YMP/91-17

U.S. DEPARTMENT OF ENERGY

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NEVADA COMMERCIAL SPENT NUCLEAR FUEL TRANSPORTATION EXPERIENCE

Exhibit 6

SEPTEMBER 1991

UNITED STATES DEPARTMENT OF ENERGY

NEVADA COMMERCIAL SPENT NUCLEAR FUEL TRANSPORTATION EXPERIENCE

Prepared By: Technical and Management Support Services Contractor
Yucca Mountain Site Characterization Project
Contract No. DE-AC08-87NV10576

Prepared for: Yucca Mountain Project Office
Office of Civilian Radioactive Waste Management
U.S. Department of Energy
Las Vegas, Nevada

SEPTEMBER 1991

ACKNOWLEDGEMENT

This document was prepared by:

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David Joy, Oak Ridge National Laboratory
Paige Hibbits, SAIC
Charles Maddigan, SAIC
Steve Schmid, SAIC,
Marie Farnstrom, SAIC
Jeff Tappen, Westinghouse
Bill Andrews, SAIC
Paul Standish, Westinghouse

This report was prepared under Contract No. DE-AC08-87NV10576.

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LIST OF ACRONYMS

AAR	Association of American Railroads
BWR	Boiling water reactor
DOE	Department of Energy
EMAD	Engine Maintenance and Disassembly
FRA	Federal Railroad Administration
GE	General Electric
HM	Hazardous materials
HMIS	Hazardous Materials Incident System
ICC	Interstate Commerce Commission
LLNL	Lawrence Livermore National Laboratory
MRS	Monitored retrievable storage
MSF	Morris Storage Facility
MTU	Metric tons of uranium
NFS	Nuclear Fuel Services
NRC	Nuclear Regulatory Commission
NTS	Nevada Test Site
NWPA	Nuclear Waste Policy Act
OCRWM	Office of Civilian Radioactive Waste Management
PWR	Pressurized water reactor
RAMRT	Radioactive Material Routing Report
RMIR	Radioactive Materials Incident Report
SNF	Spent nuclear fuel
SRP	Savannah River Plant
TMI	Three Mile Island
TOPO	Transportation Operations Project Office
DOT	U.S. Department of Transportation
VNC	Vallecitos Nuclear Center

1. EXECUTIVE SUMMARY

The purpose of this report is to present an historic overview of commercial reactor spent nuclear fuel (SNF) shipments that have occurred in the state of Nevada, and to review the accident and incident experience for this type of shipments. Results show that between 1964 and 1990, 309 truck shipments covering approximately 40,000 miles moved through Nevada; this level of activity places Nevada tenth among the states in the number of truck shipments of SNF. For the same period, 15 rail shipments moving through the State covered approximately 6,500 miles, making Nevada 20th among the states in terms of number of rail shipments. None of these shipments had an accident or an incident associated with them.

Because the data for Nevada are so limited, national data on SNF transportation and the safety of truck and rail transportation in general were also assessed. Approximately 2,600 domestic commercial loaded spent fuel shipments have taken place during the past 26 years. Since 1971, the first year of accurate safety records on SNF, 17 incidents have occurred with loaded commercial shipments, but in no case has there been injury, death, or environmental damage as a result of the radioactive nature of the cargo. This record is attributed to the extensive operational controls and cask designs for SNF shipments. During the same period, two transportation accidents occurred with loaded commercial SNF shipments. In only one of these accidents was personal injury involved, and that was not a result of radiation being release. No radioactive material was released in either accident.

Data on the safety history of truck and rail transportation in general are considered to be more reliable because they are more extensive. These data show that truck accident rates fall in the range of 0.7 to 3.0 accidents per million miles traveled and that the rail accident rate is about 11.9 accidents per million miles traveled. The computed accident rates for commercial SNF transportation at the national level match these general rates well (0.7 for truck and 9.68 for rail). For future safety assessments in Nevada, the general rates are recommended for use rather than the SNF rates. This is a conservative approach given the history of SNF accident experience as well as the stringent regulations and considerations surrounding SNF shipments.

2. INTRODUCTION

2.1 Study Purpose and Scope

The purpose of this study is to present an historic overview of commercial reactor fuel shipments that have occurred in the state of Nevada, and to review the accident and incident experience for this type of shipment. Information on SNF shipment characteristics and corresponding accident/incident experience can be useful in planning future shipments and in performing route-specific analyses of the potential risks associated with the transportation of SNF.

This study focuses on commercial reactor shipments because the vast majority of SNF that would be shipped to a potential repository would be generated by utilities and shipped under Nuclear Waste Policy Act (NWPA) provisions. Further, this study focuses on loaded shipments; empty caskload shipments are not discussed in detail because of a lack of data.

Several data sources were examined to generate an accurate summary of Nevada's spent fuel shipping experience. Data specific to Nevada are supplemented with national data where appropriate. The following sections provide background information on SNF shipments and review accident and incident reporting considerations associated with their transport.

2.2 Spent Nuclear Fuel Shipment Characteristics

SNF shipments differ by the type of fuel, the amount of fuel transported, the type of cask used, and the mode of transport. SNF can be generated from either commercial reactors used by utilities to produce electric power or research reactors.

Casks are specially designed and manufactured to move SNF by either train or truck. Truck shipments may be either legal weight (total vehicle weight of 80,000 pounds or less) or overweight (total vehicle weight greater than 80,000 pounds), with different casks utilized according to the payload. Larger casks are used for rail shipments, which carry larger quantities of SNF and utilize heavy-duty flat cars.

Because of the nature of the cargo, SNF shipments are subject to a high degree of scrutiny. SNF shipments must comply with a host of regulations and requirements for

specifying requirements and standards for package labels, vehicle placards, and shipping papers. The Nuclear Regulatory Commission (NRC) certifies cask designs, approves transport routes, and stipulates security measures for SNF in transit. The Department of Energy (DOE), which will be the shipper for SNF shipments to a repository or monitored retrievable storage (MRS) facility, will be subject to DOT and NRC regulations.

2.3 Accident/Incident Definitions

For the purposes of this study a transportation accident is defined as a vehicular or train event resulting in property damage, damage to one or more vehicles, personal injury, or death. Other events and occurrences are reported as incidents in the Hazardous Materials Incident System or Radioactive Materials Incident Report data bases. These incidents generally consist of shipments that experienced reportable levels of surface contamination or an operational abnormality related to the container or the transport vehicle. Examples include weeping problems with casks, improper placarding of vehicles, and operational breakdown of the transport vehicle.

The majority of SNF incidents involve reportable levels of cask surface contamination. Between the time when the cask surface is surveyed for off-site shipment and found to have very low levels of contamination (below regulatory limits) and the time when the cask is surveyed again, often at the shipment destination, the removable surface contamination level increases due to a phenomenon called "weeping." Weeping is associated with radioactive contamination gradually being drawn from the pores of the cask once the cask is removed from a storage pool and dried.

It should be emphasized that the levels of contamination that have been found do not pose a hazard or threat to the general population, and in only very few instances has the contamination spread from the surface of the cask to another area. In no documented case has the contamination been detected outside the confines of the transport vehicle. A few instances of cask operational deficiencies, such as failure to close a drain valve, may have contributed to cask surface contamination. Although these cases are not well documented, covers over the cask valves significantly reduce the likelihood of extensive cask surface contamination.

2.4 Data Sources

Three types of data were used for preparation of this study: (1) historical shipment records, (2) routing and mileage data, and (3) accident and incident data.

Historical Shipment Records -- The primary source of data on historical shipment activity is a 1990 report prepared by DOE's Office of Civilian Radioactive Waste Management's (OCRWM) Transportation Operations Project Office (TOPO) entitled, ***Historical Overview of Domestic Spent Fuel Shipments - Update*** [1]. This report relied on several sources including DOT's Radioactive Material Routing Report (RAMRT) for data on truck shipments; cask suppliers for the information on rail shipments; summary reports prepared by the Nuclear Assurance Corporation [2,3], the Office of Technology Assessment [4], and the NRC [5]; and personal interviews conducted with commercial cask suppliers and utilities. The shipment dates covered by these data range from 1964 to 1990.

Routing and Mileage Data -- Two transportation routing models maintained by DOE were used to supply the most likely route that would be used for high level waste shipments identified in the ***Historical Overview of Domestic Spent Fuel Shipments - Update***. The HIGHWAY model [6] was used for highway distances and the INTERLINE model [7] was used for rail distances. HIGHWAY routes are calculated by minimizing the total distance and driving time between origin and destination points. Routing constraints and hazardous materials (HM-164) guidelines were considered to reflect routes that would most likely have been granted NRC approval. For validation purposes, the routing information contained in HIGHWAY and RAMRT was compared for a sampling of shipments. No major differences in shipment routes were identified.

Accident and Incident Data -- The Radioactive Materials Incident Report (RMIR) was the major source of the incident and accident information described in this report. RMIR is a compilation of transportation events that have occurred during the shipment of radioactive materials; it was developed for DOE in 1971 to support research and development efforts [8]. Data were also obtained from DOT's Hazardous Materials Incident System (HMIS) and reviews of periodicals. The years covered by these data sources range from 1971 to 1990.

3. HISTORICAL SPENT NUCLEAR FUEL CAMPAIGNS INVOLVING NEVADA

3.1 Spent Nuclear Fuel Shipments in Nevada

For the entire U.S. from 1964 through August of 1990, a total of 2,581 shipments of 2,667 cask loads of commercial reactor SNF were transported. (Some rail shipments involved more than one cask.) Although several shipments involved a one-time movement between an origin and destination pair, 52 truck campaigns and 11 train campaigns accounted for most of the total. All shipments were reviewed to determine which shipments originated in, were destined for, or traversed the state of Nevada.

Shipments that moved through Nevada were identified using the INTERLINE and HIGHWAY models, the RAMRT data base, and by interviewing experts in the field of transport of SNF. Table 3.1 identifies shipments and campaigns that involved SNF transported through Nevada.

In 1976, Peach Bottom, a General Electric(GE)-boiling water reactor (BWR) located near Delta, PA, shipped four fuel rods to the GE research "hot cell" at the Vallecitos Nuclear Center (VNC) near Pleasanton, CA. The fuel rods were examined for cladding defects, corrosion, etc.

Four Turkey Point assemblies were moved from Battelle Memorial Institute, West Jefferson, OH to the Engine Maintenance and Disassembly (EMAD) facility in Nevada to support dry spent fuel storage studies. In addition, 13 Turkey Point assemblies were received by EMAD from the Turkey Point reactor in Dade County, FL, which is operated by Florida Power and Light.

In 1986, six shipments moved from EMAD to Idaho National Engineering Laboratory (INEL). These shipments consisted of the four Turkey Point assemblies received from Battelle West Jefferson and 13 Turkey Point assemblies received from Turkey Point.

San Onofre is a pressurized water reactor (PWR) owned by Southern California Edison Co. and located in San Clemente, CA. This facility shipped 270 assemblies, one per shipment, to GE's Morris Operation in Morris, IL. These assemblies were to be reprocessed to recover the uranium, but the Morris plant never started reprocessing activities, and the 270 assemblies remain in underwater pool storage at Morris.

Table 3.1 Spent Nuclear Fuel Shipment Experience in Nevada

Origin	Destination	Shipments	MTUs[1]	Assemblies	Year
Truck					
Peach Bottom	GE Vallecitos	1	0.02	0.102[2]	1976
Battelle	EMAD	4	1.80	4	1978-79
EMAD	INEL	6	8.08	17	1986
San Onofre	MSF	270	99.09	270	1972-80
Turkey Point	EMAD	13	5.84	13	1979
Dresden	GE Vallecitos	1	0.11	1	1964
Rocketdyne	INEL	14	34.05	224	1987-89
Subtotal		309	148.99	529	
Rail					
Humboldt Bay	NFS	15	20.52	270	1969
Total		324	169.51	799	

[1]Metric tons of uranium
[2]Partial fuel assembly consisting of a few fuel rods.

Source:
U.S. Department of Energy, Office of Civilian Radioactive Waste Management, 1990. **Historical Overview of Domestic Spent Fuel Shipments - Update**, ORNL/M-1083, ORO/TOP-5405.0.

U.S. Department of Energy, Office of Defense Waste and Byproducts Management, 1983. **Highway, A Transportation Routing Model: Program Description and Revised Users' Manual**, ORNL/TM-8759.

U.S. Department of Energy, Transportation Technology Center, 1985. **Interline, A Railroad Routing Model: Program Description and User's Manual**, ORNL/TM-8944.

Dresden, in Morris, IL, the first privately funded nuclear plant, shipped a single fuel assembly to VNC to be examined for cladding defects, corrosion, etc. The Rocketdyne to INEL shipments were associated with the Fermi Unit 1. Fermi was the first commercial breeder reactor, beginning operation in 1968. The reactor was shut down in 1970 because of a core meltdown problem, and its fuel was shipped to the Savannah River Plant (SRP). This fuel was subsequently moved from SRP to Rocketdyne in Santa Suzanna, CA, to remove the cladding. Between 1987 and 1989, it was then moved from Rocketdyne to INEL for storage and processing.

Humboldt Bay is a BWR owned by Pacific Gas and Electric Company in Eureka, CA. In 1969, 15 rail shipments were made to the Nuclear Fuel Services (NFS) Company in West Valley, NY. Each of the 15 shipments carried a single cask. A total of 270 assemblies were transported, accounting for a weight of 20.52 MTUs. All of the transported fuel was reprocessed.

3.2 Vehicle-Miles Comparisons

A complete listing of individual state experiences with SNF transportation, including total shipment mileage, is provided in the Appendix to this study. With regard to loaded commercial SNF, Nevada has experienced the tenth highest number of shipments and the thirteenth highest total of MTUs. On the basis of shipment-miles (one shipment moving one mile is a shipment-mile), Nevada has the twelfth highest total among all states.

The highway mileage used to carry SNF in Nevada was further divided according to road type. As expected, the vast majority of mileage occurred on Interstates. Of the 40,000 shipment-miles, almost 38,000, or 95 percent were relegated to the Interstate system. About 1,400 miles occurred on U.S. highways, and the remaining 700 miles were associated with local roads. The local roads were presumably used for movements from U.S. Highway 95 to the EMAD site at the Nevada Test Site (NTS).

The rail experience in Nevada is relatively low compared to the states where shipments of SNF are most frequent. Of the 22 states where SNF shipments have been moved on rail lines, Nevada, California, and Utah have the least number of shipments at 15 and the lowest total of MTUs at 20.52. (The same shipments were associated with all three states.) Nevada ranks eleventh in total number of cask-miles with 6,522. (A cask-mile is one cask moving one mile.)

4. SPENT NUCLEAR FUEL ACCIDENT EXPERIENCE

4.1 Nevada Experience With Spent Nuclear Fuel Accidents

The main source of accident data for SNF shipments was the RMIR. As previously discussed, the RMIR data base only covers SNF shipment incidents back to 1971. Between 1971 and 1990, all commercial shipments of SNF were safely moved through the state and covered almost 40,000 truck shipment-miles. Between 1964 and 1971, only one SNF truck shipment was moved in Nevada; it accounted for about 415 shipment miles. In 1969, 15 rail shipments safely transported through Nevada accounted for over 6,000 rail shipment-miles. However, it must be pointed out that since the total exposure (shipment-miles) for Nevada's SNF transportation history is so low, the fact that no accidents have yet to occur is not surprising. To provide a basis for comparison and to develop more reliable statistics that may be applied to Nevada, national data on SNF transportation safety and on general truck and rail safety were assessed.

4.2 National Experience With Spent Nuclear Fuel Accidents

During the domestic history of SNF transportation, there have been no accidents or incidents where damages to the vehicle or cask resulted in the release of radioactive materials or injury to the public. Nationally, two accidents and 17 incidents involved commercial loaded shipments of SNF that occurred in all states between 1971 and 1990. Table 4.1 categorizes these occurrences according to mode and year. For comparison, this table also supplies accident and incident data for other types of SNF shipments, including shipments from research reactors and unloaded cask shipments. These other categories were not included in the accident and incident rate calculations because data were not available to determine vehicle miles of travel for these types of shipments.

The loaded commercial truck accident indicated in Table 4.1 occurred in 1978 when a trailer hauling a cask containing six mixed oxide SNF rods buckled under the load. No radioactive material was released, and the cask was transferred to another vehicle to complete the trip. The loaded commercial rail accident reported in Table 4.1 occurred during the Three Mile Island (TMI) shipping campaign. A train hauling two casks hit an automobile at a rail crossing. The driver suffered minor injuries, the casks were undamaged, and the train's engine experienced minor damages. No radioactivity was

released. In 1971, one death occurred as a result of injury sustained from an overturned vehicle and not from a radiological release; this accident is shown as the loaded research shipment in Table 4.1.

Table 4.1. National Accident and Incident Experience Since 1971*

Shipment Type	Number of Accidents	No. of Incidents			Total
		Surface Contamination from Weeping	Operational	Both	
Commercial:					
- Loaded					
Truck	1	12	3	0	16
Rail	1	1	1	0	3
- Unloaded					
Truck	1	19	0	1	21
Rail	1	0	0	0	1
Subtotal	4	32	4	1	41
Research					
- Loaded					
Truck	1	2	0	0	3
Rail	0	0	0	0	0
- Unloaded					
Truck	0	6	0	1	7
Rail	1	0	0	1	2
Subtotal	2	8	0	2	12
TOTAL	6	40	4	3	53

*Includes both commercial and research fuel and loaded and unloaded casks

Source: RMIR

Incident rates per million miles of travel for loaded commercial SNF shipments were found to be 10.5 and 19.4 for truck and rail, respectively. Fifteen of the 17 incidents occurred on truck shipments; 12 of these incidents occurred during the period of 1977 through 1981. The reasons for the higher incident occurrence during this period are unknown, but it is possible that incident reporting practices have not remained constant over the 20-year period. It is also possible that shipment travel times could have an influence on "weeping" activity, although there is no scientific evidence to confirm this. If travel time is a factor, the increased incidents may be explained by the shipments between Morris, IL and San Onofre, CA during the 1977 through 1981 timeframe. These shipments are estimated to have taken 40 to 48 hours to complete. Another explanation for the high number of reported incidents is the fact that seven of the incidents involved reportable surface contamination on the NAC-1D spent fuel shipping cask. This cask underwent extensive external decontamination in 1981, which resulted in an immediate decrease in its reported surface contamination on receipt.

5. FUTURE SAFETY CONSIDERATIONS FOR NEVADA

5.1 Introduction

Although Nevada ranks fairly high among the states in terms of the amount of SNF that has moved through it, its experience (vehicle-miles) from a statistical standpoint is too limited to extrapolate past trends as a measure of future safety. That is, a more thorough assessment of safety involves looking at larger amounts of data to increase reliability by decreasing random variation. To accomplish this, an examination of general transportation safety was made, both in terms of *total* truck and rail safety and the entire Nation's experience with commercial SNF. The results of this examination can be applied to Nevada to supplement assessments of SNF transportation safety.

The standard measure of relative safety used in transportation safety analysis is the accident rate expressed as number of accidents per unit of travel for the vehicles involved. The unit of travel is typically a vehicle-mile and is referred to as exposure, i.e., the amount of time vehicles are "exposed" to potential accident conditions. The calculation of accident and incident rates depends on both the accuracy and compatibility of the numbers used in the numerator and denominator. In other words, accidents and exposure must be calculated accurately and must match each other for the type of travel and vehicle(s) under question.

Accident rates are used in this chapter as an indicator of safety. No SNF accident rates specific to Nevada were computed because: (1) no SNF accidents or incidents have occurred in Nevada; and (2) SNF movements by truck and rail for the period studied total only 40,000 and 6,000 miles, respectively. This exposure is far too small to compute reliable accident rates.

5.2 Safety of Loaded Commercial Spent Nuclear Fuel Shipments

Accident rates were calculated for domestic loaded commercial SNF shipments using the accident and incident information in Chapter 4 of this study and the shipment experience shown in the Appendix. Due to a lack of accident and incident data prior to 1971, the analyses performed in this study could only cover the period from 1971 to 1990.

Table 5.1 provides the accident and incident rates for truck and rail domestic SNF shipments. As shown, the accident rate per million miles of travel is lower for truck than for rail shipments. When making a comparison between modes, it is necessary to provide a rate by ton-miles, because it takes between 7 to 9 truckload shipments to move an equivalent cask load shipment by rail. When this adjustment is made, the accident rate per ton-mile is 55 percent higher for rail movements.

Table 5.1. Loaded Commercial Domestic Spent Fuel Shipment Accident and Incident Rates (1971 - 1990)

	Number of Miles	Rate Per Million Miles	Number of Ton-miles	Rate Per Million Ton-miles
Accidents (No.)				
Truck (1)	1,432,826	0.7	751,303	1.3
Rail (1)	103,257	9.7	483,727	2.1
Incidents (No.)				
Truck (15)	1,432,826	10.5	751,303	20.0
Rail (2)	103,257	19.4	483,727	4.1

Note: The mileage is computed by reviewing each documented shipment of loaded commercial SNF between 1971 and 1990. Shipment-miles are based on a review of origins and destinations, Interstates and major highways en route, and NRC previously approved SNF shipment routes. The miles calculated should not be held as the exact actual miles, but the margin of error is estimated at less than 10 percent.

Source: RMIR, HIGHWAY, and INTERLINE

The primary drawback of the SNF accident rates is that they are based on only one accident each and 1.43 million and 103,000 miles of travel for truck and rail, respectively. These are very small sample sizes on which to compute accident rates. For this reason, it is recommended to use the rates of the general population of combination trucks when performing future risk analyses.

5.3 Safety of Truck and Rail Transportation -- General Population

Data from several past studies on large truck safety were reviewed. For large trucks, accident rates have been developed by many studies over the years (Table 5.2) [references 9 through 16]. Based on these data, a reasonable range of values for large truck accident rates is between 0.7 to 3.0 accidents per million vehicle-miles, depending on the type of highway where travel occurs. Researchers have noted the positive effect of highway design on safety, and the values in Table 6.2 verify this assumption; the higher classes of highways, which are constructed and maintained to higher standards, consistently show lower accident rates.

Developing accident rates for rail shipments is simplified because of the smaller number of rail carriers and the regulations in place to collect data. The DOT compiles annual accident and fatality data collected from the rail carriers accident reports to the Federal Railroad Associations's (FRA) Office of Safety. The information includes detailed descriptions of each accident, probable cause, and the state in which the accident occurs. In regard to railcar miles, the Interstate Commerce Commission (ICC) requires that the railroads submit a representative portion of their waybills, which ideally reflects rail activity for a given period. Mileage can also be obtained from the Association of American Railroads, which publishes information on railcar-miles. A Nuclear Regulatory Commission (NRC) study [11] produced accident experience rates by year for the railroads from 1975 to 1982. In Table 5.3, the rates range from 8 to 15 accidents per million miles. The overall rate for the 8-year period is 11.9 accidents per million miles (total accidents divided by total miles for the 8-year period). The study, conducted by Lawrence Livermore National Laboratory (LLNL) for the NRC, used the average rate for all eight years when performing accident rate analyses.

5.4 Implications For Nevada

The data on which the nationwide commercial SNF accident rates were developed are not sufficient to provide a statistically significant comparison with the safety performance of truck and rail transportation in general. That is, if more data were available, the reliability of the SNF rate estimates would increase. However, as they stand, they do provide an *indication* of the safety of SNF transportation. The computed value of 0.7 truck accidents per million vehicle-miles for commercial loaded SNF nationwide is within the range of 0.7 to 3.0 for accident rates previously reported by generic large truck safety studies. Likewise, the rate of 9.7 accidents per million miles developed in this study for SNF shipments by rail falls within the range for total train rates. Table 5.4 presents a comparison of accident rates computed for this study.

Table 5.2. Large Truck Accident Rates From Previous Studies [a,b]

Total Accident Rates [c]

All Combination Trucks	Accidents Per Million Vehicle-miles	
All Land Use Types	2.89[9,10]	2.50[11]
All Urban	7.60[12]	
All Suburban	1.30[12]	
All Rural	0.60[12]	

Total Vehicle Involvement Rates by Trailer Type [c,d]

Single-Trailer Combination Trucks	Intercity	Local	All Travel	Petroleum Only
Van	0.76[10]	1.68[10]	1.01[10]	--
Tank	0.78[10]	1.42[10]	1.97[13]	5.94[11]
Platform	1.07[10]	0.70[10]	1.00[13]	--

Total Vehicle Involvement Rates by Road Type [c,d]

Single-Trailer Combination Trucks	Intercity
Rural Interstate	0.77[14]
Urban Interstate	2.79[14]
Rural Nonfreeway	0.97[14]
Urban Nonfreeway	2.94[14]

Casualty Accident Vehicle Involvement Rates [e]

Highway Class	Single Trailer Combinations Trucks [10]	All Vehicles[15]
Rural Interstate	0.27	0.26
Rural Principal Arterial	0.35	0.72
Rural Minor Arterial	0.48	N/A
Rural Minor Collector	0.64	1.00
Urban Interstate	0.55	0.47
Urban Principal Arterial	1.13	1.09

Notes:
(a) All rates are per million vehicle-miles.
(b) Sources are keyed to the references in the back of the report.
(c) Total accident and vehicle involvement rates include all reportable accidents.
(d) Total vehicle involvement rates account for multiple vehicles of the same type. For instance, if two single trailer combinations collide, they count as two single trailer vehicle involvements, but only one accident. Based on past experience, vehicle involvement rates for combinations are 1 to 2 percent higher than corresponding accident rates.
(e) Casualty accidents include only fatal and injury accidents.

Table 5.3. **Railroad Accident Rates, 1975 - 1982**

Year	Rates Per Million Miles
1975	10.64
1976	13.23
1977	13.81
1978	14.99
1979	12.75
1980	11.77
1981	8.54
1982	8.00
Rate for 1975-1982	11.88

Source:
U.S. Nuclear Regulatory Commission, **Shipping Container Response to Severe Highway and Railway Accident Conditions**, NUREG/CR-4829-V1 and V2.

Table 5.4. Summary of Truck and Rail Accident Rates[1] (per Million Vehicle Miles)

Source	Truck	Rail
SNF in Nevada	0[2]	0[2]
SNF all states	0.7	9.7
General Population (various studies)	0.7 - 3.0	11.9

[1] When applying these rates for risk and safety analyses, analysts must account for the larger shipping capacity of rail over truck, which serves to reduce the effective rate for rail, depending on cask capacity and the number of casks included in a rail shipment.

[2] Since no SNF accidents have occurred in Nevada for the period 1964 to 1990, the data set is too small to be used for risk or safety assessments.

Source: Tables 5.1, 5.2, and 5.3

Although this type of analysis is a good indication of SNF safety, there are several reasons to expect that SNF shipments are *safer* than the general population of commodities. The regulations governing SNF transportation are stringent and include route selection and special packaging and marking. The transport vehicle undergoes more thorough inspection, the drivers are screened more closely and are more highly trained, and there will be a much higher percentage of travel on well-designed Interstate highways than on lower order roads. Finally, even if an accident occurs, casks offer an extremely high degree of protection from radiation exposure; cask designs are based on the assumption that accidents will occur and that those accidents will sometimes be severe. Therefore, the regulations require that the packaging be designed and constructed to provide maximum protection to reduce the adverse consequences.

Based on this discussion, use of the rates from general truck and rail transportation is a conservative approach for conducting safety and risk analyses. When comparing these two modes, the different cargo capacities must be considered. Because rail casks

are larger than truck casks,fewer rail shipments would be required to move an equal quantity of SNF. Further, multiple rail casks can be included in the same shipment.

Although Nevada's SNF transportation safety history is unblemished, the low amount of actual travel within the State does not allow extrapolating this trend into the future. The safety record of SNF shipments nationwide is based on more data. Although those data indicate that SNF accident rates are within the range of general truck and rail transportation, the data are not extensive enough for use in future studies in Nevada.

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16. U.S. Department of Energy, by Argonne National Laboratory, 1989. **Data Base of Accident and Agricultural Statistics for Transportation Risk Assessment.**

APPENDIX

COMMERCIAL SPENT NUCLEAR FUEL TRUCK SHIPMENTS BY STATE, 1964-1990

Table A. Commercial Spent Nuclear Fuel Truck Shipments by State (1964-1990)

State	No. of Shipments	Shipment Rank	Total Miles (Shipments * route miles)	Total Miles Rank	Weight (MTUs)	MTU's Rank
NY	1,406	1	236,506	1	442.258	2
IL	1,362	2	116,034	7	490.937	1
PA	990	3	84,859	10	381.228	3
OH	904	4	219,822	2	347.867	4
IN	848	5	129,431	6	295.937	5
WI	476	6	72,978	11	186.680	9
UT	458	7	134,665	5	215.940	7
WY	420	8	164,570	3	165.830	12
AZ	312	9	21,354	16	176.920	10
NV	309	10	40,048	12	148.980	13
CA	304	11	86,290	9	167.160	11
NE	303	12	136,863	4	133.297	14
IA	303	12	92,829	8	133.297	14
SC	217	14	23,692	14	226.990	6
NC	196	15	15,696	18	191.280	8
ID	171	16	22,462	15	109.460	16
NJ	149	17	24,296	13	84.414	17
CO	139	18	15,824	17	41.280	21
CT	90	19	6,469	27	37.704	24
VA	85	20	10,908	21	83.913	18
WV	48	21	6,940	25	46.850	20
GA	40	22	11,254	19	52.780	19
TN	38	23	10,013	22	41.103	22
AR	32	24	5.721	29	39.743	23
MI	30	25	690	37	34.200	25
MD	27	26	2,601	34	31.840	29

State	No. of Shipments	Shipment Rank	Total Miles (Shipments * route miles)	Total Miles Rank	Weight (MTUs)	MTU's Rank
KY	25	27	3,501	32	8.370	31
FL	22	28	9,420	23	18.880	30
TX	18	29	3,204	33	33,900	26
OK	18	29	6,120	28	33,900	26
MO	18	29	4,572	31	8.070	32
KS	18	29	7,812	24	8.070	32
NM	18	29	6,732	26	33.900	26
MN	13	34	2,363	35	4.170	34
WA	11	35	4,810	30	3.960	35
MT	11	35	10,950	20	3.960	35
MA	5	37	432	38	2.244	37
VT	4	38	64	40	2.184	38
ND	2	39	702	36	0.370	39
NH	1	40	16	41	0.060	40
ME	1	40	92	39	0.060	40

Source:
HIGHWAY and INTERLINE

U.S. Department of Energy, Office of Civilian Radioactive Waste Management, 1990. **Historical Overview of Domestic Spent Fuel Shipments - Update**, ORNL/M-1083, ORO/TOP-5405.0.