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European Nuclear Safety Regulators Group

REPUBLIKA SLOVENIJA
MINISTRSTVO ZA NARAVNE VIRE IN PROSTOR
UPRAVA REPUBLIKE SLOVENIJE
ZA JEDRSKO VARNOST

NEK

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National Presentation of Slovenia

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Slovenian Presentation Outline

REPUBLIKA SLOVENIJA
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List of candidate installations and their regulation

1. NPP
2. Dedicated spent fuel storage
3. Waste

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- The Slovenian selection includes:
  - Krško Nuclear Power Plant,
  - Spent Fuel Storage Facility, and
  - On-site Storage Facilities for Radioactive Waste.
- The Spent Fuel Storage Facility and On-site Storage Facilities for Radioactive Waste are on-site facilities, both located inside Krško NPP fence and they operate with the operating license of Krško NPP.
- Krško NPP's operating license has no time limitation, but it's dependent on the regulatory approval of every subsequent Periodic Safety Review (PSR).
- Krško NPP, Spent Fuel Storage and On-site Storage Facilities for radioactive waste have a common fire protection program, as well as fire protection and detection system and all other systems (including electrical supply).

- The Krško NPP reports annually and quarterly to the Slovenian Regulatory body (SNSA) and a part of these reports is dedicated to the reporting about fire safety.
- The SNSA obtains information about the status of fire safety analyses in three ways:
  - Review and assessment of the modifications (a lot of modifications directly or indirectly change the contents of fire safety analyses);
  - Regular reporting of the Krško NPP;
  - Thematic inspections performed by SNSA.
- The SNSA performs regular thematic inspections in order to assess the status of fire safety analyses and the level of overall fire safety in the NPP.

Fire safety analysis (FSA)
(cf TS 02.1)

NPP

Deterministic Fire Hazard Analysis

- The deterministic fire hazard analysis (FHA) for NPP Krško is carried out and kept updated to demonstrate that the fire safety objectives for the plant are met.
- FHA is performed and implemented in accordance with the 10CFR50 Appendix R, Slovenian regulation, and in accordance with the requirements of the WENRA Safety Reference Levels for Existing Reactors.
- Current version of FHA includes all facilities inside Krško NPP including the Spent Fuel Storage Facility and On-site Storage Facilities for Radioactive Waste.

Fire safety analysis (FSA) (cf TS 02.1)

NPP

- **The fire hazard analysis has the following objectives:**
  - to consider potential fixed and transient fire hazards;
  - to determine the effects of a fire in any location in the plant on the ability to safely shut down the reactor, maintain safe shutdown condition, remove SFP decay heat and to prevent or minimize the release of radioactivity to the environment;
  - to specify measures for fire prevention, detection, suppression, and containment for each fire area containing SSCs important to safety, in accordance with the NRC guidelines and regulations; and
  - consider credible combination of events.

- **Main Assumptions:**
  - Fire will damage all systems and equipment located within a fire area or zone.
  - Fire damage is assumed to occur regardless of the amount of combustibles in the area, the ignition temperatures, or the lack of an ignition source.
  - The presence of automatic or manual fire suppression and detection capability is also not credited.
  - The fire is postulated whatever the normal operating status of the plant, whether at power or during shutdown.
  - The Fire Containment Approach (FCA) is used to assess the capability of fire barriers to withstand the fire.

Fire safety analysis (FSA)
(cf TS 02.1)

NPP

Fire Probabilstic Safety Analysis

- Krško NPP has the Level 1 and Level 2 fire PSA analyses available in accordance with the national legislation for all suitable and reasonable conditions of the power plant (Ionising Radiation Protection and Nuclear Safety Act, Official Gazette of the Republic of Slovenia).
- Fire probabilistic safety (risk) analysis (Fire PSA) is a systematic and comprehensive methodology to evaluate safety (risks) from fire events at the plant.
- To mitigate the fire risk, presented with the Fire PSA results, Fire Protection Action Plan (FPAP) was initiated in the ‘90s. Within this program, plant fire safety was crucially increased by plant fire protection upgrade. Consequently, fire PSA analyses were updated to reflect plant changes.
- The Fire PSA update is currently in progress, to reflect the latest available support documents and latest available standards, as part of the third periodic safety review (PSR3) action plan.

Active fire protection

Fire detection (cf TS 03.2.1)

NPP

- Fire detection and alarm annunciation systems are designed in accordance with U.S. legislation and they are incorporated into the overall fire protection design.
- All areas of the NPP are provided with fire detection system.
- All detectors are addressable which means that they have discrete identification in the Main Control Room, Firefighter's office and in Emergency Control Room.
- Fire detection/alarming system is powered by safety power bus with diesel backup and with additional battery for 24 hours of operation.

Fire suppression (cf TS 03.2.2)

NPP

- Fire suppression is achieved by a combination of manual firefighting and automatic/semi-automatic fire extinguishing systems, that protect equipment, systems or areas as defined in FHA.
- The plant has a separate fire protection water supply and distribution system capable of supplying water to the point of the demands.
- Portable hand fire extinguishers are provided for use on small incipient fires.
- Fixed fire extinguishing systems are provided for several specific fire hazards.

Passive fire protection

Compartmentation (cf TS 03.3.1)

NPP

- The Fire Containment Approach (FCA) is used to assess the capability of fire barriers to withstand the fire.
- Where separation of redundant equipment in separate fire compartment was not possible, required protective measures were introduced to achieve operational availability (fixed fire extinguishing system, separation, wrapping, etc.), i.e. Fire Influence Approach (FIA) was applied.
- Fire barriers are evaluated using a combustible loading methodology to verify with conservative margin that fire barriers are capable of containing a fire that consumes all combustibles within a given fire area.
- Any new introduction of fixed combustible loads must be evaluated through modification's process, which includes control of fire barriers, fire protection equipment impact and revision of Fire Hazard Analysis.
- Introduction of transient fire loads in fire areas must be approved and it is periodically controlled. This process is supported by using the digitalized application.

Ventilation management (cf TS 03.3.2)

NPP

- The ventilation systems, installed in the NPP Krško are designed in respect to fire protection principals in accordance with applicable U.S. legislation and they are equipped with smoke detectors and fire dampers.
- In case of fire, the shutdown of ventilation system and actuation of dedicated smoke exhaust system are performed through manual actions in accordance with response procedures.
- Fire dampers in Krško NPP are visually inspected in accordance with applicable procedure, every fuel cycle (18 months).
- Additionally, to visual inspection, the fire dampers are also functionally tested every 4 fuel cycles (72 month), which includes test of activating the actuation mechanism and verifying the proper damper closure.

Conclusion

TS 01.3 and TS 04

NPP

- Krško NPP has two approaches to assure fire safety through a comprehensive deterministic fire hazard analysis and probabilistic fire safety analysis.
- Based on performed fire analyses, risk-based modifications were implemented and consequently, total CDF was significantly reduced.
- Krško NPP purchased additional mobile equipment and performed modifications in scope of Safety Upgrade Program (SUP), as a response to NEI 06-12 B.5.b ”Phase 2&3 Submittal Guideline” requirements and Fukushima accident.
- Additional deterministic fire hazard analyses and revisions of some existing programs and procedures were conducted to comply with WENRA requirements.

Conclusion

TS 01.3 and TS 04

NPP

- Examples of mobile and alternative equipment, installed in scope of Safety Upgrade Program (SUP), are presented below.

- **Main strengths:**
  - Fire safety analyses are regularly reviewed (every two years) and updated to account for the plant modifications that were carried out.
  - The fire safety of the Krško NPP was substantially enhanced with availability of mobile equipment and implementation of the Krško NPP's SUP modifications.
  - External professional firefighting brigade is involved in day-to-day activities in NPP and at the same time gains experience in interventions outside of NPP.
  - A deterministic and probabilistic analyses of the combination of events were carried out.
  - Operating experience, external events and lessons learned are processed in the scope of the Corrective Action Program. Each related event is analyzed and actions for preventing a similar event is defined.
- **Main weakness:**
  - Circuit analysis was not performed in accordance with the NEI 00-01 guideline. Safe shutdown analysis (SSA) shall consider multiple spurious operation (MSO).

Fire safety analysis

Fire safety analysis (FSA) (cf TS 02.3)

Spent fuel storage

- The Fire Safety Analysis (FSA) for Spent Fuel Dry Storage (SFDS) was performed. The postulated fire events evaluated within FSA are compared against thermal evaluations performed for design basis fire events.
- Acceptance criteria was that the long-term operational temperature of SFDS side wall, roof materials, shielding materials and surface coating must remain below the specified values.
- The SFDS is analyzed for potential effects of combined external hazards that mainly result from natural phenomena or possible explosion.
- Both individual and combined effects of hazards are analyzed, and results are included in system design.

Fire safety analysis

Fire safety analysis (FSA) (cf TS 02.3)

Spent fuel storage

- Probabilistic Safety Analysis (PSA) is performed in accordance with NUREG-1864.
- Study from NUREG-1864 was used for Krško NPP with plant specific initiating events. As a result of Probabilistic Safety Analysis, cumulative risk is provided for transfer and storage phases.
- Both the deterministic and probabilistic part of fire safety analyses were carried out for the SFDS, as part of the regular revision of the Krško NPP programs and procedures, after the implementation of the modification.
- Fire safety analyses regarding the SFDS are in compliance with Slovenian regulation (National Fire Safety Code, Rule on Radiation and Nuclear Safety Factors) and U.S. legislation.

Fire safety analysis

Fire safety analysis (FSA) (cf TS 02.3)

Spent fuel storage

- The potential of a fire accident in DSB is low, since there are no ignition sources and introduction of combustible materials is prohibited, during normal operation.
- The only credible concern is related to diesel fuel fire of transport vehicle during cask transport campaigns.
- Two walls of SFDS are equipped with neutron shield, constructed with panels of sandwiched HDPE (High Density Polyethylene) between steel sheets.
- Since HDPE is flammable material, appropriate analyses, calculations and assessments were made to determine the fire protection measures for the shielding construction (HDPE plates) to follow NFPA 801 requirements.
- The results of performed analyses and calculation were considered in Fire Safety Study, which defined all fire safety and protection measures in SFDS during the cask manipulation, which are:
  - temporary fire barrier installation
  - professional fire fighter guard
- The neutron shield (HDPE) installation with performed analyses and prescribed protective measures listed above, were approved by an independent reviewer and the Slovenian regulator (SNSA).

Active fire protection

Fire detection (cf TS 03.2.1)

Spent fuel storage

- Fire detection and alarm annunciation system are incorporated into the overall NPP fire protection design, in accordance with applicable U.S. standards.
- An appropriate combination of fire detectors in SFDS are installed.
- All detectors in SFDS are addressable, as well as throughout Krško NPP, which means that they have discrete identification.
- The detectors alarm on a central panel giving their address and display an appropriate message with graphical identification of fire location in the Main Control Room, Firefighter’s office and in the Emergency Control Room.

Active fire protection

Fire suppression (cf TS 03.2.2)

Spent fuel storage

- Fire suppression is provided with portable fire extinguishers and external hydrant network for manual fire fighting.

Conclusion

TS 01.3 and TS 04

Spent fuel storage

- The main result for the Krško NPP Dry Storage Building shows that there is enough safety margin, robustness and redundancy incorporated in the design of facilities and their support systems.
- All fire safety precautions and measures reduce the probability of a fire event.
- The FSA also shows that radiological impact following a fire event, cannot cause significant or important doze release, even if considering the combination of multiple events.
- Since the SFDS is a new nuclear installation, at the moment there is no events, reviews, fire safety related missions, etc. for this facility. There is also no identified strengths and weaknesses at the moment.
- Main strength: both the deterministic and probabilistic part of fire safety analyses were carried out for the SFDS.

Fire safety analysis

Fire safety analysis (FSA) (cf TS 02.4)

Waste

- Fire Hazard Analysis for Rad-Waste Storage Facilities (RWSF) was prepared at the same way as for other fire areas in Krško NPP.
- A basic assumption is that there will be a fire damage to all systems and equipment located within a fire compartment/building.
- Fire damage is assumed to occur regardless of the amount of combustibles in the area, the ignition temperatures, or the lack of an ignition source.
- FHA for radwaste storage facilities also considers effect of ventilation system, which confines the radioactive material, if any.

Active fire protection

Fire detection and fire suppression (cf TS 03.2.1/TS 03.2.2)

Waste

- Fire protection concept and its implementation is common for the whole Krško NPP's site, including waste storage facilities.
- Fire detection is installed in all fire area and fire detection/alarming system is addressable and allows precise location of fires.
- Area smoke detectors provide signals for automatically building isolation, in case of a detected fire and will as such prevent any possible radioactive releases to the environment.
- Fire detection system provides alarm in the Main Control Room, Emergency Control Room and in Fire Brigade House.
- Portable extinguishers, hose cabinets and outside hydrants are provided within the facilities for manual fire fighting.

Passive fire protection

Compartmentation (cf TS 03.3.1)

Waste

- The Fire Containment Approach (FCA) approach is used to assess the capability of fire barriers to withstand the fire.
- Fire loads are limited to not exceed fire rating of barriers. This is achieved by design and through control process of fire loads.
- Ventilation systems for radwaste storage facilities are equipped with fire and isolation dampers, which will automatically close to isolate the buildings and will as such prevent any possible radioactive releases to the environment.
- Fire dampers are visually inspected and functionally tested in scope of applicable procedures, common for whole NPP.

Conclusion

TS 01.3 and TS 04

Waste

- In accordance with observations and findings of various events, reviews and missions, the following improvements were performed in recent years, related to waste storage facilities:
  - Fire plans for waste storage facilities were prepared;
  - Fire Hazard Analysis was revised to include waste storage facilities;
  - Krško NPP considers RWSF as a separate fire area (RWS) in the currently revision of fire safety analysis.

- **Main strengths:**
  - The facility is divided into several buildings that are separated from each other by three hour rated fire walls.
  - Amount of combustible material is minimized by performing procedural controls.
  - The related quantities of source terms are so low that they could not cause the raise of radioactivity on the site to the level needed for the activation of an emergency event in accordance with Emergency Planning Procedure.
- **Main weakness:**
  - Fire detection system is missing in fire area DB-1 (old steam generators warehouse with a negligible combustible load). BUT: the action plan for installation of fire detectors in DB-1 fire area was already initiated in 2024.

Conclusion

- Fire Protection Systems in Krško NPP are designed to provide adequate fire protection from all known fire hazards.
- The safe and stable operation of Krško NPP without major or minor events, including events related to fire, is also the result of the robust Fire Protection Program where all prescribed precautions and instructions are strictly followed.
- In addition to the Fire Protection Program and Fire Protection System, there are many design features of the plant that would contribute to confining and limiting a potential fire condition.
- The fire safety at the plant was constantly improved and therefore risk from fires was minimized, what can be also observed from the reduction of fire CDF.
- A periodic review of FHA is required after each 2 years to evaluate and summarize the changes done in the plant and to reflect the as-built configuration of the plant.
- Expert missions of the Insurance Pool's Fire protection area are conducted every 4 years to review the current situation on the fire safety and to give recommendations for improvement for that area. All received recommendations have already been resolved.
- The fire protection of the Krško NPP is on a high level.