Regulatory practices of Radiation Safety of SNF Transportation in Russia

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Abstract. This paper overviews current regulatory practices for the assurance of nuclear and radiation safety during railway transportation of SNF on the territory of Russian Federation from NPP's to longterm-storage of reprocessing sites. The legal and regulatory requirements (mostly compliant with IAEA ST-1), licensing procedure for NM transportation are discussed. The current procedure does not require a regulatory approval for each particular shipment if the SNF fully comply with the Rosatom's branch standard and is transported in approved casks. It has been demonstrated that SNF packages compliant with the branch standard, which is knowingly provide sufficient safety margin, will conform to the federal level regulations. The regulatory approval is required if a particular shipment does not comply with the branch standard. In this case, the shipment can be approved only after regulatory review of Applicant's documents to demonstrate that the shipment still conformant to the higher level (federal) regulations. The regulatory review frequently needs a full calculation test of the radiation safety assurance. This test can take a lot of time. That's why the special calculation tools were created in SEC NRS. These tools aimed for precision calculation of the radiation safety parameters by SNF transportation use preliminary calculated Green's functions. Such approach allows quickly simulate any source distribution and optimize spant fuel assemblies placement in cask due to the transport equation property of linearity relatively the source. The short description of calculation tools are presented. Also, the paper discusses foreseen implications related to transportation of mixed-oxide SNF.

KEYWORDS: SNF transportation, radiation safety, regulatory practices.

1. Introduction

The safety of radiation materials (RM) transportation provides with State regulation system based on imperative licensing of transport organizations and organizations responsible for RM sending off and receiving, on system of drawing up of the so-called certification-authorization for casks and transportation operations, on accident prevention system, on vehicles and vessels escort and secure, on system of registration and control, on safety systems placed in special vehicle and vessel design.

2. Regulatory basis of RM and NM transportation

The main document regulating safety of RM transportation in Russian Federation is "Safety Rules at transportation of radioactive materials" [1]. The Rules [1] requirements for casks and transportation conditions are based on the following:

(a) The limitation of radiation levels on casks, vehicles and vessels, of their surface radiation contamination and of the quantity of radiation contents go out from casks.

(b) The limitation of quantity and radionuclide composition of radioactive contents to be transport in one cask, depending on cask's property to provide the containment in necessary limits and radiation safety in different transportation conditions and on radiation content's ability for dispersion.

(c) The limitation of fissile nuclear materials (NM) in casks and (or) defining of the requirements for exclusion of nuclear criticality.

(d) Using the casks witch operation safety provides with their design and minimizes the special technical actions carried through the shipment.

(e) The limitation of casks quantity to be transport on one vehicle or vessel depending on their radiation and criticality danger.

(f) Drawing up of the certification (certification-authorization) for casks, vehicles, vessels and transportation operations.

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The radiation safety of RM and NM transportation provides with using ALARA and limitation of individual doses by the established limits. Organizations involved in transportation process must carry out the actions for any incident or accidents prevention and actions for liquidation of radiation consequences of the accident under the Rules [1] and other regulatory documents requirements.

The legal basis in Russian Federation obliges to analyze the initiating events for basic and for over-basic accidents. The single failure principle is used in basic accidents analysis. For over-basic analysis the most adverse ways of accident evolution are considered.

3. SNF transportation specific and SEC NRS experience

The current procedure does not require a regulatory approval for each particular shipment if the spent nuclear fuel (SNF) fully complies with the Rosatom's branch standard [2] and is transported in approved casks. It has been demonstrated that SNF packages compliant with the branch standard, which is knowingly provide sufficient safety margin, will conform to the State level regulations. The regulatory approval is required if a particular shipment does not comply with the branch standard. In this case, the shipment can be approved only after regulatory review of Applicant's documents to demonstrate that the shipment still conformant to the higher level (State) regulations.

3.1 Calculation tools

The regulatory review frequently needs a full calculation test of the radiation safety assurance. This test can take a lot of time. That's why the special calculation tools were created in Scientific and Engineering Center for Nuclear and Radiation Safety (SEC NRS). These tools aimed for precision calculation of the radiation safety parameters by SNF transportation use preliminary calculated Green's functions. Such approach allows quickly simulate any source distribution and optimize spent fuel assemblies placement in cask due to the transport equation property of the linearity about the source.

Such a property enabled to get the value of dose rate from any source by de-escalation this source on Green's function determined by contributions from single sources of every type in every piece of area to dose rate:

$$\dot{H}(\vec{x}) = \int q(\vec{x})\, G(\vec{x}) d\vec{x} \qquad (1)$$

Thus, the dose rate behind the cask radiation shield for any specific composition of SNF may be determined by division the SNF volume in cask into several zones and calculation the contributions from single sources (normalized on one particle) of neutron and gamma irradiation for every zone.

The special calculation tools created in SEC NRS and realized the methodology described above consist of Green's functions libraries calculated by precision programs for irradiation transport design and program using these libraries for fast calculation of dose rate behind the cask radiation shield.

3.2 Radiation field calculation for casks with spent MOX-fuel

Today the MOX-fuel operating is considered to be the most perspective way to increase the effectiveness of fuel cycles. However, this way also has some difficulties in particular in transportation safety ensuring. This fact takes place because the concentration of isotopes affect on dose rate behind the cask radiation shield for the spent MOX-fuel is higher than ones for the spent uranium fuel. So the dose rate on the cask surface with spent MOX-fuel is higher than ones on the cask surface with spent uranium fuel. Moreover this dose rate for MOX-fuel can run up to the allowed limitation.

In purpose to investigate this factor influence the calculation tools were updated for conditions of MOX-fuel transportation. The results of calculations are brought to the following aspects:

(a) The dose rate would not exceed the limitation allowed by Rules [1] for the MOX-fuel of 33 MWt·day/kg burn up.
(b) The dose rate for this fuel is comparable with dose rate for uranium fuel of the highest burn up allowed for transportation without regulatory review by the Rosatom's branch standard [2].

REFERENCES

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