U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment

NUREG-2125

Spent Fuel Transportation Risk Assessment

Final Report

EXHIBIT V – HLRW
Document consists of 4 pages.
Entire Exhibit provided.
Meeting Date: 02-21-14

Office of Nuclear Materials Safety and Safeguards

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 during the past 35 years. Regulations, shipping practices, and cask designs for transporting radioactive material have remained essentially unchanged during this time. Therefore, the *actual* per shipment risk over this time period also would have remained essentially the same. What *has* changed during this period is the *calculated* risks. This change was brought about by the improved ability to evaluate cask responses and their spent fuel contents to accident environments. The improvements include advancements in 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 consequences and risks resulting from accidents calculated in this study are several orders of magnitude less than those calculated in previous risk assessments.

In this study, the risk associated with the transportation of spent nuclear fuel (SNF) was estimated by examining the behavior of three NRC-certified casks during routine transportation and in transportation accidents. Two casks are designed for transport by railroad: (1) a cask with steel gamma shielding and an inner welded canister for the spent fuel and (2) a cask with lead gamma shielding that can transport spent fuel within an inner welded canister (referred to in this report as canistered fuel) or without an inner canister (referred to as directly loaded fuel). A third cask with depleted uranium (DU) gamma shielding is designed to transport directly loaded spent fuel by highway. The response of these casks is typical of other cask designs. The use of certified cask designs means this risk assessment includes the factors of safety typically included in cask designs but not specifically considered in previous risk assessments.

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

If an accident occurs during shipment, most likely there is no damage to the cask. In this type of accident the shipping vehicle is stopped for a period of time, which exposes 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 emanating from the cask. If the lead shielded cask was 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 using detailed 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 DU-shielded cask have no release and no loss of gamma shielding effectiveness even under the most severe impacts studied, which encompass all historic or even realistic accidents. The lead

shielded cask experiences some loss of gamma shielding effectiveness during severe impacts. Also, when spent fuel is transported without an inner welded canister some release of radioactive material could occur during exceptionally severe impacts.

If material were to be released, weather conditions at the accident location would affect the dispersal of that material. The risk assessment uses national average weather conditions because the time and location of an accident are unknown. The number of people exposed to the dispersed material is a function of the population density at the site of the accident, which is determined from census data. The amount of material released, the dispersion, and the population density are combined to determine the consequence (potential effects) of a release. The estimated dose from the most severe accident scenarios evaluated in this study is less than that required to produce an immediate injury or fatality.

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 16 representative truck routes and 16 representative rail routes. The representative routes chosen are for illustrative purposes only, and no SNF shipments are planned from any of the points of origin to any of the destinations.

The study reached the findings listed below.

- The collective dose risks from routine transportation are very small. These doses are approximately four to five orders of magnitude less than the collective background radiation dose.

- The routes selected for this study adequately represent the routes for SNF transport, and there was relatively little variation in the risks per kilometer (km) 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.

- If there were an accident during a spent fuel shipment, there is only about one-in-a-billion chance that the accident would result in a release of radioactive material.

- If there were a release of radioactive material in a spent fuel shipment accident, the dose to the maximally exposed individual (MEI) would be less than 2 sieverts (Sv) (200 rem) and would not result in an acute lethality.

- The collective dose risks for the two types of extremely severe accidents (accidents involving a release of radioactive material and loss of lead shielding (LOS) accidents) are negligible compared to the risk from a no-release, no-loss of shielding accident.

- The risk of gamma shielding loss from a fire is negligible.

- None of the fire accidents investigated in this study resulted in a release of radioactive material.

Based on these findings, this study reconfirms that radiological impacts from spent fuel transportation conducted in compliance with NRC regulations are low. In fact, they are generally less than previous, already low, estimates. Accordingly, this study also reconfirms the NRC's previous conclusion that regulations for transportation of radioactive material are adequate to protect the public against unreasonable risk.

A more complete plain-language summary of the report is given in the following section.