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PLACING THE SPECIAL TRAINS ISSUE IN PERSPECTIVE

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May 1978

Prepared for the
U.S. Department of Energy
under Contract EY-76-C-06-1830

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BACKGROUND

Spent fuel from nuclear reactors has been transported in routine commerce in the U.S. for over 25 years. During this period, no accident has occurred that resulted in the release of radioactive material from a spent fuel cask. It is estimated that about 535 rail shipments of spent fuel totaling 800,000 km (500,000 mi) could be made annually by the mid 1980's. This represents an increase of about a factor of 15 over 1976 levels. Because of these increases, the railroad industry contends that the transportation environment for spent fuel shipments must be controlled more stringently to maintain this excellent safety record. To provide this control over the transportation environment, the Association of American Railroads (AAR) has recommended to member railroads that all spent fuel be handled in special train service. A proposed set of operating practices includes the following restrictions for special trains carrying radioactive materials:

- Speed - Special trains would not move faster than 35 mph.
- Passing - When a special train meets, passes, or is passed by another train, one train would stand while the other moves past at a speed of less than 35 mph.
- No-Other-Freight - Special trains can carry no nonradioactive freight.

On February 18, 1976, the railroads published new rules in their tariffs implementing these requirements. The former Energy Research and Development Administration (now the Department of Energy) and the nuclear industry filed protests with the Interstate Commerce Commission (ICC) seeking cancellation of these new safety oriented rules. In March 1976, the ICC instituted an investigation into the tariff filing. The burden of proof under the Interstate Commerce Act rests with the railroads to show that the tariff changes are just and reasonable.

Testimony was presented to the ICC by the Government/nuclear industry protestants and the railroads. Three separate week-long hearings were held for the purpose of cross-examining shipper and railroad witnesses. The last hearing took place in November 1976. Legal briefs were filed shortly thereafter, and in August 1977 the ICC Administrative Law Judge issued his initial decision in the processing.

In trying to prove their case, the railroads claimed that shippers' studies of cask strength and integrity did not take the very severe railroad accident conditions which the casks might encounter adequately into account. They questioned the adequacy of the cask design criteria in the Department of Transportation (DOT) and Nuclear Regulatory Commission (NRC) regulations, and contended that the cask testing environment was not representative of the real transportation world. Moreover, they argued that any increase in costs due to the use of

special train service, would be offset by lower cask use charges (about \$3000/day) as a result of expedited handling and shorter transit times enroute.

For these reasons, and in light of their concerns about adverse publicity and severe economic liability, the railroads argued that the AAR's recommended operating restrictions would reduce their risk in transporting spent fuel and radioactive waste.

The former ERDA/industry position was that shippers would be forced to accept an extremely costly service which was not warranted, was not necessary for safety, and which resulted in unnecessary and wasteful transportation. They claimed that use of special train service would result in large increases in shipping costs relative to normal freight service. The government presented evidence to show that the cost of shipping low-level waste could be as much as 1,600% higher if special train service were required.

The ERDA and the nuclear industry contended that the cask/container systems currently in use and being designed were the best and strongest containers used to transport any hazardous material; that they were designed to maintain their containment integrity even if they were involved in rail accidents. It was argued that the railroads had not shown that there was any significant degree of additional safety in the use of special train service. In fact, it was felt that there may be less safety in some cases, for example, in the case of a head-on collision there would be less cars in a special train to absorb some of the accident impacts.

The ICC's staff investigated the potential environmental impacts of mandatory use of special train service for spent fuel and radioactive waste. They concluded that, approval of the special train tariff would result in 1,160 additional train movements annually. Other conclusions were that the nonradiological impacts of this action would include: (1) the additional consumption of 873,000 gallons of fuel; (2) additional emission of 85 tons of carbon monoxide, 61 tons of hydrocarbons, and 169 tons of nitrogen oxides; and (3) an additional 17 accidents and 1.6 fatalities each year. The ICC went on to say that,

"With respect to radiological impacts, special train service will, under normal transport conditions, cause an additional 0.81×10^{-3} latent cancer fatalities (LCF) annually (on the average one additional fatality every 1,235 years). Special train service will decrease accident fatalities by 4.4×10^{-4} LCF (on the average one death every 2,272 years). Special trains will increase the environmental risk from the nonradiological standpoint and from the radiological standpoint under normal transport conditions. However, special trains will decrease the environmental risk from the radiological standpoint under accident conditions. In all cases, however, the incremental environmental impact of special trains as opposed to regular trains is very small." (1)

In his initial decision, the Administrative Law Judge stated that he found that the tariffs should be canceled because the railroads had not satisfied their burden of proof, as required by the Interstate Commerce Act, to show that the tariff changes were just and reasonable. He stated also that,

"The record will support a finding that special trains for the carriage of spent fuel is unnecessary and wasteful transportation, and, therefore an uneconomic burden on shippers and the energy using public."

Understandably, the railroads did not agree with the Judge's findings. They felt that the Law Judge erred in finding that the tariff changes were unjust and unreasonable, and have appealed to the Commission to consider and reverse the Judge's findings. These appeals are largely safety oriented and restatements of their initial position. The former ERDA and other interested shippers have replied to these railroad appeals, contending that the railroads have failed to demonstrate any error in the Judge's decision.

The matter is now in the hands of the Commission and the ICC decision is expected soon. The positions of both the shippers and the railroads are polarized, and follow-on appeals in the courts can probably be expected.

SAFETY AND ECONOMICS OF SPECIAL TRAIN SHIPMENTS OF SPENT FUEL

Pacific Northwest Laboratory (PNL) has undertaken a study sponsored by the DOE to evaluate the potential effects of the special train operating restrictions on the safety and cost of shipping spent fuel by train.⁽²⁾ Since data were not available to compare the safety of special trains and conventional freight trains directly, the potential effects of the operating restrictions were examined using data from the Federal Railroad Administration for freight train accidents that occurred from 1972-1974. Based on this data, evaluations were made on the relative safety of special trains and conventional trains using accident frequency and severity as comparative measures.

Dollar damage to railroad equipment during an accident was selected as the best available measure of accident severity. Increased cask and equipment damage (expressed in terms of dollar damage) does not necessarily represent decreased safety to the general public. Threshold levels of accident stresses (e.g., impact and puncture forces and fire temperature and duration) are required to compromise the integrity of spent fuel casks before any of the contained radioactive materials could be released. Analytical studies, scale model tests and full scale tests of spent fuel casks will survive severe accident conditions.⁽³⁾ Analyses of accident severity using dollar damage as a basis can provide some insights into the potential safety benefits of the proposed special train requirements. However, the absolute significance of the results should be interpreted with caution because there is no direct correlation between dollar damage and cask integrity.

The potential effect of the speed restriction was investigated by analyzing data on the frequencies of train accidents as a function of train speed and accident severity. Data for all train accidents and for head-on, rear-end and side or raking collision accidents only were analyzed. It was found that about 80% of all freight train accidents occur at speeds less than 35 mph. It was also estimated that the accident rate (accidents/mile traveled) for travel at speeds below 35 mph was more than double the accident rate for travel at speeds above 35 mph. This suggests that accident-producing factors are greatest in those portions of the railroad system that have speed limits below 35 mph. Thus, it appears that speed restrictions may not significantly affect the safety of the current shipping system.

Three levels of dollar damage were investigated to determine the effect of the speed restriction on the frequency of involvement in severe accidents. The three levels of dollar damage used - \$75,000, \$150,000 and \$250,000 - represent, respectively, 7%, 3% and 1% of all freight train accidents. It was determined that about 58% of accidents resulting in \$75,000 or more damage; about 70% of all accidents resulting in \$150,000 damage or more; and 77% of all accidents resulting in \$250,000 damage or more, occur at speeds above 35 mph. This indicates that accidents at speeds above 35 mph are more likely to result in high dollar damage than accidents at lower speeds. The 35 mph speed restriction does, therefore, appear to have some potential for reducing the frequency of involvement of a spent fuel cask in high dollar damage accidents. Much of the apparent benefit of the speed restriction in reducing the frequency of severe accidents may lie in the fact that, on the average, more cars are involved per accident in accidents at higher speeds. It was found that the average dollar damage per car is not strongly dependent on the speed at which the accident occurs. This may be partly explained by the fact that only the first few cars involved in an accident experience the impact forces. After initial contact, the relative speed of other cars involved in the accident is reduced.

Data for head-on, rear-end and side-or-raking collision accidents also show that the speed restriction has only a limited potential for improving the safety of spent fuel transportation. It was found that 20% of collision accidents resulting in \$75,000 damage or more, 18% of collision accidents resulting in \$150,000 damage or more and 23% of collision accidents resulting in \$250,000 damage or more occur at speeds greater than 35 mph. Based on this data, imposition of the 35 mph speed restriction could have the potential to eliminate a maximum of about 20% of the most severe head-on, rear-on, and side-or-raking collision accidents.

The effect of the passing restriction was investigated by analyzing data for side or raking accidents. This restriction may be redundant, since on many rail lines, one train is stopped or moving at low speeds on a siding when a passing situation occurs. The restriction appears to have a potential for improving safety primarily on railroad lines with double main tracks.

These lines presently comprise about 11% of the total length of roadway for Class I line haul railroads. It was found that currently about 71% of side or raking accidents occur with one train standing. The passing restriction, therefore, appears to have a small effect on the safety of spent fuel transportation.

The effect of the no-other-freight restriction was investigated by examining the expected frequency of exposure of a spent fuel cask to fires lasting longer than 30 minutes. This fire duration was selected because as part of the licensing process spent fuel casks must be shown to be capable of maintaining their containment integrity after exposure to a 1475°F fire for 30 minutes. Although exposure to fires of longer duration does not necessarily imply a release of radioactive materials, the licensing standard does provide a basis for comparing the fire hazard in regular train service with special train service. It was estimated that for 1986 shipping levels, a spent fuel cask carried in regular train service might be exposed to a fire lasting longer than 30 minutes once in 1300 years. For casks carried in special train service many of the potential fire sources present in a regular train are eliminated. The casks may still be exposed to locomotive fires and other fires, however. It was estimated that for 1986 shipping levels, a spent fuel cask carried in special trains might be exposed to a fire lasting longer than 30 minutes once in 1600 years. The no-other-freight restriction appears to have only a small effect on the safety of shipping spent fuel by rail.

The results of the safety comparison of the shipment of spent fuel in special trains and in regular train service are summarized in Table 1. The table compares the estimated frequency of involvement of a spent fuel cask in accidents of various types and severities for shipments in special trains and in regular train service. A spent fuel transportation system shipping about 535 rail shipments a total of 800,000 km (500,000 mi) per year in 1986 was used to prepare the table. The basic accident data used in the analysis are summarized in another paper being presented at this conference.(4)

The economics analysis examined the differences in costs between conventional freight and special train shipments of spent fuel. Average shipper costs were calculated for a set of reference shipping parameters. Average shipping costs for conventional freight train service were estimated to be \$15.50 per kg U (kg of uranium in the fuel) and \$23.50 per kg U if special trains were used. A sensitivity analysis was performed to determine the relative importance of the reference shipping parameters and to evaluate the effects of changes in the basic cost assumptions. It was found that the assumption regarding cask use charges, cask turn-around

TABLE 1. Summary of Comparison of Safety of Spent Fuel Shipments in Regular Trains and Special Train Service

Operating Restrictions	Accident Type	Severity Level	Accident Involvement Interval (Average Years Between Events for 1986 Shipping Levels)	
			Regular Trains	Special Trains
Speed <35 mph	All Types	Damage >\$ 75,000	20	40
		Damage >\$150,000	40	120
		Damage >\$250,000	85	320
Speed <35 mph	Collisions	Damage >\$ 75,000	360	400
		Damage >\$150,000	470	500
		Damage >\$250,000	2000	2100
Passing	Side or Raking	Damage >\$ 75,000	870	1100
		Damage >\$150,000	3000	3800
		Damage >\$250,000	6000	7700
No-Other-Freight	Fire	Duration >30 min	1300	1600

time, average train speed and special train cost charges were the most sensitive in the analysis. Analysis of possible variations in these parameters showed that the cost of shipping spent fuel in special train service could range from 20% lower to 200% higher than the cost of shipping the fuel in regular train service. It was also found that for the reference shipping parameters, the cost of shipping spent fuel in special train service is minimized if three spent fuel casks are shipped in each special train.

The results of the study indicate that transportation of spent fuel in special trains under the operating restrictions proposed by the AAR has the potential to substantially increase the costs of spent fuel transportation. Although special trains could offer economic or logistic advantages for some shippers, analysis of available data does not indicate any substantial advantage of the special train operating practices from a safety standpoint. Although the estimated accident frequencies summarized in Table 1 indicate a small decrease in the frequency of involvement of spent fuel casks in accidents if special trains are used, the accident frequencies for regular train service are already quite low and the small improvement indicated for special train service does not appear to justify the potential increase in shipping costs.

POSSIBLE ALTERNATIVES TO THE CURRENT SITUATION

The special train issue has placed the railroads and shippers of radioactive materials in an adversary relationship. Since movement of radioactive materials by rail is necessary for the efficient functioning of the nuclear fuel cycle, it is imperative that possible methods to resolve the special train issue be explored. It does not seem likely that continuation of the current posture of legal and quasi-legal confrontations between the railroads and shippers will produce the efficient transportation system that the nuclear industry and federal government require. A variety of actions could be taken by the government, the nuclear industry and the railroads to improve the current situation. Several of these actions are discussed in the remainder of this paper.

The railroads have raised many questions about the safety of radioactive material shipments by train. To nuclear industry people experienced in the design, testing and operation of radioactive material shipping packages, it is clear that the packages being used provide a significant margin of safety. Although the safety issues raised by the railroads appear to represent an honest concern for protecting their equipment and employees, some of their questions reflect a lack of understanding of the basic safety concepts involved in cask design and licensing. More participation by the railroads in planning and performing safety studies conducted by DOE and other governmental organizations should clear up some of these misunderstandings and give DOE and the nuclear industry a clearer picture of the specific problems involved in rail transport.

Before significant improvements can be made in the relationship between the railroads and the shippers, it is necessary to open channels of communication to develop a mutual awareness of the issues of primary concern to each group. A forum for discussions between the railroads and shippers could be established by the Department of Energy (DOE) and industry trade groups. The concerns of each side must be understood by the other before meaningful solutions to the controversy can be developed. There are also misconceptions on both sides of the issues that could be identified and dealt with in such a forum. The need, desirability and scope of a cooperative DOE/nuclear industry/railroad research and study program could be explored.

Individual shippers or groups of shippers should be encouraged to examine the economic and logistic parameters associated with their shipments of radioactive material by rail. This analysis should include consultations with railroad personnel and the receivers of the shipments. These studies would identify the type of railroad service that would provide the best utilization of nuclear industry and railroad equipment, minimize the cost of transportation services and optimize other logistic considerations of the shipper and receiver.

Utilities, owners of fuel cycle facilities and architect-engineers should involve railroad operations specialists during the siting and design phases of a new nuclear facility. Advanced logistics planning that includes participation by the railroads can improve the facility operation and promote cooperation between shipper and carrier, thereby improving the quality of service.

Mutual benefits may result from shippers and railroads working together to innovate a range of service options and appropriate rate structures for the shipment of different types of nuclear material. Such a variable service and rate structure may require some changes in the present tariff structure, but it could provide the shipper with additional flexibility to optimize system logistics and furnish the railroads with opportunity to employ operational procedures and practices which could alleviate some of their perceived concerns about the safety of nuclear shipments.

For example, the shipper's service needs for spent fuel are quite different from his needs for low level waste shipments. For spent fuel the shipper needs rail service that provides minimum delays in pickup, transit and delivery of the shipment to minimize his total shipping costs. Some form of expedited service at appropriate rates could meet these service needs. The extra attention that the shipment would be afforded by the railroads to provide this expedited service could provide the railroads with the extra control they desire over the shipment during transit. For shipments of low level waste, the most economically and logistically advantageous option for the shippers may be regular freight movement.

In summary, we believe that regardless of the final outcome of the current legal battles, the commonly desired goal of safe and effective rail transportation services for radioactive materials will not be achieved unless more positive approaches to the problem are also pursued. There appears to be a middle ground between the currently polarized views of the railroads and the nuclear industry that could provide a mutually satisfactory solution to this issue.

REFERENCES

1. Final Environmental Impact Statement - Transportation of Radioactive Materials by Rail. Office of Proceedings, Section of Energy and Environment, U.S. Interstate Commerce Commission, Washington DC, August 23, 1977.
2. W. V. Loscutoff et al., A Safety and Economic Study of Special Trains for Shipment of Spent Fuel. BNWL-2263, Battelle, Pacific Northwest Laboratories, Richland, WA, December 1977.
3. H. R. Yoshimura and M. Huerta, Full Scale Tests of Spent-Nuclear Fuel Shipping Systems. SAND-76-5707, Sandia Laboratories, Albuquerque, NM, July 1976.
4. E. S. Murphy, "Analysis of Freight Train Accident Statistics for 1972-1974." Presented at Fifth International Symposium on Packaging and Transportation of Radioactive Materials, Las Vegas, NV, May 7-12, 1978.