Commercial Experience in the Transportation of Spent Fuel in the United States*

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INTRODUCTION

This article presents information on experience in the United States involving the transportation of spent fuel Ref.[1]. A short summary of US spent fuel policy and the commercial shipping experience for spent fuel is presented and a review of the transportation incident/accident experience for spent fuel or similar transport systems is also included, based on the available records of the US Department of Transportation and the Nuclear Regulatory Commission. Details of the transportation and handling of spent fuel from the US Navy's nuclear propulsion programme are not available except to say that this is an integrated programme involving standardized casks and handling systems from several ports to a reprocessing plant.

SPENT FUEL POLICY AND COMMERCIAL EXPERIENCE IN THE UNITED STATES Ref. [2]

In October 1977, the US Department of Energy announced a spent fuel storage policy for nuclear power reactors. Under this policy, utilities will be given the opportunity to place spent fuel in government custody on payment of a fee. The government will also be in a position to accept a limited amount of spent fuel from foreign sources if this would contribute to meeting non-proliferation goals. Spent fuel transferred to the US Government will be delivered, at user expense, to a Government approved storage site.

In the United States, it was originally planned that spent fuel would be reprocessed several months after its discharge from the reactor, and the recovered uranium and plutonium recycled shortly thereafter. Shipments of spent fuel have been made to two reprocessing facilities: Nuclear Fuel Services' plant at West Valley, New York (not currently operating) and the General Electric Company's plant at Morris, Illinois Actual reprocessing of spent fuel occurred only at West Valley. Another reprocessing plant is owned by Allied-General Nuclear Services and is located at Barnwell, South Carolina. Due to changes in Government policy on reprocessing, the Barnwell plant has not received any spent fuel shipments.

Nuclear Fuel Services has received approximately 2000 spent fuel assemblies and much of this material has been reprocessed. The storage capacity at West Valley is 925 fuel assemblies (either BWR or PWR). General Electric has in storage approximately 1200 assemblies of various types, with storage capacity for 700 tonnes and a request pending to increase this capacity by an additional 1100 tonnes. These storage capacity figures can be expressed in terms of fuel assemblies if one multiplies them by 2 for PWR fuel or by 5 for BWR fuel.

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Table 1. Characteristics of spent fuel casks available in the United States

Cask Type	Primary Transport Mode	Weight Loaded (Tonnes)	Capacity in Elements PWR/BWR	Fluid in Cavity	Cavity Length/Dia (cm)	Design Heat Generation Rate (kW)	Major Shielding	Neutron Shielding	Number of Casks Available	Number of Casks Ordered
NAC-1	Truck	22.25	1/2	Water/ Air	452/34 2	11 5	Lead & Steel	Borated Water Antifreeze	4	–
NFS-4[a]	Truck	22 25	1/2	Water/ Air	452/34 2	11 5	Lead & Steel	Borated Water Antifreeze	2	–
NLI-1/2	Truck	21 4	1/2	Helium	452/32	10 6	Lead & Steel	Water	5	–
NLI-10/24	Rail	86 6	10/24	Helium	404/114	77	Lead & Steel	Water	1	–
TN-8	Truck/ Rail	35.7	3 PWR	Air	427/170	35 5	Lead & Steel	Borated Solid Resin	–	4
TN-9	Truck/ Rail	33 9	7 BWR	Air	452/170	21 5	Lead & Steel	Borated Solid Resin	–	4
TN-12[b]	Rail	95 6	12/32	Air	465/240	135	Steel	Borated Solid Resin	–	–
GE-IF-300	Rail	60 7	7/16	Water/ Air	458/95 2	61 5	Uranium & Steel	Water/ Glycol	4	–

NAC Nuclear Assurance Corp.
NFS Nuclear Fuel Services
NLI National Lead Company
TN Transnuclear
GE General Electric Co.

[a] NAC-1 and NFS-4 are of the same design.
[b] TN-12 application for licensing currently under review

US Energy Research & Development Administration, *Alternatives for Managing Wastes from Reactors and Post Fission Operations in the LWR Fuel Cycle*, ERDA-76-43, May 1976, Vol. 3, p. 22 13–22 17

Nuclear Fuel Services has handled four cask types: NFS-1, NFS-2, NFS-4, and WECX. All but the NFS-4 are out of service. General Electric has also handled four cask types: IF-100, IF-200, IF-300, and NAC-1 (same as NFS-4). Of these only the IF-300 and the NAC-1 remain in service. A summary of spent fuel casks available in the United States is shown in Table 1.

SPENT FUEL TRANSPORT EXPERIENCE IN THE UNITED STATES

The transport of spent fuel casks can be viewed as a relatively straightforward operation, with common carriers, either trucking companies or railroads, used to move the casks. Of the trucking companies, Tri-State Motor Transit Company has handled a large number of the shipments that have been made in the United States. Tri-State owns a fleet of ten trailers, which accommodate the NAC-1, NFS-4, NLI-1/2, and can be adapted to the TN-8, and TN-9 casks. Tri-State also has a trailer for carrying the special cask used to transport Peach Bottom I test reactor fuel. Other trucking companies have also made nuclear shipments or have expressed interest in shipping nuclear materials and are potential future transporters.

The US railroads have on several occasions attempted to refuse to carry spent fuel shipping casks under the common carrier tariff regulations, insisting that such shipments represent a risk above that normally accepted by the carrier (this provision extends to empty as well as loaded casks). While litigation in this area is still underway the first three cases have been ruled upon by the Interstate Commerce Commission. Their finding was that the shipment of spent fuel casks did not constitute an unusual hazard and that the railroad should treat shipment of these systems as common carriers so long as the casks meet all of the packaging and regulatory requirements of the Department of Transportation and the Nuclear Regulatory Commission. All currently licensed US rail casks (the NLI-10/2 and GE IF-300) utilize auxiliary cooling systems on the railcar and complex tiedown systems and therefore special purpose railcars are used to transport these casks. It is expected that specially designed railcars will also be provided for future designs of rail cask.

All operating nuclear power plants give rise to spent fuel and are potential shippers of it. Some utilities in the United States have made spent fuel shipments to the reprocessing facilities of Nuclear Fuel Services or General Electric or between reactor spent fuel pools within a utility or utility group. However, most US utilities have not yet begun their shipments of spent fuel to storage sites away from the reactor or to reprocessing plants.

A list of those utilities that have shipped spent fuel is shown in Table 2. In summary, this table indicates that there have been 906 spent fuel assemblies transferred between spent fuel pools within a reactor site (i.e., no off-site transportation). In addition, there have been 3891 spent fuel assemblies shipped from reactor sites to other locations.

To date there have been no shipments of high-level wastes associated with commercial nuclear fuel cycles in the United States. The high-level wastes arising from the US defence programme have been generated and stored on Government reservations and, hence, have not been transported by common carrier

TRANSPORTATION ACCIDENT/INCIDENT EXPERIENCE

Since 1971, a uniform hazardous material incident reporting system (covering all transportation modes) has been in effect in the United States as a requirement of the Department of Transportation regulations, and carriers of hazardous materials are required to report all

Table 2. US spent fuel shipments: Commercial power reactors (Compiled by Fuel-trac, Nuclear Assurance Corporation, September 1979)

Utility/Reactor	Assemblies Shipped	Date
Carolina Power and Light		
H.B. Robinson to Brunswick	56	1977- 1978
	126	1978–1979
	(shipments continuing until 304 transferred)	
H.B. Robinson to INEL	1	1975
Brunswick 2 to Brunswick 1	144	1978
Commonwealth Edison		
Dresden 1 to NFS	181	1964
	97	1966
	200	1967
	106	1969
	96	1970
	96	1971
	113	1973
Dresden 1 to GE-Vallecitos	1	1964
Dresden 1 to Savannah River	8	1964
Dresden 1 to B&W-Lynchburg	1	1973
Dresden 1 to INEL	2	1973
	1	1978
Dresden 2 to GE-Morris	244	1976
	509	1976–1977
Desden 2 to BCL	1	1976
Connecticut Yankee Atomic Power Company		
Conn Yankee to GE-Morris	80	1974–1975
Consolidated Edison Company		
Indian Point 1 to NFS	124	1966–1969
	80	1969
	40	1971–1972
Consumers Power Company		
Big Rock Point to NFS	48	1970
	139	1971
	72	1973
	13	1974
Dairyland Co-operative		
LaCrosse to Savannah River	1	1973
LaCrosse to GE-Morris	8	1979

Utility/Reactor	Assemblies Shipped	Date
Duke Power Company		
Oconee to B&W-Lynchburg	1	1975
(and return)	1	1976
	2	1978
Oconee to Crystal River	4	1978
Oconee to Oconee	131	1976–1977
	153	1978–1979
Florida Power and Light Company		
Turkey Point to Turkey Point	206	1976–1977
	272	1977–1978
Turkey Point to BCL	5	1978
Jersey Central Power and Light Company		
Oyster Creek to NFS	224	1975
Pacific Gas and Electric Company		
Humboldt Bay to NFS	270	1971
Philadelphia Electric		
Peach Bottom 2 to INEL	2	1976
Rochester Gas and Electric		
R.E. Ginna to NFS	121	1973–1975
Southern California Edison		
San Onofre 1 to GE-Morris	74	1972–1973
	21	1975
	55	1976
	104	1977–1978
	(will continue in 1979)	
Wisconsin Electric Power Company		
Point Beach to NFS	44	1974
	76	1975
Point Beach to GE-Morris	34	1975
	38	1976
	35	1977
Point Beach to BCL	2	1976–1977
(and then to GE-Morris)	2	

Utility/Reactor	Assemblies Shipped	Date
Yankee Atomic Power Company		
Yankee Rowe to NFS	74	1964
	39	1965
	37	1966
	38	1967
	36	1968
	36	1970
	36	1971
	36	1972

Abbreviations

INEL – Idaho National Engineering Laboratory
NFS – Nuclear Fuel Services
GE – General Electric
B+W – Babcock and Wilcox
BCL – Battelle, Columbus Laboratories

transport incidents to the Department of Transportation. The criteria for reporting includes death, personal injury, property damage, and in the case of radioactive materials, *suspected* radioactive contamination. The totals of these hazardous material incident reports through 1978 are shown in Table 3.

Table 3. Hazardous Material Incident Summary 1971–78

	1971–1975	1976	1977	1978	Totals (71–78)
Radioactive Materials	144	62	93	90	389
All Other Hazardous Materials	31 874	12 001	15 384	18 058	77 312
SUB TOTALS	32 018	12 063	15 477	18 143	77 701

A detailed summary of the hazardous material incident reports for the period 1971–75 has been prepared Ref. [3] and this analysis is currently being extended at Sandia Laboratories through 1978. Grella Ref. [3] determined that the road and rail transport modes, the pertinent modes for spent fuel movement, produced 70 of the 144 hazardous material incident reports. Of these 70 incident reports, 24 indicated a release of radioactive material. It is important at this point to make note of a distinction that can only be determined by detailed examination of the incident reports and any attached documentation; that is, all hazardous material incidents are *not* transport accidents. For example, a detailed study of the reports reveals that a significant number of cases involve minor cask or trailer contamination that has occurred during normal (incident-free) transport operations.

Table 4. United States transport accidents involving fuel cycle materials* (1978) Ref. [4]

Accident Date	Accident/Incident Description	Transport Mode	Material Type	Package Description	Contamination/ Exposure
Feb 78	Trailer buckled	Highway	Irradiated mixed oxide fuel	Spent fuel cask	None
Feb 78	No accident	Highway	Empty	Spent fuel cask	Slight contamination of cask outer surface
Feb 78	No accident	Highway	Empty	Spent fuel cask	Slight contamination of cask outer surface
Feb 78	Package fell off truck	Highway	Dewatered resins	Department of Transportation approved package	None
Mar 78	No accident	Highway	Empty	Waste shipping cask	Slight contamination of cask outer surface
Apr 78	Truck overturned	Highway	Empty	Radioactive waste shipping cask	None
May 78	Lid of container missing	Highway	Low-level waste	Plywood box	None
May 78	Improper packaging	Highway	Liquid filters	Department of Transportation approved package	None
May 78	No accident	Highway	Spent fuel	Spent fuel shipping cask	Slight contamination of cask outer surface
Jul 78	No accident	Highway	Solid depleted uranium waste	55 gallon drum	Slight contamination of truck only

Accident Date	Accident/Incident Description	Transport Mode	Material Type	Package Description	Contamination/ Exposure
July 78	No accident	Highway	Empty	Spent fuel shipping cask	Slight contamination of cask outer surface
July 78	No accident	Highway	Spent fuel	Spent fuel shipping cask	Slight contamination of cask outer surface
Aug 78	Cask broke truck bed	Highway	Empty	Radioactive waste shipping cask	None
Aug 78	Truck overturned	Highway	Solidified reactor waste	55 gallon drum	None
Aug 78	No accident	Highway	Spent fuel	Spent fuel shipping cask	Slight contamination of cask outer surface
Sep 78	Lifting yoke broke trailer floor	Highway	Contaminated lifting yoke	—	None
Dec 78	Truck overturned	Highway	Solidified depleted uranium waste	Metal drums	None
Dec 78	Freezing	Highway	Low-level waste	55 gallon frum	Slight contamination of truck only

* Back end of fuel cycle only

The conclusions in Reference [3] were based on the experience in the United States for the period 1971–75 and it was noted that radioactive material incidents comprised a very small fraction of the total of all hazardous material incidents. The totals through 1978 still verify this since radioactive material incidents represent only 0.5 percent of all hazardous material incidents. The releases noted in Reference [3] frequently involved Type A packages containing such limited quantities of radioactive material that if a complete release of the contents were to occur, as a result of a transport accident, there could be no significant radiological consequence. These Type A packages are, of course, not of the same integrity as a massive spent fuel package.

Sandia Laboratories is currently examining Department of Transportation and Nuclear Regulatory Commission records in order to extend Grella's work to the present. This work has not been completed but a summary of some recent United States transport experience gained since January 1978 for spent fuel or similar transport systems is shown in Table 4. The events in this table were taken from Nuclear Regulatory Commission records for incidents involving shipments of all classes of radioactive materials during 1978.

The table indicate that very little spent fuel is being transported, as was mentioned earlier, and that road (truck) transport predominates in the accident record. (This is to be expected since little movement is occurring by rail). There has been little or no radiological health hazard produced by these transport accidents. A detailed examination of the hazardous material incident reports reveals that in many cases the cause of the incident was the "leaching out" of surface contamination during normal (incident-free) transportation.

CONCLUDING REMARKS

The primary aim of this article has been to present the information available on United States experience in the transportation of spent fuel. The limited number of shipments of commercial spent reactor fuel are a reflection of United States policy in this area. (There have been no commercial high-level wastes shipped to date.) Since radioactive materials are shipped in approved packagings in commercial transport operations, we have reviewed some recent transport accident experience involving these materials We have observed that this recent experience has produced very little radiological contamination or exposure (in most cases none). This work is preliminary but part of an on-going effort to tabulate and evaluate accident statistics on the transport of radioactive material and, in general, determine the nature of the transportation accident environment. When this transport accident analysis is completed, it is expected that a definitive statement can be made on the number of significant releases that have occurred in the USA from Type B packages used for the transport of spent fuel or high-level waste; to date we know of no such incidents. This information, when coupled to more detailed risk analyses, will alow the systematic determination of the risks involved with radioactive material transportation operations.

References

[1] A.K BHATTACHARYYA et al , Spent Fuel Casks and Handling Systems in the United States, IEAL-78/003-02/1, International Energy Associates Limited, 2600 Virginia Ave , NW, Washington, DC (November 1978).

[2] Draft Environmental Impact Statement, Storage of US Spent Power Reactor Fuel, DOE/EIS-0015-D, US Department of Energy (August 1978)

[3] A W. GRELLA, "A Review of Five Years Accident Experience in the USA Involving Nuclear Transportation (1971–1975)", IAEA-SR-10/5, International Atomic Energy Agency, Vienna, Austria (August 1976)

[4] US Nuclear Regulatory Commission, (March 1979)