Developing a New Generation of Spent Fuel Casks

W.H. Lake

U.S. Department of Energy, Washington, DC, United States of America

INTRODUCTION

The Department of Energy (DOE) has been authorized under the 1982 Nuclear Waste Policy Act (NWPA), and its 1987 amendment to develcp a national program for the disposal of nuclear spent fuel and high level radioactive waste. One of the responsibilities derived from the NWPA is to provide a means of transporting the waste material from reactors to a final disposal site. In addition a temporary disposal facility might be used in the program. The NWPA places a number of significant requirements on DOE. These include use of private industry to the maximum extent possible, development of a transportation system that is not only safe, but efficient as well, and the stipulation that transport of spent fuel be subject to licensing and regulation of the Nuclear Regulatory Commission (NRC), and the Department of Transportation (DOT).

The Office of Civilian Radioactive Waste Management (OCRWM) has been established to carry out all DOE responsibilities under the NWPA, including waste transportation. The business aspects of the transportation system are described in the, "Transportation Business Plan" (1986). The "Transportation Institutional Plan," (1986), discusses the plans for interaction with parties interested in the program.

The transportation activities under the NWPA include two major phases, cask development, and transport operations. The cask development program has four initiatives. Initiative 1 covers development of spent fuel casks for shipment from reactors. The casks developed under initiative 1 will handle most of the radioactive waste to be shipped. Initiative 2 will be completed if a monitored retrievable storage (MRS) facility is developed. A third initiative covers the procurement of specialty casks for shipment of nonstandard fuel and radioactive hardware destined for repository disposal. The fourth initiative addresses development of defense high level waste casks.

The five cask contracts were awarded between February and July 1988. The contracts include two legal weight truck (LWT) casks (each contract having an option for development of an overweight truck (OWT) cask), and three rail/barge (R/B) casks. The strategy associated with selection and awarding of these contracts is discussed by Callaghan and Lake (1988).

The cask contracts are being managed by EG&G Idaho, Inc., through DOE's Idaho Operations Office. All of the contractors are well into the preliminary design phase. The status of the From Reactor cask design activity is described by K. Henry, and W. Lattin (1989). Based on current projected schedules, the cask contractors are expected to apply to the NRC for certification between the fourth quarter of 1990 and the third quarter of 1991. Ideally ten cask prototypes can be expected, two of each design, certified, acceptance tested, and ready to go in 1995.

This paper discusses the new generation of spent fuel casks being developed by DOE to satisfy the NWPA. This new generation of casks is disscussed in general terms, and is contrasted to the present generation of spent fuel casks. To attain the efficiencies demanded by the NWPA, the cask development program has two major components, one concentrating on the cask design and certification, the other on technology development. The two components are intended to support each other. The importance and means of attaining interaction of the two are discussed in the paper.

THE PRESENT GENERATION OF SPENT FUEL CASKS

Of the six light water reactor (LWR) spent fuel casks presently certified by the NRC, two are rail casks and four are truck casks. Three of the truck casks are overweight casks that are similar in design. Table 1. presents some details of these cask designs.

TABLE 1. PRESENT GENERATION OF LWR SPENT FUEL CASKS

Cask Model	Mode	WT(tons)	Cask Capacity (assemblies) PWRs	BWRs
IF-300	rail	70	7	18
NLI-10/24	rail	100	10	24
NLI-1/2	truck	25	1	2
TN-8	truck	40	3	-
TN-8L	truck	40	3	-
TN-9	truck	40	-	7

The six spent fuel casks in Table 1 are designed for transport of spent fuel that has been cooled, or out of reactor, typically, for one hundred and fifty days. These casks are designed to dissipate high internal heat and shield against high gamma radiation. The high internal heat associated with short cooling time contributes to limitations on the number of fuel assemblies that a cask can accommodate. The high gamma radiation, also associated with short cooling time, requires the use of thick high density metal shielding which drives the cask weight up.

All of the present generation spent fuel casks identified in Table 1 have been certified by the NRC as meeting the requirements of 10 CFR 71. The NRC regulations are performance requirements which are similar to the transport regulations of the International Atomic Energy Agency (IAEA).

The transportation regulations (NRC's and IAEA's) identify nuclear performance requirements. The nuclear performance requirements address containment of radioactive material, protection from external radiation (shielding), and assurance of subcriticality. Cask designs must satisfy these nuclear performance requirements under conditions or tests that are intended to represent normal and accident conditions of transport. Demonstrations of compliance with the performance requirements can be based on test, or analysis.

A NEW GENERATION OF SPENT FUEL CASKS

DOE's task under NWPA involves the annual transport of up to three thousand metric tons of spent fuel. The spent fuel that is to be shipped will be cooled (or out of the reactor core) for at least five years before shipping, with an average cooling time of well over ten years. The design basis of ten year cooled fuel is now being used in the program. This fuel is much cooler than the one hundred fifty day cooled fuel used as a design basis for present generation casks. The fuel will be both thermally and radioactively cooler than one hundred and fifty day cooled fuel. The problem of heat dissipation becomes less severe, and gamma shielding requirements are reduced. These factors contribute significantly to higher payload to cask weight ratios.

Because this program involves movement of large amounts of spent fuel, it offers an incentive to look for and take advantage of all opportunities to improve not only safety, but efficiency as well. The operating costs for the program will be much greater than the development costs, making it an ideal candidate for investment in technical development that will provide long term benefits to the transportation program.

The primary means of improving the efficiency of the transportation system is to increase cask capacities. This can be done without sacrificing safety. As a matter of fact, if a transportation system is developed with individual casks that are as safe as present generation casks, but with larger capacity, fewer shipments can be expected, thereby, reducing environmental impacts, both radiological and non-radiological. Current OCRWM cask design capacities are compared with present generation cask capacities in Table 2.

TABLE 2. CASK CAPACITIES

	Present	OCRWM
LWT with PWR	1	3 - 4
LWT with BWR	2	7 - 9
OWT with PWR	3	4 - 6
OWT with BWR	7	14
R/B with PWR	10	21 - 26
R/B with BWR	24	48 - 52

OCRWM's strategy for developing safe and efficient casks for the From Reactor cask initiative is to use existing cask technology as a base, and to pursue technical innovations that promise to benefit the program. The cask contractors are responsible for design and certification of their casks. They are also encouraged to use innovative features in their cask designs. The challenge for the cask contractors is to incorporate design innovation without jeopardizing cask certification. Innovation can come from the contractors themselves, from DOE's technical development activities, or from the general technical community. The current approach is to give the contractors freedom to choose which features to incorporate into their cask designs, while always keeping in mind their obligation to provide DOE with NRC certified cask designs.

Some of the innovative approaches found to be beneficial may raise technical issues within the program and with the NRC. The DOE intends to perform complete, thorough, and technically sound demonstrations of adequacy and applicability of any approaches that are proposed, whether innovative or ordinary. For cask certification, contractors will be responsible for submitting technical information to the NRC pertaining to their specific cask designs. Technical information can be generated by the cask contractors; however, information with more general applicability to the program, or of a specialized nature will be addressed through DOE's technical development activities.

TECHNICAL DEVELOPMENT ACTIVITIES

The technical development activities are being performed by Sandia National Laboratories (SNL) through DOE's Idaho Operations Office. These activities include technical issues resolution, development of systems, components, concepts, applied technology, and testing. Another important activity that SNL performs is that of technology transfer. Some of these topics will be discussed in this section.

The technical issues resolution actions include burnup credit, source term evaluation, and cask contamination or "weeping." These activities have been identified as those having major impact on the cask development program. Burnup credit in cask criticality design would allow consideration of reduced reactivity of spent fuel in cask design, resulting in higher capacities, and thus, fewer shipments. DOE has studied this issue and determined its technical feasibility and program benefits (T. Sanders, et. al., 1987). Currently, DOE is looking into approaches for implementing burnup credit for transportation of spent fuel (T. Sanders, and W. Lake, 1989). The source term evaluation activity seeks to develop a consistent and technically defensible approach for demonstrating adequate containment for spent fuel casks. An important benefit sought in this activity is rapid cask turnaround which will reduce both worker exposures and the cask fleet size.

DOE's source term evaluation program is discussed by T. Sanders, et. al. (1989). Weeping is characterized by increased surface contamination for casks. Weeping becomes a problem when a cask begins a trip with acceptable surface contamination only to arrive at its destination above regulatory limits. The DOE efforts on this issue are discussed by P. Bennett (1989). DOE seeks to find the causes of weeping, develop methods of prevention, and develop corrective measures.

Development of systems, components,and concepts provides basic engineering data for use in design and design optimization. The cask system is made up of a number of components which provide containment, shielding, assurance of subcriticality, and protection against external forces (e.g., normal and accident environments). All the components add to the system's safety and performance, all of them add to the system's weight. Efficient components perform their design functions with minimum additional system weight. Impact limiter design, structural materials, and shielding are all candidates for optimization under this activity.

A cask component issue that is of current interest is the behavior of elastomer seals over temperature ranges expected under normal and accident conditions of transport. The purpose of this activity is to determine seal characteristics and behavior at extreme temperatures, causes of that behavior, seal properties that correspond to that behavior, and to develop standards for selection and test of elastomer seals. This activity addresses the fundamental problems of seal behavior and testing of specific seals that will be used by the cask contractors.

Engineering component testing, scale model testing, and prototype acceptance testing will be done by the cask contractors. Other tests, such as, operational testing will be done by DOE. Although five contractors are responsible for testing, SNL will review their test activities, and DOE will have approval authority. This approach provides free choice by the contractors in certification issues while providing DOE with sufficient control and assurance of consistency.

The integration of analysis and scale model testing is an important feature of the OCRWM cask development program. Cask design is based primarily on the use of familiar analytic and design tools. The use of this approach naturally requires assumptions about relationships between analytic models and the system being examined. The designer typically uses safety margins to protect against uncertainties in these assumptions. The larger the uncertainty the larger the safety margin must be. On the other hand if the designer manages to reduce uncertainty in a design then the safety margin could be reduced accordingly. Testing is one very effective way of reducing uncertainty in design. The OCRWM program has chosen to use scale model testing for design verification. By relying on well developed scaling laws we can obtain a great deal of data from our test efforts.

Technology transfer is a key to successful use of state-of-the-art technology in this program. The work being done by SNL has been judged beneficial to the program by DOE. In order for this benefit to be realized the cask contractors have to incorporate the products of technical development into their designs. The cask contractors must be aware of the technical developments and fully understand them. This technology transfer is accomplished in several ways including published reports and direct contact between the cask contractors and SNL.

CONCLUSION

The OCRWM cask development program has been designed to address both the cask and the system in which it will operate. The decision to develop a new generation of spent fuel casks for the Federal waste system is based on the realization that efficiency demands it. The use of technical development has been introduced to find and explore opportunities to further improve safety and efficiency of the transportation system.

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