IMPLEMENTATION OF DOE'S SPENT FUEL PROGRAM:
A FIRST ANNIVERSARY REPORT

D. F. Newman and B. M. Cole
Pacific Northwest Laboratory
Operated for the U.S. Department of Energy
by Battelle Memorial Institute
Richland, Washington

ABSTRACT

The instrument for carrying out Department of Energy (DOE) actions with respect to spent fuel storage in the next decade and a half will be the Commercial Spent Fuel Management Program. This paper reviews the accomplishments of the CSFM Program in the last year, the status of ongoing activities, and the schedule for the availability of dry storage and rod consolidation as licensed options for utility deployment. The plans and strategy for meeting DOE's obligations, stemming from the NWPA, are described. These cover performing cooperative licensed demonstrations of dry storage and rod consolidation technologies with utilities, conducting spent fuel R&D to expedite utility licensing efforts for these new technologies, and implementing Federal Interim Storage as needed.

INTRODUCTION

The DOE Program on Commercial Spent Fuel Management (CSFM) includes responsibility for implementing the provisions of the Nuclear Waste Policy Act (NWPA)[1] regarding research, development and demonstrations (RD&D) for storage of spent fuel (Section 218 of the Act) and providing Federal Interim Storage capacity as needed (Section 135 of the Act). The Pacific Northwest Laboratory, operated by Battelle Memorial Institute for the DOE, has the responsibility for managing the program.

In Section 131 of the Act, Congress found that the owners and operators of nuclear power plants have the primary responsibility for providing storage of spent fuel by maximizing, to the extent practical, the use of existing at-reactor capacity. The DOE has the responsibility to encourage and to expedite the use of, and additions to, that capacity. To ensure the continued orderly operation of these reactors, the DOE also has the responsibility to provide Federal Interim Storage (FIS) capacity for the spent fuel, which the Nuclear Regulatory Commission (NRC) determines the utility cannot provide despite their best efforts.

For several years, utilities have been assessing their spent fuel storage situation and analyzing the storage options currently available to them while monitoring those new technologies under development, which may become licensed options in the near future. The CSFM Program has developed estimates of the storage requirements[2] for spent fuel that has, and will be, discharged from light water reactors (LWRs) based on information supplied by the utilities. Figure 1 shows the most recent estimates of the amount discharged and the additional requirements.

As additional storage capacity is needed at reactor sites, beyond that available by reracking existing water basins and intra-utility transshipments, new storage concepts: rod consolidation and dry storage technologies, will be employed. The near-term storage requirements identified before 1986 will be provided through dry storage research and development (R&D) that will be conducted at the DOE's Idaho National Engineering Laboratory (INEL) facilities (TAN-607) starting this year.

The objective of DOE's RD&D activities is to establish one or more technologies that the Nuclear Regulatory Commission (NRC) may, by rule, approve for use at the sites of civilian nuclear power reactors without the need for additional site-specific approvals. These activities[3] include participation in cooperative demonstrations of dry storage and rod consolidation technologies at reactor sites and development of the technical bases needed to license those new spent fuel storage technologies.

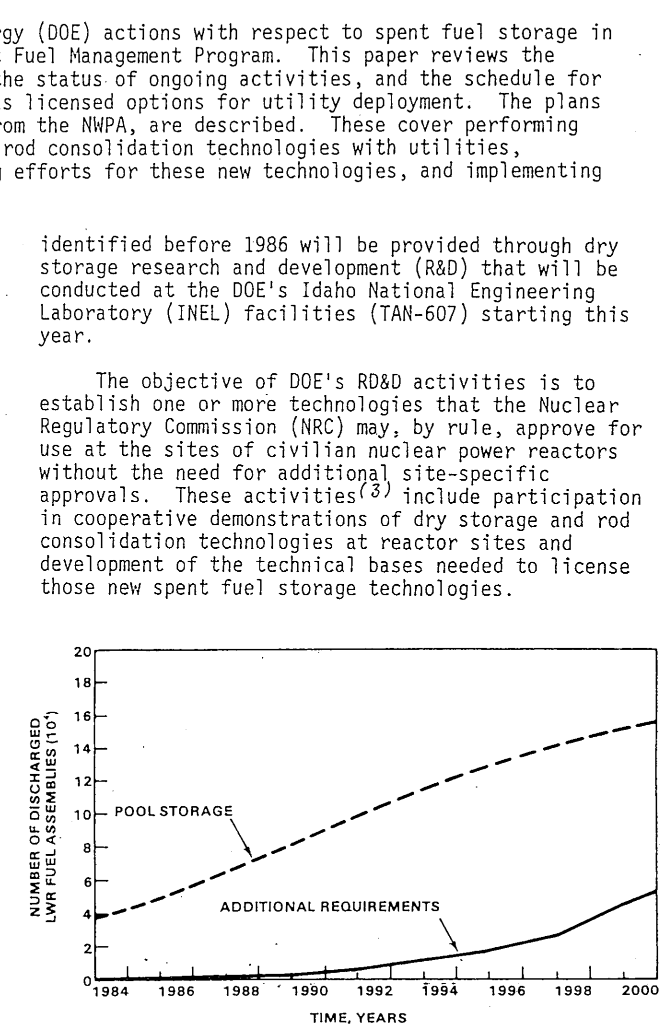

Fig. 1. Projected U.S. LWR Spent Fuel Inventory

TECHNICAL BASES FOR SPENT FUEL STORAGE

In February 1983, the CSFM Program issued an assessment of the characteristics and behavior of LWR spent fuel in dry storage.[4] This report documented the existing world-wide experience including safety analyses, fuel emplacement and retrieval, cover gas technology, and facility design and operation. A Dry Storage Design Standard, drafted by the ANS 57.9

working group, was in the final stages of review[5] and a consensus was developing that sufficient experience exists with dry storage casks for NRC to license them at reactors sites using a monitored inert cover gas maintained at a conservative temperature limit. The CSFM Program documented the technical basis for storing LWR spent fuel in inert gas below 380°C.[6]

The information needed to establish the technical bases for dry storage in air or in inert gas without monitoring is not yet available. Multiple coordinated R&D projects by DOE, NRC, and the utilities are underway to determine the allowable temperature for air storage. The principal concern is that air at sufficiently high temperatures may oxidize exposed UO_2 to U_3O_8. Since U_3O_8 has much lower density than UO_2, oxidation of spent fuel has the potential for propagation of cracks and mechanical splitting of the cladding. Through this process, U_3O_8 could be released from the cladding into the storage container, complicating future handling and packaging of the fuel.

A dry storage cask test is being conducted at the General Electric facilities in Morris, Illinois, (GE/MO) to provide data for licensing efforts; determine operating characteristics for spent fuel clad temperatures and radiation dose rates at the cask surface; obtain storage cask handling and decontamination experience; provide a data base for heat transfer, shielding, and decay heat computer code evaluations; and identify candidate dry storage system improvements. Prior to loading fuel in the cask, tools for attaching thermocouples on spent fuel bundles were designed and fabricated by PNL. The attachment device and the installation tool were then tested at GE/MO in air and underwater, to develop the methodology needed for remotely installing thermocouples. Initial handling of the REA-2023 dry storage cask owned by DOE was completed at the Allied General Nuclear Services (AGNS) facility in Barnwell, South Carolina, in June 1983. In December 1983, the REA cask was inspected and delivered to GE/Morris for the cask test. The test is being conducted under the R&D provision (10 CFR 72.35) of the existing license at GE/Morris and is scheduled for completion by the end of 1984.

An existing spent fuel calorimeter was modified to handle boiling water reactor (BWR) spent fuel from the Cooper Nuclear Station that will be used in the cask test, and to provide for more accurate measurement of gamma energy which escapes from the calorimeter. Thermal measurements were made on two long-cooled, low-burnup BWR spent fuel bundles from the Dresden Nuclear Station. Existing calorimetric measurements of the decay heat from 19 PWR assemblies from Turkey Point, San Onofre, and Point Beach were used to verify the decay heat generation rates calculated with the ORIGEN2 code[7] for pressurized water reactor (PWR) spent fuel.

Close coordination exists between the CSFM Program and the Electric Power Research Institute (EPRI) studies regarding surveillance of spent fuel in wet storage. The CSFM Program is determining the behavior of fuel rods with defective cladding that go from wet to dry storage, the possible influence of rod consolidation on the integrity of spent fuel during subsequent storage, and the influence of crud on fuel rod consolidation and wet storage operations. For example, the cladding temperature in a consolidated fuel assembly will be measured at TVA's Browns Ferry site and the aspects of rod consolidation operations on spent fuel integrity will be assessed.

ROD CONSOLIDATION DEMONSTRATIONS

Rod consolidation is a process that involves dismantling the fuel assembly and rearranging the spent fuel rods into a close-packed geometry in a storage canister. As a storage technology, rod consolidation has the potential to increase the existing water basin storage capacity by a factor of two. It is a relatively low-cost alternative for pools that have sufficient structural strength to safely support the added weight.

In the fall of 1982, a hot demonstration of removing the fuel rods from four PWR assemblies and consolidating the rods into two storage canisters was conducted by Duke Power at its Oconee station. Westinghouse equipment (shown in Fig. 2) was used for the disassembly and compaction operations. The next planned hot demonstration will be conducted under a cooperative agreement between DOE and the Tennessee Valley Authority (TVA). This will consist of the disassembly and compaction of 12 BWR spent fuel assemblies at the Browns Ferry station. This project is expected to be completed in 1984 using equipment and canisters built for DOE by AGNS based on Nuclear Assurance Corporation design specifications. The equipment was delivered to TVA in June of 1983. This test will be conducted under the R&D provisions (10 CFR 50.59) of the existing reactor license, as was the demonstration by Duke Power.

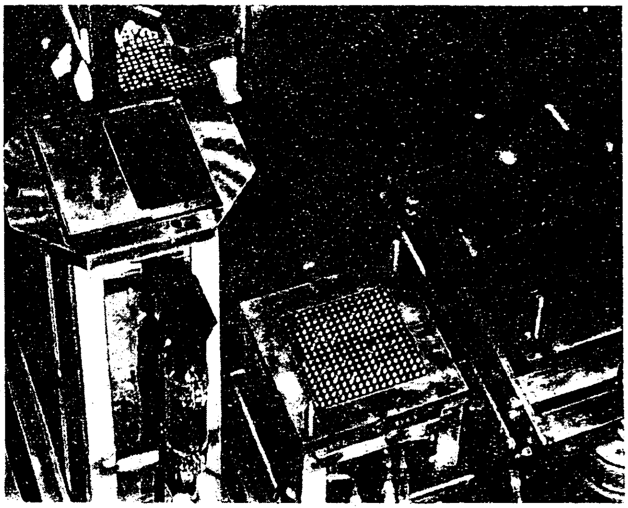

Fig. 2. Spent Fuel Rod Consolidation Equipment.

Another planned demonstration will also take a major step by licensing the existing water basin for storing maximum density consolidated fuel in the entire pool. This project is planned by Northeast Utilities (NUSCO) at its Millstone 2 plant, using equipment developed by Combustion Engineering. Currently the project is supported by EPRI and the Baltimore Gas and Electric. However, DOE has also announced its desire to *participate in this* demonstration and is in the process of negotiating a cooperative agreement with NUSCO. The first phase of the hot demonstration, involving the consolidation of 12 PWR assemblies at Millstone 2, is scheduled for completion in 1985.

The rod consolidation demonstrations will establish the technology as a licensed alternative for expansion of spent fuel storage capacity and provide utilities a basis for evaluating its economic incentives. In addition, rod consolidation could significantly reduce the cost of dry storage of cooled spent fuel by improving the utilization of space in the storage module (i.e., cask, silo, or drywell).

DRY STORAGE DEMONSTRATIONS

Dry storage technology can provide alternatives for additional spent fuel capacity at reactors that cannot increase pool storage due to seismic or structural constraints. Dry storage concepts can be cost competitive with wet storage. Dry storage also has the advantage of being added in smaller increments of capacity to meet needs as they occur. To confirm the potential of various dry storage concepts and to resolve some remaining uncertainties in exercising the licensing process, DOE is involved with several dry storage demonstrations, in cooperation with utilities.

Following the tests at GE/Morris in 1984, DOE's REA cask (shown in Fig. 3) will be used at the TVA's Browns Ferry station for a two-year licensed demonstration loaded with 52 unconsolidated BWR assemblies that have been cooled at least 5 years. Another two-year licensed demonstration will be conducted simultaneously at the same TVA facility using a CASTOR-1C nodular cast iron cask supplied by GNS from Germany. The GNS cask holds 16 unconsolidated BWR assemblies, but can dissipate the heat from spent fuel that has been in pool storage for as little as 1 year.

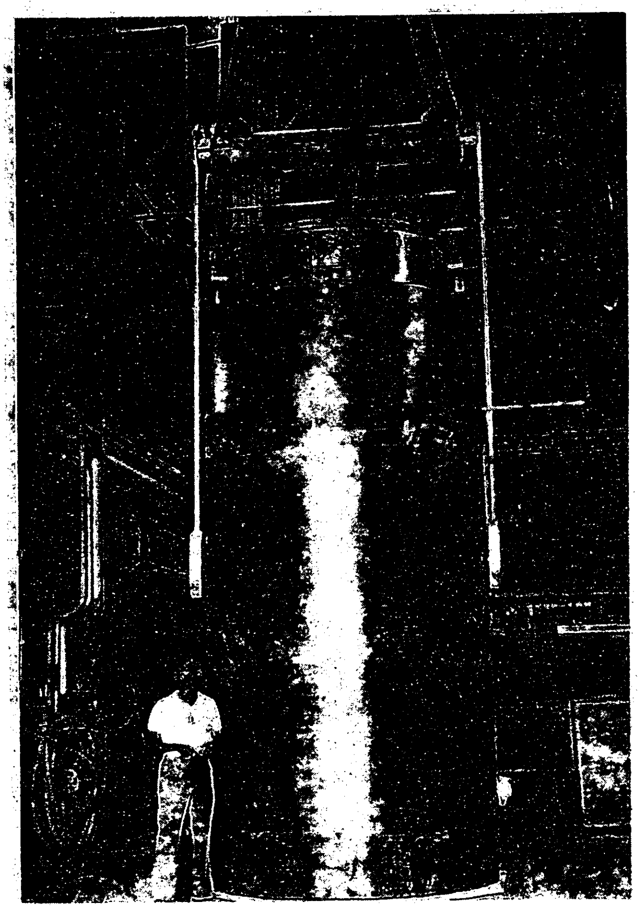

Fig. 3. REA-2023 Dry Storage Cask

In October 1983, DOE selected the Virginia Electric and Power Company (VEPCO) and Carolina Power and Light (CP&L) for negotiation of cooperative agreements to demonstrate dry storage concepts for PWR spent fuel. The program proposed by VEPCO includes the testing of four metal casks at a Federal site as well as the licensed demonstration of five metal casks at the VEPCO Surry station. The tests at the Federal site are scheduled to begin in 1984 and will include both intact and consolidated fuel using both helium and air cover gases at bounding conditions. Data from these tests will confirm storage system performance, predictive modeling capabilities, fuel integrity at prototypical storage conditions, and capital and operating costs. In addition, the VEPCO dry storage demonstrations at the Surry station will develop a licensing base, initially for conservative conditions, and later for consolidated fuel and air storage.

CP&L is planning to demonstrate licensed on-site dry storage with a unique concept (shown in Fig. 4) involving 3 horizontal concrete silos that will be constructed at the H.B. Robinson station in 1985. Each of these silos will store 7 PWR assemblies in a sealed canister that is cooled by natural convection air flow through the concrete storage module. The canisters are loaded in the spent fuel pool, filled with helium and loaded into the existing IF-300 shipping cask owned by CP&L for transfer into the storage modules. This dry storage system is expected to have a significant cost advantage over metal storage casks and can be integrated with shipping casks to facilitate removal of the spent fuel from the site in the future.

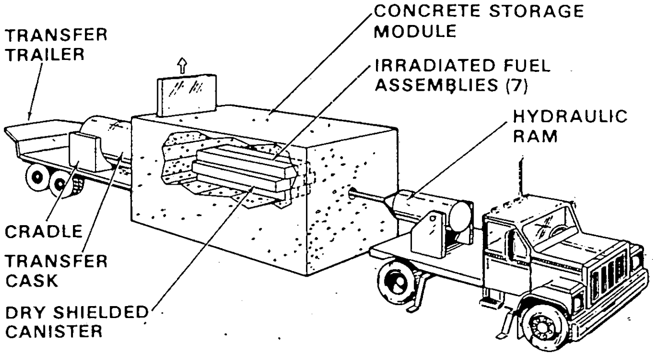

Fig. 4. CP&L Horizontal Silo Concept

FEDERAL INTERIM STORAGE

The NWPA required that a report be sent to Congress on or before July 7, 1983, defining the magnitude of the cost of providing FIS services and recommending a mechanism for collecting fees to be charged. The CSFM Program completed an FIS fee study in June and the report to Congress[8] was delivered on June 28, 1983. The actual fee schedule for this service was prepared by the CSFM Program and published in the Federal Register on December 2, 1983. This schedule became effective on January 1, 1984. The fee schedule will remain in effect for one year, at which time a new or adjusted fee will be established. The method of deploying or providing this service was reported to Congress[9] on January 9, 1984.

To this date, no utility has applied for FIS. Consequently no actions have been initiated with regard to site selection. If an application is received which DOE believes has a reasonable chance for NRC approval, the governors of those states containing acceptable storage sites will be notified and cooperative and consultation agreements will be established with the state government and any affected Indian tribes. Upon establishing successful agreements, site preparation will commence at a schedule required to accept spent fuel from the contracting utility.

CONCLUSIONS

The NWPA set a target date of January 31, 1998 for DOE to begin accepting spent fuel at reactor sites for ultimate disposition. For the period until 1998, the NWPA clearly states that the utilities have the primary responsibility for providing their own spent fuel storage capacity. DOE has the responsibility to expedite and encourage the effective use of existing storage facilities and to assist in adding new storage capacity at reactor sites through research, development and demonstration activities and through direct consultative and technical assistance. The emphasis of DOE's efforts is to expedite the development of rod consolidation and dry storage technologies so that utilities have licensed alternatives to provide storage capacity for their spent fuel as it is needed. For example, E.R. Johnson Associates has estimated[10] that rod consolidation and dry storage should be available as licensed options in the 1988-1990 time frame, based on current development plans. If a utility is delayed in licensing the construction of new storage capacity at their reactor site and NRC determines that the delay is beyond their reasonable control, DOE has developed plans to provide Federal Interim Storage capacity to permit continued orderly operations of the nuclear power plant.

REFERENCES

1. The Nuclear Waste Policy Act of 1982, as signed by the President on January 7, 1983 (Pub. L. 97-425, 96 Stat. 2201, 42 U.S.C. 10101 *et seq.*, referred to herein as "the Act").

2. Department of Energy, "Spent Fuel Storage Requirements," DOE/RL-83-1, Richland, Washington (January 1983).

3. R.W. Lambert, D.F. Newman, and J.W. Moegling, "Spent Fuel Research Development and Demonstration," *Proc. of Civilian Radioactive Waste Management Information Meeting*, Washington, DC, December 12-15, 1983 (CONF-831217).

4. A.B. Johnson, Jr., E.R. Gilbert, and R.J. Guenther, "Behavior of Spent Nuclear Fuel and Storage System Components in Dry Interim Storage," PNL-4189, Rev. 1, Pacific Northwest Laboratory (February 1983).

5. J. Nevshemal, "Status of Standards Development for Spent Fuel Activites," *Proc. of INMM Seminar on Spent Fuel Storage*, Washington, DC, January 10-13, 1984.

6. A.B. Johnson, Jr. and E.R. Gilbert, "Technical Basis for Storage of Zircaloy-Clad Spent Fuel in Inert Gas," PNL-4835, Pacific Northwest Laboratory (September 1983).

7. F. Schmittroth, "ORIGEN2 Calculations of PWR Spent Fuel Decay Heat Compared with Calorimeter Data," HEDL-TME-83-32, Hanford Engineering Development Laboratory (November 1983).

8. Department of Energy, "Payment Charges for Federal Interim Storage of Spent Nuclear Fuel from Civilian Nuclear Power Plants in the United States", DOE/S-0022 (July 1983).

9. Department of Energy, "Initial Implementation Plan for Deployment of Federal Interim Storage Facilities for Commercial Spent Nuclear Fuel," DOE/RW-0003, Office of Civilian Radioactive Waste Management, Washington, DC (January 1984).

10. O.P. Gormley and J.A. McBride, "Factors Affecting Federal Interim Storage Requirements," *Proc. of INMM Seminar on Spent Fuel Storage*, Washington, DC, January 10-13, 1984.