CONF-941207--17

WHC-SA-2508-FP

Interim Dry Cask Storage of Irradiated Fast Flux Test Facility Fuel

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Westinghouse Hanford Company Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

Approved for Public Release

MASTER

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

Interim Dry Cask Storage of Irradiated Fast Flux Test Facility Fuel

P. L. Scott

Date Published
September 1994

To Be Presented at
DOE Spent Nuclear Fuel Challenges '94
Salt Lake City, Utah
December 13 - 16, 1994

Prepared for the U.S. Department of Energy
Office of Environmental Restoration and
Waste Management

Westinghouse Hanford Company P.O Box 1970 Richland, Washington

Hanford Operations and Engineering Contractor for the
U.S. Department of Energy under Contract DE-AC06-87RL10930

INTERIM DRY CASK STORAGE OF FFTF IRRADIATED FUEL

Peggy L. Scott
Westinghouse Hanford Company
P.O. Box 1970
Richland, Washington 99352
(509)376-4219

ABSTRACT

This paper will give an overview of the FFTF Spent Fuel Offload project. Major discussion areas will address the status of the fuel offload project, including an overview of the fuel offload system and detailed discussion on the individual components that make up the dry cask storage portion of this system. These components consist of the Interim Storage Cask (ISC) and Core Component Container (CCC). In conclusion, this paper will also discuss the challenges that have been addressed in the evolution of this project.

I. BACKGROUND

The Fast Flux Test Facility (FFTF), located at the U.S. Department of Energy's (DOE's) Hanford Site, is the largest, most modern, liquid metal-cooled test reactor in the world. Originally constructed to support the U.S. Liquid Metal Fast Breeder Reactor Program, the FFTF supported various missions from 1980 to 1992, including both national and international breeder reactor programs, production of medical and industrial isotopes, material testing for the fusion and space programs, and providing customized neutron environments to meet a variety of customer's needs.

During this period of continuous operation, the need for additional irradiated fuel storage capacity, beyond the existing sodium storage pools, was recognized. In response, a system capable of handling clusters of six irradiated fuel assemblies and using the existing waste offload equipment to prepare the fuel clusters for shipment to a reprocessing facility was pursued.

Subsequent to this project initiation, the decision was made not to reprocess the irradiated fuel, resulting in modification to the original project scope. The new concept used the original cluster handling capabilities but also provided aboveground dry storage casks. These casks were to be capable of interfacing with the existing facility waste handling equipment and also providing a maximum of 50 years of interim storage until the spent fuel could be dispositioned. These casks would have provided the overflow storage required to support continued FFTF operation.

However, in January 1990, after an evaluation of long-term missions for FFTF, the DOE-Headquarters concluded that justification to support the expense of continued operation did not exist. After commissioning an Independent Review Team to assess the degree to which FFTF could be made self-supporting by operating as a multimission facility, the DOE directed the FFTF to commence shutdown on December 15, 1993. In response, Westinghouse Hanford Company completed the Shutdown Program Plan and submitted it to DOE on March 4, 1994. This plan outlines the activities required to accomplish the complete shutdown of the FFTF to an industrially safe condition within the 5-year goal set by DOE which assumed funding availability. Part of this plan is the Spent Fuel Offload Project, which calls for offloading all irradiated spent fuel that is presently in sodium pool storage to aboveground dry cask storage. Because of the aggressive schedule outlined by this plan, the dry cask storage system project scope was expanded and expedited to support initial loading of spent fuel into Interim Storage Casks (ISCs) by October of 1995.

II. INTRODUCTION

The FFTF Shutdown Program Plan was developed to define the most cost-effective progression of steps required to place the FFTF in a long-term environmentally safe and stable configuration. The Spent Fuel Offload Project forms a portion of the overall integrated FFTF deactivation plans. This project calls for retrieving all fuel that is currently in liquid-metal sodium pool storage, preparing these fuel assemblies for dry storage, and, finally, placing the prepared clusters of assemblies into dry storage casks. Completion of the offload effort is scheduled to occur over the span of 2.8 years and will require approximately fifty-seven dry storage casks.

During development of the FFTF Shutdown Program Plan several different de-activation strategies were evaluated. Of all strategies considered, the single major driving factor was the economic impact associated with maintaining sodium systems for extended fuel storage. This factor dictated that the primary effort for de-activating the FFTF should be to expeditiously drain the sodium from the facility. Since removal of the spent fuel is required prior to draining the total inventory of sodium, the dry storage project is critical path.

In addition to considering only the economics for FFTF de-activation, however, dry cask storage also provides several other advantages over sodium pool storage. The first, and foremost, advantage is that dry cask storage provides a low maintenance spent fuel configuration. Another major advantage is the system's ability to provide the requisite barriers for the long-term interim storage period. This is especially critical if the long-term integrity of the spent fuel cladding cannot be guaranteed for the existing storage system's projected lifetime. By providing an inner container design with a mechanically sealed or welded closure, the cladding can be effectively replaced as a barrier. Since this inner "can" has not seen the same high fluence irradiation history as the spent fuel cladding there is added barrier integrity assurance. The "can" barrier is essentially "decoupled" from degradation effects of the sensitized cladding materials. The inner "can" also provides the vehicle for structurally sound retrievability, and long-term geometry and contamination migration control of the spent fuel assemblies. These are all major considerations for future spent fuel disposition activities.

An additional secondary barrier is also provided by a dry cask storage system concept. The cask provides the redundant leaktight boundary for a defense-in-depth approach to containment of spent fuel. By maintaining the inert atmosphere or "limited air" environment, the cask eliminates the continuous supply of oxygen and moisture that are required to accelerate spent fuel assembly degradation over the interim storage life-time. The dry storage cask also provides the radiation shielding required for aboveground storage at the facility.

When considering the factors mentioned above, it is clear that dry casks can be considered a feasible solution for long-term interim storage of spent fuel until final disposition. By providing barriers that are effective for the life of the storage system, dry cask storage can prevent the development of a future critical clean-up task.

III. FUEL OFFLOAD SYSTEM OVERVIEW

The requirements considered when developing the FFTF dry cask storage system concept were; the flexibility to easily relocate the system to a central storage complex at a future date, the ability to interface with the facility's existing waste offload equipment, and, also, the ability to meet the demands of the FFTF Shutdown schedule. The flexibility and facility interfacing requirements dictated that the design concept of the FFTF dry storage system be based on top-loading vertical storage casks called Interim Storage Casks (ISCs). There are several other components that also comprise the spent fuel off-load system. These components are best described by their respective functions in the spent fuel handling offload sequence. The sequence takes the spent fuel, which is initially located in the sodium storage pool, to it's final storage configuration. In the final storage configuration, the fuel will be located inside a sealed Core Component Container (CCC), which is inside a redundantly sealed Interim Storage Cask (ISC), which is located in the Interim Storage Area (ISA).

The offload sequence starts with the spent fuel which is initially located in sodium pool storage. Each spent fuel assembly will be transferred individually to the Interim Examination and Maintenance Hot Cell using the existing reactor refueling machines. In the Hot Cell, which is argon inerted, the fuel will be cleaned of all residual sodium. This cleaning is required, prior to long-term dry storage of the spent fuel, due to the corrosive and reactive nature of the sodium. The rate at which fuel can be offloaded is limited by the time it takes to wash the assemblies. The throughput rate of the six assemblies required to fill a Core Component Container (CCC) is approximately eight days assuming round-the-clock, seven day per week operation with no equipment down time. If a 50% availability factor is assumed to account for equipment maintenance activities, the current inventory of approximately 371 assemblies can be offloaded in 2.8 years. After each assembly has been washed individually, it will be dried and placed into a clean Core Component Container (CCC).

The Core Component Container is an unshielded, closed container, or "can", that provides the primary barrier for the 50 year design life of the dry storage system. It was designed by Westinghouse Hanford Company (WHC) and, in addition to providing the primary barrier, the CCC also provides long-term handling capability, retrievability, and geometry control for the spent fuel. A private company will fabricate the CCC from stainless steel and nickel alloy materials to provide a long-term corrosion resistant fuel storage container. The design provides six separate bottom-sealed tubes clustered around a central support tube. Each tube is capable of storing a spent fuel assembly. The center tube is also capable of storing an additional assembly if the fuel assembly nozzle is cut off using existing Hot Cell equipment. Only the upper gas spaces of the CCC communicate. For fuel accountability control, each CCC is identified by serial number and each tube is also separately identified. When the CCC contains all spent fuel assemblies to be stored, it's cover, which contains a mechanical seal and 12 bolts, will be secured using the Hot Cell manipulators. The CCC will then be leak tested to ensure the mechanical seal is functional and, upon final package acceptance, be transferred from the Hot Cell into the Solid Waste Cask (SWC).

The Solid Waste Cask is an existing transfer cask that is used in conjunction with the facility cranes to provide shielded and sealed mobility for transferring a CCC from the Hot Cell to the Reactor Service Building Cask Loading Station (RSB-CLS). This cask, which was previously used to transfer non-fuel irradiated components to a waste burial cask, has been upgraded to handle the spent fuel in CCCs.

At the RSB-CLS, which has also been modified to accommodate dry fuel transfers, the CCC will be lowered through sealing and shielding equipment into the Interim Storage Cask (ISC).

The ISC is a top-loading dry storage cask capable of receiving and storing a CCC. Design and fabrication of the ISC is being performed by General Atomics (GA) with Sierra Nuclear Corporation (SNC). The design is modeled after SNC's Ventilated Storage Cask (VSC) design which has been licensed under the Nuclear Regulatory Commission's general licensing provisions. The design is a passively ventilated concrete and steel shielded cask with a carbon steel secondary containment boundary. The ISC is much smaller than a VSC. Its maximum weight, with the 2,268 kilogram (5,000 pound)

CCC payload, is 51,800 kilograms (114,200 pounds). The outer diameter of the ISC is 216 centimeters (85 inches) and the overall length is 457 centimeters (180 inches). The inner cavity is 53 centimeters (21 inches) in diameter and 373 centimeters (147 inches) in length to accommodate the CCC. An impact limiter located at the bottom of the internal cavity of the ISC will protect the fuel if an inadvertent drop of the CCC were to occur while loading. After the CCC has been placed into the ISC, the shielded closure will be installed.

The ISC's shielded closure, which is secured by torquing the 16 bolts, provides redundant mechanical seals and a cavity test port. After installation of the closure, the ISC/CCC package will be inerted with helium or argon using the cavity test port. The secondary boundary's redundant mechanical seals will then be certified as leaktight. Upon meeting the final ISC/CCC package acceptance criteria, the ISC will then be transferred, using the existing cask transporter, to the Interim Storage Area (ISA). The closure design also accommodates intermittent testing of the internal cavity atmosphere and the closure seals.

The sequence described above will be repeated until all FFTF spent fuel assemblies have been offloaded from sodium pool storage to long-term low maintenance dry cask storage. Final configuration will consist of 57 ISC's located in the ISA, which is a concrete pad, 120 feet long by 90 feet wide, surrounded by an eight foot high fence.

Over the 50 year design life of the dry storage system only a minimal amount of maintenance will be required. These long-term maintenance items will consist of removing any debris build-up from the storage area, and periodic inspections for inventory and cask condition acceptance.

IV. PROJECT CHALLENGES

During the evolution of this project several challenges were encountered. This section will describe some of the challenges as they occurred in the sequence of project development. This sequence starts with the initial project definition, covers final design development, and, finally, ends with project implementation.

Early in the initial project definition, one requirement of the dry fuel storage system was that it had to be easily relocatable onsite. This requirement would allow for eventual consolidation of the spent fuel. Cask storage versus modular storage evolved from the "easily relocatable" requirement. Then, after the FFTF shutdown order was received, the system was required to be implemented in a short time-frame. The implementation requirement led to the development of the vertical top-loading storage cask concept that is smaller in size than a typical commercial cask. The smaller size was necessary for the cask to interface with the existing irradiated waste offload equipment, therefore, avoiding extensive and time-consuming facility modifications.

After project definition, justification of the cost of the smaller cask concept was the first issue. It is true that when comparing the "per fuel assembly" costs of smaller storage casks the costs will be higher. However, comparison of cask costs alone is not a valid indicator of the total spent fuel storage costs. A cask-only comparison cost does not factor in the schedular costs of maintaining the FFTF spent fuel in sodium storage pools or the facility operational costs associated with delaying dry storage. When these costs are factored in, the one-time purchase cost of dry storage casks is small in comparison to the costs of delaying dry storage. The schedular and operational costs are major factors in determining and evaluating total costs of spent fuel storage. At FFTF it was not cost-effective to delay the dry storage cask project to modify the facility for commercial-size storage casks. The one-time realized savings would have been lost by the delay. Another concern associated with delaying the dry storage project was that if the fuel is stored for an extended period of time in existing sodium pool storage there is the potential risk of creating a fuel storage legacy.

Another challenge occurred during the design development of the CCC. The first CCC design was an open basket design. This concept was consistent with commercial dry storage in that it relied upon the cladding as a barrier. However, this reliance on the cladding as a barrier was challenged based on a phenomena termed "hot cell rot". This phenomena, where spent fuel cladding was observed to lose its strength and ductility, had been seen to occur with sodium cooled reactor fuel pins that had been stored in "non limited air" hot cells for extended periods of time. "Hot cell rot" is postulated to be a form of caustic stress corrosion cracking that occurs due to the sodium hydroxide attacking the intergranular structure of the sensitized stainless steel cladding.

From this concern, an agreement developed to resolve the "hot cell rot" issue. This agreement outlined changes to the project requirements that would conservatively address the long-term concerns. Consequently, the CCC design was changed to add a cover with a mechanical seal, close the fuel support tubes with nickel alloy cups, and re-perform the criticality analysis to address the effects of the most extreme case of "hot cell rot".

These new requirements imposed major design changes for the CCC. And, since all the handling equipment dimensions were based on the shorter open CCC dimensions, addition of the closure cups and the lid complicated the design. There was minimal clearance on the lid to add bolts and a seal. This required the development of special made clover-leaf shaped mechanical seal. These features added to the expense of the CCC. The added barrier, however, will be worth the incremental cost increase, due to the benefits in future retrieval operations, if "hot cell rot" occurs.

The next phase of the project was the specification development for the ISC. This was not a detailed design effort, but instead, was performance-based. This was because it was desired to have an experienced transport or storage cask designer, with NRC licensing experience, design and fabricate the cask to meet the specification requirements and the 10CFR72 regulations. The specification, therefore, consisted of enough site information and design acceptance criteria to allow the designer to develop the detailed design. The information provided consisted of: defining the radiation and thermal source of the spent fuel, defining cask design requirements such as: maximum fuel temperature, maximum dose rate, maximum surface temperature, and also defining the site accident and design conditions. In addition to the design information and acceptance criteria, requirements were also imposed on the ISC design based on on-site transport criteria. These requirements would allow for future spent fuel consolidation and ensure the casks would be "easily relocatable". The only detailed design requirements that were included in the specification were the existing facility interfacing requirements for the cask. These interface requirements defined the maximum weight and outer dimensions of the ISC. Finally, the specification also included performance testing requirements for each cask. Prior to final design acceptance, the first ISC will have to pass the acceptance tests which include: a thermal test, gamma scans for shielding acceptability, a pressure test, a leak test, a handling/interface test, and also a proof load test of the cask's lifting attachment points. Final fabrication approval of the additional ISCs are contingent on the acceptable results of the performance tests. WHC has a high degree of confidence these performance constraints can be met. This confidence is based on scoping analyses that were performed prior to releasing the specification.

Implementation of the Spent Fuel Offload Project consists of a joint effort by WHC and GA. The ISC is being designed and fabricated by GA in parallel with the design and fabrication of the CCC, RSB-CLS interfaces, and the ISA by WHC. This has been successful and has required some modifications to work out all the required interfaces. However, with any project that evolves, this is to be expected.

V. CONCLUSION

Although the short-term initial expenditure for FFTF dry cask storage is aggressive, when the total spent fuel lifetime costs are compared with the yearly costs to maintain sodium pool storage, these costs are justified. Furthermore, if the spent fuel cladding degraded while in extended sodium pool storage, the dry storage costs will be magnitudes less than any clean-up costs that could occur. Therefore, planning that prevents the creation of any future legacies will, over the long-run, allow all future resources to be focussed on pre-existing environmental issues. Dry spent fuel storage is, therefore, the method of choice for the FFTF de-activation effort and will leave no legacies, beyond future disposition of prepared fuel clusters, to a future workforce and, more importantly, to a new generation of stakeholders.

ACKNOWLEDGMENTS

This work was performed by Westinghouse Hanford Company for the Department of Energy.

REFERENCES

1. "Fast Flux Test Facility Shutdown Program Plan", WHC-SD-FF-SSP-004, Rev.0, 1994

2. 10CFR72, Code of Federal Regulations, "Licensing requirements for the Independent Storage of Spent Nuclear Fuel and High-level Radioactive Waste", 1991