## EXECUTIVE SUMMARY

The U. S. Nuclear Regulatory Commission (NRC) has conducted several risk assessments and other analyses to evaluate the safety of transportation of spent power reactor nuclear fuel over the past 40 years. Regulations, shipping practices, and cask designs for transporting radioactive material have remained essentially unchanged during this time. Therefore, it is expected that the actual per-shipment risk over this period of time would also have remained essentially the same. This is not the case. What *has* changed is the improvement in the ability to evaluate the responses of the casks and their spent fuel contents to accident environments. The improvements include advancements in the tools available to determine those responses and to calculate the consequences and risks that result from their response. This has resulted in a decrease in the calculated per shipment risk. The calculated consequences and risks in this study are several orders of magnitude less than those calculated in previously performed risk assessments.

In this study the risk associated with the transportation of spent nuclear fuel was estimated by examining the behavior of three NRC-certified casks during routine transportation and in transportation accidents. Two of these casks are designed for transport by railroad: the first has a steel gamma shield and has an inner welded canister to for the spent fuel; the other has a lead gamma shield and can transport spent fuel either with an inner welded canister (referred to in this report as canistered fuel) or without an inner canister (referred to as directly loaded fuel). The third cask has a depleted uranium for gamma shield and is used to transport directly loaded spent fuel by highway. The response of these casks is typical of that of other cask designs. The use of certified casks designs means this risk assessment includes the factors of safety that are typically included in cask designs but were not specifically considered in previous risk assessments.

The risks associated with routine shipments (incident free) and those associated with shipments where an accident occurs are calculated separately. In routine transportation, the risk and the consequence are the same. For this case, the dose to residents living along a transportation route, the dose to people sharing the highway or railway, the dose to people at stops, and the dose to transportation workers are all calculated. Regulations allow limited external radiation from the cask. The dose to members of the public from this radiation during routine transportation is a small fraction of the naturally occurring background radiation dose exposed individuals experience during the same time as the shipment.

If there is an accident during the shipment, the most likely result is that there is no damage to the cask, but the vehicle is stopped for a period of time, exposing people in the vicinity of this stop (nearby residents, emergency response workers, etc.) to the allowed external radiation from the cask. If the accident is more severe, the shielding effectiveness of the cask could be reduced. If the cask is involved in a fire, the plastic neutron shielding material could melt, resulting in a slightly elevated amount of radiation coming off the cask. If the lead shielded cask were to be involved in an exceptionally severe long-lasting fire, there could be a reduction in the effectiveness of the gamma shielding. The response of the cask to fire accidents was determined

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**Comment [csb4]:** This term may not be widely familiar to the public.

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**Comment [JRC5]:** Don't know why change "from". "Off" sounds like contamination?

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using detailed three-dimensional finite element computer analyses. Even in the worst-case fires analyzed, no cask experienced a seal failure that could have led to a release of radioactive material from the spent fuel cask.

For impact accidents, the steel shielded cask with inner welded canister and the depleted uranium shielded cask have no release and no loss of shielding effectiveness even under the most severe impacts studied, which encompass all realistic accidents. The lead shielded cask experiences some loss of shielding effectiveness during severe impacts and in the case where spent fuel is transported without an inner welded canister there could be some release of radioactive material for exceptionally severe impacts.

If material were to be released, that release would be affected by the weather conditions at the accident location. The risk assessment uses national average weather (conditions?) because the time and location of an accident are not known. The number of people exposed to the dispersed material is a function of the population density at the site of the accident, as determined from census data. The amount of material released, the dispersion, and the population density are combined to determine the consequence (potential affects) of a release. The worst-case release from this study would not produce any immediate health effects.

Accident risk is the product of the consequence of the accident and its probability. The probability of an accident that has an effect on the cask is the product of the probability that the cask is involved in an accident and the conditional probability that the accident is severe enough to reduce the shielding or containment effectiveness of the cask. The conditional probability is based on state accident statistics for all types of heavy trucks and railcars. The accident probability is determined by multiplying these state-by-state accident rates by the distance traveled within each state. This was done for sixteen representative routes.

The following conclusions are reached from the study:

- The collective dose risks from routine transportation are vanishingly small. Theses doses are about four to five orders of magnitude less than collective background radiation dose.
- The routes selected for this study adequately represent the routes for spent nuclear fuel transport, and there was relatively little variation in the risks per kilometer over these routes.
- Radioactive material would not be released in an accident if the fuel is contained in an inner welded canister inside the cask.
- Only rail casks without inner welded canisters would release radioactive material, and only then in exceptionally severe accidents and…?.
- Only one in one hundred thousand potential accidents would result in a release of radioactive material.
- The collective dose risks for the two types of extra-regulatory accidents (accidents involving a release of radioactive material and loss of lead shielding accidents) are negligible compared to the risk from a no-release, no-loss of shielding accident.

**Comment [JRC6]:** I like it, but delete for public understanding.

**Comment [JRC7]:** Can we add "and historical"?

**Comment [csb8]:** Are these releases within the regulatory limits or not? If so, that should certainly be stated.

**Comment [csb9]:** This does not make sense. There is not distribution by the weather conditions...the conditions affect how it is dispursed.

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**Comment [JRC10]:** Agree, but Chapter 1.3 states "The risk estimates indicate ... when and where they will happen, ..." Change that text.

**Comment [JRC11]:** Don't like this term. "The estimated dose from the most severe accident scenarios evaluated in this study is less than that required to produce an immediate injury."

**Comment [csb12]:** What does this mean?

**Comment [JRC13]:** Truck and rail

**Comment [JRC14]:** These should be consistently stated throughout the report.

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**Comment [JRC16]:** That many?

- The risk of either a release or loss of shielding from a fire is negligible.
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