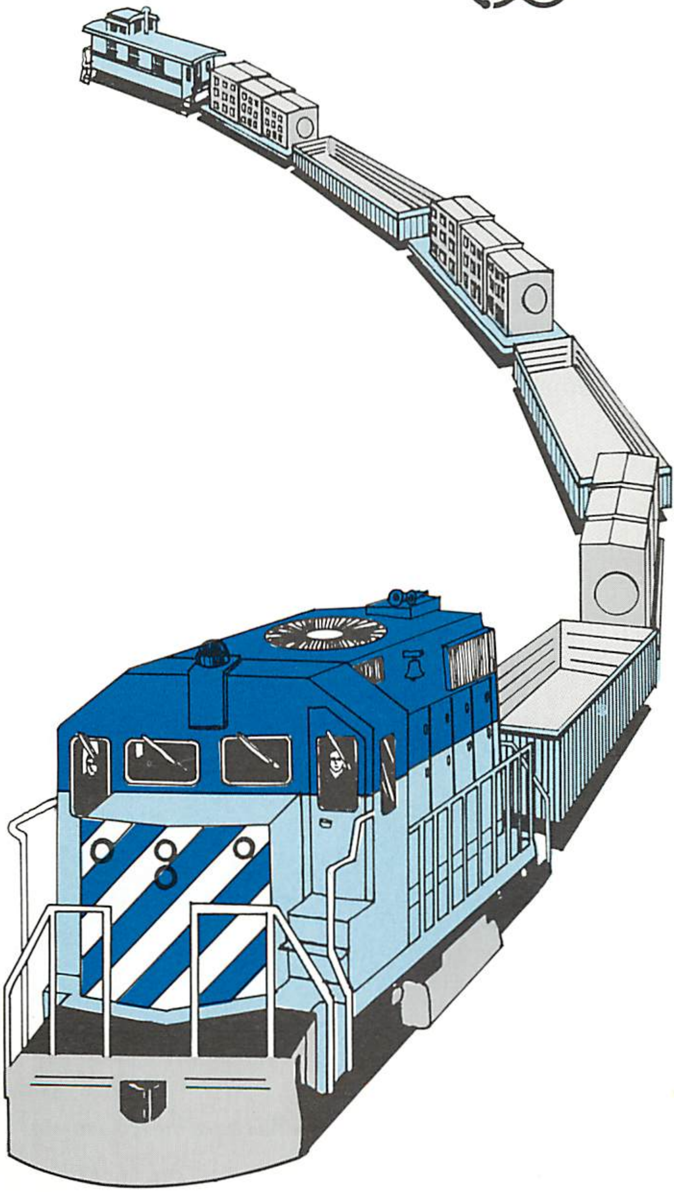
Shipping Nuclear Fuel:

Safety In Motion



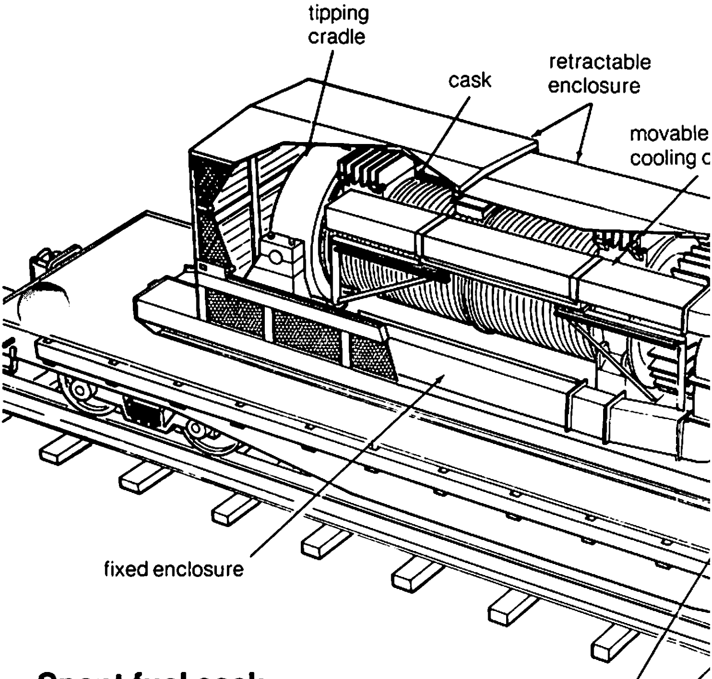
A safety record second to none

Carrying a 25-ton shipping cask filled with highly radioactive spent nuclear fuel, the tractor-trailer rounded a curve on busy U.S. Highway 25 near Oak Ridge, Tennessee.

Suddenly, the driver swerved the rig to avoid a head-on collision. The truck went out of control and overturned.

The trailer, with the heavy spent fuel cask still attached, broke away from the tractor and skidded for more than 100 feet before landing in a rain-filled ditch. The cask suffered minor damage but released no radioactive material. In fact, it completed its mission on another tractor-trailer and returned to routine service following repairs and inspection.

This event, in December 1971, was the most severe of only three traffic accidents involving the shipment of spent nuclear fuel in the United States over the past 25 years. It illustrates that the casks used in moving spent fuel are rigorously designed to prevent the release of their radioactive contents in the case of severe traffic accidents.



Spent fuel cask mounted for rail shipment

Due to these and other safety features, more than 5,000 spent nuclear fuel assemblies have been shipped without a single injury due to a release of radioactivity.

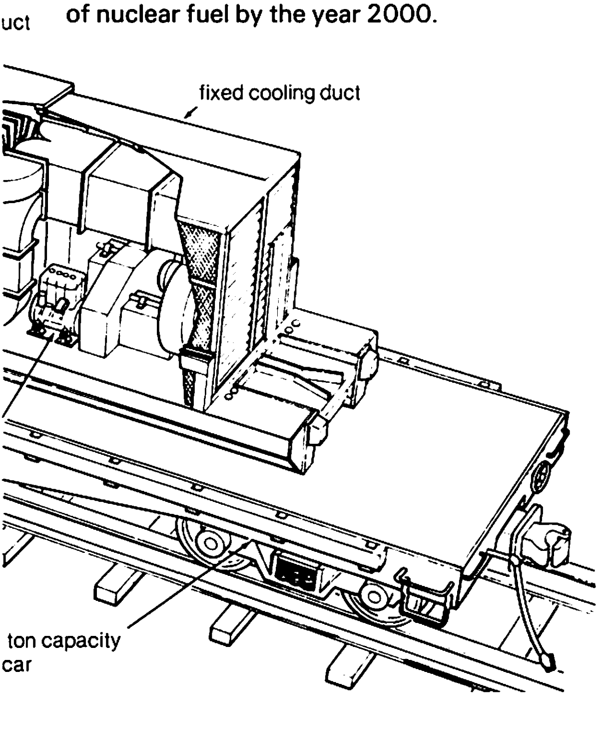
By comparison, shipping other energy resources has not fared nearly as well: dozens of people are killed annually transporting natural gas; some 55 lives are lost each year from trucking gasoline and hundreds die from rail shipments of coal.

While shipments of spent fuel have been relatively few in the past, they are expected to multiply in the future, demanding continued rigor in container design and persistent vigilance in operating procedures.

Most fuel stored on-site

Over the past three decades, however, most spent fuel removed from nuclear reactors has been housed in large, water-filled bays — called spent fuel pools — at the power plant site.

Moving spent nuclear fuel, therefore, has been primarily from one reactor storage pool to another as older ones fill up. Without space to unload their spent fuel, these reactors would be forced to shut down, resulting in potentially more expensive electricity for utility customers. As many as 50 commercial nuclear power plants may be unable to discharge a full core of nuclear fuel by the year 2000.



Storage solution

A solution to this storage problem, however, is being implemented. The Nuclear Waste Policy Act of 1982 requires the U.S. Department of Energy to operate geologic repositories for underground disposal of spent nuclear fuel, beginning in 1998. Meanwhile, the government is also required to provide limited storage — up to 1,900 metric tons — for utilities that cannot find space elsewhere.

Once the burial sites open — or should interim storage become necessary — spent fuel shipments will increase dramatically. An estimated 12,000 metric tons of spent fuel are currently awaiting transfer to government repositories, and this amount will grow to more than 50,000 metric tons by 1998. The first federal repository should begin receiving about 3,000 metric tons of spent nuclear fuel annually after the turn of the century.

Most of this spent nuclear fuel will move by rail, which is more economical and efficient since more assemblies can be transported in larger and heavier containers. About half of the nuclear plants now operating in the U.S., however, are not connected to rail spurs. These utilities, then, will have to rely on short truck shipments to the nearest rail head.

The reactor core

The core of a nuclear reactor consists of several hundred, 14-foot long vertical fuel assemblies, each containing sealed, metal rods packed with uranium dioxide pellets. These fuel rods are typically assembled in square bundles from five to eight inches on a side and weighing from one-quarter to three-quarters of a ton. During reactor operation, Uranium-235 in the pellets fissions to produce heat for the steam generation of electricity.

The fresh fuel assemblies begin losing some of their power generating efficiency immediately after fission begins. After some three years of service, therefore, they are withdrawn from the reactor core.

Once removed from the reactor, the fuel rods and pellets provide the *first line* of protection against release of radioactive materials. Even under the high temperature and severe pressure found during reactor operation, the dense pellets inside the metal rods retain essentially all waste products generated during fission. Although the ceramic-like pellets sustain the fission reaction while inside the nuclear reactor core, this process cannot be duplicated inside the shipping cask.

Further, under no circumstances can the spent fuel explode. However, it is highly radioactive and, accordingly, generates heat that must be dissipated. For this reason, it is handled and shipped in a uniquely cautious manner, unlike other hazardous materials — such as chlorine or gasoline — the containers for which are designed simply to carry the substance.

The *second line* of safety comes when the spent fuel assemblies are placed in storage pools at the plant site — under 40 feet of water and behind six-foot concrete walls. There, after about six months, 95 per cent of their heat and radioactivity has faded away.

A typical 1,000,000-kilowatt nuclear plant produces enough electricity annually for a community of more than a half-million people and discharges 30 tons of fuel. This 30 tons translates into between 60 to 140 spent fuel assemblies per unit, depending on the type of reactor, or a total of about 6,000 fuel assemblies discharged from the 85 reactors operating in 1984. Once routine shipments to the federal repository begin, about 25 truckloads or 10 railcar shipments for each plant will be needed to carry away the spent fuel rods.

By comparison, a 1,000,000-kilowatt coal-fired generating station consumes 2.5 million tons of coal annually, producing nearly 200,000 tons of coal ash and about 250,000 tons of pollution control sludge per year.

Unique cask design survives torture tests

The heavy, rugged, government-approved casks used to transport spent nuclear fuel are the most carefully designed, fabricated and tested in the history of all commercial shipping containers. They feature in-depth protection, from the sealed metal fuel rods that make up the fuel assemblies to the multiple layers of steel, lead and other dense metals that form the cask.

Under federal regulations, these casks must be designed to withstand a series of severe torture tests: a 30-foot drop onto a flat, unyielding surface, followed by a 40-inch drop onto a vertical steel rod, followed by exposure to a 1,475°F all-engulfing fire for 30 minutes, followed by submersion under 3 feet of water for 8 hours.

Going beyond these requirements, however, the federal government in the late 1970s sponsored full-scale tests, open to the public, on nuclear fuel shipping casks at Sandia National Laboratories in Albuquerque, N.M.

First, a tractor-trailer carrying a cask and traveling at 84 miles per hour was crashed into a 690-ton concrete wall backed by 1,760 tons of dirt. Another cask-bearing tractor-trailer was parked across a railroad track and broadsided by a 120-ton locomotive traveling at 80 miles per hour.

Next, a smaller cask was dropped 2,000 feet from a helicopter onto a hard desert floor, landing at 235 miles per hour. Then a cask was submitted to a burning inferno of jet fuel for an hour and a half at temperatures exceeding 2,000°F. Finally, a cask was immersed in water.

In each case, the casks retained their shielding and containment integrity, confirming the results of previous computer analysis and 1/8th scale model tests. The casks in the full-scale tests were older models that had been removed from service. Casks used today in transporting spent nuclear fuel assemblies are built even better.

Some shipments of spent nuclear fuel have moved and will continue to move by tractor-trailer.

Sabotage, too

But scientists have gone even further and tested the casks for deliberate sabotage in a would-be urban setting.

The mock scene in this most severe of "what if" settings: a busy, downtown street in New York City in midafternoon with no time allowed for evacuation. To simulate the test, scientists attacked a full-scale cask with high explosives in a large cylindrical chamber equipped with monitors to gauge dispersals of radioactive material.

The study found that although it is possible for certain high energy devices to penetrate a large spent fuel cask when directly assaulted, such an attack in a heavily populated urban setting would not result in any immediate deaths and — at worst — could result in one latent cancer fatality, occurring many years later.

The specially-designed shipping casks, then, become the *next line* of safety against radiation exposure when the spent fuel is removed from the storage pools and moved again for permanent storage. The repositories will form the *final line* of protection, closing the circle in the nuclear fuel cycle as the spent uranium is returned to the ground.

Putting it in perspective

A final comparison, by the numbers, places shipment of spent nuclear fuel in perspective:

Of the 500 billion packages of all kinds shipped in interstate commerce each year, about 100 million contain hazardous materials — those that are flammable, explosive, corrosive, poisonous or radioactive. But out of that 100 million shipments, only two per cent is classified as radioactive and less than one per cent involves the nuclear fuel cycle — bringing in fresh fuel or taking away spent fuel. The rest include low-level radioactive materials used in medicine, agriculture and research.

The nuclear power industry's safety record in transporting spent nuclear fuel has been excellent. Continued concern and care will ensure that the record endures.

Most people would agree that the low level of risk involved in the transportation of spent nuclear fuel is far outweighed by the significant benefit nuclear power returns in the form of economic, safe and environmentally sound electricity.

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