SPENT FUEL STORAGE TECHNOLOGY DEMONSTRATIONS AT THE IDAHO NATIONAL ENGINEERING LABORATORY[a]

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ABSTRACT

Spent nuclear fuel research and development activities are conducted in accordance with Section 218 of the 1982 Nuclear Waste Policy Act (NWPA). The major objectives of the act are to encourage and expedite the efficient use of existing storage facilities and the addition of new at-reactor storage capacity through:

- o A cooperative demonstration program with the private sector to demonstrate spent fuel rod consolidation in existing water basins
- o Consultative and technical assistance to utilities on a cost-shared basis in anticipation of NRC licensing of on-site storage technologies
- o A cooperative demonstration program with the private sector to develop dry storage technologies that NRC can generically approve, and
- o A cost-shared dry storage research and development program at Federal facilities to collect the necessary licensing data.

The latter two objectives are encompassed by tasks being performed at the Idaho National Engineering Laboratory (INEL). Research and development programs at the INEL include the testing of metal storage casks containing either consolidated or intact spent fuel in inert gas atmospheres. The casks, weighing nearly 100 tons, are fabricated using nodular cast iron or forged carbon steel and contain basket assemblies which provide criticality control and spacing of fuel assemblies in individual cells. Small-scale rod consolidation systems are also being developed.

The Test Area North 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 in support of these spent fuel storage programs. The INEL site is located in Southeastern Idaho near Idaho Falls. These dry storage cask demonstrations support the Department of Energy Office of Civilian Radioactive Waste Management and NWPA objectives and will establish a data base which can be used for Nuclear Regulatory Commission licensing by generic rule of at-reactor dry storage cask installations. The latter will provide a significant expansion of at-reactor (on-site) spent fuel storage.

INTRODUCTION

The spent fuel testing program in planning or being performed at the Idaho National Engineering Laboratory (INEL) for the U.S. Department of Energy (DOE) comprises three major projects:

- o Virginia Power (VP)/DOE Cask Testing Project--performance testing of four storage casks
- o Nuclear Fuel Services, Inc., (NFS) Project--licensing and shipment of two loaded transportable storage casks
- o Prototypical Consolidation Demonstration Project (PCDP)--hot demonstration using production oriented rod consolidation equipment.

All three projects use commercial spent nuclear fuel in a dry testing environment at the INEL.

The testing programs will provide important technical data in two categories: cask performance testing and dry consolidation of spent fuel rods. Cask performance testing activities will provide engineering data during the VP/DOE project when the casks are tested with different cover gases while containing either intact or consolidated fuel. Also, cask performance and surveillance data will be obtained from the NFS transportable/storage cask project.

Dry consolidation of spent fuel rods will occur during the small-scale rod consolidation activities in the VP/DOE project and on a production-oriented scale during the PCDP.

VP/DOE Project

The purpose of the VP/DOE storage cask performance testing at INEL is to remove conservatism from the licensing of dry storage casks and provide a storage technology that is generically applicable so that the Nuclear Regulatory Commission (NRC) can license dry storage of spent fuel by rule. The VP/DOE cask testing project is a cooperative effort involving Virginia Power, DOE, and the Electric Power Research Institute. The cooperative agreement was established in 1984. The spent fuel assemblies are shipped from

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the Virginia Power Surry nuclear power station to the INEL using conventional licensed shipping methods. The testing at the INEL will include casks containing both consolidated and intact fuel. Decay heat generation rates for the selected fuel assemblies will total near the cask design limits. Thus, the casks may be tested above the NRC licensing limit. Data from the INEL testing will confirm storage cask performance, predictive modeling capabilities, and fuel integrity at prototypical storage conditions; and will provide operational data to support the economics studies of dry fuel storage. The technical objectives are developed by Pacific Northwest Laboratories (PNL), reviewed by the cooperative agreement participants, and implemented by EG&G Idaho at the INEL.

The VP/DOE project, which will last approximately four years, began in mid-1984. INEL site preparations, fuel receipt, and start of testing occurred in 1985. Storage cask testing with intact fuel will be concluded this year and cask testing with consolidated fuel will be completed in 1987. Completion of testing reports and termination of the project is scheduled for mid-1988.

NFS Project

The 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. The project will provide data for the railroad transportation of loaded spent fuel storage casks, using NRC licensing for the one-time shipment of each cask.

License applications for both casks are presently being processed at the NRC for Transnuclear, Inc., the manufacturer of the casks. For this project, the 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. Personnel from West Valley Nuclear Services and the West Valley Demonstration Project Office of DOE will prepare the West Valley facility and supervise the fuel loading operations in the West Valley pool.

After arriving at the INEL, the NFS Project casks, TN-BRP and TN-REG, will be placed directly on the INEL Test Area North (TAN) storage cask test pad for long-term monitoring and surveillance. The project began in early 1984 under a DOE contract with NFS for removal of the spent fuel from the West Valley pool. NFS in turn contracted with Transnuclear, Inc., for two large transportable storage casks, one to hold 85 boiling water reactor (BWR) assemblies (stacked in two layers) and one to hold 40 pressurized water reactor (PWR) assemblies. A summary of cask information for these two casks is provided in (Table I.) Ownership of the fuel will transfer from NFS to DOE following cask loading at West Valley. Project completion is planned for October 1986.

Prototypical Consolidation Demonstration Project

The PCDP will demonstrate production-scale spent fuel rod consolidation in a dry environment at the TAN facility. The consolidation equipment developed during this project will provide the design bases for future equipment to be used at high-level waste repositories or the proposed Monitored Retrievable Storage facility. This project will expedite the engineering development and demonstration of prototypical dry rod consolidation equipment and associated handling equipment. It will be developed under a competitive design

TABLE I

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 (tons)	100	100
Nominal length (ft)	16.5	16.5
Nominal diameter (ft)	8.5	8.5
Maximum dose rate at 2 m (mR/h)	10	10
Heat load (kW)	Less than 5	Less than 5
Cover gas	Nitrogen	Nitrogen

effort by the private sector and tested at the INEL, using spent fuel assemblies acquired for the demonstration.

To obtain private-sector involvement, a single, four-phase request for proposal (RFP) is being 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 those used in the light water reactor industry. The competitive design with private sector involvement is in progress with completion of the hot demonstration projected for mid-1989.

ACCOMPLISHMENTS AND STATUS

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

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 October 1986.

Progress in the NFS Project included completion of the manufacturing of the TN-BRP and TN-REG casks in 1985 and delivery of the casks to West Valley, New York. Processing of the applications for NRC licensing of the casks for one-time shipments is also in progress. Current plans are to load and ship the associated NFS fuel from West Valley before the end of September 1986.

VP/DOE storage cask testing and demonstrations are progressing on schedule. The INEL TAN facilities were modified to accommodate the remote transfer of spent fuel in 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 test pad was constructed near the hot shop for storage of loaded fuel casks. Storage will be in an open environment with appropriate monitoring and surveillance.

The GNS Castor V/21, the first storage cask, 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 was loaded with spent fuel in July and August of 1985. The dual-cask workstand in the TAN-607 facility hot shop is shown in Fig. 1. The GNS Castor V/21 storage cask is shown (Fig. 2) during testing in the horizontal position in the TAN warm shop. Short-term monitoring and testing was completed in September 1985.

The GNS Castor V/21 is designed for a heat load of 26 kW and will hold 21 fuel assemblies. The cask can accommodate intact fuel assemblies or consolidated rod canisters.

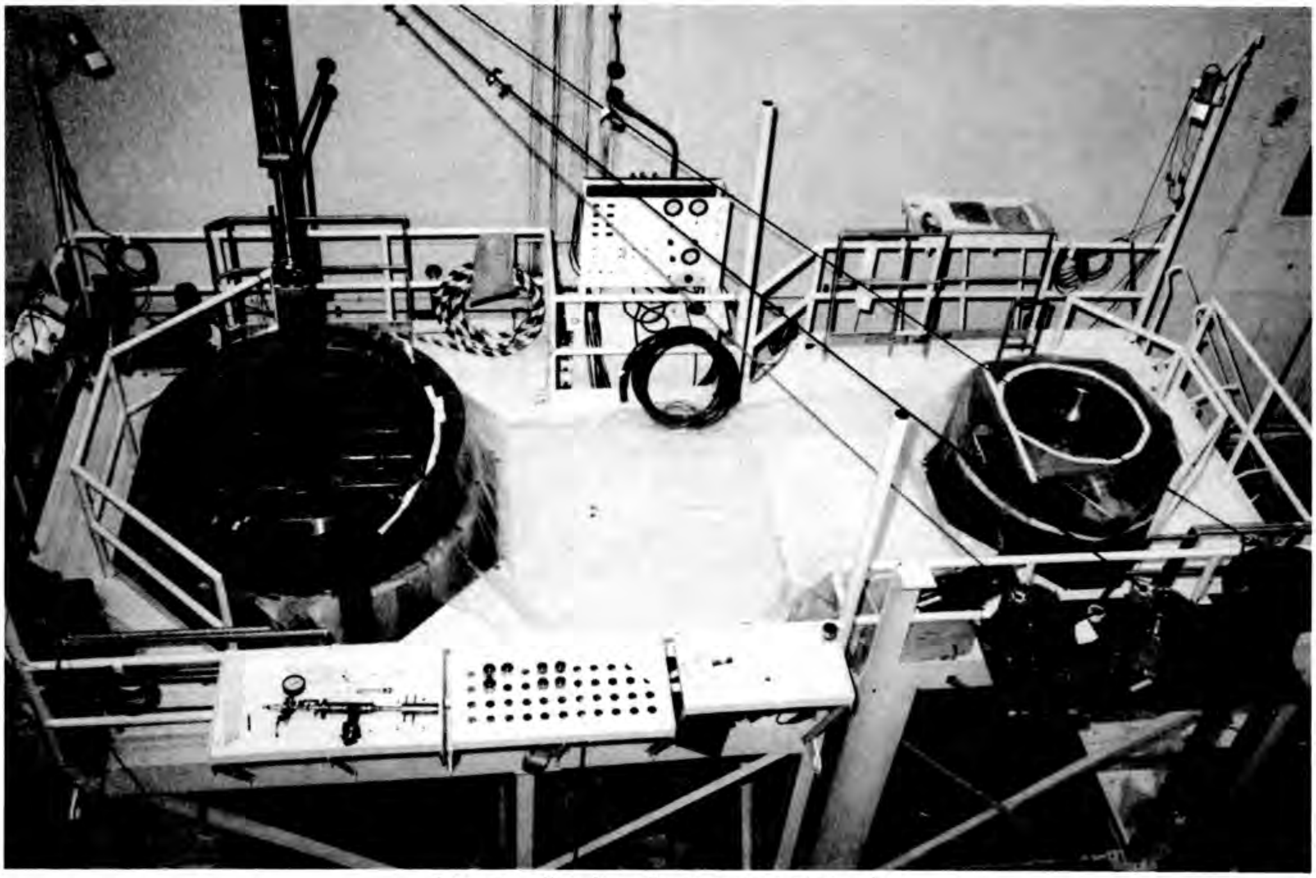

Fig. 1. Hot Shop Dual-cask Workstand.

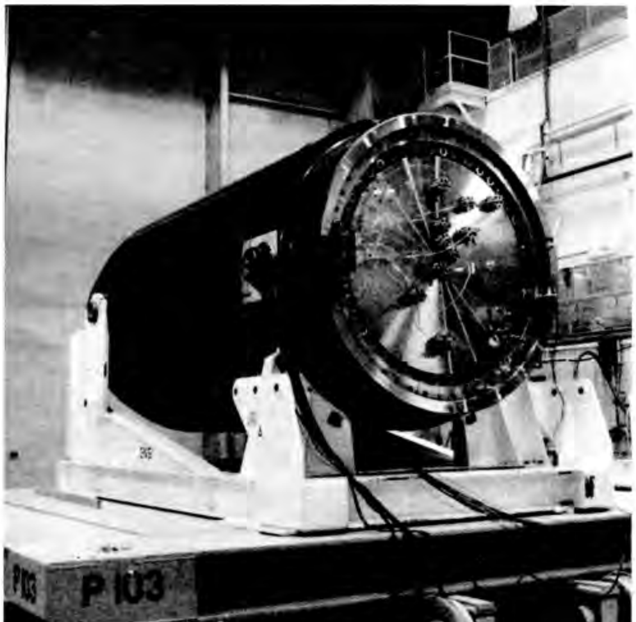

Fig. 2. Horizontal Testing of First Storage Cask (Castor V/21).

The second cask, TN-24P, arrived in October 1985 and loaded in November through December of 1985. Similar testing with intact fuel is currently being conducted. 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 conditions. The TN-24P cask (Fig. 3) will be placed on the test pad in the spring of 1986.

The third storage cask, the Westinghouse MC-10, which is planned to be received in March 1986, is shown in Fig. 4. This cask is designed for a heat load of 24 kW and will hold 24 fuel assemblies or consolidated rod canisters. Preparations are in progress for receiving, loading, and testing this cask. Completion of loading and testing is planned for the spring and early summer of 1986.

The fourth storage cask has not yet been designated for the VP/DOE cooperative agreement. If the fourth cask is authorized for the program, it will be needed by late 1987. Dry storage cask features for the GNS Castor V/21, TN-24P, and Westinghouse MC-10 storage casks are shown in Table II.

VP/DOE CASK TESTING

Where possible, testing of the VP/DOE storage casks is structured for testing to the design limits

Fig. 3. Second Storage Cask (TN-24P).

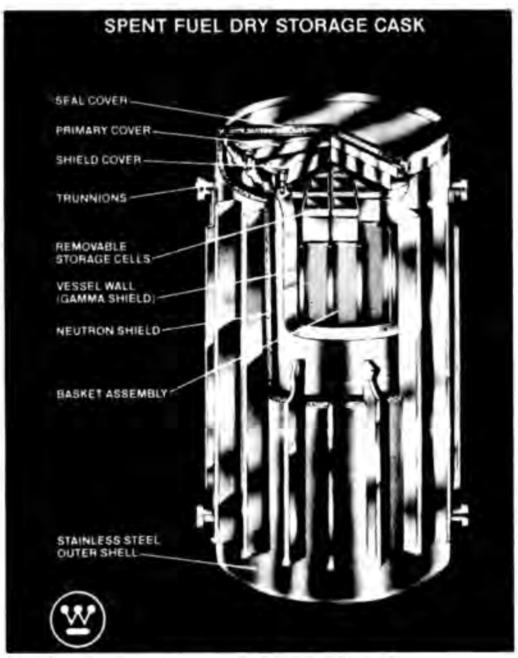

Fig. 4. Third Storage Cask (MC-10).

of the cask. Thus, performance testing at the INEL may be in excess of the parameters identified for NRC licensing of a particular cask and will provide a basis for removing conservatism from the associated licensing process.

Each loaded storage cask will be tested to verify thermal code predictions relative to cover gas or vacuum conditions within the cask, measuring both internal and external temperatures. This testing is performed for each cask with vacuum, helium, and nitrogen cover gases with the casks oriented in both the horizontal and vertical positions. The operational data are shown in Table III. Radiation measurements are compared to shielding (dose rate) predictions. The *containment* specifications are also verified. Cask testing will provide additional cask data and information, as shown in Table IV.

TABLE II

Dry Storage Cask Design Features

Design Features	GNS Castor V/21	TN-24P	Westinghouse MC-10
1. Maximum weight on crane hook (tons)	115	100	100
2. Capacity	21 PWR	24 PWR	24 PWR
3. Proposed licensed heat generation capacity (kW)	21	24	24
4. Overall length (ft)	16	16.5	16
5. Outside diameter (ft)	8	8	8
6. Materials of construction	Nodular cast iron	Forged steel	Forged steel
7. Neutron shielding	Polyethylene	Borated plastic	Borated plastic

TABLE III

Anticipated Operational Data for Spent Fuel Storage Cask (vertical)

Data	Respective Cask Values		
	GNS Castor V/21	TN-24P	Westinghouse MC-10
Maximum temperature (°F)a			
Outer cask body	201	237	221
Inner cask body	237	285	248
Basket	640	601	357
Seal leak rate (atm-cc/s)	1 E-06	5 E-07	1 E-04
Pressure			
Interlid or overpressure chamber (psia)	101.5	--	--
Cover gas (psia)	11.6	17.6	22
Dose rate (mR/h) at 3 ft	13.0	5.0	15

a. With solar insulation.

In addition, limited fuel integrity examinations have been performed. This examination provides some data relative to fuel integrity, crud appearance/characteristics, and the typical phenomenon of elevation differences in fuel rods that occurs during reactor operation. Inspection of fuel rod growth in irradiated fuel assemblies provides evidence of random elevation differences of several rods in each inspected assembly (Fig. 5).

SUMMARY AND CONCLUSIONS

Temperature profiles and other data collected for the casks which have been tested support the code estimates and design predictions for the casks. Particularly, the PNL HYDRA temperature code predictions agree very closely with measured data. Dose rate measurements also are in good agreement with the cask

TABLE IV

Dry Storage Monitoring Program Cask Data Provided

Cask Testing Elements

- o Mechanical integrity of the cask
- o Heat removal
- o Radiation shielding
- o Heat generation rate of the fuel
- o Monitoring requirements
- o Handling procedures
- o Decontamination requirements
- o Validate cover gas integrity
- o Validation of thermal and shielding codes
- o Consequences of system failures

Fig. 5. Irradiated Fuel Rod Inspection.

manufacturers' predictions. PNL is analyzing the data for inclusion into the test report for the first storage cask and the final program report. Preliminary data for the first storage cask test is shown in Table V. The testing information for this cask will be in the above reports.

Typical temperature and dose rate profiles for the GNS Castor V/21 storage cask are shown in Figs. 6 and 7.

The cask testing performance data will be used to support Virginia Power licensing activities, provide a basis for NRC licensing by rule of on-site dry storage cask installations, provide an information base which will aid cask designers with design improvements, and permit evaluation and qualification

TABLE V

Preliminary Testing Data for First Storage Cask

Cask Temperatures

Run No.	Cask Orientation	Backfill	Measured Peak Guide Tube Temp., °C	Estimated Peak Clad Temp., °C
1	Vertical	Helium	347	352
2	Vertical	Nitrogen	358	368
3	Vertical	Vacuum	414	424
4	Horizontal	Helium	360	365
5	Horizontal	Nitrogen	395	405

Cask Dose Rates

(Portable instruments)

Top: γ - 2 to 44 mR/h
n - 5 to 50 mR/h

Side: γ - 3 to 140 mR/h
n - 3 to 20 mR/h

Bottom: γ - 8 to 30 mR/h
n - 4 to 70 mR/h

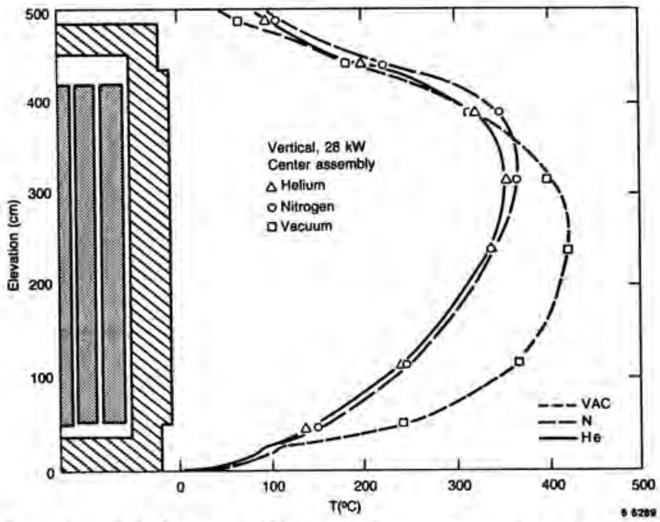

Fig. 6. GNS Castor V/21 Axial Temperature Profiles.

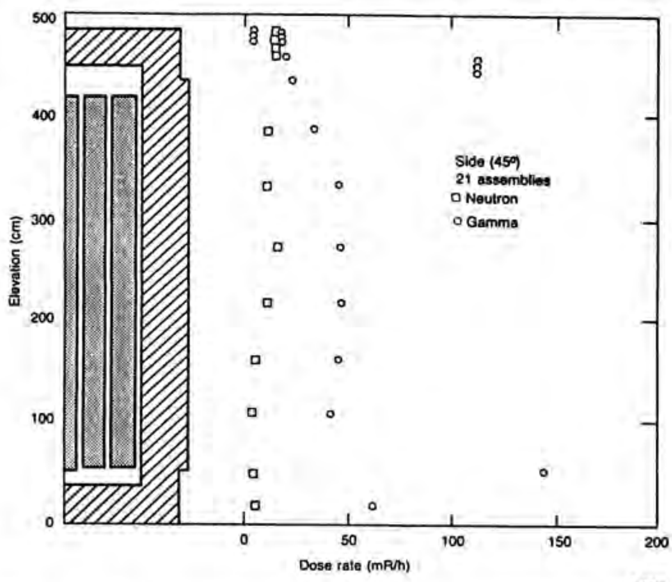

Fig. 7. Gamma and Neutron Dose Rates on GNS V/21 Side.

of applicable computer codes. The dry storage cask installation at the Virginia Power Surry Station, already in progress, may be a forerunner of many such installations for the expansion of on-site storage capability by other utilities.

In conclusion, the spent fuel testing and storage demonstrations at the INEL will enhance the overall dry storage technology data base. The initial results from the GNS Castor V/21 testing indicate that the shielding and thermal performance of the cask are good. Cask performance testing with the casks loaded with consolidated rod canisters will further support the verification of the performance modeling. It is postulated that future cask designs will be able to use the code predictions with confidence.

Rod consolidation activities scheduled to be performed in 1987 at the INEL will add to the current dry cask storage technology data base. This testing will use two of the casks previously tested with intact fuel.

The NFS Project transportation/storage cask activities will likewise add to the data base for railroad shipments and provide storage cask monitoring and surveillance information.

The PCDP will broaden the engineering information associated with production-scale rod consolidation operations and provide valuable information/insight on design needs for future DOE installations.

Although extensive details regarding each program cannot be presented in detail herein, specific cask data or related information can be discussed in separate meetings or obtained from the participants.