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INTRODUCTION

Under the Standard Contract for Disposal of Spent Fuel and High-Level Waste (10 CFR 961), the Department of Energy (DOE) will accept spent fuel for disposal from current owners. Current projections (DOE 1989a) suggest 2010 as the earliest date for the availability of a geologic repository for the disposal of spent fuel. In addition, DOE (1989a) suggests that a monitored retrievable storage (MRS) facility with full hot cell capabilities could not be in full service until 2000. As a result, there is a period of about two years wherein DOE is expected to receive and store spent fuel, but during which none of the proposed Federal Waste Management System (FWMS) facilities would be fully functional. During early 1990, a study was initiated to identify, describe, and provide a preliminary evaluation of some short-term alternatives that would permit DOE to accept and store spent fuel during this period. This paper summarizes some key results of this study.

SUMMARY

Three basic alternative approaches for initial spent nuclear fuel (SNF) acceptance and storage were evaluated. These are:

- Transportable Storage Casks (TSCs) loaded at reactors and transported to the MRS facility for storage;
- Multiple Element Sealed Canisters (MESCs) loaded at reactors and transported to the MRS facility and stored in horizontal storage modules (HSMs); and
- Standard Truck and Rail Casks loaded at reactors and transported to the MRS facility, where transfers of the spent fuel are made to MRS Storage Casks for storage.

In comparison with the reference DOE waste management system (DOE 1990), transportable storage casks have the advantage that spent fuel acceptance from utilities could proceed in advance of completion of the full-scale receiving and handling facilities at the MRS. However, current limitations on rail access or site handling capability at the reactors would prevent about half of the fuel scheduled (under an oldest-fuel-first allocation) for shipment during 1998 and 1999 from being loaded into TSCs or shipped by rail from the sites. For this reason, the TSC option was generalized for this study, using a small transfer cask for removing the fuel from the pool and placing it into the large rail TSCs at those sites unable to handle the TSCs in the storage pools. At sites lacking rail access, the use of heavy-haul of the rail casks to and from the nearest railhead was examined. A TSC with a capacity for 26 pressurized water reactor (PWR) or 52 boiling water reactor (BWR) assemblies was assumed.

The second basic option involved the use of the MESC concept to facilitate acceptance. This alternative would involve a transport cask designed to transport the large MESCs to the MRS facility, where they would be transferred to horizontal storage modules, without the need for an on-site hot cell. The same variations (field transfer and/or heavy-haul) as were appropriate for TSCs are applicable to MESCs. MESCs were assumed to have capacities for 24 PWR or 48 BWR assemblies.

The third alternative utilized the standard fleet of truck or rail transport casks, which would be loaded in reactor pools, and transported in the normal manner to the MRS facility, where the spent fuel would be transferred from the transport casks to MRS storage casks in a manner similar to the at-reactor transfer in the TSC

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option. This approach introduced the fewest additional complications at the reactor sites and appeared to be the least costly of the three alternatives, but might complicate licensing or construction of an MRS facility.

AT-REACTOR CONDITIONS

The relevant categories of cask-handling capacity are set by the sizes of typical casks. The standard rail-barge casks now under design have loaded weights of 100 tons. A typical transportable storage cask (as characterized by the NAC STC) will have a loaded weight of 125 tons. Thus, cask handling data was characterized into 3 groups: I) less than 100 tons, II) 100 tons or greater but less 125 tons, and III) 125 tons or greater. Combining these categories with reactor type and modal mix data, the number of sites and total MTU of fuel in each of 12 reactor categories was derived using the PNL spent fuel database (DOE 1989b) and preliminary data from an ORNL study, the Facilities Interface Capability Assessment (FICA). The capabilities present at each reactor site define the operations that can be possible at that site, and hence, which acceptance alternatives are viable for a given transport storage option. Table 1 summarizes this data for an oldest-fuel-first acceptance scenario in which approximately 1200 MTU would be accepted. This data was used in conjunction with unit cost estimates for each of several spent fuel handling operations in a comparative analysis of options.

ANALYSIS OF OPTIONS

When combined with possible variations in at-reactor conditions, the three basic hardware concepts described above result in several possible spent fuel handling options. Table 2 outlines the characteristics and operational considerations associated with each option. These options are depicted schematically in Figure 1.

DIRECT COST ESTIMATES

Preliminary estimates of the cost of providing acceptance of 1200/yr MTU of SNF in both 1998 and 1999 using these alternatives were developed. Equipment and facility costs were estimated using assumptions based in some cases on the authors' best judgment. Tables 3 and 4 present cost estimates for each of the options, partitioned into the functional steps shown in Figure 1. These estimates are shown as calculated, but they are regarded as accurate to ~± 30% only. For both PWR and BWR fuel, direct costs for options utilizing TSCs are significantly higher than those for MESC-based options, which are in turn slightly higher than those for cask-to-cask transfer at the MRS. The estimates assume that the entire capital cost of casks, transfer equipment, etc., is amortized over the two-year period. These same relations among unit costs also held for cases in which only SNF necessary to preclude encroachment on Full Core Reserve ("FCR" allocation - a total of approximately

Table 1. Number of pools and quantities of SNF scheduled for pickup in 1998 and 1999, by handling capability and reactor type (oldest fuel first allocation)

		TRUCK ACCESS ONLY						RAIL OR TRUCK ACCESS						
		PWR			BWR			PWR			BWR			
YEAR		I	II	III	I	II	III	I	II	III	I	II	III	TOTALS
1998	POOLS	3	2	2	0	2	0	1	1	8	5	1	6	31
	ASSEMBLIES	216	240	79	0	400	0	160	179	642	420	378	2198	4,912
	MTU	76	100	36	0	78	0	31	74	255	42	73	406	1,171
1999	POOLS	3	3	5	0	2	2	1	3	11	4	2	7	43
	ASSEMBLIES	113	419	329	0	300	374	72	133	511	159	95	1863	4,368
	MTU	37	173	144	0	58	72	33	59	221	18	18	360	1,193
2-Year Totals:														
	POOLS	6	5	7	0	4	2	2	4	19	9	3	13	74
	ASSEMBLIES	329	659	408	0	700	374	232	312	1153	579	473	4061	9,280
	MTU	113	273	180	0	136	72	64	133	476	60	91	766	2,364

I = Crane capacity less than 100 tons.
II = Crane capacity greater than or equal to 100 tons but less than 125 tons.
III = Crane capacity equal to or greater than 125 tons.

Table 2. Outline of system alternatives evaluated

Alternative	Reactor Handling Capability (tons)	Rail Access	MRS Storage Module	Operational Considerations
1. TSC Utilization				
1-1	125+	Yes	Rail TSC	Rail TSC pool-loaded
1-2	125+	No	Rail TSC	Rail TSC pool-loaded, heavy-haul to railhead
1-3	<125	Yes	Rail TSC	Fuel canned, transfer cask pool-loaded, field transfer to Rail TSC
1-4	<125	No	Rail TSC	Field canned, transfer cask pool-loaded, transfer to Rail TSC, heavy-haul to railhead
1-5	<125	No	Truck TSC	Truck TSC pool-loaded, truck transport
2. MESC Utilization				
2-1	125+	Yes	Rail MESC, HMS	Rail MESC pool-loaded
2-2	125+	No	Rail MESC, HMS	Rail MESC pool-loaded, heavy-haul to railhead
2-3	<125	Yes	Rail MESC, HMS	Fuel canned, transfer cask pool-loaded, transfer to Rail MESC
2-4	<125	No	Rail MESC, HMS	Fuel canned, transfer cask pool-loaded transfer to Rail MESC, heavy-haul
2-5	<125	No	Truck MESC	Truck MESC pool-loaded, truck transport
3. MRS Field Transfer				
3-1	As Available	As Available	MRS Storage Cask	Truck/rail casks pool-loaded, transfer at MRS to MRS Storage Casks

950 MTU) was accepted, although the cost advantage for the at-MRS transfer option was reduced due to lower throughput.

Tables 3 and 4 show the estimated unit costs of operations for both PWR and BWR SNF assemblies. No costs have been shown in those tables for truck TSCs or MESCs. It was found that the truck TSC alone would cost over $400/kgU and the other operations associated therewith would be higher (or at least no less) than those associated with the use of a rail TSC--and truck MESCs could be expected to be nearly as high.

OTHER CONSIDERATIONS

The costs shown in Tables 3 and 4 are estimated direct cost for limited use of three concepts, with adaptions as required by at-reactor conditions. They do not represent net economic costs to DOE for two reasons. First, the avoided cost of normal transfer and storage should be accounted for. This can range from less than $10 per kg for SNF which would have been stored in a spent fuel pool with adequate capacity (for which early acceptance resulted in no avoided at-reactor dry storage cost) up to approximately $100 per kg for fuel which would have normally been stored in metal storage-only casks at reactor.

Second, the residual value-in-use of the equipment required for the three concepts could be a factor in the relative economics among the three concepts. Although the TSC options have the highest direct costs, reuse of TSCs for extended storage or transport would result in additional avoided system costs and a lower net

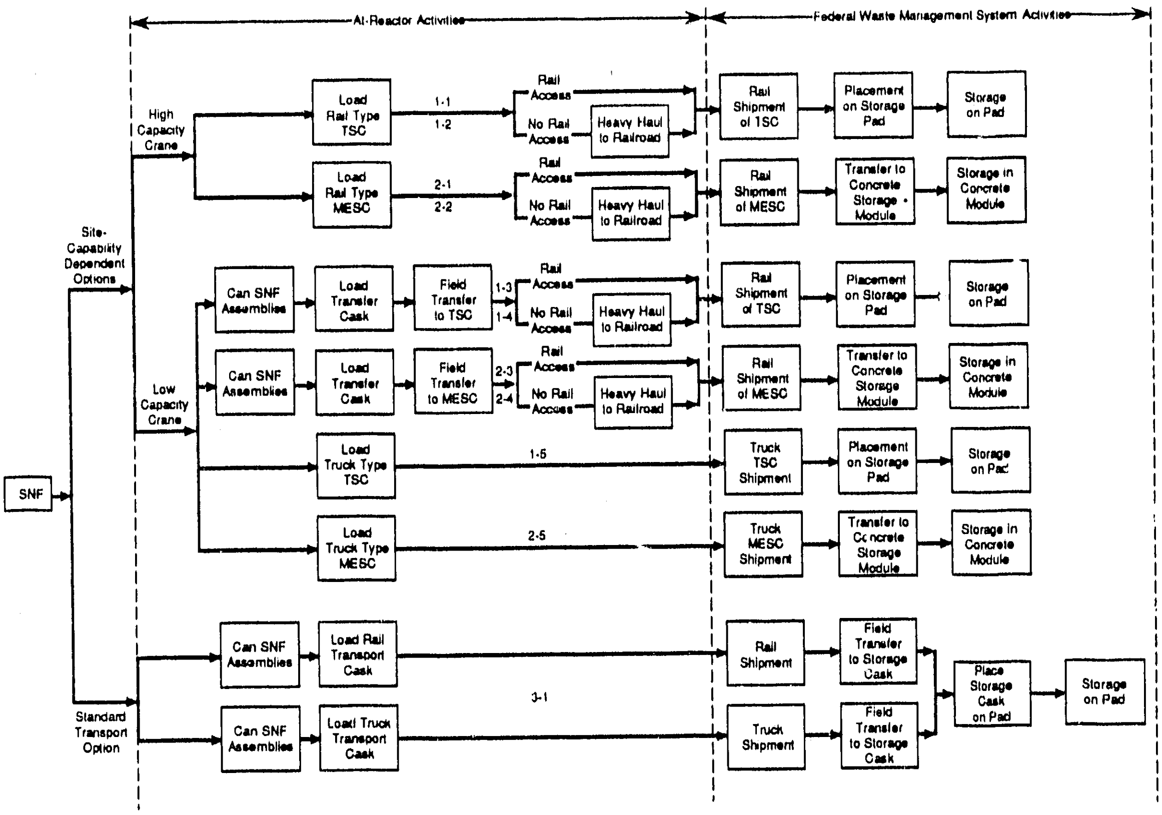

Figure 1. Alternatives for Early Acceptance and Storage of Spent Fuel at an MRS Facility with No Hot-Cell Unloading Capability

economic cost for this option than is shown here. The extent of this reduction is sensitive to system operational details, but the general magnitude is indicated by the previous estimate (ER Johnson 1989) that the federal system might provide economic reuse applications for only 50 TSCs (of the several hundred postulated here).

This study did not examine these concepts from a licensing or constructability perspective. These factors could prove crucial in selecting a concept for 1998 and 1999 acceptance. In addition, several other concepts for this purpose that have not been evaluated here are also under evaluation by DOE.

The choice of a concept for Phase 1 of an MRS facility is expected to be made based on additional system studies, including detailed evaluation of the avoided costs associated with several concepts, and preliminary engineering studies for selected concepts.

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Table 3. Comparison of estimated costs for use of TSCs and MESCs for early MRS operations--
PWR fuel ($/kgU, 1990)

	Alternative									
	1-2 Rail TSC; Reactor Has 125 Ton Crane and No Rail Access	1-1 Rail TSC; Reactor Has 125 Ton Crane and Rail Access	2-2 Rail MESC; Reactor Has 125 Ton Crane and No Rail Access	2-1 Rail MESC; Reactor Has 125 Ton Crane and Rail Access	1-4 Rail TSC; Reactor Has Low Capacity Crane and No Rail Access	1-3 Rail TSC; Reactor Has Low Capacity Crane and Rail Access	2-4 Rail MESC; Reactor Has Low Capacity Crane and No Rail Access	2-3 Rail MESC; Reactor Has Low Capacity Crane and Rail Access	3-1 Truck, Rail Transport Casks, Field Transfer at MRS: Rail	3-1 Truck, Rail Transport Casks, Field Transfer at MRS: Truck
TSC or MESC	125.15	125.15	31.14	31.14	125.15	125.15	31.14	31.14	-	-
Can Assemblies	-	-	-	-	13.29	13.29	13.29	13.29	13.29	13.29
Load TSC or MESC	0.57	0.57	1.49	1.49	9.66	9.66	10.93	10.93	0.66	3.47
Heavy Haul to Rail	0.89	-	0.97	-	0.89	-	0.97	-	-	-
From-Reactor Shipment	2.65	2.65	21.03	21.03	2.70	2.70	21.08	21.08	6.83	9.22
Placement in Storage	0.18	0.18	0.33	0.33	0.18	0.18	0.33	0.33	-	-
Storage	23.56	23.56	39.15	39.15	23.56	23.56	39.15	39.15	58.69	58.69
Removal from Storage and Unload TSC or MESC	0.14	0.14	0.36	0.36	0.14	0.14	0.36	0.36	-	-
Incr. Container and Empl. Cost	-	-	-	-	-	-	-	-	-	-
Disposal of Storage Module	2.66	2.66	1.92	1.92	2.66	2.66	1.92	1.92	0.65	0.65
Total	$155.80	$154.91	$96.39	$95.42	$178.23	$177.34	$119.17	$118.20	$80.12	85.32

Table 4. Comparison of estimated costs for use of TSCs and MESCs for early MRS operations–BWR fuel ($/kgU, 1990)

	Alternative 1-2 Rail TSC; Reactor Has 125 Ton Crane and No Rail Access	1-1 Rail TSC; Reactor Has 125 Ton Crane and Rail Access	2-2 Rail MESC; Reactor Has 125 Ton Crane and No Rail Access	2-1 Rail MESC; Reactor Has 125 Ton Crane and Rail Access	1-4 Rail TSC; Reactor Has Low Capacity Crane and No Rail Access	1-3 Rail TSC; Reactor Has Low Capacity Crane and Rail Access	2-4 Rail MESC; Reactor Has Low Capacity Crane and No Rail Access	2-3 Rail MESC; Reactor Has Low Capacity Crane and Rail Access	3-1 Truck, Rail Transport Casks, Field Transfer at MRS: Rail	3-1: Truck
TSC or MESC	157.63	157.63	39.22	39.22	157.63	157.63	39.22	39.22	-	-
Can Assemblies	-	-	-	-	11.22	11.22	11.22	11.22	11.22	11.22
Load TSC or MESC	0.97	0.97	2.12	2.12	8.82	8.82	10.26	10.26	1.00	4.02
Heavy Haul to Rail	1.12	-	1.22	-	1.12	-	1.22	-	-	-
From-Reactor Shipment	3.34	3.34	27.96	27.96	3.39	3.39	28.01	28.01	7.74	9.93
Placement in Storage	0.22	0.22	0.41	0.41	0.22	0.22	0.41	0.41	-	-
Storage	29.68	29.68	49.32	49.32	29.68	29.68	49.32	49.32	59.34	59.34
Removal from Storage and Unload TSC or MESC	0.22	0.22	0.47	0.47	0.22	0.22	0.47	0.47	-	-
Incr. Container and Empl. Cost	-	-	-	-	7.84	7.84	7.84	7.84	7.84	7.84
Disposal of Storage Module	3.35	3.35	2.41	2.41	3.35	3.35	2.41	2.41	0.65	0.65
Total	$196.53	$195.41	$123.13	$121.91	$223.49	$222.37	$150.38	$149.16	87.79	93.00

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