# Criticality Risks During Transportation of Spent Nuclear Fuel -ABSTRACT

Risks during transportation of spent nuclear fuel have been addressed in NUREG/CR-4829, *Shipping Container Response to Severe Highway and Railway Accident Conditions*, and NUREG/CR-6672, *Reexamination of Spent Fuel Shipment Risk Estimates*. These studies assess the risks of accidents that potentially breach the transportation package, resulting in releases of radioactive material to the environment, but do not quantify the frequency of criticality accidents directly.

The results from a best-estimate probabilistic risk assessment (PRA) to quantify the frequency of criticality accidents during railroad transportation of spent nuclear fuel casks are presented. The assessment is of sufficient detail to enable full scrutiny of the model logic and the basis for each quantitative parameter contributing to the criticality accident scenario frequencies.

The probability of any criticality accident over a total of 11,000 shipments is estimated to range from 2.0E-13 to 9.2E-15, which constitutes a negligible risk. This result arises from a number of independent factors:

- Significant safety margin for the effective multiplication factor, $k_{eff}$, when fuel is loaded into a spent fuel cask in accordance with its Certificate of Compliance.
-Very low likelihood of a misload due to the controls and verification requirements followed when loading the spent fuel cask.
- Extremely low likelihood that a railroad accident will produce the damage and immersion needed to achieve criticality, as determined by U.S. NRC-sponsored research.
- Criticality may not be achieved even if the cask has been misloaded, damaged, and immersed in water. The misload must introduce a significant additional amount of reactivity, and the damage must be such that water can leak into the cask to allow the moderation needed for criticality.

Given these results, restricting burnup credit to actinides only and requiring a measurement that confirms the reactor record of assembly burnup produce negligible reductions in criticality risks. Using risk-informed arguments coupled with cost-benefit analyses demonstrates that use of burnup-credit-designed storage and transportation systems should be encouraged to minimize radiological and non-radiological risks. Favorable cost-benefit analysis results mostly derive from a reduction in the number of shipments, while enhancements in safety mostly derive from reducing handling and non-radiological transportation risks.