Design Considerations for an On-Site Spent Fuel Transfer System

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INTRODUCTION

The use of large casks (e.g., 100 - 125 tons) for the storage or shipping of spent nuclear fuel has been shown to yield operational and economic advantages to utilities that are able to accommodate such units at their reactor facilities. There are, however, some plants that are unable to handle these large casks due to crane capacity or dimensional restrictions. Additionally, some concrete storage casks are not designed to be loaded following conventional underwater cask handling practices within the reactor or fuel storage building. The possibility exists that some of these facilities can avail themselves of the benefits of large casks through the use of a system that employs a small, shielded transfer device to shuttle fuel between the storage pool and the large cask. Further benefits may be derived from the system if it has the added ability to transfer fuel from a large storage cask to a large transport cask at the end of the storage period, thus avoiding returning fuel to the pool.

It is important to acknowledge that the use of a transfer system for spent fuel is not a new idea. Several early power and test reactors used shielded transfer devices to move fuel from the core to the storage pool. Further, in recent years TMI-2 fuel debris canisters have been moved from wet storage to a shipping cask using an in-plant transfer system. What makes the subject of this study somewhat unique is that it addresses a system that: 1) may be operated inside or outside of the reactor or fuel storage building; 2) could be a dry or wet transfer; and 3) will be a routine, rather than specialized, operation.

Sensing the need to look more closely at this opportunity, the Electric Power Research Institute (EPRI) contracted with S. Levy Incorporated (SLI) of Campbell, CA to develop a set of design considerations for such a transfer system. The establishment of these considerations or criteria was regarded by EPRI as a necessary precursor to any actual system design effort. This paper describes the study process, presents the design considerations, and discusses the application of the consideration.

STUDY PROCESS

The development of the design considerations involved three sequential steps. The first was the generation of the initial design considerations complete with supporting rationale. The second was the trial application of the considerations to several actual or studied systems that perform similar transfers. This application phase was intended as a completeness check on the considerations. The last step was the adjustment of the considerations based on the applications phase. Utility company comments were solicited and, as applicable, also integrated into the final step adjustments. Throughout the process the logistics of the transfer operation were examined to get a feel for the importance of certain Considerations.

PRESENTATION OF DESIGN CONSIDERATIONS

Based on a detailed analysis of the operations required to conduct the at-reactor transfer of spent fuel assemblies from the storage pool to a large storage cask or transport cask, this section presents the design considerations or criteria for such a system. The EPRI study report contains both the considerations and the rationale for each consideration. Due to space limitations, this paper will not address the rationale, but rather focus on the considerations.

There are thirty-six General Considerations and two Special Considerations. The General Considerations apply to all systems. The Special Considerations apply to two scenarios that also could be part of a utility's spent fuel management plan: 1) the transfer of fuel from dry storage back to the storage pool for loading into a shipping cask; and 2) the transfer of fuel from a dry storage cask directly to a large transport cask.

Some of the considerations are mandatory while the others are desirable but not essential. To aid in the visualization of these to a design, Figures 1, 2, and 3 illustrate fundamental features of both dry and wet transfer systems. However, these illustrations should not be interpreted as constraints on the design of such a system.

The spent fuel transfer system consists of a shielded transfer device that operates between the spent fuel storage pool and a large storage or shipping cask, moving one or more assemblies at a time; the system could also move fuel from a large storage cask to a large transport cask. Some interfacing equipment is necessary to facilitate these transfers. This equipment provides the transition between casks and possibly between the pool and the transfer cask, depending on the design. Figure 1 illustrates interface equipment that is portable whereas Figures 2 and 3 illustrate interface equipment that more closely resembles a permanent facility.

General Considerations

The thirty-six General Considerations are presented in abbreviated form as follows:

1. Use on-site only
2. Readily licensable
3. Meets 10 CFR 20/ALARA
4. Facility compatible
5. No major facility modifications required
6. Some permanent site structures acceptable
7. Minimal disruption of site activities
8. Must accept intact and consolidated LWR fuel
9. 65 PWR/180 BWR transfer in less than 6 weeks
10. Any transfer position into or out of cask
11. Vertical loading of transfer device while in pool
12. Visual loading of transfer device recommended
13. Preloading functional checkout capability
14. Fuel position verification in transfer device
15. Transfer device malfunction recovery capability
16. Decay heat and criticality control taken into account
17. Operated primarily by site personnel
18. Avoidance of the use of fuel canisters for containment
19. Transfer device must be capable of being sealed, dried, and tested
20. Readily cleanable exterior and interior
21. Compatible on-site transporter
22. Double seal/accident resistant during on-site movement
23. Two independent containment boundaries during transfers to/from dry storage
24. Adequate maneuvering space at transfer location
25. Must interface with a number of cask designs
26. To-storage transfer equipment functioning must be verifiable
27. To-storage cask transfer in any position, and wet or dry
28. Visual to-storage transfer recommended
29. Remote or manual transfer w/minimal risk of fuel damage
30. Transfer malfunction recovery capability

31. Mechanically failed fuel handling/recovery

32. Multiple-assembly transfer capability

33. S/T cask prepared for service while maintaining containment

34. System to accommodate S/T cask drying

35. Equipment must be easily decontaminated

36. Manual maintenance

Special Considerations

The two Special Considerations are presented in abbreviated form as follows:

1. Return to pool

This requires the reversibility of the transfer system and the ability to operate the system following a storage period that could be as long as 40 years.

2. Transfer to transport cask

This operation differs from the return-to-pool operation because the transfer system must provide the interface for both casks. Further, containment must be preserved for each cask during operations since each will have fuel. Additionally, the system must be able to accommodate odd lots, that is, the capacities of the two casks will not be identical thus a storage cask will have to be returned to storage partially unloaded to await the next shipment.

For a cask-to-cask transfer the interface is constrained. Both units are top loaded, thus there is less flexibility in the transfer system than when the origin or destination is a pool. This constraint reflects most strongly on the design of the transfer device and/or any interfacing equipment.

One of the more difficult considerations to anticipate in system design is the configuration of future transport casks. Although casks being developed today look similar to those of several decades ago, it is still difficult to forecast how the casks of 40 years from now might look.

The potential for a 40 year use/storage period for the transfer system should affect how the system is designed. This includes such considerations as corrosion protection, deterioration of components, and even obsolescence of essential parts.

Application of the Considerations

To test how well the study results could be applied, several conceptual studies or actual applications were selected and compared to the thirty-six General and two Special Considerations. The selected systems were:

1. The conceptual system designed by NUS for Sandia, reported in: TTC-0736, *Dry Transfer Cask Design and Feasibility Study - Final Report*, September 30, 1987.

2. The actual system designed by Nuclear Packaging for the shipment of TMI-2 fuel debris in canisters using the NUPAC- 125B cask.

3. A hypothetical independent pool transfer facility.

This last system was created by the authors since no actual or conceptual system was found in the available literature. It is important to note that this comparative exercise was not intended to critique the three systems.

The results of this applications study showed that the thirty-six General Considerations and two Special Considerations were sufficient to assure that the system could be safely and efficiently operated. Further, the considerations were not so specific as to constrain a designer's creativity.

Several observations were made with respect to the operations and logistics of a system designed to meet the above considerations. Perhaps the most challenging design requirement is that of contamination control. The preferred system does not canister the fuel, thus containment at mating component interfaces is critical. This is particularly true if the transfer to storage is being performed in an unenclosed area. Additionally, the time constraints on performing this operation suggest that multiple assembly transfers will be required, especially for BWR's where there are a sizable number of assemblies to be transferred. This places a greater design burden on those systems that move/position the fuel and verify that it is properly located. Time also dictates that the transfer cycle turnaround be performed as rapidly as is reasonable considering both safety and facility resources.

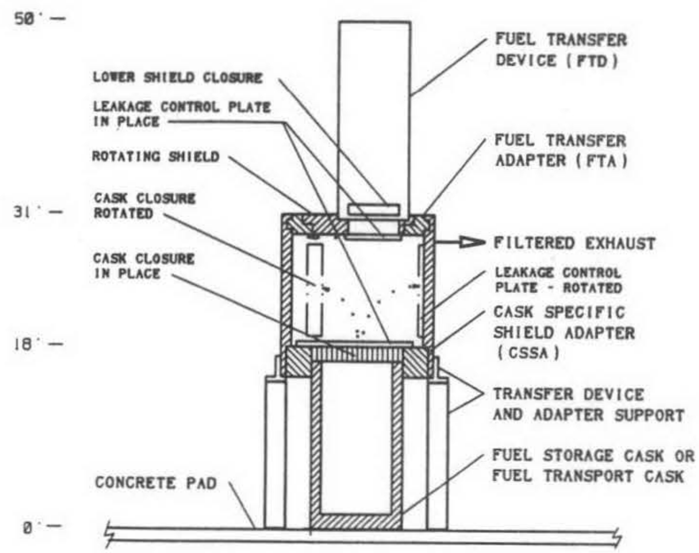
CONCLUSION

This EPRI-sponsored project successfully generated a set of considerations or criteria to be used by the designer of a shuttle system for the on-site transfer of spent fuel from a storage pool to a large storage or transport cask. The considerations were tested for their completeness by applying them to several actual or conceptual systems. Adjustments were made as a result of the aforementioned tests plus comments from utility and EPRI personnel.

Many of the considerations, such as those dealing with the control of contamination, will challenge the designer. Further, the logistics of the transfer operation essentially dictate transferring multiple assemblies at a time. This requirement places much emphasis on transfer device positioning and movement, and validation of fuel position. A further logistical issue coming from the study is the need to reduce the transfer cycle time to something measured in hours rather than days.

A cursory economic study supplementing the project suggests two additional conclusions on fuel transfers. First, if a utility plans to use metal storage casks and can upgrade the facility crane to handle such casks for direct-loading, this is a better choice than using a transfer system. Second, the use of a transfer system in conjunction with concrete storage casks is competitive with the use of direct-loaded metal storage casks, with or without crane upgrading.

Finally, the design considerations are relatively numerous, and in a few instances somewhat restrictive. However, nothing in this project suggests that the design and operation of an on-site transfer system meeting the aforementioned considerations cannot be achieved.



DRY FUEL TRANSFER ASSEMBLY

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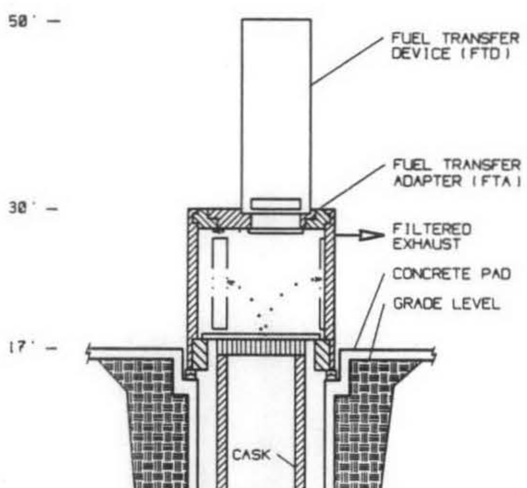
FIGURE 1



DRY FUEL TRANSFER ASSEMBLY

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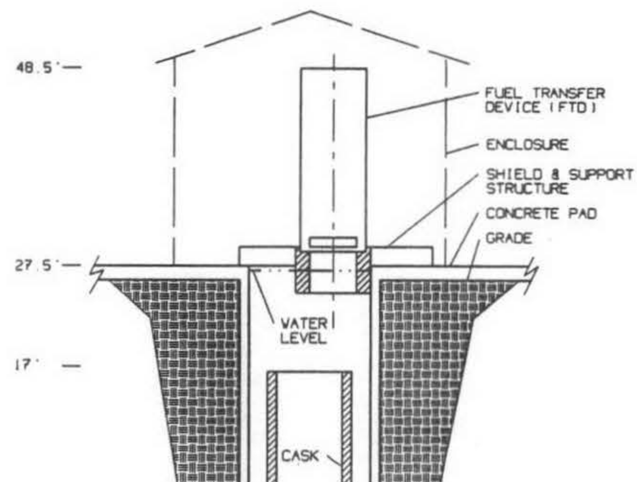
FIGURE 2



WET FUEL TRANSFER ASSEMBLY

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FIGURE 3

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Regulations