SPENT FUEL STORAGE: WHAT'S THE NEXT STEP?

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SUMMARY

Based on past and current Federal performance in the area of high level waste disposal, utility-supplied interim storage of spent fuel should be planned for beyond the year 1998.

Recent work performed by Gilbert/Commonwealth (G/C) indicates that spent fuel rod consideration and independent wet spent fuel storage pools may be the most logical steps for utilities to supply needed storage capacity. G/C studies show that rod consolidation is feasible, however, there are several areas which require special attention. Experience with one study suggests that more detailed analysis methods can help qualify spent fuel pools for rod consolidation which were once thought to be limited by structural design limits.

A first-of-a-kind project has shown that wet pool storage can be less expensive than dry storage in many situations. Based on these findings and proven pool storage technology, experience, licensability, and modular expansion, independent pool storage should be seriously considered for providing additional spent fuel storage capacity.

INTRODUCTION

The National Waste Policy Act (NWPA) of 1982 reaffirms the utilities' responsibility to provide spent fuel storage until a Federal repository is operational. Even though the NWPA calls for a Federal repository to be ready by 1998, the past record of the federal government on this issue, the currently expected delays in meeting the NWPA schedule, and the lead time needed to ship fuel to a repository or monitored retrievable storage facility make it prudent to plan for utility-supplied storage of spent fuel beyond the year 1998. For the majority of cases to date, the utilities have been able to expand their on-site storage with higher density racks in order to meet their increased storage needs. With many on-site pools reracked to their fullest extent, however, and transshipment being a politically troubled option which is available only to utilities with more than one reactor, upon what spent fuel storage options will the majority of the utilities rely?

The major factors which control the answer to this question are the storage option's availability, its licensability (i.e. safety and technology development), and economics. Based on study, design, and licensing work recently completed at Gilbert/Commonwealth (G/C), we expect that for many plants spent fuel rod consolidation to obtain small storage capacity increases and independent wet pool fuel storage for large capacity increases are the most logical next steps.

While commercial dry storage may be advantageous in the future, its current unknown licensability and incomplete technology development make it an uncertain storage option. In addition, the economics of rod consolidation in existing spent fuel pools is expected to be better than for new dry storage, and for larger storage capacity the cost of independent, on-site wet pool modular storage is estimated to be lower than metal dry storage casks or drywells.

ROD CONSOLIDATION

Most studies have shown that the expanded use of existing spent fuel storage facilities, if technically feasible, is more economical than new facilities which provide additional storage capacity. This conclusion has been borne out by the number of spent fuel rack replacements in the past and the current interest in rod consolidation that has been expressed to some degree by many utilities.

One of the first steps in determining the availability, licensability, and economics of rod consolidation is a site specific feasibility study. G/C has performed such studies as part of an overall utility assessment of alternative interim storage methods. Spent fuel rod consolidation was evaluated in multi-discipline studies that assessed the areas of:

1. Thermohydraulics.

2. Special nuclear material accountability.

3. Structural capability of the existing spent fuel pools and storage racks.

4. Spent fuel pool cooling and cleaning.

5. Shielding.

6. Nuclear criticality safety.

7. Rod consolidation equipment development.

8. Licensing.

9. Cost.

10. Schedule.

The study's goals were to identify any adverse conditions which might prohibit or limit the pool's capability to accept additional spent fuel by storing fuel rods in a more dense configuration and to assess the ability of consolidation equipment to physically manipulate spent fuel into a densified configuration.

The evaluations indicated that while several of the areas studied required special attention, they should not have a significant adverse impact on the feasibility of rod consolidation. For example, special nuclear material accountability requirements should not prohibit rod consolidation, but the consolidation of integral numbers of fuel assemblies into one canister can have significant operational advantages for maintaining records and conducting inventories. In addition, the storage canister will most likely have to be designed with permanently attached means for unique identification and with tamper indicating seals.

Nuclear criticality safety should not be a problem since consolidated fuel is less reactive than a fuel assembly, due to the displacement of the water moderator. However, the canister must still be properly designed in terms of its size and structural integrity in order to prevent the possibility of nuclear criticality in the event that consolidated rods are separated due to a consolidation process malfunction or a dropped consolidation canister.

The evaluation of rod consolidation technology determined that the contemplated operations needed for fuel disassembly and consolidation are known to be possible. This has been demonstrated at nuclear power plants by the past history of spent fuel disassembly and the safe handling of thousands of individual rods. These operations were performed to repair or inspect spent fuel. Current technology development focuses on equipment to consolidate spent fuel within the plant spent fuel pool on a routine basis to achieve increased storage density.

LICENSING CONSIDERATIONS

Rod consolidation is believed to be a safe, licensable process even though the NRC has not yet granted a license. The licensing uncertainty surrounding rod consolidation can be traced, for the most part, to the fact that no established regulatory or design requirements exist specifically for rod consolidation. Therefore, based on past experience in similar situations, the requirements tend to be negotiated during the licensing process. This can result in an unnecessarily long licensing process. The industry is currently writing a design standard for rod consolidation under the auspices of the American National Standards Institute with the American Nuclear Society acting as the manager of this effort. The Working Group Committee for this standard began the development effort approximately eight months ago. The standard will hopefully be ballotted by the end of 1984 with approval by mid-1985. One of the goals of the Committee is to prepare criteria on which both the industry and the NRC can agree. This will, hopefully, lead to NRC endorsement of the standard and streamline the licensing process.

STRUCTURAL DESIGN CONSIDERATIONS

The structural capacity of a spent fuel pool may be a limitation on the feasiblity of rod consolidation. One of the studies performed by G/C evaluated the pool and existing storage racks employing the same structural analysis method originally used for the operating license. This method indicated that the pool lacked structural capacity for the additional fuel weight. Further analysis by the original plant designer led to their prediction that the pool would require extensive structural modifications beneath the pool in order to support the additional weight due to rod consolidation. Further investigation by G/C, however, indicated that more advanced analytical techniques would successfully demonstrate additional structural capacity for new high density stainless steel storage racks and the storage of consolidated fuel rods without structural modification to the pool slab or walls. While the cost for these more detailed structural analysis techniques is higher than that for typical spent fuel pool evaluations, it is still far less expensive than the cost for construction of pool supports or for other spent fuel storage alternatives. Based on this experience, it is strongly recommended that utilities who believe their spent fuel pools are limited by structural design limits consider more detailed structural analytical techniques.

FUTURE COST IMPACT

Another reason for our belief that rod consolidation will be one of the next utility steps for the backend of the fuel cycle is an indication that consolidated fuel will be the form specified for a Monitored Retrievable Storage (MRS) facility and the geologic repository. If utilities do not consolidate their fuel, DOE will incur higher cost for transport and consolidating the fuel prior to storage or disposal. These costs must be borne by the spent fuel generators. Since there are few situations where the government can do something for less expense than the private sector, there will likely be significant economic justification for the utility to consolidate its spent fuel prior to the offsite shipment.

INDEPENDENT WET POOL STORAGE

New spent fuel storage facilities can provide additional capacity for those utility situations where reracking or rod consolidation cannot meet the storage need. In addition, government monitored retrievable storage will require construction of new spent fuel storage capacity. Dry spent fuel storage concepts such as metal casks and drywells appear to be economically attractive for small storage capacity requirements on the order of 600 MTU or less. Dry storage vaults appear to have economic advantages for larger storage capacities. Dry storage has many desirable qualities and it is receiving a great amount of attention by the industry. In fact, G/C has been involved in the development of commercial dry spent fuel storage criteria and design concepts. Nevertheless, dry storage of LWR fuel has not yet been proven as a licensable technology in the U.S. Although some dry spent fuel storage concepts have been demonstrated in the U.S. on a limited, unlicensed basis, more future work is being planned in that direction. Many questions remain unanswered concerning long term fuel integrity, the need for fuel canisterization, and the magnitude of research and development costs needed to support a dry storage concept license application.

Wet pool spent fuel storage, on the other hand, is a proven technology which has provided safe, reliable storage of spent nuclear fuel for many years. It is the only concept which has demonstrated licensability for the independent storage of LLW fuel under 10CFR72. It also appears, based on recent work done by G/C, that there are many cases where wet pool storage can be more economical than dry storage. While pool storage of spent fuel may not be the best choice for every situation, G/C believes that this storage method should be seriously considered when evaluating alternate means for providing additional spent fuel storage capacity on existing reactor sites and for providing offsite interim storage.

MRS CONCEPT

A serious shortcoming of the current DOE MRS program is that wet pool storage was not evaluated as a concept for the MRS facility. The reason for this oversight is most likely based on the prevailing attitude that wet pools are too expensive, and on a belief that they are not expandable in a modular fashion, have high operational costs, and require a long lead time before operation. Based on a first-of-a-kind project recently completed by G/C, we have found that these ideas are not necessarily true. In fact, it is possible that wet storage may be better suited for a MRS facility than many of the dry storage options that were considered. Since the MRS is to be a licensed facility used as a backup to the geological respository, proven technology with known licensability should be of prime concern to the utilities who are expecting DOE to accept fuel on time.

G/C has completed a site specific wet pool Independent Spent Fuel Storage Installation (ISFSI) design, safety analysis, environmental review, and the preparation of a complete license application meeting the requirements of 10CFR72. To our knowledge, this effort is the first such completed in the U.S. for a new, site specific wet pool ISFSI meeting current design and regulatory requirements. The results of this work have illustrated that independent spent fuel pools can provide for flexible and economic storage of decayed spent fuel. Figure 1 is a cutaway view of the facility designed for this project.

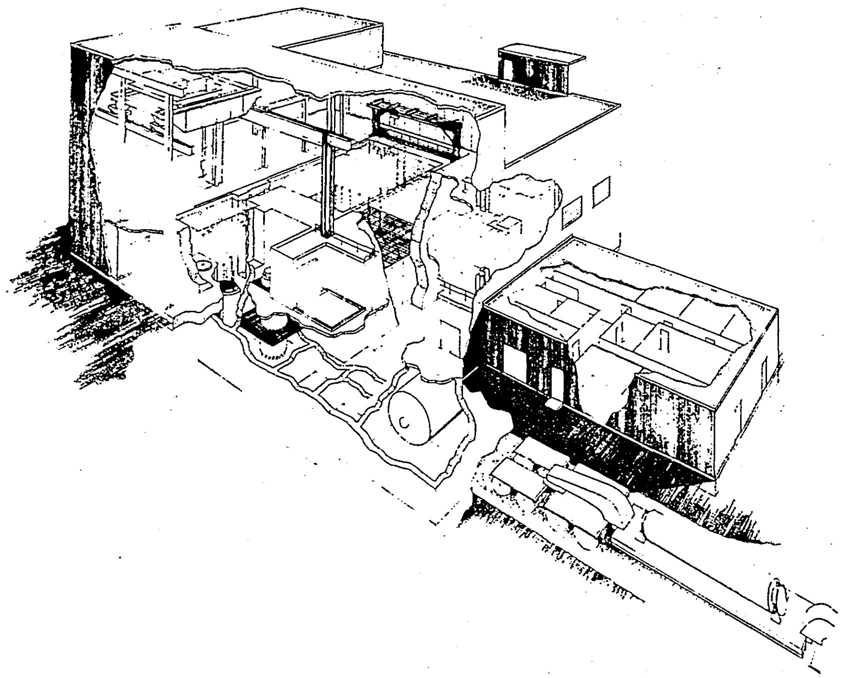

Figure 1 Gilbert/Commonwealth Independent Spent Fuel Pool Storage Installation

WET STORAGE COSTS

As part of G/C's effort for a wet pool ISFSI, a detailed estimate of the overall facility cost was prepared for a specific site application. The capital cost for the first module of storage was estimated at $26.1 million in constant 1983 dollars with an average annual operating cost of approximately $0.5 million per year. The storage capacity of the module was approximately 990 MTU of unconsolidated fuel or 1980 MTU of consolidated fuel rods. The capital cost estimate included the cost of sitework, labor, and material for constructing the facility and its associated system, equipment, and ISFSI system interfaces with the on-site nuclear plant. The estimate also included engineering fees and allowances for temporary construction facilities, owner's management costs, construction management costs, and 20% contingency.

The basis for the direct construction costs was the ISFSI layout drawings, system flow drawings, and system descriptions. Manufacturers' budgetary quotations were utilized in the pricing of major equipment. Prices for material and other equipment were obtained from catalogs, standard reference publications, and vendors. Construction labor costs were developed assuming union craft labor rates applicable to the area of the ISFSI site. Labor productivity reflects construction of a new facility separated from an operating nuclear power plant.

The cost of engineering was based on actual G/C engineering cost to design and perform all analyses for the ISFSI and prepare the license application, plus the proposed cost quoted to the client for final engineering.

The average annual operational cost was based on manhour estimates for various operations such as fuel transfer, routine maintenance, operator surveillance, security, low level radioactive waste processing, and special operation modes. In addition, the annual cost includes operational materials such as consumables, spare parts, and resins. Based on average power requirements for the installation equipment and average makeup water demand, the annual utilities costs were determined. Finally, the operational cost includes packaging, transportation, and burial of low level radioactive wastes generated by the ISFSI. The unit values for these operational items were based on known client costs or were estimated based on typical utility costs. If rod consolidation is to be performed in this facility, the operational cost for the process would need to be added.

There are several organizations that have estimated wet pool ISFSI costs at significantly higher values. While the details of these estimates are not available for examination, we believe there are several reasons why G/C's estimate provides a more accurate picture of what the actual cost can be for a wet pool ISFSI located on the site of an existing nuclear facility.

Unlike several recent studies, the G/C capital cost estimate is not based on an empirical formula with storage capacity as its only variable. In addition, the annual operational cost was not estimated as a simple percentage of capital costs. The G/C cost estimates have a sound engineered design basis. Also, the intent of the cost development was to estimate the cost of the ISFSI at the midpoint of the expected cost range. Some previous estimates have been developed on a "not to exceed" basis. This type of approach can result in a conservatively high cost estimate.

In addition to having a design basis for the G/C cost estimate, the design itself offers both capital and operational cost savings when compared to some previous pool storage concepts. Due to the decayed nature of the spent fuel stored in an ISFSI, the design requirements of 10CFR72 and ANS 57.7 are significantly less stringent than those for a reactor building storage pool. These differences in design requirements can be translated directly into economic savings. Therefore, the estimated cost of the G/C ISFSI, which is designed to 10CRF72 and ANS 57.7 requirements, should be lower than cost estimates for facilities based on 10CFR50 and ANS 57.2 requirements.

Finally, we believe that operational input from existing facilities and previous design experience have produced an ISFSI design which tends to reduce the cost of the facility and allow ease of operations and maintenance. Operational experience from both the G. E. Morris Operations and West Valley were factored into the design. In addition, G/C has designed spent fuel pool storage for more than 20 nuclear facilities including reactor spent fuel pools and five independent or adjacent spent fuel pool storage facilities. This experience has been used to produce a design and cost estimate which represents a credible effort on which to base future decisions regarding the use of pool storage for interim storage of spent fuel.

CONCLUSION

There is a broad spectrum of utility spent nuclear fuel storage needs and we predict that these needs will be met with a wide variety of solutions. In general, however, there appear to be many reasons for an overall utility move toward spent fuel rod consolidation. And for those utilities which believe their pools are structurally limited, thus not allowing for consolidation, there may be analytical methods which can help this problem.

For storage capacity beyond that provided by rod consolidation, utilities and DOE sould seriously consider new wet pool storge facilities when evaluating different alternatives. Current work has shown that wet pool storage can be flexible, expandable in modular form, and cost effective in addition to its proven safety, fuel retrievability, and licensability.