TRANSPORTATION OF FAILED OR DAMAGED FOREIGN RESEARCH REACTOR SPENT NUCLEAR FUEL

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ABSTRACT

Since initiating the Foreign Research Reactor Spent Nuclear Fuel (FRR SNF) Acceptance Program in 1996, the Program has had to deal with difficult issues associated with the transportation of failed or damaged spent fuel. In several instances, problems with failed or damaged fuel have prevented the acceptance of the fuel at considerable cost to both the Department of Energy and research reactor operators. In response to the problems faced by the Acceptance Program, DOE has undertaken significant steps to better define the spent fuel acceptance criteria. DOE has worked closely with the U.S. Nuclear Regulatory Commission to address failed or damaged research reactor spent fuel causing a degradation of the fuel assembly exposing fuel meat and to identify cask certificate issues which must be resolved by cask owners and foreign regulatory authorities.

The specific issues and implementation challenges associated with the transport of MTR-type FRR SNF will be discussed. The information presented will include U.S. Nuclear Regulatory Commission regulatory issues, cask certificate issues, technical constraints, implementation status, and lessons learned. Specific information will also be provided on the latest efforts to revise DOE's Appendix B, Transport Package (Cask) Acceptance Criteria. The information presented in this paper will be of interest to foreign research reactor operators, shippers, and cask vendors in evaluating the condition of their fuel to ensure it can be transported in accordance with appropriate cask certificate requirements.

SUMMARY

Since initiating the Foreign Research Reactor Spent Nuclear Fuel (FRR SNF) Acceptance Program in 1996, the Program has had to deal with difficult issues associated with the transportation of failed or damaged spent fuel. In several instances, problems with failed or damaged fuel have prevented the acceptance of the fuel at considerable cost to both the Department of Energy and research reactor operators. In response to the problems faced by the Program, DOE has taken significant steps to characterize Materials Testing Reactor (MTR)-type FRR SNF that is damaged or failed resulting in fuel meat exposure. Using this characterization methodology, many cask vendors have submitted and obtained amendments to their cask's Certificate of Compliance and Certificate of Competent Authority to allow transport of damaged or failed SNF. This information is of interest to foreign research reactor operators, shippers, and cask vendors, so that requests for amendments to cask certificates can be submitted in a timely manner to facilitate the safe and scheduled transport of MTR-type FRR SNF.

INTRODUCTION

Beginning in the 1950s, as part of the "Atoms for Peace" program, the United States provided nuclear technology to foreign nations for peaceful applications in exchange for their promise to forego development of nuclear weapons. A major element of this program was the provision of research reactor technology and the highly enriched uranium (HEU) needed in the early years to fuel the research reactors. In the past, after irradiation in the research reactor, the spent nuclear fuel was returned to the United States so that the United States maintained control over disposition of the HEU that it provided to other nations. The United States accepted foreign research reactor spent nuclear fuel until the "Off-Site Fuels Policy" expired in 1988 for HEU fuel and 1992 for low enriched uranium (LEU) fuel.

On May 13, 1996, the U.S. Department of Energy issued a *Record of Decision on Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* [1]. The goal of the long-term policy is to recover enriched uranium exported from the United States, while giving foreign research reactor (FRR) operators sufficient time to develop their own long-term solutions for storage and disposal of spent fuel. The spent nuclear fuel (SNF) accepted by the U.S. DOE under the policy must be discharged from the research reactors by May 13, 2006 and returned to the U.S. by May 12, 2009.

Forty-one countries have U.S.-origin enriched uranium and are eligible for shipment to the United States under the policy. The total inventory of eligible fuel contains approximately 17,000 Materials Testing Reactor (MTR)-type SNF assemblies and approximately 5,000 Training, Research, Isotope, General Atomic (TRIGA)-type SNF elements. The SNF will be packaged in shipping casks at the sites and transported to one of two DOE receiving sites. For MTR-type fuel, the receiving site will be the Savannah River Site (SRS) in Aiken, South Carolina. For TRIGA fuel, the receiving site will be the Idaho National

Engineering and Environmental Laboratory (INEEL) in Idaho Falls, Idaho. All SNF will be transported dry in U.S. Nuclear Regulatory Commission (NRC) licensed or Department of Transportation (DOT) validated casks. The MTR SNF will be initially stored under water at existing wet storage facilities at SRS. The TRIGA SNF will be stored dry upon receipt at the INEEL Irradiated Fuel Storage Facility.

Much of the FRR spent fuel that will be accepted by the DOE has been stored for long periods of time (10 to 30 years) in facilities not designed for long-term storage. The deterioration of some of the spent fuel in storage required that the DOE develop acceptance criteria for the transportation and storage of the spent fuel, especially in light of the numbers of assemblies to be accepted under the new policy.

IMPLEMENTATION

In order to ensure the safe transport of failed or damaged SNF, a phased approach was initiated in 1997. This approach is described in the Department's paper entitled *Transportation of Failed or Damaged Foreign Research Reactor Spent Nuclear Fuel* [2].

Phase I was initiated in response to the absence of clear regulatory guidance or technical standards for canning MTR-type fuel which has material conditions such as through-clad pitting. The Westinghouse Savannah River Company (WSRC) undertook an effort to develop standards by which MTR-type spent fuel would be judged for purposes of canning prior to transport. The task was based on a conservative approach in implementing definitions made in the *Environmental Impact Statement on a Proposed Nuclear Weapons Nonproliferation Policy Concerning Foreign Research Reactor Spent Nuclear Fuel* (EIS) [3]. As stated in the EIS, the definition of "failed fuel" could be interpreted to require encapsulation of any spent fuel whose external cladding, in any way, "has cracked, pitted, corroded or potentially allows the leakage of radioactive material." As was the case in the development of the WSRC criteria, such a broad interpretation could result in encapsulation of spent fuel that would not otherwise require encapsulation in order to meet requirements for safe transportation or storage.

This conservative interpretation resulted in the original SRS acceptance and storage criteria specifying that no exposed fuel meat from any form of cladding penetration on a fuel plate was allowed.

Phase II was initiated when DOE recognized that the transport and storage criteria being used could have a tremendous impact on transport costs and storage requirements with no health or safety benefits. In response, DOE undertook efforts to clarify the criteria for transportation and storage of research reactor SNF, including the definition of "failed fuel" for those purposes. The clarification was necessary in order to distinguish failed fuel for purposes of transportation and storage from the nuclear industry's interpretation of reactor failed fuel as fuel that is no longer acceptable for use in the reactor. Fuel that is no longer suitable for use in a reactor may be perfectly suitable for safe transportation and storage.

Because the accepted nuclear industry definition of reactor “failed fuel” applies to the performance of fuel during reactor operation and implies release of fission products during reactor operation, reactor failed fuel was considered an inappropriate term to use in considering the acceptability of fuel for transportation and storage. A more appropriate approach to the problem would be to define "acceptability" with respect to SNF behavior under the environmental conditions present during transportation and storage. The definition of "acceptability" depends principally on three factors: (1) fuel condition, (2) transportation requirements (per DOT and NRC regulations), and (3) receipt and storage at SRS or INEEL.

After holding a series of discussions and mock technical reviews, the two receiving sites, INEEL and SRS, developed criteria for accepting spent nuclear fuel based on more scientific-based interpretations of statements in the *EIS* [3]. The DOE Savannah River Operations Office’s Appendix B, *Transport Package (Cask) Acceptance Criteria* [4], was subsequently revised for MTR-type SNF based on this criterion and is the current requirement for receipt and storage at SRS.

However, as subsequent shipments demonstrated, our initial efforts did not entirely resolve this issue for transportation. While DOE resolved internal operational and procedural requirements at its management site, the acceptance criteria did not address cask certification issues, which would allow the shipment of failed or damaged SNF. Cask certificates were considered to be under the purview of the cask vendors and regulatory authorities including the U.S. Department of Transportation (DOT) and the U.S. Nuclear Regulatory Commission (NRC) within the United States. Many casks were represented to be certified to transport failed or damaged SNF with only minor certificate amendments, if an amendment was necessary at all. Therefore, DOE’s acceptance criteria effort focused strongly on potential canning requirements for interim storage at the DOE management sites and not transportation.

Phase III was initiated to address the issue of certification of casks to clearly allow the transport of failed or damaged fuel. DOE, WSRC, and the U.S. NRC worked together to develop a methodology that can be used by cask vendors to consider the transport of damaged fuel with exposed fuel meat in the safety analyses for their casks. This effort resulted in a preliminary report issued by WSRC in October 1998 that provides a methodology for containment analysis of the transportation of damaged aluminum-based SNF [5]. Many cask vendors, regulatory authorities that certify or validate casks, shippers of SNF, and other interested organizations participated in presentations and implementation strategy meetings on the technical details of the report. The meetings were held in November 1998 and were very successful identifying transportation issues associated with shipping damaged fuel.

The data in the WSRC report proved to be invaluable to cask vendors interested in transporting MTR-type SNF in the United States. The report provided a methodology that could be used by cask vendors in the containment analysis for their casks to consider

transport of damaged aluminum clad fuel. The report uses United States recognized standards and methodology for conducting analytical calculations such as ANSI 14.5 and NUREG/CR-6487. The report also provides data which will help cask vendors identify the bounding conditions in which failed or damaged SNF can be safely transported in each specific cask. These conditions could then be incorporated into cask safety analysis. The cask's Certificate of Compliance or Certificate of Competent Authority can then be appropriately amended.

The implementation of Phase III resulted in several cask vendors embracing this strategy and receiving certificate amendments allowing transport of failed or damaged SNF. Currently, the following packages are certified in the United States to transport failed or damaged MTR-type SNF with exposed fuel meat without encapsulation:

- NAC International's LWT
- General Electric Company's GE-2000
- Gesellschoft für Nucklear-Service mbH's GNS-11
- Gesellschoft für Nucklear-Service mbH's GNS-16

Other packages expected to become certified to transport failed or damaged MTR-type SNF with exposed fuel meat without encapsulation are:

- Transnucleaire-Paris' TN-MTR
- Nuclear Cargo + Services' TN-7/2

These certificate amendments identify allowable fuel meat exposure based on the characteristics of the SNF and the specific package. These specifications should be considered along with actual SNF condition when preparing a shipment of SNF to the United States.

Unfortunately, during the time required to implement this approach, several shipments were delayed and/or canceled. However, full implementation and participation by all cask vendors will allow the greatest flexibility in package selection and efficient use of available packages world-wide.

CONCLUSION

The DOE FRR SNF Acceptance Program continues to face the challenges associated with the shipment of failed or damaged SNF. Cask vendors and other organizations involved with the shipment of MTR-type SNF must be sensitive to damaged fuel issues and take early action to address problems so that shipment delays and other related costs can be avoided while maintaining their cask eligible for use. Interested parties are highly encouraged to evaluate the assumptions, bases, and conclusions of the report, *Bases for Containment Analysis for Transportation of Aluminum-Based Spent Nuclear Fuel (Draft)* [5]. FRR's should take appropriate actions to characterize their SNF to identify packages acceptable for use in transport of their fuel. FRR's in countries with other-than-high-income should characterize or assist DOE in the characterization of their SNF to allow proper shipment planning to enable the safe transport of failed or damaged MTR-type SNF to the United States.

REFERENCES

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