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SPENT FUEL STORAGE CASK TESTING  
AND OPERATIONAL EXPERIENCE AT THE  
IDAHO NATIONAL ENGINEERING LABORATORY

TITLE

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SPENT FUEL STORAGE CASK TESTING  
AND OPERATIONAL EXPERIENCE AT THE  
IDAHO NATIONAL ENGINEERING LABORATORY\*

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ABSTRACT

Spent fuel research and development demonstrations and associated transportation activities are being performed for DOE's Office of Civilian Radioactive Waste Management (OCRWM) as a part of the Storage Cask Performance Testing Programs. The cask testing program at Federal sites and other locations supports the Nuclear Waste Policy Act (NWPA) and Department of Energy (DOE) objective for cooperative demonstrations with the cask vendors and utilities for development of at-reactor dry cask storage capabilities for spent nuclear fuel assemblies.

Research and development programs for storage cask performance testing and operation were conducted for the DOE and the Electric Power Research Institute (EPRI) by the Pacific Northwest Laboratory (PNL), operated for DOE by Battelle Memorial Institute, and the Idaho National Engineering Laboratory (INEL), operated for DOE by EG&G Idaho, Inc. (EG&G Idaho). Testing was conducted at the INEL's Test Area North (TAN) cask-testing facility and consisted of pretest preparations, performance testing, and post-test activities. TAN 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 facilities needed to receive and store commercial spent fuel assemblies.

PROGRAM INFORMATION

The Spent Fuel Programs completed or being performed at the INEL for DOE are comprised of:

- Performance testing of three metal fuel storage casks for the VP/DOE Cooperative Agreement
- Performance testing of a ventilated concrete storage cask for the PSN/DOE Cooperative Agreement
- Licensing and shipping of two loaded transportable/storage casks for the NFS Project

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These dry storage cask demonstrations support OCRWM and NWA objectives and will establish a data base which can be used for NRC licensing by generic rule of at-reactor dry storage cask installations.

#### METAL STORAGE CASK PERFORMANCE TESTING

The first research and development program for storage cask performance testing involved metal storage casks and was initiated through a cooperative agreement between Virginia Power (VP) and DOE in 1984. Three different metal casks, the Gesellschaft fur Nuklear Service (GNS) CASTOR-V/21, Transnuclear TN-24P, and the Westinghouse MC-10 were tested with intact spent fuel.

The primary objective of cask performance testing was to obtain heat transfer and shielding data and limited spent fuel integrity data needed to support at-reactor licensing efforts. Other objectives of the testing effort are to provide data to other utilities: gain cask-handling experience; identify candidate cask design improvements; and obtain heat transfer and shielding data for computer code evaluations. The spent fuel assemblies used during testing were of a standard Westinghouse 15x15 rod design which was the fuel type used in all three of the metal cask tests.

#### GNS CASTOR-V/21

The GNS V/21 PWR spent fuel storage cask consists of a nodular cast-iron body. The cast-iron/graphite material exhibits good strength and ductility and provides effective gamma shielding. Two concentric rows of polyethylene rods are incorporated in the cask wall to provide neutron shielding. The external surface consists of heat transfer fins oriented circumferentially around the cask surface. The fuel basket within the cask is configured to hold 21 PWR spent fuel assemblies and is constructed of stainless steel and borated stainless steel for criticality control. The cask is closed with two lids having both elastomer and metallic O-rings to seal the cask cavity from the environment.

#### Transnuclear TN-24<sup>1</sup>

The TN-24P spent fuel storage cask consists of a forged steel body for structural integrity and gamma shielding, surrounded by a resin layer for neutron shielding. The resin layer is enclosed in a smooth steel outer shell. The fuel basket within the cask is configured to hold 24 PWR spent fuel assemblies and is composed of stacked, interlocking plates constructed of aluminum and boron.

#### Westinghouse MC-10

The Westinghouse cask is a low alloy steel shielded container with forged steel walls and bottom to provide structural integrity. The capacity of the MC-10 is 24 PWR intact spent fuel assemblies. Shielding is provided by the thick wall of low alloy steel for gamma radiation absorption and by solid hydrogenous material and borated material for neutron absorption. Control of criticality is provided by neutron-absorbing material located in inserts placed in each basket cell. Passive heat removal is provided by a

heat-conducting matrix of grid plates in the cask interior and heat dissipation to the ambient environment at the cask exterior by convection and thermal radiation.

### GNS CASTOR-V/21 Performance Testing Summary

This section summarizes the heat transfer, shielding, and performance test results on the GNS CASTOR-V/21 storage cask. Due to time constraints test results for only the GNS V/21, with intact fuel, will be presented in this paper.<sup>2</sup>

Based on pretest ORIGEN2 predictions, fuel assembly decay heat generation rates totaled approximately 28 kw at the start of testing. Thirteen of the 21 fuel assemblies were loaded in the cask with the hot assemblies in the outer regions of each quadrant. The cask test matrix included assessments of performance in the vertical and horizontal cask orientations, and vacuum, nitrogen, and helium backfill environments. Pretest heat transfer predictions using the HYDRA computer program indicated that peak cladding temperatures in nitrogen and helium would be below or near 380°C.

The outer surface of the cask was instrumented with 35 thermocouples (TCs), 69 gamma dose rate sensors, and 69 neutron dose rate sensors. Sixty TCs contained in ten lances (tubes) were inserted through the cask lid into fuel assembly guide tubes or basket void spaces. Of the ten TC lances, 8 were inserted into fuel assembly guide tubes, and two were positioned in basket void spaces.

In the vertical cask orientation with nitrogen and helium backfills, peak cladding temperatures were less than the 380°C expected. This was also the case for the horizontal helium test run. The vertical vacuum and horizontal nitrogen test runs resulted in peak cladding temperatures over 380°C, but not exceeding 425°C. In general, the cask heat transfer performance was concluded to be exceptionally good, exceeding design expectations.

Gamma and neutron dose rates were measured on the top, side, and bottom of the cask. A peak gamma dose rate of 56 mrem/hr was measured on the top of the primary lid. The total dose rate (gamma plus neutrons) was approximately 85 mrem/hr at the center of the primary lid. The total dose rates along most of the cask side were less than 50 mrem/hr. There were localized peaks in the gamma and neutrons dose rates of up to 140 mrem/hr and 21 mrem/hr, respectively. The neutron dose rate peaks were relatively low, but the gamma peaks were substantial. The localized peaks occurred at locations adjacent to fuel assembly upper and lower end fittings. However, minor refinements in the gamma shielding design at locations corresponding to the dose rate peaks could reduce the gamma peaks significantly. The overall shielding performance of the CASTOR-V/21 cask was good and met the intended design goal of  $\leq 200$  mrem/hr, even though the test fuel had a higher source strength than fuel considered in the topical safety analysis report. With a very minor refinement in the gamma shielding design, total dose rates could easily be reduced to less than 75 mrem/hr.

The results of the cask operational performance permit the following conclusions:

- The CASTOR-V/21 cask can be satisfactorily handled in many reactor facilities. Only minor modifications to the supplied handling equipment and procedures were required to conduct testing at TAN.
- The dual elastomer/metallic O-ring sealing technique used in the CASTOR-V/21 cask performed exceptionally well during many repetitive on/off lid operations.
- Approximately 1 hour was required to pump the cask down to 1 mbar. During a double pumpdown/backfill operation, measured guide tube temperatures increased by  $<20^{\circ}\text{C}$  during a 2-hour period.
- The total personnel radiation exposures during handling, loading, and testing of the cask were relatively low, being approximately 1.8 man-rem.

### TN-24 Performance Testing with Consolidated Fuel<sup>3</sup>

Performance testing of a TN-24P PWR spent fuel storage cask, loaded with 24 Dry Rod Consolidated Technology consolidated fuel canisters<sup>4</sup>, was exceptionally good, as indicated by acceptable peak cladding temperature ( $<340^{\circ}\text{C}$  allowable for the fuel cladding and the  $<375^{\circ}\text{C}$  cask design goal for 24 kw). The shielding performance met design expectations ( $<60$  mrem/hr), with the exception of the bottom of the cask. Dose rates of  $<60$  mrem/hr could be easily established with minor neutron shielding design refinements on the bottom of the cask if desired.

From both heat transfer and shielding perspectives, the TN-24P cask can, with minor refinements, be used effectively to safely store consolidated spent fuel at reactor sites and central storage facilities.

### Metal Storage Cask Testing Summary

Performance testing of the three metal storage casks with intact fuel were successfully completed at TAN. The tests demonstrated that the casks could be satisfactorily handled and loaded dry. The overall shielding performance of the casks were good and with minor gamma and neutron shielding design refinements could meet the design expectations. The heat transfer performance of the casks were exceptionally good, as indicated by acceptable peak cladding temperatures. All three casks can, with minor refinements, be used effectively to safely store spent fuel at reactor sites and central storage facilities.

### Pacific Sierra Nuclear VSC-17 Concrete Storage Cask

Since the development and testing of large metal spent fuel storage casks studies have suggested that concrete, instead of metal, storage casks may be more economical and technically desirable. Therefore, it has been

decided to conduct testing on concrete casks to technically evaluate the benefits of concrete as a storage cask material and to assist in licensing activities for private contractors.

In March of 1987, the DOE requested PNL to assist them in the procurement of storage casks for testing. The methodology for pursuing this activity was cooperative agreement whereby cask vendors were solicited to supply cask systems for testing. In September 1988, a contract was entered into with Pacific Sierra Nuclear Associates (PSN) to supply a Ventilated Storage Cask (VSC) that holds 17 PWR assemblies or consolidated fuel canisters.

The cask will be tested to determine heat transfer and shielding performance. PNL will perform pretest predictions prior to testing to evaluate computer codes and analysis methods.

Testing is scheduled to be completed in FY-1990. EG&G will transmit the test data to PNL for reduction and analysis. The reduced data along with a description of the cask, consolidated fuel, and test procedures will be documented in a formal EPRI final report. EG&G will assist in preparation of the report and be coauthors.

#### NFS Spent Fuel Shipping/Storage Cask Demonstration

The purpose of the Nuclear Fuel Service (NFS) Transportable Storage Cask Demonstration Project is to demonstrate the feasibility of packaging, transporting, and storing commercial spent fuel in the same dry storage cask. Three specific objectives have been defined by the Department of Energy, Office of Systems Integration and Regulation: (a) remove the NFS fuel from the storage pool at West Valley where it is currently stored; (b) demonstrate that fuel can be stored in large-capacity storage casks; and (c) demonstrate that Nuclear Regulatory Commission (NRC) Certificates of Compliance (CoCs) can be obtained to use the same cask for storage and shipping.

DOE-ID entered into a contract with NFS to conduct this demonstration. NFS supplied fuel (stored at West Valley) and two specially designed casks. The casks are designated TN-BRP, which holds 85 BRP boiling water reactor assemblies, and TN-REG, which holds 40 REG pressurized water reactor assemblies. Design and fabrication of the casks began in FY-1984 and the cask were completed in FY-1985. NFS's contribution to the project is complete.

DOE is seeking NRC Certificates of Compliance (CoC) for shipping the casks. In FY-1986, Transnuclear, Inc. (TN), supplier of the casks, under contract to EG&G Idaho and at the direction of DOE-Headquarters (DOE-HQ), submitted Safety Analysis Reports (SARs) to NRC on behalf of DOE. NRC reviewed the TN-BRP SAR and identified a number of technical issues to be resolved. These were subsequently resolved through extensive testing and analysis. The TN-BRP CoC was issued on July 10, 1989. The TN-REG SAR has been revised to resolve the same issues for TN-REG and was submitted to NRC

on September 1, 1989. One key requirement for certification is that the casks be shipped half full of fuel with structural supports placed in the empty fuel baskets slots.

The schedule for shipping is being assessed by DOE-HQ; however, shipments will not be made in FY-1990. When the casks are shipped, each cask will be shipped twice, with half a load of fuel in each shipment. Fuel from the first shipment will be removed from the casks in the TAN Hot Shop and placed in interim storage in the TAN silo and TN-24 storage cask. The empty casks will be returned to West Valley and loaded half full with the remaining fuel. The casks will then be returned to the Hot Shop and the fuel in interim storage will be returned to fill the casks. The casks will then be moved to the test pad for long-term testing and storage demonstration.

#### REFERENCES

1. EPRI NP-5128, "The TN-24P PWR Spent-Fuel Storage Cask: Testing and Analyses".
2. EPRI NP-4887, "The CASTOR-V/21 PWR Spent-Fuel Storage Cask: Testing and Analyses".
3. EPRI NP-6191, "Testing and Analyses of the TN-24P PWR Spent-Fuel Dry Storage Cask Loaded with Consolidated Fuel".
4. EGG-WM-8059, "Dry Rod Consolidation Technology Project at the Idaho National Engineering Laboratory".