LOW-COST CONCEPTS FOR DRY TRANSFER OF SPENT FUEL AND WASTE BETWEEN STORAGE AND TRANSPORTATION CASKS

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ABSTRACT

The federal government may provide interim storage for spent fuel from commercial nuclear power reactors that have used up their available storage capacity. One of the leading candidate concepts for this interim storage is to place spent fuel in large metal shielding casks. The Federal Interim Storage (FIS) site may not have the capability to transfer spent fuel from transportation casks to storage casks and vice versa. Thus, there may be an incentive to construct a relatively inexpensive but reliable intercask transfer system for use at an FIS site. This report documents the results of a preliminary study of preconceptual design and analysis of four intercask transfer concepts.

The four concepts are: 1) a large shielded cylindrical turntable that contains an integral fuel handling machine (turntable concept); 2) a shielded fuel handling machine under which shipping and storage casks are moved horizontally (shuttle concept); 3) a small hot cell containing equipment for transferring fuel between shipping and storage casks (that enter and leave the cell on carts) in a bifurcated trench (trench concept); and 4) a large hot cell, shielded by an earthen berm, that houses equipment for handling fuel between casks that enter and leave the cell on a single cart (igloo concept).

Information derived for each of the concepts is operating, capital and relocation costs; implementation and relocation time requirements; and overall characteristics.

BACKGROUND

One or more federal government sites may provide interim storage for spent fuel from commercial nuclear power reactors that have used up all their available storage capacity. Such federal interim storage, if provided, would only be for a short term, on the order of ten years.

One of the leading candidate concepts for this interim dry storage is to place spent fuel in large metal shielding casks. Spent fuel would likely be transported in conventional transportation casks in the initial stages of the Federal Interim Storage (FIS) program. Storage casks may be licensed for transportation in later years of the FIS program. In the case of reactors unable to handle large casks, transportation would always be in conventional transportation casks. Thus, the FIS site would need the capability to transfer the spent fuel from shipping casks to the storage casks, and vice versa, after completion of the storage.

The transfer capability is not readily available at some potential federal storage sites. Thus, there may be a need to construct a relatively inexpensive but reliable intercask transfer system for use at an FIS site. In addition, there may be other uses for such an intercask transfer system at other sites (e.g., at selected reactor or fuel reprocessing sites that may implement on-site interim cask storage of spent fuel). Thus, there may be an advantage in having an intercask transfer system that is largely portable for reuse at other sites.

Based on these considerations, the Department of Energy commissioned its Commercial Spent Fuel Management Program Office, operated by the Pacific Northwest Laboratory, to carry out a brief pre-conceptual study on the feasibility of several potential low-cost intercask transfer systems that would satisfy the needs described above. These studies were carried out by staff at Kaiser Engineers-Hanford, at Raymond Kaiser Engineers-Oakland, at GA Technologies-San Diego, and at the Pacific Northwest Laboratory-Richland.

A host site for federal interim storage (and the intercask transfer system) is assumed to provide the required utility services, the roadway capability to receive large shipping casks by the truck and rail transport modes, general administrative and security services, and 0.6 to 3 hectares of land for an intercask transfer system, if used.

The transfer systems were conceived to handle the transportation casks designated as NL 1 1/2 NAC-1 (or NFS 4), NL 1 10/24, TN8/TN9, and GE 1F300; and the storage casks designated as REA 2023 and GNS Castor V.

FOUR CONCEPTS

Four concepts were conceived, all of which include a large crane for lifting the casks, a transfer car for moving the storage casks to their on-site storage positions, and an outer building to help control potential contamination. To aid in portability, all of the concepts to some degree use separate trailers to house auxiliary needs (i.e., exhaust ventilation treatment, personnel change room, operating control room, and chemical handling of decontamination solutions). The four concepts, in decreasing order of portability, are:

- <u>Turntable.</u> This concept consists of a large lifting crane and a large-diameter, shielded cylinder in a prefabricated metal building. The base of the cylinder is a large rotating turntable on which a transport and a storage cask are set. Transfers of spent fuel or canisters between casks are made by alternately rotating the turntable so the transport cask is under the lifting mechanism and a fuel assembly or canister can be removed, then rotating so that the receiving cask is in position to receive the fuel assembly as the lifting mechanism is lowered (see Fig. 1).

- o Shuttle. This concept consists of a shielded fuel handling machine mounted on a bridge-like structure. The bridge allows shipping and storage casks in a vertical position, each on its individual transfer car, to be shuttled into position under the fuel handling machine. Adapters allow mating of the cask openings to the bottom of the fuel handling machine. Spent fuel is lifted from the shipping cask; the shipping cask is then moved back and the storage cask is moved into position to receive the fuel assembly or canister from the fuel handling machine. The fuel handling and shuttle systems are located inside a prefabricated metal building (see Fig. 2).

- o Trench. This concept consists of a small hot cell (called fuel transfer room) that is made of prefabricated stacking concrete sections and extends from a trench to above grade. Inside the metal building that houses the fuel transfer system, a large bridge crane places the two types of casks vertically onto individual transfer cars located in a short, concrete-lined trench. The transfer cars, which are integral with part of the hot cell shielding walls, move the casks into the fuel transfer room where the intercask transfer is accomplished by manipulators and in-cell cranes (see Fig. 3).

- o Igloo. This concept includes a large, rectangular hot cell (called fuel transfer chamber), made of an oval-shaped corrugated steel metal liner shielded by an earthen berm. The two types of casks are placed vertically on a single transfer car by an outside crane. The transfer car moves the two casks into the fuel transfer chamber (through an airlock chamber that is an extension of the fuel transfer chamber). Spent fuel is transferred by alternately moving the transfer car to orient the two casks to their position under a fuel transfer tower. The fuel transfer tower, similar to that in the turntable concept, extends to above the earthen berm (see Fig. 4).

CONCEPT CHARACTERISTICS

Overall characteristics of the four concepts are summarized in Table I. The first six characteristics in Table I were alluded to in the descriptions above. Cask decontamination locations include in-pit, in-place and in a decontamination cell. Spent fuel decontamination and possible recanning or repair capabilities vary from essentially none in the turntable and shuttle concepts to some in the trench and igloo concepts. All concepts have calculated transfer capacities equal to or greater than the 400 MTHM/yr criterion set for this study. The operating staff required for all concepts is estimated to be about 29 to 33. Capital costs (discussed below) for nontransportable parts of the facility are estimated to be the lowest for the turntable and shuttle concepts at 1.9% and 2.6%, respectivly; somewhat higher for the trench concept at 7.6%, and the highest for the igloo concept at 29%. The implementation time is estimated to be relatively long for the turntable concept, about 41 months, because of the new design/development and special fabrication needs. Implementation times for the shuttle and trench concepts are about 24 months each; and for the igloo concept only about 18 months because of simpler design and construction. Time for shutdown, dismantling, transport to a new site, reassembly and shake-down tests is estimated at 10 months for the turntable and 14 months for the other three concepts. About six months time and effort is

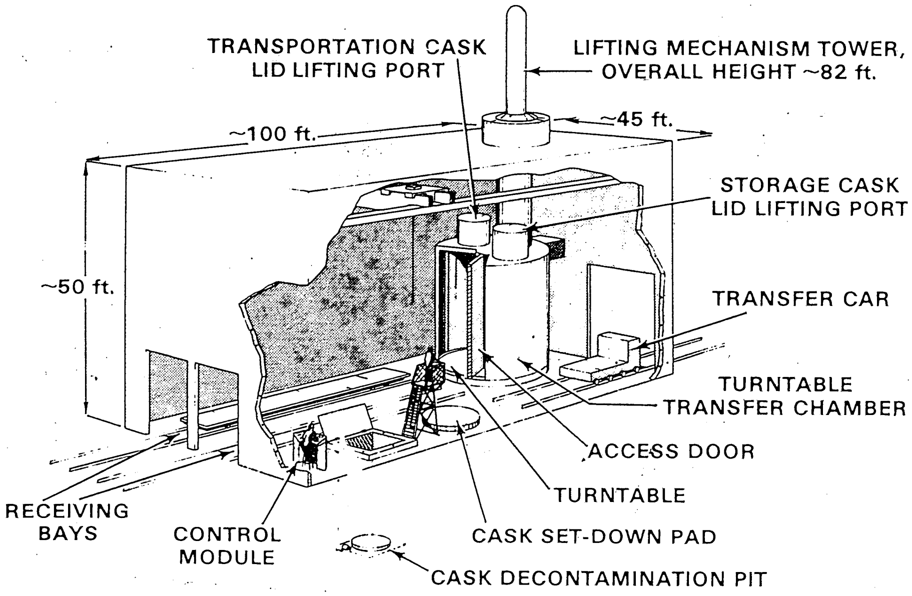

Fig. 1. Turntable concept for intercask transfer.

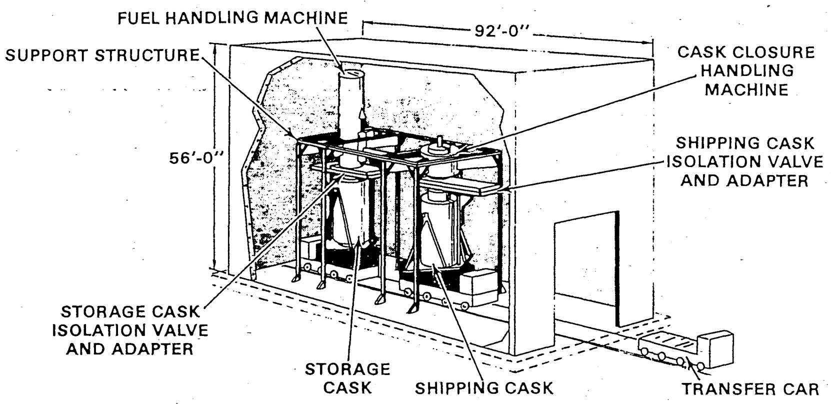

Fig. 2. Shuttle concept for intercask transfer.

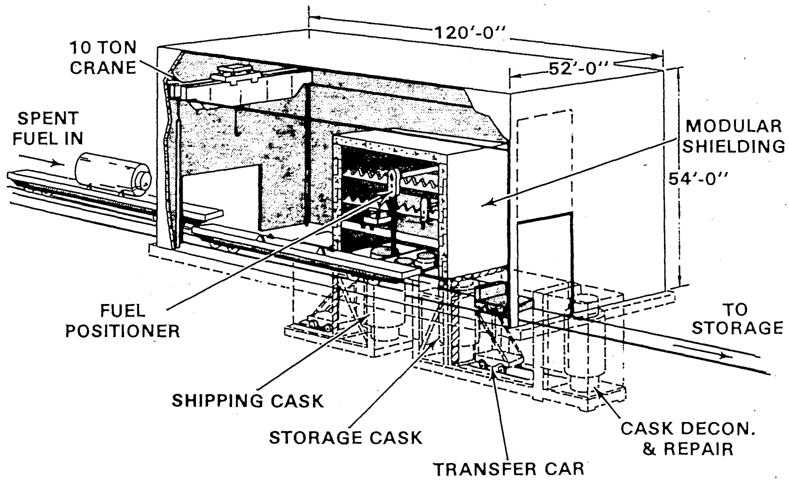

Fig. 3. Trench concept for intercask transfer.

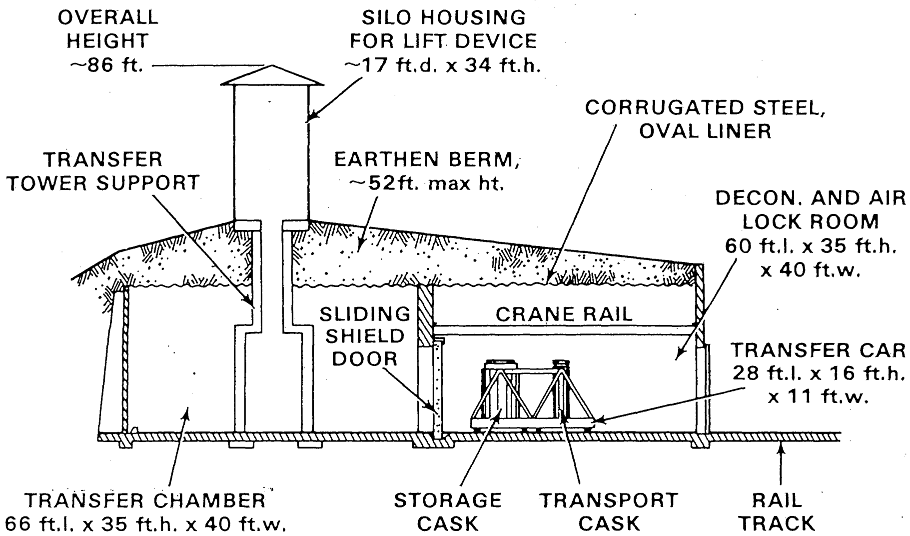

Fig. 4. Igloo concept for intercask transfer.

TABLE I. Summary of general characteristics of the intercask transfer concepts.

Characteristic	Turntable	Shuttle	Trench	Igloo
1. Cask lifting inside or outside of outer building	Inside	Outside	Inside	Outside
2. Transfer cars used for casks	No	Yes	Yes	Yes
3 Hot cell	None	None	Small	Large
4. Major gamma shielding	Steel/lead	Steel	Concrete	Earthen berm
5. Operating technique	Automated machinery	Automated machinery	Hot cell	Hot cell & automation
6. Viewing	CCTV[(a)]	CCTV[(a)]	Windows/CCTV[(a)]	CCTV[(a)]
7 Cask decontamination location	In pit	In place	In pit	In decon. cell
8. Spent fuel decontamination capability	~None	~None	Yes	Yes
9 Recanning/can repair capability	~None	~None	Possible	Possible
10 Operating capacity, MTU/yr[(b)]	<540[(c)]	>525	435	>480
11 Number of full-time operating staff	33	30	29	29
12. % of capital costs that are for a non-transportable portion of the facility[(d)]	1.9	2.6	7.6	28.9
13. Implementation time, months[(e)]	41	24	24	18
14. Relocation time, months	10	14	14	14
15. Development required	Yes	Some	No	No

(a) CCTV = closed circuit television
(b) For unconsolidated spent fuel received 50% by truck and 50% by rail, facility operating 250 days/year, 24 hours/day; other bases believed to be conservative
(c) Based on 2 transport casks in the system (one being unloaded; the other in preparation) at one time. For one transport cask at one time, the capacity is ~390
(d) Based on capital costs exclusive of design and development costs.
(e) From start of design and development--assuming licensing by the NRC is not required.

believed to be necessary for development and conceptual design of the turntable concept, and some effort may be necessary for the shuttle concept because of the relatively nonstandard design of these concepts. The other concepts should require essentially no conceptual design.

CONCEPT COSTS

High-spot estimates of costs (in 1982 dollars) are shown in Table II for the four concepts. Design and engineering costs range from $1.2 to $2.2 million, with the higher costs for the more readily transportable concepts. The capital costs for these concepts are also higher at $9.1 to $11 million compared to about $8 million for the trench and igloo concepts. Operating costs are about equal for each concept at about $2 million/year. Relocation costs are about $1 million for the more readily transportable concepts to $2.7 million for the igloo concept (which reflects new construction needed at the second site). Transportation costs for relocation were not estimated for any concept.

CONCLUSIONS

From the results of this study, the following overall conclusions are drawn:

- A variety of concepts may be used as a minimum-investment dry intercask transfer facility for spent fuel or canisters, with a spent fuel transfer capacity of 400 to 500 MTHM/yr. Higher capacities may require further study.
- Total design and capital costs (in the range of $9 to $13 million at a host federal site) are moderate compared to costs for most current concepts of hot cells.
- An intercask transfer system can be designed with as little as 2% of the construction costs required for nonportable construction. However, portability adds $2 to $4 million to the capital costs of the more conventional hot cell type of systems (which have 8% to 30% of the construction costs for nonportable construction).
- Implementation times of conventional hot cell type systems are in the range of 18 to 24 months. More complex systems with highly automated machinery may require up to about 40 months because of the special development/design and fabrication requirements.
- Sufficient information has been developed in this study to provide the bases for initiation of optimizing design efforts.
- The more conventional hot cell type of systems offer more flexibility for abnormal activities such as repairing or recanning the spent fuel or canisters, or performing decontamination of the containers of high-level materials, than do the more compact and automated systems.
- The potential advantage of maximum portability of an intercask transfer system must be weighed against its higher cost and lower operational flexibility.

If plans materialize for implementation of systems discussed in this study, cost/benefit studies should be carried out in concert with evaluation of potential sites for one or more FIS facilities to determine the incentives for a minimum-investment type of intercask transfer capability. In addition, more detailed concept design studies could be undertaken to identify a more optimized system than those conceived in this study.

REFERENCE

Schneider, K. J. 1983. Equipment Concepts for Dry Intercask Transfer of Spent Fuel. PNL-4795, Pacific Northwest Laboratory, Richland, Washington.

TABLE II. Summary of costs of intercask concepts

Cost Item	Turntable	Shuttle	Trench	Igloo
	Costs for Concept[a]			
Design and Engineering, M$	2.2	1.5	1.2	1.2
Capital, M$[b]	11.0	9.1	8.1	7.6
Operating, M$/yr[c]	2.3	2.1	2.0	2.0
Relocation, M$[d]	1.1	1.0	1.6	2.7

(a) All costs are in 1982 dollars and include 30% contingency.
(b) Capital costs include those for a 100-Mg crane for cask handling and an on-site transporter vehicle for the storage cask; costs do not include host site costs for bringing utilities, fencing, roads to the facility.
(c) Based on operating at 400 MTU/yr of unconsolidated spent fuel transferred/year.
(d) Include costs of shut-down and dismantling at the first site, reassembly and shakedown tests plus new capital costs at the second site. Transport costs are not included.