Transportation System Benefits of Early Deployment of a 75-Ton Multipurpose Canister System*

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In 1993 the United States Civilian Radioactive Waste Management System (CRWMS) began developing two multipurpose canister (MPC) systems to provide a standardized method for interim storage and transportation of spent nuclear fuel (SNF) at commercial nuclear power plants. One is a 75-ton concept with an estimated payload of about 6 metric tons (t) of SNF, and the other is a 125-ton concept with an estimated payload of nearly 11 t of SNF. These payloads are two to three times the payloads of the largest currently certified U.S. rail transport casks, the IF-300. Although it is recognized that a fully developed 125-ton MPC system is likely to provide a greater cost benefit and radiation exposure benefit than the lower-capacity 75-ton MPC, this paper suggests that development and deployment of the 75-ton MPC prior to developing and deploying a 125-ton MPC is a desirable strategy. Reasons that support this include:

1. Facility constraints can restrict handling of the 125-ton MPC. More facilities are expected to have the capability to operate the 75-ton MPC, thus making it more universally acceptable.

2. The facilities expected to make the first deliveries into the CRWMS are more suited to the 75-ton MPC.

3. The commercial marketplace already provides relatively high-capacity storage systems that weigh about 100 tons and closely resemble the 125-ton MPC, but the marketplace does not currently offer a smaller-capacity, lower-weight system to serve those facilities with limited lifting capability, which will need out-of-pool storage early on.

4. The 75-ton system is expected to have a higher probability of near-term regulatory certification success than the 125-ton system. Because little is expected to be common between the two designs, the concurrent development of two MPC designs could dilute each effort, thus prolonging the certification process for both.

5. The 75-ton MPC is expected to use a standard 4-axle rail car, whereas the 125-ton MPC is expected to use a higher-weight 6-axle rail car. The 6-axle cars could impose additional handling, maneuvering, rail routing, and parking limitations. Also, heavy-haul transportation of the 125-ton MPC is expected to encounter more weight and dimension restrictions on road routes and bridges.

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The Site and Facility Waste Transportation Services Planning Documents (SPDs) (Ratledge et al. 1991) and the SPD Summaries were prepared by using data collected from the Facility Interface Capability Assessment (FICA) (ORNL 1995), the Near-Site Transportation Infrastructure (NSTI) study (DOE 1995), and other sources to support planning, preparation, and shipping of SNF from the Nation's commercial nuclear facilities into the CRWMS.

Table 1 contains summary results of the SPD Summaries listed in the order that the SPD or SPD summary was completed. It is based on the oldest fuel-first disposal allocation listed in the Annual Capacity Report (DOE May 1993), and considers the long lead time for plant or facility modifications or special equipment requirements.

Table 1. Results of SPD Summaries
(entries in bold depict facilities currently capable of using only a legal weight truck cask system)

Facility	Cask weight	Shipment mode	Facility	Cask weight	Shipment mode
Millstone 1	110-ton	Direct rail[a]	**LaCrosse**	**40-ton**	**LWT road**
Oyster Creek	100-ton	H-H on-site barge[b]	**Dresden 1**	**24-ton**	**LWT road**
Indian Point 1	75-ton	LWT/OWT road	GE-Morris	125-ton	Direct rail
Big Rock Point	**24-ton**	**LWT road**	Point Beach 1&2	125-ton	H-H to off-site rail[c]
Surry	100-ton	H-H on-site barge[b]	**Crystal River**	**25-ton**	LWT road
Peach Bottom 2&3	110-ton	LWT/OWT road	Monticello	85-ton	Direct rail
San Onofre 1	**70-ton**	**H-H to on-site rail**	Nine Mile Point 1	100-ton	Direct rail
R.E. Ginna	**30-ton**	**LWT road**	Dresden 2&3	75-ton	Direct rail
Maine Yankee	100-ton	Direct rail	Oconee 1,2&3	100-ton	H-H to off-site rail
Duane Arnold	75-ton	Direct rail	Humboldt Bay	75-ton	LWT road
Yankee-Rowe	75-ton	LWT road	H.B. Robinson	75-ton	Direct rail
Quad Cities 1&2	75-ton	Direct rail	Turkey Point	25-ton	H-H on-site barge
Pilgrim	**26-ton**	**LWT road**	**Fort Calhoun**	**40-ton**	**LWT road**
Indian Point 2	**40-ton**	**LWT road**	North Anna 1&2	105-ton	H-H to on-site rail
Palisades	100-ton	H-H to off-site rail	Haddam Neck	100-ton	H-H on-site barge
Vermont Yankee	110-ton	H-H to on-site rail	Calvert Cliffs 1&2	125-ton	H-H on-site barge
Brunswick 1&2	75-ton	Direct rail	Ark Nuc One-1&2	100-ton	Direct rail
Kewaunee	120-ton	H-H to off-site rail	San Onofre 2&3	125-ton	H-H to on-site rail
Millstone 2	100-ton	Direct rail	Shearon Harris	97.5-ton	Direct rail
Three Mile Island 1	110-ton	Direct rail	Limerick 1&2	110-ton	Direct rail
Nine Mile Point 2	110-ton	H-H to on-site rail	Diablo Canyon	110-ton	H-H to off-site rail
Braidwood 1&2	110-ton	Direct rail	**FitzPatrick**	**62.5-ton**	**Direct rail**
Prairie Island 1&2	125-ton	Direct rail	Davis-Besse	140-ton	Direct rail
Browns Ferry	106-ton	H-H to off-site rail	Cooper	75-ton	H-H to off-site rail
Farley 1&2	125-ton	H-H to on-site rail	Zion 1&2	110-ton	Direct rail
St Lucie 1&2	25/110-ton	H-H on-site barge	E.I. Hatch 1&2	125-ton	Direct rail
Salem 1&2	110-ton	H-H on-site barge	McGuire 1&2	100-ton	Direct rail
Beaver Valley 1&2	60/100-ton	Direct rail	Sequoyah 1&2	80-ton	Direct rail
V.C. Summer	125-ton	Direct rail	LaSalle 1&2	100-ton	Direct rail
D.C. Cook 1&2	**60-ton**	**Direct rail**	Susquehanna 1&2	125-ton	Direct rail
Hope Creek	130-ton	H-H on-site barge	Catawba 1&2	125-ton	Direct rail
Grand Gulf	125-ton	H-H on-site barge	Wolf Creek	125-ton	Direct rail
Waterford	125-ton	Direct rail	Byron 1&2	110-ton	Direct rail
Palo Verde 1,2&3	150-ton	Direct rail	River Bend	125-ton	H-H to off-site rail
Indian Point 3	**40-ton**	**LWT road**	Callaway	125-ton	H-H to off-site rail
Vogtle 1&2	109-ton	H-H to off-site rail	Clinton	100-ton	H-H to on-site rail
Enrico Fermi 2	117-ton	H-H to on-site rail	Perry 1	125-ton	H-H to on-site rail
Seabrook	125-ton	H-H to on-site rail	Millstone 3	125-ton	Direct rail
Wash. Nuclear 2	125-ton	H-H to on-site rail	Comanche Peak	130-ton	H-H to on-site rail
South Texas 1&2	150-ton	H-H to on-site rail			

[a]Direct Rail = capability to deliver a cask into the cask handling/loading area.
[b]H-H to rail or barge = the expected use by a special heavy-haul truck system to move the loaded MPC or cask to a transfer point where a rail car would be standing by.
[c]On-site = transfer or activity within the owner-controlled area.
[d]Off-site = transfer or activity outside of the owner-controlled area.
LWT - legal-weight truck shipments.
OWT - overweight truck shipments.

The SPD-Summary provides the current weight limitation for each facility based on the authors' assessment of the most limiting condition of crane capacity, derating to meet cask-drop-accident criteria, or floor-load limitation.

The shipment mode was selected to support a "majority-rail" operating strategy. Of the 83 combinations (note that some of the combined facilities include two results) shown in Table 1:

- 82% (68 facilities) are currently capable of operating a 75-ton MPC system;
- 40% of these (26 facilities) are currently capable of operating the 125-ton MPC system; and
- 18% (15 facilities denoted by bold-type in Table 1) are currently capable of using only a LWT cask system.

Timing is a key issue in the deployment of the MPCs. This is especially true for those sites expected to deliver SNF into the system during the first years of CRWMS operation. Table 2 shows the results of an assessment of early deployment of MPCs based on a start-up acceptance rate of 400 t the first year, 1,200 t the second year, and 2,000 t each year thereafter. It shows a breakdown of the number of each kind of MPC which would likely be used during the first 3 years compared to the total number of MPCs used if only the 75-ton MPC were available. An additional 158 75-ton MPCs would be needed in place of the 91 125-ton MPCs estimated to be used during that time period to provide storage. Three years was chosen as a reasonable time-frame between the deployment of the first MPC model and the certification and deployment of a second MPC model. Also, 3 years should be sufficient time to evaluate the field experience and to incorporate the results into the second MPC model design.

Table 2. MPC Early Deployment Based on Acceptance Rate
(in number of loaded MPCs to be shipped)

Year	75-ton MPCs	125-ton MPCs	If all by 75-ton MPCs	Additional 75-ton MPCs required
First	50	21	85	35
Second	95	28	143	48
Third	117	42	192	75
Total	262	91	420	158

Some of the sites relegated to LWT cask status because they lack the current capacity could be readily re-evaluated to lift cask systems weighing up to 75-tons. Also some facilities that currently have the capability to lift the 75-ton MPC system could be upgraded to lift the 125-ton system. These sites are identified in Table 3. There has been no facility operator input to these upgrade assessments, which were based on the expectations of the authors of this paper.

Table 3 shows that eight of 15 facilities currently limited to handling only LWT casks could be reasonably upgraded to 75-ton MPC status. One facility currently limited to LWT casks could be upgraded to 125-ton MPC status. Ten facilities currently limited to 75-ton MPC capability could be reasonably upgraded to 125-ton status. If these upgrades are completed, the number of facilities capable of handling MPCs grows dramatically; most of the gains occur in upgrading to 125-ton MPC capability as shown below:

	Pre-upgrade capability	Post-upgrade capability
125-ton MPC	26	37
75-ton MPC	68	66
LWT (truck)	15	6
Total:	109	109

Table 3. Sites Presumed to be Capable of Upgrading to Higher-Capacity Cask Capability

Site	Current cask capability[a]	Upgrade capability[b]
Dresden-1	24-ton (LWT truck)	75-ton (75-ton MPC)
Crystal River	25-ton (LWT truck)	75-ton (75-ton MPC)
Fort Calhoun	40-ton (LWT truck)	75-ton (75-ton MPC)
FitzPatrick	62.5-ton (LWT truck)	75-ton (75-ton MPC)
D.C. Cook-1&2	60-ton (LWT truck)	125-ton (125-ton MPC)
St Lucie 1	25-ton (LWT truck)	100-ton (75-ton MPC)
Beaver Valley 1	60-ton (LWT truck)	100-ton (75-ton MPC)
Turkey Point 1&2	25-ton (LWT truck)	100-ton (75-ton MPC)
San Onofre-1	70-ton (75-ton MPC)	75-ton (75-ton MPC)
Sequoyah 1&2	80-ton (75-ton MPC)	125-ton (125-ton MPC)
D.C Cook 1&2	60-ton (LWT truck)	120-ton (125-ton MPC)
Shearon Harris	97.5-ton (75-ton MPC)	150-ton (125-ton MPC)
Vogtle 1&2	98-ton (75-ton MPC)	125-ton (125-ton MPC)
Maine Yankee	100-ton (75-ton MPC)	125-ton (125-ton MPC)
McGuire 1&2	100-ton (75-ton MPC)	125-ton (125-ton MPC)
LaSalle 1&2	100-ton (75-ton MPC)	125-ton (125-ton MPC)
Clinton	100-ton (75-ton MPC)	125-ton (125-ton MPC)
North Anna	105-ton (75-ton MPC)	125-ton (125-ton MPC)
Browns Ferry	106-ton (75-ton MPC)	125-ton (125-ton MPC)

[a]Based on the SPD-Summary, see Table 1.
[b]Based on the assessment of the authors.

However, the projected increase in the number of sites expected to be upgraded to handle the 125-ton MPC might be off-set by those sites with current 125-ton MPC capacity. Some of the facility operators might be reluctant to use the entire crane capacity because of the age of the crane components and not having operated the cranes at their maximum lifting capacity over the years. Also, in some boiling-water reactor (BWR) facilities, an MPC system might have to be lifted as much as 100 ft. above the receiving area floor. This coupled with potential weight limitations (in the receiving areas over the drywell torus area) might further limit the use of a 125-ton MPC system at BWR facilities. Regardless of any current limitation, 100% of the commercial reactor and SNF storage facilities are expected to be capable of supporting the operation of a 25-ton LWT, GA-4/9 cask system; however, truck shipments of SNF are not expected until the third year of transportation system operation.

Beyond the facility-capability issue is an infrastructure issue. MPC systems that weigh more than 75 tons may become too heavy to allow unlimited interchange via standard 4-axle rail car with a 263,000 lb gross weight. The additional weight of the 125-ton system would necessitate special 6-axle railcars that could pose handling or parking problems at some reactor sites and could create routing problems for some railroads. Also, there are numerous facilities with no direct rail service to the utility cask receiving area. This will necessitate the use of heavy-haul trucks to move loaded MPCs to a nearby barge or rail-transfer area. The additional 50 tons of weight on a single heavy-haul vehicle carrying a 125-ton MPC over certain roads or bridges could limit routing and restrict some of these intermodal transfers. Table 4 shows a summary of transportation infrastructure capabilities of the commercial sites based on the SPD Summary.

Table 4. Current Transportation Infrastructure Capability

	Total sites	75-ton MPC	125-ton MPC
Direct rail capability[a]	35	35	11
Heavy haul to rail	33	33	15
Truck only	15		
Total	83	68	26

[a]To the utility cask receiving area.

Over 50% of the 75-ton-capable facilities have direct rail capability compared with 42% of the 125-ton-capable facilities. During the first 3 years of CRWMS operation, the breakdown is even more pronounced. A higher direct-rail capability provides some schedule cushion for the development and deployment of heavy-haul and transfer technologies. Even so, the development of a 75-ton MPC heavy-haul transfer mechanism is seen as less problematic than the development of a 125-ton MPC transfer capability.

Another reason to favor development of the 75-ton MPC is that the commercial suppliers of spent-fuel storage modules and systems (including Nuclear Assurance Corporation, Sierra Nuclear, Trans-Nuclear, VECTRA, etc.) have chosen to provide systems that weigh around 100 tons rather than a larger 125 tons. It seems reasonable that these suppliers would serve the broadest portion of the market. The marketplace chooses lowest cost per metric ton for storage, and the suppliers have focused on the 100-ton system as being the best marketplace compromise. It seems reasonable that the CRWMS would develop a product that serves portions of the market not already served by the commercial vendors at both ends of the spectrum. Many of these in the early market are older facilities, many of which have a limited cask or MPC lifting limitation. None of these early facilities is using dry storage systems weighing significantly more than 100 tons, and most would be limited to a 75-ton MPC. The CRWMS would better serve those early sites by developing a 75-ton MPC first and delaying a 125-ton MPC until it was needed by future CRWMS purchasers.

The authors postulate that the 75-ton MPC could have a speedier and a higher probability of certification. Fewer structural problems are expected because of the lower weights and smaller size. Also, no burnup credit is expected to be needed to assure criticality safety. Because both MPCs have distinct design and certification lives, it seems likely that both efforts would be diluted and prolonged, costing more in time and money. Although there may be some advantages to keeping the MPC design team together throughout the certification process, it would probably be divisive to have them working on two development programs simultaneously. Last, it would be valuable for the CRWMS to build up operating experience with the first MPC model deployed then to apply the lessons learned to the second or any subsequent MPC model. If the 125-ton system is the most efficient MPC, it should be the system that benefits from field experience developed after the deployment of the 75-ton MPC.

SUMMARY

The CRWMS will need to provide a reliable MPC system to start serving the commercial power reactors in the United States in the near future. The CRWMS could accomplish this by establishing a successful MPC system to prove the case for developing a higher-capacity 125-ton MPC system that will minimize handling and transportation efforts and costs. It is recommended that the development approach should focus on first deploying a 75-ton MPC system that will minimize facility capability and transportation infrastructure difficulties for the early-served facilities and that would be more likely to gain regulatory certification. Also, because generic questions and defects can surface after the product is deployed, early-system failures could be limited to a small inventory of a single class of MPC, the 75-ton model. Corrections or revisions could be made to the second MPC system before the higher quantities of spent fuel are placed into storage, thus avoiding a system-wide cessation of activity.

REFERENCES

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