THE NATIONAL ACADEMIES
REPORT IN BRIEF

Going the Distance? The Safe Transport of Spent Nuclear Fuel and High-Level Radioactive Waste in the United States

There are no fundamental technical barriers to the safe transport of spent nuclear fuel and high-level radioactive waste in the United States. When conducted in strict adherence to existing regulations, such transport is a low radiological risk activity with manageable safety, health, and environmental consequences. However, there are a number of social and institutional challenges to the successful initial implementation of large-quantity shipping programs.

About 55,000 metric tons of spent nuclear fuel and high-level radioactive waste—byproducts of nuclear power production, defense-related activities, and research activities—are stored at more than 70 sites around the United States (see Figure 1). The vast majority is commercial spent fuel stored at nuclear power plant sites. The remainder is defense-related spent fuel and high-level waste stored at four government-owned sites. These materials are highly radioactive and, without proper shielding, can be harmful or fatal to those exposed to it.

All of the U.S. sites are considered interim storage solutions. The federal plan is to transport spent fuel and high level waste from those sites to permanent disposal in a geologic repository that is to be built at Yucca Mountain, Nevada. The U.S. Department of Energy (DOE) is responsible for transporting spent fuel and high-level waste to the repository.

Transportation of spent fuel on our nation's railways and highways is nothing new. Since the 1950s, it has been transported in small quantities from a variety of sources, including nuclear-powered naval ships, research facilities, and nuclear power plant sites that have been shut down or run short of storage. It is also being transported in many other countries, in some cases in much larger quantities than in the United States. To date, only about 3,000 metric tons of the total U.S. inventory has been transported, and that inventory is growing by about 2,000 metric tons per year.

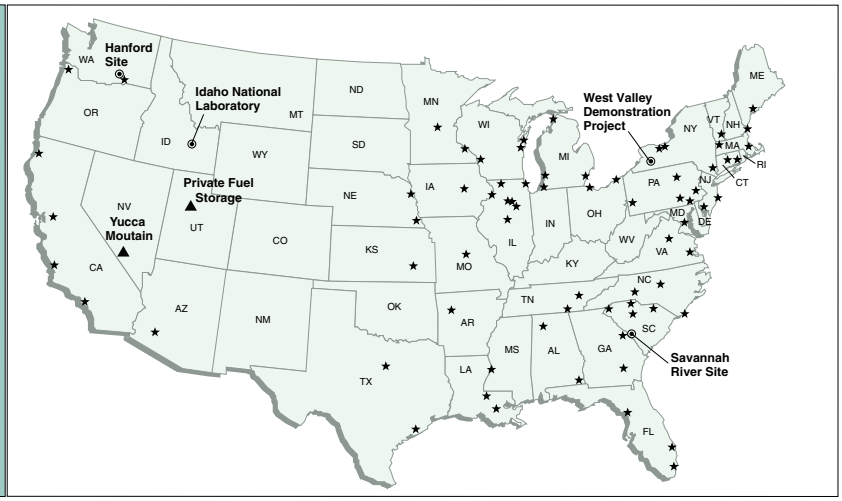

Figure 1. Locations of current spent fuel and high-level waste storage sites, Yucca Mountain, and Private Fuel Storage. The stars are nuclear power plant sites; circles are government-owned sites for defense-related wastes.

Source: Modified from the U.S. Department of Energy

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With the potential opening of Yucca Mountain now estimated at 2017, attention has turned to the question of how to safely transport much larger quantities of spent fuel and high-level waste in the future. A large-scale transportation program is especially challenging because much of the U.S. commercial spent fuel inventory is now being stored at sites near large populations, and shipments would pass through 31 states and many major population centers on their way to the repository.

Recognizing the need for an independent examination of the risks and key concerns associated with this transport, the National Research Council's Nuclear and Radiation Studies Board and Transportation Research Board jointly initiated this study. A key finding of the study report is that transport by highway (for small-quantity shipments) and by rail (for large-quantity shipments) is, from a technical viewpoint, a low radiological risk activity with manageable safety, health, and environmental consequences when conducted in strict adherence to existing regulations. However, there are a number of social and institutional challenges to the successful initial implementation of large-quantity shipping programs that require expeditious resolution as described in the report. Moreover, the challenges of sustained implementation should not be underestimated.

Assessing Transportation Risks

Risk is a multidimensional concept: It includes the health and safety risks that potentially arise from exposures of workers and members of the public to radiation from spent fuel and high-level waste. It also includes social risks that arise from social processes and people's perceptions even in the absence of radiation exposures. Risks can also arise from incidents such as terrorist attacks, but such incidents are not addressed in this report.

Health and Safety Risks of Transport Are Generally Low

There are two potential sources of radiation exposure during transport of spent fuel and high-level waste: 1) emitted radiation or "radiation shine" from packages during routine transport conditions; and 2) potential increases in radiation shine and release of radioactive materials under accident conditions severe enough to compromise the robust containers or "packages" used to transport the spent fuel and high-level waste. The report finds that the radiological risks associated with the transportation of spent fuel and high-level waste are well understood and are generally low. This statement is based on several factors (described in chapters 2 and 3 of the report) that include the following:

- Rigorous international standards and U.S. regulations for the design, construction, testing, and maintenance of spent fuel packages;
- Full-scale crash testing of transport packages under severe accident conditions;
- A series of increasingly sophisticated analytical and computer modeling studies of spent fuel transport package performance; and
- Reconstructions of the mechanical and thermal loading conditions from severe accidents that did not involve spent fuel to assess how spent fuel packages would have performed under the same conditions.

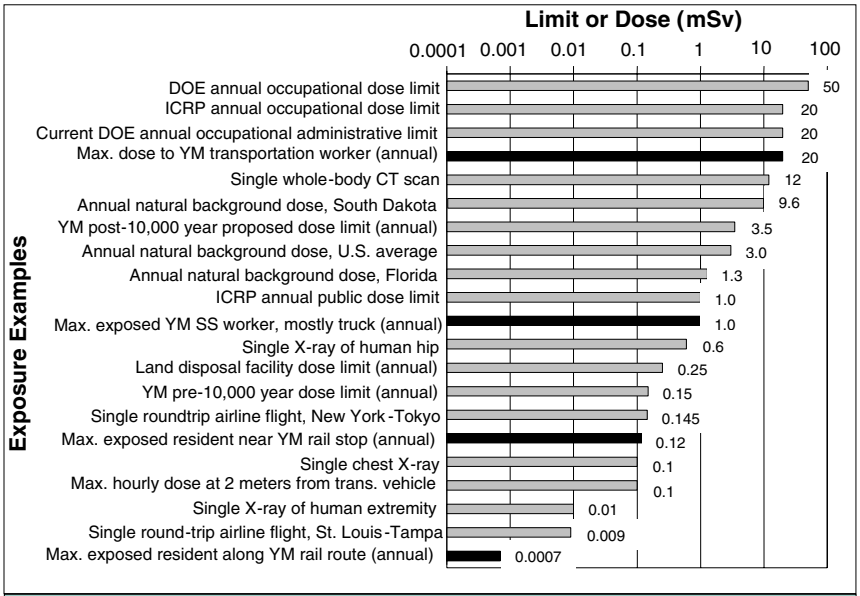

Figure 2. Estimates of radiation exposure from transport of spent fuel and high-level waste under routine conditions.

However, extreme accidents involving very-long-duration (hours to days) fires that fully engulf the transportation package might compromise its ability to contain its radioactive contents. While the likelihood of such extreme accidents appears to be very small, their occurrence cannot be ruled out based on historical data for other types of hazardous materials shipments. However, the likelihood of occurrence and consequences can be reduced further through relatively

simple operational steps and route-specific analyses. The report recommends that transportation planners and managers undertake detailed surveys of transportation routes to identify potential hazards that could lead to or exacerbate extreme accidents involving long duration, fully engulfing fires, and also take steps to avoid or mitigate such hazards. The report also recommends that the Nuclear Regulatory Commission build on recent progress in understanding package performance in very long duration fires through additional analyses.

Potential for Harmful Radiation Exposure Low

Transportation packages contain heavy shielding to protect workers and the public from the radiation emitted by the spent fuel or high-level waste contained within them. The packages are effective in shielding well over 99 percent of this emitted radiation, but a small amount (below regulatory limits) of radiation, primarily gamma rays, can escape from the interior of the packages and provide small doses to workers and the public.

Under routine transportation conditions, workers who are responsible for loading, inspecting, and transporting these packages might also receive doses. Individuals who travel, work, and live along the routes used for shipping spent fuel and high-level waste might also receive very small radiation doses when loaded packages are transported in their vicinity. Figure 2 compares estimated radiation doses from a Yucca Mountain transportation program with doses received in the course of other daily activities. The report also provides estimates of exposure for severe accident conditions. The report concludes that expected fatalities for severe accidents involving spent fuel are significantly lower than for other types of hazardous materials transport.

Social Risks Should be Managed Proactively

Social risks can result in a variety of impacts: reductions in property values along transportation routes, reductions in tourism, increased anxiety, and stigmatization of people and places are some examples. The social risks for spent fuel and high-level waste transportation pose important challenges to the successful implementation of programs for transporting spent fuel and high-level waste in the United States. The report recommends that early and proactive steps should be taken to establish formal mechanisms for gathering high-quality and diverse advice about social risks and their management on an on-going basis. The report provides specific advice to the Department of Energy for gathering information about social risks in its Yucca Mountain transport program:

1. Expand the membership and scope of an existing advisory group to obtain outside advice on social risks, and
2. Establish a transportation risk advisory group that is explicitly designed to provide advice on characterizing, communicating, and mitigating the social, security, and health and safety risks that arise from the transport of spent fuel.

Although these recommendation are focused primarily on the Department of Energy, they apply to any large-quantity shipping program, including the program to ship commercial spent fuel to centralized interim storage (e.g., Private Fuel Storage, LLC in Utah).

Transportation Route Selection Processes are Reasonable

One of the most controversial issues concerning transport of spent fuel has been the selection of highway and rail routes. The report examines the procedures the Department of Energy uses to select rail and highway routes for transporting spent fuel from research reactors to its facilities. The report finds that the Department of Energy's procedures for selecting routes within the United States for shipments of research reactor spent fuel appear on the whole to be adequate and reasonable. They are risk-informed; they use standard risk-assessment methodologies to identify a suite of potential routes; and they select final routes taking into account security, preferences of state and tribal governments, and information from states and tribes on local transport conditions.

The report recommends that the Department of Energy continue to ensure the systematic, effective involvement of states and tribal governments in its decisions involving routing and scheduling research reactor spent fuel shipments. The Department of Transportation should ensure that state-designated routes for shipment of spent fuel are supported with sound risk assessments, and that all potentially affected states are aware of and prepared to fulfill their responsibilities regarding highway route designations.

Possibility of Malevolent Acts Warrants Further Study

The report finds that malevolent acts against spent fuel and high-level waste shipments are a major technical and societal concern, especially following

the September 11, 2001 terrorist attacks on the United States. The report does not provide an in-depth technical examination of transportation security because of information constraints. Instead, the report recommends that an independent examination of the security of spent fuel and high-level waste transportation be carried out prior to the commencement of large-quantity shipments to a federal repository or to interim storage. This examination should provide an integrated evaluation of the threat environment, the response of packages to credible malevolent acts, and operational security requirements for protecting spent fuel and high-level waste while in transport.

Additional Report Recommendations

The report offers several other recommendations for improving the Department of Energy's program for transporting spent fuel and high-level waste, some of which are summarized below. Many of the recommendations in this report would apply to the implementation of any large-quantity shipping program in the United States.

Rail Shipments and Routing. The report strongly endorses the Department of Energy's plan to ship spent fuel and high-level waste to a federal repository using a "mostly rail" option. The report recommends that the Department of Energy fully implement this option before commencing large quantity shipments. The Department of Energy should also identify and make public its suite of preferred highway and rail routes for transporting spent fuel and high-level waste to a federal repository as soon as practicable to support state, tribal, and local planning, especially for emergency responder preparedness.

Emergency Response Planning. The Department of Energy should begin immediately to execute its emergency responder preparedness responsibilities defined in Section 180(c) of the Nuclear Waste Policy Act.

Information Sharing. The Department of Energy, Department of Homeland Security, Department of Transportation, and Nuclear Regulatory Commission should promptly complete the job of developing, applying, and disclosing consistent, reasonable, and understandable criteria for protecting sensitive information about spent fuel and high-level waste transportation. These agencies should also commit to the open sharing of information that does not require such protection and facilitate timely access to such information.

Organizational Structure. The Secretary of Energy and the U.S. Congress should examine options for changing the organizational structure of the Department of Energy's program to transport spent fuel and high-level waste to a federal repository to improve its chances for success.

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This report brief was prepared by the National Research Council based on the committee's report. For more information, contact the Nuclear and Radiation Studies Board at (202) 334-3066 or visit http://nationalacademies.org/nrsb. Copies of *Going the Distance? The Safe Transport of Spent Nuclear Fuel and Radioactive Waste in the United States* are available from the National Academies Press, 500 Fifth Street, NW, Washington, D.C. 20001; (800) 624-6242; www.nap.edu.