Dry Spent-Fuel Transfer System Design

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OVERVIEW

EPRI has had a continuing interest in developing a fuel transfer capability with the initial interest targeted at improved storage efficiency of Spent Nuclear Fuel. Noting that many utilities with smaller cranes or other plant restrictions would need additional technology to move their SNF to large, heavy, favorably economical storage systems, EPRI took the early technical lead to explore the possibility of using a small-cask-to large-cask dry transfer system. Potential uses of the transfer system have now been broadened to include the following:

- Enable large package on-site storage;
- Allow plants with limitation to provide DOE with SNF in sealed canisters, such as MPCs;
- Permit shutdown reactor sites to decommission pools.
- Facilitate early receipt into a future Federal facility.
- Provide capability at interim storage facilities to transfer assemblies from small transportation casks to sealed canisters.
- Provide capability at DOE sites with limited crane capacity to transfer non-LWR assemblies into large storage packages.

Under a cooperative program co-sponsored by DOE and EPRI, EPRI contracted with Transnuclear, Inc. to develop a design for a Dry Transfer System (DTS) that would permit the transfer of bare SNF assemblies from a top loading transfer cask (source cask) to a canister in a storage or transportation overpack (receiving cask).

The project objectives were to prepare the detail design and to determine the following attributes:

- Engineering and technical feasibility,
- Operation feasibility, including utility acceptance,
- Licensability, and
- Cost of the system.

DESIGN FEASIBILITY

It was necessary to focus the direction of the design on specific desired characteristics of the system. Performance Requirements based on the previous studies were further developed using the following primary characteristics to narrow the focus of the design effort:

- assume limited access reactors as reference case;
- transfer fuel into a receiving cask;
- transfer bare uncanistered PWR fuel;
- specify realistic cooling time;
- use a dual confinement approach; and
- design the equipment to be transportable .

The Performance Requirements that most influenced the DTS design were:

1. The DTS shall be designed to transfer bare spent-fuel assemblies from a top loading transfer cask with a capacity of one to four PWR assemblies to a multipurpose canister (MPC-125 ton size) in an MPC Transportation Overpack. The total heat generated by the fuel assemblies loaded into the MPC shall not exceed 15.5 kw.

2. The DTS shall be designed to transfer single PWR assemblies.

3. The DTS shall be designed to the requirements of 10 CFR 72, including the siting requirements of Subpart E.

4. The DTS design shall include the capability, after any design event, to safely recover a fuel assembly and place it in either the source or receiving cask and close and remove the source and receiving casks from the DTS.

5. The DTS design shall provide confinement of radioactive contamination within the TCA boundary by use of at least one physical barrier. In addition, negative pressure differentials shall be maintained between areas such that air will flow toward areas of increasing levels of contamination under all operating conditions.

6. The DTS design may use either remote-manual or automated technology for transfer of fuel assemblies and initial closure of canisters and casks containing spent fuel.

7. The DTS design shall provide means to dissipate the decay heat of the assemblies that are in the source and receiving casks during the transfer of assemblies.

8. The DTS shall be enclosed in a weather protection structure. The DTS structure may perform part or all of the weather protection function.

The designs of the cask and fuel assembly handling equipment were based on the experience of SGN at La Hague and other facilities. FWEC and GEC Alsthom designed the reinforced concrete structure and NTS and LMG designed the HVAC system. Transnuclear served as the Project Manager and design integrator. Transnuclear performed the shielding and radiation dose calculations.

A reinforced concrete structure used for confinement and shielding during fuel transfer was selected early in the preliminary design phase of the project. The structure houses the Lower Access Area and the Transfer Confinement Area (TCA). A Preparation Area is attached to the front of the structure and separated from the Lower Access Area by a steel shielding door. Figures 1 and 2 show details of the layout.

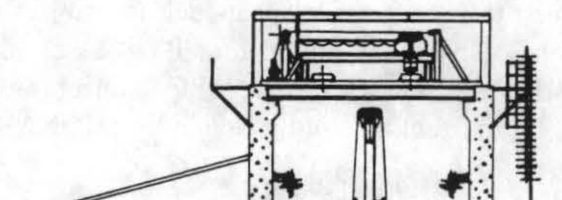

FIGURE 1
ELEVATION VIEW

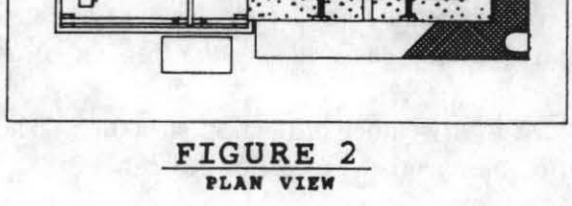

FIGURE 2
PLAN VIEW

The alternative concept was a fuel transfer machine wherein the machine or transfer "cask" encloses a crane and functions as the confinement and shielding for the assembly. While a machine concept eliminates the need for a permanent shielded structure, it was viewed to be more complex and to provide less flexibility than the structure concept. The structure concept provides flexibility, in that with minor modifications, it can be made to accommodate any set of casks and various fuel types and easily accommodates the sealed canister technology. Different machines and supporting equipment would be required for each cask design and for each fuel assembly type. The costs of the two systems were estimated to be of the same magnitude.

The structure concept is designed to be fully certified by the NRC. Confidence in the licensability of the system is based on the following considerations:

- It is similar to other systems and structures previously reviewed and licensed by the NRC.
- It is designed to seismic and tornado missile requirements.
- It uses conventional HVAC equipment.
- It provides confinement and relative isolation of the transfer activity from the environment.
- The transfer tube reduces the risk of spreading contamination during transfer.
- The system will meet ALARA requirements since it is heavily shielded and operated from a remote location.
- Backup exists for all major functions.

The Preparation Area houses operations performed on the casks prior to placement of the casks in the Lower Access Area and upon removal of the casks following completion of fuel transfers. Casks are uprighted and securely mounted in a vertical position on cask trolleys by a mobile crane that is not included as part of the DTS. The trolley is seismically restrained on the rails. The overpack lid and the canister closure lids are removed from the receiving cask by a crane and stored in this area until the canister is filled. Remote welding equipment is used to weld the canister lids after fuel loading. Gas sampling, vacuum drying, inerting, lid bolt removal/installation and any required decontamination operations also occur in this area.

The Lower Access Area is directly below the TCA. The casks are brought into this area from the adjacent Preparation Area. In this area, the casks are mated to the TCA by a device that seals the cask to the TCA for contamination control. The rail system in this area maintains the location and restricts movement of the casks.

Fuel transfer from the source cask to the receiving cask occurs in the TCA using a dedicated crane. This crane with its fuel transfer tube controls the movement of the fuel assembly. An additional crane is provided to remove and store the lid of the transfer cask and the shield plug of the canister. Cameras and lighting are used to monitor movement of the fuel, the cranes, grapples, etc., necessary to execute fuel transfer. Appropriate interlocks are incorporated into the system design to assure that proper operation sequencing is performed during the transfer of the assemblies. Fuel transfer crane positioning is automatically controlled and visually verified prior to assembly grappling and release. Its position can be manually adjusted to assure perfect alignment of the assembly with the cask or canister basket.

Several evaluations of the design have been performed by the Technical Management Committee (TMC) made up of EPRI and DOE representatives, with participation by the utility community. Utility input resulted in a number of design adjustments and was invaluable from an operations development perspective. The utility reviewers concluded that the system could be operated by utility personnel with no additional specialized skills following appropriate training.

LICENSABILITY

Three Project meetings have been held with the NRC staff. These meetings familiarized the staff with the DTS design and identified concerns that were addressed in subsequent design activities. All concerns have been addressed and there are no issues that would prevent licensing of the DTS.

It is intended that the Topical Report be submitted to the NRC for review to the technical requirements of 10 CFR 72. Following approval of the Topical Report, an operator desiring to build the DTS would file a site specific application with the NRC. This application would address those site specific items not addressed in the Topical Report as well as those site specific items that are different from the generic analysis of the Topical Report.

COSTS

The total estimated cost of the DTS structure, equipment, and systems for operation with a sealed canister system is $5.531 million (1995 dollars) and is itemized in Table 1. Other costs related to the site-specific design, procurement, and construction of the DTS are estimated to be $825,000 and are itemized in Table 2. The total cost estimate to build this facility is $7.627 million in 1995 dollars (including $1.271 million contingency). Refer to Table 3 for a compilation of these costs.

Table 1
Compilation of Costs for the DTS Structure, Equipment Fabrication, and Site Specific Construction

Lower Access Area & Transfer Confinement Area	$1,689,000
Preparation Area	$145,000
Cask Transfer Subsystem	$510,000
Fuel Assembly Handling Subsystem	$540,000
Upper Crane	$500,000
TC Port Covers	$100,000
TC Cask Mating Subsystem	$700,000
Closed Circuit Television Subsystem	$241,000
Control Subsystem	$90,000
General Lighting Subsystem	$7,000
Radiation Monitoring Subsystem	$85,000
Power Subsystem	$200,000
HVAC Subsystem	$305,000
Packaging Subsystem	$39,000
TN Design Scope Subtotal	**$5,151,000**
MPC Weld Equipment	$300,000
Leak Test, Vacuum Pump, Valves, etc.	$30,000
Miscellaneous Hardware	$50,000
Other Equipment Req'd. Subtotal	**$380,000**
Total	**$5,531,000**

Table 2
Estimated Site Costs

Site specific structural design and resulting equipment design modifications:	$100,000
Site preparation:	$250,000
Transportation of fabricated equipment to site:	$50,000
Installation crane rental (2 weeks):	$10,000
Project Engineering costs related to construction and fabrication of equipment including construction management :	$330,000
Procurement administrative	$85,000
Total	**$825,000**

Table 3
Summary of Total DTS Estimated Costs

Equipment Costs (from Table 1)	$5.531 million
Site-related Costs (from Table 2)	$0.825
Subtotal	$6.356
Contingency (20%)	$1.271
Total Estimated Cost	**$7.627 million**

It should be noted that, since the DTS mechanical equipment and electronic and electrical subsystems can be moved from one DTS site to another these costs, procurement administration costs, and project engineering costs (fabrication follow and quality assurance) can be reduced by utilizing the equipment at more than one site.

Operating costs of the DTS will vary from utility to utility. Input from participating utilities on manpower requirements has been used to develop the following estimate of the total operating costs per assembly transferred. Those costs are shown below:

Operating Costs for the DTS per Assembly Transferred

	PWR	BWR
MPC Overpack Receiving Cask	\$3,100	\$1,600
Bare Assembly Receiving Cask	\$2,700	\$1,400

STATUS

Design of the DTS is complete and the EPRI Project Report is complete and will be issued by EPRI late this year.

Remaining Project deliverables are the Topical Safety Analysis Report and the Project Design Record Package.These documents will be completed in the first part of 1996.

CONCLUSION

The final design of the Dry Transfer System meets all the project technical objectives for safely transferring bare spent-fuel assemblies between casks. The DTS will be able to safely transfer spent fuel between casks and maintain flexibility to accommodate a variety of fuel assembly types, and source and receiving casks wth minimal equipment modifications. The DTS design features simplicity of operation and ease of maintenance with mechanical equipment that can be transfered from one site to another. Among the applications for this system are the Federal or private storage facilities, shutdown reactors, operating facilities with limited crane or pool facilities, or DOE site fuel storage facilities. Review of the design by the NRC is necessary to determine licensability. The estimated cost of the system is within the range that suggests economic viability. It is expected that a plan for demonstration of the system will be developed in 1996.

REFERENCES

NP-6425, July 1989, "Design Considerations for On-Site Transfer Systems".
NP-7459, September 1991, "Design for On-Site Transfer System".