comprehensive PSR program at the start** is very important for successful and timely performance of PSR and preparation of action plan
- Organization of work and documentation is important, tracing the PSR findings through grouping and prioritization to the PSR action plan
- Periodic reassessment of the site external hazards gives valuable information (seismic, flooding hazard, human induced external events)
- After Fukushima accident – even such external events with low frequency but with large consequences need to be considered – in Design Extension Conditions (DEC)
- In PSR3, three new safety factors, new PS 1.01, NEK SUP completed, lifetime extension
- Based on PSR report – license is extended for 10 years
- PSR action plan to be implemented in 5 years (possible 3 years extension)
- Continuous safety upgrades and safety reviews to assure high level of safety of the Krško NPP
- Good **regulator + operator cooperation** and open communication lead to successful PSR results





Questions?

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[Publication of summary of the Third Periodic Safety Review report and the implementation action of the Krško NPP | GOV.SI](#)



Slovenian Nuclear
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Galešnjak