Spent Fuel Storage and Transportation Experience for the Idaho National Engineering Laboratory

C.P. Gertz, D.H. Schoonen, and B.H. Wakeman
Idaho National Engineering Laboratory
EG&G Idaho, Inc.
Idaho Falls, Idaho 83415

Abstract
Spent-fuel research and development demonstrations and associated transportation activities are being performed for the Department of Energy (DOE) Office of Civilian Radioactive Waste Management (OCRWM) as a part of the storage cask performance testing programs at the Idaho National Engineering Laboratory (INEL). These spent-fuel programs support the Nuclear Waste Policy Act (NWPA) and DOE objectives for co-operative demonstrations with the utilities, testing at federal sites, and alternatives for viable transportation systems. The shipment of spent fuel to the INEL from the Surry Power Station and the Nevada Test Site (NTS) required shipping plans and co-ordination between DOE, EG&G Idaho, and Virginia Power (VP) transportation personnel, as well as extensive communication with the corridor states.

Résumé
Les démonstrations development des récherches des combustibles épuisant et activities des transportation associé exéuter pour le Department d'Energie, le Bureau de l'Usure Radioactif Direction [DOE Office of Radioactive Waste Management (OCRWM)] au parti des programmes du tests regardant le fonctionnement des caisses d'emmagasinage au Laboratoire Nationale d'Idaho [Idaho National Engineering Laboratory (INEL)]. Ces programmes s'appuyent l'Acte pour les Politiques des Usures Nucléaire [Nuclear Waste Policy Act (NWPA)] et les objectifs DOE pour les démonstrations cooperatifs avec les utilités, les tests aux facilités fédérales, et les alternatives pour les systèmes du transport démontré. Le transport des combustibles épuisant au INEL, de Surry Power Station, et le Facilité des Testes au Nevada [Nevada Test Site (NTS)] se réquirent les plans du transport et la coordination entre DOE, EG&G Idaho, et Virginia Power (VP) et aussi les rapports extensifs avec les états affectés.

Program Information

Introduction

The spent-fuel programs being performed and planned at the INEL for DOE are composed of

- spent-fuel storage casks performance testing that involves performance of fuel storage casks with intact or consolidated fuel;
- fuel assembly rod consolidation projects, to develop dry-rod consolidation technology and prototypical equipment, as well as perform testing of storage casks containing consolidated fuel rods in canisters;
- the Nuclear Fuel Services, Inc. (NFS) spent-fuel transportable storage casks project, which involves the licensing and shipping of two loaded, transportable storage casks from West Valley, New York to the INEL;
- the cask systems acquisition (CSA) project to develop a complement of Nuclear Regulatory Commission (NRC)-certified prototype casks for shipment of spent fuel from reactor facilities to future repository sites.

The first two programs, cask performance testing and dry consolidation of spent fuel rods, provide engineering data from loaded-cask testing containing both intact and consolidated fuel. Dry consolidation of spent fuel rods will occur during the DOE-sponsored small-scale rod consolidation activities, and on a production-oriented scale during the prototypical rod consolidation project. The NFS transportable storage cask project will provide additional cask performance and surveillance data at the INEL. The CSA project will involve procurement of both transportation casks as well as transportable storage casks for DOE.

The Test Area North (TAN) facility located at the INEL was determined to be the appropriate federal facility in which to conduct these activities because of the availability of experienced staff, hot and cold test development areas, and the support needed to receive and store commercial spent-fuel assemblies.

These dry storage cask demonstrations support OCRWM and NWPA objectives and will establish a data base that

Keywords: nuclear, spent fuel, spent fuel transportation, spent fuel storage, cask performance testing, storage, consolidation, shipping.

can be used for NRC licensing by generic rule of at-reactor dry storage cask installations.

The transportation experience includes the handling of large empty metal spent-fuel storage casks, received by rail, and the shipment of a large number of spent fuel assemblies in NRC-certified shipping casks, transported over highways in transport vehicles having state-issued special permits, and meeting applicable Department of Transportation (DOT) requirements, as stated in 49CFR (Code of Federal Regulations 49, revised annually) and in accordance with specific DOE policies (DOE Order ID-1540.1, 1982).

Spent-Fuel Storage Cask Performance Testing

The VP / DOE cask testing project is a co-operative effort involving Virginia Power, DOE, and the Electrical Power Research Institute (EPRI). The co-operative agreement was established in 1984. The testing at the INEL will include casks containing both consolidated and intact fuel. The spent-fuel assemblies are shipped from the Virginia Power Surry Power Station to the INEL, using conventional licensed shipping methods.

The purpose of VP / DOE storage cask performance testing at the INEL is to remove conservatism from the licensing of dry storage casks and provide a storage technology that is generically applicable, so that the NRC can license dry storage of spent fuel by rule. Decay heat generation rates for selected fuel assemblies will total near the cask design limits. Thus, the casks may be tested above the NRC licensing limit. Data from INEL testing will confirm storage cask performance, predictive modelling capabilities, and fuel integrity at prototypical storage conditions; and will provide operational data to support the life-cycle cost studies of dry fuel storage.

The cask performance testing technical objectives are developed by Pacific Northwest Laboratories (PNL), reviewed by the co-operative agreement participants, and implemented by EG&G Idaho at the INEL.

INEL site preparations, fuel receipt, and the start of testing occurred in 1985. Storage cask testing with intact fuel was concluded in 1986, and cask testing with consolidated fuel will be completed in 1987 / 1988. Completion of testing reports and termination of the project is scheduled for mid-1988.

Fuel Assembly Rod Consolidation Projects

The rod consolidation projects consist of DOE dry rod consolidation technology (DRCT) and the prototypical consolidation demonstration project (PCDP). The small scale DRCT project will consolidate 48 fuel assemblies into 24 canisters with a consolidation ratio goal of 2:1. Furthermore, consolidation system characteristics and technical data (such as rod pulling forces, rod diameter measurements, and crud collection) will be obtained that can be utilized by the PCDP project and future DOE rod-consolidation facilities or programs.

The PCDP will demonstrate production-scale spent-fuel rod consolidation in a dry environment at the Idaho National Engineering Laboratory (INEL) Test Area North (TAN) facility. The consolidation equipment developed during this project will provide the design basis for future equipment to be used at high-level waste repositories, or the Monitored Retrievable Storage (MRS) facility. This project will expedite the engineering development and demonstration of prototypical dry rod consolidation and associated handling equipment. It will be developed under a competitive design effort by the private sector and tested at the INEL using spent-fuel assemblies acquired for the demonstration.

To obtain private-sector involvement, a four-phased single request for proposal (RFP) has been developed, covering the phases of this project: a) preliminary design competition; b) detailed (final) design competition; c) equipment fabrication, installation, and cold checkout; and d) hot demonstration and qualification of equipment at the TAN facility. The hot demonstration will be performed at the INEL using approximately 100 PWR and 100 BWR spent-fuel assemblies typical of the light water reactor industry. The competitive design with private sector demonstration is to be completed by mid-1989. The selection and shipment of spent-fuel assemblies, and procurement and receipt of the casks that will later store the consolidated canisters, are being evaluated.

Spent-Fuel Transportable Storage Cask Project

The Nuclear Fuel Services, Inc. (NFS) spent-fuel transportable storage cask project will demonstrate the feasibility of packaging, transporting, and storing, aged spent fuel in two large dry storage casks, designated the Transnuclear, Inc. Big Rock Point (TN-BRP) and the Transnuclear, Inc. R.E. Ginna (TN-REG) casks. The project was initiated in early 1984, when DOE contracted with NFS for removal of spent fuel from the West Valley pool. NFS in turn contracted with Transnuclear, Inc. for two large transportable storage casks, one to hold 85 BWR assemblies stacked in two layers, and one to hold 40 BWR assemblies. Applications for both casks are presently being processed at the NRC by Transnuclear, Inc., the manufacturer of the casks. West Valley Nuclear Services (WVNS) and the WV Demonstration Project Office (WVDPO) will prepare the West Valley facility and supervise the fuel loading operations in the WV pool gfor this project.

The project will provide data for railroad transportation of loaded, spent-fuel dry storage casks, utilizing NRC licensing for the one-time shipment of each cask. Demonstration of transportation and dry storage of spent nuclear fuel will involve the shipment of two casks loaded with fuel from West Valley, New York, to the INEL for cask testing and monitoring under storage conditions. After arrival at the INEL, the TN-BRP and

Table 1: Information Summary for TN-BRP and TN-REG Casks

Features	*TN-REG*	*TN-BRP*
Fuel assembly capacity	40 PWR	85 BWR
Material	Forged steel	Forged steel
Nominal weight loaded (kilograms)	90,718 kg (100 tons)	90,718 kg (100 tons)
Nominal length (metres)	5.03 m (16.5 ft)	5.03 m (16.5 ft)
Nominal diameter (metres)	2.59 m (8.5 ft)	2.59 m (8.5 ft)
Maximum dose rate at 2 m (Sv/h)	1.0 E-4 (10 mR/h)	1.0 E-4 (10 mR/h)
Heat load (kW) (total)	Less than 5	Less than 5
Cover gas	Nitrogen	Nitrogen

TN-REG casks will be placed directly on the TAN storage cask test pad for long-term monitoring and surveillance. A summary of cask information is provided in Table 1.

Cask System Acquisition

The CSA project will review and evaluate proposals from private industry and eventually place several contracts for transportation casks as well as for at least two transportable storage casks. The casks may include innovative designs and materials. The CSA project will not be discussed further in this paper.

Project Status

The progress of the first three program elements (VP / DOE cask testing, PCDP, and NFS project) are discussed in reverse order in this section, because most of the activity to date has been with the cask testing project.

Progress in the NFS project included completion of manufacture of the TN-BRP and TN-REG casks in 1985, and delivery of the casks to West Valley, NY. Processing of the applications for NRC licensing of the casks for one-time shipments is also in progress. Current plans are to load the fuel into the casks at West Valley while the licensing activities are in progress, and make the shipments at a later date when the casks are approved.

The RFP for the PCDP was issued January 13, 1986. Appropriate evaluation criteria have been established, and completion of the private-sector competitive preliminary designs is planned by late 1986. This will be followed by a review of the proposals and selection of the competitors for the final design.

VP / DOE spent-fuel storage cask testing and demonstrations are progressing on schedule. The INEL TAN facilities were modified to accommodate the remote transfer of spent fuel in the TAN 607 Hot Shop, from the shipping casks to the storage casks, and to permit cask testing in the TAN 607 Warm Shop. In addition to the completion of all preparations for receiving and handling the casks and spent fuel, a concrete pad was constructed near the Hot Shop for temporary storage of loaded fuel casks. Storage will be in an open environment, with appropriate monitoring and surveillance.

The first storage cask, GNS Castor V/21, arrived at the INEL by rail in December 1984, was moved by heavy haul transporter from the INEL railhead to the TAN facility in February 1985, and loaded with spent fuel in July and August 1985. The dual-cask work-stand in the TAN 607 facility Hot Shop is shown in Figure 1. The first storage cask is shown (Figure 2) during testing in the horizontal position in the TAN Warm Shop. Short-

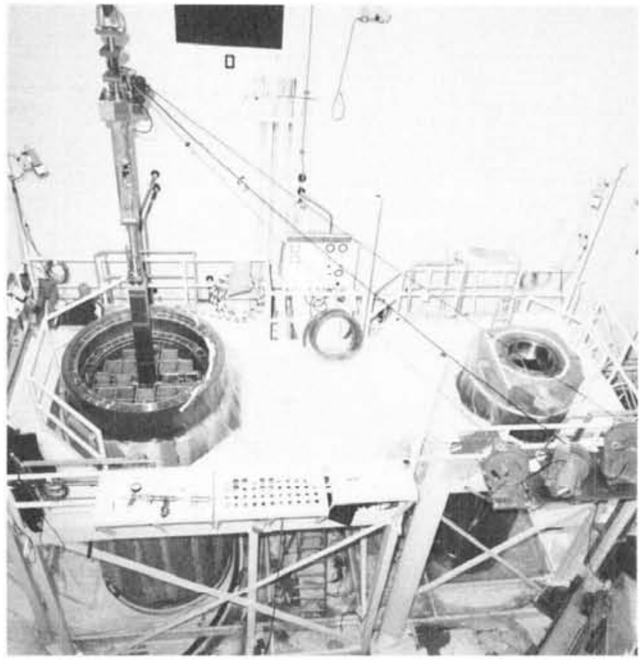

Figure 1: Hot Shop dual-cask work-stand for remote in-air transfer of fuel from shipping casks to storage casks (Spring 1986).

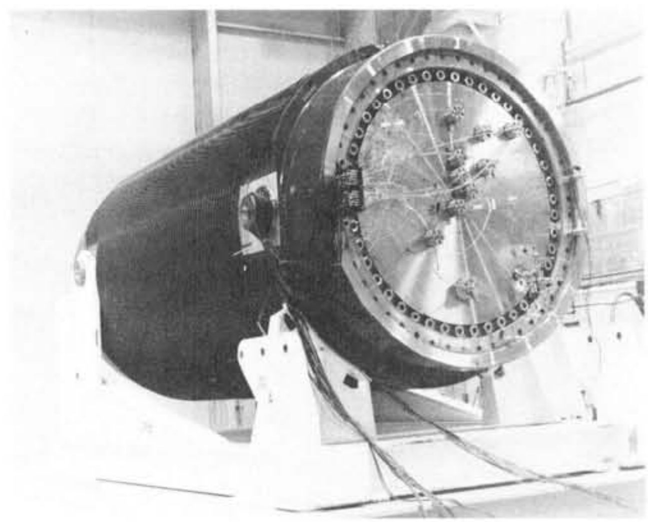

Figure 2: Horizontal testing of the first storage cask (GNS Castor V/21) built by General Nuclear Services.

Figure 3: The second storage cask (TN-24P) built by Transnuclear, Inc.

Figure 4: The third storage cask (MC-10) built by Westinghouse Electric Corporation.

term monitoring and testing of this cask was completed in September 1985.

The General Nuclear Services, GNS Castor V / 21, cask is designed for a heat load of 21 kW and will hold 21 fuel assemblies. The cask can accommodate intact fuel assemblies or consolidated rod canisters.

The second cask, the TN-24P, shown in Figure 3, was received in October 1985 and loaded in November through December 1985, and similarly tested with intact fuel. This cask will hold 24 fuel assemblies and can also accommodate consolidated rod canisters. The cask is designed to dissipate a 24 kW heat load under specific ambient and solar input conditions. The TN-24P cask was placed on the test pad in the spring of this year.

The third storage cask, the Westinghouse Electric Corporation MC-10 (Figure 4), was received in mid-March 1986. This cask is designed for a heat load of 24 kW and will hold 24 fuel assemblies or consolidated rod canisters. Completion of loading and testing of this cask was accomplished in June 1986.

The fourth storage cask has not yet been designated for the VP / DOE co-operative agreement. Procurement of the fourth cask is in progress for acquisition by late 1987. Dry storage cask features for the GNS Castor V / 21, Transnuclear, Inc. TN-24P, and Westinghouse MC-10 storage casks are shown in Table 2.

Cask Handling Experience

Handling of the approximately 100-ton storage casks, as well as numerous spent-fuel shipments, provided valuable cask-handling experience at the INEL.

The precise alignment of shipping / storage cask lids

Table 2: Dry-Storage Cask Design Features

	Dry Storage Cask		
Design features	*GNS Castor V / 21*	*TN-24P*	*Westinghouse MC-10*
1. Maximum weight on crane hook	104,326 kg (115 tons)	90,718 kg (100 tons)	90,718 kg (100 tons)
2. Capacity	21 PWR	24 PWR	24 PWR
3. Proposed licensed heat generation capacity	21 kW	24 kW	24 kW
4. Overall length	4.88 m (16 ft)	5.03 m (16.5 ft)	4.88 m (16 ft)
5. Outside diameter	2.44 m (8 ft)	2.44 m (8 ft)	2.44 m (8 ft)
6. Materials of construction	Nodular cast iron	Forged steel	Forged steel
7. Neutron shielding	Polyethylene	Borated plastic	Borated plastic

and fixtures must be evaluated, and alignment and handling of the lid systems verified prior to in-air remote fuel transfer operations. Likewise, the seal surface protectors that protect the cask sealing surfaces from damage must be checked out prior to initiating remote fuel-transfer activities in the Hot Shop.

High-quality metal or elastomer gaskets are essential for repetitive use where incremental fuel-loading or testing activities cause the lid to be removed and replaced several times. The metallic gasket on the GNS Castor V/21 primary lid was subjected to at least twelve such use cycles, and continues to function within the specified leak-rate limits.

The cover gas system used to evacuate, backfill, monitor, and obtain gas samples should be carefully designed, fabricated, and tested. High-quality fittings, quick disconnects, and valves should be utilized. A quick disconnect should not be utilized as the final barrier for air ingress, but should be backed by a block valve. The difficulty associated with backfilling the cask with a pure (>99%) cover gas, and obtaining gas samples without introducing air should not be underestimated. Procedures should specify that the cask be pumped down and backfilled at least twice, to ensure purity (>99%) of the final cover gas.

The information required prior to handling a cask should include design drawings and specifications, operating and maintenance manuals, procedures, and spare parts. The dry-run operational checkout of the cask and associated equipment should be performed for all phases, including handling, loading and backfilling the cask with a cover gas, and gas sampling. Cask vendor representatives should be in attendance and provide initial equipment training.

The preliminary training and operational checkout support provided by the cask vendors was very beneficial. Eighty-six fuel assemblies were transferred within the Hot Shop and all cask-handling activities were performed without incident.

The spent fuel cask testing and storage demonstrations at the INEL will enhance the overall dry-storage technology data base. The initial results indicate that the shielding and thermal performance are good. Testing with the casks loaded with consolidated rod canisters will further support the verification of the performance modelling.

Transportation Experience

The shipment of DOE-owned spent fuel is a well-structured activity, and is performed in accordance with certain DOE and DOT policies. Specific guidelines are established for the carrier, the originating facility, and the terminal point.

In addition to invoking all applicable DOT requirements, the shipping costs and schedules were evaluated for both DOE commercial spent-fuel shipments and the NRC shipping requirements. Applicable shipping forms are specified by the DOT per 49CFR. Along with the 69 fuel assemblies moved in 23 trips from Surry to the INEL, there were 17 fuel assemblies moved from the NTS to the INEL. An additional two assemblies will be moved from the Battelle, Columbus facility to the INEL. For these shipments, a policy to provide notification to state governors or representatives in advance of shipments (a courtesy communications system) was developed and implemented in order to keep the participating states fully informed.

Communications equipment is a vital part of the transportation planning. The communications network requires a central control point and the capability to contact local emergency response organizations. Call-ins by the carrier at specified intervals, normally every two hours, assures that key personnel are cognizant of the location and status of each shipment and can initiate an immediate response to any unusual situation.

The drivers are DOT-licensed and trained in the transporting of highway-route-controlled quantities of radioactive material in accordance with 49 CFR. Escort drivers or personnel are provided as required.

Constant surveillance of each shipment is provided by one of the drivers or escort personnel. The potential for acts of terrorism exists, and a vehicle immobilization system is required whereby the driver can immobilize the truck so that it cannot be restarted without performing specific mechanical or electrical maintenance procedures.

Routes are specified in the written transportation plan, which is reviewed and approved by the proper authorities. Following route approval and issuance of the transportation plan, the state overweight permits, as required, are obtained, and travel restrictions for the shipments provided to the drivers. In some cases, courtesy communications for each shipment is provided so that state patrol escorts can accompany the shipment within the state, or so that state inspections can take place.

Before initiating the spent-fuel shipments, a courtesy communication from the responsible DOE field office manager is provided to the designated representative for each affected state. The notification is provided in keeping with the spirit of consultation and co-operation described in the Nuclear Waste Policy Act of 1982. The approximate dates, duration, and number of shipments are provided. Also, the preferred routes are specified, but may be renegotiated by state officials to be in agreement with local preferences.

Major procurement activities were initiated by Virginia Power at the start of the DOE/VP/EPRI co-operative agreement, in order to supply the storage casks for the program. Three storage casks were procured from different vendors and transported empty to the DOE at the INEL. Also, it was necessary to lease shipping casks for the proposed spent-fuel shipments. Two NRC-licensed spent-fuel shipping casks, as specified in Transnuclear

(TN) TN-8L Certificate of Compliance USA / 9015B( )F were utilized to transport the spent fuel. Each cask, with a capacity of three PWR fuel assemblies, was hauled on TN-supplied trailers.

The spent-fuel shipping casks, transported by highway from both loading sites to the INEL, utilized diesel units supplied by an Interstate Commerce Commission (ICC)-licensed shipping contractor, Tri-State Motor Transit Company. Overweight permits for the 50,802.35 kg (112,000 pound) combined units were required. The shipments followed the state-preferred highway routes as specified in the transportation plan.

Cask loading and transporter activities at both the Surry Power Station (SPS) and Nevada Test Site (NTS) facility were performed in accordance with applicable transportation and safety regulations. The documentation for each shipment was prepared, reviewed, and approved in accordance with 49CFR. Prior to each shipment leaving a loading site, a DOE-ID / EG&G Idaho, Inc. representative reviewed and signed the paperwork, accepting title to the fuel and shipment responsibility.

Notifications for each shipment were made by the DOE-ID / EG&G Idaho, Inc. traffic representative to the INEL receiving facility and the DOE Transportation Manager in Washington, D.C.

Meetings with state officials in the originating states were conducted to apprise them of intended shipments and key facts associated with the shipments. Periodic review meetings were also held with the carrier, shipping cask representatives, and DOE / EG&G Idaho / VP traffic personnel to discuss overall transport equipment readiness, procedures for driver activities, tractor / trailer permits, backup equipment, route conditions, and handling of shipping papers / permits.

For shipments from the SPS to the INEL, estimates of average round-trip times ranged from 12 to 14 days, depending upon the travel route used. Actual experience was 17 days for campaign #1, 13 days for campaign #2, and 11 days for campaign #3.

The reduction in round-trip times resulted from optimization of the travel route; changing to back-to-back shipments, so that crews and shipping casks were available for continuous loading and unloading, to provide a more cost-effective and efficient operation; and reduced handling times at SPS and the INEL, as workers became more familiar with their tasks. At SPS, in particular, cask loading times were reduced from 30 hours to 15 hours. The trip from SPS to the INEL averaged three days during campaign #3.

A substantial effort was made to ensure tractor and trailer readiness prior to each shipment from the SPS. A local contractor was retained to provide inspections, maintenance, and repairs, if necessary. SPS quality control personnel performed incoming and outgoing inspections, and Virginia State Police hazardous material personnel performed outgoing inspections. Similar arrangements were established for the shipments from the NTS.

Comprehensive planning, attention to details, communications networks, and compliance with establishing requirements resulted in a relatively trouble-free series of shipping campaigns, with 86 spent-fuel assemblies received at the INEL.

Conclusion

The cask performance and testing demonstrations, along with the long-distance transportation of a large number of spent fuel assemblies are considered a success story. The evaluation and implementation of applicable requirements, industry perspective, and extensive planning all contributed to this achievement.

Acknowledgements

Prepared for the U.S. Department of Energy, Idaho Operations Office, under DOE contract no. DE-AC07-76IDO1570.

References

1. U.S. Department of Energy, Idaho Operations Office, DOE Order ID-1540.1. Material Transportation and Traffic Management, 1982.
2. U.S. Department of Transportation. Code of Federal Regulations, CFR49 Transportation. Revised annually. Parts 100–199.