

Consideration of damage after mechanical impacts in accident conditions of shipment in criticality, radiation and thermal safety calculations for a spent fuel cask

The technical design of the Increased Capacity Cask (ICC) for storage and shipment of 30 VVER-1000/1200/1300 spent fuel assemblies (SFA), including the possible modification for storage, shipment and disposal (in the future, in an intermediate-depth repository) of canisters with $\sim 5,4 \text{ m}^3$ of vitrified Cs-Sr fraction of High-Level Waste (HLW) resulted after spent fuel reprocessing was prepared in 2024. ICC was designed in the framework of the project "Development and Referencing Spent Fuel and High-Level Waste (HLW) Long-Term Storage Systems for Foreign Nuclear Power Plants (NPP)", part of the Sustainable Nuclear Fuel Cycle (NFC) solution of Rosatom State Corporation for Atomic Energy, which proposes spent fuel reprocessing with HLW fractioning in order to optimize spent fuel management systems' economical parameters.

A series of innovative approaches was used during ICC design calculations, which may lead to improvements of dual-purpose casks safety assessment practices:

- Storage of SFA in ICC in normal operation and during abnormal operating conditions;
- Strength calculations in accident conditions [1] takes into account accumulative damage during the worst sequence of impacts bringing maximum damage to the integrity of the ICC and radioactive contents: free drops from 0.3 m and 9 m heights on an unyielding target and free drop from 1 m to a bar according with SSR-6 (Rev.1) requirements;
- A 3D model of the SFA was developed that takes into account SFA material parameters after 60 years of storage in the ICC. The SFA 3D model was used for calculating two additional scenarios bringing worst damage to the radioactive content, also taking into account accumulative damage;
- The damage of each cask component that impacts the thermal release from SFA to the outside environment, criticality, shielding and leaks was determined and taken into account in the corresponding calculations [2], [3], [4];
- The minimal burnup of SFA with maximal U-235 enrichment was determined and taken into account in the criticality calculations [3] provided that instrumental confirmation of SFA burnup during ICC loading is foreseen in the operational flowchart of cask storage facilities (CSF).

In result the performed calculations confirmed the following:

- Safety of ICC in all analyzed operation conditions, including abnormal operation conditions and fulfillment of all regulatory limits and criteria on criticality and radiation safety is assured;
- Absence of fuel cladding breaches and of fuel material release from the fuel cladding into ICC cavity in accident conditions, compliance with fuel cladding temperature limits at all times;
- ICC design complies with the technical and economical parameters imposed by the technical specification and provides for realizing all planned operation regimes, cost optimization during long-term storage of SFA and also assures the possibility to handle vitrified radioactive waste.

Elements of the ICC design are taken into consideration for small modular reactor (SMR) spent fuel handling.

Country or International Organization

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Instructions

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